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# Development and Implementation of an Optimized Rearing Protocol for Peafowl and Pheasant Chicks

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## ABSTRACT

Maintaining high fertility and hatchability is essential for producing healthy chicks. **Objectives:** To identify factors affecting hatchability and fertility rates to develop effective rearing practices. **Methods:** The investigated factors responsible for lower fertility and lower hatchability rates were improper male-to-female ratios, the age of breeder flocks, egg storage duration, sand bedding, remnants of dead shells in incubators, rectangular brooders, and the absence of vaccinations and deworming. Data analysis involved the use of descriptive statistics and hypothesis testing. The study was based on one year of experimental data (January 2023 - September 2023) and six years of records from the Jallo Park Lahore captive breeding center (2017-2022). This research focused on two bird groups from the Galliformes order: peafowl and pheasant. This study analyzed 1,400 hatching eggs from six different peafowl breeder flocks and 1,480 hatching eggs from five pheasant breeder flocks. **Results:** Hatchability ratio in peafowl improved from 16% in 2017 to 60% in 2023, while fertility rates increased from 26% to 82% in 2023. For pheasant, hatchability rose from 34% in 2017 to 60% in 2023, with fertility rates reaching a peak of 86% in 2023. **Conclusions:** It was concluded that implementing a new protocol can improve both fertility and hatchability. Key components of this protocol for improving fertility include male-to-female ratio, timely egg collection, and proper floor bedding. To improve hatchability, clean the incubators, use circular brooders to reduce mortality, and apply vaccination and deworming, all of which significantly impact outcomes.

## INTRODUCTION

The peafowl's great beauty makes it one of the world's most attractive animals. It is part of the *Phasianidae* family and falls under the order Galliformes within the class Aves, which includes 38 genera and around 138 species [1]. Peafowl typically engage in breeding activities during the rainy season, with the breeding period spanning from April to August [2]. Peafowl normally arrive at sexual maturity at two to three years old. The peahen lays between three to six eggs, which are buff white, one egg each day, with an incubation period of 28-30 days [3]. Peafowl possess similar anatomical and physiological features to birds of the common order Galliformes, such as pheasants, but they also have unique anatomical and physiological characteristics [4]. The main distinction between peafowl and pheasants lies in their feather coloration. There are 49 recognized pheasants globally, with Pakistan hosting five

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of these species [5]. Generally, pheasants are considered game birds and are often raised for hunting in many countries. Wild birds are kept in captivity to promote optimal growth, create a suitable environment for conservation and research, and enhance reproduction rates [6]. Although it is commonly believed that captivity comes with various challenges, including the study of early mortality and the resolution of captivity-related issues [7] such as proper nutrition, suitable housing, male-to-female ratios, external stressors, internal factors due to sudden environmental changes, feeding methods, and unfavorable microclimate conditions [8]. Numerous factors impact the successful hatching of a fertilized egg, including the age of the breeder, the shape index of the egg, the weight of the egg, the color and mottling of the shell, the initial egg mass, the amount of mass lost, and the yolk sac index [9]. The age of the flock directly causes early mortality. The mating sex ratio in captivity is a significant issue that greatly impacts egg quality, fertility, hatchability, and weight [10] was carried out to assess the influence of two mating ratios (8:1 and 12:1 female to males) on the health of birds, egg production and quality, fertility, and hatchability in pheasants. The fertility of eggs produced by birds in the 8:1 mating ratio was consistently and significantly 4% higher than that of eggs from the 12:1 mating ratio. Lack of fertilization (due to insufficient sperm) was twice as high in the 12:1 enclosure, accounting for 13.7% of the eggs [11]. Storing eggs for an extended period decreases eggshell weight, eggshell thickness, yolk weight, albumen index, yolk index, Haugh unit, shell percentage, albumen percentage, and yolk percentage ($p<0.05$). By day 8, hatchability was significantly diminished, reaching its lowest value of 41.59% [12]. The causes of high embryo mortality in the hatching process can be caused by bacterial and fungal contamination and poor egg storage conditions (storage room temperature). Dickens *et al.*, found that bacteriological investigation of dead-in-shell embryos has shown that different bacterial isolates may be causing embryonic mortalities, including *Salmonella spp.*, *Escherichia coli (E. coli)*, *Staphylococcus spp.*, *Streptococcus spp.*, *Pseudomonas spp.*, *Proteus spp.*, *Bacillus subtilis*, *Klebsiella spp.*, *Micrococcus spp.* and *Mycoplasma* spp [13]. It is crucial to provide meticulous care and attention, as neglecting these essential factors can lead to increased mortality rates in captivity [8].

