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Captive Breeding and Reproductive Efficiency of Red Junglefowl: Implications for Conservation and Poultry Improvement

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Abstract

The Red Junglefowl (RJF; *Gallus gallus*) is the wild ancestor of domesticated chickens, holds significant ecological and economic importance. However, habitat destruction, genetic dilution, and declining population numbers necessitate conservation strategies. This study evaluated the productive and reproductive efficiency of RJFs under captive conditions and compared their performance with Indigenous Naked Neck (INN) chickens. A total of 20 RJFs and 20 INNs were reared under semi-intensive conditions. Key parameters such as growth rate, egg production, fertility, hatchability, and egg quality were analyzed. Results indicated that RJFs exhibited distinct phenotypic traits, including vibrant plumage in males and a more compact body structure compared to INNs. RJFs had a significantly lower body weight than INNs, with males averaging 1375.2 g and females 890.5 g. They exhibited delayed sexual maturity, reaching the point of lay at 218.4 days compared to 135.0 days in INNs. However, RJFs demonstrated promising reproductive potential, with a fertility rate of 76.00% and hatchability of 57.89%, slightly higher than that of INNs. RJF eggs were smaller (42.1 g) but exhibited superior internal quality, reflected by a significantly higher Haugh unit score (71.98) compared to INN eggs. The findings suggest that while RJFs are not optimized for high egg production, their genetic traits, including superior egg quality, adaptability, and disease resistance, could be beneficial for breeding programs. Conservation efforts incorporating RJFs into sustainable poultry farming could support biodiversity while offering economic opportunities for smallholder farmers. Future research should focus on selective breeding strategies to enhance their productivity and explore their potential in free-range.

Keywords: Red Junglefowl, reproductive efficiency, fertility, hatchability, conservation, poultry improvement.

Introduction

The poultry sector plays a pivotal role in global food security, contributing significantly to animal protein supply and rural livelihoods. In Bangladesh, the poultry industry is experiencing rapid growth due to increasing population, income levels, and urbanization (FAO, 2023). While commercial broiler and layer breeds dominate the market, there is a renewed interest in indigenous and wild poultry species for their unique genetic traits and adaptation to local environments. Among these, the Red Junglefowl (*Gallus gallus*), the wild progenitor of domestic chickens, holds exceptional evolutionary, genetic, and ecological importance (Tixier-Boichard *et al.*, 2011).

Red Junglefowl (RJF) populations are native to the dense forests of South and Southeast Asia. Despite their historical and scientific value, RJF numbers are declining due to rapid habitat destruction, interbreeding with domestic chickens, poaching, and fragmentation of forest reserves (Lawal *et al.*, 2020; Delany *et al.*, 2006). In Bangladesh, although small isolated RJF populations still exist in forested zones, their genetic purity is increasingly threatened. Consequently, conservation efforts have shifted toward ex-situ strategies like captive breeding to preserve and enhance RJF populations under human management.

Captive breeding programs offer a promising platform for both conservation and potential poultry improvement. These programs allow researchers to assess and enhance reproductive traits while minimizing genetic erosion. However, compared to commercial poultry, RJFs exhibit relatively low reproductive performance, characterized by seasonal breeding cycles, small clutch sizes, and poor hatchability (Francisco and Espina, 2015). Improving these parameters through proper management, selection, and nutritional supplementation could unlock their value in sustainable poultry systems.

Research has also shown that RJFs possess beneficial phenotypic and meat quality characteristics, including lean meat, intense flavor, higher mineral content, and robust immune response traits that are often lacking in industrial breeds (Riaz *et al.*, 2024). These qualities make RJFs highly desirable for specialized, high-value poultry markets. Additionally, crossbreeding programs involving RJFs and indigenous breeds such as the Indigenous Naked Neck (INN) chicken have the potential to yield dual-purpose birds that combine adaptability with productivity (Bhuiyan *et al.*, 2005).

