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Evaluation of age at sexual maturity and body weight in direct and reciprocal crosses using CARI Nirbheek and CARI Shyama

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Abstract
A study was conducted to evaluate the effect of direct and reciprocal crossing on age at sexual maturity (ASM) and body weight in CARI Nirbheek (CN) and CARI Shyama (CS) chickens. A total of 259 female birds from four genetic groups the direct crosses (AP×CR and KN×CR) and their reciprocal crosses (CR×AP and CR×KN) were managed under standard conditions from the 20th to the 52nd week of age. Data on body weight at 20, 40, and 52 weeks, body weight gain, and ASM were collected and analyzed using one-way ANOVA. The results revealed significant differences ($p<0.05$) in body weight among the crosses at all ages. The reciprocal cross CR×AP (CARI Nirbheek × CARI Shyama) consistently demonstrated superior body weight (1485.15g, 2249.67g, and 2296.15g at 20, 40, and 52 weeks, respectively) and the highest body weight gain (764.52g from 20-40 weeks), significantly outperforming its direct cross (AP×CR) and all other groups. In contrast, no significant differences were found in the age at sexual maturity among the crosses. The study concludes that the reciprocal cross CR×AP is the most advantageous combination, yielding a significantly heavier dual-purpose bird without delaying sexual maturity, making it a superior genetic resource for enhancing meat production in smallholder poultry systems.

Keywords: Reciprocal crosses, CARI Nirbheek, CARI Shyama, body weight, age at sexual maturity

Introduction

Poultry production remains a cornerstone of global food security, providing a vital source of high-quality protein through meat and eggs. In developing countries, particularly in rural and backyard systems, the focus often shifts from specialized high-output breeds to those with robust adaptability and balanced productivity, known as dual-purpose birds (Kashyap and Goswami, 2024) [7]. These birds must strike a critical equilibrium between efficient egg production and satisfactory body weight for meat, ensuring household nutritional and economic sustainability (Verma *et al.,* 2021; Pesti and Choct, 2023) [24, 15]. Selective breeding has given rise to specialized lines optimized for either layer or broiler production (Underwood *et al.,* 2021) [23]. However, for smallholder farmers, the genetic potential of these specialized breeds is often unrealized due to challenges in management and feed resources (Vanvanhossou *et al.,* 2021) [25]. This has driven the development and promotion of indigenous or improved dual-purpose breeds that are better suited to local conditions (Kumar and Sharma, 2025; Galina and Geffroy, 2023) [9, 5]. Within this breeding paradigm, crossbreeding emerges as a powerful tool to synthesize desirable traits from distinct genetic lines, leveraging the phenomenon of heterosis or hybrid vigor to enhance productivity, survivability, and overall performance (Ullah and Waheed, 2025) [22]. The Central Avian Research Institute (CARI) in India has developed several such improved breeds, including CARI Nirbheek, a layer-type bird known for its early sexual maturity and consistent egg production, and CARI Shyama, a dual-purpose breed recognized for its higher body weight and adaptability (Balcha *et al.,* 2024) [2]. While the pure-line performances of these breeds are well-documented, the systematic evaluation of their crossbred progeny holds significant promise (Rege *et al.,* 2020) [16]. Crucially, in such crossbreeding programs, the choice of parental line used as the dam or sire is not merely a procedural detail but a decision of profound genetic consequence (Lewis, 2021) [11]. Reciprocal crosses where the breed of the sire and dam are reversed can yield markedly different outcomes due to a combination of autosomal gene effects, sex-linked inheritance, and maternal effects (Negash and Getachew, 2025) [12]. Maternal effects, encompassing factors such as egg size, maternal antibodies, and incubation behavior, are primarily conferred by the dam and can significantly influence early growth, development, and the subsequent attainment of sexual maturity in the offspring (Negash *et al.,* 2023) [13]. Therefore, a cross where CARI Shyama is the dam is genetically and physiologically distinct from one where CARI Nirbheek is the dam, even if the sire breed is the same (Riaz *et al.,* 2024) [17]. While heterosis is a key goal, the specific combining ability of these two distinct lines for critical economic traits like Age at Sexual Maturity (ASM) and Body Weight remains an essential area of investigation. ASM directly impacts the onset of income generation for farmers, while body weight at point-of-lay is a key determinant of meat yield and overall bird robustness (Abdel-Halim *et al.,* 2024) [1]. A comprehensive comparison that includes both direct and reciprocal crosses is necessary to identify the optimal parental combination (Das *et al.,* 2017) [4]. Therefore, this study was designed to systematically evaluate and compare the age at sexual maturity and body weight in the direct and reciprocal crossbred progenies of CARI Nirbheek and CARI Shyama (Kour *et al.,* 2024) [8]. The findings aim to provide empirical evidence to guide breeding strategies and offer clear recommendations to farmers on the most advantageous cross for maximizing productivity based on their specific economic goals, whether oriented towards earlier egg production or superior meat yield.

