OPTIMIZATION OF POPULATION SIZE AND STRUCTURE IN AN OFFSPRING SELECTION PLAN FOR MILK PRODUCTION TRAITS OF RAMS FROM PALAS MILK LINE

R. Popa, H. Grosu, Dana Popa, M. Maftei, Livia Vidu, Georgeta Diniţă, Nicoleta Işfan, Carmen Nicolae

University of Agricultural Science and Veterinary Medicine of Bucharest, Faculty of Animal Science
e-mail: poparasvan@yahoo.co.uk

Abstract

The aim of this paper is the optimization of population size and structure in an offspring selection plan of rams, according to Robertson and Rendell model for bovines (1951), which will be propose for implementation in Palas Milk Line for genetic increase of milk production traits. 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 an active population size of 400 females and from those 55% represented elite group and 45% testing group.

Key words: offspring selection plan, optimization

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 [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.

MATERIAL AND METHOD

The used biological material is represented by Palas Milk Sheep Line, an ICDDOC Palas Constanta creation.

The method used in this paper work is modeling.

The population structure:

- nucleus: 400 females and 16 males;
- birth rate: 125%;
- survival rate: 82%;
- h^2 = 0,27; R = 0,30;
- average performance: 200 kg milk/lactation;
- c.v.% = 28%, σ_P = 56 kg; σ_A = 29,12 kg;
- number of rams selected by offspring (s) used in Elite group = 16;

- the average reproduction period of rams = 5 years;
- the weight of Elite group is 40% (160 sheep) and Testing group is 60% (240 sheep), characteristically values of original variant of Robertson and Rendell plan;

The genetic gain is induced within population just by males (selected in two moments), females being choose on reproduction activity without selection (genetic gain induced within population by sheep is zero).

The effect of selection per generation will be estimated for the two moments: the male's selection based on mother performance and daughter's average performances respectively:

$$R_{M.} = r_{A,P_M} \cdot i \cdot \sigma_A = r \cdot h \cdot i \cdot \sigma_A$$

$$R_{daughters} = r_{A,\overline{P}_{daughters}} \cdot i \cdot \sigma_A = r \cdot h \cdot \sqrt{\frac{n}{1+(n-1)\cdot t}} \cdot i \cdot \sigma_A$$

in which:

r_{A,P_M} = ascendant's selection accuracy (when mother performance is information source);

$r_{A,\overline{P}_{daughters}}$ = offspring's selection accuracy;

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

σ_A = additive standard deviation;

n = number of relatives which offer the information;

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

In this case, the testing capacity is represented by number of half sibs which can be recorded.

The half sibs which can be recorded will be produced by mating of candidates rams with a part of nucleus females (testing group). The weight of these represented the result of optimization calculation. The half sibs which can be recorded will be named "selection base".

Such optimizations exist on bovines, but not on sheep, because the offspring selection is applied on sheep just for carcass quality traits in Bradford and Colburn plans ([2], [4], [5]).

RESULTS AND DISCUSSIONS

For population size optimization, have been imagined 5 plan variants: 100, 200, 300, 400 and 5000 females respectively. The results of simulation are presented in Table 1.

Analyzing data presented in Table 1, can be seen that maintaining same structure of population (40% Elite and 60% Testing), of different size of this, the variant which offer the biggest selection effect per generation is that which have 5000 sheep (we note that in this case, 16 rams would not be enough, the maximum sex ratio on sheep in case of artificial insemination being 1:250), which offer a selection effect per generation by 2.259 additive standard deviations.

But, in terms of ICDDOC Palas Constanta, such population size is unacceptable because the institute resources are limited. So, the variant which have 400 sheep is the likeliest.

We note that, on actual population status, the variants which have a size population by 100 and 200 females, and a structure represented by 40% Elite and 60% Testing are impossible, because in terms of reproductive parameters, the necessary of candidates rams is higher than available.

For population structure optimization have been imagined 17 plan variants, which contains different weights of two groups, and those variants were applied to different population sizes. The results of simulation are presented in Table 1.

By variation of two groups weight is influenced the selection intensity for the two moments and offspring selection accuracy.

