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Genetic and economic evaluation of genetic improvement schemes in pigs.

II. Comparison of selection strategies in a three-way crossbreeding scheme

Summary

Alternative selection strategies for a three-way cross in pigs (Pietrain as the sire line and Large White boars mated to German Landrace sows to produce the F_1-female) are investigated to maximise both genetic gain and profit. The number of nucleus sows in the main female line (German Landrace) can vary within a wide range without noticeable effect on the genetic and economic response. Productive lifetimes of approximately one year are recommended for nucleus boars and sows after the progeny test. Boars mated to produce crossbreds should be used longer, especially in the terminal sire line. F_1-sows can have a productive lifetime of more than two years and can be used close to their biological maximum.

Four testing schemes are compared and the contribution of the three breeds to the return is evaluated. Testing crossbred animals at a central test station cannot be recommended. This capacity should be used to test purebred animals. Both monetary genetic gain and profit are higher in a scheme with a self-performance testing of boars at station, in comparison to a scheme with only progeny testing at station, by 36 and 68 %, respectively. Due to a reduced generation interval, using boars to produce breeding boars straight after their self-performance test leads to a further increase of monetary genetic gain by 5 % and profit by 13 %. In all schemes, selection in Pietrain leads to the highest return due to the highest gene proportion in and its shorter distance to the terminal product and the therefore faster transfer of genetic gain.

Key Words: genetic and economic evaluation, selection schemes, pig, crossbreeding, performance testing

Zusammenfassung

Titel der Arbeit: **Genetische und ökonomische Beurteilung von Zuchtplänen beim Schwein. 2. Mitt.: Vergleich von Zuchtplänen einer Dreirassenkreuzung**

Verschiedene Zuchtpläne für eine Dreirassenkreuzung beim Schwein (Pietrain als Vaterlinie, Edelschweineber verpaart mit Landrassesauen zur Erzeugung der F_1-Sauen) werden untersucht, um den Zuchtfortschritt und den Gewinn zu maximieren. Die Anzahl an Nukleussauen in der Deutschen Landrasse kann innerhalb eines großen Bereiches ohne großen Effekt auf genetische und ökonomische Ergebnisse schwanken. Die Nutzungsdauer von etwa zwölf Monaten nach der Nachkommenprüfung für Eber im Nukleus wird empfohlen. Eber die in Kreuzung angepaart werden sollten länger genutzt werden, vor allem in der Vaterlinie. Die F_1-Sauen sollten über zwei Jahre genutzt werden.

Vier Zuchtpläne werden verglichen und der Anteil der Rassen am Züchtungsertrag wird beurteilt. Die Prüfung von Kreuzungstieren auf einer zentralen Teststation wird nicht empfohlen. Die Stationskapazität sollte voll für Reinzuchttiere genutzt werden. Der monetäre Zuchtfortschritt und der Züchtungsgewinn ist in einem Zuchtplan mit einer Eigenleistungsprüfung der Eber auf einer zentralen Teststation um 36 bzw. 68 % höher im Vergleich zu einem Zuchtplan mit ausschließlicher Nutzung der Station zur Nachkommenprüfung. Eine weiter Steigerung des monetären Zuchtfortschrittes um 5 % und des Züchtungsgewinnes um 13 % wird durch den Einsatz der Eber in Reinzucht sofort nach der Eigenleistungsprüfung erzielt aufgrund einer Verkürzung des Generationsintervalles. In allen Zuchtplänen besitzt Pietrain den höchsten Anteil am Züchtungsertrag durch den hohen Genanteil in der Endstufe. Außerdem ist die Distanz zwischen Reinzucht und Endstufe kürzer, so daß der Zuchtfortschritt schneller übertragen werden kann.

Schlüsselwörter: Genetische und ökonomische Beurteilung, Zuchtpläne, Schwein, Kreuzungszucht, Leistungsprüfung

1. Introduction

Different genetic improvement schemes for pigs are to be evaluated and compared both for their efficiency in making genetic progress and for their return and profit (or net present value) for the investment made in genetic selection. While alternatives have been relatively well investigated regarding their impact on genetic gain (THIELE, 1983; ENGLISCH and FECHNER, 1983; ROEHE, 1991; BRISBANE and GIBSON, 1995), there have been few studies where costs are taken into account. These studies were related mostly to purebred situations (NIEBEL and FEWSON, 1979), whereas selection of lines within a crossbreeding scheme was rarely investigated (TRAPPMANN, 1978; WUENSCH et al., 1998).

