Chapter-1

Introduction

The domestication of chicken took place in South-East Asia (West and Zhou, 1988) and had multiple origins (Lui *et al.,* 2006) and the chicken (*Gallus gallus domesticus*) was domesticated over 8000 years ago (possibly as early as 58,000±16,000 years ago (Sawai *et al.,* 2010). It was evident that the red jungle fowl (*Gallus gallus*) is the main ancestor of today's chickens (Fumihito *et al.,* 1994 and Erikssen *et al.,* 2008), although there has been introgression from other jungle fowl species, such as the grey jungle fowl (*Gallus sonneratii*) (Eriksson *et al.,* 2008). Domestic chickens and red jungle fowl are still the same species and interbreed (Nicol, 2015). Red Jungle fowl (*Gallus gallus*) is considered as the direct ancestor of domesticated chickens (Hanh *et al.,* 2015).

The indigenous chicken of Bangladesh comprises about 90 percent of the total chicken population with high levels of morphological and phenotypic variation and has high fitness potentialities under natural conditions (Bhuiyan, 2011). In the indigenous chickens, there are different kinds such as Naked Neck, Hilly, Aseel and Full feathered non-descriptive deshi chicken are found.

The production performance of non-descriptive deshi was comparatively lower than exotic breed, variety and strain. Average hen-house egg production of deshi white chickens is 19.95% and black 17.65%, respectively and the yearly egg production of deshi white chicken is 90 egg/year/chicken (Khan *et al*., 2017), which was the highest than other available of deshi chickens. Deshi chickens showed average hatch weight 29g; age at first egg at 175 days (Sazzad, 1992); weight of pullet (900 g); mature body weight (1300 g); hatchability (52%); fertility (83%); 9-15% mortality up to 500 days of age (Bhuiyan *et al*., 2005, Khan *et al*., 2017). The egg weight varies from 41.27g to 43.85g for all types of deshi chicken (Khan *et al*., 2017). The egg color of non-descriptive deshi chicken is white (Khan *et al*., 2017).

Comparative study between red jungle fowl and indigenous chickens are obtained in literature (e.g. Buctot Jr. and Espina, 2015, Hanh *et al.,* 2015). The egg weight showed a significant difference at $t<0.05$ and revealed heavier weight (39.5 g). Red jungle fowl laid 8.50 to 10.50 eggs in one clutch, but a deshi hen showed comparatively higher eggs in one clutch but the differences was non-significant (Buctot Jr. and Espina,

2015). In addition, comparable results were obtained in percent fertility, percent hatchability, yolk and shell weight, egg length and width, egg shape index and yolk color score was also obtained by Hanh *et al.,* (2015). However, in literature no complete comparative study between Red Jungle fowl and indigenous chicken was found elsewhere including Bangladesh, most of the researchers studied a few traits only. Therefore, the present study was conducted under semi-intensive management conditions with the following objectives.

Objectives of the study

1. To compare the morphometric traits of Red Jungle fowl (RJf) and Non-descriptive deshi (ND) chicken under semi-intensive conditions
2. To study the comparative growth performance of RJf and ND chicken under semi-intensive conditions.
3. To study the productive and reproductive performance of RJf and ND chicken under semi-intensive conditions.

Chapter-2

Review of Literature

2.1 History and domestication of chicken

Chicken are considered to have been domesticated earlier than other poultry. Over 150 million years ago, first known bird called Archaeopteryx (ancient winged creature) took its birth. It was almost the size of crow and not like as day birds. The ancestry of domestic chicken's can be traced back to four species of wild jungle fowl from Southeast Asia (Xiang *et al.,* 2015). It is not known as of now when the first chicken was captured and domesticated. In 1400 B.C. Archaeological surveys indicated that fowls were domesticated in china (Eda *et al*., 2016). Conventionally known that the chicken was domesticated in India but recent evidence insists that domestication of the chicken was already underway in Vietnam over 10,000 years ago (Wikipedia, 2017). It is probably appear that over 5000 years ago people domesticated chickens, after centuries of hunting the wild jungle fowl. Centuries ago the Chinese began raising a variety of bird that was gradually brought to the West Asia, Greece and Rome (Moiseyeva *et al*., 2003). Chickens then spread through the Eastern Asia and reached Persia at about 1000 B.C. and played a role in their ancient religion. In 600 B.C they were taken to Babylon from India and were introduced in Rome and Greece around 500 B.C (Kanginakudru *et al*., 2008). By around 500 B.C. Greeks raised the chickens for the 'sport' of Cock fighting. After centuries of selection and breeding for numerous extremes, chickens now exist in many colors, sizes and shapes (Kanginakudru *et al*., 2008). Artificial selection has made phenotypic characters more likely to disappear (e.g. eclipse plumage) or to be modified (legs, combs or calls) and most of the changes are associated with secondary sexual characteristics of cocks (Peterson and Brisbin, 1998). Domestication has modified morphological appearance, production traits, physiology, behaviour and genetic structure (Al-Nasser *et al.,* 2007), indigenous chickens locally known as Deshi (*Gallus domesticus*) are reported to be driven from *Gallus gallus* (Dutta *et al*., 2013 and Al Nasser *et al*., 2007) whereas *Gallus bankiva* is believed to be the major contributor to the development of modern commercial breeds (Lush, 1945). Geographic variation is very marked in red jungle fowl and this has been recognized by designating several sub-species for Red Jungle fowl (Moreng and Avens,

1985, Crawford, 1990a, Collias and Collias, 1996, Moiseyeva *et al*., 2003, USDA/ITIS, 2006a-j, Wikipedia, 2006).

2.2 Red Jungle fowl types, habitat and nature

Red Jungle fowl is the most abundant, widely distributed and with diverse subspecies and consists of continental (*G. g. gallus, G. g. jabouillei, G. g. murghi and G. g. spadiceus*) and island (*G. g. bankiva*) sub-species. Similarly, Darwin (1868) reported contrasting morphological features of Malayan and Indian Red Jungle fowl. Chickens and their feral descendants (chickens that have returned back to a wild state) are recognized as sub-species of the Red Jungle fowl (Table 1).

Table 1: The natural home range of five wild sub species of the Red Jungle fowl

Subspecies of the Red Jungle fowl	**Natural home range**
Gallus gallus gallus	Indochina, east Thailand, central and south Laos, Cambodia, central and south Vietnam
Gallus gallus jabouillei	Vietnam, southeast China
Gallus gallus murghi	North and northeast India
Gallus gallus spadiceus	southwest China, east India, Myanmar, non- eastern Thailand, Peninsular Malaysia and north Sumatra
Gallus gallus bankiva	Java, Indonesia
Reference: Crawford, 1990; del Hoyo *et al.*, 2001	

Although jungle fowl have been adapted to a wide range of habitats, they frequently run in secondary forests (Collias and Collias, 1967, Crawford, 1990, Javed and Rahmani, 2000) and commercial plantations (Syahar *et al.*, 2014). In regions where Red Jungle fowl is available, the average size of home range is around one hectare per adult bird (Collias and Collias, 1967). Daily and monthly home ranges are wider for cocks (Arshad and Zakaria, 2011). Wide species range can be associated with availability of resources and physiological demands. In jungle fowl, home range size

varies between seasons (Arshad and Zakaria, 2011) and is more frequently sighted during the summer (Javed and Rahmani, 2000).

