GENETIC BACKGROUND OF CONFORMATION DEFECTS IN POLISH BLACK-AND-WHITE HOLSTEIN-FRIESIAN BULLS – ANALYSIS OF PHENOTYPIC DISTRIBUTION*

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Abstract

Phenotypic distribution of 22 routinely evaluated conformation defects was analysed in a population of Polish Black-and-White Holstein-Friesian bulls, sired by different males. Some variation was observed in mean frequency of different morphological defects and in their severity. Large differences were found in frequency of conformation defects and in their number between groups of half-brothers. The most common defects in the bull population analysed were two types of leg defects: wide interdigital space and soft pasterns, which occurred in 199 and 70 animals, respectively. Wide interdigital space was most frequent in 4 groups of half-brothers, in which this defect affected more than 25% of the bulls. The least common defects were the defects of external genitalia, which were found in single animals. The only defect that did not occur was that of testes. The statistical significance of the phenotypic distributions obtained for bull conformation defects was confirmed using the chi-square test of independence and the Fisher-Yates exact test.

Key words: defective type characteristics, sire, Holstein-Friesian

In many countries, including Poland, the recording of external conformation defects has become an integral part of routine assessment of type and conformation in dairy cattle (Brotherstone et al., 1990; Principles of Danish Cattle Breeding, 1999; Wang et al., 2002).

The Polish programme for conformation assessment of Polish Black-and-White Holstein-Friesian bulls accounts for 22 conformation defects in addition to descriptive traits, detailed traits and one measurable trait (rump height). These traits are scored separately but are related to descriptive conformation traits and thus influence the overall score (KCHZ, 2002).

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Like conformation of cattle (Boettcher et al., 1998), conformation defects are associated with length of productive life (Wang et al., 2002).

According to most studies, descriptive and detailed scores for type and conformation traits are linearly related to variously defined survival traits, with non-optimal values of conformation traits being conducive to earlier culling (Sewalem et al., 2004; Buenger et al., 2001; Caraviello et al., 2004). In this respect, the authors cited above found particularly unfavourable relationships between longevity (survival) and three groups of conformation traits that include structure of udder, legs and feet, and rump. Similarly, the conformation defects of these body parts are an important reason for early culling of cattle. Wang et al. (2002) found only unfavourable genetic correlations between this group of traits and length of productive life.

The incidence of conformation defects in the Polish population of bulls is only recorded and serves to provide a more detailed description of the animals evaluated. With regard to individual animals, they provide the breeder with direct selection information that is only used as a phenotypic source of information.

A search of the specialist literature reveals no studies on the genetic background of conformation defects in Holstein-Friesian bulls. The few studies in this area cover only the female population*. Considering the priority given to sire paths in dairy cattle selection programmes, in particular the sire-son pathway, it is appropriate to subject the Polish population of breeding bulls to these analyses.

Studying the mechanism of trait inheritance through comparative analysis of the distribution of parent and offspring phenotypes is the basic method of acquiring information on the genetic background of these defects.

The objective of the study was to analyse the incidence of conformation defects in a population of Polish Holstein-Friesian bulls sired by different males.

Material and methods

The study used a set of data on conformation defects of 3 691 Polish Black-and-White Holstein-Friesian bulls, evaluated in the years 2002–2008. This set contains pedigree information and scores for 22 conformation defects, classified into 6 groups: front, middle, back, rump, legs, and external genitalia. The morphological defects are recorded in three categories (0 – no defect, 1 – minor defect, 2 – serious defect).

Statistical analyses were performed on a set of data created from groups of half-brothers, from which groups with less than 20 animals were removed. The final data set for analysis consisted of 2055 records on bulls sired by 49 males. The numbers of bulls in half-brother groups are given in Tables 2 and 3.

The results obtained were analysed using the chi-square test of independence and the Fisher-Yates exact test.

*The Polish studies are generally related to phenotypic characteristics of conformation defects (Guliński et al., 2002; Stenzel et al., 2003; Wójcik et al., 2004).

The chi-square test of independence is one of the most common methods for studying statistical relationships between categorical variables, but when the expected number is less than 5, this method may lead to inaccurate interpretation of results. When this is the case, the results have to be confirmed with the exact test for small counts. The Fisher-Yates exact test is one of the most popular tests used in practice.

