Journal for Nature Conservation xxx (xxxx) 126821

Contents lists available at ScienceDirect

Journal for Nature Conservation

journal homepage: www.elsevier.com/locate/jnc

Protecting red junglefowl by preventing hybridization with domestic chickens

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ARTICLE INFO

Keywords:
Poultry
Red junglefowl
Conservation
Hybridization
Breeding

ABSTRACT

The genetic integrity of the red junglefowl (*Gallus gallus*), the wild ancestor of domestic chickens (*Gallus gallus domesticus*), is under threat due to increasing hybridization with domesticated breeds. This issue has significant ecological and conservation implications, as hybridization diminishes the genetic diversity of red junglefowl, essential for species survival. The loss of this genetic pool also compromises the potential for future genetic improvements in domesticated chickens. Addressing this problem requires urgent, coordinated efforts, including policy interventions and conservation strategies. This paper highlights the genetic, ecological, and regulatory challenges posed by hybridization and calls for action to protect the genetic distinctiveness of red junglefowl, ensuring both species' long-term viability.

1. Introduction

The erosion of genetic diversity in livestock and poultry is a pressing concern for global agriculture, as highlighted by the Food and Agriculture Organization of the United Nations (Fulton and Delany 2003). Each year, billions of domesticated chickens are hatched to meet global food demands, but the loss of genetic diversity in both industrial and locally adapted breeds, as well as in the wild red junglefowl—the ancestor of domestic chickens—is often overlooked (Fulton and Delany 2003). A critical issue is the increasing interbreeding between domestic chickens (*Gallus gallus domesticus*) and red junglefowl (*Gallus gallus*), which compromises the genetic integrity of the latter, posing serious ecological and conservation challenges (Peters et al. 2022; Tixier-Boichard 2020). This hybridization not only threatens the survival of red junglefowl but also impacts the future genetic improvement of domesticated chicken breeds for human consumption (Peterson and Brisbin 1998; Wu et al. 2020). This paper explores the genetic, ecological, and policy dimensions of this hybridization, underscoring the need for urgent and coordinated actions to safeguard the genetic distinctiveness of red junglefowl.

2. The genetic consequences of interbreeding

Red junglefowl, native to the tropical and subtropical forests of Southeast Asia (Fig. 1), are the wild ancestors of domesticated chickens (Fulton et al. 2004; Hata et al. 2021; Rubin et al. 2010). They serve as crucial genetic reservoirs for poultry breeding, offering traits such as disease resistance, adaptability, and enhanced productivity (Tixier-Boichard 2020). Preserving these wild populations is vital for improving the resilience and sustainability of poultry, supporting global food security, and adapting breeding programs to meet evolving environmental and market demands (Fulton and Delany 2003).

However, interbreeding between domestic chickens and red junglefowl has become increasingly common, particularly in Southeast Asia, where red junglefowl are native. In Thailand, for example, many agencies release wild chickens raised in captivity back into the wild each year, which may has led to significant hybridization with wild red junglefowl (Rubin et al. 2010). While these agencies have publicized the need for genetic testing before release, these measures are often questioned and met with scepticism (such as https://greennews.agency/?p=24965). This highlights the critical issue of genetic contamination between wild and domestic chickens. Similar instances have been documented in Peninsular Malaysia (Desta 2019), Java Indonesia (Kawabe et al. 2014), northeastern India (Thakur et al. 2018), Sri Lanka (Hata et al. 2021) and Philippines (Compendio 2022; Compendio and Nishibori 2021). Red junglefowl were threatened by habitat destruction, poaching, egg collection, predation, and genetic hybridization (Ali et al. 1987; Peterson and Brisbin Jr 1998). In Singapore, a city-state, red junglefowl have been observed in various parts of the country over the past 26 years, particularly in forested areas and nature reserves such as Pulau Ubin and Bukit Timah Nature Reserve (Wu et al. 2020). However, rapid urbanization has fragmented their habitat, increasing the likelihood of interactions between wild red junglefowl and domestic chickens, which are often kept as pets rather than for egg production. The resulting hybrids often display mixed traits, such as varied plumage patterns, feather and leg colours (Desta 2019; Rubin et al. 2010; Wu et al.

https://doi.org/10.1016/j.jnc.2024.126821
Received 8 November 2024; Received in revised form 27 December 2024; Accepted 30 December 2024
1617-1381/