Flocks of jungle fowl are dominated by a single cock (Collias and Saichuae, 1967). The effective number of breeding males is reduced due to limited access to mate of subordinate cocks (Collias and Collias, 1967). The Red jungle fowl cocks accompany more hens than grey and Ceylon cocks (Collias and Collias, 1967) and hens out number cocks (Collias and Saichuae, 1967, Javed and Rahmani, 2000). Aggressive nature of cocks might be the cause of this unbalanced sex ratio (Collias and Saichuae, 1967). Selective pressure against cocks, with their territoriality and aggressive behaviour, may reduce their number (Correa *et al.,* 2005). In addition to that males are bigger than females, and, as a consequence parents invest more on the less demanding sex i.e. females (Sze´kely *et al.,* 2014).

2.3 Breeds, types and variation of chicken and non-descriptive deshi chicken

In Bangladesh, poultry population is estimated about 304.17 million where chicken population is about 255.31 million (DLS, 2015). The growth rate of chicken for last 10 years was 3.75 % (Hamid *et al*., 2017). Chicken is the integral part of farming system in Bangladesh. It has created both direct and indirect employment opportunity including support service for about 6 million people (Ansarey, 2012). There are different breeds and types of chickens are available in Bangladesh which characteristics is shown in Table 2.

Chicken that is originated from a certain place with same or similar characteristics are of same class. For example, Asiatic class, European class, American class etc. chicken with same size, shape and characteristic similarity with each other are of same breed (Islam and Nishibori, 2009) like, Leghorn, Minorca etc.

According to origin the chicken are of four types of classes were observed.

- Asiatic class: Brahma, Langshan, Cochin, Assel etc.
- English class: Austrolorp, Cornish, Dorking, Orpington etc.
- Mediterranean class: Leghorn, Minorca, Ancona, Fayoumi etc.
- American class: Rhode Island Red, New Hampshire, Plymouth Rock etc.

On the basis of production chicken are of three types as given below.

Layer

Layer is for solely developed egg production and used for commercial purpose. Some popular layer breeds: Leghorn, Minorca, Ancona, Fayoumi, and strains: ISA brown, Star cross, Lohman etc.

Broiler

Broiler chickens are meat type chickens having higher growth rate; they are mostly reared worldwide for commercial purpose. Some popular broiler strains are Star brow, Mini brow, Hi-line etc.

Dual (egg and meat) type

These types of breed are used for both egg and meat production purposes. Rhode Island Red, New Hampshire, Plymouth Rock etc. (Islam and Nishibori, 2009) are popular breeds for both egg and meat production.

The non-descriptive deshi chicken is more acceptable and reared by rural peoples of Bangladesh due to their lower nutritional demand and higher resistance to diseases and heat stress as an important source of meat and eggs (Barua and Howlider, 1990) and cash income. Variation of the indigenous chickens of Bangladesh are found on the basis of plumage color, comb type and feather pattern (Faruque *et al*., 2017 and Khan *et al*., 2017). Variation on morphological characteristics and production performance of chickens of Bangladesh has been reported by Howlider *et al*. (1995) and Islam and Nishibori (2009).

Table 2: Types/breed in chicken found in Bangladesh

Sl. no	Breed	Characteristics
01	Rhode Island Red	Yellow skin[1,4,3]
		Single and rose comb[2,3]
		Medium size[1,2,4]
02	Fayoumi	Skin-yellow/white[2,4]
		Comb-single[1,2,3,4]
		Tight plumage[2,3]
03	Assel	Red earlobes[3,4]
		Massive size and loose plumage[1]
04	Naked neck	Medium size[1,2,3,4]
		Non-feather neck region[1,2,3,4]
05	Hilly chicken	Small size and round[1,2,3]
		Tight plumage[2,3]
06	Indigenous chicken	Plumage color black and red[1,3,4]
		Comb type mainly single[1,3,4]
		Egg size medium[1,3,4]
07	Red Jungle Fowl	Small size, has eclipse plumage[6,7]
		Mixed feather colors with orange, brown, red, gold, grey, white, olive, metallic green pumage[6,7]
		Long tail feathers in male(upto 28cm)[6,7]

[1]Faruque *et al*. (2017), [2]Khan *et al*. (2017), [3]Faruque *et al*. (2010), [4]Bhuiyan *et al*. (2005)**,** [5]Khan *et al*. (2004), [6]Wikipedia (2020), [7]Thai national parks (2020)

2.4 Morphological and behavioural Characteristics of Red Jungle fowl and non-descriptive deshi chicken

Non-descriptive deshi chickens are morphologically more diverse than Red Jungle fowl. As a consequence, a number of attributes that are displayed by jungle fowl have been captured by chicken. For example, Earlobe colour is red in Malayan and white in Indian Red Jungle fowl (Darwin, 1868), therefore, chickens of the Mediterranean region may have been descended from Indian Red Jungle fowl, whilst the majority of

chickens with red earlobes may have originated from Malayan and other jungle fowl. Chickens express variants of comb shapes (Desta *et al.*, 2013, Desta, 2015); however, only a single comb variant is known to exist in jungle fowl. Amongst jungle fowl, Lafayette's jungle fowl morphologically resembles red jungle fowl (Darwin, 1868; Sawai *et al.*, 2010).

Another resemblance is eclipse plumage. Eclipse (dull plumage) refers to the moulting of bright feather during the post-breeding period. Eclipse plumage is usually observed in red, grey and Ceylon jungle fowl (Collias and Collias, 1967, Peterson and Brisbin, 1998, Pheasantry and Pradesh, 2004). Its presence is a reliable indicator of genetic purity (Syahar *et al.*, 2014). Moulting in laying hens reduces feed intake and body weight and suspends reproduction whilst enhancing the bird's productive lifetime (Himeno and Tanabe, 1957, Yousaf and Chaudhry, 2008).

Basic behavioural characteristics of red jungle fowl are similar to native chickens (Collias, 1987). Jungle fowl are terrestrial and sedentary and aggressive. They can take off for short-ranged flights unlike chickens. The most noticeable difference is the suspicious behaviour of jungle fowl (Collias and Collias, 1967, Collias and Saichuae, 1967, Arshad and Zakaria, 2011) which is rarely seen in non-descriptive chickens. As a result of this behavior there are difficulties in captive management (Darwin, 1868). To escape from hunters (Arshad *et al.*, 2000) and to avoid predators this behavior plays a vital role as well.

