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Assessing Productive and Reproductive Performance in Kashmiri Black Australorp Chicken Over 200 Generations

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BS conceptualized the study and authored the manuscript. MIK designed the methodology and offered technical guidance for data recording. SI conducted experimental work and performed statistical analysis.

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Australorp chicken, Egg production, Egg quality traits, Dead-in-germ embryos, Productive performance, Reproductive performance

ABSTRACT

Local chicken breeds are essential genetic reservoirs with dual roles in both technical advancement of production systems and preservation of social-cultural heritage. This study focused on the Kashmiri Black Australorp (KBA) breed, which has been maintained for over 200 generations at the Government Poultry Farm Chacksagher, Mirpur, under intensive management conditions. The research assessed the productive and reproductive performances of 1050 KBA birds, which were fed a standard formulated chick mash during the initial eight weeks of brooding, followed by grower ration from nine to twenty weeks, and layers mash from twenty-one weeks onward. At 40 weeks of age, the average body weight was 2.68 kg for roosters and 2.32 kg for hens. Hens attained sexual maturity at 145.16±1.08 days, with a body weight of 1.64±0.02 kg. Throughout a 60-week period, the average egg production rate was 63.18±2.10%. The study further investigated various egg quality attributes, including weight, dimensions, shell characteristics, and internal components. Significant positive correlations were identified among age and body weight (r=0.90, P<0.0001), age and egg weight (r=0.74, P=0.002), body weight and egg weight (r=0.79, P=0.0008), and egg weight and yolk weight (r=0.96, P=0.002). Fertility and hatchability rates were 89.56±0.55% and 84.25±0.73%, respectively, for a total of 43,700 eggs. Positive correlations were observed between age and fertility (r=0.511, P=0.042), fertility and overall egg hatchability (r=0.975, P<0.0001), and hatchability of fertile eggs with that of all eggs (r=0.895, P<0.0001). In contrast, negative correlations were found between fertility and dead-in-germ embryos (r=-0.741, P=0.001), dead-in-germ embryos and hatchability of fertile eggs (r=-0.989, P<0.0001), and dead-in-germ embryos and overall hatchability (r=-0.868, P<0.0001). The study concludes that the KBA breed demonstrates enhanced dual-purpose performance, well-suited to local conditions and intensive management systems.

INTRODUCTION

The developing world's poultry industry is cognizant of the need to satisfy nutritional requirements, alleviate poverty, contribute significantly to the protein intake and ensure food security. Rapid population growth in the country has brought about increased demand for food, especially sources of proteins in developing countries. The latter is because it can help address protein malnutrition, economic empowerment of marginalized communities, and complement subsistence farming activities which remain a major practice in these nations (Usman *et al*., 2020).

Productivity in the poultry industry is closely tied to the volume of meat and eggs produced. How much meat and eggs chickens produce are very affected by the rate they mature. This growth rate varies depending on factors such as breed types, environmental conditions and is considered as an index for direct fitness in chickens. By increasing the speed at which that this growth takes place, productivity can be made more efficient while lowering overall production costs (Iraqi *et al*., 2002). Growth refers to all accumulated effects produced by harmonious work of entire animal body tissues. Housing systems, genotypes and their interaction are among other things that determine productive performance in chicken breeds (Ahmad *et al*., 2019).

A comprehensive understanding of internal and

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external egg quality characteristics is critical for producing high-quality eggs (Roberts, 2004), and for filling gaps in knowledge regarding indigenous or native breeds/strains raised in regions where genetic diversity monitoring may not be consistently emphasized (Tixier-Boichard *et al.*, 2009). It is well established that genotype and feeding practices play a significant role in egg geometry and hatching traits, however, it is equally important to note that housing systems can have a significant impact on live performance and egg quality (Chen *et al*., 2013). The egg industry places great importance on egg quality, which is driven by consumer preferences. Furthermore, the interior composition of eggs also affects hatching outcomes, particularly chick yield (Rehman *et al*., 2017).

