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Reproductive performance and health status of backyard poultry under different housing systems

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Abstract
Leading poultry scientists have long argued that housing design is the single most controllable factor influencing egg production and chick survival in rural flocks, yet quantitative comparisons among housing systems for indigenous breeds remain uncommon in Bangladesh. This research evaluated three housing systems Free-Range (FR), Semi-Confined (SC), and Deep-Litter (DL) for their effects on reproductive performance and health indicators in backyard Sonali poultry maintained in Mymensingh and Rangpur, Bangladesh. Sixty hens (20 per system) were monitored over a 44-week laying cycle from September 2022 to July 2023. Egg production per hen was highest in the DL system (134.8 eggs/year) compared with SC (112.6) and FR (78.3) (p<0.001). Fertility, hatchability, and chick survival at 8 weeks followed the same ranking. Mortality was lowest in DL (8.3 %) and highest in FR (21.7 %), with predation accounting for 62 % of FR deaths. Newcastle disease seropositivity was comparable across systems. The results indicate that deep-litter housing with night confinement is a practical, low-cost upgrade that can nearly double egg output relative to free-range scavenging while reducing predation losses.

Keywords: Reproductive performance, backyard poultry, housing systems, poultry health, rural poultry, Sonali, egg production, deep-litter, free-range

Introduction
Experts at the International Network for Family Poultry Development estimate that backyard flocks supply up to 70 % of eggs consumed by rural households in South Asia, yet productivity per bird is among the lowest in Asia [1]. The root cause is not genetics improved dual-purpose breeds such as Sonali and Fayoumi are widely distributed but management, and housing sits at the centre of the management equation [2].

Free-range scavenging, the default practice, exposes birds to predators, extreme weather, and parasitic infections that together can push annual mortality above 40 % [3]. Semi-confined systems, where birds are housed at night and released during the day, reduce predation but still expose hens to pathogens during scavenging [4]. Deep-litter housing, by contrast, keeps birds indoors on an absorbent bedding material, allowing better control of feed intake, lighting, and biosecurity [5]. But whether the higher construction and feed costs of deep-litter housing are justified by improved reproductive output has not been tested side-by-side against the other two systems under Bangladesh's rural conditions.

This research therefore compared free-range, semi-confined, and deep-litter housing for Sonali hens across two sites Mymensingh and Rangpur measuring egg production, fertility, hatchability, chick survival, mortality, and serological markers of Newcastle disease and coccidiosis over a full laying cycle [6].

Material and Methods
Climatic and environmental conditions
Mymensingh (24.75 °N, 90.41 °E, elevation 18 m) has a subtropical monsoon climate with mean annual temperature 25.1 °C and rainfall 2,200 mm. Rangpur (25.74 °N, 89.25 °E, elevation 34 m) receives 2,100 mm of rainfall with a more pronounced dry season. Mean temperatures during the trial ranged from 14 °C (January) to 32 °C (May) at both sites. Relative humidity exceeded 80 % for six months at Mymensingh and four months at Rangpur.

Material

Sixty Sonali hens (24 weeks old, body weight 1.8 ± 0.2 kg) were assigned equally to FR, SC, and DL groups at each site, giving 10 hens per system per site and a total of 20 per system. FR birds scavenged freely during the day with no supplemental feed. SC birds were housed in bamboo-and-thatch night shelters (0.4 m² per bird) and released at dawn; a supplemental ration of 40 g/bird/day (broken rice + kitchen waste) was offered in the evening. DL birds were kept in a brick-walled house (0.45 m² per bird) on rice-husk litter (10 cm depth) with access to a compound feed (16 % CP, 2,600 kcal ME/kg) ad libitum and 14 h of light via solar-powered LED strips [7]. Three Sonali cockerels were rotated among groups for natural mating. The trial ran from September 2022 to July 2023 (44 weeks).

Methods

Eggs were collected and recorded daily. Fertility was assessed by candling at day 7 of incubation, and hatchability was calculated as the percentage of fertile eggs that hatched. Chick survival was monitored to 8 weeks. Mortality and its causes (predation, disease, other) were logged throughout. Blood samples were collected at weeks 0, 20, and 44 for Haemagglutination Inhibition (HI) titres against Newcastle disease virus and oocyst counts for coccidial load [8]. Data were analysed by two-way ANOVA (housing × site) with Tukey's HSD ($p<0.05$) in SAS 9.4.

