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Coefficients of repeatability for colostrum and milk composition of PLW and PL sows over three consecutive lactations

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ABSTRACT

To date, there have been no studies determining the coefficients of heritability or repeatability for colostrum and milk composition of sows in successive lactations. In the case of sows, estimation of such coefficient of repeatability may give a preliminary indication of whether these traits can be used in the breeding and selection of pigs. The aim of the experiment was to make preliminary estimates of the coefficients of repeatability for the content of the Polish Large White (PLW) and Polish Landrace (PL) sow colostrum and milk components over three consecutive lactations. Subjects were 72 sows of the PLW (30 sows) and PL breeds (42 sows). During three consecutive lactations, samples of colostrum and milk on day 14 of lactation were collected from the first, third and sixth teats of the sows (each sample from teats 1, 3 and 6 totalled 50 ml in volume). In total, 432 samples of colostrum and milk were collected from sows of the two breeds. The samples were analysed for fat, crude protein, lactose, solids, and non-protein solids. Summarizing the results, it is concluded that the highest coefficient of repeatability was estimated for colostrum lactose and solids content over two consecutive lactations: second and third ($r=0.3$). Also in the milk of second- and third-lactation sows, the lactose content was characterized by the highest coefficient of repeatability ($r=0.18$). Considering the three consecutive lactations, it was found that colostrum produced by the sows had a consistent content of lactose ($r=0.18$) as well as solids ($r=0.17$) and protein ($r=0.16$). Therefore, it can be stated that the lactose content of sow colostrum in the first lactation could be indicative of a female's predisposition to produce colostrum and milk with similar lactose content over two consecutive lactations.

1. Introduction

The number of piglets born alive and weaned per litter determines the economics of pig production. For this reason efforts have been made to improve these traits, also through selection, but the genetic progress realized to date has been slow. This results from the fact that the above traits are characterized by low heritability and repeatability (Bichard and David, 1985; Holm et al., 2004; Su et al., 2007; Distl, 2007). Consequently, the search was on to find additional traits that would improve sow reproductive performance after being included in the selection index. Many studies that determined heritability values for the weight of born piglets reported low values (Damgaard et al., 2003; Canario et al., 2010; Bergsma et al., 2008). Likewise, low heritabilities, ranging from $h^2=0.05$ to $h^2=0.10$, were estimated for sow longevity (Serenius and Stalder, 2004). Slightly higher values of this parameter were obtained for feed consumption by a lactating sow ($h^2=0.14$) (Gilbert et al., 2012).

Good reproductive performance of a sow is associated with a large number of strong and healthy piglets on the day of weaning, and largely depends on the sow's milk yield and maternal care. The genetic parameters of these traits are not exactly known. Bergsma et al. (2008) estimated the coefficients of heritability for lactation performance of sows ($h^2=0.12$) and the associated litter weight gain ($h^2=0.18$). To date no studies are known to determine the coefficients of heritability or repeatability for colostrum and milk composition of sows in successive lactations. This is because it is difficult to acquire data from a sufficiently large number of sows kept under farm conditions. More studies in this area were performed with cattle (Van Tassell et al., 1999; Suzuki and Van Vleck, 1994; Aspilcueta-Borquis et al., 2010) and they showed that heritability of milk yield varied, depending on breed, between $h^2=0.18$ and $h^2=0.54$. In turn, heritability of milk fat and protein content was higher and ranged from $h^2=0.26$ to $h^2=0.39$. The coefficient of repeatability for these traits in successive lactations was high at about $r=0.5$ (Suzuki and Van Vleck, 1994). The high coefficient of repeatability for milk traits suggests that the results of next lactations could be predicted from a single lactation. In the

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Table 1
Effect of breed and lactation on basic composition of colostrum and milk from PLW (30 head) and PL sows (42 head) on day 14 of lactation.

	No. of milk samples	Mean	Standard deviation	Coefficient of variation	Significance		
					breed	lactation	breed × lactation
Colostrum:							
Fat	432	5.15	2.44	47.34	**	**	ns
Protein	432	14.90	3.04	20.46	**	ns	ns
Lactose	432	1.94	0.87	44.76	**	**	ns
Solids	432	22.62	3.14	13.91	**	*	ns
Non-protein solids	432	17.44	2.32	13.28	*	ns	ns
Milk, day 14 of lactation:							
Fat	432	7.22	1.72	23.86	ns	ns	ns
Protein	432	4.85	1.74	35.77	ns	**	ns
Lactose	432	5.56	0.75	13.42	ns	**	ns
Solids	432	18.01	1.56	8.68	*	**	ns
Non-protein solids	432	10.85	1.34	12.37	ns	**	ns
Rearing performance of piglets:							
No. of born piglets	432	11.58	1.15	9.96	ns	ns	ns
Litter weight at birth	432	16.82	2.35	14.03	ns	ns	ns
No. of piglets on day 21 of age	432	10.27	1.36	13.29	ns	ns	ns
Litter weight on day 21 of age	432	56.44	9.78	17.33	ns	*	ns