WUENSCH et al. (1998) applied an approach of genetic and economic evaluation of selecting lines in a three-way crossbreeding system of pigs (Pietrain as the sire line and Large White boars mated to German Landrace sows to produce the F_1-female). That paper showed the input parameters (population structure, indices, genetic, biological, technological and economic parameters) and gave some results on the basic genetic improvement. The aim of the present paper is to report first on the effect of optimise the nucleus size of German Landrace sows and the productive lifetime of various selection groups with respect to the genetic and economic response. Furthermore, four additional selection strategies with different ways of testing boars in the field and at the central test station were compared to the basic scheme. Results concerning the (monetary) genetic gain for the aggregate breeding value, the return, the costs and the profit are shown. Finally, the contribution of the three breeds to these criteria and to the genetic gain for single traits will be presented.

2. Material and Method

Using the gene-flow method (McCLINTOCK and CUNNINGHAM, 1974), selection index procedures with inclusion of fixed and variable breeding costs, the computer program ZPLAN (KARRAS et al., 1993) was applied which makes it possible to analyse different breeding strategies for a defined investment period with respect to maximising annual genetic gain and profit. The method is described by NITTER et al. (1994).

The evaluated breeding system is a three-way cross breeding scheme with Pietrain as the sire line, and German Landrace (GL) and Large White (LW) as dam lines. GL currently consists of 4000 sows, including 800 sows in the nucleus and 3200 sows for producing crossbred sows. LW contains 100, Pietrain 125 and the F_1-generation (LW x GL) 46000 sows. The traits measured are daily gain (test period, DG), lean meat percentage (LMP), feed efficiency (FE), pH_1-value (pH_1), number of piglets born alive (NBA), average daily gain (life time, ADG) and ultrasonic side-fat thickness (US) among which the first five traits are the components of the aggregate breeding objective.

The various genetic improvement schemes are defined according to testing animals in various selection groups (Table 1). All schemes are based on a self-performance test of sows in the field (traits ADG and US in a first selection step and NBA in a second). Scheme A is the basic scheme described by WUENSCH et al. (1999). Scheme B is identical to scheme A, but is optimised for the nucleus size in GL and for productive lifetime of all selection groups. Young boars in schemes A/B and C are performance tested in the field (traits ADG and US) whereas those in schemes D and E are performance tested at the station (traits DG, FE, ADG and US). In all schemes except E, there is a station progeny-test for a second selection step of the boars used to produce purebreds (traits DG, FE, LMP, pH_1, ADG and US). In all schemes, there is a field progeny-test for Pi_C boars (Pietrain boars mated to F_1-sows to produce terminal crossbreds; traits ADG, LMP and pH_1). There is also a progeny test for LW_C-boars (LW boars mated to GL sows to produce the F_1-generation), namely in the field for schemes A/B, D and E and at the station for scheme C.

The station test of LW_C progeny causes the only difference of scheme C compared to A/B. As the station capacity is assumed to be limited, in this case the progeny test for purebreds has to be reduced. The difference of scheme D compared to A/B is simply the shift of the self-performance test of boars into the station. Finally, scheme E differs from D through the fact that boars to breed boars are selected already after the self-performance test and their productive lifetime is limited to six months.

Table 1
Characterisation of selection schemes A to E according to testing animals either in the field (F) or in the station (S). SPT = self-performance test; PT = progeny test (Darstellung der Zuchtpläne A bis F entsprechend der Prüfung der Tiere im Feld (F) oder in der Station (S). SPT = Eigenleistungsprüfung; PT = Nachkommenprüfung)

Characteristic	A/B	C	D	E
SPT of sows in all breeds	F	F	F	F
SPT of boars in all breeds	F	F	S	S
PT of boars in all breeds in a second selection step to produce purebreds	S	S	S	--
PT of Pi_C boars	F	F	F	F
PT of LW_C boars	F	S	F	F

LW_C = Large White boars mated with German Landrace sows to produce the F_1-generation
Pi_C = Pietrain boars mated with F_1-generation to produce the terminal products

In breeding schemes B to E, the number of tested boars and tested sib groups per boar are varied in order to find the combination with the maximum profit for a determined station size. For evaluating young boars in the self-performance test, information from tested full- and half-sibs at station are taken into account.