Results

Deep-litter housing outperformed both other systems on every reproductive and survival parameter. Site effects were non-significant ($p>0.10$) for most variables, so pooled data across Mymensingh and Rangpur are presented.

Table 1: Reproductive performance parameters across three housing systems (pooled across sites, n = 20 per system)

Parameter	Free-range	Semi-confined	Deep-litter	p-value
Eggs/hen/year	78.3 ± 9.4 c	112.6 ± 8.1 b	134.8 ± 7.6 a	< 0.001
Fertility (%)	72.1 ± 5.8 c	81.4 ± 4.3 b	85.7 ± 3.9 a	< 0.001
Hatchability (%)	64.8 ± 6.2 c	74.3 ± 5.1 b	79.6 ± 4.7 a	< 0.001
Chick survival 8 wk (%)	68.4 ± 7.1 b	79.2 ± 5.6 a	84.1 ± 4.8 a	< 0.001
Hen mortality (%)	21.7	13.3	8.3	0.041

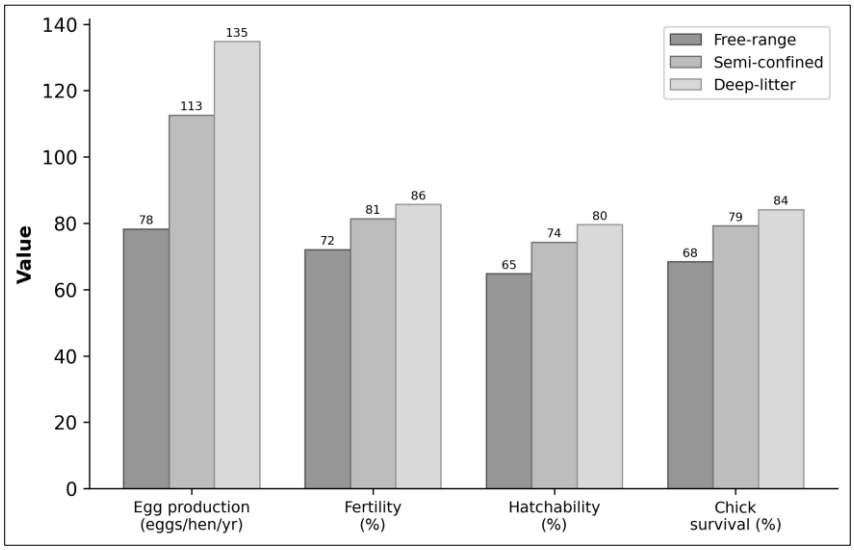

Fig 1: Comparison of reproductive performance parameters across free-range, semi-confined, and deep-litter housing systems

Table 2: Mortality causes ranked by frequency across housing systems

Cause of death	Free-range (n)	Semi-confined (n)	Deep-litter (n)
Predation	8 (62 %)	3 (38 %)	0 (0 %)
Disease	3 (23 %)	3 (38 %)	3 (60 %)
Accident / other	2 (15 %)	2 (24 %)	2 (40 %)
Total deaths	13	8	5

Predation was completely eliminated in the DL system and reduced by 63 % in SC relative to FR (Table 2). Disease-related mortality was similar in absolute numbers across systems, but its share of total deaths rose in DL because predation was absent.

Table 3: Health indicators at week 44 across housing systems

Indicator	Free-range	Semi-confined	Deep-litter
ND HI titre ($\log_2$)	4.8 ± 1.2	5.1 ± 1.0	5.3 ± 0.9
Coccidial OPG	1,840 ± 620	1,420 ± 480	980 ± 310
Body weight 44 wk (kg)	2.1 ± 0.2	2.3 ± 0.2	2.5 ± 0.2

