Selective Breeding to Improve Productive and Reproductive Performances and Survivability of Indigenous *Sakini* Chicken

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ABSTRACT

Indigenous chickens are quite popular in Family Poultry Production System (FPPS) in Nepal, but are constrained with their low productive performance. The present study evaluated the productive and reproductive performance of *Sakini* chicken in different filial generations and sexes. In addition, research also aimed at understanding the effect of generations on above performances. Initially, base populations (G-0) of *Sakini* were maintained by collecting eight weeks old birds from different agro-ecologial zones of Nepal. Performance of the birds of G-0 was evaluated based on weekly body weight (12-24 weeks), laying performance, fertility, hatchability, hatch weight and survivability. Selected birds of base population (G-0) were used to produce first (G-1), second (G-2) and third (G-3) generations through selective breeding in each generation. Similarly, body weights at hatching, 12 weeks, 16 weeks, 20 week and 24 weeks were significantly (p<0.001) improved from G0 to G3 and were also significantly (p<0.001) differ for sex (males were always heavier than females). Likewise, there was significant (p<0.05) improvement in egg production (per hen per year), age at first lay (days), body weight at sexual maturity, egg number and egg weight at 90 days of laying in progressive generations. Fertility, hatchability and survivability significantly (p<0.05) improved in selected generations in comparison to base population, whereas, no significant difference was obtained within the different selected population. Thus, indigenous *Sakini* chicken under this experiment performed better with respect to survivability, fertility and hatchability in later generations that provides ample scope of advancing selective breeding activities within the indigenous population in order to bring significant improvement in the overall productive performance of *Sakini* chicken in Nepal.

Keywords: Indigenous chicken, production, reproduction, *Sakini*, selective breeding

सारांश

नेपालको ग्रामिण कुखुरापालन प्रणालीमा स्थानिय कुखुरा धेरै लोकप्रिय छ । स्थानिय साकिनी कुखुराको शारिरिक तौल बढाउन र प्रजनन् क्षमतामा चल्लाको पुस्ता र लिंग जस्ता गैर-आनुबांशिक कारकहरुले पार्ने प्रभाव बारे बुभ्न नेपाल कृषि अनुसन्धान परिषद, खुमलटार अन्तर्गत पशु प्रजनन् महाशाखामा एक अनुसन्धान गरिएको थियो । यसका लागि साकिनीको आधार संख्या (जी०) तयार गर्न नेपालको विभिन्न कृषि-पर्यावरणिय क्षेत्रबाट ८ हप्ता पुगेका भाले तथा पोथी कुखुराहरूलाई संकलन गरि नेपाल कृषि अनुसन्धान परिषद अन्तर्गत बंगुर तथा कुखुरा अनुसन्धान कार्यक्रममा बिभिन्न समूहमा बिभाजन गरि राखिएको थियो । जि० का कुखुराको उत्पादन क्षमता मूल्यांकनको लागि साप्ताहिक शारिरिक तौल (विशेष गरि १२, १६, २० र २४ हप्ताको तौल), अण्डा उत्पादन, प्रजनन क्षमता, अण्डाबाट चल्ला निस्कने प्रतिशत र चल्ला जिवित रहने प्रतिशत, आदी तथ्याङ्ग संकलन गरिएको थियो । आधार संख्याबाट छनौट गरिएका कुखुराहरूबाट तीनीहरूको प्रत्येक पुस्तामा छनौटिय प्रजनन् विधी अपनाई पहिलो (जि१), दोस्रो (जि२) र तेस्रो (जि३) पुस्ता तयार गरिएको थियो । यसरी तयार गरिएका पहिलो पुस्ता, दोस्रो पुस्ता र तेस्रो पुस्ताका चल्लाहरुको तौललाई पनि थप अध्ययन गर्दा हरेक पुस्ताका चल्लाहरुको १२ हप्ता, १६ हप्ता, २० हप्ता र २४ हप्ताको तौल बीच उल्लेख्य फरक (पि.<०.००१) पाइयो । अर्को तर्फ चल्लाको बृद्धि हुने क्षमतामा लिङ्गले पनि महत्वपूर्ण प्रभाव पारेको थियो र सबै उमेर समूहका पोथी कुखुरा भन्दा भाले कुखुराको तौल बढि थियो । त्यसैगरि हरेक पुस्तामा छनौट गरि तयार गरिएका कुखुराहरुको अण्डाको उत्पादन क्षमता, फुल पार्ने उमेर (दिन), यौन परिपक्वता हुँदाको शारीरिक तौल (किग्रा), ९० दिनमा अण्डाको उत्पादन (गोटा) र अण्डाको तौल गुणहरुमा पनि उल्लेखनीय सुधार आएको पाईयो । त्यसै गरि सुरुको पुस्ता भन्दा छनौट गरिएको पछिल्लो पुस्ताका कुखुराहरुको प्रजनन् क्षमता, अण्डाबाट चल्ला निस्कने प्रतिशत र बाँच्न सक्ने क्षमतामा

