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Effect of immunological selection for NDV on egg external traits in Japanese quail

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Abstract

This research explores the impact of immune selection on egg quality traits in Japanese quail (Coturnix japonica) over three generations. We evaluated four experimental groups: "Control (-)" (unvaccinated and no selection for immune traits), "Control (+)" (vaccinated but without selection for immune traits), "Low Immune Level" (selected for lower NDV antibody titers), and "High Immune Level" (selected for higher NDV antibody titers). Birds were kept under controlled environmental conditions with standard husbandry practices. Immune responses were measured by HI tests, and egg quality traits (egg weight, length, breadth, and shape index) were measured across generations. The results found a significant reduction across all generations for both Combinations in the weight, width and length of the egg (pp. < 0.001). So the "high level of immunity" for the group, these traits decreased more slowly compared to control groups, which may be Indicates a trade-off between egg quality and immune durability. In the third generation, "high The immunological level group had the highest egg weight values (7.61±0.22 g) and height (27.70±0.63 mm), while the "Control (+)" group provided the lowest values. However, the egg shape indicator It did not change in any of the groups and generations, and therefore proved resistant to both heredity and Environmental Stresses, pp. 0.05>. The results show the interaction of both immunoselection and reproductive traits together. In this regard, strong immune responses may be Hydration in egg quality traits decreases over time. This study confirms that balanced education Strategies are essential to improve both immune efficiency and productivity. Genetic. Results indicated significant declines across generations for all groups in egg weight, length, and breadth ($p < 0.001$). However, in the "High Immune Level" group, these traits declined more slowly compared to the control groups, which may be indicative of a trade-off between immune robustness and egg quality. In Generation 3, the "High Immune Level" group had the highest values of egg weight (7.61±0.22 g) and length (27.70±0.63 mm), while the "Control (+)" group presented the lowest values. However, the egg shape index did not change in any of the groups and generations, thus proving resistant to both genetic and environmental pressures, $p > 0.05$. These findings illustrate how immune selection and reproductive traits interact with one another; in this regard, strong immune responses may dampen declines in egg quality traits over time. The results of this study emphasize the importance of balanced parenting strategies in order to improve both productivity and immune efficiency. The genetic and active mechanisms underlying these trade-offs should be investigated in future research to improve sustainable poultry farming programs.

Key Words: Egg, Traits, Selection, Japanese quail.

Introduction:

Newcastle viral disease (NDV) is a highly contagious viral disease that affects various bird species, including wild birds and commercial poultry. The chicken industry is under threat globally, resulting in increased mortality rates and significant economic losses, decreased Productivity and trade constraints (Alexander, 2000; Miller et al., 2010). The vaccination process is A prevalent preventive strategy against NDV, but the possibility of vaccine failure and the need for repeated doses add to the inability to mitigate inherent heredity Readiness (Seal et al., 2000; Kapczynski et al., 2013). Parenting strategies designed for Improving genetic resistance to the nitrogen hemorrhetic virus has gained increasing attention as a sustainable strategy for Disease Management (Deeb & Lamont, 2002; Fulton et al., 2012).

Domesticated Japanese quail eggs (Coturnix japonica), widely known for their high-yielding egg-laying and ability to survive in various habitats, are the best models to investigate Genetic foundations of disease resistance and production traits (Minvielle, 2004; et al., 1983).Determines the quality of eggs, a key factor in poultry production, by Attributes such as albumin homogeneity, yolk size, shell strength and consumer attractiveness (Monira et al., 2003;Narushin et al., 2021).It is imperative to identify the trade-offs between good egg quality and disease resistance in order to implement a successful breeding program (Rath et al., 2015;Zhou & Lamont, 1999).

Immunological selection includes the use of animals that display enhanced immunity to viruses such as NDV. The basic approach here is the assessment of the vaccinations and infection-induced antibody titers as adaptive immunity markers (Schneider et al., 2019; Koenen et al., 2002). On the other hand, selecting for resistance to some diseases may inadvertently influence other traits because of pleiotropy or genetic connections (Leshchinsky & Klasing, 2001; Muir & Aggrey, 2003). The past experiments with hens confirmed that pursuing strengthening of the defense system on the immune side may lead to low growth rates, feeding inefficiencies, and reproduction problems (Pinard et al., 1998; De Ketelaere et al., 2004). The study of immunological selection for NDV resistance is yet to be deeply explored for its true effect on egg quality attributes in Japanese quail.

Egg quality traits are complex and influenced by genetic factors, environmental factors, and nutrition. Some of the essential physical traits include shell thickness and shell strength, both vital in enhancing resistance to microbial contaminants and in ensuring that eggs travel safely without breakage (Kulshreshtha et al., 2010; Dunn et al., 2009). Parameters such as albumen height and Haugh units serve as evaluation criteria for the internal quality of eggs, with yolk quality, such as color and weight, being extremely important in determining buyers' preference and the market value of these eggs (Romanov & Weigend, 2001; Sharma et al., 2008).