* $P \leq 0.05$,
** $P \leq 0.01$

case of sows, these data could provide valuable information about the mother and her predisposition to produce milk of consistent quality in successive lactations. The estimates of the coefficients of repeatability may also give a preliminary indication of whether these traits can be used in the breeding and selection of pigs. Bergsma et al. (2013) demonstrated that in the absence of antagonistic genetic correlations, selection for growing-finishing traits in dam lines could be combined with selection for lactation performance traits.

The objective of the experiment was to make preliminary estimates of the coefficients of repeatability for the content of the PLW and PL sow colostrum and milk components over three consecutive lactations.

2. Materials and methods

The experiment used 72 sows of the maternal breeds Polish Large White (30 sows) and Polish Landrace (42 sows). Throughout the production period, sows were kept on one farm under the same hygienic conditions and received the same feeds. During three consecutive lactations, samples of colostrum and milk were collected from the first, third and sixth teats of the sows (each sample from teats 1, 3 and 6 totalled 50 ml in volume). Colostrum was sampled within one hour after placental expulsion and milk on day 14 of lactation, two hours after the morning feeding, following the intramuscular administration of 2 ml oxytocin. Then, the samples were labelled and chilled to 4 °C. The chilled samples of fresh milk were transported to the Laboratory of Milk Assessment and Analysis of the Wrocław University of Environmental and Life Sciences to determine basic milk components. A total of 432 samples of colostrum and milk were analysed for fat, crude protein, lactose, solids, and non-protein solids. During lactation, data were collected on the number and body weight of piglets at birth, and the number and body weight of piglets on day 21 of lactation.

The collected data were statistically analysed using the ANOVA procedure of Statistica v. 10 (StatSoft Inc., 2011) according to the model:

$$Y_{ijm} = m + a_i + b_j + (\mathrm{cd})_{ij} + e_{ijm}$$

where: m=mean, a_i=effect of breed (i=1, 2), b_j=effect of lactation (j=1–3), $(\mathrm{cd})_{ij}$ – interaction between a_i and b_j, e_{ijm} – random error.

Differences between the means for individual traits were tested for significance at the 5% and 1% level using Duncan's multiple range test.

For both breeds together, the coefficient of repeatability (r) was estimated for each analysed trait from the analysis of variance components, based on VARCOMP procedure of the SAS package (SAS Institute, 2012). The r coefficient was estimated for three consecutive lactations and a between the first and second, second and third, and first and third lactations, using the model:

$$Y_{ijkl} = m + a_i + b_j + c_k + e_{ijkl}$$

where: m=mean, a_i – fixed effect of breed (i=1, 2), b_j – random effect of the sow's sire, c_k – random effect of sow, e_{ijkl} – random error

thus:

$$r = (\sigma_b^2 + \sigma_c^2)/(\sigma_b^2 + \sigma_c^2 + \sigma_e^2)$$

where: σ_b^2 – sire variance, σ_c^2 – sow variance, σ_e^2 – error variance.

3. Results

Table 1 shows the results of preliminary statistical analysis of the studied parameters (chemical composition of 432 colostrum and milk samples of sows on day 14 of lactation, number of piglets and litter weight at birth and at 21 days of age) with regard to breed by lactation interaction as well as the main effects of breed and lactation. No interaction between the analysed factors (breed × lactation) was found for any of the traits under analysis. The presented data show that breed had an effect primarily on colostrum components: fat, protein, lactose and solids ($P \leq 0.01$) and non-protein solids ($P \leq 0.05$). Lactation had an effect on the content of fat ($P \leq 0.01$), lactose ($P \leq 0.01$) and solids in colostrum ($P \leq 0.05$), as well as an effect ($P \leq 0.01$) on the content of protein, lactose, solids, and non-protein solids in milk on day 14 of lactation. The breed factor had no effect on the number of piglets and litter weight. Lactation had an effect ($P \leq 0.05$) only on litter weight at 21 days of age.

Detailed analysis of the effect of breed on the analysed traits demonstrated (Table 2) that compared to PLW sows, PL sows produce colostrum with a higher ($P \leq 0.01$) content of fat, protein,