पनि उल्लेखनीय सुधार भएको पाईयो । यसप्रकार, यस अनुसन्धानको नतिजाबाट स्थानिय साकिनी कुखुराहरुमा पुस्तै पिच्छे छनौट प्रजनन् बिधिको प्रयोग गरि पछिल्लो पुस्ताहरूमा चल्लाहरुको बृद्धिदर, जिवित रहने प्रतिशत, प्रजनन क्षमता, अण्डाबाट चल्ला निस्कने प्रतिशत आदि जस्ता महत्वपूर्ण आर्थिक गुणहरुमा उल्लेखनीय सुधार गर्न सकिने निस्कर्ष निकाल्न सकिन्छ ।

INTRODUCTION

Chicken is an important livestock species contributing 9 percent in Agriculture Gross Domestic Products (AGDP) and 17.4 percent of total meat production in the country. In Nepal, indigenous chicken has almost equal shares as commercial (Country Report 2014) and have been playing significant roles in fulfilling protein requirements through egg and meat (DLS 2018). Moreover, Family Poultry Production System (FPPS) has made a unique blend with other livestock rearing system in rural areas of Nepal in terms of diversifying the integrated farming. However, poor productive performance in terms of growth, egg production and egg size of the indigenous chicken (Bhurtel 1998, Tadelle et al 2000, Anjum et al 2012) are the main reason for shifting the commercial farmer's likeliness towards other dual purpose trans-boundary and/or exotic breeds thus affecting significant expansion and promotion of rearing indigenous breeds through FPPS (ABD 2018) in Nepal. Even though we cannot overlook the fact that farmers' following the traditional farming still embrace indigenous poultry breed.

There are three identified indigenous breeds of poultry such as *Sakini*, Ghanti Khuile (Naked Neck, Pwankh Ulte (Frizzled Feather) and are huge reservoir of poultry genome (Paneru et al 2016). Among the indigenous chicken, *Sakini* is the principal breed that cover more than 50% of total national poultry population. *Sakini* chicken are well-adapted from temperate high hills to tropical Terai (Country Report, 2014) and are therefore found throughout the country and are maintained in terms of static population from conservation viewpoint (Neopane and Gorkhali 2008, Country Report 2014). They have cultural and social values in different ethnic communities and religions. Moreover, indigenous chicken breeds have been reported to possess resistance to diseases and are surviving through centuries-old adaptation to local harsh environmental condition (Bhatti et al 1990). *Sakini* chickens have good scavenging ability and can also live without structured feeding (Ajayi 2010). Even within the breed, hatchability, fertility, survivability and production performance diversified depending on genetic and environmental influence (Ajayi and Agaviezor 2016). Indigenous chicken has many utility genes in their gene pool which have biologically related to the adaptation in the harsh environment thus have more survivability in the existing environment to the exotic breeds. It is therefore used for genetic exploration and moreover can be easily managed in indigenous poultry farmers (Ajayi 2010).

The productive and reproductive performances of chicken are the resultant of two major factors: one is genetic potential and the other is the environment such as feeding, health, care, shed and the ecological conditions. The genetic potential of an animal is inherited from its parents and is passed from parents to off-springs. Through simple selection, animals with targeted characters are selected and thus the high genetic merit can be passed on the future generation. When selection is done over many generations, it results in improvement of targeted traits. The possibility of improvement in production performance, hatchability, fertility and survivability of indigenous chickens through selective breeding over multiple generation has been widely reported (Gueye 1998, Sahota et al 2003, Anjum et al 2012, Islam et al 2015). With this view, a research was done to explore the genetic potentiality of indigenous *Sakini* chicken with the objective of determining the effect of selective breeding procedure to the production, reproduction along with survivability in different generations.

