Animal Science Papers and Reports vol. 26 (2008) no. 4, 297-304
Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

The use of indexes that take into account sows' stayability to assess their reproductive utility

Aurelia Mucha[1]*, Marian Różycki[1], Tadeusz Blicharski[2]

[1] National Research Institute of Animal Production,
Department of Genetics and Animal Breeding,
Krakowska 1, 32-083 Balice, Poland

[2] Institute of Genetics and Animal Breeding Polish Academy of Sciences,
Department of Animal Immunogenetics,
Jastrzębiec, 05-552 Wólka Kosowska, Poland

(Received November 3, 2008; accepted December 8, 2008

The material consisted of the data concerning reproductive performance traits of the Polish Large White sows, which was used in the breeding value estimation using the BLUP method in second half of May 2008. The analysis covered sows, which gave from one to eight litters. The following two indexes were computed: W_I – total number of days from sow birth date to last litter delivery day over the sum of piglets born, and W_{II} – total number of days from sow birth date to last litter delivery day over the sum of piglets in day 21 of live. The values of both indexes decreased with successive litters. Regression coefficients were estimated on the basis of correlation between individual reproduction traits and indexes. The impact of individual traits upon the indexes changed in successive litters during the period of the use of a sow. The impact of total number of piglets in a litter decreased, and the impact of the period between first farrowing and last litter delivery increased. Considering this, longevity of sows may affect pork production profitability.

KEY WORDS: breeding value / pork / sow / reproductive traits / stayability

Pork production profitability depends to a large extent on reproductive ability of sows. However, traits determining this ability are characterized by low heritability [Tholen *et al*. 1996, National Swine Improvement Federation 2003, Tyra and Różycki

*Corresponding author e-mail: amucha@izoo.krakow.pl

2004, Canario *et al*. 2006] and their improvement through selection is slow. This results from their high phenotypic, compared to genetic variation. Nonetheless, reproductive traits play important role in many animal breeding programmes. Polish breeding programme implemented by "POLSUS" assumes 60% of share in multitrait evaluation model for maternal lines and 30% for paternal lines. Significance near 50% has also been assumed in other programmes. Considering this, there is a problem involving selection of traits, which will represent these traits.

Relations between individual reproduction traits have been assessed by numerous authors. For the Polish Large White breed, Tyra and Różycki [2002] estimated genetic correlations between total number of piglets born and raised in a litter until day 21, litter weight on day 21, and interlitter interval to reach 0.962, 0.651 and 0.148, respectively. For American population [National Swine Improvement Federation 2003], the coefficients between total number of piglets born and the number of piglets raised, and litter weight on the day of birth and on day 21 were determined at the level of: 0.88, 0.67 and 0.93, respectively. According to Rosendo *et al.* [2007], correlations for these traits were 0.98, 0.66 and 0.74.

Quoted correlations indicate that there is no need to describe reproductive ability with many traits as relations between them indicate that by improving one trait we improve the other ones as well. However, it seems that considered should be traits, which would give view on production economics. On one hand they should specify total number of piglets in a litter, and on the other the period allowed for their production.

Presented paper tries to combine these factors, and, on this basis, to determine the optimum value that would guarantee lowest cost involved in a piglet production.

Material and methods

The material consisted of the data regarding reproduction performance traits of Polish Large White (PLW) sows, which was included in the scope of breeding value estimation using the BLUP method in second half of May 2008. The analysis covered sows, which gave from one to eight litters. The size of sow population in successive reproduction cycles is given below.

Item	Successive litter							
	1	2	3	4	5	6	7	8
Number of sows	6119	4635	4145	3706	2647	1979	1249	753

Completed calculations took into account: the sum of piglets born, the sum of piglets raised until day 21 of live in successive litters, number of days from sow birth date to last litter delivery day (D_{UO}), number of days from sow birth date to the day of first farrowing (D_{UP}), and number of days from first farrowing date to last litter delivery day (D_{PO}). These data provided grounds to compute the following indexes:

$$W_I = \frac{D_{UO}}{n_1}$$

$$W_{II} = \frac{D_{UO}}{n_{21}}$$

where:

W_I – index I (total number of days from sow birth date up to last litter delivery day over the sum of piglets born);

W_{II} – index II (total number of days from sow birth date up to last litter delivery day over the sum of piglets on day 21 of live);

n_1 – the sum of piglets on their birth day from one sow;

n_{21} – the sum of piglets raised until day 21 from one sow;

D_{UO} – number of days from sow birth date to last litter delivery day.

