

Native chicken production in India: present status and challenges

S Haunshi and U Rajkumar

ICAR-Directorate of Poultry Research, Hyderabad, Telangana 500 030, India
ullengala@yahoo.com

Abstract

Native chickens are the mainstay of backyard or free range systems of farming in India. They contributed about 11.5% to the total egg production of the country in the year 2019. Over the years their contribution to the total egg production is declining. Furthermore, they were neglected due to their low production potential and given least importance in the past. However, in recent years native chickens are gaining importance due to increasing demand for their meat and eggs. Consumers are willing to pay higher price for meat and eggs of native chickens due to their perceived health benefits. A total of 19 breeds were recognized and registered as native chicken breeds at breed registry (ICAR-NBAGR). They are known to be hardy, able to thrive under adverse climatic conditions and also reported to be resistant to bacterial and parasitic diseases. Studies on some of these native breeds carried out at intensive system indicated that there is high genetic diversity and they possess unique characteristics which are lacking in the improved or commercial chickens. In this paper the status of native chicken production with respect to characterization for growth and production traits, immune competence/ disease resistance carcass and meat quality traits, nutrient requirements and improvement studies and challenges to the native chicken production in the country are discussed. Authors believe this information could be useful for characterization and improvement of the performance of native chicken breeds in India and other developing countries.

Key words: *challenges, characterization, growth, native chickens*

Introduction

Traditionally, native chickens (NC) were the mainstay of poultry production in rural and tribal areas in the country. Mostly free range and backyard systems of production with little or no proper housing are followed for NC production across the country. Free range and backyard systems are of low input and low output systems. NC production is gaining attention in recent years due to higher demand for their meat and eggs. This can be attributed to their desirable flavour and perceived health benefits due to their slow growth, low fat content and lack of antimicrobial usage as growth promoters. The increasing demand of NC is particularly higher in urban areas due to the increasing purchasing power and growing population in cities.

Therefore, there is a huge scope for increasing NC production in the country as they can play a vital role in bridging the gap in the requirement and supply of poultry meat and eggs. NC possess unique attributes such as attractive multicoloured plumage, hardiness, ability to adapt to low input suboptimal rearing conditions and harsh environment, broodiness, perceived desirable taste and flavour of meat and eggs, aggressiveness to protect their young ones, higher genetic diversity, etc. Rearing of NC generates subsidiary income by utilizing minimum inputs and minimum human

attention. It also helps in women empowerment, social up-liftment and providing household nutritional security to the rural/tribal people as mostly women and children are involved in rearing. Furthermore, they cater to the needs of consumers who are willing to pay higher prices for coloured birds and light brown shelled eggs of NC.

Present status of NC in India

Egg production in the country grew at the rate of 6.16% annually from 2008-09 to 2018-19 and 8.51% in 2019 with a total of 103.32 billion eggs produced in the year 2018-19. The per capita availability of eggs in the country was 79 eggs per annum in 2019 (BAHS 2019). Native chickens (NC) contributed about 14.4% to the total egg production of the country in the year 2016. However, their contribution reduced to 11.96% in 2017, to 11.83% in 2018 and further to 11.5% in 2019 (BAHS 2019). This decline in contribution of NC to total egg production is despite the fact that the population of NC increased from 106.7 million (2016) to 109.22 million (2019). This may be due to increase in the population as well as productivity of improved commercial layers and also due to stagnation in the productivity of native chickens. The total egg production from commercial poultry is reported to be 84.91 billion and that of backyard poultry (both improved crosses and native chickens) is 18.41 billion amounting to 82.2% and 17.8% of total egg production, respectively in the country. Although the data on contribution of NC to total poultry meat production is not available but their contribution to the total meat production could have marginally increased as their population increased during the period.

Native chicken breeds

NC comprise mostly of non-descript types in the country. However, till date a total of 19 breeds have been recognized and registered as native breeds of chicken in India. They are Aseel, Kadaknath, Ghagus, Nicobari, Ankaleshwar, Bursa, Chitagong, Denki, Daothigir, Haringhatta Black, Kalashthi, Kashmir Faverolla, Miri, Punjab Brown, Tellichery, Mewari, Kaunayen, Hansli, and Uttara (<http://www.nbagr.res.in/regchi.html>). Some of the lesser known NC ecotypes such as Tripura black, Titri, Teni, Brown Desi, etc were also reported. NC with major genes of tropical adaptability features such as naked neck and frizzle genes (Frizzle fowl) are also available. Among NC most popular breeds are Aseel, Kadaknath, Ghagus and Nicobari. These breeds are witnessing high demand due to their unique attributes. Some of the important NC breeds mentioned below were characterized in detail for production traits.

