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Effects of Kinship Matings on Embryo Losses and Hatch-Weight in Japanese Quails: Half Sibling Matings are Safe

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Abstract

Inbreeding, which is the mating of related individuals, increases homozygosity and leads to depression, especially in traits with low heritability. In this study, parent-offspring, full-sibling and half-sibling mating groups were formed and their effects on embryo loss and hatch weight were investigated. In the study, a total of 2130 fertile Japanese quail eggs were used. Embryo losses were divided into three periods; early period (first 5-day), middle period (6-12th days) and late period (13-17th days). It was observed that mating groups affect all traits subject of this study ($P \leq 0.0001$). The lowest hatchability of fertile eggs was observed in dam-male offspring mating (DM), while the highest was observed in half-sibling (HS) and control (C) matings ($P \leq 0.05$). However, the highest hatch-weight were found in eggs of DM matings ($P \leq 0.05$). DM has also the highest embryo losses for all periods ($P \leq 0.05$). Most of the embryo losses, except the half-sibling group, occurred in the early period.

Introduction

In populations, negative effects of inbreeding can be seen in many traits, especially in traits with low heritability, such as viability and reproduction (Cahaner et al., 1980; Falconer, 1984; Sewalem et al., 1999; Spielman et al., 2004; Calleri et al. 2006). Although most reports point out that inbreeding depression is more pronounced in traits with low heritability, there are also reports that inbreeding has similar effects on other traits (Doekes et al. 2021). Inbreeding increases the rate of homozygosity and leads to genetic impoverishment. Furthermore, there are negative effects due to the coincidence of recessive semi-lethal or lethal alleles (Monson and Sadler 2010; Doekes et al. 2021). However, in rare cases called pursing, survivability and reproductive characteristics can be improved as a result of the elimination of negative affecting alleles in the inbred population (Gulisija ve Crow 2007; Savaş, 2008).

Furthermore, the positive and negative effects of inbreeding can coexist in the population (Barczak et al. 2009). Inbreeding depression is generally expressed as a regression of the inbreeding coefficients on trait value (Doekes, et al., 2021). However, it must also be considered that the inbreeding effect does not always have to be linear (Sittmann et al., 1966; Kulenkamp et al., 1973). The inbreeding coefficient is estimated from the genetic relatedness of the individual's parents. The genetic relatedness coefficient between two individuals predicts or determines the proportion of genes of common origin among relatives. Whether the relatedness coefficient is an estimate or absolute depends on the kind of relatedness. While the relatedness coefficient between parents and their offspring is absolute, it corresponds to the average genetic relatedness between other kindreds.

Accordingly, the effects of mating between different kindreds on inbreeding depression may be different. In this study, the effect of different kinship matings on embryo loss and hatch weight in quail eggs was investigated.

Materials and Methods

This study were conducted in Çanakkale Onsekiz Mart University Experimental Research Application and Research Center Poultry Unit. Male and female Japanese quails were obtained from 5 different regions (Çanakkale, Bandırma, Biga, Ezine, Lapseki) to ensure that the quails used in the study are not related. The base population was established by mating breeding birds in one region with another region. Mating was performed in individual cages. 29, 27, 25, 22 and 60 female quails were used in dam-male offspring (DM), sire-female offspring (SF), full sibling (FS), half-sibling (HS) and non-kin matings (C), respectively. A total of 2130 fertilized quail eggs were obtained; 368 from DM, 376 from SF, 389 from FS, 342 from HS, and 655 from C, to investigate embryonic mortality (EM), hatch rate of fertilized eggs (HR) and hatch weight (HW). The sex ratio was 1:1, except C; it was 1:2 for them. The eggs were incubated for 15 days at 37.7 °C and 55% humidity. Then, the eggs were taken into the hatching basket at 37.5 °C and 65 % humidity, and hatching occurred on the 17th day. Embryo losses were divided into three periods (early period (EP) =first 5-incubation days, middle period (MP) = 6-12th incubation days; late period (LP)=13-17th incubation days). The number of non-fertile eggs was 41, 41, 41, 30 and 129 for DM, SF, FS, HS and C respectively. After hatching, dried chicks were weighed.

Binary data (HR and EM) were analyzed using a generalized estimating equation with mating type as a fixed factor (SAS, 2002). Odds ratios ($\Psi = b^e$) were calculated using the estimated parameters (b) and the Euler number (e). HWs were analyzed using a factorial analysis of variance in which mating groups, sex and their interaction were fixed factors. The Wald chi-square test was performed for the post hoc analysis of binary traits. For the post hoc analysis for HW, the HW Tukey test was used.

Results

Table 1 shows that there are significant differences between mating groups relating to the HR and HW ($P \leq 0.0001$). Lower HR was observed in the eggs from DM, SF, FS groups than in the C group. According to odds ratios, the HR probabilities in DM, SF, and FS are 54%, 38%, and 27% below C, respectively. However, the HS group has a light higher (1.15 times), but not significant HR probability than C (P>0.05). Although the DM group eggs had the lowest HR probability, they had the highest mean hatch weight (P=0.0001). While the hatch weights of the eggs of SF, HS and C groups were similar, the FS group had the lowest hatch weight.