Table 1. Incidence rate of morphological defects in the population of Polish Black-and-White Holstein-Friesian bulls

Type of defect	Incidence rate (%)		
	no defect	minor defect	serious defect
Heavy head	99.90	0.10	0.00
Short head	99.95	0.05	0.00
Short neck	99.90	0.10	0.00
Loose shoulders	98.54	1.36	0.10
Shallow chest	99.76	0.24	0.00
Narrow shoulders	98.69	1.22	0.10
Pendulous belly	98.25	1.70	0.05
Tucked-up belly	99.66	0.34	0.00
Swayed back	98.05	1.90	0.05
Roached back	98.05	1.95	0.00
Hip points projecting above dorsal line	99.76	0.24	0.00
Short pelvis	99.81	0.19	0.00
High tail head	98.73	1.27	0.00
Sunken anus	99.95	0.05	0.00
Sickle-hocked legs	99.76	0.19	0.05
Toeing out	99.76	0.24	0.00
Upright pastern	98.35	1.56	0.10
Soft pastern	96.59	2.97	0.44
Wide interdigital space	90.32	7.49	2.19
Heavy penis	99.95	0.05	0.00
Long scrotum	99.71	0.29	0.00
Testicular defects	100.00	0.00	0.00
MEANS	98.79	1.07	0.14

This test is based on a Markov chain Monte Carlo simulation algorithm, which provides more accurate probability estimates when the number of samples has a count of 5 or less (Johnson, 1972).

The descriptive analyses, the chi-square test of independence and the Fisher-Yates exact test were performed using the FREQ procedure of SAS.

Table 2. Incidence rate and number of bulls with conformation defects sired by different males in population of Polish Black-and-White Holstein-Friesian bulls

Number of bull	Name of bull	Number of defects							
		none		1		2-3		4-5	
		n	%	n	%	n	%	n	%
1	2	3	4	5	6	7	8	9	10
DE000578448776	LAUDAN	18	69.23	7	26.92	1	3.85	0	0.00
FR002998012650	OKENDO	52	77.61	11	16.42	4	5.97	0	0.00
PL000609159341	RUDOLPH	16	80.00	3	15.00	0	0.00	1	5.00
PL000609223245	LEE	35	89.74	2	5.13	2	5.13	0	0.00
PL000609285241	OUTSIDE	15	75.00	5	25.00	0	0.00	0	0.00
PL000609312745	FESTIVAL	12	60.00	2	10.00	5	25.00	1	5.00
PL000609353446	CONVINCER	15	53.57	8	28.57	5	17.86	0	0.00
PL000609353541	LANTZ	18	81.82	0	0.00	4	18.19	0	0.00
PL000609391145	BRETT	22	61.11	5	13.89	6	16.61	3	8.34
PL000609395846	HERSHEL	20	80.00	3	12.00	2	8.00	0	0.00
PL000609396840	JESTHER	37	60.66	17	27.87	6	9.84	1	1.64
PL000609438642	MARSHALL	51	75.00	10	14.71	6	8.82	1	1.47
PL000609438947	INQUIRER	47	74.60	12	19.05	4	6.35	0	0.00
PL000609439246	MONDAY	27	71.05	6	15.79	5	13.16	0	0.00
PL000609444144	MANAT	31	67.39	8	17.39	7	15.22	0	0.00
PL000609475747	DOUTCH BOY	37	84.09	7	15.91	0	0.00	0	0.00
PL000609487643	MTOTO	36	85.71	5	11.90	1	2.38	0	0.00
PL000609492246	MERDRIGNAC	24	88.89	3	11.11	0	0.00	0	0.00
PL000609496042	GARTER	44	78.57	10	17.86	2	3.57	0	0.00
PL000609497646	STORMATIC	57	91.94	5	8.06	0	0.00	0	0.00
PL000609511145	MONZA	20	90.91	2	9.09	0	0.00	0	0.00
PL000609512444	OZZIE	23	95.83	1	4.17	0	0.00	0	0.00
PL000609512549	MACHOMAN	36	94.74	1	2.63	1	2.63	0	0.00
PL000609521043	MORTY	49	80.33	11	18.03	1	1.64	0	0.00
PL000609541249	FINLEY	45	83.33	8	14.81	1	1.85	0	0.00
PL000609579345	LANCELOT	24	66.67	11	30.56	1	2.78	0	0.00
PL000609604946	DAWSON	40	72.73	13	23.64	2	3.64	0	0.00
PL000609605045	LHEROS	21	84.00	2	8.00	1	4.00	1	4.00
PL000609606144	JUSTICE	58	78.38	12	16.22	4	5.40	0	0.00
PL005020207602	TUTOR	31	86.11	4	11.11	1	2.78	0	0.00
PL005020208066	HIGHWAY	19	86.36	3	13.64	0	0.00	0	0.00
PL005034928757	NIKO	26	100.00	0	0.00	0	0.00	0	0.00
PL005053032503	SAMBIA	27	96.43	1	3.57	0	0.00	0	0.00