3. Results

Optimum proportion of purebred mating sows in the GL breed

The calculations are based on parameters described by WUENSCH et al. (1999). The first step of this study consisted of finding out the most efficient extent of purebred matings for GL sows. In the basic scheme A this number was assumed to be 800 sows. The lower limit is determined as the number of sows needed to reproduce the purebred population, the upper limit is determined by the minimum number of sows needed to reproduce the F_1-generation. This was investigated first under the assumption of a constant boar to sow ratio and secondly with a constant number of boars used.

Under both assumptions, the monetary genetic gain decreases when the number of sows used for purebred matings in the nucleus is reduced (Table 2). This is due to a decreased selection intensity caused by the smaller population size. Assuming fixed number of boars, the monetary genetic gains show greater differences than calculations with a constant boar to sow ratio due to different proportions of selected boars. In the case of a constant boar to sow ratio, there is an opposite development of monetary genetic gain and profit for a varied number of sows. The profit increases since the costs sink more than the return decreases. With a fixed number of boars, the profit decreases slightly when the number of purebred sows is smaller. Costs in both variants are identical because the number of old boars affects the production costs and not the breeding costs. As the effect of the proportion of purebred mated GL sows is shown to be small, for the following calculations this is assumed to be 800 sows to ensure the reproduction of both groups of GL sows.

Table 2
Monetary genetic gain (MGG) per year, profit, return and costs (all units in DM) depending on the number of German Landrace sows in the nucleus either with a constant boar to sow ratio or with fixed number of selected boars (Monetärer Zuchtfortschritt je Jahr, Züchtungsgewinn, Züchtungsertrag und Züchtungskosten (alle Angaben in DM) in Abhängigkeit der Anzahl von Sauen der Deutschen Landrasse im Nukleus bei konstantem Eber-Sauen-Verhältnis oder bei konstanter Anzahl der selektierten Eber)

Number of sows			Constant boar to sow ratio			Fixed number of boars		
GL_P	GL_C	Costs	MGG	Return	Profit	MGG	Return	Profit
950	3050	13.15	**4.37**	**23.91**	10.76	**4.42**	**24.20**	11.05
900	3100	13.04	4.36	23.90	10.86	4.40	24.10	**11.06**
850	3150	12.93	4.36	23.88	10.95	4.38	23.98	11.05
800	**3200**	**12.83**	**4.35**	**23.85**	**11.02**	**4.35**	**23.85**	**11.02**
750	3250	12.71	4.35	23.81	11.10	4.32	23.68	10.99
700	3300	12.61	4.34	23.75	**11.14**	4.28	23.50	10.91

GL_P = German Landrace sows mated with German Landrace boar to produce purebred sows
GL_C = German Landrace sows mated with Large White boars to produce crossbred sows

Productive lifetime

Table 3 shows the productive lifetime for different groups of boars if the maximum profit is the criterion for evaluation. The service period of boars used to produce purebred boars should be between 10 and 14 months after the second selection step with minor differences between the breeds. The productive lifetime for boars used to produce crossbreds should be longer, especially for the terminal sire line. This is due to the fact that their offspring will not be selected and do not contribute to the cumulative genetic gain.

Purebred sows should be used for about 1.5 years except sows used to produce boars, which are selected after the first litter and thus have an optimum productive lifetime reduced to approximately one year. Sows used to produce F_1-sows should be mated for about 1.5 years. This shows the importance of the fast transfer of the generated genetic gain in the nucleus to the multiplier level. F_1-sows should have a productive lifetime of more than two years, i.e. until being close to their biological maximum. It should be noticed, however, that optimal productive lifetime is not a fixed criterion, as selection should be applied across age groups. But the results give some guidelines for the design of a breeding program.

