STUDY ON CATTLE MANAGEMENT AND EFFECT OF WATER HYACINTH (*Eichhornia crassipes*) ON MILK YIELD OF LOCAL AND GRADED COWS AT NARAYANGONJ DISTRICT IN BANGLADESH - A SURVEY

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Examination Roll No: MS-100715

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DECLARATION

This thesis report is the original research work of the author, except as otherwise stated. The material presented has not submitted either in whole or in part for a degree for this or any other university. The findings of the research has not been/will not be published anywhere without the written concurrence of the concerned supervisor. Legal action will be taken in any case of infringement regarding the declaration.

MD. FAIZUL KARIM JAHANGIR .... 08.06.2015 ....

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DEDICATED TO MY

MOST RESPECTABLE PARENTS

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CONTENTS

LIST OF ABBREVIATIONS

WH	= Water hyacinth
BBS	= Bureau of Statistics
$Ca(OH)_2$	= Calcium hydro-oxide
CaO	= Calcium oxide
CP	= Crude protein
DM	= Digestible matter
FRS	= Fresh rice straw
FY	= Fiscal Year
GDP	= Gross domestic product
Ha	= Hector
ME	= Metabolic energy
NaOH	= Sodium hydro-oxide
OMI	= Organic matter intake
PPM	= Per's per mole
TDN	= Total digestible materials
UL	= Urea-lime

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ABSTRACT

The experiment was conducted to evaluate the effect of water hyacinth as a source of roughage on milk production and feed intake as well as to know the cattle management system at Narayangong district in Bangladesh. A total of 92 cows (58 graded and 34 improved local) were selected from 23 different small holders' and local and graded cows were grouped into three according to their body weight such as for local cows: group A (100 kg to 125 kg), group B (125 kg to 140 kg) and group C (140 kg to 150 kg) and for graded cows: group A (130 kg to 140 kg), group B (140 kg to 150 kg) and group C (150 kg to 180 kg). Each of the animals was supplied concentrates at amount of 3.0 kg per day. Untreated straw, untreated straw and water hyacinth (1:1) and fresh water hyacinth was supplied to group A, group B and group C respectively. Milk production was significantly ($P<0.01$) increased by both local and graded cows when water hyacinth was supplied to the animals as a source of roughage. Whereas, only local cows showed increased ($P<0.05$) milk production when untreated straw was provided, this could be due to the ability of local cows to utilize rice straw efficiently. The results of the present study revealed that substitution of rice straw by water hyacinth can increase milk production since it increases feed intake. Considering cattle management system, ninety percent (90%) of the cows were inseminated artificially under proper hygienic condition and thirty seven percent (37%) of the total cows were milch per farm.

CHAPTER 1

INTRODUCTION

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Bangladesh is the largest delta of the world and it lies between 20°24′& 26°38′ north latitude and 88°01′& 92°41′ east longitude. It consists of low flat and fertile land except the hilly regions in the northeast and the southeast and some areas of high lands in the north northwestern part.

It is one of the densely populated countries and the fourth largest agricultural country in the world (Ahmed, 1987). The economy of Bangladesh largely depends on agriculture because most of the people (79.90%) live in rural areas. Livestock being one of the four major components of agriculture and plays a vital rule in national economy, which contributing about 9% gross domestic product (GDP) and 13% of total foreign exchange earnings (DLS, 1994).

Livestock, being one of the major components of the farming systems, plays vital role in agriculture. In an intensive agrarian country like Bangladesh, feed resources for ruminants are derived mainly from crop residues, cereal by-products, shrubs, fodder trees, and grasses growing in wayside bunds and embankment.

The success of livestock farming greatly depends on the continuous supply of good quality balanced feed. The cost and availability of concentrate feeds play important role in livestock production at farmer's doorstep. The green roughage availability for feeding of livestock is restricted to certain parts of our country and nutritional surveys in various parts of the country show that animals are mostly maintained on straw based rations (Maruthiram *et al.,* 1976). Animals on such rations often suffer from poor nutrition (Kumar Amrith *et al.,* 1980). Straws are known to be of low nutritive value as they lack in protein, minerals and vitamins. Voluntary intake and digestibility of these straws are low due to high lignifications (Gupta, 1991).

The available cattle feeds in Bangladesh can be grouped into agricultural and agro-industrial by-products which include agricultural crop residues such as straws, sugarcane tops etc; by-products from agro-industries e.g. molasses, oil-cakes, pineapple wastes, shrimp waste etc; and milling by-products such as brans. Green roughage include non-cultivated indigenous grasses grown on road side, embankment, bunds etc; leaves of the jack fruit and mango tree, ipil ipil (*Leucaena leucocephala*) etc; and aquatic plants such as water hyacinths, dol grass, azolla, duck weed etc. Cultivated fodder includes both perennials, such as Napier, Para, German, Splendida, Andropogon, and Gamboo grasses; and seasonal crops such as maize, cowpea, khesari, oat, sunhemp etc.

The bulk of the roughages for ruminant feeding are derived from crop residues of rice, wheat, pulse etc. Tree leaves, indigenous grasses, and cultivated fodder contribute little to the bulk. The total area for Bhadoi and Rabi fodder is about 6,312 ha, producing only about 47,000 m tons of fodder crops. Very little grain is available for feeding the animals in the country. It is estimated that about 190,000 m tons of grain is available for livestock feeding, contributing only about 15.7 percent of the total amount of concentrate feed (banglapedia.org).

According to Banglapedia, total cattle population is about 23.4 million of which 11.91 million are males and 11.49 million are female. Among then 3.53 million milking cows, 2.61 million dry cows (cows without milk), 2.31 million drought cattle and 4.20 improved cattle. About 8.17 million (BBS, 2003) holding are improved with cattle rearing .The relative density of cattle population is high and the country ranks 12th in terms of cattle population in the world and 3rd in the Asian countries (Alam *et al.,* 1994).

