Optimization of Generation Interval in a Selection Plan for Palas Meat Line

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Abstract

The aim of the paper work is to optimize the generation interval in a selection plan, according to model developed by Colburn (1961), which will be proposed to be applied for live weight and traits associated with carcass and meat quality improvement in Palas Meat Line. 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 use of collateral selection and a maximum value for i/T ratio which can be obtained when average length of service is 5 years for females and 1 year for males.

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 cannot 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 Meat Line Palas, a biological creation of ICDDOC Palas Constanta. Research method used is simulation.

The population structure is:

- population: 400 females and 20 males;
- birth rate: 123.5%;
- rate of survival: 80%;
- h^2 for traits associated with growth speed is 0.3 and for traits associated with carcass and meat quality is 0.5;
- cv%: for average daily gain 15%, for live weight at 150 days is 16%, for slaughter efficiency is 12% and for carcass quality is 12%.

For Meat Line of ICDDOC Palas Constanta we propose a plan to improve growth speed and traits associated with carcass and meat quality, according to the model proposed by Colburn. In 1961, Colburn [2, 3, 4] develop a scheme for rams selection for live weight at 6 month (own performances) and carcass quality (offspring performances).

In Colburn plan, 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).

We note that the generation interval may be decrease by excluding offspring selection.

In this vein, the ideal would be that the Rams test to be done simultaneously for all characters (growth speed and traits associated with carcass and meat quality). Thus, an alternative to the offspring selection would be the selection on collaterals that would allow reducing the interval between generations, through all its components (through mothers and dads).

For example, it may be proposed a selection plan that aims to genetic improve of the two characters in a sheep population: the average daily gain and percent of lean meat. So:

$$H = v_1 \cdot A_1 + v_2 \cdot A_2$$

In which:

H = selection objective (aggregate genotype);

A_1 = breeding value of candidates for average daily gain;

A_2 = breeding value of candidates for percent of lean meat;

v = economical weights.

In associated selection index structure will be admitted just the traits that is possible to be measured on the live candidates (reducing, in this way, costs associated with selection by avoiding slaughter of collaterals). Thus:

$$I = b_1 \cdot P_1 + b_2 \cdot \bar{P}_{2,SF}$$

In which:

P_1 = own performance of candidate for average daily gain;

$\bar{P}_{2,SF}$ = average performance of half sibs for average daily gain.

The structure of V, C and G matrices will be:

$$V = \begin{bmatrix} V_F(P_1) & Cov_F(P_1, \bar{P}_{2,SF}) \\ Cov_F(\bar{P}_{2,SF}, P_1) & V_F(\bar{P}_{2,SF}) \end{bmatrix} =$$

$$= \begin{bmatrix} 1 & 0.25 \cdot h_1^2 \\ 0.25 \cdot h_1^2 & \frac{1+(n-1)\cdot 0.25 \cdot h_1^2}{n} \end{bmatrix};$$

$$C = \begin{bmatrix} Cov(A_1; P_1) & Cov(A_1; \bar{P}_{2,SF}) \\ Cov(A_2; P_1) & Cov(A_2; \bar{P}_{2,SF}) \end{bmatrix} =$$

$$= \begin{bmatrix} h_1^2 & 0.25 \cdot h_1^2 \\ r_G \cdot h_1 \cdot h_2 & r_G \cdot h_1 \cdot h_2 \end{bmatrix};$$

$$G = \begin{bmatrix} V_A(P_1) & Cov_A(P_1, P_2) \\ Cov_A(P_2, P_1) & V_A(P_2) \end{bmatrix} =$$

$$= \begin{bmatrix} h_1^2 & r_G \cdot h_1 \cdot h_2 \\ r_G \cdot h_1 \cdot h_2 & h_2^2 \end{bmatrix}$$

In which:

h_1^2 = heritability of average daily gain;

h_2^2 = heritability of lean meat percent;

$h_1 = \sqrt{h_1^2}$;

$h_2 = \sqrt{h_2^2}$;

r_G = genetic correlation between the two traits;

n = number of relatives (collaterals).