Another critical dimension is the role of RJF genetics in the study of domestication and evolutionary biology. Genomic studies have confirmed that modern chickens retain a substantial portion of their ancestry from RJFs (Eda, 2021), underlining their importance for genetic diversity conservation. Therefore, well-structured breeding and monitoring programs are essential to maintain their genetic identity and evaluate their productivity under controlled environments.

In this context, the present study evaluates the phenotypic, productive, and reproductive characteristics of RJFs reared in captivity, with comparisons to INN chickens as a reference indigenous breed. By assessing parameters such as fertility, egg production, hatchability, and chick viability, this research aims to provide actionable insights for conservation breeding strategies and for enhancing the role of RJFs in rural poultry development. The findings are expected to benefit both conservation scientists and poultry breeders seeking resilient and genetically diverse alternatives to commercial strains.

Materials and Methods

Study Location and Duration

The study was conducted at the Advanced Avian Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh, from June to December 2020. The farm is equipped with controlled housing and monitoring facilities, ensuring optimal conditions for poultry research. The geographic location of Dinajpur provides a suitable subtropical climate, which aligns with the natural habitat conditions of RJFs, making it an ideal site for the study.

Experimental Birds and Management

A total of 20 RJFs and 20 INNs (5 males and 15 females per breed) were reared under semi-intensive conditions. Birds were housed in deep-litter pens, ensuring sufficient space for natural behaviors. The environmental parameters were maintained at 30°C ambient temperature, adjusted using lighting and ventilation, while humidity levels ranged between 55-75%. A 16-hour light cycle was maintained to optimize reproductive performance.

Standard health protocols were strictly followed. Birds were vaccinated against common poultry diseases, including Newcastle Disease, Infectious Bursal Disease (Gumboro), and Fowl Pox, to ensure flock health. Regular deworming was carried out using broad-spectrum anthelmintics, and birds were monitored for any signs of illness or distress. The pens were cleaned and disinfected regularly to maintain hygienic conditions, reducing the risk of disease transmission.

Diet and Nutrition

The birds were provided a balanced breeder diet formulated with maize, rice polish, soybean meal, animal protein, vitamins, and minerals. Each bird received 100 g of feed per day to meet nutritional requirements. The feed formulation was designed to provide adequate protein, energy, and essential micronutrients to support growth, egg production, and overall health. The nutrient composition of the diet (Table 1) adhered to established poultry nutrition standards, as recommended by Aftab Bahumukhi Farms Ltd., Bangladesh.

Table 1. Nutrient composition of experimental diet

Nutrients	Amount
DM (%)	88.00
Crude protein (%)	21.00
Calcium (%)	2.00
Phosphorus (%)	0.45
Crude Fat (%)	5.00
ME (kcal/kg)	3000−3100

Source: Aftab Bahumukhi Farms Ltd. Bangladesh

Fresh water was available *ad libitum*, and electrolyte supplementation (Renalytes, Renata Ltd., Bangladesh) was provided during high-temperature conditions to prevent heat stress. To enhance gut health and feed efficiency, probiotics and organic acids were periodically incorporated into the diet. Additionally, crushed oyster shells were provided as a calcium supplement to improve eggshell quality.

Data Collection

Several key parameters were recorded to evaluate the productive and reproductive efficiency of RJFs.

Growth performance: Live weight was measured weekly using a digital weighing scale at different growth stages, including juvenile, sub-adult, and adult phases.

Egg production and quality: Daily egg production was recorded, and egg weight, shell thickness, yolk index, and albumen height were measured using standard methodologies (Haugh, 1937; Reddy *et al.*, 1979). The shape index was determined by measuring the length and width of eggs using a slide caliper.

Fertility and hatchability: Fertility rate was assessed by candling eggs on the 7th and 14th day of incubation. Hatchability percentage was calculated based on the number of chicks hatched from fertile eggs.

Embryonic mortality: Eggs that failed to hatch were examined for embryonic mortality, which was classified into early, mid, and late mortality based on the developmental stage at which embryonic death occurred.