Materials and Methods

The present study was planned for study of comparative evaluation of crosses reciprocal to CARI Shyama (KN×CR) and CARI Nirbheek (AP×CR) in the Division of Avian Genetics and Breeding (AG&B), Central Avian Research Institute (CARI), Izatnagar, Bareilly-243122. Standard feeding as well as other farm management was followed in the all experimental groups of birds and timely recording of required data. A lighting schedule of 16 hour per day was given to laying birds. The birds were allowed ad libitum access of feed and remaining part of feed at next day was subtracted in to determine the daily feed consumption. Water was also given ad libitum to these birds. For production performance, daily eggs were collected twice a day and separately group wise number of eggs was recorded every day. The study was carried out from 20th week of age and was continued up to 52nd week of age.

Four genetic groups i.e. First group (G1) have 60, second (G2) have 64, third (G3) have 62 and fourth group (G4) have 73, respectively, with total 259 female birds were taken in this present experiment. The body weight was measured at 20thweek, 40th week and 52nd week of age with help of electronic weighing balance. The age at sexual maturity was measured from the date of hatch till the pullets laid their first egg.

Statistical analysis

Collected data during the study was analyzed using SPSS (20) with one-way ANOVA (Snedecor and Cochran, 1980) [21]. Significant means among groups were compared by Tukey's b test.

Results and Discussion

Body weight

The data on body weight in different genetic groups (crosses) as well as comparison between pure crossbreds and their reciprocal crosses at 20th, 40th and 52nd week are presented in Table 1. Reciprocal crosses revealed almost similar to slightly higher body weight at almost all age of measurement with respect to their counterpart crosses. The body weight of reciprocal cross CR×KN was 1405.40, 1630.44 and 1707.68 g at 20th, 40th and 52nd week of age, respectively, whereas, in its direct cross KN×CR it was 1211.55, 1569.97 and 1647.81g, respectively. Reciprocal cross CR×AP have 1485.15, 2249.67 and 2296.15 g at 20th, 40th and 52nd week of age, respectively, whereas, in its direct cross AP×CR it was 1428.15, 1830.87 and 1854.84 g, respectively. Such superiority of crossbreds over purebreds in body weight has also been reported by Sivaprasad *et al*. (2012) [20].

Body weight gain

The data on body weight gain in different genetic groups (crosses) as well as comparison between pure crossbreds and their reciprocal crosses at 20th, 40th and 52nd week shown in Table 2. Analysis of variance showing the significant differences among crosses and in their reciprocals in body weight gain. All the groups showing different body weight gain from 20th to 52nd week of age. Maximum body weight gain was recorded in 20th to 40th week of age in all groups as compare to 40th to 52nd week body weight gain. In present study, recorded weight gain in the reciprocal cross (CR×AP) have significantly (p<0.05) higher as compared to their respective counterpart cross (AP×CR) and in other hand reciprocal cross (CR×KN) have lower body weight gain as compared to their respective pure cross (KN×CR) at all ages. The present study shows close agreement with body weight gain finding of Ganeshan (2015) [6].

Body weight gain in reciprocal crosses

The body weight gain From 20th to 40th week of age in reciprocal cross CR×AP have highest gain (764.52 g) as compared to all other crosses and lowest body weight gain (225.04 g) by reciprocal crosses CR×KN. Period from 20th to 52nd week of age, the highest body weight gain was in reciprocal cross CR×AP (811g) and reciprocal cross CR×KN (302.28g) had lowest body weight gain.

Body weight gain in pure crosses

The body weight gain in respective pure cross like KN×CR and AP×CR have 358.22g and 402.72g at 20th to 40th week, respectively, and 436.26g, 426.69g, respectively, at 20th to 52nd week of age. It showed lesser body weight gain in same period as compare to their reciprocal crosses.

Age at sexual maturity (ASM)

The Mean±SE values for age at sexual maturity (days) of different crosses are given in Fig. 1. The age at sexual maturity (days) for reciprocal crosses were recorded 189.92 ±2.2 and 191.19±2.33 for CR×KN and CR x AP, respectively, which was non-significant to their counterpart cross i.e. KN×CR (188.71±2.48) and AP×CR (192.10±2.87), respectively. The ASM of present finding of different crosses is in close agreement with finding of Ganeshan (2015) [6] who reported overallASM of 181.52±1.15 days. Singh (2016) [18] recorded that crossbreds achieved sexual maturity significantly (p<0.01) earlier by 8 days as compared to the purebreds. The variation in age at sexual maturity between breed/varieties of back yard poultry were also reported by Singh (2001) [19] and perhaps varieties are to be reckoned as an important source of variations in any system of housing, feeding and management (Pal *et al.,* 2019) [14]. The observed superiority of the CR×AP cross for body weight underscores the critical role of maternal effects in poultry breeding. The CARI Shyama dam, being a heavier, dual-purpose bird, likely provided a superior maternal environment via larger egg size and nutrient reserves, conferring a lasting growth advantage to her progeny (Kurrey *et al.,* 2019) [10]. This explains the significant weight gain in CR×AP compared to its reciprocal. The absence of significant difference in ASM suggests this trait is less influenced by the dam and more by the overall genetic makeup of the cross. Thus, the CR×AP cross is optimal for maximizing meat yield (Dalal *et al.,* 2022) [3s].