1. Aseel: It is the most popular breed of India and it is known for aggressive behaviour, fighting quality and majestic gait. Its breeding tract is located in coastal Andhra Pradesh, Chhattisgarh states. Seven varieties of Aseel breed such as Peela (Golden red), Yakub (black and red), Nurie (White), Kagar (black), Sabja (white and golden or black with yellow or silver), Teekar (brown) and Reza (light red) were reported (Panda and Mohapatra 1989). Furthermore, farmers of coastal Andhra Pradesh rear different ecotypes of Aseel breed and such ecotypes of Aseel breeds were recently collected from their home tract and are being characterized and conserved under semi-intensive system of rearing at ICAR-Directorate of Poultry Research (ICAR-DPR), Hyderabad. The annual egg production of Aseel breed was 64 eggs (Rajkumar et al 2017).

2. Kadaknath: This breed is also known as '*Kalamashi*' in Hindi due to its black coloured flesh. This black colour is due to hyperpigmentation associated with fibromelanosis (Fm) gene (Arora et al 2011). In this breed all body parts including blood and flesh are black in colour. Three varieties of this breed were reported viz., Jet black, Golden and Penciled based on plumage colour pattern. The home tract of this breed is in *Jhabua* and *Dhar* districts of western Madhya Pradesh. The meat of this breed although appears to be repulsive for sight has delicious flavour (Panda and Mohapatra 1989) and is reported to have high protein (22 to 25%) content (Mohan et al 2008; Haunshi et al 2013). Its body size is small. The annual egg production of Kadaknath was in the range of 93.6 to 105 eggs (Singh and Prasad 2005, <http://www.icar.org.in/cari/native.html>).

3. Ghagus: It is a medium sized bird with good mothering ability and broodiness character. Male birds of this breed are morphologically characterized by the shining bluish black feathers on breast, tail and thighs. Neck is covered with golden yellow feathers. Female birds have mostly brown coloured plumage. (Haunshi et al 2015a). Its native tract is located in Kolar district of Karnataka and border areas of Andhra Pradesh and Karnataka (Anonymous 2011). They are known for high incidence of broodiness (Up to 66% of the flock) and good fertility (91.5%) and hatchability (90.8% on fertile eggs set). Annual egg production recorded was 116 eggs with egg weight of 47.62g at 72 weeks of age (Haunshi et al 2019b).

4. Nicobari: Nicobari breed was evolved by the Nicobari tribes in the Nicobar group of Islands. They were mostly reared in free range conditions by the tribal people. They are brownish matty coloured, medium sized birds with compact body, short legs, single comb and pink or red coloured wattles. They have short and thick necks, bulged breast and long saddle feathers. Nicobari fowls are classified as dwarf birds with short shank of 3.7 cm length at 10 weeks of age (Chatterjee and Yadav 2008). Annual egg production recorded was 169.1 with egg weight of 46.16g at 72 weeks of age (Haunshi et al 2019b).

5. Miri: These are small sized compact birds reared mainly by Miri (Mising) tribes of Assam. Its native breeding tract is located in upper Assam districts. Egg production up to 40 weeks of age was 33.59 eggs with egg weight of 38.67g at 40 weeks and age at first egg of 147 days. Body weight at 40 weeks of age was 1507 and 1214g respectively in male and female birds (Haunshi et al 2009).

6. Mewari: The home tract of this breed is Mewari region of Rajasthan. Mewari breed is light to dark brown colour plumage with long arching tail feathers, single comb and yellow shank and skin. Adult weight is about 1.9 kg in cocks and 1.2 kg in hens. Annual egg production ranges from 37 to 52. Egg weight is about 53 g (Yadav et al 2017).

7. Hansli: This breed is predominantly reared in *Mayurbhanj* and some parts of *Keonjhar* district of Odisha. Birds of this breed phenotypically resemble to Aseel breed. The 20 weeks body weight of male and female birds was reported to be 1629 and 1318g respectively (Behera et al 2017).

