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POLYMORPHISM OF CHROMOSOME SIZE IN THE SOWS OF POLISH LANDRACE BREED (PBZ)

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Assessment was made of sex chromosomes and autosomes based on measuring their areas in the Polish landrace, and of the connection of the observed polymorphism with reproductive traits. The average area of sex chromosomes in examined sows was 7.4779 μm^2, with the values ranging from 6.9739 μm^2 to 8.1331 μm^2. And the average autosomes area was 143.7742 μm^2. Considerably greater variability was found within the sex chromosomes area than the autosomes area. The variability index of the chromatids area of sex chromosomes was between 0.3182% and 7.9053%. The variability of autosomal chromosomes area, however, was between 1.0491% and 1.3069%. The average areas of sex chromosomes and autosomes as well as the average total areas of chromosomes proved relatively highly and positively correlated with the number of piglets born in the fourth litter, and the values of correlation indexes were respectively r = 0.4044, r = 0.3257 and r = 0.3488.

Keywords: polymorphism, chromosomes, reproductive traits, sows, Polish landrace breed

1. INTRODUCTION

Each animal breed is characterized by a specific complement of chromosomes, both in terms of their number and morphology. Assessing whether the chromosome complement is normal requires taking into consideration the fact of occurrence of chromosome polymorphism. In respect of chromosomes, the following forms of polymorphism can be distinguished:

- chromosome length polymorphism (the relative length of sex chromosomes was assessed, particularly the Y-chromosome in various animal breeds – sheep, cattle, horses, and pigs) [3, 5, 9],
- polymorphism of the number and size of specific chromosome sections in terms of structure and function (the size of centromeric heterochromatin blocks and the nucleolus organizer areas) [9, 10],
- polymorphism of the number of chromosomes (may arise from centric fusions or occurrence of a varied number of chromosomes) [2, 5].

The objective of the study is to analyze the polymorphism of chromosomes based on measurement of the sex chromosome area and the autosomal chromosome area in sows of the Polish landrace breed, as well as the connection between the observed polymorphism and reproductive traits.

2. MATERIAL AND METHODS

The research material was constituted by blood coming from 20 sows of the Polish landrace breed. Animals came from two brood herds from the land of the Kujawsko--Pomorskie province. Whole blood lymphocytes were maintained on RPMI1640 medium with an addition of calf serum LF-7, and antibiotic. The metaphase spread preparations were made in accordance with generally accepted methods [7]. The metaphase spreads were stained using the GTG method and the Giemsa stain [7]. The preparations were analyzed in a light microscope with the magnification of 1250X, and using the Multi-Scan Karyotype computer software v. 8.01 [4].

Size of the chromosomes was measured in minimum three metaphase platelets with the use of the 'surface' function and recorded in the Microsoft Excel program. Average values of sex chromosomes and autosomes were calculated (μm^2).

The relative size of the sex chromosome area (%) and participation of heterosomes were calculated according to the following formulas:

Relative size of sex chromosomes = [total of heterochromosome area (μm^2) / total of autosome area (μm^2)] x 100%.

Sex chromosomes participation = [total of heterochromosome area (μm^2) / total of autosomes and heterochromosomes (μm^2)] x 100%.

Variability of the examined chromosome traits was estimated by calculating the standard deviation (S_x) and the variability index (V_x) [8]. Simple correlations between the analysed chromosome traits and the first littering as well as the number of piglets born alive were estimated in the first, second, and third litter [8].

3. RESULTS

Table 1 presents average values of sex chromosome and autosome area, as well as the average relative area and chromosomes participation in all metaphase chromosomes.

Average sex chromosome area in sows of the Polish landrace breed was 7.4779 μm^2. The smallest average sex chromosome area was observed in sow no. 33 – 6.9739 μm^2, and the largest of 8.1331 μm^2 in sow no. 45 (Table 1).

In terms of average values of the areas of autosomal chromosome chromatids areas, values observed in sows number 35 and 50 are worth noting (Table 1). Sow no. 50 was characterized by the largest autosome area of 158.9862 μm^2, and sow number 35 the smallest of 126.3322 μm^2. The average chromosome area in the examined group of sows was 143.7742 μm^2 (Table 1).