The results were as fallows:

- on a population size of 100 sheep, the biggest selection effect per generation (0.6952 additive standard deviations) has been achieved when the two groups weight was 75% Elite and 25% Testing;
- on a population size of 200 sheep, the biggest selection effect per generation (0.9242 additive standard deviations) has been achieved when the two groups weight was 60% Elite and 40% Testing;

Table 1 Optimization if population size and structure in Palas Milk Line

Pop. size	Population structure		Selection base	n	No of cand. daughter	No of cand. rams	No of rams which finish testing	Ac. I	Ac. II	P. I	P. II	I. I	I. II	R I	R II	R tot.
	E	T														
100	90	10	25.625	1.36389	1.09111	23.4853	18.788226	0.26	0.270755	0.261	0.266	1.2268	1.2159	0.319	0.3292	0.6482
100	85	15	38.4375	1.67041	1.33633	28.7635	23.010784	0.26	0.297205	0.338	0.217	1.0749	1.3254	0.2795	0.3939	0.6734
100	80	20	51.25	1.92883	1.54306	33.2132	26.570565	0.26	0.31721	0.415	0.188	0.9405	1.3994	0.2445	0.4439	0.6884
100	75	25	64.0625	2.15649	1.72519	37.1335	29.706794	0.26	0.333438	0.495	0.168	0.808	1.455	0.2101	0.4852	0.6952
100	70	30	76.875	2.36232	1.88986	40.6777	32.542163	0.26	0.347153	0.581	0.154	0.6658	1.4996	0.1731	0.5206	0.6937
100	65	35	89.6875	2.5516	2.04128	43.9369	35.149553	0.26	0.359066	0.676	0.142	0.4986	1.5367	0.1296	0.5518	0.6814
100	60	40	102.5	2.72777	2.18222	46.9706	37.576453	0.26	0.369616	0.783	0.133	0.2743	1.5684	0.0713	0.5797	0.651
100	55	45	115.3125	2.89324	2.31459	49.8198	39.855847	0.26	0.379096	0.906	0.125	-0.128	1.5961	-0.033	0.6051	0.5718
200	180	20	51.25	1.92883	1.54306	33.2132	26.570565	0.26	0.31721	0.185	0.188	1.4093	1.3994	0.3664	0.4439	0.8103
200	170	30	76.875	2.36232	1.88986	40.6777	32.542163	0.26	0.347153	0.239	0.154	1.2742	1.4996	0.3313	0.5206	0.8519
200	160	40	102.5	2.72777	2.18222	46.9706	37.576453	0.26	0.369616	0.294	0.133	1.16	1.5684	0.3016	0.5797	0.8813
200	150	50	128.125	3.04974	2.43979	52.5147	42.011751	0.26	0.387712	0.35	0.119	1.0536	1.6207	0.2739	0.6284	0.9023
200	140	60	153.75	3.34082	2.67266	57.527	46.021568	0.26	0.402918	0.411	0.109	0.9477	1.6629	0.2464	0.67	0.9164
200	130	70	179.375	3.6085	2.8868	62.1362	49.708974	0.26	0.416055	0.478	0.101	0.8362	1.6982	0.2174	0.7065	0.9239
200	120	80	205	3.85765	3.08612	66.4264	53.141129	0.26	0.427634	0.554	0.094	0.7118	1.7285	0.1851	0.7392	0.9243
200	110	90	230.625	4.09166	3.27333	70.4558	56.364679	0.26	0.437995	0.641	0.089	0.5632	1.7551	0.1464	0.7687	0.9152
200	100	100	256.25	4.31299	3.45039	74.267	59.413588	0.26	0.447373	0.743	0.084	0.3654	1.7787	0.095	0.7958	0.8908
200	90	110	281.875	4.5235	3.6188	77.8919	62.313497	0.26	0.455942	0.865	0.08	0.0368	1.8	0.0096	0.8207	0.8303
300	270	30	76.875	2.36232	1.88986	40.6777	32.542163	0.26	0.347153	0.151	0.154	1.5091	1.4996	0.3924	0.5206	0.9129
300	255	45	115.3125	2.89324	2.31459	49.8198	39.855847	0.26	0.379096	0.195	0.125	1.3803	1.5961	0.3589	0.6051	0.964
300	240	60	153.75	3.34082	2.67266	57.527	46.021568	0.26	0.402918	0.24	0.109	1.2733	1.6629	0.3311	0.67	1.0011
300	225	75	192.1875	3.73516	2.98812	64.3171	51.453677	0.26	0.422015	0.286	0.097	1.1754	1.7139	0.3056	0.7233	1.0289
300	210	90	230.625	4.09166	3.27333	70.4558	56.364679	0.26	0.437995	0.336	0.089	1.0802	1.7551	0.2808	0.7687	1.0496
300	195	105	269.0625	4.4195	3.5356	76.101	60.880812	0.26	0.45175	0.39	0.082	0.9829	1.7897	0.2556	0.8085	1.064
300	180	120	307.5	4.72464	3.77971	81.3554	65.084325	0.26	0.463833	0.452	0.077	0.879	1.8194	0.2285	0.8439	1.0724
300	165	135	345.9375	5.01124	4.00899	86.2904	69.032352	0.26	0.474612	0.523	0.072	0.7623	1.8455	0.1982	0.8759	1.0741
300	150	150	384.375	5.28231	4.22585	90.9581	72.766488	0.26	0.484342	0.606	0.069	0.6228	1.8687	0.1619	0.9051	1.067
300	135	165	422.8125	5.54013	4.43211	95.3977	76.318136	0.26	0.49321	0.707	0.066	0.4395	1.8897	0.1143	0.932	1.0463
300	120	180	461.25	5.78648	4.62918	99.6396	79.711694	0.26	0.501356	0.83	0.063	0.1489	1.9087	0.0387	0.9569	0.9957
300	105	195	499.6875	6.02276	4.81821	103.708	82.966561	0.26	0.508888	0.988	0.06	-0.998	1.9262	-0.259	0.9802	0.7207

