HERITABILITY OF SUSCEPTIBILITY TO CRYPTORCHIDISM IN SWINE

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ABSTRACT

Observations on 10,432 male pigs were used to evaluate the susceptibility of cryptorchidism in swine in relation to its heredity. Twenty-six (0.5%) Duroc-sired, 28 (1.3%) Landrace-sired and 14 (0.6%) Yorkshire-sired, progeny manifested the defect. Differences in frequency of occurrence of cryptorchidism among progeny of the three boar breeds were highly significant ($P < .001$). Frequency differences among sires within breed of boar groups and age of dam effects, within boar breed groups, were not significant. Percentage cryptorchid pigs among male siblings of affected males for Duroc and Landrace groups, respectively, was 2.4 and 2.4 times greater than the overall percentage affected in their respective breed groups. Among Yorkshire-sired pigs, no litter had more than one affected animal. Heritability of susceptibility to cryptorchidism was calculated to be 0.21 ± 0.19 and 0.28 ± 0.18 in the Duroc and Landrace-sired groups, respectively.

KEYWORDS: Cryptorchidism, Swine genetics, Duroc, Landrace, Yorkshire

RESUMEN

Se observaron 10,432 cerdos machos para evaluar la susceptibilidad al criptorquidismo en relación a su heredabilidad. El prole que manifestó el defecto abarcó 26(0.5%) de los de padre Duroc, 28 (1.3%) de los de padre Landrace y 14(0.6%) de los de padre Yorkshire. Las diferencias en la frecuencia de criptorquidismo entre el prole de sementales de las tres razas fueron significativas ($P < 0.001$). No fueron significativos las diferencias en frecuencia entre el prole de los diferentes sementales de la misma raza ni los efectos de edad de la madre dentro de los grupos raciales paternos. La frecuencia porcentual de la condición entre los hermanos de padre y madre de los machos afectados de ambos grupos raciales Duroc y Landrace fue 2.4 veces mayor que la frecuencia total en los respectivos grupos. Entre los cerdos de padre Yorkshire ninguna lechigada tuvo más de un animal afectado. Se calculó la heredabilidad de la susceptibilidad al criptorquidismo en 0.21 ± 0.19 y 0.28 ± 0.18 en los grupos de padre Durock y Landrace, respectivamente.

PALABRAS CLAVES: Criptorquidismo, genética porcina, Duroc, Landrace, Yorkshire

Introduction

Cryptorchidism is a congenital disorder characterized by retention of one (unilateral) or both (bilateral) testicles in the abdominal cavity. Bilateral cryptorchids are sterile. Unilateral cryptorchids are fertile because spermatogenesis in the scrotal testicle is normal. Evidence shows this defect is hereditary. Unilateral cryptorchids, then, are expected to transmit a genetic predisposition for this defect to their offspring.

Cryptorchidism is one of the most common congenital defects in swine. A survey (Priester at el., 1970) of data compiled by 10 United States and Canadian Veterinary College Clinics and Hospitals showed this defect to be one of the three most common defects in swine. Another survey (Mulley and Edwards, 1984) of congenital defects in piglets in a large Australian piggery identified cryptorchidism as the second most frequently encountered malformation accounting for 15 percent of all defects recorded.

Early reports (Lush and Jones, 1929; Nordby, 1933) suggested that cryptorchidism in swine occurred at a frequency of 1-2 percent of all male births. More recently, Berruecos (1980) reported cryptorchidism frequencies of 0.09, 0.25, 0.40 and 0.26 percent for Duroc, Hampshire, Yorkshire and Chester White breeds, respectively. These percentages were determined using total number of male and female piglets. In the Torun province of Poland, incidence of cryptorchidism was reported by Bernacki et al. (1976) to be 1.81% in 68,948 males studied.

Reports concerning the genetic nature of cryptorchidism show little agreement. While genetic influence on development of this defect generally has been recognized for many years (Lush and Jones, 1929; McKenzie, 1931; Nordby, 1933) inheritance patterns suggested include both monofactorial (McPhee and Buckley, 1934; Johnston et al. 1958; Triebler et al, 1974; Berruecos, 1980) and multifactorial (Sittmann and Woodhouse, 1977; Mikami and Fredeen, 1979) modes.

The purpose of this study was to analyze the effect of boar breed, sires within boar breed and dam age on development of cryptorchidism and to estimate heritability of this defect.