Pecking order is used to compete for food, mates etc. (Collias and Collias, 1967) and is dominated by alpha individual. Like cocks, hens may form a pecking order (Collias and Collias, 1967, Mench and Keeling, 2001). Dominance and hierarchy are mainly determined by social experience and aggression (Kim and Zuk, 2000). Despite having variation in degrees, social signals like aggression, courtship, dominance hierarchy, pecking order, flocking and foraging behaviour of jungle fowl have been maintained in native chickens that have developed under high impact of natural selection.

Cock fighting is another behavioural character practiced with both Red Jungle fowl and chickens (Collias and Collias, 1967). Religious ceremonies and cockfighting for abiding rituals might be the main causes for domestication of jungle fowl (Crawford, 1990, Kerje *et al.*, 2003, Jacobsson, 2005, Akaboot *et al.*, 2012). Fighting game strains are closely related to red jungle fowl (Darwin, 1868), having longer necks, smaller

wing and stronger muscle, but are poor fliers (Crawford, 1990) such as Aseel, tiger cocks. In some countries chickens have been specifically raised for cockfighting (Akaboot *et al.,* 2012).

Roosting is another common instinctive behaviour that makes jungle fowl feel safe and protected is also present in non-descriptive deshi chickens. In Jungle, roosting sites are sparsely located (Collias and Collias, 1967, Collias and Saichuae, 1967) and group size of roosting flocks is small (Collias and Collias, 1967, Collias and Saichuae, 1967). The roost is left before sunrise and is returned to before sunset. Generally, cocks and hens roost at about the same height (Johnson, 1963, Arshad and Zakaria, 2009). Hens roost earlier in order to train their chicks, and leave later (Arshad and Zakaria, 2009); and a hen with chicks will roost lower.

Crowing is the behavior to locate roosting sites of jungle fowl (Collias and Saichuae, 1967) and advertises territoriality and dominance. The sustained pitch of crowing of the red jungle fowl call resembles those of domestic cocks (Collias and Joos, 1953 as cited in Collias and Collias, 1967). Although crowing by domestic cocks is dragged and has clear-cut harmonics compared to the abruptly ended crowing by red jungle fowl cock the vocalisations are similar in Red Jungle fowl and chicken (Collias and Collias, 1967, Collias, 1987).

Extensive exposure of Red Jungle fowl to several infections in the absence of medication has enabled them to develop adaptive immunity. The Red Jungle fowl experience similar parasites and diseases compared to chicken (Collias and Saichuae, 1967). They have more heterophils and a small percentage of lymphocytes (Adnan and Babjee, 1985) having higher average of haemolytic complements. These characters represent non-specific immune defense mechanisms and high variability in natural immunity (Mekchay *et al.,* 1999). Jungle fowl exhibit a high degree of excitability and trapping and caging them in captivity has a significant stress effect (Desta, 2018) which may be indirectly leads higher mortality rate in captivity.

2.5 Body weight and weight gain of Red Jungle fowl and non-descriptive deshi chicken

Red Jungle fowl grow slowly (Kadhim *et al.*, 2011) and has low feed conversation efficiency (Zulkifli *et al.,* 2001), it also lighter in weight than non-descriptive deshi chicken. On the hand, production breeds gain more, have higher body weight and

consume larger amounts of feed (Schütz *et al.*, 2002). Dressing percentage and weights of whole breast, thigh and drumstick are higher in jungle fowl (Rahayu *et al.*, 2008), due to smaller visceral content. Jungle fowl have highest proportions of bone and lower fat and muscle. To maximize fitness, it mobilises resources towards bone and leg development and is lean and fitter than its domesticated relatives (Rahayu *et al.*, 2008). High bone weight can be linked with consumption of larger amounts of calcium (Ganabadi *et al.*, 2009). The production potential of non-descriptive deshi chicken is also low having low feed conversion ratio than commercial breeds but is higher than red jungle fowl. The feed conversion ratio or feed efficiency of non-descriptive deshi chicken is 4-5kg/kg body weight (Sazzad *et al.*, 1990). Non descriptive deshi chickens can attain 300-400g live weight at 12 weeks of age (Huque and Haque, 1990, Bulbul, 1983, and Ahmed and Islam, 1985).

2.6 Egg production characteristics

Jungle fowl can produce tastier eggs, e.g. in Red Jungle fowl, fat and cholesterol contents of breast and leg muscles are low whereas protein content is high (Rahayu *et al.*, 2008). Mating behaviour is similar in Red Jungle fowl and chicken (Collias and Collias, 1967). Jungle fowl are seasonal breeders (Jacobsson, 2005). The main breeding season of Red Jungle fowl is the local dry season which is March to June. Seasonal breeding help to mobilize minerals for skeletal development (Callaway, 2016), divert resources towards adaptive traits than growth and reproduction that maximise survival of chicks by synchronizing chick brooding with the appropriate season. In addition, courtship, mate competition and parental care make breeding season tedious and costly (Zuk and Johnsen, 1998), that requires resting period. Also egg production is affected by photoperiod that can be markedly different between seasons (Yousaf and Chaudhry, 2008). Jungle fowl lay few numbers of eggs, e.g. 4 to 7 eggs per clutch (del Hoyo *et al.*, 2001) and 10 to 15 eggs annually (Romanov and Weigend, 2001). Hens incubate eggs and brood chicks without the assistance from cock (Collias and Collias, 1967). Red jungle fowl chickens mature earlier (Schütz *et al.*, 2002; Worley *et al.*, 2010). Eggs are incubated for 18 to 20 days (del Hoyo *et al.*, 2001). Sperm from production breeds is inferior both in volume and concentration compared to red jungle fowl (Pizzari *et al.*, 2004, Malik *et al.*, 2013). Egg production characteristics of non-descriptive deshi chicken found in Bangladesh is given in Table 3.

Table 3: Egg production characteristics of non-descriptive deshi chicken and Red Jungle fowl genotype in Bangladesh

Trait	*Deshi* (ND/FF)	RJf	Reference
Age at sexual maturity (d)	225		Barua (1992)
	175		Huque (2001), Ershad (2005)
	169		Yeasmin *et al.* (2003)
	155-157		Faruque *et al.* (2007), (2010), (2013) and (2015)
	203		Shahjahan *et al.* (2011)
	133-168		Dutta *et al.* (2013)
	175		Jahan *et al.* (2017)
		150	Wikipedia(2020)
Clutch length (d)	18.07		Shahjahan *et al.* (2011)
	14.93		Ahmed *et al.* (2012)
		6.1±2.3	Ling (2009)
		4.076	Arshad & Zakaria (1999)
		4-7	Del hoyo (2001)
		5-6	Ali & Ripley (1987)
		3-7	Bump and Bohl (1961)
Clutch size	12-18		Sarkar and Bell (2006)
	15.64		Shahjahan *et al.* (2011)
	13.47		Shahjahan and Bhuiyan (2016)
	11.04		Jahan *et al.* (2017)
		5.5±1.5	Anwar *et al.*, (2016)
Clutches per year	3-4		Sarkar and Golam (2009)
	3.38		Shahjahan *et al.* (2011)
	2.75		Shahjahan and Bhuiyan (2016)
Annual egg production	35-45		Bulbul (1983), Ahmed and Islam (1985), Huque and Huque (1990), Sazzad *et al.* (1990), Amin and Bhuiyan (1995), Ershad (2005),
		10-15	Romanov and Weigend (2001)
	135		Khan (1983), Paul and Huque (1996),
	45-50		Huque (2001)
	40-54		Sarkar and Bell (2006)
	36-68		Sarkar and Golam (2009)
	50		Shahjahan *et al.* (2011)
	67		Ahmed *et al.* (2012)
	84		Faruque *et al.* (2015)