Table 3
Productive lifetime (in months) for boars and sows allowing to maximise profit (Nutzungsdauer (in Monaten) für Eber und Sauen bei einer Maximierung des Züchtungsgewinnes)

To produce	GL boars		LW boars		Pi boars		Sows	
	Young [1)]	Old [2)]	Young	Old	Young	Old	Young	Old
Purebred boars	-	14	-	10	-	13	-	12
Purebred sows	11	14	11	10	11	13	6	12
F_1-generation	-	-	11	10			6	12
Terminal products	-	-			11	21	6	20

1) after self-performance test
2) after progeny test

Self-performance test for boars in the field (schemes A/B)

Through optimisation of productive lifetimes, optimal utilisation of the test station and the field-test the monetary gain per year raises slightly from scheme A to scheme B (about 3 %, Table 4). The total return for the investment period of ten years increases by 1 DM from 23.85 DM to 24.85 DM per sow in the total population. In both schemes the trait LMP shows the highest contribution to the return (9.00 and 9.21 DM), followed by traits DG and FE. After deduction of the costs the profit obtained is higher by approximately 10 % in the Scheme B (12.08 vs. 11.02 DM).

Table 4
Monetary genetic gain (MGG) per year, generation interval, return, costs and profit for the five selection schemes; schemes A, C, D and E relative to scheme B (Monetärer Zuchtfortschritt je Jahr, Generationsintervall, Züchtungsertrag, Züchtungskosten und Züchtungsgewinn der fünf Zuchtpläne; Zuchtpläne A, C, D und E relativ zu Zuchtplan B)

Parameter	Unit	Scheme A	Scheme B	Scheme C	Scheme D	Scheme E
Generation interval	years	1.82	1.82	1.80	1.80	1.52
MGG, absolute	DM	4.35	4.45	4.35	6.03	6.36
MGG, relative	%	97.3	100.0	97.7	135.5	142.9
Return for single traits						
Daily gain	DM	6.53	6.99	6.96	11.28	12.71
Lean meat percentage	DM	9.00	9.21	8.84	9.24	8.87
Feed efficiency	DM	5.77	6.15	6.07	10.27	11.51
pH_1-value	DM	-.15	-.15	-.15	-.14	-.14
Number born alive	DM	2.70	2.65	2.70	2.50	2.87
Return, overall	DM	23.85	24.85	24.42	33.15	35.82
Return, relative	%	96.0	100.0	98.3	133.4	144.1
Costs	DM	12.83	12.77	12.70	12.88	12.88
Profit, absolute	DM	11.02	12.08	11.72	20.27	22.94
Profit, relative	%	91.2	100.0	97.0	167.8	189.9

For the three lines involved in the crossbreeding scheme, Table 5 shows the contribution to various characteristics of the genetic and economic responses. In the scheme B, trait NBA has a more than ten times higher genetic gain in the dam lines than in the Pietrain breed. LW and Pietrain are superior in traits related to fattening performance and carcass quality traits. The main difference between the lines is in

LMP, where Pietrain has the highest genetic gain with 0.513 % vs. 0.183 % in GL and 0.300 % in LW. These results lead to a monetary genetic gain in GL of 3.69 DM, whereas LW and Pietrain achieve 4.74 DM and 4.92 DM. The returns in Pietrain are more than two times higher for DG and FE, and LMP is even more than three times superior than in GL and LW. For this reason Pietrain contributes more than 50 percent to the total return per sow in the investment period (13.43 DM from 24.85 DM). In the dam lines the returns are relatively balanced between the traits. The trait pH_1 has a very small and negative contribution to the return.

Progeny test for LW_C-boars at the station (scheme C)

As a result of the additional testing of F_1-animals and a reduced testing of purebred progeny in the scheme C, the monetary genetic gain and the return decreases (Table 4). The overall return drops by 2.3 % (24.85 vs. 24.42 DM). The costs decrease to a small extent. No additional costs occur for the station test of LW_C-progeny because the costs for a station with determined capacity are fixed. The profit decreases by 3 % (12.08 vs. 11.72 DM).

The genetic gains tend to be lower in comparison to the scheme B (Table 5). Therefore, the monetary genetic gains in the lines are slightly reduced. The return in LMP decreased by 0.37 DM, of which LW contributes 0.23 DM, because LW is not field tested anymore.