8. Uttara: It is the latest breed to be registered in breed registry of NBAGR, Karnal. Its native tract is located in hill districts of Uttarakhand state. It has black coloured plumage, feathered shanks, single comb and white skin. The twenty weeks body weight was 1295 and 1129g in male and females respectively. They produce about 137 eggs in a year (Kumar et al 2018).

Characterization and conservation of NC breeds

Registered NC breeds are characterized and conserved to prevent further loss of genetic diversity and some native breeds are being improved. In situ conservation is the most ideal and preferred method of conservation of biodiversity of any germplasm. However, due to increasing urbanization there is increasing pressure on agricultural land leading to high cost involvement and hence it is becoming difficult to conserve some of the NC breeds at their native tracts. Therefore, *in vivo-ex-situ* conservation of NC available across the country needs to be taken up for conservation and utilization purposes. Identification, characterization and registration is a continuous process as newer breeds are being identified and registered as per the ICAR-National Bureau of Animal Genetic Resources guidelines (<http://www.nbagr.res.in/guidelines.html>). It is pertinent to survey, collect and characterize the NC from remote, hilly, forest and tribal areas where no exotic crosses are introduced so far to identify newer breeds or ecotypes of NC.

Molecular characterization of NC breeds

Studies on characterization using microsatellite based markers revealed high level of genetic diversity (Chatterjee et al 2015) in NC breeds. Whole genome and mitochondrial genome of recognized NC breeds need to be studied using latest technologies such as next generation sequencing to

unravel the genetic diversity of NC breeds at single nucleotide level (SNPs) or copy number variations (CNVs). Whole genome sequencing of the Aseel breed revealed the existence of about 23,000 genes in its genome (Bhattacharya and Chatterjee 2014). Furthermore, NC breeds need to be characterized for immune competence, disease resistance, carcass/meat quality, nutrient requirements, heat tolerance, etc.

Status of immune competence/disease resistance

NC is known to be hardy, able to thrive under adverse climatic conditions. They are also reported to have resistance to bacterial, protozoal, fungal and parasitic diseases (Besbes 2009). Nicobari fowls are reported to be relatively resistant to Newcastle disease, Marek's disease (Rai and Ahlawat 1995) and infectious bursal diseases (Sunder et al 2004, Chatterjee and Yadav, 2008). The systematic experiments through challenge studies to determine the resistance to specific bacterial, viral, protozoal or parasitic diseases are required as information on disease resistance is lacking in the literature. Recently, it was observed that Nicobari breed was found to be relatively resistant to fowl typhoid (*Pastorella multocida*) infection as mortality of this breed was lesser compared to Vanaraja birds (Unpublished study from ICAR-DPR). With regard to immune-competence it was reported that cell mediated immune response assessed by cutaneous basophil hypersensitivity response to PHA-P was higher in Ghagus compared to exotic Dahlem Red breed. Similarly, humoral immune response to Newcastle disease virus and counts of CD8⁺ cytotoxic T lymphocytes were significantly higher in Nicobari as compared to Dahlem Red breed (Yadav et al 2018).

Pattern recognition receptors like toll like receptors (TLRs) play crucial role in innate immunity. TLR gene expression profiling of NC breeds (Aseel and Kadaknath) revealed that expression of TLR4 and TLR5 were significantly higher in Kadaknath than WLH. Similarly, expression of TLR7 was significantly higher in Aseel and Kadaknath as compared to WLH and coloured broilers with naked neck and dwarf genes (Kannaki et al 2010). In another study it was demonstrated that expression of *TLR4* gene in LPS treated PBMC was significantly higher in NC (Aseel and Ghagus) as compared to exotic (Dahlem Red and Broilers) chickens (Karnati et al 2015). The Ghagus showed higher expression of *TLR1LB*, *MDA5*, *LGP2*, *B-Lec*, *IL1 β* , and *IL8* genes as compared to WLH (Haunshi et al 2017). All these studies suggest that NC have relatively better CMI, humoral or innate immune competence. Further, it was observed that there is higher diversity at major histocompatibility level in NC as compared to WLH (Unpublished). Further studies are required to profile all the recognized breeds of NC for disease resistance and immune competence traits to settle the claim that NC are hardy and resistant to commonly occurring infectious diseases.