The chicken business has been ignored and regarded as a minor agricultural subsector in Azad Jammu and Kashmir (AJK). The production of meat and eggs is not promising, thus overall returns are relatively low and won't draw high rates of investment. Poorly coordinated and planned efforts were undertaken to raise hens, but the productivity improvements were almost nonexistent (Rahman *et al*., 2003). In AJK, commercial poultry production is limited. However, rural or backyard poultry is a common practice especially in the rural communities. The people residing in urban and suburban areas like to keep the poultry in their backyard to fulfill their daily household need of eggs. The dual-purpose poultry breeds are commonly preferred to rear as backyard or rural poultry. The egg production of native breeds of AJK is very low. The Kashmiri Black Australorp is one of the dual-purpose poultry breed that farmers commonly demand because of its adoptability and scavenging nature.

Black Australorp breed was originated from Australia via selective breeding with Black Orpington. It is a heavy, soft feathered black dual-purpose breed that produces brown eggs and has dark-textured meat famous for laying more than 300 eggs per year (Marle-Köster *et al*., 2008). This breed was introduced in AJK in 1975 and since then, more than 200 generations of this breed have been produced in this region. Now this breed is termed as Kashmiri Black Australorp (KBA) due to the fact it is well adapted in cold climatic environment of AJK. Chickens may fail to achieve optimal productivity and reproductive performance when exposed to fluctuating environmental conditions like humidity, temperature, and climate (Lin *et al*., 2006). Research findings indicate that there are genetic-environmental relationships that affect the adaptation of different strains as reported by Clark and Amin (1965).

Most of the studies conducted on this breed have focused on crossbreeding it with native breeds to enhance their production performance. However, there is no study available on the adoptability of Black Australorp breed in terms of its productive and reproductive traits under local environment and management conditions of AJK. Thus, the aim of this research was to investigate the alterations in productive and reproductive performance of this breed after 200 generations under local environment and management conditions.

MATERIALS AND METHODS

To assess the performance of the Kashmiri Black Australorp chicken and its egg traits, data was obtained from the Government poultry farm Chacksagher, Mirpur. Azad Jammu and Kashmir and has been continuously bred and maintained for over 200 generations. Each generation was defined by a complete reproductive cycle from hatching to maturity and subsequent reproduction, ensuring the ongoing propagation of the breed. The farm's accurate record-keeping over the decades has ensured the integrity of the breeding process. Detailed lineage data and reproductive cycles were regularly documented, allowing for precise tracing of generational performance. This extended selection and breeding program contributed to the stable adaptation of the breed to local environmental and management conditions, particularly in terms of productivity and reproductive traits.

Intensive housing system

Standard management practices (including controlled temperature, ventilation, humidity, and an appropriate cage system with adequate floor space, light, and litter) were used to maintain the birds in the intensive system. To act as an absorbent for the fecal waste, straw was laid out on the floor. Newly hatched chicks were raised for three weeks in an electrically heated brooder. Male to female ratio was 1:10 when birds reached sexual maturity. The chicken was given a standard-formulated chick mash for the first eight weeks of brooding, grower diet for an additional nine to twenty weeks, and layers mash beginning at week twenty-one (Table I). Grower ration feed and water were freely available throughout the experiment.

Table I. Nutrient content in chicken feed.

Ingredients	Amount		
	Chicks	Growers	Layers
Crude protein (%)	20	17	17
Crude fiber (%)	6.0	6.0	6.0
Salt (%)	0.3-0.5	0.3-0.5	0.5
Calcium (%)	1.0	1.0	3.8
Metabolic energy (kcal/kg)	2970	2691	-

Study design

Body weight

The body weight of 1050 chickens of both sexes were monitored weekly from one week to 40 weeks of age, with a digital spring balance. The mean weight was then noted. The difference between the end and starting weights is the amount of weight gained (Khawaja *et al*., 2012).

Egg production traits

During the 60-weeks trial, detailed production data were systematically collected, including the age and body weight at sexual maturity, the daily count of hens alive, and the number of eggs produced each day. Eggs were gathered twice daily once in the morning and again in the evening and the total egg count was meticulously recorded. To assess the age at which sexual maturity was reached, observations were made until 50% of the flock had commenced laying eggs. This measurement provided a clear indicator of the onset of sexual maturity in the hens. The percentage of egg production was calculated using formula (Khawaja *et al*., 2012).

$$\text{Egg production (\%)} = \frac{\text{Total no. of eggs}}{\text{Live hens per day}} \times 100$$

Egg quality traits

A total of 20 eggs were selected from each poultry shed and assessed for external quality traits. The width and length of egg was measured by using vernier caliper with a minimum count of 0.05 millimeters whereas the weight was recorded by using digital balance. The colour of eggshell was evaluated by visual comparison with a standardized colorimetric chart that contains 15 different shades (1 to 15) dB. Egg shape index (SI) was determined by method given by Kumar *et al*. (2014), which involves the percentage expression of egg length by its width. The internal quality of the eggs was evaluated by examining different parameters.