MATERIALS AND METHODS

Location and duration of study

The study was carried out under Animal Breeding Division, NARC in Swine and Avian Research Program (SARP), NARC, Khumaltar from March 2015 to December 2018 for three consecutive generations (G-1, G-2 and G-3) from base population (G-0). The poultry unit at SARP lies at a mean elevation of about 1350 masl. Yearly average temperature in the Khumaltar is 15 to 20°C and receives yearly average precipitation of 2000-2400 mm (SARP 2018).

Formation of base population

Eight weeks chicks were collected from three sites of different agro-ecological zones of Bagmati and Gandaki provinces. Rasuwa, Nawalpur and Chitwan districts were selected as high hill, mid hill and Tarai regions respectively. A total of 105 true to type chicks (selected on the basis of pure hen and cocks), 30 females and five males from each district were collected from ethnic communities of respective districts. The most important point considered while collecting chicks was having true to type *Sakini* breed and were from unrelated populations up to two generations. From one household, at most four females were collected and males were collected from other households far from those females and transported to the station farm. These birds were reared from eight weeks to 60 weeks of age.

The chicks were raised under deep litter system (5-8 cm of rice husk) and 3-5 birds/m^2 were kept in confinement. The chicks were fed conventional starter, grower and layer rations and standard procedure were followed with respect to preventive vaccination and medication. The chicks were provided free access to fresh and clean drinking water. A standard lighting schedule was followed (artificial light was managed during night). The eggs were collected each day and incubated in every seven days under standard incubation procedure. A total of 269 birds from parent to third generations (180 hens and 89 cocks) were evaluated. Eighty-five (85) birds were from parent base population (G-0), and 57, 53 and 74 birds were from three consequent generations, G-1, G-2 and G-3 respectively. Almost 80 percent of the total birds in each generation were retained for evaluation.

Performance recording

The parameters evaluated for the productive performance of *Sakini* breed recorded on-station were live weight (g) at 12, 16, 20 and 24 weeks, age (days) and weight at first laying (wks) at 5%, number of eggs per bird per year, egg weight and egg numbers for the first 90 days.

Fertility, Hatchability and survivability

The percent fertility and hatchability on fertile egg set were estimated using the formulae as below:

> Fertility (%) = [Number of fertile eggs/Number of total eggs set]*100
> Hatchability (%) = [Number of chicks hatched/Number of fertile eggs set]*100

Similarly,
Chick survivability up to 24 weeks and after 24 weeks (%) were analyzed using the formula
Chicks survivability (<24 wks) = [Chicks survived up to 24 wks / Total chicks hatched out] × 100
Chicks survivability (>24 wks) = [Chicks survived after 24 wks/Total chicks during 24 wks of age] × 100

Statistical analysis

All data collected were subjected to ANOVA, by applying the Mixed Model Least-Squares and Maximum Likelihood Computer Program (Harvey 1990) which is based on least squares technique of variance analysis for unequal sub-class number. Duncan's Multiple Range Test (Duncan 1955) was used to compare the means of the generations and sex for weekly weight gain and only generations for reproductive performances, fertility and hatchability. The fitted fixed effect model were as follows;

$$Y_{ijk} = \mu + a_i + bj + e_{ijk} \ldots\ldots\ldots\ldots\ldots..(i)$$
$$Y_{ij} = \mu + a_i + e_{ij} \ldots\ldots\ldots\ldots\ldots\ldots..(ii)$$

Where: Y_{ijk} = an observation (weight at day old, 12, 16, 20 and 24 weeks), u = overall mean, a_i = the fixed effect of ith generation, b_j= the fixed effect of jth sex, and e_{ijk} = random error. Equation (i) gives the least square mean for weekly weight gain with respect to two non-genetic factors such as generations and sex whereas equation (ii) only considers generation as non-genetic factors and gives least square means for reproductive performances like age at first egg, body weight at sexual maturity, egg number, egg weight at 90 days of laying and egg production (per hen per year). 8 weeks weight was assumed as covariates during analysis of 12 to 24 weeks.