400	360	40	102.5	2.72777	2.18222	46.9706	37.576453	0.26	0.369616	0.13	0.133	1.5777	1.5684	0.4102	0.5797	0.9899
400	340	60	153.75	3.34082	2.67266	57.527	46.021568	0.26	0.402918	0.169	0.109	1.4524	1.6629	0.3776	0.67	1.0477
400	320	80	205	3.85765	3.08612	66.4264	53.141129	0.26	0.427634	0.208	0.094	1.3492	1.7285	0.3508	0.7392	1.09
400	300	100	256.25	4.31299	3.45039	74.267	59.413588	0.26	0.447373	0.248	0.084	1.2558	1.7787	0.3265	0.7958	1.1223
400	280	120	307.5	4.72464	3.77971	81.3554	65.084325	0.26	0.463833	0.291	0.077	1.166	1.8194	0.3032	0.8439	1.1471
400	260	140	358.75	5.10319	4.08256	87.8739	70.299106	0.26	0.477961	0.338	0.071	1.0757	1.8535	0.2797	0.8859	1.1656
400	240	160	410	5.45554	4.36444	93.9411	75.152905	0.26	0.49034	0.391	0.067	0.9809	1.8829	0.255	0.9233	1.1783
400	220	180	461.25	5.78648	4.62918	99.6396	79.711694	0.26	0.501356	0.453	0.063	0.8775	1.9087	0.2281	0.9569	1.1851
400	200	200	512.5	6.09948	4.87959	105.029	84.023503	0.26	0.511278	0.525	0.06	0.7587	1.9317	0.1973	0.9876	1.1849
400	180	220	563.75	6.39719	5.11775	110.156	88.124593	0.26	0.520303	0.612	0.057	0.6132	1.9525	0.1594	1.0159	1.1753
400	160	240	615	6.68165	5.34532	115.054	92.043135	0.26	0.528578	0.719	0.054	0.4146	1.9714	0.1078	1.042	1.1498
400	140	260	666.25	6.95448	5.56359	119.752	95.801533	0.26	0.536216	0.855	0.052	0.0713	1.9887	0.0185	1.0664	1.0849
5000	4500	500	1281.25	9.64413	7.7153	166.066	132.85282	0.26	0.599066	0.037	0.038	2.1374	2.129	0.5557	1.2754	1.8311
5000	4250	750	1921.875	11.8116	9.44928	203.389	162.71081	0.26	0.63779	0.048	0.031	2.0261	2.215	0.5268	1.4127	1.9395
5000	4000	1000	2562.5	13.6389	10.9111	234.853	187.88226	0.26	0.664782	0.059	0.027	1.9376	2.2758	0.5038	1.5129	2.0167
5000	3750	1250	3203.125	15.2487	12.199	262.573	210.05876	0.26	0.685301	0.07	0.024	1.8604	2.3227	0.4837	1.5917	2.0754
5000	3500	1500	3843.75	16.7041	13.3633	287.635	230.10784	0.26	0.701728	0.082	0.022	1.7894	2.3609	0.4652	1.6567	2.122
5000	3250	1750	4484.375	18.0425	14.434	310.681	248.54487	0.26	0.715344	0.096	0.02	1.7213	2.3932	0.4475	1.712	2.1595
5000	3000	2000	5125	19.2883	15.4306	332.132	265.70565	0.26	0.726916	0.111	0.019	1.6542	2.4211	0.4301	1.76	2.1901
5000	2750	2250	5765.625	20.4583	16.3666	352.279	281.8234	0.26	0.736938	0.128	0.018	1.5863	2.4457	0.4124	1.8023	2.2148
5000	2500	2500	6406.25	21.5649	17.2519	371.335	297.06794	0.26	0.745749	0.149	0.017	1.5159	2.4677	0.3941	1.8403	2.2344