Behavioral observations: Natural behaviors, such as foraging, roosting, and mating activities, were recorded to assess adaptation to captive conditions.

Eggs were incubated under standard conditions using a forced-air incubator (Ova-Easy Advance Series II, Brinsea, FL, USA), maintaining a temperature of 37.5°C and relative humidity of 60–65% during the incubation period. Eggs were turned five times daily until the 25th day, after which they were transferred to the hatching tray. The hatchlings were weighed and monitored for survival rates during the first week post-hatch.

Statistical Analysis

All collected data were analyzed using SPSS software (2024). A one-way ANOVA was conducted to determine significant differences between RJFs and INNs regarding growth performance, egg production, and reproductive parameters. Duncan's Multiple Range Test (DMRT) was used for post-hoc comparisons. Results were presented as the Mean ± Standard Error of the Mean (SEM), and a significance level of $P<0.05$ was considered to indicate statistically significant differences.

The findings from the statistical analysis were used to determine the efficiency of RJFs in captive breeding conditions, and comparisons with INNs helped establish benchmarks for conservation breeding programs. The results obtained from this study can contribute to further research in optimizing RJF breeding and improving their reproductive efficiency in controlled environments.

Ethical Considerations

This study was carried out in strict compliance with established ethical standards for animal research, with particular emphasis on minimizing discomfort and distress to the birds. Ethical approval was secured from the Institutional Animal Ethics Committee of Hajee Mohammad Danesh Science and Technology University (HSTU). All experimental procedures were performed in accordance with internationally accepted guidelines for the care and use of animals in reproductive research. Trained personnel handled the birds throughout the study, and semen collection was conducted using humane, non-invasive techniques designed to reduce stress. Following the completion of the study, the birds were closely monitored for any signs of adverse effects and were subsequently returned to the breeding flock under routine management and welfare conditions.

Results and Discussion

Phenotypic Characteristics

RJFs exhibited distinctive phenotypic features in comparison to INN chickens, as outlined in Table 2. RJF males showed striking sexual dimorphism, including vividly colored plumage with a single, upright comb, well-developed spurs, and long, iridescent tail feathers while females exhibited duller coloration, aiding camouflage. These traits are consistent with previous observations in *Gallus gallus* species (Amin and Bhuiyan, 1995; Del Hoyo *et al.*, 2001).

The INNs, characterized by their partially featherless necks and larger body conformation, appeared more thermotolerant and ground-adapted than RJFs. Such morphological variation can be associated with adaptive selection for specific ecological niches. RJFs demonstrated active behavioral patterns, such as tree-roosting and high predator awareness, which are typical of wild populations (Wilson, 2008).

Morphometric differences included stronger flight muscles and wing development in RJFs, adaptations for survival in the wild, whereas INNs presented thicker shanks and deeper bodies, indicative of selective breeding for meat traits under semi-intensive systems (Sangilimadan *et al.*, 2024). These phenotypic divergences underscore the evolutionary divergence between wild and domesticated poultry and emphasize the conservation value of RJFs.

Maintaining phenotypic diversity is vital for future poultry genetic improvement programs. Adaptive traits such as flight ability, disease resistance, and environmental tolerance present in RJFs offer valuable resources for enhancing the resilience of indigenous and hybrid chicken lines (Romanov and Weigend, 2001).

Productive and Reproductive Performance

The comparison of productive and reproductive performance between RJFs and INNs is presented in Table 3. Although RJFs exhibited lower body weights, they showed reproductive competence under captive conditions.