Legend: ND= Non-descriptive deshi, FF= Full feathered, RJf= Red Jungle fowl

2.7 Egg weight, fertility %, hatchability %

Red jungle fowl eggs are smaller compared to the native chickens. Egg weight of non-descriptive deshi chicken observed in Bangladesh by different studies is given on Table 4. In Kenyan native chicken, average egg weight of dwarf (38.1), normal (42.5) and naked neck (45.8 g) genotypes (Njenga, 2005) showed similar data to Table 4 findings which were partially agreed with the studies of Sunder *et al.,* (2005) on Nicobari native hen (46.70-48.20 g) and improved native chicken breeds Vanaraja (51 g), Gramapriya (49 g) and Aseel chicken (41 g) of India (Sree *et al.,* 2017). In another study of Egyptian native chicken at 46 and 94 weeks revealed that the egg weights were 44.26 and 28.60 g, respectively (Hamouda *et al.,* 2018). In case of improved backyard chicken in West Bengal of India, the average weights of first laid egg were 49.80 g, 51.20 g and 41.40 g in Gramapriya, Vanaraja and Haringhata breeds, respectively (Roy *et al.*, 2018).

Table 4: Egg weight, fertility and hatchability of non-descriptive deshi and Red Jungle fowl in Bangladesh

Trait	*Deshi* (ND/FF)	RJf	Reference
Egg weight (g)	35-39		Amin and Bhuiyan (1995), Ershad (2005), Barua and Howlider (1990), Yeasmin and Howlider (1998), Islam and Nishibori (2009)
	40.04		Islam and Dutta (2010)
	42.07		Ahmed *et al.* (2012)
	42.94-43.50		Faruque *et al.* (2010) and (2013)
		35.5-39	Buctot jr. and Espina (2015)
Fertility (%)	83		Hoque *et al.* (1975)
	91-96		Dutta *et al.* (2013) Huque and Salahuddin (2001)
	92.7		Islam *et al.* (2001)
	94.86		Khatun *et al.* (2005)
	85.70-94.39		Faruque *et al.* (2013) and (2015)
		79.86-85.00	Buctot jr. and Espina (2015)
Hatchability (%)	75		Barua (1992) Huque and Salahuddin (2001)
	84-88		Sarkar and Golam (2009), Dutta *et al.* (2013)
	86.38-89.0088.74		Faruque *et al.* (2010), (2013) and (2015) Shahjahan *et al.* (2011)
		78.13-83.48	Buctot jr. and Espina (2015)

Legend: ND= Non-descriptive deshi, FF= Full feathered, RJf= Red Jungle fowl

It was observed (Table 4) in free range condition that the fertility and hatchability of eggs were lower for ND (Hoque *et al.*, 1975, Barua, 1992, Sarkar and Golam, 2009) than an intensive system (Islam *et al.*, 2001, Khatun *et al.*, 2005), except Dutta *et al.*, (2013), who recorded maximum 96% fertility and 88% hatchability of egg of ND. In extensive system, Using an incubation system, availability of feed and physical exercise (Das *et al*., 2008), seasonal temperature and humidity, egg fertility and hygiene, size and number of incubating eggs and body surface of hen average egg hatchability performance of native chicken could be influenced (Bhuiyan *et al.*, 2005). In addition, to that eggs fertility of hen mainly depends upon availability of breeding cock, maturity of chicken with fully functional gonads, nutritional and hormonal balance and last but not least timing and sperm quality (Shahjahan, 2021). On the other hand, Mogesse (2007) reported 85-100% fertility for Ethiopian native chicken and Parveen *et al.*, (2013) for Pakistani native chicken, they observed the season-based hatchability of native chicken was in winter, summer and rainy seasons 65.43%, 49.70% and 44.45%, respectively.

Chapter 3

Materials and Methods

3.1 Study area

The study area, Hathazari (Figure 1) is located at 22.5083°N 91.8083°E. It has 52,594 households and a total area of 251.28 km^2 (Wikipedia, 2020). The main river is Halda. It is surrounded by Fatikchhari Upazila on the north, Panchlaish Thana and Chandgaon Thana on the south, Raozan Upazila on the east and Sitakunda Upazila on the west.

Figure 1: Study area in Hathazari

3.2 Selection of the study area

The study area was selected because of the location of Chattogram Veterinary and Animal Sciences University (CVASU) research and farm based campus, Hathazari and availability of study materials alongside in that area.

3.3 Study period and study population

The study was conducted from December, 2018 to November, 2019. There were 03 cocks (Figure 2) and 09 hens of Red Jungle fowls (Figure 3) and 16 cocks and 160 hens of non-descriptive deshi mature chicken (Figure 4) were used in this study.

3.4 Study materials

There were Red Jungle fowls in the Aviary at Research and Farm based campus of CVASU at Hathazary, Chattogram from which farm data was collected. Also for the data of non-descriptive deshi chicken the deshi chicken reared in households of Adarsh gram and Chandrapur of Hathazari upazilla. Both the chicken genotypes were reared under semi-intensive conditions. The chickens were reared in the fenced area, where supplementary feeds ingredients (paddy, pulses and soybean) were provided and they took necessary feed from nature. At the age of day 3, the chicks were vaccinated with Baby Chicks Ranikhet Disease Virus Vaccine (BCRDV) and a booster dose was given at 21 days of age. Furthermore, ND killed vaccine (against Newcastle diseases) was provided to the chickens at 35 days of age and routine deworming was carried out.

3.5 Method of study

The morphometric characteristics like beak length, comb and wattle length, neck length, primary and secondary feather length, shank length and spur length of Red Jungle fowl and Non-descriptive deshi chickens under semi-intensive management system was measured using a scale tape in centimeter and recorded.