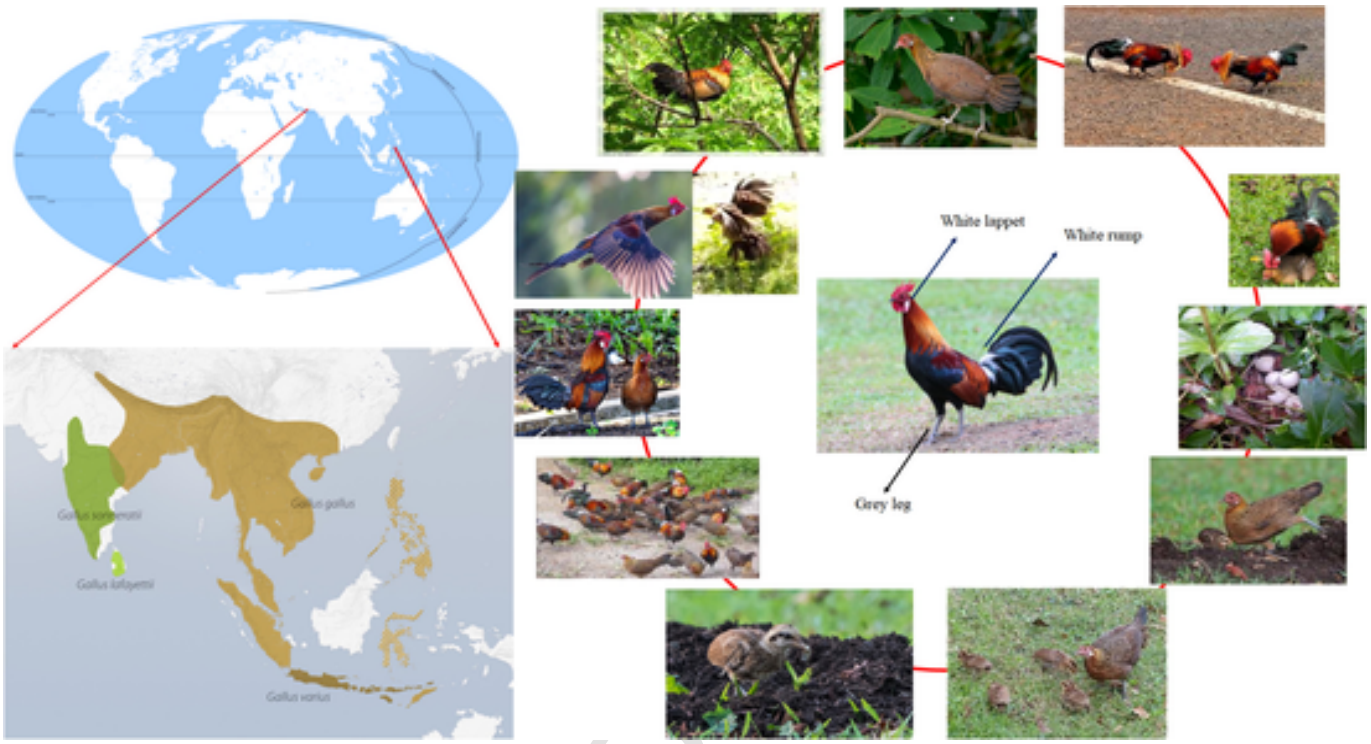

Fig. 1. Natural distribution (Left) and life cycle (Right) of the red junglefowl in the wild. The red junglefowl is native to the tropical and subtropical forests of Southeast Asia, including Malaysia, Indonesia, Singapore, Thailand, Cambodia, India, China and Bangladesh. It thrives in dense vegetation near water sources. The life cycle starts with the breeding season in spring, followed by egg-laying and a 21-day incubation period. Chicks are precocial, hatching with down feathers and the ability to forage. They reach maturity in about five months, living in small, hierarchically-structured groups. Adults are ground-dwellers by day, roosting in trees at night, and males may engage in combative behavior to establish dominance.

2020) (Fig. 2). Therefore, it is reasonable to speculate that in other countries where the wild red junglefowl is native, interactions between wild red junglefowl and domestic chickens are common, leading to a particularly high occurrence of hybrids. This phenomenon raises growing concerns for conservation efforts.

Domestic chickens are sometimes released into the wild due to abandonment, escape, small scale farming of domestic chickens in developing countries, or cultural practices, leading to encounters with wild red junglefowl (Delany and Cox 2006; Desta 2019; Hata et al. 2021; Rubin et al. 2010; Wu et al. 2020). Whole genome sequencing of these populations, anchored to museum samples from Peninsular Malaysia collected 110–150 years ago, reveals a feral–wild genomic continuum with varying levels of domestic introgression across different subpopulations in Singapore (Wu et al. 2020). As wild populations acquire more domestic chicken DNA, they risk losing their genetic diversity, reducing their resilience to environmental changes. These hybrids, with their mixed physical traits, pose a significant risk to the genetic integrity of purebred red junglefowl, raising critical questions about conservation strategies and the need for policy interventions.

3. Ecological and conservation implications

The ecological consequences of interbreeding between domestic chickens and red junglefowl extend beyond the genetic dilution of wild populations (Wu et al. 2020). Red junglefowl play integral roles in the ecosystems they inhabit, contributing to seed dispersal, insect control, and maintaining the balance of various trophic interactions (Peterson and Brisbin 1998). The introduction of hybrid individuals with altered behaviours and reduced fitness could disrupt these ecological functions, leading to unforeseen consequences for the broader ecosystem.