Self-performance test for boars at the station (scheme D)

In the scheme D, only purebred boars are tested at the central station. In this selection scheme the boars have additional to ADG and US also self-performance records for DG and FE. The self-performance records of the first selection step are used as the progeny information for the preceding generation. For this system a systematic utilisation of the test station is required. Under these circumstances, the monetary genetic gain increases in comparison to the scheme B by 35.5 % (Table 4). The overall return increases by 33.4 % and the costs increase to a negligible extent, so that the profit increases by 67.8 %. In this breeding scheme, less groups per boar are tested (Table 6), but because in the self-performance test three instead of two offspring per group in the progeny test are tested, the number of tested animals per boar increases to a small extent.

The increases in the genetic gains especially in DG and FE are considerable, whereas in LMP the values show non-uniform alteration in comparison to scheme B (Table 5). This trait cannot be measured on live animals and therefore the number of records for LMP at the station is reduced through animals used for breeding. The lowest demand of selected boars exists in GL, because they supply semen only for purebred matings. The highest number of boars is required in Pietrain through matings with F_1-sows. Therefore, the amount of LMP data available for this line is reduced to a larger extent which leads to a lower genetic gain of this trait than in the previous schemes. In pH_1-value and NBA the changes are unimportant. That is the case for all breeding schemes. The increase in total monetary genetic gain by 35.5 % is mainly caused by the increase

Table 5
Single trait (natural) and monetary genetic gain (MGG) per year, generation interval and return in lines as well as costs and profit for the selection schemes; schemes C, D und E relative to scheme B (Naturaler und monetärer Zuchtfortschritt je Jahr, Generationsintervall und Züchtungsertrag in den Rassen sowie Züchtungskosten und Züchtungsgewinn der Zuchtpläne; Zuchtpläne C, D und E relativ zu Zuchtplan B)

Parameter		Scheme B			Scheme C			Scheme D			Scheme E		
		GL	LW	Pi	GL	LW	Pi	GL	LW	Pi	GL	LW	Pi
Single trait genetic gain													
Daily gain	g	11.19	13.44	13.38	11.13	13.29	12.99	20.19	19.11	19.71	23.31	20.43	21.06
Lean meat percentage	%	0.183	0.300	0.513	0.180	0.276	0.498	0.222	0.300	0.489	0.237	0.264	0.450
Feed efficiency	kg/kg	-0.030	-0.042	-0.036	-0.030	-0.039	-0.033	-0.063	-0.060	-0.051	-0.072	-0.063	-0.054
PH_1-value	.1	-0.012	-0.012	-0.018	-0.009	-0.012	-0.015	-0.012	-0.012	-0.015	-0.012	-0.012	-0.015
Number born alive	piglets	0.078	0.069	-0.006	0.078	0.069	-0.006	0.075	0.066	-0.006	0.087	0.075	-0.006
Average daily gain	g	6.6	5.22	6.51	6.63	5.13	6.75	6.93	5.25	6.03	7.56	5.52	6.42
Side-fat thickness	mm	-0.0024	-0.0018	-0.0084	-0.0024	-0.0012	-0.009	-0.0048	-0.0042	-0.0096	-0.0054	-0.0036	-0.0102
MGG, absolute	DM	3.69	4.74	4.92	3.66	4.62	4.77	5.94	6.06	6.09	6.75	6.24	6.09
MGG, relative	%	100	100	100	99.2	97.5	97.0	161.0	127.8	123.8	182.9	131.6	123.7
Generation interval	years	1.86	1.77	1.81	1.86	1.77	1.81	1.86	1.77	1.81	1.55	1.51	1.49
Return for single traits													
Daily gain	DM	1.67	1.52	3.80	1.67	1.61	3.68	3.01	2.33	5.94	3.45	2.60	6.66
Lean meat percentage	DM	1.03	1.67	6.51	1.01	1.44	6.39	1.28	1.68	6.28	1.41	1.60	5.86
Feed efficiency	DM	1.40	1.53	3.22	1.39	1.55	3.13	2.91	2.42	4.94	3.33	2.67	5.51
PH_1-value	DM	-.03	-.03	-.09	-.03	-.03	-.09	-.03	-.03	-.08	-.03	-.03	-.08
Number born alive	DM	1.46	1.20	-.01	1.47	1.24	-.01	1.37	1.14	-.01	1.56	1.32	-.01
Return, absolute	DM	5.53	5.89	13.43	5.51	5.81	13.10	8.54	7.54	17.07	9.72	8.16	17.94
Return, relative	%	100	100	100	99.6	98.6	97.5	154.4	128.0	127.1	175.8	138.5	133.6
Breed contribution to the return	%	22.2	23.7	54.0	22.6	23.8	53.6	25.8	22.7	51.5	27.1	22.8	50.1

GL = German Landrace; LW = Large White; Pi = Pietrain in GL by 61.0 %. The reason is the largest increase in selection intensity of boars in comparison to the field test through the low number of tested boars in the basic situation.