Characterization for carcass and meat quality traits

Dressing percentage of Aseel (69.5%) chickens were comparable to broilers (Rajkumar et al 2016) although lesser ready to cook yield (without skin) was reported in Kadaknath and improved Aseel (PD-4) (Haunshi et al 2013) and 68.53% in Hansli (Behra et al 2017). The protein, fat and cholesterol content of Aseel were 21.5%, 3.4% and 72.5 mg per 100 g of meat, respectively (Rajkumar et al 2017). Higher demand for NC is mostly due to the consumer preference for desirable flavour and texture of their meat. Acceptability and texture of Aseel meat was higher than that broiler meat as found by trained sensory evaluation panel (Rajkumar et al 2016). In addition, they also have lean meat as evidenced by their lower abdominal fat content (Arora et al 2011; Haunshi et al 2013; Rajkumar et al 2016). There is little information about the cholesterol and fatty acid profile of meat and eggs of NC *vis a vis* improved/exotic chickens. Studies on profiling of NC for fatty acids profile and cholesterol content of meat and eggs are required to be taken up.

Nutrient requirements of NC

Expenditure on feeding alone accounts for about 70% of the operational cost of commercial poultry production whereas little or no expenditure is incurred on feeding of NC under backyard or free range systems. NC meets most of their nutrient requirement by scavenging in villages on insects, food waste, green grass, leafy vegetables, spilled grains, etc. Occasionally, birds are supplemented with paddy, broken rice, sorghum (jowar), millets, etc. depending upon the availability of grains and season. Little information is available on nutrient requirements of NC. Protein requirement of NC may be less but energy requirement might be high as birds reared in free range and backyard systems spend most of their time in scavenging in search of food. It was observed that the feeding Aseel birds with diet having 16% CP and 2600 kcal/kg ME during 0-8 weeks was sufficient for optimum growth (Haunshi et al 2012a). Furthermore, provision of 2800 kcal ME with 16% CP has significantly improved the FCR. Similarly, during laying period, provision of diet containing 2400 kcal/kg ME and 14% CP was economical and adequate for Aseel to elicit optimum production performance during 25 to 40 weeks of age (Haunshi et al 2015b). It shows that protein requirement of NC is somewhat lesser as compared to fast growing and high producing chickens. As such energy is the first limiting nutrient in NC reared in free range or backyard system as the food available on the range contains a lot of crude fiber (Sonaiya 2005). In a recent study it was observed that diets (crop and gizzard contents) of scavenging chickens from four different parts of the country were deficient in energy, protein and calcium compared to those reared under intensive system (Prakash et al 2018). Therefore, one of the interventions that could be made to improve the productivity of NC is feeding of energy rich grains and providing calcium supplements (Shell grit) to laying hens. Systematic studies to determine the precise requirements of major nutrients of various NC breeds are warranted.

Reproductive traits

Means of reproductive traits such as fertility and hatchability of five NC germplasm maintained at ICAR-DPR, Hyderabad are presented in Table 1. Highest fertility was observed in Ghagus while least fertility was observed in Aseel breed. Hatchability was highest in Nicobari and Ghagus while it was lowest in Aseel breed. These figures suggest that reasonably good fertility and hatchability can be obtained in NC maintained under intensive system using artificial insemination. The trends in these traits revealed no significant change over generations. Furthermore, there was no significant effect of selection for higher body weight on these traits in improved Aseel (Haunshi et al 2019a). Therefore, NC can be improved for production traits without affecting the fertility and hatchability traits adversely.

Table 1. Average fertility and hatchability in native chickens

Breed	Generations (Nos.)	Fertility (%)	Hatchability (%)	
			Fertile set	Total egg set
Improved Aseel	9	82.70±0.80	78.68±1.65	65.10±1.75
Aseel	6	70.29±4.21	79.17±3.11	54.59±4.27
Ghagus	8	88.73±1.40	88.00±1.37	80.43±2.18
Nicobari	6	83.21±1.56	88.31±0.93	73.49±1.69
Kadaknath	4	82.65±0.97	87.70±1.81	72.97±1.83

Note: Averaged over the (two or more hatches in each generation) generations using data from ICAR-DPR Annual Reports up to 2018-19

