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The Effect of Inbreeding on Lactation Performance in Holstein Cows of Iran

Research Article

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ABSTRACT

The objective of this study was to investigate the effect of inbreeding on lactation performance in Holstein cows of Iran. The pedigree file contained information of 1,025,281 animals born between 1965 and 2007. Lactation performance records from March 2000 to April 2009 comprising 193,501calving events on 123,751 cows in 85 dairy herds were included in the data set. The potential consequent effects of inbreeding on lactation traits were analyzed through mixed linear model using the MIXED procedure of the SAS. The mean level of inbreeding was shown to be 0.7%. Less than 37% of all animals were inbred, and a small proportion, 3.45%, of inbreed animals had inbreeding coefficients greater than 5%, with a maximum inbreeding coefficient of 38%. Overall mean (±SD) of 305-d milk, fat and protein yields were estimated to be 7812 (±1780), 252.5 (±64.5), and 247.8 (±50.6) kg, respectively. The 305-d milk, fat and protein yields decreased by -19 (±3.7), -0.7 (±0.13), and -0.43 (±0.13) kg per lactation for each 1% increase in inbreeding, respectively. Inbreeding showed no significant impact on fat and protein percentages.

KEY WORDS inbreeding depression, lactation traits, mixed model.

INTRODUCTION

Inbreeding is defined as the probability that 2 alleles at any locus are identical by descent and occurs when related individuals are mated to each other (Falconer and Mackay, 1996). The reduction in mean phenotypic performance associated with inbred animals is referred to as inbreeding depression (Falconer and Mackay, 1996) and can be of considerable economic loss to animal and poultry producers (Smith *et al.* 1998; Croquet *et al.* 2007). Inbreeding depression is usually expressed as the change of mean phenotype per one percent of inbreeding (Thompson and Freeman, 1967; Smith *et al.* 1998; Croquet *et al.* 2007). The average inbreeding in Holstein dairy cows seems to be increased and growing rates of inbreeding is of serious concern to dairy breeders and the industry (Short and Lawlor, 1992). Intensive selection and widespread use of artificial insemination were identified as major contributors to rising genetic likeness in the dairy population (Weigel, 2001). Dairy producers have an interest in the effect of inbreeding on phenotypic performance. Estimates of the inbreeding depression on production ranged from approximately 9 to 26 kg for milk, 0.55 to 1.09 kg for fat, and 0.69 to 0.97 kg for protein per lactation for each 1% inbreeding (Casanova *et al.* 1992; Miglior *et al.* 1995; Wiggans *et al.* 1995; Smith *et al.* 1998; Thompson *et al.* 2000a,b; Tohidi *et al.* 2000; Croquet *et al.* 2007). The objectives of this study were to investigate the trend of average inbreeding and to quantify the effect of inbreeding on lactation performance in Holstein cows of Iran.

MATERIALS AND METHODS

Data

The used data were collected by dairy producers according to procedure of Animal Breeding Center of Iran. The pedigree file contained information of 1,025,281 animals born between 1965 and 2007. The inbreeding coefficient for each animal in the pedigree was calculated using the algorithm described by Meuwissen and Luo (1992).

Calving records from March 2000 to April 2009 comprised 193,501 calving events on 123,751 cows in 85 dairy herds were included in the data set. The herds used in this study were purebred Holsteins, managed under conditions similar to most other developed countries.

The herds were under official performance and pedigree recording. Cows were milked 3 times a day. The main components of the dairy ration consisted of corn silage, alfalfa, cotton seed, cotton seed meal, barley grain, canola meal, wheat bran, fat powder, beet pulp, and feed additives, and cows were fed by total mixed ration. Herringbone milking parlors were common, and well-known milking machines were used. Artificial insemination has been used for almost all of the herds, and 60 to 80% of semen is usually of US and Canadian proven sires.

Information of 305-d milk, fat and protein collected by Animal Breeding Center of Iran were used in this study. Calf livability scores were measured on a two point scale. Calves alive at birth that survived by 48 h were identified as “D0”, while stillborn calves and those dead within 48 h after birth were coded as “D1”.

When one or both calves were born dead in twin birth, stillbirth was defined as “D1”. Information on calf birth weight was not recorded, but data contained records of multiple births, birth and calving date. Producers were also required to record sex of the calf (1=male, 2=female). Data on parity number of cows were grouped in five classes of parity 1, 2, 3, 4 and ≥5.