Therefore, this study aims to add to knowledge by investigating the effects of immunological selection on NDV resistance on major egg quality indices in Japanese quail. This study will shed light on the genetic link between disease resistance and egg-laying ability by comparing selected lines with control lines. It will also provide practical recommendations in breeding programs trying to strike a balance between improvements to NDV resistance with the maintenance of high-quality production of Japanese quail eggs.

Materials and Methods:

Japanese quail (Coturnix japonica) was used as an experimental group for its adaptability to diverse conditions and high productivity. The experimental poultry farm kept the birds in a controlled environment. The birds were also housed under standard breeding practices, which included access to water and feed, and exposed to a dark and light light period of 16:8 hours. The National Research Council (1994) recommended the formulation of feed to meet the nutritional requirements of quails. The study included four selection groups: "Control (-)" (neither vaccinated nor immune selection), "Control (+)" (vaccinated but not selected for immunological traits), "Low immunity level" (selected for low NDV antibody titer), and "High immunity level" (selected for higher NDV antibody titers). Each group has been maintained under constant environmental conditions for three generations. Selection groups vaccinated their birds with a standard NDV vaccine (Kapczynski et al., 2013). We measured immune responses through antibody titers using a hemagglutination inhibition (HI) test, and selected individuals based on their immune profile. Throughout the laying period, we collected eggs daily and selected a random subset from each group for quality analysis across generations. Egg Weight: Measured using an electronic scale with an accuracy of 0.01 g. Egg Length and Breadth: Determined using a digital caliper with an accuracy of 0.01 mm. Egg Shape Index: Calculated as the ratio of egg breadth to egg length, multiplied by 100 (Narushin et al., 2021).

The data was analyzed by using a two-way ANOVA to assess the impact of generation and selection group on egg quality traits. We used Tukey's HSD test for post-hoc comparisons among means. A significance level of $p < 0.05$ was set. We used SPSS software version 25 to perform the statistical analyses.

Result and discussion:

The findings highlight the influence of resistance selection on the egg weight of Japanese quail over three generations in Table 1.Hatchability of quails was very low, with the average overall being 37.97% and significant variation was noted between the breeding selection groups as well: Control (+) 22.97 %, Control (-) 31.82 %, High immune level 36.22 %, Intermediate immune level 48.85 % (overall). Further On, All selection resulted in significant improvements, gene preservation in family groups and closing the emergence gap, which was 3 to 6 percent. However, poorest of hatchability was obtained following artificial insemination for both males and females, which gives grounds for concern. Furthermore, All selection groups were found to significantly differ from each other across generations in all traits investigated and vice versa with a p-value = 0.001. Once hatchlings were matured, egg weights of all groups were roughly the same in Generation 0 until generation 1 when all groups reported the heaviest egg weights. For selected egg groups, “Control (-)” and “Control (+)” reported the least weight. This downward trend has continued into subsequent generations, although the other groups were able to maintain relatively large egg weights, the “High Immune Level” group stood out amongst them. Eventually in Generation 3, “Control (+)” held the lightest egg weight, that is 6.82±0.24g, while “High Immune Level” had the heaviest weight at 7.61±0.22g. Because of these findings, the converse seemed to contradict what was understood, suggesting instead that there is sufficient evidence to assert that selection helped to influence egg weight in Japanese quail. Traces left following a consistent selection for strong immune responses seems to suggest a provisioning against loss of egg weight. Perhaps it is because immune trait and growth traits are linked phenotypically (Schneider et al., 2019). Selection did serve to sustain against harsher genetic and environmental drifts that the control (unselected) groups were subjected to. That one fundamental reason is that over generations and across all abilities, aquaculture selection leads to gradual advancement in both tolerance as well as the sub-sequent attainment of approximately the same equal egg weight (Leshchinsky and Klasing, 2001). Moving forward, additional work can be performed regarding refining the selection strategies to more precisely achieve the trade-off between immune fitness and the productivity traits

.Table 1: The effect of immune selection during three generations on the egg weight of the Japanese quail

Generation	Control (-)	Control (+)	Low immune level	High Immune Level
0	8.82±0.16 a	8.38±0.15 a	8.73±0.10 a	8.91±0.18 a
1	8.20±0.19 b	7.73±0.17 b	8.25±0.15 b	8.26±0.16 b
2	8.13±0.15 b	7.75±0.20 b	8.29±0.14 b	8.41±0.18 ab
3	7.28±0.19 c	6.82±0.24 c	7.58±0.20 c	7.61±0.22 c
Sig.	0.000	0.000	0.000	0.000

The information presented in Table 2 demonstrates the relationship between immune selection and egg size over a period of three generations in Japanese quail. Over the evaluated generations, trends of significant reductions in egg length were recorded across all the groups over time ($p < 0.001$). During the first generation of analyses (Generation 0), all the groups were noted to have similar lengths whereby the facet characterized by high immune status had the largest (32.60±0.32 mm) eggs. Generational effect over time took its toll with Generation 3 recording the highest contractions in egg size across all groups of which the “Control (+)” group sites around 26.22±0.87 mm indicating having the smallest eggs on average while the group classified under graphic Hised status triumphed with longer sized eggs averaging 27.70±0.63 mm There was a clear indication that immune selection was of essence in the generation of the egg length whereby the Hised status group lowered the degree of regression within the group. This implies that if efficient immune systems promote certain features of eggs, then there is an inverse correlation between these two as investment of resources in immune systems reduces resources available for egg building(zinc etc) Leshchinsky and Klasing, 2001. The optimality of focusing on breeding programs should remain at the interface between immune strength and economically important traits (Schneider et al., 2019).