5000	2250	2750	7046.875	22.6175	18.094	389.459	311.56749	0.26	0.753587	0.173	0.016	1.4412	2.4876	0.3747	1.8746	2.2493
5000	2000	3000	7687.5	23.6232	18.8986	406.777	325.42163	0.26	0.760629	0.203	0.015	1.3598	2.5057	0.3535	1.9059	2.2594
5000	1750	3250	8328.125	24.5878	19.6702	423.387	338.70957	0.26	0.76701	0.242	0.015	1.2683	2.5223	0.3297	1.9347	2.2644
5000	1500	3500	8968.75	25.516	20.4128	439.369	351.49553	0.26	0.772831	0.293	0.014	1.1613	2.5378	0.3019	1.9613	2.2632
5000	1250	3750	9609.375	26.4115	21.1292	454.791	363.83244	0.26	0.778174	0.364	0.014	1.0291	2.5521	0.2676	1.986	2.2535
5000	1000	4000	10250	27.2777	21.8222	469.706	375.76453	0.26	0.783105	0.47	0.013	0.8497	2.5655	0.2209	2.0091	2.23
5000	750	4250	10890.625	28.1172	22.4938	484.162	387.32921	0.26	0.787677	0.646	0.013	0.5542	2.5781	0.1441	2.0307	2.1748
5000	500	4500	11531.25	28.9324	23.1459	498.198	398.55847	0.26	0.791933	0.996	0.013	-1.505	2.59	-0.391	2.0511	1.6598

Note: were not included in table the impossible variants.

Abbreviations: 1. E = size of Elite group; 2. T = size of Testing group; 3. n = total number of daughters; 4. Ac. = selection accuracy; 5. P = selection weight in two moments (I and II); 6. I = selection intensity in two moments (I and II); 7. R = selection effect per generation in two moments (I and II) and per total (tot.).

- on a population size of 300 sheep, the biggest selection effect per generation (1.0741 additive standard deviations) has been achieved when the two groups weight was 55% Elite and 45% Testing;
- on a population size of 400 sheep, the biggest selection effect per generation (1.1851 additive standard deviations) has been achieved when the two groups weight was 55% Elite and 45% Testing;
- the population size of 5000 sheep is out of the question.

It is clearly that the most likely variant is that with 400 females, whence 55% (220) will be constitute in Elite group and 45% (180) in testing group.

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 Milk Sheep Line we propose for genetic increase of milk traits an offspring selection plan, according to Robertson and Rendell plan for bovines, whose components must be optimized.

Respecting the selection plans optimization principles, a maximum genetic gain will be obtain in a population size by 400 females, with a weight of the two groups by 55% Elite and 45% Testing respectively.

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