Materials and Methods

Data are from the breeding and performance records of the swine herd of the University of Missouri-Columbia. Records were available on 10,432 progeny produced by 31 sires (4 Duroc, 9 Landrace, 8 Yorkshire) over the 9-year period 1980 through 1988. Some of these sires were used in more than one year. Each boar breed is represented among the progeny in each year. Of 1982 litters produced by purebred sire matings in the 9-year period, 1103 (55.6%) were sired by Duroc, 408 (20.6%) by Landrace and 471 (23.8%) by Yorkshire boards. Sows were crossbreds, constituted of combinations of Duroc, Landrace, and Yorkshire, and, to a lesser extent, Hampshire breeds.

At castration, 4 to 10 days after birth, cryptorchids were identified and so recorded on farrowing forms. Over the 9 years, 68 affected pigs were detected. Of these, 26, (38.2%) were sired by Duroc, 28 (41.2%) by Landrace and 14 (20.6%) by Yorkshire boars. Frequency differences among boar breeds combined over years, among sires within sire breeds and among age of dam groups within boar breeds were tested for statistical significance by the method of row by column chi-square. Incidence of cryptorchidism among full-brothers of affected males was compared with the incidence of the defect among all male progeny in each of their respective breed of sire groups. These comparisons indicate the risk of cryptorchidism among full-brothers of affected males relative to the risk among males in their respective general populations.

Table 1. Frequency of cryptorchidism by boar breed within years and combined over years.

Year	Breed of Sire	No. of Sires	No. of Litters	Healthy n	Frequency (%)	Affected n	Frequency (%)
1980	Duroc	3	52	269	100.0	0	0.0
	Landrace	2	40	196	99.5	1	0.5
	Yorkshire	1	53	293	99.6	1	0.4
1981	Duroc	1	34	162	97.2	5	2.8
	Landrace	2	91	450	95.8	11	4.2
	Yorkshire	2	84	395	98.8	5	1.2
1982	Duroc	4	114	578	99.7	2	0.3
	Landrace	2	58	301	99.0	3	1.0
	Yorkshire	3	65	323	99.1	3	0.9
1983	Durock	4	163	824	99.6	3	0.4
	Landrace	2	32	157	99.6	5	3.1
	Yorkshire	1	42	228	100.0	0	0.0
1984	Duroc	3	102	552	99.8	1	0.2
	Landrace	2	31	171	97.7	4	2.3
	Yorkshire	2	53	291	99.3	2	0.7
1985	Duroc	3	117	578	98.8	7	1.2
	Landrace	2	51	294	98.6	4	1.4
	Yorkshire	2	54	288	99.6	1	0.4
1986	Duroc	6	180	954	99.6	4	0.4
	Landrace	2	37	222	100.0	0	0.0
	Yorkshire	3	377	192	999.5	1	0.5
1987	Duroc	3	171	925	100.0	0	0.0
	Landrace	2	29	171	100.0	0	0.0
	Yorkshire	1	37	220	99.5	1	0.5
1988	Duroc	3	170	873	99.5	4	0.5
	Landrace	1	39	237	100.0	0	0.0
	Yorkshire	2	46	250	100.0	0	0.0
1980-1988 Combined[1]	Duroc	14	1103	5685	99.5	26	0.5
	Landrace	9	408	2199	98.7	28	1.3
	Yorkshire	8	471	2480	99.4	14	0.6

[1]Some boars were used in more than one year.

Heritability of susceptibility to cryptorchidism also was calculated for each breed of boar group separately. Each value was obtained by doubling the full-sib correlation for threshold traits as outlined by Falconer (1981). Standard errors of the heritability (h^2) estimates were approximated as described by Falconer (1981) as $(16)h^2/T$ where T = the total number of full-sibs used in the estimation of heritability.

Results

Table 1 shows frequency of pigs with cryptorchidism by boar breed within years and by boar breed across years. Of 10,432 male pigs farrowed over the 9-year period, 68(0.65%) were cryptorchids. Frequencies of affected progeny were 0.5%, 1.3% and 0.6% for Duroc, Landrace and Yorkshires, respectively. These differences among boar breed groups were highly significant ($P<.001$) and suggest a genetic influence on cryptorchidism development. However, frequency differences among sires within boar breed were not significant (P=0.19, Duroc; P=0.07, Landrace; P=0.62, Yorkshire). The latter, when evaluated by chi-square, compares frequencies of defect occurrence among progeny of all sires within each boar-breed group. Most of the sires in each of the three boar-breed groups had 0 or only 1 affected progeny with most affected progeny being produced by relatively few boars in each group. Inclusion of the relatively greater number of 0 or 1 values in these comparisons likely caused the lack of significance found in each of the among sires within boar-breed comparisons.