Table 2 – contd.

1	2	3	4	5	6	7	8	9	10
PL005053309926	ZETOR	38	77.55	7	14.29	4	8.16	0	0.00
PL005053310144	CIAK	21	87.50	3	12.50	0	0.00	0	0.00
PL005053310373	ZONK	85	78.70	17	15.74	5	4.63	1	0.93
PL005053310717	PRECY	23	92.00	1	4.00	1	4.00	0	0.00
PL005053311325	OURASI	40	83.33	8	16.67	0	0.00	0	0.00
PL005054463764	BEST	109	85.16	16	12.50	3	2.34	0	0.00
PL005062430543	JANKES	24	85.71	3	10.71	1	3.57	0	0.00
PL005074178648	MEN	31	91.18	3	8.82	0	0.00	0	0.00
UK000100598172	SHOTTLE	18	81.82	4	18.18	0	0.00	0	0.00
US000060000320	GARRISON	27	79.41	7	20.59	0	0.00	0	0.00
US000120754720	WIZARD	25	86.21	3	10.34	1	3.45	0	0.00
US000123066734	TITANIC	48	81.36	10	16.95	1	1.69	0	0.00
US000123586443	BOLIVER	37	86.05	6	13.95	0	0.00	0	0.00
US000125997863	SOSA	33	61.11	17	31.48	4	7.41	0	0.00
US000128920633	MURPHY	34	91.89	2	5.41	1	2.70	0	0.00
US000207124561	MODEST	19	86.36	2	9.09	1	4.55	0	0.00
TOTAL		1645	80.05	307	14.94	94	4.57	9	0.44

Results

Table 1 presents the incidence rate and severity of conformation defects in the bulls. The mean incidence of morphological defects was 1.21%, including 0.14% of serious defects. In the analysed population of bulls, the only defect that did not occur was that of testes. The incidence of the other defective traits ranged from 0.05% to 9.68%. The most frequent defects were those of legs: wide interdigital space (9.69%, including 2.19% classified as serious) and soft pastern (3.41%, including 0.44% serious); and those of the back: swayed back (1.95%, including 0.05% serious) and roached back (1.95%). The least frequent defects were short head, sunken anus and heavy penis. The frequency of each of these traits was 0.05% on average.

Incidence rate and number of bulls with conformation defects with a division into groups of half-brothers, is presented in Table 2. In the analysed population, conformation defects were found in 19.95% of animals, including 14.94% of bulls with one defect, 4.57% of bulls with two or three defects, and 0.44% of animals with four or five conformation defects. The incidence and number of bulls with defects show large variation between different groups of half-brothers. The lowest incidence rate of number of bulls with conformation defects (0–10%) was found in 9 groups. In 19 groups of half-brothers, this incidence rate of number of bulls ranged between 10 and 20%. In 13 groups, it was in the 20–30% range. The highest incidence rate of the number of bulls with morphological defects (30–50%) was found in 8 groups of half-brothers.