Estimation of inbreeding depression

The standard procedure used to estimate inbreeding depression for a trait was regression of individual performances on the individual inbreeding coefficients. The potential consequent effects of inbreeding on lactation traits were analyzed through followed mixed linear models using the MIXED procedure of the SAS (SAS, 2002).

$$Y_{ijklmn} = \mu + (parity)_i + hys_j + single_k + stillbirth_l + sire_m + b_1(age)_{ijklmn} + b_2(DIM)_{ijklmn} + b_3(F_{ijklmn}) + e_{ijklmn}$$

Where, y_{ijklm} is lactation performance of cow o in parity i (i =1, 2, 3 ,4, and ≥5), with fixed effect of the j^{th} combination of herd-year-season of calving (j=1 to 2546), k^{th} type of birth (k=1 for single and k=2 for twin birth, l^{th} calving situation (l=0 for live birth and l=1 for stillbirth), m^{th} service sire and b_1, b_2, b_3 regression coefficient of the effect of age at the first calving, days in milk (DIM) and linear form of inbreeding coefficient, respectively. Service sire and residual effect of were considered as random, meanwhile, the other effects were considered as fixed effects.

RESULTS AND DISCUSSION

The results showed that mean level of animal inbreeding was 0.7 %, less than 37% of all animals were inbred, and a small proportion, 3.45%, of inbred animals had inbreeding coefficients greater than 5%, with a maximum inbreeding coefficient of 38%. The average level of inbreeding in primiparous born between year 1998 to 2007 is presented in Figure 1.

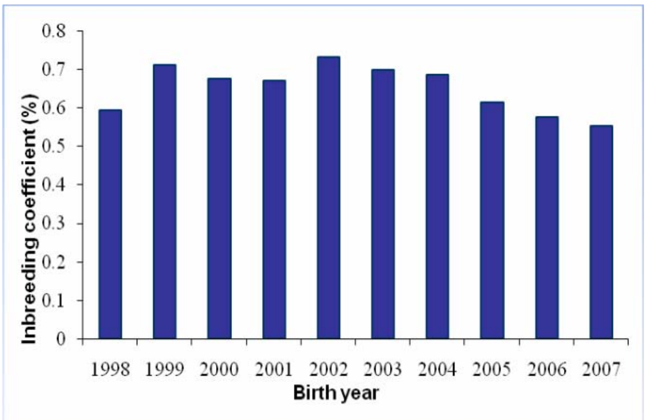

Figure 1 The average level of inbreeding (%) in primiparous born between year 1998 to 2007

There was no consistent trend for inbreeding across birth years of 1998 to 2007. Overall mean (±SD) of 305-d milk, fat and protein yields were estimated to be 7812 (±1780), 252.5 (±64.5) and 247.8 (±50.6) kg, respectively. The results of mixed linear analysis is presented in Table 1. The obtained results showed that in addition to parity, twinning, stillbirth, age at the first calving and DIM, linear form of inbreeding significantly ($P<0.01$) impacted 305-d milk, fat and protein yields but showed no significant impact ($P\geq0.05$) on milk components of fat and protein (%). The inbreeding depression per lactation for each 1% increase in inbreeding was -19 (±3.7), -0.7 (±0.13), and -0.43 (±0.13) for milk, fat, and protein yields, respectively.

The results showed that mean level of animal inbreeding was 0.7%, a small proportion, 3.45%, of inbreed animals h-had inbreeding coefficients greater than 5%, with a maximum inbreeding coefficient of 38%. Tohidi *et al.* (2000) reported that mean level of Holstein cows of Iran is 0.18%, and 0.35% of inbreed animals had inbreeding coefficients greater than 12.5%. Rokoei *et al.* (2000) reported that less than 12% of Holstein cows of Iran are inbred, and a small proportion, 2.05%, of inbreed animals had inbreeding coefficients greater than 6%. Average inbreeding in Holstein dams increased from 1.5 to 3.7% during the years of 1985 to 1996 (Adamec *et al.* 2006), but the result of this study showed consistent trend for inbreeding during the birth years of 1998 to 2007.