This study aims to examine the impact of a new rearing protocol on the successful production of eggs, fertility, and hatchability in peafowl and pheasants, as well as to contrast it with the conventional method. By highlighting the notable difference in mortality rates, hatchability, and fertility rates with pre- and post-rearing, this paper focuses on the importance of implementing novel rearing techniques to enhance the productivity and profitability of peafowl and pheasant breeding programs under captivity.

## METHODS

The cohort study was conducted at the Department of Wildlife and Parks, Lahore, Pakistan. The study lasted from January 1, 2022, to September 30, 2023. We used data from 2017 to 2022 as a historical control group to compare with the current study results. This approach allowed us to observe and interpret changes more accurately by establishing a reference baseline, similar to previous studies [14, 15]. The selected species of peafowl are Pavo cristatus (common peacock/Indian peacock), pied peacock, *Pavo cristatus Linn.* (black shoulder peacock), and *Pavo muticus* (Java green peacock). The selected species of pheasants are *Phasianus versicolor* (green pheasant), *Lophura nycthemera* (silver pheasant), *Chrysolophus pictus* (golden yellow pheasant), *Crossoptilon crossoptilon* (white pheasant), and *Phasianus colchicus* (ring-necked pheasant). The research conducted from January 2023 to September 2023 was segmented into five distinct phases. Each phase provided a concise overview of the breeding activities, following a new rearing protocol (Table 1).

**Table 1:** Phases of Study Plan Presenting Bird Type and Different Phases for the Year 2022-2023

| Bird Types | Year | Phase A | Phase B | Phase C | Phase D | Phase E |
|---|---|---|---|---|---|---|
| Peafowls | 2022-2023 | (January-February) | March - April) | (May-June) | (July-August) | (September) |
| Pheasants | 2022-2023 | (January-February) | March - April) | (May-June) | (July-August) | (September) |

In the initial phase A, from January to February (2022-2023), the selection of peafowl and pheasant pairs was based on their physical fitness and reproducibility. A total of 20 peafowl pairs were purposively selected, with a male-to-female ratio of 1:2, and 40 pheasant pairs were chosen, with a male-to-female ratio of 1:3 purposively selected present at Jallo Wildlife Park, Lahore, Pakistan. The birds were fed a standard breeder diet called "breeder layer," supplemented with legumes, seeds, peas, beans, and leafy green vegetables, including carrot tops, green scraps, and grasses [16]. In the second phase B, from February to March (2023), the 20 peafowl pairs were kept in individual breeding rooms, with a male-to-female ratio of 1:2, and the 40 pheasant pairs were housed with a male-to-female ratio of 1:3. It has been established that providing chicks with sufficient feed, particularly protein, is necessary for modern, promising, engaging, and productive farming [8]. Offering the best diet to the separated pairs is a priority, as diet directly affects their reproductive system and egg-laying capacity [17]. The selected birds were kept in captivity, with the floor bedding of paddy husk because sand, rice husk, or wheat can lead to conditions that help form diseases during decomposition, resulting in higher carbon dioxide and ammonia gases in the microclimate air.

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In the second month of Phase B (March), eggs were gathered from separate cages to maintain their breeding environments. To ensure the hygiene of the eggs, freshly laid ones were collected three times daily and organized into sets. In Phase C, from April to May 2023, disinfected eggs were transferred to an incubator asset. The incubator was maintained at a constant temperature of 99°F and a humidity level between 55-60 g.m-3 [18]. Peafowl eggs require an incubation period of 28-29 days, while pheasant eggs hatch successfully after 22-24 days. After ten days of incubation, the critical process of candling began. Candling involves rotating the eggs hourly. This process continues until the incubation is complete. The rotation of the eggs ensures proper orientation for effective heat distribution. The automatic system positions each egg with its broad face on the upper side and the pointed end on the lower side. Three days before hatching, the incubation and candling processes were completed. In the second month of Phase C (May), three days before the anticipated hatching date, the eggs were successfully moved from the incubator to a hatcher, where the temperature was maintained between 97-96°F and the humidity level was around 75 g.m-3. The hatcher provides a more suitable environment for hatching by maintaining lower temperatures and higher humidity levels. In Phase D, which ran from June to July 2023, the newly hatched chicks were transferred to specialized enclosures called circular brooders. The brooders were designed in a circular shape to provide enough space for the chicks to move around without getting stuck in corners, preventing overcrowding and accidents. To maintain a warm environment within the brooder, 100-volt bulbs were used. During the brooding period, proper nutrition was provided; in the first week, chicks were fed a starter feed specially formulated to meet their nutritional needs [19]. Flushing occurred naturally when the chicks were introduced to regular (starter) feed. The vaccination protocol spanned one month and required repetition of certain medications as per standard guidelines. Therefore, the repeated entries reflect actual practice and cannot be altered without compromising data integrity. A mixture of Amoxicillin, Tylodox, Lincomycin, Spectinomycin, and Amino Wit was administered on the first day to prevent infections. This regimen continued for one and a half months. After seven days, the Newcastle Disease (ND) vaccine was regularly sprayed to control viral infections such as influenza and colds, with this routine repeated every seven days for a month until the chicks reached three months of age [20]. On day 21, the chicks received CNC, NOCOX, and ADEK medication. This included C.N.S 200 powdered antibacterial agents (chlortetracycline HCL, neomycin sulfate, colistin sulfate) to manage diseases like coccidiosis, along with a combination of vitamins (ADEK) and NOCOX. Adding amino acids enhanced nutrient absorption from the feed, while the antibiotics provided protection. The floor bedding in the brooder was made of corrugated material, which was changed daily. The chicks remained in the brooder for one and a half months, consuming 10 to 30 grams of feed during this period [21]. Medication and feeding protocol from zero-day until 1.5-month-old fancy birds rearing are analyzed (Table 2).