Table 3. Phenotypic distribution of morphological defects in groups of half-brothers of PBWHF bulls

Number of bull	Name of bull	Number of sons	Heavy head	Short head	Short neck	Loose shoulders	Shallow chest	Narrow shoulders	Pendulous belly	Tucked-up belly	Swayed back	Roached back
1	2	3	4	5	6	7	8	9	10	11	12	13
DE000578448776	LAUDAN	26							1			3
FR002998012650	OKENDO	67						1		1	3	
PL000609159341	RUDOLPH	20										1
PL000609223245	LEE	39					1	1				
PL000609285241	OUTSIDE	20										1
PL000609312745	FESTIVAL	20	1			2		1				3
PL000609353446	CONVINCER	28				3			1		2	1
PL000609353541	LANTZ	22				2					3	
PL000609391145	BRETT	36			1	5		3	1	1	1	1
PL000609395846	HERSHEL	25										
PL000609396840	JESTHER	61			1	3		1		2		2
PL000609438642	MARSHALL	68				2	1			1	2	1
PL000609438947	INQUIRER	63						1				3
PL000609439246	MONDAY	38						1	1			
PL000609444144	MANAT	46				1	2	4			2	1
PL000609475747	DOUTCH BOY	44									1	
PL000609487643	MTOTO	42									1	
PL000609492246	MERDRIGNAC	27								1		
PL000609496042	GARTER	56				3			1		1	
PL000609497646	STORMATIC	62							1		1	
PL000609511145	MONZA	22										
PL000609512444	OZZIE	24									1	
PL000609512549	MACHOMAN	38	1						1		1	
PL000609521043	MORTY	61		1				2	1		1	
PL000609541249	FINLEY	54				1			1		1	
PL000609579345	LANCELOT	36							1			1
PL000609604946	DAWSON	55				1		2				2
PL000609605045	LHEROS	25							1			1
PL000609606144	JUSTICE	74						1	2	1	1	1
PL005020207602	TUTOR	36						1			1	1
PL005020208066	HIGHWAY	22							2		1	

Table 3 – contd.

1	2	3	4	5	6	7	8	9	10	11	12	13
PL005034928757	NIKO	26										
PL005053032503	SAMBIA	28										
PL005053309926	ZETOR	49				1			5		3	1
PL005053310144	CIAK	24									1	
PL005053310373	ZONK	108				2		3	11		1	4
PL005053310717	PRECY	25										1
PL005053311325	OURASI	48						1			1	
PL005054463764	BEST	128				1		2	1		3	4
PL005062430543	JANKES	28				1			1		1	1
PL005074178648	MEN	34					1					1
UK000100598172	SHOTTLE	22										
US000060000320	GARRISON	34										2
US000120754720	WIZARD	29									1	
US000123066734	TITANIC	59						1			4	1
US000123586443	BOLIVER	43										
US000125997863	SOSA	54				1		1	2		1	1
US000128920633	MURPHY	37										1
US000207124561	MODEST	22				1			1			
TOTAL		2055	2	1	2	30	5	27	36	7	40	40
χ^2 , F-Y (* – $P \leq 0.05$, ** – $P \leq 0.01$)						**			**			

Table 3 – contd.

Number of bull	Name of bull	Number of sons	Hip point projecting above orsal line	Short pelvis	High tail head	Sunken anus	Sickle-hooked legs	Toeing-out	Upright pastern	Soft pastern	Wide interdigital space	Heavy penis	Long scrotum	Testicular defects
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DE000578448776	LAUDAN	26								1	5			
FR002998012650	OKENDO	67								5	9			
PL000609159341	RUDOLPH	20	2	1	1					1	1			
PL000609223245	LEE	39		1					2		1			
PL000609285241	OUTSIDE	20			1				1		2			