Improvement of NC for growth and egg production traits

Low production potential of NC is the primary reason behind introduction of crossbred/exotic germplasm for improving the productivity of backyard farming. Such approach not only increases the dependency of farmers for chicks and other associated inputs but also leads to genetic erosion of NC. Genetic improvement of NC breeds and reintroduction could be used to increase the productivity of backyard/free range farming without increasing

the production cost or loss of biodiversity (Magothe et al 2012). Therefore, characterization and improvement in performance of NC through selective breeding for growth or production is the need of the hour to enhance the productivity of low input backyard poultry farming in a sustainable manner. Efforts are being made at ICAR-DPR, Hyderabad to collect, characterize and conserve NC breeds. So far this institute has collected and characterized four breeds of NC (Aseel, Ghagus, Nicobari and Kadaknath). Furthermore, efforts are also being made to improve them for production traits through selective breeding. Growth traits of NC such as Ghagus, Kadaknath and Aseel were highly heritable (Haunshi et al 2012b). These findings suggest that there is an additive genetic variation for growth traits and that could be exploited for genetic improvement of NC. Aseel population brought from AAU, Anand (Gujarat) has been improved for body weight and egg production through selective breeding for nine generations. Male and female birds of improved Aseel (*Vanashree*) can attain body weight of 2073 and 3054g respectively at 40 weeks of age (Haunshi et al 2019a). Hens *Vanashree* could lay about 195 eggs up to 72 weeks of age under intensive system with the average egg weight of 48.9g at 40 weeks of age. The performance of this improved NC at field level was tested and witnessing high demand from farmers for supply of chicks and hatching eggs. Rearing *Vanashree* birds is being considered as promising option for rural poultry as birds can be self propagate at farmers' level without affecting the productivity. The drawback with existing improved crossbred varieties for which every time farmers have to collect chicks from hatcheries to produce fresh batch of chicks is not the case with the rearing of *Vanashree*.

Marketing of NC

Demand for NC in urban areas and metro cities is picking up. Higher demand and premium price for the NC have made it remunerative to produce these slow growing NC under intensive and semi-intensive systems of production in recent years. Current price of NC in cities like Hyderabad is in the range of INR. 270 - 300 per kg live weight as compared to the broilers which is about INR. 90-100 per kg live body weight. Thus, retail price of NC is three times higher than that of broilers. This difference could be even higher in places like north-eastern states, West Bengal, Kerala and Jammu and Kashmir. The sale price of eggs ranges from INR 5.50 to 7.50 and adult birds are sold at INR 350 to 500 in Kerala (Kumar et al 2013). Current price of eggs is about INR 8.00-10.00 per egg of NC as compared to INR 4.00-5.00 per egg of WLH breed. Studies on economics of NC production are lacking. In one study it was established that main positive factors for profitability of NC production were price of NC sold to consumer, number of birds per batch and body weight at marketing while negative factors were total capital invested, price of NC sold to wholesaler, feed cost, etc. (Satheeshkumar et al 2014). Therefore, it is imperative that NC products need to be directly marketed to enhance the profitability as mostly middle man/retailer gets major share of profit while marketing of chickens. Therefore, direct selling of produce of NC to consumers will help in enhancing the returns to the farmers. E-commerce is one such option that helps both producers and consumers through integration of producers and consumers. Further, better networking and efficient procurement and transportation of native birds from producers (villages) to consumers (cities) is also the need of the hour.

Challenges for native chicken production

Although there is a huge scope for production of NC due to various advantages associated with rearing of them but it faces several challenges as detailed below.

1. Poor growth and production potential

Growth performance of most of the NC is very low as the body weight of most of the NC is reported to be in the range of 1.4 to 1.8 kg for cocks and 1.0 to 1.4 kg for hens at about 20 weeks of age. It was reported that most of the NC produce around 60-80 eggs in a year in three to four clutches with average egg weight of 35-45 g. They also mature late and their average age at first egg often ranges from 25 to 28 weeks (Table 2). Therefore, there is an immediate need for improvement of NC for both growth and production traits in order to make rearing of NC more remunerative and to enhance

the availability of meat and eggs of NC in rural and tribal areas. The experience at ICAR-DPR with Aseel improvement program clearly shows that NC can be improved both for growth and egg production without affecting their original breed characteristics and adaptability to backyard farming.