Next, the correlations were estimated between individual values of reproductive traits and indexes obtained. Statistical analysis was performed using the SAS application. The next stage involved estimation of multiple regression coefficients between individual characteristics (n, D_{UP}, D_{PO}) and indexes (W_I and W_{II}).

Results and discussion

Table 1 presents mean number of piglets born and raised in individual farrowings and the farrowing intervals, calculated after each successive litter. Moreover, the Table specifies sow age at the first farrowing. As it can be seen, average lifespan fertility of sows increases up to litter 7 (in case of number of piglets born in a litter by 1.02, and for number of piglets raised – by 0.90 piglets). Farrowing interval changed equally favourably throughout all production period of sows (stayability), as it get reduced by 9.9 days.

Table 1. Mean number of piglets born and raised, farrowing interval after successive litter, and sow age on day of first farrowing

Trait	Successive litter							
	1	2	3	4	5	6	7	8
Number of piglets born in a litter	10.64	11.04	11.25	11.37	11.50	11.56	11.66	11.58
Number of piglets raised from one farrowing	10.03	10.38	10.58	10.68	10.80	10.85	10.93	10.89
Farrowing interval	359.3*	181.4	177.5	176.7	174.3	173.9	172.8	171.5

*Age on first farrowing day.

Slightly different results were obtained for PLW population in 2007 where, according to Orzechowska and Mucha [2008], sows delivered highest number of piglets in litters 3 to 6. However, it should be remembered that this paper presents mean for the sum of piglets born between the first and the next litter, and not the mean number of piglets in a given litter. Sow's age at the first farrowing specified in this paper was 359.3 days. Orzechowska and Mucha [2008] reported slightly lower value of this trait – 354 days, while Wolf *et al*. [2005] gave higher value – 369 days.

Obtained indexes of reproduction ability are shown in Table 2. Their values decrease in successive litters – W_I from 34.61 to 16.81, and W_{II} from 36.79 to 17.90. Moreover, highly significant differences were identified between indexes for successive litters with the exception of farrowings 7 and 8, for which no significant differences were found.

Table 2. Indexes of reproductive performance traits

Index	Successive litter							
	1	2	3	4	5	6	7	8
W_I	34.61	24.93	21.35	19.62	18.41	17.76	17.07*	16.81*
W_{II}	36.79	26.60	22.72	20.89	19.60	18.90	18.19*	17.90*

W_I – index I (total number of days from sow birth date until last litter delivery day over the sum of piglets born).
W_{II} – index II (total number of days from sow birth date until last litter delivery day over the sum of piglets in day 21 of live).
*Means for litters 7and 8 do not differ significantly at $P<0.05$.

In Tables 3 and 4 correlation coefficients are presented between W_I and W_{II} and the sum of piglets born and raised until day 21 of live and number of days from sow birth date to last litter delivery day, number of days from sow birth date to first farrowing day, and number of days from first farrowing to the last litter delivery day. Highest values of relations were found between the indexes and the number of piglets born or raised in one litter. This confirms that the number of piglets born or raised in one farrow has decisive impact on the indexes. This relation is negative, which proves that the cost of a piglet (since after all we may say that the indexes determine the cost of a piglet represented as the cost of feeding a sow within specific time) decreases chiefly depending on litter size. An increase in positive values of correlations between the indexes and the number of days from sow birth date to last litter delivery day, and the number of days from first farrowing date to last litter delivery day was found in successive farrows, except for litter 8. They are much lower than correlations between the indexes and the number of piglets born and raised, which may prove that both first farrowing date and interval between successive litters have lower impact on the indexes considered in this report. Positive correlations were also estimated between the indexes and the number of days from sow birth date to first farrowing date. However, downward trends were observed for successive litters.