Table 2. Comparison of phenotypic characteristics between RJF and INN

Parameters	RJF		INN		Significance
	Male	Female	Male	Female	
Body depth (cm)	26	22	28	24	*
Beak size (cm)	1.9	1.6	2.1	1.8	*
Comb type	Single	Single	Pea	Pea	*
Comb size (cm)	8.8	4.2	6.5	3.5	*
Color of comb	Red	Red	Red	Red	NS
Wattle size (cm)	4.3	1.6	3.8	1.4	*
Ear lobe size and color	Rudimentary, Red	Rudimentary, Red	Well-developed, Red	Well-developed, Red	*
Shank color	Grey	Grey	Yellow	Yellow	*
Shank length (cm)	8.3	5.7	9.0	6.5	*
Shank width (cm)	1.3	0.8	1.5	1.0	*
Spur size (cm)	3.4	Absent	2.5	Absent	*
Wing length (cm)	16	14	17	15	NS
Sickle feather length (cm)	22	Absent	20	Absent	*
Hackle feather length (cm)	14	Absent	13	Absent	NS
Tail feather length (cm)	Absent	12	10	14	*

*Values are expressed as mean ± standard error of means; NS, Statistically not significant (P>0.05); * Statistically significant (P<0.05)*

Table 3: Productive and reproductive parameter of RJF and INN

Parameters	RJF	INN	Significance
Matured live weight(g):			
Male	1375.2±3.41	1848.00±95.06	*
Female	890.5±6.37	1205.00±82.76	*
Age at first egg laying (days)	218.4±7.21	135.00±8.90	*
Egg weight (g) at 40th weeks	42.1±0.36	38.29±2.41	*
Yearly egg production/bird	60.33±2.58	65.00±2.43	NS
Fertility (%)	80.75±4.67	76.00±3.56	*
Hatchability (%)$^{@}$	57.89±0.40	56.81±0.48	NS
Early embryonic mortality (%)	4.00±0.23	6.12±0.24	*
Late embryonic mortality (%)	8.00±0.46	5.61±0.40	*
Dead in shell (%)	8.00±0.24	7.08±0.46	NS
Mortality (%)	4.00±0.23	1.83±0.05	*
Live weight of DOC (g):			
Male	27.3±0.35	24.88±1.08	*
Female	20.25±0.25	21.23±1.00	**NS**

*$^{@}$Incubated artificially; Values are expressed as mean ± standard error of means; NS, Statistically not significant (P>0.05); * Statistically significant (P<0.05)*

A significant difference was observed in the age of sexual maturity, with RJFs reaching maturity later than INNs (P<0.05). This delay is in the agreement with classical findings by Collias and Saichuae (1967), who described the seasonal and extended juvenile periods in wild *Gallus gallus*. Delayed maturity, although a disadvantage in intensive systems, may be biologically linked to enhanced genetic fitness and longevity (Sotirov *et al.*, 2002).

Egg production in RJFs, although numerically lower, did not differ significantly from that of INNs (P>0.05). More importantly, RJFs demonstrated reproductive viability, with a fertility rate of 76.00% under controlled environments when supported by appropriate nutrition and housing (Wilson, 2008).

Hatchability percentages in RJFs were close to those of INNs, yet occasional embryonic mortality was detected at both early and late stages. Factors such as shell porosity, incubation temperature, and genetic load could contribute to such embryonic loss (Francisco and Espina, 2015). Improved incubation practices and possible genetic screening could enhance hatchability outcomes in future conservation programs.

Egg Quality Parameters

Table 4 presents a comparative analysis of egg quality traits between RJFs and INNs. RJFs laid smaller eggs but with superior internal and structural quality. Their Haugh unit scores were significantly higher (P<0.05), indicating better albumen integrity, a key trait for embryo development and egg freshness (Haugh, 1937).