Despite such a high density of cattle population, the country has been deficient in milk, meat and draught power for quite long time, because more than 90% of Bangladeshi cattle are indigenous zebu type and they are low producer. It might be due to their poor genetic make-up, inadequate nutrition etc. The remaining 10% are exotic pure breeds and their performances are not satisfactory due to pronounced genotype environment interaction. The output of milk is only 137 liters per lactation per cow (DLS, 1991) which is very poor compared to European and other exotic breeds (Holstein Friesian) in the world. Although these types of cattle are of low potential in terms of production but posses some beneficial characteristics such as remarkable heat tolerance adapted to humid climate, high rainfall, flooded and swampy condition, ability to maintain body condition on poor quality feed stuffs mainly rice straw, good degree of resistance to local diseases, early puberty of nature. Traditionally, cost of maintaining these animals by the smallholder family unit are minimal with feeds derived from home ground crops and crop residues and unimproved wayside pasture.

On the other hand, exotic breeds from temperate zone being a higher yielder in a favorable environment than indigenous type cannot adjust to hot and humid conditions. The performances of exotic breeds have often been disastrous in proper managements with retarded growth, high mortality, poor fertility and susceptibility of diseases. The performance of temperate genotype in tropical environment is 30-40% lower than that of the countries of their origin.

Smallholder farmers maintain the majority of the animals adjunct to crop agriculture as having significant dependence on livestock with little or no outside labor and with returns that provide subsistence but little for saving, capital investment or for the purchase of external agriculture inputs. Whereas in some milk pocket areas particularly in Bhaghabarighat, Sirajgong; Takerhat, Faridpur etc green fodder are available from November to April and next of the year animals are raised on rice straw and preserve fodder. Rice polish, wheat / pulse bran etc as concentrate sources are playing important role in livestock enterprises throughout the country in variable level. In hilly areas, no attention is thrown for nutritional management except in few cases when cattle are reared for milk yield. In farm conditions improved feeding and management practices are followed throughout the year (Bhuiyan, 2007).

It is estimated that the world food requirement by the year 2050 will be double that of 2010. A significant part of this requirement will emanate from the developing countries, on account of increased human populations, disposable incomes and urbanization. For livestock products, about two-thirds of this increased demand will need to be met by improving the production efficiency of feed, both forages and concentrate feeds. However, in addition to shortage of feed, it is well documented worldwide that imbalanced nutrition is a major factor responsible for low livestock productivity. Balanced nutrition contributes to improving animal output as well as to reducing both the cost of production and the emission of green house gases per unit of animal product.

Basal feeds are concentrated sources of energy and are especially rich in starches and sugars. They include the whole group of grains (e.g. wheat, maize, oats etc.) and their by-products. Basal feeds have a protein content that is greater than 16% and a maximum fibre content of 18%. The main difference between basal feeds and other feed stuffs is that basal feeds have high digestible energy content. Basal feeds make up 60 - 90% of all rations.

On the farm, roughage is normally considered to be material making up fodder such as hay, silage, pastures etc. The distinguishing characteristic of roughage is usually a high fibre content. For hay, this frequently runs between 25 - 30% of the dry matter. Technically, all feeds supplying nutrients (proteins, carbohydrates and fats) are classed as concentrates if their crude fibre content does not exceed 18%. In the feed trade, the word 'concentrate' has been used to indicate commercially prepared supplements (acsedu.co.uk).

Good quality grass is not readily available in Bangladesh and becomes scarcer during the dry season. At the same time, starch and protein sources become more expensive during this period. A number of non-conventional feed resources such as sugarcane tops, maize, including water hyacinth (*Eichhornia crassipes*) are available in Bangladesh and neighboring countries and have become more interesting for the improvement of ruminant production (Devendra, 1985).

Water hyacinth (WH) originates from Brazil and has now spread to all tropical and subtropical countries (Parsons and Cuthbertson, 2001) and is regarded as one of the world's most invasive aquatic plants. Water hyacinth is available all year round and is widespread on freshwater, especially in standing water (MWBP/RSCP, 2006). It multiplies rapidly and forms dense mats (Gopal and Goel, 1993) which interfere with waterways, decimates aquatic wildlife and creates ideal conditions for diseases and its vectors etc. (Kushwaha, 2012). Water hyacinth is also known to have significant ecological and socio-economic effects (Villamagna and Murphy, 2010). However, there are potential benefits from WH such as animal fodder, water purification, fibreboard, biogas, fertilizer and paper production (Lindsey and Hirt, 1999). Moreover, harvesting of WH can be conducted manually on a small scale and does not require new harvesting techniques to be introduced (Gunnarsson and Petersen, 2007).

Countries like Bangladesh, where poor quality rice straw is the major roughage source available. Out of total dry matter (DM), 70% constitutes dry roughage, 87% of which is rice straw (Tareque, 1991). Rice straw is very low in digestibility and highly deficient in protein and micronutrients (Preston and Leng, 1987; Akbar, 1992). Water hyacinth could offer a better alternative. A high protein content, especially in leaves (Virabalin *et* *al.*, 1993) and rapid growth (Gopal, 1987), has made Water hyacinth interesting for using as fodder to cows (Rashid *et al.* 2009).

Dairy cows were selected for feed treatment, not only because of the large potential feed market, but because they are highly productive animals requiring considerably greater amounts of total digestible nutrients (TDN) than beef cattle, thus serving as a better indicator of feed value. Depending on a dairy cow's physiological state, digestible nutrients and energy requirements may be thirty-five times higher than beef cattle in a maintenance phase (Cole, 1962). Dairy cows are good indicators to use in short term studies due to their quick response to feed values which can be measured by their daily milk production.