Table 2. Growth and production performance of native chicken breeds

Breed	40 weeks/matured Body weight (g)		Age at first egg (d)	40 wks Egg number	Egg weight 40 wks (g)	Reference
	Males	Females				
Vanashree	2736	1832	213.0	36.2	49.2	Haunshi et al (2011)
Aseel	2702	1704	214.0	18.0	38.8	Rajkumar et al (2017)
Kadaknath	1740	1322	200.0	49.2	41.4	Haunshi et al (2011)
Nicobari	2240	1340	177.8	65.5	44.0	Haunshi et al, (2019b)
Ghagus	2537	1609	175.1	32.4	45.7	Haunshi et al, (2015a)
Miri	1507	1214	147.0	33.6	38.7	Haunshi et al, (2009)
Tellicherry*	1620	1240	-	60-80#	40.0	Vijh et al, (2008)
Denki*	3115	2223	221.1	-	46.2	Vij et al, (2006)
Kalasthi*	2482	1850	216.1	-	42.9	Vij et al, (2006)

*Adult birds with no information on age under field conditions (Survey data), # Annual production

2. Losses due to predation and theft

Predation in free range or backyard system is one of the major causes of losses of chicks especially in early part of life. Although adult birds can run fast and fly to some extent to escape from predators but young chicks are vulnerable to predation. In one study it was observed in Tanzania that main causative factor for loss of chicks during first six weeks of age was predation (55%) followed by disease incidence (30%), ecto-parasites (5%), management factors (6%) and unidentified (5%) causes (Alfred et al 2012). Although there are systematic studies on losses of chicks due to predation the situation is almost similar for NC production in India. Losses due to predation and theft can be overcome by taking appropriate measures such as proper housing using locally available materials and elimination of predators by trapping and repelling.

3. Incidence of diseases

Among various diseases, Newcastle disease is the major cause of heavy losses in chicks and adult birds in free range conditions (Kornel 2008). Fowl pox is another viral disease that causes losses due to morbidity and mortality in free range and backyard poultry farming. Fortunately vaccination of birds can prevent the incidence of both diseases. Farmers need to be educated and encouraged to vaccinate their birds with the help of nearby veterinary clinics of state animal husbandry departments. Incidence of emerging and re-emerging diseases causes complete loss of native germplasm from the affected areas. Incidence of parasitic diseases is another major cause that affects the performance of chickens under backyard system of production due to poor growth and egg production (Bhat et al 2014).

4. Non availability of inputs in user required form

Non availability of inputs like medicines and vaccines in small number of doses near rural and tribal areas is one of the hindrances for NC production in the country. Thermo-stable vaccine for Newcastle disease is already a reality in Africa and Southeast Asia (Kornel 2008). Development of such vaccines using virus strains endemic in the country will go a long way in the control of the Newcastle disease. Non availability of chicks or hatching eggs of improved NC is another constraint for improving the backyard poultry production.

5. Loss of genetic diversity

Globally this is a gravest concern as 30% of poultry breeds were at risk and 9% are already extinct as the proportion of breeds at risk and extinction are highest in chickens as compared to other livestock species (Hoffmann 2009). Situation is more or less similar in India as well. Despite having various advantages, NC is being replaced with exotic germplasm (improved crosses/hybrids) to improve the productivity of backyard poultry farming. Several crossbred varieties which look like NC (Coloured plumage and brown eggs) were developed using exotic improved chicken breeds (Khan 2008). These improved crossbred varieties are being introduced in large scale through government sponsored schemes and also by private players. Therefore, NC breeds are increasingly facing the threat of genetic erosion due to large scale introduction of high yielding varieties or crosses. The way forward to overcome this challenge is to discourage the introduction of varieties in home tracts of recognized breeds of NC. For this the home tracts of all NC breeds need to be identified, demarcated and notified so that improved varieties can be propagated in non notified areas for improving the productivity of backyard farming.

Conclusions

NC production provides nutritional and livelihood security to the rural and tribal poor in the country. There is a scope for NC production as it has several advantages such as sustainability, least input requirement, environment and small holders' friendly besides catering to the specific needs of consumers for free-range reared birds which are without use of growth promoters particularly antibiotic growth promoters. There is a need for systematic study to characterize all the native breeds to find out the uniqueness among them so that those traits can be exploited/given importance in designing breeding and conservation strategies. Furthermore, NC production in India faces several challenges. The most important one is the low productivity of NC that are reared in free range or backyard system of rearing. Improvement of NC through selective breeding is required for enhancing the productivity of backyard and free range system of production. As NC are increasingly being reared in semi-intensive and intensive systems to meet the higher demand at urban areas; housing, management, nutrient requirements, feed conversion efficiency and production traits are required to be studied to develop the appropriate package of practices for NC production.

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