Albumen and yolk height

Height of albumen and yolk was determined simply by cracking egg onto a flat surface and let it rest for five minutes to ensure natural settling. A height/depth gauge with a precision of 0.01 mm was used to measure the height of both the albumen and the yolk.

Albumen and yolk weight

The weight of the albumen and yolk was measured after manual separation. An egg separator was used to transfer the yolk into a separate container, leaving the albumen in the original container. The individual masses of the albumen and yolk were then accurately measured using an electronic digital balance with a precision of ±0.01 g (US Solid-DBS82).

Yolk colour

The colour of the yolks in the eggs was evaluated with the help of Roche colour fan, which is a standardized colorimetric system that ranges from 1 to 15. A score of 1 represents a pale yellow colour, while a score of 15 represents a deep, vivid reddish orange colour.

Haugh unit (HU)

The following formula was used for calculating the Haugh unit (Haugh, 1937):

$$HU = 100\log (AH + 7.6 - 1.7\ EW^{0.37})$$

Where, HU is the Haugh unit, AH is the observed albumen height (mm), and EW is the egg weight (g).

Fertility and hatchability

The daily collection of eggs from the aviary was carried out, and any eggs that were dirty, cracked or misshapen were eliminated during the sorting process. After that, the remaining eggs were brought to the hatchery where they were kept at a temperature of 14 to 16°C and a relative humidity of 70 to 80% for assessment of fertility, hatchability, and the percentage of eggs that had died in the shell or had dead germs (Adeleke *et al*., 2012). The eggs were then incubated automatically in accordance with standard temperature and humidity settings, which were monitored regularly (Reis *et al*., 1997). The eggs were rotated at an angle of 90 degrees in the incubator after every two hours to ensure non sticking of embryo with eggshell and even development.

On the fifth and 18th days of incubation, candling was performed to assess the stages of embryonic development. The clear eggs without an embryo and dead in shell were counted and removed.

The fertility rate was calculated following the method outlined by Khan *et al*. (2014). Eggs containing viable embryos were then carefully transferred from setters to hatchers, The incubator's settings were adjusted to the standard operational parameters specified by Reis *et al*. (1997). The hatching was observed from the 19th to 21st day of incubation. On the 21st day, the hatched chicks were removed from the incubator and counted. The percentages of fertility and hatchability for the eggs were calculated using the method described by Ahmedin and Mangistu (2016):

Fertility percentage= (Total number of fertile eggs/ Total number of eggs set) × 100

Hatchability of fertile eggs percentage = (Number of chicks hatched/ Total fertile eggs) × 100

Hatchability of total eggs set percentage = (Number of chicks hatched/ Total eggs set) × 100

Statistical analysis

The data were represented as mean values with the corresponding standard error of mean (SEM) and coefficient of variance (CV). The fertility and hatchability of eggs were analyzed as percentages. The relationship between various egg quality characteristics was determined using the coefficient of correlation (r), which was calculated with the assistance of GraphPad Prism 6.01 software (developed by GraphPad Software, Inc., San Diego, CA, USA). A significance level of P≤0.05 was set as the threshold for significance.

RESULTS AND DISCUSSION

The quality parameters of the Kashmiri Black Australorp breed were assessed using eggs collected exclusively from the Government Poultry Farm in Chacksagher, Mirpur. This location was chosen due to the uniformity in management practices, controlled environmental conditions, and long-term breeding program. These factors provide a stable and uniform setting for data collection, minimizing the potential for confounding environmental or management variables. While this is a single-site study, the farm's intensive housing system and careful record-keeping ensure that the observed quality traits are representative of the breed's genetic potential, as the breeding stock has been maintained under uniform conditions for over 200 generations.

Body weight

Live body weight of Kashmiri Black Australorp chicken from week 1-40 is summarized in Table II and Figure 1. The findings indicated that the body weight of the chickens

Fig. 1. Kashmiri black Australorp hen acclimatized in AJK.

Table II. Body weights (Mean±SEM) kg of Kashmiri BA breed up to 40 weeks.