RESULTS

The results on comparative production performance both in terms of body weight (g) at different weeks, egg production related traits and survivability of *Sakini* base population (G0) and their subsequent generations (G1, G2, G3) after selective breeding has been presented and discussed here under.

Growth performances

Least-square means for body weight at different ages as affected by sex and generations are presented in **Table** 1. The overall mean weight of *Sakini* chicks at hatch day (day old), 12 weeks, 16 weeks, 20 weeks (Weight at egg laying stage) and 24 weeks of age were 34.4, 1010.3, 1301.8, 1606.8 and 1792.6 g, respectively. Generations and sex were the non-genetic factors considered during the study. The results showed significant differences of body weight at different generations at day old, 12 weeks, 16 weeks, 20 weeks and 24 weeks of age. The selection imposed to the flock was positive. The result revealed that the body weight from hatch to 24 weeks increases with generations. However, the result was not significant for second and third generations for hatching upto 16 weeks of age which were significant again for 20 weeks and 24 weeks of age. Similarly, significant difference was found for sex for 12 to 24 weeks of age. Also male in all age groups had heavier body weight than females. Body weights for males for age 12, 16, 20 and 24 weeks were 1178.7, 1459.1, 1852.5 and 2048.7 kg whereas body weights for females were 841.9, 1144.6, 1361.2 and 1536.6 kgs. Selection for body weight at different ages resulted in a positive change for males and females.

Table 1. Least square means and standard error of means (LSM±SEM) for weekly body weight gain of different generations and sex of indigenous *Sakini* chicken

Factors	LSM±SEM (g)									
	Hatch wt	N	12 weeks	N	16 weeks	N	20 weeks	N	24 weeks	N
Overall Mean	34.4±0.17	209	1010.3±14.9	269	1301.8±62.1	257	1606.8±20.3	241	1792.6±22.9	228
Generations	P<0.001		P<0.001		P<0.01		P<0.001		P<0.001	
Base population (G0)	-	-	759.5±27.7^c	85	1070.9±50.4^b	83	1370.3±36.6^c	80	1570.9±35.5^d	75
G1	33.2±0.33^b	64	900.4±24.2^b	57	1159.2±53.5^b	57	1399.2±32.4^c	55	1627.8±40.1^c	52
G2	34.9±0.33^a	65	1180.2±38.1^a	53	1444.3±62.3^a	51	1641.6±36.2^b	50	1874.4±44.5^b	48
G3	35.1±0.24^a	80	1201.2±24.3^a	74	1532.9±56.1^a	66	1916.1±49.6^a	56	2097.5±52.9^a	53
Sex			P<0.001		P<0.01		P<0.001		P<0.001	
Female	-	-	841.9±17.6^b	180	1144.6±72.5^b	175	1361.2±23.5^b	167	1536.6±25.7^b	163
Male	-	-	1178.7±23.5^a	89	1459.1±38.8^a	82	1852.5±32.5^a	74	2048.7±37.2^a	66

LSM= Least square mean, SEM= Standard error of means, N= Number of observation, Means having different superscript in the same column are significantly different (P<0.01 or <0.001).

Reproductive performances

Reproductive performances such as age at first egg, body weight at sexual maturity, egg number, egg weight at 90 days of laying and egg production (per hen per year) of indigenous *Sakini* chicken for different generations were evaluated to understand the effect of selective breeding.

Least squares means and standard errors for age at first egg, egg production (per hen per year), body weight at sexual maturity, egg number and egg weight at 90 days of laying in indigenous *Sakini* chicken for G0, G1, G2 and G3 generations are presented in **Table** 2. The least square means of age at first egg (days) for generations G0, G1, G2 and G3 were 173.4, 164.7, 157.9 and 153.6 days respectively as presented in **Table** 2.

During the laying period, significant effects (P<0.001) of generations were observed. The pullets matured earlier for later generation and age at sexual maturity was 153.6 days for third generation (G3) *Sakini* chicken. Results of the present study were in line with Woldegiorgiss (2015) that in sixth generation indigenous chickens of Ethopia which started egg production at the age of 153±0.24 days with respect to the base population which was 208±2.16 days but later than commercial (125±0.14) and crossbred (141.3±0.35 days) chicken. Similarly, third generation *Sakini* chicken produced 160 eggs per year than base population that only produced 112 eggs.