The increases in the returns per trait are considerable in DG and FE by more than 60 % in scheme D compared with scheme B, because these traits are now available as self-performance of the breeding boars. The returns for the other traits in the breeding objective remain constant. In contrast to schemes B and C, DG and FE reach higher returns than LMP if accumulated over the lines.

Boars to breed boars selected after self-performance test at the station (scheme E)

If boars are used to produce breeding boars already after the self-performance test and their productive lifetime is limited to six months (scheme E), the average generation interval is reduced from 1.80 years to 1.52 years (Table 4). The monetary genetic gain increases in comparison to scheme D by 5.5 % (6.36 vs. 6.03 DM) and the overall return by 8.1 % (33.15 vs. 35.82 DM). The profit raised also by 13.2 % (20.27 vs. 22.94 DM), because the assumed costs were identical.

In comparison to the scheme D, the lines in the scheme E contribute very differently to the result. Whereas an increase in all genetic gains in GL is observed, differences occur in LW and Pietrain between traits (Table 5). Whereas there is an improvement for DG and FE, the genetic gains for LMP decrease because a high number of LMP recordings from the field test are not available for the selection of breeding boars. These differences are reflected in the monetary genetic gains in the lines. GL shows an increase by 13.6 % (5.94 DM to 6.75 DM) in comparison to scheme D, whereas in LW and Pietrain the values are nearly equal in both schemes.

The returns per trait of DG and FE increase again, whereas in LMP the return decreases. In this breeding scheme DG and FE contribute more than two thirds to the return. For the returns in the lines the highest increase is in GL by 13.8 %. Moderate increases can be seen also in LW and Pietrain in contrast to the monetary genetic gain.

Distribution of testing capacity between the breeds

The distribution of the limited testing capacity between the breeds is shown in Table 6. Except for the scheme A, the figures are received by varying the number of tested boars and tested groups per boar with respect to maximise the profit. The fixed number of 4 groups per boar with 2 piglets tested per group in scheme A leads to a higher number of tested boars compared to the following schemes. In the schemes B to E, the number of boars is relatively constant over the breeds, except in GL. Whereas GL uses the highest proportion of the test capacity in the schemes A and B (43 and 41 %), Pietrain claims the highest proportion in schemes D and E (40 and 45 %). The number of LW_C-boars is about twice as high in comparison to LW-boars, whereas the number of Pi_C-boars compared to Pietrain boars is about five times higher. High boar to sow ratios in the multiplier and production levels (1:160 and 1:330) could be used for the crossbred matings, because inbreeding has not to be taken into account. The number of $Pietrain_C$-boars is necessary to inseminate the high number of F_1-sows.

Table 6
Number of tested boars and tested animals per boar in station and field test as well as distribution of testing capacity after variation of number testing boars, groups per boar and animals per group (Anzahl Testeber und Prüftiere je Eber in der Station und im Feld sowie Verteilung der Testkapazität nach Variation der Anzahl getesteter Eber, Prüfgruppen je Eber und Tiere je Prüfgruppe)

	Scheme A	Scheme B	Scheme C	Scheme D	Scheme E
Number of boars					
GL	36	27	26	20	16
LW	17	13	11	11	12
Pi	31	18	16	18	20
LW_C	26‡	21‡	18	22‡	22‡
Pi_C	79‡	88‡	90‡	89‡	92‡
Tested animals per boar †					
GL	8 (4)	10 (5)	8 (4)	12 (4)	12 (4)
LW	8 (4)	14 (7)	14 (7)	15 (5)	15 (5)
Pi	8 (4)	12 (6)	12 (6)	15 (5)	15 (5)
LW_C	60 (10)‡	30 (5)‡	6 (3)	30 (6)‡	30 (6)‡
Pi_C	60 (10)‡	28 (4)‡	36 (6)‡	25 (5)‡	25 (5)‡
Station places in %					
GL	43	41	31	36	28
LW	20	27	23	24	27
Pi	37	32	29	40	45
LW_C	---	---	17	---	---