Objectives

The objectives of this study are:

1. to study the cattle management system at Narayangonj District.
2. to study the effect of fresh water hyacinth on feed intake in local and graded cows with a given concentrate and rice straw and
3. to investigate the effect of fresh water hyacinth as a roughage on milk production in local and graded cows.

CHAPTER 2

REVIEW OF LITERATURE

CHAPTER TWO
REVIEW OF LITERATURE

2.1 Cattle production in Bangladesh

Bangladesh is predominantly an agrarian economy with 84.8% of its population living in villages and depending on agriculture and allied activities for their livelihood (BBS, 1992). Per capita Gross National Product is US $ 240 (World Bank, 1996). The total labor force is estimated at 32.5 million of which 21 million are women (Harun-Ar-Rashid, 1989). About 61% of the labor force is engaged in agriculture (BBS, 1992). The agriculture sector cannot absorb surplus manpower. Many landless laborers find it hard to obtain employment.

Bangladesh primarily consists of low, flat and fertile land. A network of rivers and their tributaries flow down to the Bay of Bengal. It has a sub-tropical monsoon climate. Bangladesh is under The Great River Valleys topographical region in tropical Asia (Payne, 1970). The zone is characterized by seasonal differences in rainfall. There are usually three seasons: cool-dry, hot-dry and hot-wet. Total annual rainfall varies between 305 and 2032 mm. and in general decreases with increasing distance from the equator (De La Rue *et al.,* 1957). All livestock need food, water and a suitable environment for survival. In this sense, Bangladesh has a suitable environment for the survival of cattle. Moreover, recent trials have also shown that rapid improvement of the local cattle in the tropics can be attained by cross-breeding, using semen from high quality animals. Such cross-bred animals produce satisfactorily, survive well under the local conditions and have the necessary heat tolerance. There are other factors, which favour livestock production in the tropics. The capital investment for buildings, etc. need not be so high as in the temperate zones. Only a simple building with a floor and a roof is required, as against the expensive building to keep out the cold in temperate countries. Similarly, due to the heavy rains that occur throughout the year, capital cost for irrigation, etc. need not be as high. These factors help to reduce costs of milk production.

In low-income countries dominated by agriculture, growth in a large domestic market is only possible if incomes are rising in the agricultural sector. Therefore, technological change in agriculture, which boosts production, incomes and consequently demands in rural areas, is central to a strategy that produces high rates of economic expansion and broad participation in the development process. By spreading productive resources over the largest possible segments of the population, such a strategy creates large, direct increases in agricultural employment and incomes. More importantly for poverty reduction, the linkage and multiplier effects of agricultural growth, by generating increased demand for labor-intensive goods and services produced in the non-agricultural sectors, indirectly stimulates further employment and income growth throughout the economy.

Animal production is one, and a very important, facet of agriculture. In the tropics it is no less important than in developed countries. Among the animal products, milk contains a high nutritional value. It contains all ingredients required by the human body in proper proportions and in a very easily digestible form. Also the inclusion of milk in the diet increases the digestibility of others types of food which are included in the diet. The demand for milk and milk products is increasing because of the rapid increase in population, the spread of education and growing nutrition awareness. In fact, in most of the cities milk supply at present is short of requirements. For these reasons, dairy development has assumed a position of paramount importance in the rural economy of Bangladesh. It is essential that this sector, like every other sector of tropical agriculture, should be modernized and made more productive as quickly as possible.

2.2 Existing dairy breeds and cattle production system

Dairying is an integral part of rural livelihoods especially for the landless and smallholder dairy farmers, and acts as an important economic activity in Bangladesh; it provides supplementary income, employment and nutrition to about 3.6 million households (Marks and Sultana, 2008). More than 80% of people are involved in rearing cattle; most of the cattle are nondescript indigenous Zebu-type animals (Khan, 2006). Productivity of such indigenous animals is low, which is an important constraint limiting the development of the dairy industry. The production level of these animals is far behind the stakeholders' expectations to make the industry competitive. The reason is poor genetic characteristics. Poor nutrition might be a second cause.

The total milk production of the country is 2 million tons per year, which is insufficient to meet existing demand in Bangladesh. Daily consumption is about 35 ml per capita, while 250 ml is recommended. Milk production costs are high due to high feed costs. There is limited access to milk marketing, processing costs are higher than in neighboring countries and technology uptake has been minimal.

Animals are mainly kept in stalls with limited grazing on the roadside, embankment slopes, seasonal fallow lands etc. Fibrous crop residues constitute an important source of feed for dairy cattle (Debnath *et al.*, 2003). Paddy (rice) straw is the main source of roughage among the crop residues. Green roughage and rice polish are also widely fed to cows under village conditions. Maize grain is now available due to an increase in production in recent years. Total maize production increased by 63% from 2001 to 2008 (Khaleduzzaman and Khandaker, 2009). Therefore, farmers can supply dairy cows with crushed maize in addition to rice polish, wheat bran, and oil cakes. But there is scant information regarding the proportion of ingredients in concentrate feeds and nutritional demand of cows with regard to milk production at village level. Many feed manufacturing companies are preparing concentrate feed mixtures and supplying large dairy farmers, but smallholders are unable to buy because of high prices. This study was undertaken to measure the effect of supplementary maize-based concentrate feeding on milk yield of indigenous cows under village conditions and the cost-benefit analysis.