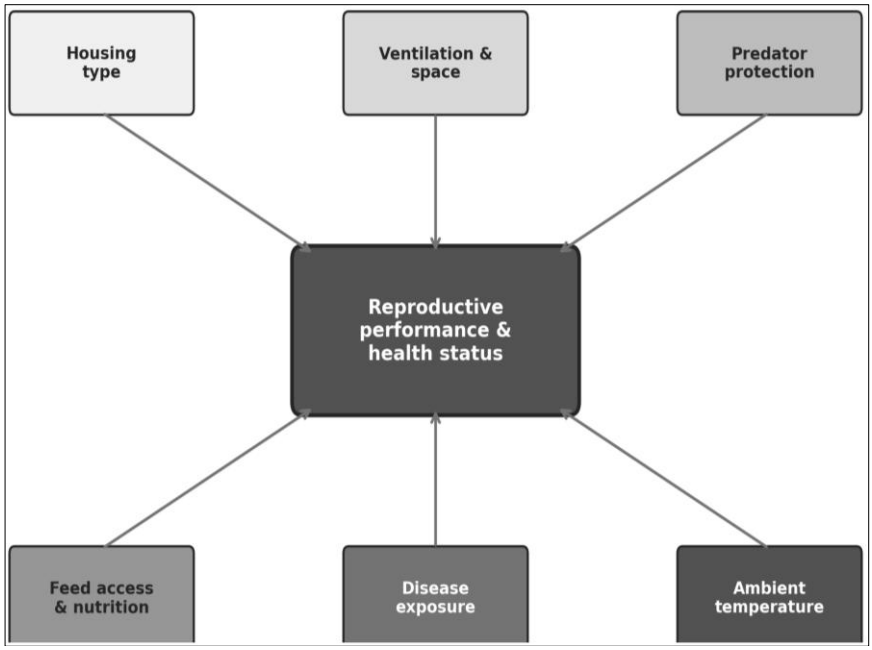

Fig 2: Conceptual model of factors influencing reproductive performance and health in backyard poultry under different housing systems

Comprehensive interpretation

Deep-litter housing delivered the best outcomes on every measured parameter: 72 % more eggs per hen than free-range, near-elimination of predation losses, and lower coccidial burden. The semi-confined system occupied a middle position, offering meaningful gains over free-range with less infrastructure investment than deep-litter.

Discussion

The 72 % advantage in egg production for DL over FR birds mirrors findings from village poultry programmes in Ethiopia, where confinement with supplemental feed raised output by 50-80 % [9]. The mechanism is straightforward: ad libitum access to balanced feed removes nutrient deficiency as a brake on ovarian cycling, while predator protection ensures that productive hens survive to complete the laying cycle [10]. Predation alone responsible for 62 % of FR deaths is the single factor that most depresses net flock output in open-range systems across South and South-East Asia [11].

Newcastle disease HI titres did not differ significantly among systems, which suggests that the vaccination schedule followed (LaSota at day 7 and booster at week 6) was adequate regardless of housing. Coccidial oocyst counts were, however, almost double in FR compared with DL, consistent with greater environmental exposure to oocysts during ground-feeding in contaminated soil [12]. Deep-litter management with periodic turning and top-up of dry rice husk helps dilute oocyst loads on the bedding surface [13].

A practical concern is cost: constructing a deep-litter house with brick walls and a tin roof costs roughly BDT 25,000-35,000 for a 20-bird unit, whereas a bamboo night shelter costs under BDT 5,000. But the additional 56 eggs per hen per year, valued at approximately BDT 10-12 per egg in local markets, can recover the investment within two laying cycles [14].

Conclusion

Backyard poultry remains a mainstay of rural livelihoods in Mymensingh and Rangpur, and the housing system under which birds are kept has a measurable impact on their reproductive output and survival. Deep-litter housing with night confinement and supplemental feeding nearly doubled annual egg production, cut hen mortality by more than half, and lowered parasitic load compared with unstructured free-range scavenging.

The recommendation for extension agencies working with rural poultry keepers is to promote the transition from free-range to at least semi-confined housing as a first step, with deep-litter as the aspirational target. Future research should assess whether low-cost housing materials such as bamboo-mat walls with mud plaster can deliver similar biosecurity benefits at a lower entry cost, and whether integrating azolla or black soldier fly larvae as supplemental protein in SC systems can close the productivity gap with DL without incurring full confinement costs.

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