Body weight at sexual maturity for selected line had positive and moderate phenotypic correlation with egg number (0.49) and egg weight at first 90 days of laying (0.68) as reported by Abdel-Ghany and Abdel-Ghany (2011). Significant differences were found between generations for body weight at sexual maturity, number and egg weight at first 90 days of laying.

Table 2. Age at first egg, body weight at sexual maturity, egg number, egg weight at 90 days of laying and egg production of indigenous *Sakini* chicken in different generations

Factors				LSM±SEM				
	N	Age at first egg (days)	N	Body weight at first egg laying (g)	Egg Number (1st 90 days) No.	Egg weight (1st 90 days) (g)	N	Egg production per hen per year (N)
Overall Mean	167	162.7±1.1	167	1365.7±41.9	27.52±0.43	45.62±0.9	160	136.7±1.6
Generations		P<0.001		P<0.001	P<0.001	P<0.001		P<0.01
Base Population (G0)	65	173.4±0.6a	65	1241.2±26.6c	23.43±0.32b	42.03±0.6c	60	111.9±1.6b
G1	41	164.7±0.8b	41	1292.2±31.7c	24.76±0.34b	45.62±0.7b	40	115.7±1.2b
G2	30	157.9±0.9bc	30	1393.6±32.2b	31.28±0.40a	46.24±0.7b	30	162.3±1.2a
G3	31	153.6±0.9c	31	1537.1±39.6a	31.73±0.41a	48.79±0.8a	30	157.5±1.1a

LSM= Least square mean, SEM= Standard error of means, N= Number of observation, Means having different superscript in the same column are significantly different (P<0.01 or <0.001).

Fertility

Results of this study revealed that overall mean fertility of *Sakini* chicken eggs was 93.4 percent (**Table** 3). Fertility significantly differed (p<0.05) with respect to selection. Accordingly, it was observed that fertility increased by 7.7, 8.3 and 8.8 percent in first, second and third generation of selection, respectively as compared to that of base population.

Hatchability

As presented in **Table** 3, the overall mean hatchability over total incubated and over total fertile eggs was determined 85.0 and 90.3 percent, respectively. Selection over the generations was found an important source of variation with respect to the hatchability over total incubated eggs (p<0.001) and hatchability over total fertile eggs (p<0.05). In each case, the hatchability was significantly higher in the hens of later generations as compared to that of base population.

Table 3. Fertility and hatchability percentage of different generations of indigenous *Sakini* chicken

Generations	Fertility (%)	Hatchability (%) over total set eggs	Hatchability (%) over fertile eggs
Overall Mean	93.4	85.0	90.3
Base population (G0)	88.0b	78.0c	88.6b
G1	94.8a	86.6b	91.3a
G2	95.3a	86.0b	90.2a
G3	95.7a	89.4a	90.9a
Level of Significance	P<0.05	P<0.001	P<0.05

Means having different superscript in the same column are significantly different (P<0.05 or <0.001).

Survivability

Overall mean survivability of *Sakini* chicken before 24 weeks and after 24 weeks was obtained 90.2 and 96.0 percent, respectively (**Table** 4). Results reflected that survivability of the chicks before 24 weeks did not significantly differ among the generations. But, survivability after 24 weeks was significantly affected by the generation between base population and generations of selection however, no significant difference was observed among generations of selection. The traits like survivability may be stabilized with few generations of selection. Accordingly, highest survivability was observed in second generation of selection followed by first and third as compared to that of base population. Similarly, sex was also found as an important source of variation with the survivability of chickens from 12-24 weeks however, survivability for male chicks after 24 weeks was unrealistic to calculate as most of the cocks were culled to maintain sex ratio in the flock (different from survivability perspective). Accordingly, higher survivability was observed for females as compared to that of male chicks.

Table 4. Survivability of indigenous Sakini chicken before and after 24 weeks of age under intensive management system

Factors	Survivability (%)	
	< 24 weeks#	>24 weeks ##
Generations		
Overall mean	90.2	96.0
Base population (G0)	89.2	91.7[b]
G1	91.2	97.5[a]
G2	90.6	98.2[a]
G3	89.2	96.7[a]
Level of significance	NS	(p<0.05)
Sex		
Female	93.9	96.3
Male	79.9	NA
Level of significance	(p<0.01)	

#= Survivability was estimated for 12-24 weeks chicks, ##=Survivability was estimated for the laying hens only as a large number of males were culled out to maintain sex ratio]; NS= Not Significant, means with the different superscripts differed significantly within the column (P<0.05 or <0.01), NA= Not applicable.