Age in weeks	Body weight of male (kg)	Gain in body weight (male)	Body weight of female (kg)	Gain in body weight (female)
1	0.03±0.002		0.03±0.002	
2	0.05±0.002	0.02±0.004	0.05±0.002	0.02±0.004
3	0.09±0.005	0.05±0.006	0.09±0.005	0.05±0.006
4	0.15±0.006	0.07±0.009	0.15±0.006	0.07±0.009
5	0.27±0.013	0.11±0.009	0.24±0.012	0.09±0.015
6	0.35±0.013	0.08±0.021	0.31±0.011	0.07±0.016
7	0.53±0.028	0.19±0.035	0.36±0.029	0.05±0.036
8	0.57±0.029	0.04±0.037	0.44±0.021	0.09±0.039
9	0.77±0.027	0.20±0.041	0.60±0.034	0.16±0.023
10	0.92±0.041	0.14±0.053	0.70±0.037	0.10±0.044
11	0.94±0.047	0.02±0.076	0.84±0.024	0.14±0.039
12	0.97±0.042	0.03±0.063	0.85±0.022	0.01±0.006
13	1.15±0.037	0.19±0.072	0.89±0.018	0.04±0.024
14	1.36±0.064	0.21±0.064	0.92±0.009	0.03±0.011
15	1.55±0.064	0.19±0.026	1.17±0.061	0.25±0.063
16	1.66±0.084	0.11±0.081	1.26±0.052	0.09±0.030
17	1.87±0.053	0.21±0.078	1.49±0.029	0.23±0.057
18	2.16±0.041	0.29±0.063	1.51±0.042	0.02±0.035
19	2.18±0.040	0.02±0.051	1.53±0.027	0.02±0.019
20	2.24±0.075	0.06±0.078	1.54±0.023	0.01±0.041
21	2.29±0.076	0.05±0.087	1.68±0.052	0.14±0.055
22	2.32±0.042	0.03±0.085	1.70±0.048	0.02±0.070
23	2.33±0.024	0.02±0.057	1.82±0.053	0.12±0.041
24	2.34±0.041	0.01±0.054	1.98±0.067	0.16±0.081
25	2.36±0.044	0.03±0.028	1.99±0.068	0.01±0.007
26	2.37±0.036	0.004±0.028	2.03±0.043	0.05±0.068
27	2.38±0.042	0.01±0.027	2.09±0.080	0.06±0.119
28	2.42±0.021	0.04±0.035	2.14±0.050	0.05±0.081
29	2.51±0.099	0.10±0.103	2.16±0.062	0.02±0.051
30	2.61±0.033	0.09±0.103	2.17±0.070	0.02±0.063
31	2.61±0.025	0.01±0.026	2.18±0.055	0.01±0.055
32	2.61±0.029	0.0005±0.032	2.20±0.034	0.01±0.055
33	2.61±0.047	0.003±0.053	2.21±0.027	0.02±0.028
34	2.63±0.055	0.01±0.047	2.24±0.070	0.03±0.082
35	2.63±0.045	0.01±0.070	2.24±0.049	0.003±0.097
36	2.66±0.053	0.03±0.067	2.26±0.049	0.02±0.072
37	2.66±0.074	0.004±0.102	2.29±0.081	0.03±0.098
38	2.67±0.061	0.01±0.097	2.29±0.075	0.004±0.086
39	2.67±0.054	0.01±0.081	2.30±0.071	0.003±0.085
40	2.68±0.075	0.02±0.078	2.32±0.063	0.03±0.101

was found to increase gradually up to 30 weeks and after 30 weeks the weight of chicken remained almost constant. This constancy in body weight after a certain age of chicken may be due to nutrition supply in the intensive housing system. Furthermore, the birds were fed a controlled amount of feed in accordance with their age. The amount of feed was increased until week 21. After that the same amount of feed (114 g/ bird) was provided to the chickens which could have been the reason for the control in their body weights.