Table 1 Estimated LSMEANS and standard errors (within parentheses) and level of significance of the effect of factors affecting lactation performance

Variable	Milk (kg)	Fat (kg)	Protein (kg)
HYS	P<0.01	P<0.01	P<0.01
Parity	P<0.01	P<0.01	P<0.01
Parity 1	6814 (17)[e]	221.1 (0.6)[e]	218.2 (0.1)[e]
Parity 2	7637 (18)[c]	247.5 (0.6)[c]	247.1 (0.1)[c]
Parity 3	7940 (20)[a]	257.6 (0.7)[a]	255.2 (0.2)a
Parity 4	7820 (20)[b]	254.0 (0.7)[b]	250.6 (0.3)[b]
Parity ≥ 5	7485 (22)[d]	245.3 (0.8)[d]	241.1 (0.4)[d]
Type of birth	P<0.01	P<0.01	P<0.01
Single	7625 (15)[a]	248.7 (0.5)[a]	244.4 (0.1)[a]
Twin	7453 (24)[b]	241.8 (0.9)[b]	240.5 (0.4)[b]
Birth situation	P<0.01	P<0.01	P<0.01
Live birth	7785 (16)[a]	251.8 (0.6)[a]	248.5 (0.1)[a]
Stillbirth	7294 (23)[b]	238.5 (0.8)[b]	236.5 (0.3)[b]
Regression coefficients			
Age at 1th calving	0.23 (0.06)*	0.02 (0.002)*	0.01 (0.002)*
Total days in milk (DIM)	5.9 (0.05)*	0.2 (0.001)*	0.18 (0.002)*
Linear form of inbreeding	-19 (3.7)*	-0.7 (0.13)*	-0.43 (0.13)*

Least square means within the same column of each factor having different superscript letters are significantly different (P<0.05).
* Significant at (P<0.05).

The average of inbreeding coefficient showed a decling trend from 0.73 (at birth year of 2002) to 0.55% (at birth year of 2007), which can be partly explained as follows. In recent years, the number of agencies who import semen from the EU and North America countries have increased, which might have resulted to decreased inbreeding coefficient.

The results of this study showed that milk, fat and protein yields decreased by -19 (±3.7), -0.7 (±0.13) and -0.43 (±0.13) kg per lactation for each 1% inbreeding, respectively. Inbreeding showed no significant impact on fat and protein percentages. It is widely documented that inbreeding can directly influence production traits, such as milk or fat yields in dairy cattle. Croquet *et al.* (2007) found that the inbreeding depression per lactation for each 1% inbreeding was -22.1, -1.1 and -0.72 kg for milk, fat and protein, respectively. Smith *et al.* (1998) reported that milk, fat and protein yield decreased by 95.49 (±33.35) to 177.17 (±34.18), 3.25 (±1.21) to 6.01 (±1.24) and 2.93 (±1.05) to 5.45 (±1.07) kg, respectively per lactation for 1% increasing in inbreeding. In Holstein dairy cattle, inbreeding depression for 305-d milk and fat yields per lactation for each 1% inbreeding were reported to be -23 and -0.78 (Thompson and Freeman, 1967), and -22.85 and -0.628 kg (Hodges *et al.* 1979), respectively. Wiggans *et al.* (1995) estimated inbreeding depression per 1% inbreeding to be 29.6 and 21.34 kg (for milk yield), 1.08 and 1.03 kg (for fat yield) and 0.97 and 0.88 kg (for protein yield) in Holstein and Jersey breeds, respectively. In Holstein cows of Iran, inbreeding depression for 305-d milk and fat per lactation were reported to be approximately -12 to 13 and -0.39 kg for each 1% increasing in inbreeding, respectively (Tohidi *et al.* 2000; Rokoei *et al.* 2000).

This observation can be plainly explained by the way milk and its components are synthesized by activity of genes located in mammary gland tissue or in organs connected to the mammary glands through metabolic pathways.

Relationships between estimates of inbreeding depression or their interpretation can be directly traced to relationships between individual traits. Inbreeding appears to be more evident in phenotypic expression of milk, fat or protein production than in relative proportions of milk components (Fuerst and Solkner, 1994; Miglior *et al.* 1995), where zero or even small positive influence was found. In this instance, inbreeding seems to work favorably with the relative overall metabolic efficiency, but it simultaneously depresses volume. Association between effect of inbreeding on body size, milk yield and milk fat (or protein) percentage could be hypothesized as a reason.

CONCLUSION

Inbreeding appears to be more evident in phenotypic expression of milk, fat or protein production than in relative proportions of milk components, therefore, inbreeding seems to work favorably with the relative overall metabolic efficiency, but it simultaneously depresses volume.

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