Table 1: Means body weight (g) at different intervals age and Age at sexual maturity (ASM) of different crosses

Body Wt. (g)	KN×CR CARI Shyama	CR×KN Reciprocal CS	AP×CR CARI Nirbheek	CR×AP Reciprocal CN	Significant level
20 week	$1211.55^{a}\pm22$	$1405.40^{b}\pm21$	$1428.15^{b}\pm65$	$1485.15^{b}\pm17$	P< 0.05
40 week	$1569.97^{a}\pm25$	$1630.44^{ab}\pm27$	$1830.87^{ab}\pm69$	$2249.67^{b}\pm29$	P< 0.05
52 week	$1647.81^{a}\pm22$	$1707.68^{a}\pm28$	$1854.84^{b}\pm28$	$2296.15^{c}\pm28$	P< 0.05
ASM (Days)	188.71±2.48	189.92±2.2	192.10±2.87	191.19±2.33	NS

Mean values bearing different superscript in row differ significantly (P<0.05)

Table 2: Means of Body weight gain (g) different crosses from 20th to 52nd week of age

Body Wt. (g)	KN×CR CARI Shyama	CR×KN Reciprocal CS	AP×CR CARI Nirbheek	CR×AP Reciprocal CN
20-40 week	358.42	225.04	402.68	764.52
40-52 week	70.84	77.24	24.01	46.48
20- 52 week	436.26			

Mean values bearing different superscript in row differ significantly (P<0.05)

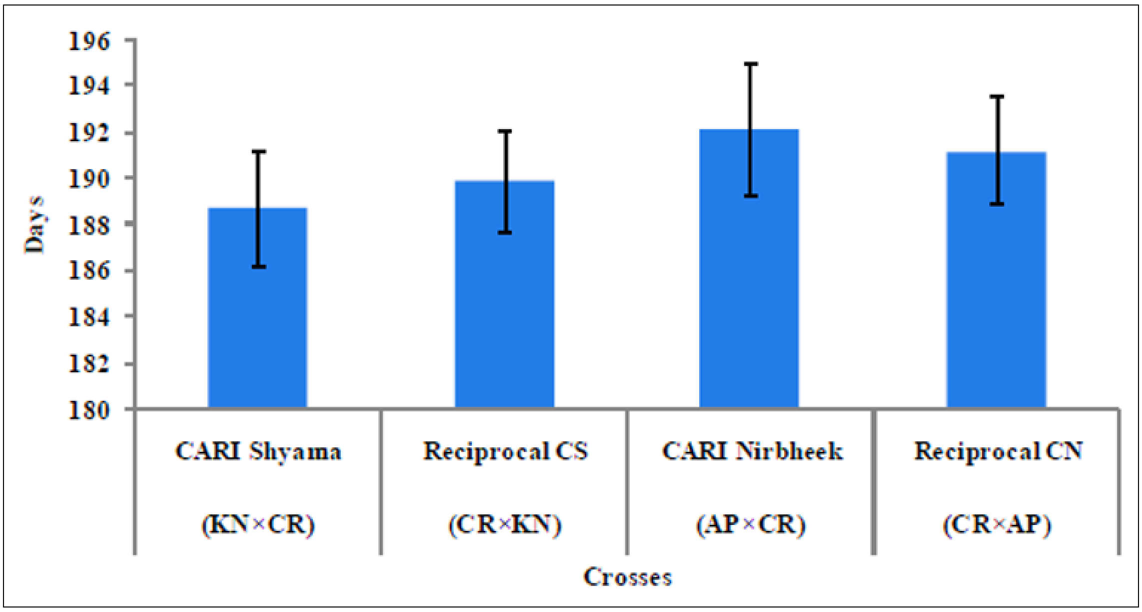

Fig 1: Graphical representation of Age at sexual maturity (ASM) of different crosses in days

Conclusion

This study evaluated the impact of direct and reciprocal crosses between CARI Nirbheek (CN) and CARI Shyama (CS) on age at sexual maturity (ASM) and body weight. Results show that reciprocal crossing significantly influenced body weight but not ASM, which remained unchanged. The reciprocal cross CR×AP was superior, achieving significantly higher body weights at 20, 40, and 52 weeks and the greatest weight gain from 20-40 weeks. This advantage is likely due to the strong maternal effects of the CS dam. For farmers prioritizing meat yield in a dual-purpose system, the CR×AP cross is the recommended genetic strategy, as it enhances body weight without delaying the onset of egg production.

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Conflict of Interest

Not available.

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