Table 3. Correlation coefficients between index I and the sum of piglets born and raised until day 21 of live, number of days from sow birth date to last litter delivery day, number of days from sow birth date to first farrowing, and number of days from the date of first farrowing to last litter delivery date

Trait	Successive litter							
	1	2	3	4	5	6	7	8
$W_I \times n_1$	-0.700	-0.767	-0.767	-0.731	-0.757	-0.745	-0.681	-0.677
$W_I \times n_{21}$	-0.624	-0.707	-0.681	-0.644	-0.619	-0.634	-0.554	-0.596
$W_I \times D_{UO}$	0.440	0.546	0.620	0.658	0.690	0.689	0.748	0.682
$W_I \times D_{UP}$	0.440	0.412	0.374	0.413	0.347	0.350	0.348	0.337
$W_I \times D_{PO}$		0.391	0.508	0.555	0.603	0.608	0.707	0.632

W_I – index I (total number of days from sow birth date until last litter delivery day over the sum of piglets born).
W_{II} – index II (total number of days from sow birth date until last litter delivery day over the sum of piglets in day 21 of live).
n_1 – the sum of piglets on their birth day from one sow.
n_{21} – the sum of piglets raised until day 21of live from one sow.
D_{UO} – number of days from sow birth date to the day of last litter delivery.
D_{UP} – number of days from sow birth date to first farrowing day.
D_{PO} – number of days from first farrowing date to last litter delivery day.

Table 4. Correlation coefficients between index II and the sum of piglets born and raised until day 21 of live, number of days from sow birth date to last litter delivery day, number of days from sow birth date to day of first farrowing, and number of days from first farrowing to delivery day of last litter

Cecha	Successive litter							
	1	2	3	4	5	6	7	8
$W_{II} \times n_1$	-0.604	-0.636	-0.643	-0.594	-0.631	-0.600	-0.532	-0.512
$W_{II} \times n_{21}$	-0.735	-0.763	-0.785	-0.745	-0.745	-0.727	-0.662	-0.677
$W_{II} \times D_{UO}$	0.432	0.522	0.607	0.659	0.678	0.713	0.762	0.721
$W_{II} \times D_{UP}$	0.432	0.382	0.365	0.390	0.320	0.338	0.347	0.308
$W_{II} \times D_{PO}$		0.388	0.500	0.570	0.603	0.641	0.723	0.687

Explanations are given at the bottom of Table 3.

Correlation coefficients between the sum of piglets born and raised until day 21 of live and the number of days from sow birth date to last litter delivery day, the number of days from sow birth date to first farrowing day, and the number of days from first farrowing date to last litter delivery day are shown in Table 5. Very low values of relations between individual traits were observed in all cases. The highest value occurred between the number of days from sow birth date to first farrowing day and the number of days from first farrowing to last litter delivery day in litter no. 7, and the lowest between the sum of piglets born and the number of days from sow birth date and first farrowing day in litter 8.

Table 5. Correlation coefficients between the sum of piglets born and raised until day 21 of live, number of days from sow birth date to last litter delivery day, number of days from sow birth date to first farrowing day, and number of days from the date of first farrowing to the day of delivery of the last litter

Trait	Successive litter							
	1	2	3	4	5	6	7	8
$n_1 \times D_{UP}$	0.022	0.005	-0.004	-0.024	-0.050	-0.051	0.011	-0.001
$n_1 \times D_{PO}$	-	-0.014	-0.042	0.014	-0.065	-0.037	-0.044	0.068
$n_{21} \times D_{UP}$	0.005	-0.024	-0.016	-0.010	-0.002	-0.025	0.022	0.039
$n_{21} \times D_{PO}$	-	-0.044	-0.063	-0.030	-0.048	-0.053	-0.042	-0.006
$D_{UP} \times D_{PO}$	-	0.080	0.040	0.107	0.019	0.042	0.148	0.130

Explanations are given at the bottom of Table 3.