DISCUSSION

This section deals with the discussion over the results on comparative production performance both in terms of body weight (g) at different weeks, egg production related traits and survivability of *Sakini* base population (G0) and their subsequent generations (G1, G2, G3).

Improvement through selection is permanent and the result indicated that improvement can be gained within second generation for increased body weight. These results of body weight are in an agreement with the results of several researchers at different ages of local chicken strains (Abdel-Halim 1999; El-Tahawy 2000, Kosba et al 2002, Abdel-Ghany 2006, and Balat et al 2008, Abdel-Ghany and Abdel-Ghany 2011 and Sapkota et al 2013).

Decreasing the days of sexual maturity of selected line during the 1st, 2nd, 3rd generations reflected the effect of selection for high egg number. Results regarding age at first egg, egg production (per hen per year), body weight at sexual maturity, egg number and egg weight at 90 days of laying were in line with the study by El-Wardany et al (1992), Abdel-Halim (1999), Younis and Abdel-Ghany (2004), Abdel-Ghany (2006) and Aly et al (2010). This study was supported with Woldegiorgiss (2015) who observed the improved chickens produced more eggs per year (171) than unimproved that only produced 66.5 eggs. In addition, El-Dlebshany (2008) demonstrated that least squares mean of age at sexual maturity for early, medium and late sexual maturity of egg line dams were 128.5, 152.8 and 166.6 days, respectively. Similarly, average egg weight during 90 days of laying for selected line had positive and higher correlation with egg number (0.71) at first 90 days of laying as reported by Abdel-Ghany and Abdel-Ghany (2011). Body weight at sexual maturity of *Sakini* chicken in this study were also supported by El-Wardany et al (1992), Abdel-Halim (1999), Younis and Abdel-Ghany (2004), Abdel-Ghany (2006) and Sapkota et al (2017).

Fertility and hatchability traits play an important role in overall profitability. Fertility of *Sakini* chicken in present study was in accordance with the findings of Schmidt and Figueiredo (2005) who reported the fertility of white egg layer strains in different generations of selection ranging from 78.83 to 94.50 percent. However, Esatu et al (2011), reported lower fertility of Horro (77.0%), Fayoumi (81.5%), Lohmann Silver (91.35%) and Potchefstroom Koekoek (77.7%) breeds of Chicken as contrast to the results of this study. Similarly, hatchability based on total incubated eggs in present study was lower than that of indigenous chicken in Bangladesh (Islam et al 2015) however it was comparable to the hatchability of eggs in later generations of selection. Hatchability of eggs on fertile egg basis, in all four generations in this study were recorded higher than that of Azharul et al (2005) who obtained 87% for the indigenous chicken in Bangladesh on the same basis. Esatu et al (2011) suggested that fertility and hatchability can be maintained in populations under multiple trait selection through culling of paternal and maternal families with low performance. This culling only of families with low fertility and hatchability allows the breeder

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to use higher selection intensity and to obtain greater genetic progress in primary traits such as egg production (Fairfull and Gowe 1990).

Higher survivability of the female chicks as compared to that of males in this study might be due to the normal mortality of the chicks plus the effect of cannibalism among the male chicks (Scheideler 2007) under intensive management system. In line with the findings of this study, Haunshi et al (2019) observed the survivability of White Leghorn, Nicobari and Ghagus breeds of chicken as 91.6, 87.1 and 82.9 percent, respectively. However, in contrast to the findings of present study, Islam et al (2015) reported very low survivability (46.55-51.15%) of indigenous chicken In-situ reared under different breeding strategies.

CONCLUSION

The findings of this study focused with growth performance (live weight at different weeks) and reproductive traits such as age at first laying, weight at first laying, egg number, egg weight and egg production per hen per year, fertility, and hatchability of *Sakini* birds was increased in progressive generations of selection under intensive management system. Thus, the results clearly indicated that indigenous *Sakini* chicken performed better with respect to growth, survivability, fertility and hatchability in later generations suggesting the great scope of selective breeding within the indigenous population for bringing significant improvement on these economically important traits under intensive management.

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