Table 1. Average areas of sex chromosomes and autosomes, and the relative value and percentage of heterochromosomes of Polish landrace sows

Tabela 1. Średnie wielkości powierzchni chromosomów płci i autosomów oraz względna wartość i udział heterochromosomów loch rasy pbz

Sow no. Nr lochy	Average area of sex chromosomes [μm^2] Średnia powierzchnia chromosomów płci	Average area of chromatids of autosomal chromosomes [μm^2] Średnia powierzchnia chromatyd chromosomów autosomalnych	Average area of sex chromosomes and autosomal chromosomes [μm^2] Średnia powierzchnia chromosomów płci i chromosomów autosomalnych	Average relative area of sex chromosomes [%] Średnia powierzchnia względna chromosomów płci	Percentage of chromatids of sex chromosomes [%] Udział chromatyd chromosomów płci
13	7.0674	156.6813	163.7487	4.5107	4.3160
14	7.3393	141.5705	148.9099	5.1842	4.9287
15	7.4612	140.7087	148.1699	5.3026	5.0356
16	7.2644	142.0309	149.2952	5.1146	4.8658
24	7.6749	140.5813	148.2562	5.4594	5.1768
27	7.1342	141.7830	148.9172	5.0318	4.7907
28	7.3540	142.1166	149.4707	5.1746	4.9201
33	6.9739	142.0519	149.0257	4.9094	4.6797
35	7.2841	126.3322	133.6163	5.7658	5.4515
36	7.4285	136.2987	143.7272	5.4501	5.1685
38	7.9078	136.0207	143.9285	5.8137	5.4942
39	7.3417	142.4695	149.8112	5.1531	4.9006
40	7.8043	144.1579	151.9622	5.4137	5.1357
41	8.1020	146.5895	154.6915	5.5270	5.2375
42	7.7914	150.5954	158.3868	5.1738	4.9192
44	8.1250	147.4180	155.5430	5.5116	5.2237
45	8.1331	146.1240	154.2571	5.5659	5.2725
49	7.2623	142.4365	149.6988	5.0987	4.8513
50	7.0492	158.9862	166.0354	4.4338	4.2456
51	7.0591	150.5310	157.5901	4.6895	4.4794
Average Średnia	7.4779	143.7742	151.2521	5.2142	4.9440

The average chromosome area (the total of autosomes and sex chromosomes) in the metaphase platelets in examined sows was 151.2521 μm^2, assuming values from 133.6163 μm^2 (sow no. 35) to 166.0354 μm^2 (sow no. 50) (Table 1).

In the examined group of sows, the average relative area of sex chromosomes was 5.2142%, and participation of sex chromosomes was 4.9440% (Table 1). The sow numbered 50 was characterized by the smallest values of the average relative area, equalling to 4.4338% and participation of sex chromosomes in all metaphase chromosomes (4.2456%). On the other hand, the highest values of the average relative area of sex chromosomes and the participation of sex chromosomes was observed in sow no. 38 (Table 1).

Analyzing the variability of the metaphase chromosomes area in the examined group of Polish landrace sows, significantly higher variability was found within the sex chromosomes than autosomes. The variability index of the sex chromosome chromatids

was between 0.3182% (sow no. 27) and 7.9053% (sow no. 42), whereas the variability of autosomal chromosome area was between 1.0491% (sow no. 13) and 1.3069% (sow no. 42) (Table 2). Taking into consideration the total area of sex chromosomes and autosomes, the lowest variability was observed in sow no. 1 (Vx = 0.9833%), and the highest in sow no. 42 (Vx = 1.2127%) (Table 2). Among the 20 sows, the highest variability, in terms of chromosome area in respect of both sex chromosomes and autosomes, was found in sow no. 42 (Table 2).