In comparing the average body weight of Black Australorp (BA) chickens at the 35th week of age between different studies, notable variations were observed. The current study reported an average weight of 2.63±0.045 kg in males and 2.24±0.049 kg in females, which contrasts with findings from Mori *et al*. (2020) where the average weight was 1.58 kg. Similarly, Sharma *et al*. (2021) documented higher weights of 8-week-old Black Australorp chickens in India at 1.35 kg, whereas Ramkrushna (2011) reported weights of 0.59 kg, both exceeding the weights observed in our study (0.57±0.029 kg for roosters and 0.44±0.021 kg for hens). The body weight of chickens at a particular age can serve as a predictor of growth features, as it reflects the chicken's genetic makeup and habitat-specific adaptations (Chambers, 1990). However, variations in poultry production outcomes are influenced by diverse factors including farm management practices, mortality rates, feed quality and quantity, environmental conditions such as temperature and seasonality, and the genetic composition of the chicken breeds supplied (Khawaja *et al*., 2012).

The mean values for body weight gain over 40 weeks ranged from 0.0005±0.032 kg to 0.29±0.063 kg for males and 0.003±0.097 kg to 0.25±0.063 kg for females in the Kashmiri Black Australorp (KBA) chickens. These results indicate a steady increase in body weight for both sexes of the KBA breed. In comparison, Sharma *et al*. (2021) reported specific weekly weight gains for Black Australorp chickens in India, showing increments of 0.08, 0.09, 0.11, 0.15, 0.18, 0.20, and 0.23 kg from weeks 2 to 8. Additionally, it was observed that under intensive management system, there was a continuous gain in body weight of Black Australorp chickens from 9 to 29 weeks of age (Gondwe and Wolny, 2003). The average weight of Black Australorp chicks increased more than elevenfold during the first eight weeks of life, underscoring their growth potential early in development. Additionally, sexual category was found to significantly influence body weight gain in the intensive housing systems of Black Australorp chickens (Fayeye *et al*., 2005). Significant effects of genetic groups and sex on growth have been stated by Ajayi and Ejiofor (2009).

Egg production traits

The egg production and quality traits of Kashmiri Black Australorp hens are summarized in Table III and Figure 2. The hens reached sexual maturity at approximately 145.16±1.08 days, with an average body weight of 1.64±0.02 kg at this point. The average egg production rate of hen was 63.18±2.10% over a span of 63 weeks from December to August. The performance of hen is measured by various indicators which include total egg, laying frequency and sexual maturity age (Nowier *et al*., 2018). There are several factors that can influence egg production including breed, age, condition and management practices (Rayan *et al*., 2013). Studies indicate that early maturing birds may have a shorter period of productivity than those maturing later (Adedokun and Sonaiya, 2002). In the present study, it was observed that with an increase in age there is a decreasing trend in the egg production percent among Kashmiri Black Australorp hens indicated by negative correlation (r = -0.24) between age and egg production. This therefore means that effective management practices should be adopted to enhance and sustain egg production in these hens throughout their reproductive life cycle.

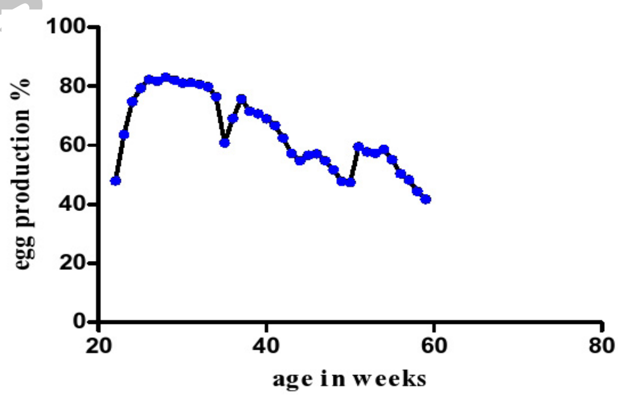

Fig. 2. Relationship between age and egg production of Kashmiri black Australorp.

Egg quality traits

The external and internal egg quality traits of KBA chickens are presented in Table III. The average egg weight for KBA chickens was found to be 49.92±0.45 g, which aligns with regional studies conducted on local and indigenous breeds in Pakistan and surrounding regions. For example, Khawaja *et al*. (2012) reported similar egg weights in Desi and Fayoumi chickens reared under local conditions in Northern Punjab. This consistency suggests that the KBA breed has adapted well to local environmental and management conditions, reflecting stable egg weight after 200 generations of breeding in AJK. Variations in

Table III. Egg production (Mean±SEM) and quality traits (Mean±SEM) in Kashmiri Black Australorp breed.