A total of 03 cocks and 09 hens of Red Jungle fowls (RJf) and 16 cocks and 160 hens of non-descriptive deshi (ND) mature chicken were reared under semi-intensive system for this study, at a sex ratio of 1: 3 (male: female) for RJf and 1: 10 for ND. The fertility % of eggs was calculated from the proportion of the number of eggs set for hatching and number of fertile eggs observed by candling and the hatchability % of

fertile eggs was obtained from the proportion of number of fertile eggs and the number of day old chicks hatched. The eggs were hatched by broody hen and a number of 17 male and 24 female of RJF and 155 male and 300 female of ND day old chicks were hatched and used for live weight and live weight gain up to mature age. Live weight of chicks was measured at periodically from day old up to age at sexual maturity and the age and weight at age at sexual maturity was taken and recorded. Live weight of chickens was measured early in the morning before feeding using an electronic balance (0.1g least count). More than 38 to 40 weeks aged chickens were considered as mature chicken and mature live weight of chicken was recorded during this time.

The egg was collected when laid from the onset until a clutch of laying in a year; after collection, the number of the produced eggs was recorded in a data sheet. The egg production per chicken per clutch and then it was converted into yearly production per hen.

The mortality of the chickens was recorded routinely when a chicken died or loss of due to predator. Broodiness, nesting behavior and egg shell colour was observed for all chicken. To measure the egg weights a digital weighing balance (Digiscale™, Germany) with 0.01g accuracy was used.

The following statistical mixed model was used to obtain the least square means for the parameters from morphometric and growth using PROC GLM of SAS (SAS, 2010) and the values of the egg production parameter a completely randomized design (CRD) was used. The models are given as:

$Y_{ijk} = \mu + T_{i\,(G\times S)} + S_j + e_{ijk}$---------- (1)

$Y_{ij} = \mu + T_i + e_{ij}$---------- (II)

Where, Y_{ij} is the values of the trait, μ is the overall mean, T_i is the effect of chicken genotype, $T_{i(G\times S)}$ is the effects of i^{th} genotype and sex, Sj is the effects of same sex under each genotype and $e_{ij(k)}$ is the residual effect, distributed as N (0 σ^2).

The mean differences were compared using least significant difference (LSD) (Steel *et al.,* 1997) at 5% level of significance.

Chapter-4

Results

4.1 Morphometric characteristics of Red Jungle fowl and Non-descriptive deshi chicken

The mean with a standard error value of Morphometric characteristics of the males of Red Jungle fowl (RJf) and non-descriptive deshi (ND) chickens between genotype, sexes in genotype and male to male and female to female between genotype under semi-intensive condition is presented in Table 5.

Except comb length, all the studied morphometric traits (beak, wattle, primary, secondary, sickle /tail feather, shank and spur lengths) of ND chickens differed significantly ($P<0.05$) between genotype, and it was observed that ND showed higher value for these traits than the RJf (Table 5). Within RJf genotype, between sexes, it was found that the value of morphometric traits was significantly higher in males than females. Similar results were reported within ND chickens, except shank length (male, 8.58cm and female, 7.98cm), which showed non-significant ($P>0.05$) differences between sexes.

In comparisons, of morphogenetic traits between male under RJf and ND, it was observed that excluding shank (RJf, 6.97cm, ND, 8.58cm) and spur length (RJf, 2.13cm, ND, 3.19cm) all the traits differed significantly ($P<0.05$) between male to male for RJf and ND and it was obtained that these traits were higher in ND than RJf (Table 5). In case of female to female, The beak length (2.00cm) and primary feather length (5.95cm) of ND was significantly ($P<0.05$) higher than RJf (Beak, 1.43cm, Primary feather length, 4.07cm), whereas comb length of RJf (4.27cm) showed higher than ND (2.96cm). Furthermore, all other traits were not significantly differed between females among RJf and ND.

Table 5: Morphometric characteristics of the males of Red Jungle fowl and non-descriptive deshi chickens between genotype, sexes in genotype and between males and females among genotype under semi-intensive condition

Traits	Genotype					
	Red Jungle fowl			Non-descriptive deshi		
	Male (N=3)	Female (N=9)	Average	Male (N=10)	Female (N=160)	Average
Beak length (cm)	$2.47^{xt}\pm0.108$	$1.43^{\alpha k}\pm0.033$	$1.95^{a}\pm0.071$	$3.12^{y\psi}\pm0.068$	$2.00^{\beta\lambda}\pm0.046$	$2.56^{b}\pm0.057$
Comb length (cm)	$8.57^{xt}\pm0.041$	$4.27^{\beta k}\pm0.536$	6.42 ± 0.289	$10.73^{y\psi}\pm0.151$	$2.96^{\alpha\lambda}\pm0.071$	6.85 ± 0.111
Wattles length (cm)	$3.51^{xt}\pm0.063$	$1.80^{k}\pm0.252$	$2.65^{a}\pm0.158$	$4.83^{y\psi}\pm0.077$	$1.63^{\lambda}\pm0.027$	$3.23^{b}\pm0.052$
Neck length (cm)	$8.67^{xt}\pm0.108$	$7.43^{k}\pm0.066$	$8.05^{a}\pm0.087$	$11.44^{y\psi}\pm0.797$	$7.94^{\lambda}\pm0.097$	$9.69^{b}\pm0.447$
Primary feather length (cm)	$6.55^{xt}\pm0.178$	$4.07^{\alpha k}\pm0.067$	$5.31^{a}\pm0.123$	$9.25^{y\psi}\pm0.782$	$5.95^{\beta\lambda}\pm0.065$	$7.60^{b}\pm0.424$
Secondary feather (cm)	$16.63^{xt}\pm0.426$	$14.67^{k}\pm0.167$	$15.65^{a}\pm0.297$	$20.33^{y\psi}\pm1.103$	$15.33^{\lambda}\pm0.113$	$17.83^{b}\pm0.608$
Sickle/tail feather* (cm)	$20.42^{xt}\pm0.441$	$11.83^{k}\pm0.441$	$16.13^{a}\pm0.441$	$32.68^{y\psi}\pm2.341$	$11.68^{\lambda}\pm0.248$	$22.18^{b}\pm1.294$
Shank length (cm)	$6.97^{t}\pm0.177$	$5.33^{k}\pm0.882$	$6.15^{a}\pm0.529$	8.58 ± 0.615	7.98 ± 1.061	$8.28^{b}\pm0.838$
Spur length (cm)	$2.13^{t}\pm0.036$	$0.17^{k}\pm0.167$	$1.15^{a}\pm0.102$	$3.19^{\psi}\pm0.472$	$0.39^{\lambda}\pm0.013$	$1.79^{b}\pm0.243$

Means with different super script letter between genotype (a and b), between sexes (k and t; ψ and λ) and in genotype and between males (x and y) and females (α and β) among genotype differed significantly ($P<0.05$). * Sickle for male and tail for female.