Tabele 2. Variability of the area of sex chromosomes and autosomes in sows of the Polish landrace breed

Tabela 2. Zmienność wielkości powierzchni chromosomów płci i autosomów loch rasy pbz

Individual Osobnik	Trait – Cecha					
	Area of chromatids of sex chromosomes Powierzchnia chromatyd chromosomów płci		Area of chromatids of autosomal chromosomes Powierzchnia chromatyd chromosomów autosomalnych		Area of sex chromosomes and autosomal chromosomes Powierzchnia chromosomów płci i chromosomów autosomalnych	
	Statistical measures – Miary statystyczne					
	Sx [μm^2]	Vx [%]	Sx [μm^2]	Vx [%]	Sx [μm^2]	Vx [%]
13	0.1014	1.4341	1.6438	1.0491	1.6102	0.9833
14	0.0529	0.7202	1.6997	1.2006	1.6551	1.1115
15	0.0465	0.6227	1.6102	1.1444	1.5674	1.0579
16	0.3261	4.4887	1.7679	1.2447	1.7239	1.1547
24	0.2799	3.6472	1.7572	1.2500	1.7110	1.1541
27	0.0227	0.3182	1.6345	1.1528	1.5927	1.0695
28	0.2231	3.0344	1.7383	1.2232	1.6933	1.1329
33	0.1211	1.7368	1.8237	1.2838	1.7778	1.1929
35	0.3018	4.1432	1.4139	1.1192	1.3776	1.0310
36	0.1298	1.7476	1.5610	1.1453	1.5193	1.0571
38	0.3155	3.9902	1.6133	1.1861	1.5718	1.0921
39	0.1882	2.5639	1.7585	1.2343	1.7128	1.1433
40	0.0764	0.9786	1.8493	1.2828	1.7998	1.1843
41	0.3104	3.8313	1.8589	1.2681	1.8102	1.1702
42	0.6159	7.9053	1.9682	1.3069	1.8102	1.2127
44	0.5046	6.2098	1.7149	1.1633	1.6721	1.0750
45	0.6079	7.4747	1.8303	1.2525	1.7852	1.1573
49	0.4169	5.7404	1.7698	1.2425	1.7260	1.1530
50	0.1151	1.6326	1.8181	1.1436	1.7806	1.0724
51	0.1393	1.9734	1.6698	1.1093	1.6317	1.0354
Average Średnia	0.3948	5.2793	7.0836	4.9269	7.1551	4.7306

The Polish landrace breed is counted as a maternal breed, therefore some of the most important production traits are the traits characterizing reproduction. The examined group of sows littered for the first time at the age of 353 days on average. Attention should be drawn to considerable diversity of sows as regards the age of first littering, ranging from 303 days (sow no. 33) up to 397 days (sow no. 49) (Table 3). The average number of piglets born alive in subsequent four litters in the examined group was relatively high and equalled 13 (first litter) up to 15 (third litter) piglets (Table 3).

Tabele 3. Values of selected reproduction traits of Polish landrace sows
Tabela 3. Wartości wybranych cech rozrodczych loch rasy pbz

Sow no. Nr lochy	Age of first littering Wiek pierwszego oproszenia	Number of piglets born alive in the first litter Liczba prosiąt żywo urodzonych w 1. miocie	Number of piglets born alive in the second litter Liczba prosiąt żywo urodzonych w 2. miocie	Number of piglets born alive in the third litter Liczba prosiąt żywo urodzonych w 3. miocie	Number of piglets born alive in the fourth litter Liczba prosiąt żywo urodzonych w 4. miocie
13	369	13	14	–	–
14	369	15	12	14	–
15	316	14	13	–	–
16	354	13	12	–	–
24	372	12	14	17	16
27	353	9	10	13	14
28	324	15	14	20	14
33	303	14	17	14	14
35	346	11	12	13	14
36	323	15	13	15	–
38	328	14	13	14	13
39	358	14	14	14	13
40	375	12	13	–	–
41	397	11	–	–	–
42	337	12	12	–	–
44	396	14	13	15	15
45	352	13	13	14	16
49	397	13	14	15	13
50	345	13	15	16	15
51	344	12	12	16	14
Average Średnia	353	13	13	15	14

The observed polymorphism of the size of sex chromosomes and autosomes in the examined sows may be connected with production traits. Relations between the size of the chromosome area and the selected reproduction traits of the group of examined sows are shown in Table 4. In the examined group of sows, the values of correlation indexes were between [–0.2733] (the number of piglets born alive in the second litter – percentage of sex chromosomes) and 0.4044 (the number of piglets born alive in the fourth litter – average sex chromosome area) (Table 4).