LW_C = Large White boars mated with German Landrace sows to produce the F_1-generation; Pi_C = Pietrain boars mated with F_1-generation to produce the terminal products; † tested groups per boar in brackets; ‡ field test

At the station, generally between 8 and 15 animals per boar should be tested. For scheme C the additional test of LW_C-boars should be mentioned, which absorbs a substantial part of the limited testing capacity. In the field test around 30 animals per LW_C-boar and between 25 and 30 animals per Pi_C-boar are recommended to be tested.

4. Discussion and Conclusions

The optimal number of GL sows in the nucleus herd is higher when assuming a fixed number of boars rather than a constant boar to sow ratio. The number of 800 GL-sows in the nucleus is specific to the investigated population structure and depending on the biological and technological coefficients. Productive lifetimes of approximately one year are recommended for nucleus boars and sows after the second selection stage. Boars mated to produce crossbreds should be used longer, especially in the terminal sire line. F_1-sows should have a productive lifetime of more than two years and can be used close to their biological maximum.

In a scheme involving the self-performance test of boars in the field, LW and Pietrain have larger contributions to the response of traits related to fattening performance and carcass quality. The higher monetary genetic gain in LW and Pietrain in spite of smaller population sizes is explained by the inclusion of information from crossbred offspring in the evaluation of nucleus boars. The main difference between these two lines concerns the trait LMP, for which Pietrain is superior. This emphasises its position as a sire line. The returns in Pietrain contribute more than 50 % to the total return and are more than two times higher for the traits DG and FE, and more than three times higher for LMP than in the dam lines.

Crossbred animals contribute to the genetic gain only through the correlation assumed between traits of purebred and crossbred animals. By testing crossbred animals at the station instead of in the field, assuming a fixed station capacity, genetic gains are reduced in comparison to a scheme, where only purebred animals are tested at station. The highest decrease occurs in LMP and is caused through missing the high number of LMP recordings in the field test. The accuracy of the breeding value of the LW_c-boars increased when moving the progeny test from the field into the station since in the station more traits are measured. The increase was not high enough to balance the losses in accuracy of the purebred boars, which occur through the reduced testing of purebred progeny. However, a scheme with a test of crossbred animals at station is still to recommend for breeding associations/companies, which can not provide reasonable results in the field, because monetary genetic gain and profit are reduced only by 3 %. But generally, central station testing should be used only for purebred animals.

Using the station only for a self-performance test of boars, monetary genetic gain and profit are increased by 35.5 % and 67.8 %, respectively, in comparison to a scheme with only progeny test at station. It indicates that through self-performance testing of boars at the station the return increases considerably whereas the costs increase to a small extent. Because the self-performance recordings for the first selection step are used as the progeny performances for the preceding generation, a systematic exploitation of the test station is required. In this scenario the contributions of DG and FE to the return are higher than the contribution of LMP. This is caused by recording the traits DG and FE on selected boars and by the loss of LMP, which is not measurable on these animals. The implementation of a scheme with self-performance test of boars at the station in a cooperative structure is only realistic, if breeders are willing to submit their boars as piglets to the central test station.
A scheme with the use of boars to produce boars straight after the self-performance test is superior to a scheme with a two step selection by 5.5 % in the monetary genetic gain and 13.2 % in the profit. The effect of the shorter generation interval is higher than the effect of losing information for the accuracy of the breeding value due to the lack of progeny records. As far as the different lines are concerned, in GL a clear superiority occurs, but in LW and Pietrain the advantages are small. Through selection of boars in these lines straight after the self-performance test, not only a loss of progeny information for selection from purebred animals, but also from crossbred progeny and thereby a lower accuracy of the breeding value must be compensated through the advantages of a shorter generation interval. In these two breeds, selection of boars straight after the self-performance is not significantly superior in the presented selection strategies.

In all schemes the trait NBA has a more than ten times higher genetic gain in the dam lines, especially in GL, than in the Pietrain breed. This is caused by the small number of Pietrain sows and that the reproductive trait is not expressed in their crossbred offspring.

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