4.2 Live weight and live weight gain

The mean with a standard error value of live weight and live weight gain of Red Jungle fowl (RJf) and non-descriptive deshi (ND) chickens between genotype, sexes in genotype and males and females among genotype under semi-intensive condition is presented in Table 6. Except age at sexual maturity (158 days for RJf and 159.5 days for ND) all the traits (age and weight at sexual maturity, mature weight and weight gain up to sexual maturity and mature age) differed significantly ($P<0.05$) between genotype and comparatively higher value was obtained for ND than RJf (Table 6). Within RJf and ND genotype between the males and females, all the trait value differed significantly except the weight of day old chicks (19.08g for RJf and 24g for ND). Between males among genotype, it was observed that the value of the all traits was significantly higher in ND males than RJf males. Similar results were obtained in the case of females among genotype, except the age at sexual maturity, which showed that ND was better than RJf female as they showed earlier maturity than RJf.

Table 6: Live weight and live weight gain of Red Jungle fowl and non-descriptive deshi chickens between genotype, sexes in genotype and males and females among genotype under semi-intensive condition

Traits	Genotype					
	Red Jungle fowl			Non-descriptive deshi		
	Male (N=3)	Female (N=9)	Average	Male (N=10)	Female (N=160)	Average
Day old chicks weight (g)	$19.5^{x}\pm0.43$	$18.65^{\alpha}\pm0.87$	$19.08^{a}\pm0.651$	$24.3^{y}\pm0.15$	$23.7^{\beta}\pm0.39$	$24.00^{b}\pm0.270$
Weight at sexual maturity (g)	$760^{xt}\pm7.68$	$573^{\alpha k}\pm9.76$	$666.50^{a}\pm8.722$	$1070^{y\psi}\pm13.76$	$839^{\beta\lambda}\pm16.35$	$954.50^{b}\pm15.055$
Age at sexual maturity (days)	$142^{xk}\pm2.45$	$174^{\beta t}\pm3.81$	158.00±3.140	$152^{y\lambda}\pm2.87$	$167^{\alpha\psi}\pm3.91$	159.50±3.392
Mature live weight (g) at 38 weeks of age	$1050^{xt}\pm17.80$	$795^{\alpha k}\pm13.98$	$922.50^{a}\pm15.893$	$1530^{y\psi}\pm86.54$	$1254^{\beta\lambda}\pm41.43$	$1392.00^{b}\pm63.985$
Weight gain (g/d) up to sexual maturity	$5.21^{xt}\pm0.09$	$3.81^{\alpha k}\pm0.12$	$4.51^{a}\pm0.105$	$6.88^{y\psi}\pm0.08$	$4.88^{\beta\lambda}\pm0.10$	$5.88^{b}\pm0.087$
Weight gain (g/d) up to mature age	$3.87^{xt}\pm0.17$	$2.91^{\alpha k}\pm0.10$	$3.39^{a}\pm-0.135$	$5.66^{y\psi}\pm0.23$	$4.63^{\beta\lambda}\pm0.29$	$5.15^{b}\pm0.256$

Means with different super script letter between genotype (a and b), between sexes (k and t; λ and ψ) and in genotype and males (x and y) and females (α and β)among genotype differed significantly ($P<0.05$).

4.3 Egg production characteristics

The mean with a standard error value of egg production traits of Red Jungle fowl (RJf) and non-descriptive deshi (ND) chickens under semi-intensive condition is presented in Table 7. Fertility (%) of eggs, hatchability (%) of fertile eggs, and clutch size (days) were significantly ($P<0.05$) higher in ND than RJf. But the number of clutches per year (no) was higher in RJf (5 no) than the ND genotype (4 no), but the differences were not statistically significant ($P>0.05$). Hen day egg production (HDEP) per year (no) and egg weight (EW) were also found to be significantly ($P<0.05$) higher in ND chicken (HDEP 52.8 no and EW 40.7g) than the RJf (HDEP 28.0 no and EW 30.4g). It was observed that RJf hens are seasonal breeder, whose laying season ranges from spring to monsoon, on the other hand, ND hens laid eggs throughout the year. The egg color of RJf was recorded light brown and in case of ND the egg color was brownish or whitish.

Table 7: Egg production characteristics of Red Jungle Fowl and Non-descriptive deshi chickens under semi-intensive condition

Traits	Genotypes		p-value
	Red Jungle fowl (N=9)	Non-descriptive deshi (N=160)	
Fertility of eggs (%)	$76.65^{a}\pm1.65$	$88.76^{b}\pm1.24$	0.021
Hatchability of fertile eggs (%)	$47.5^{a}\pm2.51$	$76.54^{b}\pm2.78$	0.001
Clutch size (days)	$5.6^{a}\pm0.32$	$10.56^{b}\pm0.72$	0.035
Number of clutches per year (No)	5.0±0.43	4.0±0.56	0.760
Hen day egg production per year (No)	$28.0^{a}\pm0.54$	$52.8^{b}\pm0.75$	0.014
Egg weight (g)	$30.4^{a}\pm0.52$	$40.7^{b}\pm0.50$	0.015
Laying season	Spring to Monsoon (March – July)	Throughout the year	-
Egg shell colour	Light brown	Brownish or Whitish	-

Means with different super script letter differed significantly ($P<0.05$)

Chapter-5

Discussion

5.1 Morphometric characteristics of Red Jungle fowl and Non-descriptive deshi chicken

All the studied morphometric traits (beak, wattle, primary, secondary, sickle /tail feather, shank and spur lengths) of ND chickens differed significantly ($P<0.05$) between genotype, and ND showed higher value for these traits than the RJf. The lower value for the morphometric traits obtained in the RJf as the shape and size of RJf was comparatively lower than the ND. The lower shape and size of RJf is responsible for lower quantitative values of different morphometric traits reported by Zulkifli *et al.* (2001) and Thai National Park (2020). In the current study, the comb length value ranges from 2.96 to 10.73 cm irrespective of genotype and sexes, which was similar with other researchers (Ferdaus *et al*., 2016), who reported the comb length value was 5.12 cm in female and 12.61cm in male in the case of indigenous chicken of Bangladesh. These current findings also agreed with the results of Faruque *et al.* (2010). Within RJf genotype, between males and females, it was found that the value of morphometric traits was significantly higher in males than females. Similar results were reported in ND chickens, except shank length, which showed non-significant differences between sexes. The differences for the morphometric traits of RJf and ND by sexes was also reported by other researchers elsewhere (Moreda *et al.,* 2014 and Tadele *et al.*, 2018).

The primary and secondary feather length of ND was significantly higher than the RJf. These findings were agreed with the results of Condon (2012). The beak and spur length of RJf was same as reported by Condon (2012), who also stated that this two traits are most effective for males of RJf. The shank, spur and wattle length value under this investigation was agreed with the previous study of Faruque *et al.,* (2013) and Condon (2012), where they mentioned wattle length ranged from 4.09 to 5.12 cm and shank length 10.35 to11.09 cm and spur length 0.25 to 3.26 cm considering the genotypes, non-descriptive deshi, Hilly and Naked neck and RJf. Neck length under this investigation was smaller than the previous study of Ferdaus *et al.* (2016) in indigenous chicken of Bangladesh, which might be due to genotype variability and other environment factor. This was revealed that the morphometric characteristics of ND was larger than the RJf.