The age of the first litter turned out to be positively correlated with all examined chromosome parameters. However, the highest correlation value was found in the case of the average sex chromosome area – r = 0.3598 (Table 4). Correlations between the examined average chromosome areas (sex, autosomes, and total) and the number of piglets born alive in the first litter turned out to be negative with the value near to zero (Table 4).

However, the relative sex chromosomes size, their percentage and average area turned out to be negatively correlated with the number of piglets born alive in the second and third litters. The average autosome area and the average chromosome area turned out to be positively correlated with the number of piglets born alive in the second, third, and fourth litter (Table 4).

Table 4. Simple correlation indexes between the examined traits
Tabela 4. Współczynniki korelacji prostych pomiędzy badanymi cechami

Correlated traits Cechy korelowane	Age of first littering Wiek pierwszego oproszenia	Number of piglets born alive in the first litter Liczba żywo urodzonych prosiąt w 1. miocie	Number of piglets born alive in the second litter Liczba żywo urodzonych prosiąt w 2. miocie	Number of piglets born alive in the third litter Liczba żywo urodzonych prosiąt w 3. miocie	Number of piglets born alive in the fourth litter Liczba żywo urodzonych prosiąt w 4. miocie
Age of first littering Wiek pierwszego oproszenia	–	–0.3050	–	–	–
Relative size of sex chromosomes Względna wielkość chromosomów płci	0.0876	0.0067	–0.2728	–0.2448	–0.0568
Percentage of sex chromosomes % udział chromosomów płci	0.0878	0.0071	–0.2733	–0.2443	–0.0564
Average area of sex chromosomes Średnia powierzchnia chromosomów płci	0.3598	–0.0097	–0.1876	–0.0331	–0.4044
Average area of autosomal chromosomes Średnia powierzchnia chromosomów autosomalnych	0.2250	–0.0306	0.2234	0.3189	0,3257
Average area of chromosomes (autosomes, heterochromosomes) Średnia powierzchnia chromosomów (autosomy, heterochromosomy)	0.2448	–0.0312	0.2153	0.3185	0,3488

Interesting relations were observed between the examined chromosome traits and the number of piglets born alive in the fourth litter. The average areas of sex chromosomes and autosomes proved to have a relatively high positive correlation with the number of piglets born alive in the fourth litter, the values being respectively $r = 0.4044$, $r = 0.3257$ and $r = 0.3488$ (Table 4). Obtained values of correlation indexes might come in useful as indexes concerning prediction of the number of piglets to be born alive in the fourth litter.

4. DISCUSSION

Polymorphism of the relative length of sex chromosomes was assessed in several breeds of farm animals, including pigs. Polymorphism of the chromosome length was examined in sex chromosomes based on their relative length expressed by the centromeric index, that is the ratio of the long arms to the short arms (q:p), or the percentage of length of the haploidal autosomes complement and the sex X-chromosome [4]. In several breeds and synthetic lines of breeding pigs in Poland, a polymorphism was observed of the relative length of the sex Y-chromosome, the smallest and relatively easy to identify in the animals' karyotype. It was found that polymorphic variants of the relative length of the Y-chromosome may be considered as characteristic traits of particular pig breeds. It seems that the observed differences in the relative length of the Y-chromosome stem from the varied size of the large heterochromatin block, which includes the q arm of this chromosome. Measuring the length of chromosomes, chiefly sex chromosomes, correlation was sought between polymorphic variants and determined fertility indexes [4, 5].

It was not concluded explicitly what the influence of the chromosome size polymorphism was on the animals' production traits. However, the research has proved the thesis that chromosome polymorphism can be applied in seeking chromosome markers and gene mapping [1, 2, 3].

Chromosome polymorphism observations conducted in population covering one breed allow one to reveal inter-individual differences, as well as to determine the breed trend [5, 6].