Traits	Mean±SE
Age at sexual maturity (days)	145.16±1.08
Average body weight at sexual maturity (kg)	1.64±0.02
Egg production (%)	63.18±2.10
External egg quality traits	
Egg weight (g)	49.92±0.45
Egg length (cm)	5.33 ±0.02
Egg width (cm)	4.09 ±0.01
Eggshell thickness (mm)	0.28±0.01
Eggshell weight (g)	4.65±0.04
Eggshell colour	6.20±0.48
Shape index (%)	76.87±0.23
Internal egg quality traits	
Albumen height (mm)	5.36±0.17
Yolk height (mm)	14.99±0.33
Albumen weight (g)	26.83±0.35
Yolk weight (g)	16.40±0.19
Yolk colour	8.09±0.08
Haugh unit	75.25±1.24

egg weight between different studies from other regions can be attributed to differences in management, feeding practices, and environmental conditions, which are not directly comparable to the conditions in AJK.

In terms of egg dimensions, our study recorded an average egg length of 5.33±0.02 cm and an average width of 4.09±0.01 cm, which is consistent with regional reports on other poultry breeds raised in comparable environments. The shape of an egg, determined by the ratio of length to width, is typically associated with egg weight, and our findings align with regional studies that have identified similar relationships between these traits. The eggshell quality, measured in terms of weight, thickness, and strength, is critical for commercial egg production. The average value for eggshell thickness in our study (0.28±0.01 mm) is within the range reported in regional studies, though slightly lower than what has been documented in indigenous breeds in neighboring areas. Shell strength and thickness are known to vary with environmental and genetic factors, as well as management practices, emphasizing the importance of region-specific studies in evaluating these traits. Studies conducted on local breeds in Pakistan have reported similar findings, indicating that thinner eggshells may be more susceptible to breakage, but this is a common challenge in the region due to local climate conditions and management practices (Ahmad *et al*., 2019).

Table IV. Correlation among various egg quality traits of Kashmiri Black Australorp breed.

	Age	BW	EW	EL	EWD	ESW	EST	ESC	SI	AW	AH	YW	YH	YC	HU
Age	1														
BW	0.90***	1													
EW	0.74**	0.79***	1												
EL	0.32	0.31	0.93**	1											
EWD	0.17	0.12	0.96**	0.85	1										
ESW	0.11	0.46	0.61	0.55	0.45	1									
EST	0.45	0.40	-0.13	0.20	-0.15	-0.21	1								
ESC	0.33	0.21	-0.80	-0.78	-0.72	-0.60	0.18	1							
SI	-0.56	-0.53	-0.36	-0.66	-0.19	-0.27	-0.66	0.28	1						
AW	0.51	0.71	0.75	0.72	0.62	0.88	-0.05	-0.47	-0.46	1					
AH	0.89	0.85	0.84	0.84	0.90	0.23	0.18	-0.42	-0.43	0.65	1				
YW	0.43	0.40	0.96**	0.96	0.93**	0.54	0.13	-0.67	-0.53	0.77	0.94	1			
YH	0.86	0.92	0.93	0.94	0.93	0.44	0.10	-0.61	-0.52	0.80	0.97*	0.99**	1		
YC	-0.24	-0.45	-0.58	-0.68	-0.34	-0.82	-0.04	0.61	0.69	-0.80*	-0.26	-0.56	-0.48	1	
HU	0.91	0.81	0.77	0.79	0.85	0.12	0.26	-0.31	-0.42	0.56	0.99**	0.89	0.94	-0.17	1

*P ≤ 0.05, **P ≤ 0.01, ***P ≤ 0.001. BW, body weight (g); EW, egg weight (g); EL, egg length (cm); EWD, egg width (cm); ESW, eggshell weight (g); EST, eggshell thickness (mm); ESC, eggshell colour; SI, shape index (%); AW, albumen weight (g); AH, albumen height (mm); YW, yolk weight (g); YH, yolk height (mm); YC, yolk colour; HU, haugh unit.