Human activities such as habitat destruction, poaching, and the illegal pet trade have already placed considerable pressure on red junglefowl populations (Singchat et al. 2022). The added threat of genetic dilution through interbreeding exacerbates these challenges, making it even more difficult to conserve and restore healthy populations of red junglefowl. The loss of these birds could have cascading effects on the ecosystems they support, highlighting the urgent need for conservation action.

4. Policy implications and recommendations

Addressing the issue of interbreeding between domestic chickens and red junglefowl requires a multifaceted approach involving conservation organizations, governmental agencies, poultry breeders, and the public. The following policy recommendations are proposed to mitigate the threats posed by interbreeding and preserve the genetic integrity of the red junglefowl:

4.1. Establishing protected areas and conservation programs

Creating protected areas where purebred red junglefowl populations can thrive without the threat of interbreeding is essential (Delany and Cox 2006). These areas should be managed to minimize human interference and protect the natural habitats of red junglefowl. Additionally, targeted conservation programs should be developed to monitor and support these populations.

4.2. Educating poultry breeders, farmers, and chicken hobbyists

Public awareness campaigns and educational programs should be implemented to inform poultry breeders, farmers, and the public about

Fig. 2. Phenotypic changes observed in hybrids produced by interbreeding between red junglefowl and domesticated chickens in the wild in Singapore. The black box shows, in the upper two images, the typical appearance of domesticated broilers and egg-laying hens, and in the lower three images, the typical appearance of red junglefowl. The red box highlights the first row showing mixed populations of red junglefowl and domesticated chickens in the wild, while the second to fourth rows depict altered phenotypes (e.g., white legs, white feathers) in the hybrids resulting from this interbreeding. It is critical to prevent the inbreeding between domesticated chickens with the red junglefowls to avoid the threat to the genetic integrity of the red junglefowl.

the risks of interbreeding and the importance of maintaining the genetic purity of red junglefowl (Ardoin et al. 2020). These programs should promote responsible breeding practices and encourage the separation of domestic chickens from wild populations.

4.3. Regulating the trade and release of domestic chickens

Governments should enforce stricter regulations to prevent the illegal trade and release of domestic chickens into areas inhabited by red junglefowl as done for conservation of other endangered animal species (Rivera et al. 2021). This could include imposing fines and penalties for those caught releasing domestic chickens in protected areas or regions where red junglefowl are known to exist. Additionally, relevant guidelines from the International Union for Conservation of Nature (IUCN) on the rehabilitation and release of wild animals back into their natural habitats should be considered (Phillips and Union 2002). These guidelines emphasize the importance of preserving genetic purity and ensuring that released animals do not pose a threat to the survival or genetic health of native species.

4.4. Genetic monitoring and research

Ongoing genetic monitoring and research are crucial for assessing the extent of hybridization between domestic chickens and red junglefowl (Kawabe et al. 2014; Wu et al. 2020). This research should focus on identifying at-risk populations, understanding the genetic consequences of interbreeding, and developing strategies to mitigate these effects. Collaboration between geneticists, ecologists, and conservationists will be essential in this effort.

4.5. Restoring natural habitats

Efforts to conserve and restore the natural habitats of red junglefowl should be prioritized (Delany and Cox 2006; Singchat et al. 2022). Habitat restoration projects can reduce the likelihood of contact between domestic chickens and wild populations, thereby minimizing the risk of interbreeding. These projects should also consider the broader ecological context, ensuring that red junglefowl have access to the resources they need to survive and thrive. Unfortunately, to date, no conservation program has been established for red junglefowl.

5. Integrating science and policy

The issue of interbreeding between domestic chickens and red junglefowl exemplifies the complex interplay between science and society (Martin et al. 2016). Effective policy responses must be informed by scientific research, yet also consider the socio-economic realities of the communities involved (Ghimire and Pimbert 2013). For instance, in regions where poultry farming is a primary source of livelihood, policies must balance conservation goals with the needs of local farmers. This could involve providing incentives for responsible breeding practices or developing alternative income-generating activities that reduce pressure on wild red junglefowl populations.

Moreover, the global nature of the poultry industry (Mottet and Tempio 2017) means that international cooperation is crucial for addressing this issue. Cross-border trade and the movement of domestic chickens pose a significant risk to the genetic integrity of red junglefowl in multiple countries. International agreements and collaborations between conservation organizations, governments, and the private sector can help standardize regulations and promote best practices for preventing interbreeding.

6. Conclusion

The interbreeding between domestic chickens and red junglefowl presents a significant threat to the genetic integrity of the red junglefowl and the ecosystems they inhabit. To address this issue, a comprehensive and coordinated approach that integrates scientific research,

conservation efforts, and policy interventions is required. By taking decisive action now, we can safeguard the genetic diversity and ecological integrity of these iconic birds for future generations. This will not only benefit the species involved but also contribute to the broader goals of biodiversity conservation and sustainable development. The intersection of science and society in this context highlights the importance of informed policy-making that considers both the scientific evidence and the socio-economic realities of the communities affected.

CRediT authorship contribution statement

Gen Hua Yue: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

All data are form cited papers.

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