Table 2 summarized the results of the embryo losses in eggs by mating types. In EP, the probability of embryo losses of eggs of DM, SF and FS did not differ significantly (P>0.05). The lowest probability of embryo losses was in the HS group. The probability of embryo loss in EP occurred mostly in DM and SF eggs (1.77 times and 1.73 times higher than C, respectively). The HS and C groups have similar EP probabilities. In MP, only the DM group differs significantly from the C group (P≤0.05). No differences were found between DM, SF, FS eggs in LP (P>0.05). However, the LP of the eggs of DM and SF differed significantly from the C eggs (P≤0.05). As seen in Table 2, middle period embryo losses are less than in other periods, except for the DM group.

Discussion

A high ratio of shared genes between parents can increase homozygosity (Edly-wright et al., 2007). The increasing genetic similarity in the population, in other words, increasing homozygosity reduces the success of hatching (Daniels and Walters, 2000; Spottiswoode and Møller, 2004; Hemmings et al. 2012;). Sato et al. (1984) and Hemmings et al. (2012) reported that hatchability and viability were lower in full-sibling mating than random mating quails. In a study with Zebra fish, the difference between full-sibling and half-sibling mating was not significant in terms of the hatchability of fertile eggs (Mrakovcic and Haley, 1979). However, according to the authors, the number of fertile eggs and survivability of fry is lower in full-sibling matings than in half-sibling matings, while the rate of crippled fry is higher. Since half-siblings have different gene pools based on different dams, the likelihood of homozygosity and lethal genes in the offspring from half-sibling matings is comparatively lower than in parent-offspring or full-sibling matings. The DM group has the lowest HR, but the highest HW. The hatching chicks had a higher average hatch weight, as the higher embryo loss may have led to the elimination of the low hatch weight, low viability chicks.

Hatching success depends on a highly complex process that includes parental age, feeding, storage condition and storage time of hatching eggs, and genetic factors (Liptói and Hidas, 2006). Most of the embryo losses that occur during the incubation period are seen in the early and late periods (Romanof, 1949). Schmidt et al. (2009) reported that early (first 6 days) and late (18 to 21 days) embryo losses in broilers were higher than in other periods. Genetic abnormalities, the combination of recessive lethal genes, abnormalities during meiosis are some of the factors leading to early embryo losses (Liptói and Hidas, 2006). Sittmann et al. (1966) reported that embryo losses increased with the increase

Table 1. Estimated values (b) and its standard errors (SE), odds raito (Ψ) for hatchability of fertile eggs, and least-square means ($\bar{X}$) and standard errors (SE) for hatch-weight

	Hatchability of fertile eggs				Hatch-weight	
	b	SE	Ψ	%	$\bar{x}$	SE
DM	-0.79[a]	0.137	0.46	58	8.70[a]	0.066
SF	-0.48[b]	0.139	0.62	63	8.54[ac]	0.065
FS	-0.32[b]	0.139	0.73	69	8.30[b]	0.059
HS	0.14[c]	0.155	1.15	76	8.49[c]	0.060
C	0[c]	0	1	73	8.50[c]	0.041

DM: Dam-male offspring; SF: Sire- female offspring, FS: Full sibling, HS: Half sibling, C: Non-kin mating.
Different letters indicate significant differences between the "*b*" and "$\bar{X}$" in the same column (P<0.05).

Table 2. Estimated values (b) and its standard error (SE), odds ratios (Ψ) for embryo losses by period

Period	Early				Middle				Late			
	b	SE	Ψ	%	*b*	SE	Ψ	%	*b*	SE	Ψ	%
DM	0.57[a]	0.188	1.77	17	1.34[a]	0.225	3.80	16	0.56[a]	0.223	1.75	11
SF	0.55[a]	0.181	1.73	19	0.39[b]	0.265	1.48	7	0.44[ab]	0.220	1.55	11
FS	0.27[ac]	0.188	1.31	15	0.30[b]	0.265	1.35	7	0.39[abc]	0.216	1.48	11
HS	-0.36[b]	0.225	0.70	9	0.00[b]	0.288	1.00	6	0.04[bc]	0.237	1.04	9
C	0.00[bc]	0.000	1.00	13	0.00[b]	0.000	1.00	6	0.00[c]	0.000	1.00	8

DM: Dam-male offspring; SF: Sire- female offspring, FS: Full sibling, HS: Half sibling, C: Non-kin mating,
Different letters in the same column indicate significance (P<0.05).

in inbreeding coefficient and most of the embryo losses were in the first 8 days. In this study, it was observed that DM, SF, and FS matings caused high early period embryo losses compared to HS and C matings. In the study, it is seen that middle period embryo losses are higher in DM mating compared to other matings. Considering that all groups are exposed to the same environmental conditions, it is possible to think that middle period embryo losses in DM are caused by some genetic factors. As it is known, there is an absolute 50% genetic similarity between the parent and the offspring. Therefore, the probability of combining gens originated from the common ancestor and also recessive lethal or sublethal genes in parent-offspring matings is higher than in other matings. In addition, this possible situation is seen considering the early and late period embryo losses. It is seen that embryo loss occurring in these periods is higher in parent-offspring matings than in C and/or HS mating.

Conclusion

The results clearly point to differences between kinship matings in terms of HR, HW, and embryo losses. However, while the influence of kin mating (except HS) on HR and embryo losses is negative, a clearly positive influence on HW, especially in DM, can be observed. Whether this result is indicative of purging needs to be proofing, which is beyond the scope of this study

Although they have the same inbreeding coefficient, it can be seen that parent-offspring pairings have lower HR and more embryo losses than full-sibling pairings. This shows that in addition to the average coefficient of inbreeding, which related individuals contribute to inbreeding is also important.

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