Relatively homogeneous variety or group of dairy cattle within a species having similar appearance and usually developed by deliberate selection. No specific cattle breed has yet been established in Bangladesh. But with the long natural selection some improved indigenous varieties of cattle exist in the country. This results from the centenary selection of better animals for increasing milk production. These **improved local varieties** are Pabna Cattle, Red Chittagong, Munshiganj Cattle, and North Bengal Grey Cattle. Their production potentiality is higher as compared to average overall performance of the common local indigenous cattle in Bangladesh.

Of about 23.4 million cattle heads in Bangladesh, most are **non-descriptive indigenous Zebu** (humped) type multipurpose animals. The average milk yield being about 206 kg/lactation/cow. Cattle are almost evenly distributed with a little higher concentration in northern part of the country. They are the good source of milk, meat, and draught power; cow dung is used as manure and fuel. The local variety has some good criteria, viz resistant to diseases and parasites, efficient to utilize low quality roughages, and well-adapted to harsh environmental conditions.

To improve the production potentialities of the local cattle, efforts were made to cross breed with different exotic breeds several times in the past. The introduced breeds are Holstein-Friesian, Jersy, Sahiwal, Harians, Sindhi, Australian, Sahiwal-Friesian, etc. A number of **exotic pure breeds**, their **crossbreeds,** and **up-graded cattle** termed as **graded cattle** are found in the government dairy farms, commercial dairy farms, milk pocket area, and in urban and semi-urban areas of Bangladesh (banglapedia.org).

Dairy animal rearing is a component of farming system in Bangladesh since ancient time. The animal are reared by farmers for milk production and the cow gives birth female calf is used as future milking animal and male calf is used as future bullock for traction, transport and to sale for cash money. Small farmers keep 1-2 milch animals of low genetic production potential. Most of the dairy farms are small holders and are located in different regions of the country with more concentration to north-west of the country. The average family size of the smallholder dairy farms consists of 5-6 persons, where the adult male and female take cares the animals on a part time work in addition to their normal work. In some areas, farmers have built up groups or cooperatives under the brand name of Milk Vita. The cooperatives gives veterinary and A.I. services free of cost and sell concentrated feed to the members on credit. The farms sell their produced milk to the cooperatives at a fixed price on the basis of milk fat percentage. Their debt and credit is cleared every fortnight. With the above system in operation the farmers produce 1.62 million tonnes milk per day (Saha and Haque, 2001). This amount of milk production can cover only 15 per cent of the requirement. In the last few years milk consumption has increased rapidly and linearly with an estimated 1.2% increase annually (DLS, 2007).

Dairying is a good source of income to the small and marginal farmers. The feeds required for milk production can be met from their limited land resources as most of the milch animals are ruminants and the majority of their food can be derived from forages, coarse roughages and byproducts not utilized by human beings, without incurring much additional cost. Dairy animals, comprising cows and buffaloes, are the major livestock and hold a very important place in the national economy of Bangladesh. Apart from their role in milk production they contribute a huge quantity of organic manure, which is one of the major inputs in Bangladesh agriculture. Dairying is a subsidiary occupation of almost all farmers of Bangladesh. More than 60% of the families involved in dairying consist of small and marginal farmers and even agricultural laborers. Most of the small-farmers and landless labourers are under employed and there is also surplus labour in the rural areas. Therefore, the supply of such labour for dairy development or the involvement of rural farmers in the dairy industry would not only create employment but raise the standards of living of the rural people.

The total number of cows and buffaloes is 24 million and 1 million respectively. Among them, 2 million are improved breed cows (Livestock Directory, 1992-93). The contribution of livestock in the GDP is about 6.5% (Alam, 1994). About 20% of Bangladesh's population is directly or indirectly engaged in the livestock sector. Its share in the foreign exchange earnings in terms of exporting leather and other live stock by-products is about 9%. It provides 80 million tones of dung which is 10% of the total fertilizer used in agriculture per year (AIS, 1998).

Total annual national production of milk in Bangladesh is 1.338 million metric tons out of which 97% is produced in rural areas and 3% in urban areas. About 83% of the milk is obtained from non-commercial livestock enterprises. The quantity of national milk production can only meet about 13% of the actual demand for milk of the population. See table 2.1.

Table 2.1: Consumption and Production of milk

Per capita need	Per capita availability	Total need (Year)	Total production (Year)	Total deficit (Year)
250 ml/day	33.95 ml/day	9.855 mmt (100%)	1.338 mmt (13.58%)	8.517 mmt (86.42%)

Mmt = Million metric ton
***Source:** Alam, J (1994),*

Table 2.2: Design of livestock technologies for industrialized and developing countries

	Industrialized	**Developing**
Climate	Mostly temperate	Mostly tropical
Role of livestock	Specialized	Multipurpose
Target group	The rich	The poor
Resource base:		
Feed	Starch-protein	Fibre-sugars
Genetic status	Improved	Native
Capital	High	Low
Labour	Low	High
Mechanization	High	Low
Agrochemical	High	Low
Infrastructure	Good	Poor
Marketing	Good	Poor

Source: Netherlands Development Cooperation, 1987.

These differences help to explain why there are conflicts concerning the strategies that should be applied when national governments, supported by international and bilateral technical assistance agencies (whose policies are largely determined by professionals from the industrialized countries), attempt to introduce innovations in the field of livestock research, technology transfer and training.