**Table 2:** Medication and Feeding Protocol from Zero-Day Until 1.5-Month-Aged Fancy Birds Rearing

| Age (Day) | Vaccination Program ( Peacocks and Pheasants) | Feed Activity | Method |
|---|---|---|---|
| 00 | Flushing with 4% sugar solution, Amino wit | Nil | At Hatchery |
| 01 | (Amoxicillina/Tylodox/ Linkomycin/Spectinomycin) + Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 02 | (Amoxicillina/Tylodox/ Linkomycin/Spectinomycin) + Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 03 | (Amoxicillina/Tylodox/ Linkomycin/Spectinomycin) + Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 04 | (Amoxicillina/Tylodox/ Linkomycin/Spectinomycin) + Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 05 | (Amoxicillina/Tylodox/ Linkomycin/Spectinomycin) + Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 07 | N.D vaccine | Starter feed + Promotor L (Amino Wits) nutrition | Spray |
| 08 | Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 09 | Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 14 | N.D vaccine | Starter feed + Promotor L (Amino Wits) nutrition | Spray |
| 15 | Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 16 | Amino wit | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 20 | N.D vaccine | Starter feed + Promotor L (Amino Wits) nutrition | Spray |
| 21 | CNC + NOCOX + ADEK | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 22 | CNC + NOCOX + ADEK | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 23 | CNC + NOCOX + ADEK | Starter feed + Promotor L (Amino Wits) nutrition | Water |
| 27 | N.D vaccine | Starter feed + Promotor L (Amino Wits) nutrition | Spray |

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Amino wit: Two days a week for six weeks. Deworming: At the age of 1.5 months, after 15 days, then after one month. N.D vaccine: After every month

Phase E commenced in August and continued through September 2023. The chicks were carefully transferred to the rearing section. The diet and medication plans were maintained, consisting of starter feed combined with Promotor L (Amino Wits) for nutrition and CNC, NOCOX, and ADEK for three months. Deworming procedures were also implemented in the rearing section to ensure the cleanliness of the internal parasites in the stomach. This process began at one and a half months of age, followed by a repeat after fifteen days and again after one month. The floor bedding in the rearing section consisted of rice husk and wood shavings. After three months in the rearing section, the chicks matured successfully. A one-way ANOVA was conducted to evaluate the variation in egg production across all years. Protocols for the yearly rearing of peafowl are shown (Figure 1).

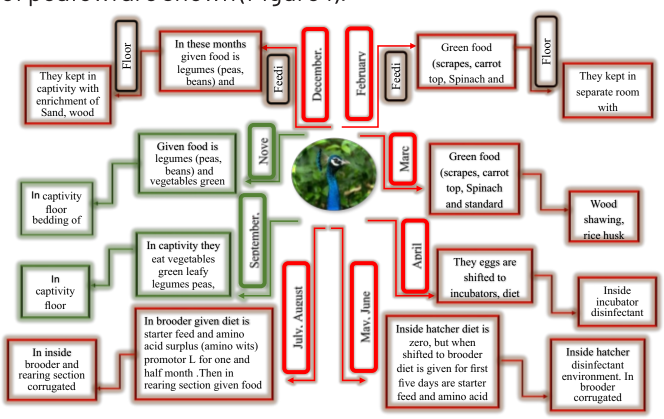


**Figure 1:** Yearly Rearing Protocol of Peafowl

Protocols for the yearly rearing of pheasants are shown (Figure 2).