Table 3 – contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PL000609312745	FESTIVAL	20			1				1	3	5			
PL000609353446	CONVINCER	28	1		1		1		2	1	5			
PL000609353541	LANTZ	22			1					1	2			
PL000609391145	BRETT	36	1		3				1	4	9			
PL000609395846	HERSHEL	25			1					2	5			
PL000609396840	JESTHER	61			2			1	1	4	17			
PL000609438642	MARSHALL	68			4			1	1	5	8			
PL000609438947	INQUIRER	63		1				1	1	3	9	1		
PL000609439246	MONDAY	38					1			6	7		1	
PL000609444144	MANAT	46			2				2		8			
PL000609475747	DOUTCH BOY	44									6			
PL000609487643	MTOTO	42			1					3	2			
PL000609492246	MERDRIGNAC	27									1			
PL000609496042	GARTER	56			2				1	1	5			
PL000609497646	STORMATIC	62							1	1	1			
PL000609511145	MONZA	22							1		1			
PL000609512444	OZZIE	24												
PL000609512549	MACHOMAN	38								1	7			
PL000609521043	MORTY	61							1	1	6			
PL000609541249	FINLEY	54	1						1		9			
PL000609579345	LANCELOT	36							2		8			
PL000609604946	DAWSON	55							1	3	3			
PL000609605045	LHEROS	25			1				1	1	6			
PL000609606144	JUSTICE	74		1					1	7	2			
PL005020207602	TUTOR	36								1				
PL005020208066	HIGHWAY	22												
PL005034928757	NIKO	26												
PL005053032503	SAMBIA	28			1									
PL005053309926	ZETOR	49							1	1	4			
PL005053310144	CIAK	24								1	1			
PL005053310373	ZONK	108				1	1	1	3	2	2			
PL005053310717	PRECY	25								1	1		1	
PL005053311325	OURASI	48			1				1	1	3			
PL005054463764	BEST	128			1				3	2	3		2	
PL005062430543	JANKES	28							1					
PL005074178648	MEN	34											1	
UK000100598172	SHOTTLE	22									4			

Table 3 – contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
US000060000320	GARRISON	34							2		3			
US000120754720	WIZARD	29			1		1			1			1	
US000123066734	TITANIC	59							1		5			
US000123586443	BOLIVER	43						1			5			
US000125997863	SOSA	54								4	15			
US000128920633	MURPHY	37					1			2				
US000207124561	MODEST	22									3			
TOTAL		2055	5	4	26	1	5	5	34	70	199	1	6	0
χ^2 , F-Y (* – $P \leq 0.05$, ** – $P \leq 0.01$)			**		*					**	**			

Table 3 gives the frequency of different conformation defects in bulls sired by different males, and in several cases the phenotypic distribution of conformation defects was confirmed with the chi-square test of independence and the Fisher-Yates exact test. The most common defects in the bull population analysed were two types of leg defects: wide interdigital space and soft pasterns, which occurred in 199 and 70 animals, respectively. Wide interdigital space was most frequent in 4 groups of half-brothers, in which this defect affected more than 25% of the bulls. This defect did not occur only in 9 groups of half-brothers. The third most frequent defect was upright pastern. This defect occurred in 1.65% of the population. In the analysed population, defects of the middle part of the body also formed a large group in terms of frequency. In this category, two defects were the most frequent: pendulous belly (36) and narrow shoulders (27). The phenotypic distribution of these defects was not confirmed by the tests.

Discussion

The frequency of external conformation traits in Polish Black-and-White Holstein-Friesian bulls is close to the frequency reported by Wang et al. (2002) for a Canadian population of Holstein-Friesian cows, which ranged from 0.09% to 11.94%. Among defective traits analogous to those used to classify morphological defects in Polish bulls, one type of leg defect, i.e. coarse hock, was the most frequent. This defective trait affects 10.63% (1.31% as a serious defect) of the Canadian Holstein-Friesian cow population on average.

It is worth noting the relatively high incidence of leg defects in our study, because both research and practical experience show that leg problems are one of the main reasons for culling in herds of Holstein-Friesian cattle and are detrimental in economic terms (Schneider et al., 2003; Booth et al., 2004; Cramer et al., 2009; Topolski and Jagusiak, 2010). Noteworthy in this context is the relatively high frequency of defects of the back and, among defects of the front, loose shoulders. In practice, bulls with loose shoulders and defects of the back, especially swayed back, are at risk of

injury when stepping down from mounting. Once these injuries occur, the bulls fail to attempt further mounts, which makes it difficult or impossible to collect semen, resulting in the culling of these animals.

Of all defect categories, the least common defects were those of external genitalia (heavy penis and long scrotum), which were found in single animals. In the analysed population, the only defect that did not occur was that of testes.

The low frequency of the defects within categories mentioned above may result directly from selection work in the population of bulls chosen to be sires of the next generation, from which animals with this type of defects are eliminated. Before selection for the next stage of breeding, all young bulls are provisionally qualified based on veterinary examination, the main component of which is breeding soundness evaluation, in particular the conformation assessment of external genitalia.