Table 4: External and internal qualities of eggs of RJF and INN chicken

Parameters	**RJF**	**INN**	**Significance**
External characters			
Egg weight (g)	33.21±1.23	38.29±2.03	*
Egg length (mm)	48.40±3.28	52.44±3.54	*
Egg width (mm)	37.48±2.88	37.35±2.56	NS
Shape Index (%)	77.43±4.06	71.51±4.98	*
Egg surface area (cm^2)	47.10±3.02	68.03±3.84	*
Shell weight (g)	4.49±0.30	4.55±0.23	NS
Shell thickness (mm)	0.32±0.02	0.35±0.02	NS
Shell ratio (%)	13.51±0.04	11.89±0.68	NS
Internal characters			
Albumen length (mm)	82.85±4.37	80.59±3.29	NS
Albumen width (mm)	62.23±2.96	63.62±3.36	NS
Albumen height (mm)	04.22±0.12	03.75±0.11	NS
Albumen weight (g)	19.01±1.21	20.94±1.03	NS
Albumen Index (%)	06.74±0.23	05.24±0.35	NS
Albumen ratio (%)	61.63±2.85	54.72±1.96	*
Haugh Unit	71.98±4.72	66.13±5.52	*
Yolk length (mm)	40.10±2.05	38.09±2.21	NS
Yolk width (mm)	36.09±1.86	37.10±1.98	NS
Yolk diameter (mm)	36.74±2.30	37.59±2.34	NS
Yolk height (mm)	12.10±0.29	15.06±0.59	NS
Yolk weight (g)	11.71±0.12	12.81±0.34	NS
Yolk Index (%)	38.51±2.05	39.85±3.08	NS
Yolk ratio (%)	32.39±1.55	33.40±2.09	NS
Yolk Albumen ratio (%)	59.87±2.48	60.04±3.67	NS

*Values are expressed as mean ± standard error of means; NS, Statistically not significant (P>0.05); * Statistically significant (P<0.05)*

Although RJF eggs had slightly thinner shells (0.32 mm) compared to INNs (0.35 mm), their overall egg structure, including a higher Haugh unit and better albumen quality, indicates superior internal egg quality and resilience. Stronger shells may compensate for smaller size by increasing hatchability and resistance to handling during incubation and transport (Francisco and Espina, 2015). These features enhance their market value in niche sectors focused on traditional or organic poultry products.

While the smaller egg size of RJFs may be seen as a production constraint, the nutritional quality, freshness, and hatchability potential present compelling arguments for their inclusion in breeding programs targeting quality over quantity.

Implications for Conservation and Poultry Improvement

The study demonstrates that RJFs, despite slower growth and delayed sexual maturity, possess traits that are highly favorable for both conservation and future breeding initiatives. Their reproductive performance, under managed conditions, is encouraging and may be improved with further refinements in husbandry, artificial insemination, and feeding protocols.

Their distinct genetic identity, demonstrated by unique phenotypic and behavioral traits, is valuable for preventing genetic homogenization and preserving biodiversity. As emphasized by Romanov and Weigend (2001), integrating indigenous and wild poultry in breeding frameworks is essential to buffer against environmental stress and emerging diseases in intensive poultry systems.

Selective breeding programs could be tailored to enhance body weight and reproductive traits in RJFs without diluting their genetic distinctiveness. Furthermore, their potential contribution to smallholder systems should be investigated, particularly under free-range and organic production models where natural behaviors and adaptability are assets rather than limitations.

RJFs may also serve as sentinel or base populations for rewilding, ecological research, and heritage conservation programs. With the right policy and scientific framework, captive breeding and reproductive optimization of RJFs could play a key role in poultry sustainability and rural development in Bangladesh and beyond.

Conclusion

RJFs in captivity exhibit viable productive and reproductive traits, supporting their conservation and potential use in sustainable poultry farming. Despite lower egg production, their high fertility and superior egg quality make them valuable genetic resources. Future studies should focus on selective breeding to improve performance without compromising genetic diversity. Conservation efforts integrating RJFs into breeding programs can contribute to the preservation of indigenous poultry breeds, ultimately benefiting both biodiversity and rural farming communities. Additionally, further research into the economic feasibility and long-term sustainability of RJF farming could provide valuable insights into their genetic contribution, ecological adaptability, and potential economic roles in the poultry industry. This research supports the inclusion of RJFs in national genetic conservation programs and suggests their utility in diversifying poultry production systems.

Authors' Contribution

All authors contributed equally at all stages of research and manuscript preparation. Final form of manuscript was approved by all authors.

Conflict of Interest

Authors declare there is no conflict of interest for the present publication.

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