Experience has shown quite clearly that it is counter-productive in developing countries to base these activities on the models that have been, or are currently being, applied in the industrialized countries. The conclusions of a recent evaluation report on Dutch assistance to the livestock sector in Third World countries (Netherlands Development Cooperation, 1987)

Cattle any large, even-toed hoofed, ruminant mammal of the genus *Bos*, family Bovidae. Domestic cattle mostly descended from the wild aurochs (European Ox, now extinct). Domestication of cattle and their propagation at the world level started in the Neolithic ages in about 2000 BC. *Bos indicus* and *Bos taurus* are the two distinct species of cattle. *B. indicus*, the Indian Zebu (humped) is available in the Indian subcontinent, characterized in general by lower growth rate, smaller size, late sexual maturity, poor production, and prone to parasitic attack but resistant to some infectious diseases. On the other hand *B. taurus* (temperate cattle) is characterized by medium to heavy size, early sexual maturity, and has high production potentialities in terms of meat and milk Cattle has multipurpose functions; it is used for traction of lands and cartage and produces milk and meat. Cow dung is used as manure and as fuel, and a substrate for methane production. Cattle hides and skin are used for clothing, bags, shoes etc (banglapedia.org).

2.5 Shortage of Quality Breeds

The main problem of dairy development lies in its very low production and low productivity. Breeding is the major technological improvement process in the dairy industry. A cross-breeding program for cattle was introduced in the country in 1976 with a view to improving the milk production efficiency of indigenous cows. The program serves with a network of 847 artificial insemination centres (Livestock Directory, 1992-93). The results obtained, so far, on the organized farms and research institutes, is quite encouraging. However, no systematic study has been conducted in the country to objectively evaluate the economic performance of the cross-breed cows under field conditions.

The adoption of milch crossed cattle has brought about an immediate upward shift in the threshold level of milk yield, enabling the farmers to get more milk at the existing level of input use. However, the farmers failed in consolidating such technological gain as they were unable to adjust to the new requirements of the crossbred technology. The artificial insemination centres in Bangladesh lack required amenities and there are none experts in these centres, hampering smooth functioning of artificial insemination programs (Khamar, 1995). In addition to the technology related to breeding, a number of other areas such as feeding efficiency, processing technology, transportation, diseases and marketing efficiency also require careful analysis. Moreover, although a large number of veterinary centres and AI centres exist in the country, there seems to be no system to reach the farmers to advise them on various aspects of animal production and health.

In order to correct the deficiency of the AI facilities, it is important not only to provide adequate training to the personnel in charge of the AI stations and the farmers, but also to improve the quality of the infrastructural facilities with the AI stations.

2.6 Potential feeds for dairy cows in Bangladesh

Rice is the most important crop in Bangladesh. It covers more than any other crops in terms of area and others are sugarcane and vegetables specially. Therefore, the biggest crop is paddy rice and it is estimated that a similar amount of rice straw is produced (Chowdhury *et al.*, 1995). Better use of these feed resources is very important in cattle development in Bangladesh.

In Bangladesh, dairy cattle production has been developed for some decades and the cows are managed mostly in small-scale crop-livestock systems. Feeds are mainly based on natural grasses and crop residues with supplementation of concentrate. Shortages of roughage, and especially of good roughage for dairy cattle, have been reported by many researchers (Cuong, 1993; Man, 1995). This problem is more serious in the low land area even when water is available. Most of grasses cannot grow well in the flooding season or in the dry season.

How to solve this problem is an important question while straw sources is underutilized, being left to rot in the monsoon, flooding season and burned in the dry season? The production is seasonal and appropriate conservation techniques are needed to store the material to facilitate feeding it to animals over a long period. Rice straw, in wet or dry form, is the most potentially useful feed resource for cattle in the region and urea treatment is a good way to preserve and improve the nutritive value of straw, as reported in many studies (Chowdhury and Huque, 1996b).

2.6.1 Pastures

Natural pastures are generally poor in yield and quality and include species such as Napier, Para, German, Splendida, Andropogon, and Gamboo grasses and seasonal crops such as maize, cowpea, khesari, oat, sunhemp etc (banglapedia.org). As there is no proper pasture management, over-grazing has become a serious problem often resulting in soil erosion (Ly, 1995). In a period marked by accelerated industrialization and modernization as well as increased population pressure, natural grasslands are converted to crop farming or used for buildings.

Recently, grass cultivation has been studied and developed in research institutions and state farms in Vietnam with focus on species such as elephant grass (*Pennisetum purpureum*), *Panicum maximum*, *Paspalum atratum and* pangola grass (*Digitaria decumbens*). These grasses have reasonable productivity but variation depends much on season, soil type and management conditions. Elephant grass is main fresh forage for cattle production in many farms due to its high yield and simple management technique while growing other species is not popular in smallholder farms. Legumes and multi-purpose trees such as *Stylosanthes guianensis, Sesbania sesban, Sesbania grandiflora, Gliricidia sepium, Flemingia macrophylla* and *Leucaena leucocephala* are less used as green fodders.

2.6.2 Citrus and sugar beet pulps

Due to the high digestibility of their non lignified cell walls they favor, as opposed to molasses, the cellulolytic activity of the rumen. Due to the relatively moderate rate of fermentation (as opposed to sugars) they also represent good carriers of NPN and ensure an efficient microbial synthesis (synchronization of both ATP and NH3 releases). They can constitute the major part of the diet as well as an excellent energy supplement for diets based on fibrous crop residues.

2.6.3 Oil cakes and seeds and by-products of animal origin

They have been comprehensively reviewed in the 1988 IDRC and ICAR's publication. They constitute the largest source of supplementary protein. As mentioned earlier in this paper, the assessment of their potential use as protein supplement will be based on the degree of degradability of their nitrogen in the rumen.

As they represent a source of foreign exchange and of high quality protein for human and non ruminant animals, their use as protein supplement for ruminants should be considered against the local availability of legumes and or legume trees.

2.6.4 Cereal milling by-products

They are very well known and their use is expanding. Their major asset is the fact that they supply at a time, moderately fermentable energy, dietary protein and neoglucogenic nutrients. As an example, rice polishing can play a remarkable role in balancing sugarcane based diets.