5.2 Live weight and live weight gain

The day old chicks weight values of RJf and ND was ranging from 18.65 to 24.30g and highest values for both sexes was observed for ND than the RJf. The day old chick's weight is depends on the egg weight. Though the weight of the egg of ND was higher than RJf, so the higher weight of day old chicks of ND was obtained. Similar weight of day old chicks was reported by Faruque *et al.* (2007) for ND and by Vijh *et al.* (2007) for RJf, they reported weight day old chicks of ND was 27 to 29g and for RJf 15 to 18g, respectively.

Age at sexual maturity recorded in RJf male and female was 142 days and 174 days, respectively. Compared to RJf male ND male showed later age at sexual maturity (152days) but females became early at sexual maturity (167days) and the outcome of this study was similar to the findings of Dutta *et al.* (2013), Jahan *et al.* (2017), Yeasmin *et al.* (2003), Huque (2001), Ershad (2005), Faruque *et al.* (2007), (2010), (2013) and (2015). However, these findings did not agree with the findings of Barua (1992) and Shahjahan *et al.* (2011), who found higher ages at sexual maturity which were 225 and 203 days, respectively, and these differences might be due to differences of environmental factors (e.g. feeding, production system etc.). Onset of sexual maturation is importance both evolutionarily and economically. It was also reported by Wright *et al.* (2012) that RJf, attain maturity approximately 20% earlier than ND.

On the other hand, weight at sexual maturity of RJf was higher to the ND. The weight at sexual maturity of RJf was similar with the Sutherland *et al.* (2018) and for ND with the Faruque *et al.* (2007) and Noor *et al.* (2021). The mature live weight at 38 weeks of age of ND was superior to the RJf. In this study, the mature live weight of ND was recorded from 1254g for female and 1530g for male and for RJf was 795g for female and 1050g for males, respectively, those values were similar with the other researchers elsewhere Noor *et al.* (2021), Vijh *et al.* (2007).

The weight gain up to sexual maturity and weight gain (g/d) up to mature age values indicated that the ND grew faster than the RJf, and the growth rate of chickens depends on the weight at maturity and mature live weight as the weight was calculated from the difference of final weight minus the initial weight and this observed value was divided by the age of birds in days. However, weight gain of ND chickens that are reported in the

current study was in similar with Khan *et al.* (2007) and the RJf weight gain was similar to the study of Sutherland *et al.* (2018).

The live weight and live weight gain values showed that the ND was superior to the RJf due to the genetic differences and also the effects of domestication as domestication increases the production performance of animals (Encyclopedia of Agriculture and Food system, 2014; *https://www.sciencedirect.com/topics/earthandplanetarysciences/Domestication*).

5.3 Egg production characteristics

The fertility (%) and hatchability (%) of ND was significantly higher than the RJf. The findings of ND were supported by the study of Hoque *et al.* (1975) and Faruque *et al.* (2013, 2015). However, this result was lower than the findings of Dutta *et al.* (2013), Huque and Salahuddin (2001), Islam *et al.* (2001) and Khatun *et al.* (2005). On the other hand, the fertility of RJf was similar with Fazhana and Azhar (2014). However, hatchability comparatively lower with the Fazhana and Azhar (2014). The lower hatchability was obtained due to the broody hen did not set broody eggs all time, sometimes they were left the eggs in the cage. The fertility depends on various factors such as breed, season, pre-incubation holding period, lighting, level of nutrition, mating and time of mating (Miazi *et al.,* 2020). Temperature is a major factor for the production of the fertile eggs.

On the other hand, Barua (1990) found the hatchability of ND was 75%. There are several factors was also reported by other researchers, including genetic makeup, care of hatching eggs, storage temperature, moisture, age of broody birds, the quality of eggs, seasons, nutrition influenced the hatchability of fertile eggs (Kamphues *et al.,* 2001, Miazi *et al.,* 2020). Both high and very low moisture contents in the weather badly affect the hatchability but the moderate moisture content of the air enhances better result (Das *et al.,* 2005). This result supported that the hatchability rate varies breed to breed and it is also affected by the environmental factors.

The ND female has a higher clutch size than RJf female. Clutch size found in this study was similar to Jahan *et al.* (2017) and Vijh *et al.* (2007), but was lower than the findings of Sarkar and Bell (2006), Shahjahan *et al.* (2011), Shahjahan and Bhuiyan (2016).

The RJf has a high number of clutches per year (5 number) than ND female (4 number). The result of ND was similar to the findings of Sarkar and Golam (2009), Shahjahan *et al.*, (2011) and higher than the findings of Shahjahan and Bhuiyan (2016). On the other hands, the clutches of RJf was same as Vijh *et al.*, (2007).The difference of clutches per year may be due to geographical location, natural resources, nutrition and overall management.

The yearly egg production was higher in ND chicken (52.8 eggs) than the RJf (28 eggs), which was nearly half the yield of ND chicken. The difference was due to the seasonal breeding behavior of RJf. However, the result of ND chicken was similar to Shahjahan *et al.*, (2011), Sarkar and Golam (2009), Sarkar and Bell (2006). However, it was lower than the findings of Ahmed *et al.* (2012), Faruque *et al.* (2015) and Paul and Huque (1996). On the other hand, the hen day egg production of RJf was similar with Vijh *et al.* (2007).

The RJf produces smaller sized eggs than the ND deshi chickens and the egg weight of RJf was lower (only 30.4g) than the ND chicken eggs weighing as average of 40.7g. The values of ND was similar to the Ershad (2005), Barua and Howlider (1990) and it was also supported by Yeasmin and Howlider (1998), Islam and Nishibori (2009). However, Ahmed *et al.* (2012) and Faruque *et al.* (2010 and 2013) obtained slightly higher egg weight than the current study. On the other hand, the egg weight of RJf was similar with Vijh *et al.* (2007), they reported an average weight of RJf eggs was from 24 to 32g.

In addition to that the laying season of RJf is spring to monsoon (March- July) but ND female laid eggs throughout the year. The egg color of RJf and ND chicken was light brown and Brownish or whitish, respectively. The similar egg colour was also reported for ND and RJf by Khan *et al.* (2017*)* and Vijh *et al.* (2007), respectively.

The egg production characteristics of ND was superior to the RJf due to the genetic differences and also the effects of domestication the causes described in earlier sub-heading.