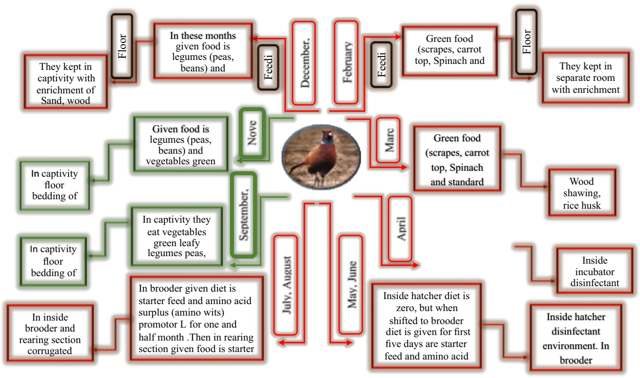


**Figure 2:** Yearly Rearing Protocol of Pheasants

## RESULTS

By implementing established protocols in captivity on peafowl and pheasant selected species, the following percentages of fertility and hatchability and total number of eggs from 2017 to 2023 were analyzed using one-way ANOVA. The study compared fertility and hatchability rates in peafowl and pheasants from 2017–2023 using a one-way ANOVA. Statistical analysis revealed significant differences in hatchability across years ($F(6, 28) = 8.34$, $p = 0.001$, 95% CI [12.3, 28.7]), with post-hoc tests confirming higher rates in 2023 versus baseline years (all $p < 0.05$) (Figure 3). According to previous records, there has been a notable variation over the years—the number of eggs produced by peafowls recorded year-wise. As shown in Figure 3A, egg production varied from 860 in 2017 to a low of 680 in both 2018 and 2019. Recovery started in 2020 with 980 eggs, then significant growth to 1,200 in 2021. After a decline to 737 in 2022, production increased to 1,400 in 2023. In 2023, a significant peak in egg production of peafowls was observed, with a total of 1,400 eggs following the implementation of an established rearing protocol. The fertility rates of peafowl eggs have steadily increased over the years, as shown in Figure 3C. In 2017, the fertility percentage was 26%, rising to 31% in 2018 and 30% in 2019. After slightly declining to 27% in 2020, the fertility rate improved to 34% in 2021 and 48% in 2022. By 2023, the fertility rate reached 82%, indicating a substantial enhancement due to the new protocol. For peafowl, hatchability improved from 16% (2017) to 60% (2023) ($F(4, 18) = 5.22$, $p = 0.006$) (Figure 3E). Hatchability percentages were 16% in 2017, 34% in 2018, and 47% in 2019. During 2020, the rate decreased slightly to 46%, then dropped to 33% in 2021, recovering to 38% in 2022. The hatchability rate peaked at 60% in 2023, demonstrating the effectiveness of the new rearing practices. Pheasant fertility, hatchability rates, and egg output have all changed significantly. The total number of eggs produced by pheasants is shown in Figure 3B. In 2017, a total of 860 eggs were recorded. This number saw a significant increase in 2018, reaching 1,580 eggs, and continued to rise to 1,720 eggs in 2019. In 2020, egg production slightly decreased to 1,680 eggs and then dropped to 1,180 eggs in 2021. In 2022, production was 1,260 eggs, and by 2023, it increased to 1,480 eggs. In Figure 3D, the fertility rates of pheasants have also shown notable changes over the years. The fertility percentage was 33% in 2017, increasing to 56% in 2018 and 77% in 2019. In 2020, the fertility rate was 71% and 70% in 2021. There was a significant improvement in 2022, with a fertility rate of 86% in 2023, marking the highest rate observed. Pheasants showed similar gains in hatchability (34% to 60%; $F(4, 18) = 4.91, p = 0.008$) (Figure 3F). Hatchability percentages for pheasants were 34% in 2017 and remained the same in 2018. In 2019, hatchability improved to 47%, while in 2020, it was 46%. The hatchability rate dropped to 33% in 2021 but improved to 38% in 2022 and peaked at 60% in 2023

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**Figure 3:** Year-Wise Comparison of Peafowl and Pheasant's Total Eggs, Hatchability, And Fertility Ratio