2.6.5 Forage-based Supplementary Feeding

In areas where dairy cattle are kept near a pineapple factory, palm oil mill, sugarcane plantation or in any major agriculture operation from which crop by-products are plentiful, a complete year round feeding system involving these by-products could be established. Byproducts do not provide a balanced feed on their own, being either excessive or deficient in certain minerals, but they are good roughage with high metabolisable energy. They may be available or harvested only in a certain period of the year, mostly approaching the dry season when shortage of green forage is experienced.

Besides the agriculture by-products, the conservation of feed in the form of silage or hay maybe another alternative to ease the situation of feed shortage on the farm. Due to low leaf:stem ration or high fibre content, tropical pasture may not be that good for silage and hay making, but with some additional mixing with leguminous shrubs, good quality feed can still be maintained. Hence, using forage as a basic diet, supplementary feeding of formulated byproducts in the ration, may possible be able to maintain full milk production throughout the year.

2.7 Factors affecting the quality of rice straw

Rice straw has been used in ruminant feeding in China and other rice producing countries for thousands of years. Cellulose is the best available organic substance for rumen microbial fermentation in rice straw (Juliano, 1985). Biogenic silica, especially in the cuticle silica layer, is a barrier to stop pathogens from attacking the plant tissue, including cellulose, during rice growth (Deren *et al.*, 1994), but it also reduces the digestion of straw after the rice is harvested (Van Soest and Jones, 1968; Jackson, 1977; Van Soest, 1981). This factor can be altered by chemical treatment and urea is the most convenient agent in the tropics. In addition to supplying inorganic nitrogen (Van Soest, 1994), the major goal of urea treatment is upgrading the rice straw by improving the availability of cellulose to the rumen microbes through its effect on the factors limiting straw degradation.

The earliest extensive work on the use of urea for farm-scale treatment of rice straw with urea is probably that done in Bangladesh (Dolberg *et al.,* 1981). Since then the technology package has been applied and developed widely in the tropics, and many of the technical and socio-economical issues have been reviewed by Sundstol and Owen (1984). Besides straw, urea has been used in ensiling tropical grasses and other high moisture industrial by-products, and significant improvements were shown in many reports (Singh and Taparia, 1992; Ambre and Toro, 1993; Matsuzaki and Ogawa, 1994 and Sharma et al., 1995).

2.7.1 Urea – lime treated rice straw

The use of urea alone as preservative is still an expensive way of supplying nitrogen to ruminants, as the level required for effective treatment of straw is some 50% greater than what is needed by the rumen microbes (Preston, 1995). In addition, the price of urea is tending to rise due to reduced agricultural subsidies, which may put an end to the application of this method one day. Therefore it is worth trying levels of urea application lower than usually recommended (4-6%) complemented with cheaper alkaline agents, and among these lime ($CaO/Ca(OH)_2$) seems to be a good alternative . There have been many studies to reduce the level of urea by adding lime to reduce the cost of treatment. Treatment of rice straw with lime should be given priority for research at the moment since it is cheap and readily available. Lime is not only an alkaline agent; it can also be used to supplement calcium, which has been found in negative balance in cattle fed on rice straw (Nath *et al.,* 1969). A number of researchers have studied the effect of treatment with lime on the quality of cereal straw. Results from available reports (Saadullah *et al.*, 1981a; Hague *et al.*, 1981; Bass *et al.*, 1982; Garmo, 1984; Djajanegara *et al.,* 1984) seem to be equivocal. Usually, digestibility was increased, but dry matter intake was decreased due to unpalatability. Pradhan *et al.* (1997) reported that ensiling rice straw with 4% or 6% $Ca(OH)_2$ gave higher in-vitro dry matter digestibility than with 4% or 6% urea. However, heavy mould growth was observed in the $Ca(OH)_2$ treated straw, as also was observed in previous studies on barley straw (Owen and Nwadukwe, 1980; Bass *et al.,* 1982; Hadjipanayiotou, 1984). The same results were found in the present study (trial 1 of experiment 1). The use of 3% lime only was not a good method to preserve fresh rice straw. Mold was present in high amounts in this treatment (3% lime only: U_0L_3) at 9 weeks of storing and also pH of the treated straw was low (6.6).

Furthermore, the problem of unpalatability due to high levels of lime should still remain. It seems that a combination of lime and urea in straw treatment gives better effects than the use of urea or lime alone. Such a combination would take advantage of highly increased digestibility and calcium supplementation due to lime, with the well-known alkaline and preservative effects acting together with the increased nitrogen content of straw due to urea. The additive effects of the two chemical treatments were demonstrated by Saadullah *et al.* (1981b).