Rosendo *et al*. [2007] studied also the relations between the age at first heat and the number of piglets born and number of piglets raised and reported the respective values to be-0.40 and -0.03), whereas according to Wolf *et al*. [2005] correlations between first litter and the other ones ranged from 0.96 to 0.996. Tholen *et al*. [1996] report that genetic relations between the interfarrowing interval and stayability range vary from -0.24 to -0.54, and Serenius and Stalder [2006] state that longevity is correlated with the interfarrowing interval at the level of -0.40, and with litter size at the level of 0.26.

Regression coefficients between the total of piglets born in a litter, number of days from sow birth date to first farrowing day, number of days from first farrowing to last litter delivery day, and indexes I and II are listed in Tables 6 and 7. The coefficient indicates how much the dependent variable *y* will change with variable *x* increase by a unit. Regression coefficient b'_1 determines the influence of the following: the sum of piglets (born or raised in one litter) upon the index, b'_2 – number of days from sow birth date to first farrowing day upon the index, and b'_3 – number of days from

Table 6. Regression coefficients between index I and the sum of piglets born in a given litter, number of days from sow's birth date to first farrowing day, and number of days from first farrowing date and day of delivery of the last litter

	Successive litter						
	2	3	4	5	6	7	8
b'_1	-1.0479	-0.7462	-0.7307	-0.7061	-0.7091	-0.6557	-0.7208
b'_2	0.3853	0.3526	0.3342	0.3026	0.2898	0.2534	0.2478
b'_3	0.3493	0.4626	0.5290	0.5514	0.5696	0.6396	0.6483

b'_1 – determines the influence of: the sum of piglets (born or raised in one farrowing) on the index.
b'_2 – number of days from sow birth date to first farrowing day on the index.
b'_3 - number of days from first farrowing date to last litter delivery day on the index.

Table 7. Regression coefficients between index II and the sum of piglets born in a given litter, number of days from sow's birth date to first farrowing day, and number of days from fist farrowing date and last litter delivery day

	Successive litter						
	2	3	4	5	6	7	8
b'_1	-0.7404	-0.7520	-0.7263	-0.7174	-0.6882	-0.6402	-0.6829
b'_2	0.3362	0.3363	0.3237	0.3085	0.2963	0.2567	0.2448
b'_3	0.3284	0.4392	0.5131	0.5627	0.5921	0.6571	0.6504

Explanations are given at the bottom of Table 6.

first farrowing to last litter delivery day upon the index. Highest values of negative coefficients were observed between the sum of piglets (in case of index I – piglets born, in case of index II – piglets raised) and indexes. Regression coefficients between the number of days from sow birth to first farrowing and the indexes were positive and decreased for successive litters, whereas they were increasing between the number of days from first farrowing to last litter delivery day and the indexes for each successive litter.

The worldwide research conducted so far leads to the conclusion that stayability period of a sow, that is so-called longevity is characterized by low heritability, same as all reproduction-related traits, with the estimated value ranging from 0.109 to 0.268 [Yazdi *et al*., 2000] Non-genetic factors related to feeding, maintenance or health highly affect time of keeping a sow in a herd [Stalder *et al*. 2004; Serenius and Stalder 2006]. Therefore, efforts should be made to find genetic impact on the grounds of methods based on utility of relatives, principally on the mother's or grandmother's side.

Regression coefficients estimated between the reproductive traits and reproduction indexes developed confirmed relations, which were found earlier. In successive litters throughout sows' life, the proportions in which individual traits affect the indexes, are subject to changes. For each successive litter, the impact of the number of piglets in a litter on the indexes decreases, and the impact of the period from first farrowing day to the day of delivery of last litter increases. Thus, longevity of sows may affect the economy of pork production. However, a question appears how to use this trait in the selection process.