Conclusions

The findings of this study reveal that there are a number of similarities and differences in phenotypic characteristics between Red Jungle fowl and Non-descriptive deshi chickens. As chickens were descended from the jungle fowl, therefore, native chickens have retained a considerable number of phenotypical and behavioural characters from junglefowl due to the low impact of anthropogenic effects in the course of their breeding history. Differences between junglefowl and chickens may be caused by evolution due to domestication and also differences in breeding and management histories. This study also reveals morphometrically non-descriptive deshi chickens were larger than Red Jungle fowl. In growth and live weight gain aspect Red Jungle fowl shows low performance in semi-intensive condition than non-descriptive deshi chicken only exception was age at sexual maturity, where Red Jungle fowl male gains early maturity than the non-descriptive deshi male but in females, non-descriptive deshi chicken showed earlier maturity. Egg production characteristics in non-descriptive deshi chicken were superior in every aspect than the Red Jungle fowl. The egg weight was lower in Red Jungle fowl and hatchability percentage of fertile eggs was much lower than the non-descriptive deshi chicken, which may be the result of their captive rearing under human surveillance apart from their natural habitat. This study was solely done to understand the phonotypical characteristics, growth and weight gain and to see the egg production performance under semi-intensive condition. However, this study was done with small population of both genotypes under semi-intensive condition in a small area. To further know their performance study should be done in their natural habitats, which demands more extensive study. Such work would require large number of representative samples and cover a wide geographic range.

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Photo Gallery

Cocks and hens movement inside aviary

Feeding of cocks and hens inside aviary

Scavenging inside aviary

Aviary

Figure 2: Cocks of Red Jungle fowl

Mature hen

Hen with chicks

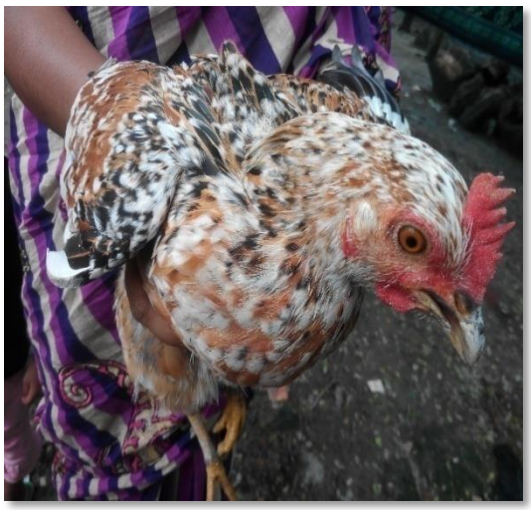
Figure 3: Hens of Red Jungle fowl

Brown black type

White black type

Brown black type

Black type



Spotted type

Figure 4: Different types of Non-descriptive deshi chicken

APPENDICES

APPENDIX 1: Morphological data collection form

Chattogram Veterinary and Animal Sciences University

TITLE: STUDY ON THE MORPHOMETRIC, GROWTH AND EGG PRODUCTION CHARACTERISTICS OF RED JUNGLE FOWL AND NON-DESCRIPTIVE DESHI CHICKEN UNDER SEMI-INTENSIVE CONDITION

Farmer's Name: Mobile No. :

Sl. No.	Hen/ Cock With ID	Age	Color	Beak length (In Cm)	Comb length(In Cm)	Wattles(In Cm)	Neck(In Cm)	Primary flight feathers(In Cm)	Secondary flight feathers	Main tail feathers(In Cm)	shank(In Cm)	Spur(In Cm)	Egg Prod./Year
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													

APPENDIX 2: Live weight and Growth data collection form

Chattogram Veterinary and Animal Sciences University

TITLE: STUDY ON THE MORPHOMETRIC, GROWTH AND EGG PRODUCTION CHARACTERISTICS OF RED JUNGLE FOWL AND NON-DESCRIPTIVE DESHI CHICKEN UNDER SEMI-INTENSIVE CONDITION

Farmer's Name: Mobile No. :

Record on live weight of Red jungle fowl and Non-descriptive deshi chicken

Sl. No.	**Hen/ Cock With ID**	**DOC Weight (g)**	**Mature live weight at 38 weeks of age (g)**																																							
			1st week	2nd week	3rd week	4th week	5th week	6th week	7th week	8th week	9th week	10th week	11th week	12th week	13th week	14th week	15th week	16th week	17th week	18th week	19th week	20th week	21st week	22nd week	23rd week	24th week	25th week	26th week	27th week	28th week	29th week	30th week	31st week	32nd week	33rd week	34th week	35th week	36th week	37th week	38th week
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APPENDIX 3: Live weight and weight gain data collection form

Chattogram Veterinary and Animal Sciences University

TITLE: STUDY THE MORPHOMETRIC, GROWTH AND EGG PRODUCTION CHARACTERISTICS OF RED JUNGLE FOWL AND NON-DESCRIPTIVE DESHI CHICKEN OF BANGLADESH

Farmer's Name: Mobile No. :

Live weight and weight gain records of Red jungle fowl/Non-descriptive deshi chicken

Sl. No.	**Hen/ Cock With ID**	**Weight at sexual maturity (g)**	**Weight gain (g/d) up to sexual maturity and mature age**																																							
			1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**	**13th**	**14th**	**15th**	**16th**	**17th**	**18th**	**19th**	**20th**	**21st**	**22nd**	**23rd**	**24th**	**25th**	**26th**	**27th**	**28th**	**29th**	**30th**	**31st**	**32nd**	**33rd**	**34th**	**35th**	**36th**	**37th**	**38th**	**39th**	**40th**
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APPENDIX 4: Egg production traits data collection form

Chattogram Veterinary and Animal Sciences University

TITLE: STUDY ON THE MORPHOMETRIC, GROWTH AND EGG PRODUCTION CHARACTERISTICS OF RED JUNGLE FOWL AND NON-DESCRIPTIVE DESHI CHICKEN OF BANGLADESH

Farmer's Name: Mobile No. :

Egg production records of Red jungle fowl/Non-descriptive deshi chicken

Sl. No.	Hen/ Cock With ID	Age at sexual maturity (days)	Clutch size (days)																Hen day egg production per year (No)	Number of clutches per year (No)					Egg weight (g)	Egg shell color
			1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13rd	14th	15th	16th	17th		1st	2nd	3rd	4th	5th		
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Biography

This is DR. Progayan Chakma, Son of Mr. Amar Sneha Chakma and Late Mrs. Bina Chakma from Ruma Upazilla under Bandarban district of Bangladesh. He completed the Secondary School Certificate (SSC) Examination in 2009 from Chittagong Residential School and College, Chattogram, followed by Higher Secondary Certificate (HSC) Examination in 2011, from Bandarban Cantonment Public College, Bandarban. He obtained his Doctor of Veterinary Medicine (DVM) degree in 2017 from Chattogram Veterinary and Animal Sciences University, Chattogram. Now, He is a candidate for the degree of Masters of Science in Animal Breeding and Genetics at the Department of Genetics and Animal Breeding, Faculty of Veterinary Medicine, CVASU, Chattogram, Bangladesh. He is currently working as Livestock Extension Officer under Livestock and Dairy Development Project, DLS. His professional goal is to involve himself as a researcher since his passion has always been to serve the country and to improve quality of life of the people.