The mean eggshell weight for KBA chickens (4.65±0.04 g) was also consistent with findings from local studies on other breeds reared under intensive management conditions in Pakistan. While some international studies report higher eggshell weights, these differences can be attributed to variations in feed and genetic factors, which are less relevant to our regional context. The average shell color recorded in our study (6.20±0.48) aligns with local reports of light brown hues in eggs produced by dual-purpose breeds, further confirming the suitability of the KBA breed for local production. The shape index (76.87±0.23%) classifies the eggs as round, which is a common trait observed in regional poultry studies. The mean yolk and albumen heights, along with the Haugh unit (75.25±1.24), were within the range reported in studies conducted in Pakistan on other indigenous and dual-purpose breeds. Regional studies have observed similar correlations between these traits, particularly in relation to environmental factors such as temperature and feed, which are known to influence albumen quality and Haugh unit values.

The correlation analysis among various egg quality traits revealed several significant positive associations, particularly between age, body weight, and egg weight (Table IV). These findings are consistent with previous regional studies, such as those conducted by Khawaja *et al*. (2012) and Ahmad *et al*. (2019), which identified similar relationships among egg quality traits in local poultry breeds. The observed correlations underscore the importance of genetic and environmental factors in shaping egg quality traits, especially in the specific climatic conditions of AJK.

Fertility and hatchability

Out of 43,700 eggs, 4574 eggs were considered unsuitable for hatching and removed due to reasons like cracks, small size or poor quality of eggshells. The remaining 39126 eggs were considered fertile and suitable for hatching.

The mean fertility percentage for Black Australorp eggs (as shown in Table V) was found to be 89.56±0.55%. This result agrees with findings from another study for the same breed conducted in Iraq, which reported a fertility percentage of 89.93±1.01% (Mohammad *et al*., 2020). This stability across different geographic regions suggests that the fertility rate of Black Australorps remains stable irrespective of geographical location. However, the drop in fertility with age, recorded in various poultry breeds (Wen *et al*., 2022), is particularly affected by other factors related to male reproductive health. Significant aspects that influenced fertility include sperm quality and the prevalence of defective or non-viable sperm (Bramwell *et al*., 1996). These factors together contribute to the reproductive performance and fertility rates as seen in Black Australorp chickens in present and many other studies.

Table V. Percentage of fertility and hatchability in Kashmiri Black Australorp breed for year 2022.

Date of hatch	Eggs set (n)	Fertile eggs (n)	Chicks hatched (n)	Fertility (%)	Hatchability of fertile eggs (%)	Hatchability of all eggs (%)
2nd Feb	2800	2355	2165	84.11	91.93	77.32
9th Feb	2800	2415	2245	86.25	92.96	80.18
16th Feb	2800	2470	2305	88.21	93.32	82.32
23rd Feb	2700	2431	2306	90.04	94.86	85.41
2nd Mar	2650	2390	2245	90.19	93.93	84.72
9th Mar	2850	2562	2449	89.89	95.59	85.93
16th Mar	2600	2368	2254	91.08	95.19	86.69
23rd Mar	2650	2454	2323	92.60	94.66	87.66
30th Mar	2650	2442	2307	92.15	94.47	87.06
6th Apr	2800	2502	2317	89.36	92.61	82.75
13th Apr	2700	2352	2167	87.11	92.13	80.26
20th Apr	2700	2405	2253	89.07	93.68	83.44
27th Apr	2800	2537	2416	90.61	95.23	86.29
5th Apr	2800	2532	2403	90.43	94.91	85.82
11th May	2800	2570	2427	91.79	94.44	86.68
18th May	2600	2341	2224	90.04	95.00	85.54
	43700	39126	36806	89.56± 0.55	94.06± 0.29	84.25± 0.73

The average rates of hatchability for fertile eggs and all eggs set were 94.06±0.29% and 84.25±0.74%, respectively as given in Table V. The hatchability for fertile eggs and all eggs is similar reported in Iraq, where hatchability rates were 93.42±0.56% for fertile eggs and 84.03±1.04% for all eggs (Mohammad *et al*., 2020). However, a study in Malawi reported significantly lower hatchability rates, with only 48.89±0.15% of all eggs hatching (Chikomola, 2014). The stability of our results with those from Iraq showed a strong hatchability performance for this breed across different geographical locations. This consistency indicated that the Black Australorp breed maintains high reproductive efficiency despite varying geographic and environmental conditions. Nonetheless, hatchability can be influenced by several factors, including environmental conditions, genetic diversity, management practices. Addressing these factors is crucial for optimizing hatchery efficiency and improving hatchability rates in poultry enterprises. Right management of these factors can greatly improve the reproductive performance and lead to more consistent and successful hatching outcomes.