Table 2: The effect of immune selection during three generations on the egg length of the Japanese quail

Generation	Control (-)	Control (+)	Low immune level	High Immune Level
0	31.97±0.24 a	31.70±0.20 a	32.18±0.18 a	32.60±0.32 a
1	29.78±0.52 b	29.48±0.44 b	30.41±0.39 b	30.49±0.37 b
2	29.54±0.43 b	29.38±0.44 b	30.48±0.35 b	30.61±0.40 b
3	26.46±0.77 c	26.22±0.87 c	27.98±0.66 c	27.70±0.63 c
Sig.	0.000	0.000	0.000	0.000

Table 3 summarizes the impact of immune selection on Japanese quail egg breadth after three generations. Baseline measurements revealed no significant differences among groups at Generation 0.values varied between 24.95±0.13 mm ("Control (+)") and 25.27±0.16 mm

("Control (-)"). Generation 1, all groups displayed a significantly reduced egg breadth with the "High Immune Level" group still producing slightly larger (23.55±0.22 mm) eggs. This downward trend continued through Generation 3; in Generation 3 the “Control (+)” group demonstrated the narrowest egg width (20.67±0.68 mm), whereas the "Low Immune Level" category resulted in comparatively elevated measurements (21.77±0.53 mm). Egg breadth was shaped by immune selection across generations, with all groups developing significantly narrower eggs over time ($p < 0.001$). The gradual decline in the "High Immune Level" and "Low Immune Level" groups indicates the possibility of an evolutionary trade-off between immune function and reproductive characteristics, where selective pressure targeting immunity counteracts reductions in egg size (Leshchinsky and Klasing, 2001; Klasing, 2005). But the bigger drop in that occurs under no immune pressure could be augmented in the face of such random losses (or also environmental stress (Schneider et al., 2019). Optimized strategies for selection may allow for increased maintenance of both immune function and productive traits in the context of sustainable breeding.

Table 3: The effect of immune selection during three generations on the egg breadth of the Japanese quail

Generation	Control (-)	Control (+)	Low immune level	High Immune Level
0	25.27±0.16 a	24.95±0.13 a	25.15±0.11 a	25.19±0.16 a
1	23.40±0.29 b	23.18±0.33 b	23.57±0.29 b	23.55±0.22 b
2	23.42±0.27 b	23.25±0.36 b	23.79±0.29 b	23.70±0.25 b
3	21.00±0.56 c	20.67±0.68 c	21.77±0.53 c	21.50±0.47 c
Sig.	0.000	0.000	0.000	0.000

Table 4 presents the results of immune selection on the egg shape index in Japanese quail during three generations. In general, there were no statistically significant differences among all groups and generations in the egg shape index ($p > 0.05$). The recorded values in Generation 0 ranged from 77.39±0.46 ("High Immune Level") to 79.12±0.52 ("Control (-)"). A similar pattern occurred between Generations 1 and 3, but it was marked by minimal ups and downs without serious changes. The "Control (-)" group always had the largest shape index, while the "High Immune Level" group always had the lowest value. In contrast to egg weight, length, and breadth, the egg shape index did not experience significant influence from immune selection; therefore, this characteristic may exhibit greater stability in response to genetic or environmental pressures exerted by such selection. The consistency of the index may indicate substantial heritability and evolutionary optimization for its functional role (Narushin et al., 2021). The trade-offs in immune responses, concerning reproductive traits, may also be prioritized, including egg size but not shape, in response to energy constraints. Romanov and Weigend (2001) pointed out that the shape indices of those bird species under selection were relatively constant due to small variation. Further studies may focus on the correlations between immune selection and other morphological or functional parameters of eggs (Schneider et al., 2019).

Table 4: The effect of immune selection during three generations on the egg shape index of the Japanese quail

Generation	Control (-)	Control (+)	Low immune level	High Immune Level
0	79.12±0.52 a	78.74±0.43 a	78.21±0.49 a	77.39±0.46 a
1	79.04±0.62 a	78.70±0.50 a	77.54±0.48 a	77.29±0.44 a
2	79.41±0.53 a	79.16±0.51 a	78.05±0.47 a	77.52±0.48 a
3	79.51±0.58 a	78.88±0.58 a	77.79±0.50 a	77.67±0.51 a
Sig.	0.929	0.914	0.770	0.955

Conclusion:

The results indicate that the immune selection has a considerable impact on Japanese quail egg weights, lengths, and breadths with significant descending trends, predominantly in control groups, throughout the generations. The egg shape index, on the other hand, remained constant, indicating its ability to withstand selection pressures. Together, these results reflect trade-offs between immune function and potential reproductive traits, and they highlight the importance of balanced breeding decision-making that maximizes immune robustness while minimizing egg output and quality effects.

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