Computing of regression coefficients is made according to the formula [2]:

$$b = v' \cdot C' \cdot V^{-1}$$

Computing selection accuracy is made according to the formula [2]:

$$r_{I,H} = \sqrt{\frac{S_I^2}{S_H^2}} = \sqrt{\frac{b' \cdot V \cdot b}{v' \cdot G \cdot v}}$$

Computing of global genetic gain is made according to the formula [2]:

$$\Delta H = i \cdot r_{I,H} \cdot S_H$$

Computing of genetic gain for each trait is made according to the formula [2]:

$$\Delta G_i = \frac{b_i \cdot C}{S_I}$$

3. Results and discussion

Eight selection plan variants have been imagined by varying the number of half sibs on each candidate ram (n).
Note that, for the simulation, have been established as values:

- $h_1^2 = 0.3$;
- $h_2^2 = 0.5$;
- $r_G = 0.37$ (genetic correlation between average daily gain and lean meat percent)
- for economical weights vector, will be taking in account 3 variants:
  - $v = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 0.6 \\ 0.4 \end{bmatrix}$;
  - $v = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix}$;
  - $v = \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 0.4 \\ 0.6 \end{bmatrix}$.

Simulation results are presented in Table 1.

Table 1. Simulation results in simultaneous selection plan

Specification		b		S_I	S_H	$r_{I,H}$	ΔH (i)	ΔG_i (i)	
		b_1	b_2					ADG	%LM
	n = 3	0.1847	0.3377	0.2953	0.5067	0.5826	0.2953	0.3515	0.2108
	n = 4	0.1782	0.4243	0.3134	0.5067	0.6185	0.3134	0.3646	0.2366
	n = 5	0.1724	0.5014	0.3287	0.5067	0.6487	0.3287	0.3759	0.2579
$v = \begin{bmatrix} 0.6 \\ 0.4 \end{bmatrix}$	n = 6	0.1672	0.5706	0.3419	0.5067	0.6747	0.3419	0.3859	0.2758
	n = 7	0.1625	0.6329	0.3533	0.5067	0.6972	0.3533	0.3947	0.2912
	n = 8	0.1583	0.6895	0.3634	0.5067	0.7171	0.3634	0.4026	0.3046
	n = 9	0.1544	0.7409	0.3723	0.5067	0.7347	0.3723	0.4096	0.3163
	n = 10	0.1509	0.7880	0.3803	0.5067	0.7504	0.3803	0.4160	0.3267
	n = 3	0.1618	0.3422	0.2817	0.5212	0.5406	0.2817	0.3464	0.2171
	n = 4	0.1553	0.4299	0.3012	0.5212	0.5779	0.3012	0.3592	0.2432
	n = 5	0.1494	0.5081	0.3175	0.5212	0.6092	0.3175	0.3704	0.2646
$v = \begin{bmatrix} 0.5 \\ 0.5 \end{bmatrix}$	n = 6	0.1441	0.5781	0.3315	0.5212	0.6360	0.3315	0.3804	0.2826
	n = 7	0.1394	0.6413	0.3436	0.5212	0.6592	0.3436	0.3892	0.2979
	n = 8	0.1351	0.6986	0.3542	0.5212	0.6795	0.3542	0.3971	0.3113
	n = 9	0.1312	0.7507	0.3636	0.5212	0.6975	0.3636	0.4042	0.3230
	n = 10	0.1276	0.7984	0.3719	0.5212	0.7136	0.3719	0.4105	0.3333
	n = 3	0.1390	0.3466	0.2695	0.5448	0.4946	0.2695	0.3391	0.2230
	n = 4	0.1323	0.4355	0.2902	0.5448	0.5328	0.2902	0.3518	0.2492
	n = 5	0.1264	0.5147	0.3076	0.5448	0.5646	0.3076	0.3631	0.2706
$v = \begin{bmatrix} 0.4 \\ 0.6 \end{bmatrix}$	n = 6	0.1211	0.5857	0.3223	0.5448	0.5917	0.3223	0.3731	0.2885
	n = 7	0.1163	0.6497	0.3351	0.5448	0.6151	0.3351	0.3819	0.3039
	n = 8	0.1119	0.7077	0.3462	0.5448	0.6356	0.3462	0.3899	0.3171
	n = 9	0.1080	0.7605	0.3561	0.5448	0.6536	0.3561	0.3970	0.3288
	n = 10	0.1043	0.8088	0.3649	0.5448	0.6697	0.3649	0.4035	0.3391

Note: ΔH and ΔG_i are expressed in „selection intensity units”.

