Optimization of Population Structure in a Selection Plan for Palas Prolificacy Line

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Abstract
The aim of the paper work is to optimize the population structure in a selection plan, according to model developed by King (1961), which will be proposed to be applied for prolificacy improvement in Prolific Line Palas. The method used in this paper work is modeling, which exist in the most animal breeding scientifically papers. After the simulations, we observed that the most convenient variant was that which prefigure a weight of two groups by 70% (A) and 30% (B). This variant offer a genetic gain per generation by 0.452 additive standard deviations.

Keywords: optimization, selection plan, sheep.

1. Introduction

The breeding program represent a deliberate combination of breeding factors for obtains populations with economic adapted genetic structures. Based on three criteria, we can judge the breeding programs and choose optimum variant [1]:
- the selection effect;
- the inbreeding management (to sustain the genetic variability);
- the expenses related with program realization and implementation.

These three criteria can not be separated in choosing of optimum variant.
The selection plan is an indissoluble component of breeding program. The selection plan is drafts which contain all operations related with replace animals in nucleus.
Each component of this draft can constitute an object of optimization: population size and structure, demographical parameters, animal recording (recording method, capacity of testing space, family structure in testing space, etc.), selection method (BLP or BLUP).
The selection plan efficiency must be seen from two points of view: genetic and economic. These two aspects must be optimum combined, so that the final variant shall ensure maximum genetic gain with minimum effort, expenses and time.
From genetic point of view, in 1944 Dickerson and Hazel [2, 3] say that a selection plan is efficient if: (a) selection effect increase more than generation interval, or (b) selection effect increase and generation interval decrease.

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2. Materials and methods

Biological material used is the Prolific Line Palas, a biological creation of ICDDOC Palas Constanta. Research method used is simulation.

The population structure is:

- population: 400 females and 18 males;
- birth rate: 150%;
- rate of survival: 82%;
- $h^2 = 0{,}15$; $R = 0{,}25$;
- average performance: 1,5 lambs/calving;
- c.v.% = 35%, $\sigma_P = 0{,}525$ lambs; $\sigma_A = 0{,}203$ lambs.

For prolific population of ICDDOC Palas Constanta, we propose a plan to improve prolificacy, according to the model proposed by King. In 1961, King [2] develops a scheme for the selection of rams, fathers of hybrid mothers. Being a low heritable trait, it becomes obligatory, for selection accuracy increase, using as sources of information a great number of performances from ascendants and collateral relatives.

Genetic gain is induced in the population only to males (selected in two moments), females being admitted to reproduction without selection (genetic gain by females will be null).

The response of selection can be estimated for the two moments: the selection of males based on the average performance of mothers and based on average performance of half sibs, each having *m* performances:

$$R_{asc.} = r_{A,\overline{P}_{M(3calvings)}} \cdot i \cdot \sigma_A = r \cdot h \cdot \sqrt{\frac{m_1}{1 + (m_1 - 1) \cdot R}} \cdot i \cdot \sigma_A$$

$$R_{col.} = r_{A,\overline{P}_{HS(2calvings)}} \cdot i \cdot \sigma_A = r \cdot h \cdot \sqrt{\frac{n}{\frac{1 + (m_2 - 1) \cdot R}{m_2} + (n-1) \cdot t}} \cdot i \cdot \sigma_A$$

In which:

$r_{A,\overline{P}_{M(3calvings)}}$ = ascendants selection accuracy;

$r_{A,\overline{P}_{HS(2calvings)}}$ = collateral relatives selection accuracy;

i = selection intensity (different for the two moments);

σ_A = genetic additive standard deviation;

m = number of performances considered (3 for mothers – m_1 – and 2 for half sibs – m_2);

n = number of relatives who provide information (half sibs);

t = phenotypic relationship between relatives ($t = r \cdot h^2$)

On the current parameters of population, according to model developed by King, the program involves dividing the population into two groups as follows:

1. Group A - composed of 162 virgin sheep and 162 sheep at first haircut;
2. Group B – composed of 76 sheep at third calving, deducted from the 324 Group A, based on results obtained in the first two births.

The 324 females of group A mates with a 18 one year-old rams, resulting a sex ratio of 1:18. To ensure balanced groups of descendants, rams are distributed for nine virgin sheep and for nine sheep at first haircut. On the current reproductive parameters, from each ram will get 11 daughters (half sibs) which will be admitted to reproduction activity without selection (however are obtained a surplus of females that can be sold to other farms).