Table VI. Correlation among different hatchability traits in Kashmiri Black Australorp breed.

	Age	Egg weight	Shape index	Fertility	Dead in germ	Dead in shell	Hatchability of fertile eggs	Hatchability of all eggs
Age	1							
Egg weight	0.519	1						
Shape index	-0.224	-0.247	1					
Fertility	0.511*	0.442	-0.002	1				
Dead in germ	-0.307	-0.206	-0.303	-0.741**	1			
Dead in shell	-0.323	0.178	0.221	-0.198	0.376	1		
Hatchability of fertile eggs	0.356	0.166	0.228	0.775	-0.989***	-0.388	1	
Hatchability of all eggs	0.484	0.363	0.094	0.975***	-0.868***	-0.276	0.895***	1

*$P \leq 0.05$, **$P \leq 0.01$, s***$P \leq 0.001$.

Correlation of different hatchability traits

The analysis of various hatchability characters in this study indicated a range of correlations, ranging from -0.989 to 0.975 (Table VI). Significant positive correlations were observed between age and fertility (r=0.511, P=0.042), fertility and overall egg hatchability (r=0.975, P<0.0001), and between the hatchability of fertile eggs and all eggs (r=0.895, P<0.0001). These findings indicated that as fertility improves, there is a corresponding increase in overall hatchability and the success rate of hatching fertile eggs. In contrast, highly significant negative correlations were observed between fertility and dead-in-germ embryos (r= -0.741, P= 0.001), dead-in-germ embryos and the hatchability of fertile eggs (r=-0.989, P<0.0001), and dead-in-germ embryos and overall hatchability (r= -0.868, P<0.0001). These negative correlations indicated that a rise in dead-in-germ embryos is associated with reduced fertility and hatchability rates, highlighting the detrimental effect of embryo mortality on overall hatchability outcomes.

In current research it was found that neither fertility nor overall hatchability of eggs were significantly correlated with the shape index. This is not in agreement with previous research conducted by Verma *et al.* (2018) in Aseel and Kadaknath hens, in which a positive correlation between shape index and hatchability was observed (r=0.986) and (r=0.998). The lack of a correlation in present study suggests that egg shape may not significantly influence hatchability in Kashmiri Black Australorp hens. This result aligns with previous studies that reported positive correlations between fertility and hatchability, such as the hatchability of fertile eggs and all eggs, among various poultry breeds (Islam *et al.*, 2002). The observed positive correlation between fertility and hatchability implies that enhancing fertility rates can lead to improved hatchability outcomes. These findings highlight the complex interactions that affect reproductive performance and underline the significance of focusing factors like embryo mortality to enhance hatchability in poultry farming.

Additionally, a positive correlation between egg weight and hatchability has been identified in our study. This relationship reflects the impact of various breeding flock factors, including nutrition, age, health, and egg management practices. Many other factors such as egg weight, size, quality, and storage conditions were identified to add positively to this correlation, agrees with findings from Ng'ambi *et al.* (2013) and Tona *et al.* (2005).

An impressive productive and reproductive performance in this study was shown by Kashmiri Black Australorp, with an egg production percentage of 63.18% and a prominent lack of broodiness. This performance is substantially superior to that of indigenous chicken breeds, which usually exhibit broodiness and a lower egg production percentage (29%) (Khawaja *et al.*, 2012). This comparison underscores the efficiency of Kashmiri Black Australorps in both egg production and overall reproductive performance.

Although the current study focuses on a single location, the standardized management practices and environmental controls applied at the farm ensure that the quality parameters observed are reflective of the breed's genetic traits. Future studies could explore the performance of the breed in other environments to further validate the consistency of these findings. However, the controlled nature of this research location serves to reduce external variability, thus offering a clear assessment of the Kashmiri Black Australorp's productive and reproductive potential.

CONCLUSION

The results of present study underscore that the Kashmiri Black Australorp breed has successfully adapted to the local environment and exhibits superior productivity and reproductive performance when managed under intensive conditions. The management conditions offered on the farms are the important component to hens performing at their best. Therefore, the Kashmiri Black Australorp breed is recommended to propagate in whole state of Azad Jammu and Kashmir for livelihood generation of rural communities as a backyard poultry breed by maintaining breeding flock at government poultry farms.

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Statements of conflict of interest

The authors declare that there are no conflicts of interest associated with the publication of this study.

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