2.7.2 Urea treated rice straw

Urea, a common chemical fertilizer, is readily available in many parts of the tropics, and is a relatively safe chemical that is easy to store and also easy to dissolve in water. In addition, urea is a solid chemical, so it is easy to handle and transport (Sundstol and Coxworth, 1984). Another advantage of urea is that in many developing countries, it is considerably cheaper than NaOH or ammonia, and is much more readily available. Urea can be a substitute for alkali as a delignification agent through ammoniation. To increase the nitrogen content, urea treatment of straw promotes saponification of phenolic ester linkages (Dias-da-Silva and Guedes, 1990). An additional effect of urea treatment seems to be that it increases the content of extractable biogenic silica (Shen *et al.*, 1998), and thus enhances its digestibility (Dias-da-Silva and Guedes, 1990). Urea, when used for treatment of straw, enhances the nutritional quality of the straw in terms of increased nitrogen content, and improved palatability and digestibility. Urea treatment is also a suitable method for improving the feeding value of rice straw or the nutritional level of a diet based on rice straw. During the treatment process, ammonia is generated from urea, and in the presence of water it forms an alkali, ammonium hydroxide. It has been well-established that alkali treatment makes the cell walls more available for fermentation in the rumen. In temperate climates, anhydrous ammoniation or aqueous ammonia (ammonia dissolved in water) is used for the ammoniation of straw. In warmer climates urea treatment is more feasible because of the easy availability of urea and its quick breakdown into ammonia compounds under higher ambient temperatures. Urea treatment is also a good preservation method. Ammonia, trapped in the straw heap or bag, causes an increased straw pH (>8) that inhibits oxidative and microbial fermentation and keeps treated straw in a good condition. In our study (trial 1 of experiment 1), most of the treatments with a high level of urea (3% and higher) had a strong ammonia smell, and pH value higher than 8, and the treated straw was in good state of preservation. With lower levels of urea treatment, not very much ammonia was produced and this resulted in a low pH and slight ammonia smell. However the long storing period caused loss of ammonia, which resulted in decreased pH value and created conditions for mold development. The additional effect may be achieved as calcium hydroxide enhances the decomposition of urea into ammonium hydroxide (Van Soest, 1994). Therefore, the levels of application for both lime and urea in combination can be considerably reduced. In finding a good combination level of urea and lime, of 3% urea plus 4% lime was the most effective treatment for improving the digestibility of paddy straw. Zaman *et al.* (1994) reported that a level of at least 1.5% urea is needed to prevent mold in straw ensiled with lime. Trach *et al.* (2001b) suggested an effective level of 2% urea and 3% lime applied in straw preservation. In their study, Zaman and Owen (1995) concluded that mixtures of $Ca(OH)_2$ and urea would be the best alternatives to NaOH or ammonia for improvement of the nutritive value of straw.

2.8 Improving nutritive value and degradation of fresh rice straw (FRS) by treatment with urea and lime

Rice straw and other fibrous materials are normally low in protein. Therefore the added nitrogen is considered as one of the advantages of urea treatment. In a very early study on rice straw, Saadullah *et al.* (1981b) reported an increase of 2.3 – 2.5 times the CP in the untreated straw concentration of 33 g/kg DM. Treated straw CP increased significantly with urea concentration in the treatment (Jayasuriya and Perera, 1982; Verma *et al.*, 1996) and a concentration of 40 to 50g urea/kg DM straw is considered to be an appropriate level (Jayasuriya and Perera, 1982 and Verma *et al.*, 1996). The advantage of using higher levels was marginal in terms of digestibility.

The magnitude of the CP increase of treated straw varies according to many factors such as material, environment and procedure of the treatment process. Variation of material CP concentration determines the magnitude of the increase, and higher increases were noted for straws with low CP concentration after urea treatment, as shown in many studies (Chowdhury and Huque, 1996b). In studies on fresh rice straw the CP increases were from 3.6 to 6.4 fold over that of untreated fresh rice straw CP concentration (4.8%

of DM) in the study of Chowdhury and Huque (1996a), 2.1 fold in the untreated rice straw (6.88% of DM) in the study of Man and Wiktorsson (2001) and in the present study an increase of 1.8 to 2.4 fold the CP content was found, depending on level of urea.

Water is used to dissolve and hydrolyze urea in urea treatment and also to act as a means of moving ammonia compounds into the straw. Too low water to straw ratios result in low N content, but too wet straw allows fungal growth, particularly if ammonia escapes. An amount of water ranging from 30 – 65 liter per 100 kg DM straw seems to be optimum, depending upon the water availability (Rai *et al.*, 1993).

However, from practical experience high moisture enhances the upgrading effect of the ammonia and improves the voluntary intake of ammonia treated straw. In our study, the variation of very high ratios of water in fresh straw (68.6% and 47.2%: Paper 1) did not affect the CP content increase. The degradation, the ratio of dry matter loss after rumen incubation in the nylon bag incubation technique (Orskov *et al.*, 1980), is used to illustrate the improvement of straw quality after urea treatment. In the present study (paper 1) the degradation ratios of fresh rice straw preserved with urea were always higher than the untreated straw. Similar results were found in many other reports (Chowdhury and Huque, 1996b; Man and Wiktorsson, 2001). Higher degradation of urea preserved straw is probably due to the greater accessibility of hydrolytic enzymes to fibrous material as a result of the solubilization of hemicellulose and lignin by the NH_3 (Orskov *et al.*, 1980). The increase of treated straw degradation in the present study varied with the level of urea used in the treatment, and in the treatment with 4 and 5% of urea our results are similar to those in studies reported by Mgheni *et al.* (1993), Chowdhury and Huque (1996b) and Man and Wiktorsson (2001). The increase is not only in the potentially degradable fraction, but also in its rate of degradation (Ibrahim *et al.*, 1988).

2.8.1 Using urea – lime treated rice straw as feed for cattle

The combination of calcium hydroxide (2-3% of straw dry matter) and urea (2% of straw dry matter) has been used to treat straw (50% DM) for feeding to cattle in Vietnam, with excellent results (Trach *et al.*, 2001b). In their study on feeding treated straw to cattle they reported that using 3% lime and 2% urea increased straw organic matter intake (OMI) and organic matter digestibility and the value was higher than the treatment with 4% urea alone. Treatment of straw with 2% urea plus 3% lime increased OMI by 32% and 24% in growing cattle and in adult cattle, respectively (Trach *et al.*, 2001b). According to Trach *et al.* (2001) a combination of 3% lime with 4% urea was more effective than 3% lime alone in increasing intake, digestibility, growth rate and feed utilization. And the average daily gain of cattle fed on 3% lime plus 4% urea was 8.2% higher than that of those fed on 4% urea treated straw. Similarly, Singh *et al.* (1982) reported much higher growth rate in response to wheat straw treated with 4% lime plus 4% urea compared to 4% lime alone. Other researchers (Rai, 1993; Zaman and Owen, 1995; Pradhan *et al.*, 1997) have also found that ensiling straw with lime and urea highly increased its intake, and in-vitro and in-vivo digestibility. However in a comparison of the mix roughage DMI results the direction of the effect was not the same in our study with urea-lime treatment and the results reported by Man and Wiktorsson (2001) with urea as sole treatment. There was a slightly lower DMI in the urea-lime treatment. However the level of urea used in our study was lower compared to their study (3% vs 5%) and also the rice varieties were different.