## DISCUSSION

This study investigates the effects of established rearing protocols on the hatchability and fertility rates of peafowl and pheasant eggs at the Jallo Breeding Center in Lahore, Pakistan. The protocol was established by visiting the Breeding Center. The most highlighted factor which directly affects hatchability and fertility is improper male-to-female ratios, the age of breeder flocks, egg storage duration, lack of supplements during breeding and chick growth stages, sand bedding, remnants of dead shells in incubators, rectangular brooders, and the absence of vaccinations and deworming. All problematic factors that lead to low fertility and hatchability rates and including embryonic mortality, are addressed by consulting with the veterinary officers at Jallo Breeding Center. Furthermore, a new rearing protocol was established and implemented in 2023. The current study compares the outcomes from 2023, during which the new protocols were implemented, with the previous records from 2017 to 2022, when standard rearing practices were followed. In the case of peafowls and pheasants, a significant peak was observed in 2023. According to Fukuhara et al., hatchability is closely linked to egg fertility and embryonic mortality throughout the hatching process [22]. All factors that influence egg fertility and contribute to embryonic mortality during incubation are addressed through innovative methods. The established rearing protocol showed a very positive ratio of hatchability and fertility rates. The most effective change which improves fertility rate was proper male-to-female ratios. For peafowls, a ratio of 1:2 was maintained, while for pheasants, a ratio of 1:3 was implemented. The healthiest individuals were carefully chosen as breeding pairs to ensure the propagation of desirable traits. Eggs were gathered three times daily; proper management of egg storage conditions influences the developmental conditions for embryos. To avoid bacterial infection, a modification to the breeding environment, including the replacement of sand bedding with rice husk. The hatchability level improved by thoroughly cleaning the incubators and removing dead shells and dead embryos. The rectangular brooder design was replaced with a circular brooder to reduce mortality rates. A comprehensive vaccination and deworming program was initiated to protect the birds against common diseases and parasitic infestations. It was shown that fertility rates improved by a male-to-female sex ratio, as well as the health and genetics of birds [23]. Storage of eggs with proper care increases development and consequently results in lower total embryo mortality and higher hatchability [24]. Research has demonstrated that embryonic mortality during incubation is caused by the presence of bacteria, which infiltrate the eggshell and result in dead embryos. According to Ibrahim et al., disinfectants enhance hatchability [19]. Tainika et al., observed that the mating sex ratio and timely egg collection use of disinfectants before incubation help maintain hatchability and fertility rates [25]. The main source of contamination is floor bedding in the hatchery [26]. It was shown that hens kept on rice husk bedding produced more eggs and were contamination-free [27]. According to Saidane et al., it was shown that vaccination is essential for animal health; it provides individual protection and stimulates the production of antibodies that enhance survival rates [28]. Vaccination has successfully managed most infectious diseases in chickens. Vaccines lower the occurrence of diseases like Newcastle disease and infectious bursal disease, thereby enhancing animal welfare and the economic sustainability of poultry farming [29]. Hauck and Macklin emphasize that various management factors lead to differences in hatchability across breeder farms [20]. These factors encompass housing systems, egg handling practices, methods of egg collection, storage management, genetics, nutrition, and health. Furthermore, the level of microbial contamination in hatching eggs is affected by housing systems [30] and the laying nest utilized, which can significantly influence hatchability. According to Tomczyk et al., potential results of hatchability would be obtained by following the hatchery management [31]. The findings of this study suggest that implementing a well-designed hatchery protocol can positively impact fertility rates and hatchability outcomes in poultry production. By optimizing factors such as

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breeder selection, nutrition, egg handling, incubation conditions, and chick management, hatcheries can enhance the efficiency of their operations and ensure the availability of high-quality chicks for subsequent rearing stages.

## CONCLUSIONS

It was concluded that the implementation of the revised rearing protocol significantly enhances fertility rates, hatchability rates, and overall chick quality in both peafowl and pheasants. The optimization of male-to-female ratios, improved egg collection practices, and stringent hygiene measures (incubators, floor bedding, vaccination, deworming) have proven to be critical factors in achieving these advancements. These findings highlight the vital role of effective management practices in hatchery operations for achieving successful breeding outcomes. Based on the quantitative results, it was concluded that targeted interventions can lead to substantial improvements in poultry production. These findings provide a practical framework for wildlife breeding centers and aviculture programs to optimize rearing protocols to improve the health, growth, and survival of their peafowl and pheasant chicks.

## Authors Contribution

Conceptualization: BNK
Methodology: MNF, BNK, MRK
Formal analysis: HMMH, ZT, MRK, MA
Writing review and editing: MNF, BNK, HR, FB, HMMH, ZT, MRK
All authors have read and agreed to the published version of the manuscript.

## Conflicts of Interest

All the authors declare no conflict of interest.

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