In the next year, the 76 females of group B will be mated with the same 18 rams (now having 2 years old). On the current reproductive parameters, from offspring of the 76 sheep, 46 females will get, which can be admitted on reproduction without selection (surplus can be sold to other farms) and 47 males of which will be selected 18 rams based on average performances of mother (3 calving) and based on average performance of half sibs obtained last year (now at second calving)

For inbreeding increase avoid, the selection of rams must be done from at least 4-5 fathers. The 18 rams chosen will be promoted on reproduction activity and the cycle repeats [2, 3, 4].

3. Results and discussion

Changeing the two groups weight affects genetic gain as follows:

affect the availability of youth obtained from both groups and the number of half sibs that is evaluated each candidate ram, with repercussions on the accuracy of genetic evaluation;

affect the availability of youth candidate and selection intensity in its first moment.

There have been imagined seven variants that can enter the competition plan, presented in Table 1a and Table 1b, by varying the weight of the two groups. The data analysis presented in Table 1a and Table 1b, it appears that, in terms of population response to selection on generation, the best variant is that in which the two groups weight is 20% and 80% respectively, but at least two aspects make this inadvisable in practice:

- decreases the availability of youth replacement obtained from the first group and as a result, females for replacement will come mostly from older mothers, increasing the generation interval and adversely affect the annual effect of selection;
- a lower proportion of group A causes major complications in the supply of group B with sheep at third lactation.

Therefore, it seems advisable to practice variant in which the weight of the two groups is 70% (A) and 30% (B), that providing a population selection response by 0.452 additive standard deviations.

Table 1a. Optimization of population structure for Palas Prolificacy Line

Nucleus		Group A		Group B	N	S	SS	F in first series	F adm. in nucleus in first series	Offspring in second series	M in second series	M selected in first mom. of selection.	M selected in second mom. of selection
M	F	I	II	III									
18	400	162	162	76	1.5	0.82	11.07	199.26	116	93.48	46.74	29	18
18	400	180	180	40	1.5	0.82	12.3	221.4	116	49.2	24.6	29	18
18	400	160	160	80	1.5	0.82	10.93	196.8	116	98.4	49.2	29	18
18	**400**	**140**	**140**	**120**	**1.5**	**0.82**	**9.57**	**172.2**	**116**	**147.6**	**73.8**	**29**	**18**
18	400	120	120	160	1.5	0.82	8.2	147.6	116	196.8	98.4	29	18
18	400	100	100	200	1.5	0.82	6.83	123	116	246	123	29	18
18	400	80	80	240	1.5	0.82	5.47	98.4	98	295.2	147.6	29	18
18	400	40	40	320	1.5	0.82	2.73	49.2	49	393.6	196.8	29	18

Table 1b. Optimization of population structure for Palas Prolificacy Line (further)

P I	P II	I I	I II	A I	A II	R I	R II	R TOT
0.62	0.621	0.598	0.598	0.274	0.321	0.164	0.192	0.3562
Impossible								
0.589	0.621	0.652	0.598	0.274	0.32	0.179	0.192	0.3701
0.393	**0.621**	**0.978**	**0.598**	**0.274**	**0.308**	**0.268**	**0.184**	**0.4520**
0.295	0.621	1.158	0.598	0.274	0.293	0.317	0.175	0.4923
0.236	0.621	1.282	0.598	0.274	0.275	0.351	0.165	0.5159
0.196	0.621	1.377	0.598	0.274	0.254	0.377	0.152	0.5294
0.147	0.621	1.52	0.598	0.274	0.193	0.416	0.115	0.5315

[1]N = birth rate
[2]S = survival rate
[3]SS = number of half sibs
[4]M = male
[5]F = female
[6]P = selection ratio
[7]I = selection intensity
[8]A = selection accuracy
[9]R = response to selection

4. Conclusions

The selection plan efficiency must be seen from two points of view: genetic and economic. These two aspects must be optimum combined, so that the final variant shall ensure maximum genetic gain with minimum effort, expenses and time.

For ICDDOC Palas Constanta Prolificacy Sheep Line we propose for genetic increase of prolificacy a selection plan, according to the model proposed by King, whose components must be optimized.

Respecting the selection plans optimization principles, a maximum genetic gain will be obtain in a population which prefigure a weight of the two groups by 70% for group A (140 virgin sheep and 140 sheep at first haircuting) and 30% for group B (120 sheep at third lactation).

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