REFERENCES

1. CANARIO L., ROY N., GRUAND J., BIDANEL J.P., 2006 – Genetic variation of farrowing kinetics traits and their relationships with litter size and perinatal mortality in French Large White sows. ***Journal of Animal Science*** 84, 1053-1058.
2. National Swine Improvement Federation., 2003 – Guidelines for uniform swine improvement programs. Appendix E: Selection index. http://www.nsif.com/guidel/_APPENDE.HTM#01.
3. ORZECHOWSKA B., MUCHA A., 2008 –. Ocena użytkowości rozpłodowej loch. Stan hodowli i wyniki oceny świń. (Evaluation of Reproductive Performance of Sows. Present Situation of Breeding and Results of Pig Evaluation). Wyd. własne IZ, Kraków, 3-19. In Polish. Published by the National Research Institute for Animal Production, Cracow, 3-19.

4. ROSENDO A., DRUET T., GOGUÉ J., CANARIO L., BIDANEL J.P., 2007 – Correlation responses for litter traits to six generation of selection for ovulation rate or prenatal survival in French Large White pigs. ***Journal of Animal Science*** 85(7), 1615-1624.
5. THOLEN E., BUNTER K.L., HERMESCH S., GRASER H.U., 1996 – The genetic foundation of fitness and reproduction traits in Australian pig population. 2. Relationship between weaning to conception interval, farrowing interval, stayability and other common reproduction traits***. Australian Journal of Agricultural Research*** 47(8), 1275-1290.
6. TYRA M., RÓŻYCKI M., 2002 – Phenotypic and genetic correlation between reproductive traits of pigs. ***Annals of Animal Science*** 2(2), 23-29.
7. TYRA M., RÓŻYCKI M., 2004. – Heritability of reproductive traits in pigs. ***Animal Science Papers and Reports***, Supplement 3, 22, 235-242.
8. STALDER K.J., KNAUER M., BAAS T.J., ROTHSCHILD F., MABRY J.W., 2004 – Sow Longevity. ***Pig News and Information*** 25, 53N-74N.
9. SERENIUS T., STALDER K.J., 2006 – Selection for sow longevity. ***Journal of Animal Science*** 84, E166-E171.
10. WOLF J., ŽÁKOWÁ E., GROENEVALD E., 2005 – Genetic parameters for a joint genetic evaluation of production and reproduction traits in pigs. ***Czech Journal of Animal Science,*** 50(3): 96-103.
11. YAZDI M., RYDHMER L., INGMAR-CEDERBERG E., LUNDEHEIM N., JOHANSSON K., 2000 – Genetic study of longevity in Swedish Landrace sows. ***Livestock Production Science*** 63(3), 255-264.

Aurelia Mucha, Marian Różyczki, Tadeusz Blacharski

Wykorzystanie w ocenie użytkowości rozpłodowej loch wskaźników uwzględniających okres ich użytkowania

S t r e s z c z e n i e

Materiał stanowiły dane o użytkowości rozpłodowej loch rasy wbp objętej szacowaniem wartości hodowlanej metodą BLUP w drugiej połowie maja 2008 r. W analizie uwzględniono lochy, które dały od jednego do ośmiu miotów. Obliczono wskaźnik W_I (liczba dni od daty urodzenia lochy do dnia urodzenia przez nią ostatniego miotu dzielona przez sumę urodzonych prosiąt) i wskaźnik W_{II} (liczba dni od daty urodzenia lochy do dnia urodzenia przez nią ostatniego miotu dzielona przez sumę prosiąt w 21 dniu życia). Wartość wskaźników maleje z kolejnym miotem. Na podstawie korelacji między poszczególnymi cechami loch a obliczonymi wskaźnikami oszacowano współczynniki regresji. Stwierdzono, że w okresie użytkowania lochy zmienia się w kolejnych miotach wpływ poszczególnych cech na badane wskaźniki. Maleje wpływ liczby prosiąt w miocie, a rośnie wpływ długości okresu od pierwszego oproszenia do urodzenia ostatniego miotu. W tym świetle wnioskuje się, że długowieczność loch może wpływać na rentowność produkcji wieprzowiny.