From the analysis of the data presented in table 1, it is noted that the accuracy of selection is considered a non-linear trend (there is a tendency for capping the value of this parameter). It is also apparent that the economic weight of the two characters does not influence the accuracy of the selection variation according to "n".
Thus, regardless of the economic weight of the two traits (dictated by the market), it appears that each candidate should be evaluated taking into account a number of 6 half sibs, (capping
Unlike the classic model elaborated by Colburn, in plan which provides simultaneous selection may tendency appears next to the value corresponding to n=6).
We believe that a population constitute by 400 ewes and 13 rams (have not been taken into account sizes larger than 400 females, which are unacceptable for ICCDOC Palas Constanta, as a result of the limited resources available to the Institute) provides a large enough selection basis, allowing to evaluate candidates based on their performance and the average performance of 6 half sibs (collaterals are not slaughtered).
be the females evaluate. Thus, genetic progress can be induced in population through the females

also, providing a faster genetic improvement of the population.
To decrease the value of the interval between generations is necessary to optimize the average duration of reproduction service. The optimal value of this parameter is the one that maximizes the ratio i/T.
Simulation results for i/T ratio are presented in Table 2.

Table 2. Evolution of i/T ratio according to duration of reproduction service

NUCLEUS		d		p		i		T		i/T on population level
M	F	M	F	M	F	M	F	M	F	
13	400	5	5	0.0109	0.3361	2.6474	1.079	4	4	0.4658
13	400	5	4	0.0109	0.4202	2.6474	0.9321	4	3.5	0.4641
13	400	5	3	0.0109	0.5602	2.6474	0.7008	4	3	0.4477
13	400	5	2	0.0109	0.8403	2.6474	0.1191	4	2.5	0.3547
13	400	5	1				Impossible			
13	400	4	5	0.0137	0.3361	2.5547	1.079	3.5	4	0.4998
13	400	4	4	0.0137	0.4202	2.5547	0.9321	3.5	3.5	0.4981
13	400	4	3	0.0137	0.5602	2.5547	0.7008	3.5	3	0.4818
13	400	4	2	0.0137	0.8403	2.5547	0.1191	3.5	2.5	0.3888
13	400	4	1				Impossible			
13	400	3	5	0.0182	0.3361	2.4349	1.079	3	4	0.5407
13	400	3	4	0.0182	0.4202	2.4349	0.9321	3	3.5	0.539
13	400	3	3	0.0182	0.5602	2.4349	0.7008	3	3	0.5226
13	400	3	2	0.0182	0.8403	2.4349	0.1191	3	2.5	0.4296
13	400	3	1				Impossible			
13	400	2	5	0.0273	0.3361	2.2648	1.079	2.5	4	0.5878
13	400	2	4	0.0273	0.4202	2.2648	0.9321	2.5	3.5	0.5861
13	400	2	3	0.0273	0.5602	2.2648	0.7008	2.5	3	0.5698
13	400	2	2	0.0273	0.8403	2.2648	0.1191	2.5	2.5	0.4768
13	400	2	1				Impossible			
13	400	1	5	0.0546	0.3361	1.969	1.079	2	4	0.6271
13	400	1	4	0.0546	0.4202	1.969	0.9321	2	3.5	0.6254
13	400	1	3	0.0546	0.5602	1.969	0.7008	2	3	0.609
13	400	1	2	0.0546	0.8403	1.969	0.1191	2	2.5	0.5161
13	400	1	1				Impossible			

Note: M = male; F = female; in simulation was taking in account a birth rate of 140% and a survival rate of 85%.

From the analysis of the data presented in table 2, it is noted that the variant which maximize the value of i/T ratio is the one that provides duration of reproduction service by 5 years to female and 1 year to males.

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 decreasing the generation interval, we propose a simultaneous selection plan, using candidate own performance and average performance of 6 half sibs. Unlike the classic model elaborated by Colburn, in plan which provides simultaneous selection may be the females evaluate. Thus, genetic progress can be induced in population through the females also, providing a faster genetic improvement of the population. Also, for genetic gain maximization, the duration of reproduction service is 5 years to female and 1 year to males.

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