5. CONCLUSION

1. The examined sows, belonging to the Polish landrace breed, had the number of chromosomes normal for this breed and sex, namely 2n = 38 XX.
2. Significant differences were found in terms of the area of autosomal chromosomes and the total area of sex chromosomes and autosomes in diploidal cells of the examined sows. From among the calculated correlation indexes, the phenotypic correlation index between the average sex chromosome area and the number of piglets born alive in the fourth litter (r = 0.4044) is worth noting.
3. The observed relations between traits determining the size of chromosomes (autosomes and sex chromosomes) and the traits regarding the sows reproduction indicate the possibility of using the chromosome polymorphism as a marker of reproductive traits.
4. The results, which are to be considered preliminary, provide the basis for further research with the objective of seeking production (reproduction) traits markers in sows.

REFERENCES

[1] Danielak-Czech B., 2000. Strukturalna niestabilność chromosomów zwierząt gospodarskich. [Structural instability of farm animals chromosomes]. Biul. Inf. IZXXXVIII(4), 5–10.

[2] Danielak-Czech B., 2001. Struktura niestabilności genomu przyczyną nieprawidłowości kariotypu świń. [Structural instability of genome as a reason for abnormalities of pig karyotype]. Biul. Inf. IZXXXIX(4), 15–20.

[3] Kozubska-Sobocińska A., 1998. Chromosomy płciowe u zwierząt gospodarskich w aspekcie zjawiska polimorfizmu i konserwatyzmu genetycznego. [Sex chromosomes in farm animals in the aspect of the phenomenon of polymorphism and genetic conservatism]. Biul. Inf. IZXXXVI(2), 5–10.

[4] Kozubska-Sobocińska A., Słota E., Bugno M., Danielak-Czech B., Rejduch B., 1999. Zastosowanie systemu Multiscan do oceny polimorfizmu chromosomów. [Application of the Multiscan system for assessment of chromosome polymorphism]. Rocz. Nauk. Zoot. 26(3), 9–19.

[5] Kozubska-Sobocińska A., Słota E., Danielak-Czech B., Rejduch B., 1995. Klasyfikacja polimorfizmu chromosomu Y u czterech ras bydła na podstawie pomiarów długości chromosomów płciowych. [Classification of Y-chromosome polymorphism in four cattle breeds based on sex chromosome length measurements]. Rocz. Nauk. Zoot. 22(2), 29–36.

[6] Lassota Z., 1987. Biologia molekularna. Informacja genetyczna. PWN Warszawa.

[7] Olszewska M., 1981. Metody badań chromosomów. PWRiL Warszawa.

[8] Ruszczyc Z., 1970. Metodyka doświadczeń zootechnicznych. PWRiL Warszawa.

[9] Słota E., 1998. Polimorfizm chromosomów świń. IZ Kraków.

[10] Świtoński M., Pietrzak A., Buczyński J., 1997. Chromosomal Markers (C-band and Ag-NOR) in the Zlotnicka Spotted Pig. Anim. Sci. Pap. Rep. 15(3), 173–178.

POLIMORFIZM WIELKOŚCI CHROMOSOMÓW U LOCH RASY POLSKA BIAŁA ZWISŁOUCHA (PBZ)

Streszczenie

Oceniono polimorfizm chromosomów płci i autosomów na podstawie pomiaru ich powierzchni u loch rasy polska biała zwisłoucha oraz związek zaobserwowanego polimorfizmu z cechami rozrodczymi. Średnia powierzchnia chromosomów płci u badanych loch wynosiła 7,4779 μm^2, przy zakresie wartości od 6,9739 μm^2 do 8,1331 μm^2. Średnia powierzchnia autosomów wynosiła natomiast 143,7742 μm^2. Stwierdzono znacznie większą zmienność w obrębie chromosomów płci niż autosomów. Współczynnik zmienności powierzchni chromatyd chromosomów płci wahał się w granicach od 0,3182% do 7,9053%. Zmienność powierzchni chromosomów autosomalnych zawierała się w granicach od 1,0491% do 1,3069%. Średnie powierzchnie chromosomów płci i autosomów oraz średnie powierzchnie całkowite chromosomów okazały się stosunkowo wysoko dodatnio skorelowane z liczbą prosiąt żywo urodzonych w czwartym miocie, a wartości współczynników korelacji wynosiły odpowiednio: r = 0,4044; r = 0,3257 i r = 0,3488.

Słowa kluczowe: polimorfizm, chromosomy, cechy rozrodcze, lochy, rasa pbz