Table 2 shows frequency of cryptorchidism for eight age-of-dam groups, for each breed of sire group separately Frequency differences were wide varying from 0.00% to 0.78% for Durocs, 0.00% to 1.82% for Landrace and 0.00% to 1.69% for Yorkshires. However, none of these age of dam differences was significant (P=0.10,Duroc; P=0.55, Landrace; P=0.62, Yorkshire).

Within boar-breed comparisons of the incidence of cryptorchidism in full-brothers of affected males with the incidence among males in the general population show related males to have values 2.4 times as high in both Durock and Landrace boar groups. Among Yorkshire pigs, no litter had more than one affected animal.

Heritability of susceptibility to cryptorchidism was calculated to be $0,21\pm0.19$ and $0.28+0.18$ in the Durock and Landrace-sired groups, respectively.

Discussion

Genetical influence on development of cryptorchidism generally has been recognized for many years. Lush and Jones (1929) state that veterinary writers of numerous case histories generally believed cryptorchidism to be hereditary but the manner of its inheritance had not been worked out. In a subsequent article (McKenzie, 1933), results of inbreeding in a swine family in which cryptorchidism had occurred prompted the conclusion that "cryptorchidism seems to be inherited". Monofactorial inheritance is proposed in both early (McPhee and Buckley, 1934) and relatively recent (Triebler, 1974; Berruecos, 1980) studies. In a review (Sittman and Woodhouse, 1977) of published swine data it was concluded that cryptorchidism in Chester Whites and Yorkshires is caused by "completely penetrant recessive genes at two autosomal loci", but in Lacombes, "multifactorial modes of inheritance are more plausible." In a 1979 report (Mikami and Fredeen), it was suggested that results obtained in previous studies were more suggestive of quantitative inheritance.

Table 2. Number healthy (N) and affected (A) pigs by dam age and boar breed group.

Age-of-dam (days)	Duroc			Landrace			Yorkshire		
	N	A	%	N	A	%	N	A	%
<450	1886	13	0.68	157	1	0.63	174	3	1.69
451-630	1141	9	0.78	504	9	1.75	652	3	0.46
631-810	1072	1	0.09	593	11	1.82	686	3	0.44
811-990	585	2	0.34	437	3	0.68	463	3	0.64
991-1170	343	0	0.00	257	3	1.15	272	1	0.37
1171-1350	404	0	0.00	160	1	0.62	130	1	0.76
1351-1530	170	1	0.58	49	0	0.00	65	0	0.00
>1531	84	0	0.00	42	0	0.00	38	0	0.00

These authors (Mikami and Fredeen, 1979) then calculated heritability of cryptorchidism using a technique appropriate to quantitative traits characterized by quasi-continuous variation and expressed as threshold traits. Using data from Yorkshire and Lacombe breeds, they determined heritability of cryptorchidism to be 0.52 and 0.50 in these two breeds, respectively.

The present study, also using a technique appropriate to polygenic traits manifested at a threshold value, estimated heritability of susceptibility to development of cryptorchidism to be 0.21±0.19 and 0.28±0.18 for Durock and Landrace-sired groups, respectively. These estimates are reasonable and consistent and support the suggestion of a polygenic mode of inheritance for this defect. They also are in agreement with those in the report of Mikami and Fredeen (1979). Data from the Yorkshire-sired group of pigs does not allow an interpretation as to mode of inheritance for this defect.

Anatomical structures relevant to development of cryptorchidism manifest continuous variations. Variations in these structures have been described in swine (Warwick, 1926) and in humans (Anson et al., 1960). In the former, measurements on 38 newborn male pigs showed variation in the diameter of the internal vaginal rings and in the external inguinal rings but magnitude of the variations was not given. In the latter, observations of natural variations in the inguinohypogastric structures of 500 human body halves showed wide variations in all components. It seems reasonable that these variations are polygenically influenced and, then, also would give rise to an underlying continuous variation associated with development of cryptorchidism.

Given the suggested polygenic mode of inheritance for cryptorchidism, it isn't likely that complete elimination of this defect from swine populations can be attained. However, it is reasonable to expect a reduction in its frequency of occurrence as a consequence of selection pressure against it. Such selection obviously involves culling individuals with the defect (individual selection). Individual selection represents the least the breeder could do to minimize the frequency of the defect through selection. Additional selection pressure could be applied by culling half-sibs and/or full-sibs of affected progeny and the sires and dams that produce the affected progeny (family selection). Inclusion of types of family selection would be more effective than individual selection alone but may not be practical since it could reduce considerably the size of the breeding herd. A reasonable compromise might be individual selection plus the culling of families (particularly litter-mate males and females and parents) with the greatest incidence of cryptorchidism.

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