It is particularly worth noting the differences in the frequency of conformation defects, especially leg defects, between groups of half-brothers. These differences indicate that selection of sires of bulls used for genetic improvement of Polish Black-and-White Holstein-Friesian cattle may to a certain extent determine the frequency of external conformation defects in the groups of sons sired by them. This is of major importance in breeding practice because mating combinations that account for the results of our study may help to eliminate external conformation defects from the Polish population of Holstein-Friesian cattle. These activities could be evaluated for effectiveness and optimized based on knowledge of the genetic parameters of conformation traits and the correlation of these traits with production and functional traits being improved in the population. Therefore, it is necessary in the future to make proper estimation of the genetic parameters of bull conformation defects, which is largely dependent on the properties of individual traits. The results obtained warrant further investigation in this area.

In conclusion, the present study showed a relatively high frequency of some conformation defects in the population of Polish Black-and-White Holstein-Friesian bulls, which are important from the economic and breeding point of view. In addition, the results obtained showed differences in the frequency of bull conformation defects between different groups of half-brothers. In the population of bulls that are actively used for reproduction in Poland, some groups of half-brothers exhibit a higher frequency of conformation defects than others. This fact is important for breeding practice because the results obtained could be used as an additional source of information during planning of matings, especially when selecting animals as sires of bulls. Our study also shows the need to estimate the genetic parameters of bull conformation defects, which would enable an optimum selection strategy to be developed.

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Badania nad genetycznymi uwarunkowaniami wad pokroju w populacji buhajów rasy polskiej holsztyńsko-fryzyskiej odmiany czarno-białej – analiza rozkładu fenotypowego

STRESZCZENIE

W literaturze specjalistycznej brak jest prac poświęconych zagadnieniom związanym z genetycznymi uwarunkowaniami wad pokroju buhajów bydła holsztyńsko-fryzyskiego. Nielicznie prezentowane wyniki badań dotyczące tej tematyki obejmują wyłącznie żeńską część populacji. Biorąc pod uwagę priorytetowe znaczenie ścieżek ojcowskich w programach hodowlanych bydła mlecznego, a zwłaszcza ścieżki ojciec – syn, wskazane jest objęcie takimi analizami krajowej populacji buhajów hodowlanych. Badanie mechanizmu dziedziczenia cech poprzez porównawczą analizę rozkładu fenotypów rodziców i potomstwa jest podstawowym sposobem zdobywania wiedzy o ich genetycznych uwarunkowaniach. W ramach badań analizowano rozkład fenotypowy 22 rutynowo ocenianych wad pokroju w populacji buhajów rasy polskiej holsztyńsko-fryzyskiej odmiany czarno-białej, pochodzących po różnych ojcach. Wykazano zmienność w średniej frekwencji występowania poszczególnych wad budowy zewnętrznej

i stopniu ich nasilenia. Stwierdzono duże zróżnicowanie w częstości występowania wad pokroju oraz ich liczbie pomiędzy grupami półbraci. Dominującymi defektami w analizowanej populacji buhajów są dwa rodzaje wad kończyn: zbyt szeroka szpara racicy oraz miękka pęcina, które wystąpiły odpowiednio u 199 i 70 osobników. W przypadku pierwszej z wymienionych cech stwierdzono wyraźną dominację jej częstości w 4 grupach półbraci, w obrębie których buhaje z tym rodzajem defektu stanowiły powyżej 25%. Najrzadziej występującymi wadami były defekty zewnętrznych narządów rozrodczych, które odnotowano u pojedynczych osobników. Nie stwierdzono występowania jedynie jednej cechy – wady jąder. Statystyczną istotność uzyskanych rozkładów fenotypowych wad pokroju buhajów potwierdzono testem niezależności chi-kwadrat i testem dokładności Fishera-Yatesa. Otrzymane wyniki świadczą także o możliwości podjęcia badań nad oszacowaniem parametrów genetycznych wad pokroju buhajów, których znajomość pozwoliłaby na opracowanie optymalnej strategii selekcji w krajowej populacji bydła holsztyńsko-fryzyjskiego.