2.9 Feeds and Fodder

A major constraint to small ruminant production is the severe scarcity of feed. Various opportunities for improving the feed supply and quality exist in this country. One method is to increase crop residue production by increasing the cropping intensity and utilizing nonconventional agro-industrial by-products. Although the area under rice cultivation has increased in Bangladesh, the net availability of rice straw has decreased (Jackson, 1980). Among the reasons for this is a large increase in acreage in the boro season and this type of rice is harvested in monsoon. Because of the difficult drying situation, most of the straws rot and become unsuitable for animal consumption. Apart from the nutritional benefits of treating straw with urea or lime, it is important to note that these chemicals can also be used to preserve wet straw and, thus, increase the availability of straw for livestock feeding. In addition, it seems to be extremely cost effective to use urea or lime to treat straw, e.g., to save 1 kg of straw (equivalent to BDT 1.0), only 50 g of urea is required (equivalent to BDT 0.25) (in 1986, 33 Bangladesh taka (BDT) = 1

United States dollar (USD)). Moreover, the nutritive value of the treated straw also increases significantly.

In terms of selecting high-yielding grain and straw varieties, the local varieties of rice are being replaced by the dwarf and intermediate high-yielding varieties, which yield less straw per unit of land than the local type of rice; as such, there is a possibility that total production of straw might be reduced (Jackson, 1980). It has also been reported by the farmers in Bangladesh that straw from high-yielding varieties of rice is less acceptable than the local varieties. Haque et al. (1981) observed a significant difference in dacron bag DM digestibility of straw between the local variety of Naizershail and the high-yielding varieties of BR-3 and BR-4; however, the straw from IR-20 and BR-5 was found to be as good as the straw from Naizershail with respect to DM digestibility. They could also increase the DM digestibility of different varieties with lime.

Saadullah (1981a) reported that there was no significant difference among the different local and high-yielding varieties (two local and five high yielding) with respect to cell contents, cell materials, hemicellulose, lignin, crude protein, and ash contents. Swapan and Saadullah (1984) compared the natural variability in chemical composition and nylon bag digestibility of straw from the rice varieties of Paijam, Patnai, Dhulabog, BR-4, BR-10, DA-31, DA-29, B-I, B-II, and B-III. The highest and lowest DM digestibility of 70 and 44% were observed with the varieties of Patnai and BR-4, respectively. Such variation in digestibility of straw might also exist for other local and high-yielding varieties of rice. There is a need for a systematic study to assess the quantity and quality in terms of nutritive value as cattle feed, which is directly related to more intake and productivity. It is felt that identification of superior varieties can influence plant-breeding research, initiating breeding to increase the quality of straw and encourage high grain yield.

2.9.1 Available feeds and fodder for dairy cows

Feed resources for ruminants in Bangladesh consist of some natural pastures and of large quantities of agricultural by-products (Ly, 1995). Available fodder and their sources are given in table 2.3.There exist three categories of feeds:

2.9.1.1 Crop residues

The dominant food crop of Bangladesh is rice, accounting for about 75 percent of agricultural land use (and 28 percent of GDP).Rice production increased every year in the 1980s except FY 1981, but the annual increases have generally been modest, barely keeping pace with the population. Rice production exceeded 15 million tons for the first time in FY 1986. In the mid-1980s, Bangladesh was the fourth largest rice producer in the world, but its productivity was low compared with other Asian countries, such as Malaysia and Indonesia. It is currently the world's sixth-largest producer. Assuming a grain/straw ratio = 1/1.1, approximately 25 million tons of rice straw is produced annually. Rice straw is therefore the most abundant crop residue for feeding of ruminants and it is available all year round. However, it has low digestibility and protein content (Van Soest, 2006). Additional crop residues, suitable as feeds for cattle, include sugarcane tops, pineapple peel as well as maize and cassava (*Manihot esculenta*) foliage.

In developing countries urea/ammonia treatment has also been applied to rice straw to increase its feeding value (Khang and Wiktorsson, 2004; Man and Wiktorsson, 2001). However, this technology has not been much adopted, particularly in small scale farms in the region due to technical and practical aspects of treating rice straw. A laborious treatment process, high costs of inputs, especially urea, and labour were highlighted in an electronic conference, summarized by Owen *et al.* (2012).

In the future, the urea/ammonia technology may become economical as a result of increased scarcity of animal feed, and may also be promoted to reduce environmental pollution from burning rice straw in the fields (Owen *et al.*, 2012).

As an alternative to urea-treated rice straw, molasses-urea cake is recommended to supplement low quality diets with energy and digestible protein (Owen *et al.*, 2012). This alternative is attractive due to its low cost relative to protein supplements for improving intake and performance. Sugarcane tops and maize stalks are also available in large quantities but are rarely used as animal feeds.

Table 2.3: Types of available fodder and their sources

Origin	Type
Agricultural land	Cultivated fodder Crop residues By-products from processing of harvested materials (haulms) Weeds Grass and weeds from fallow land Natural vegetation (grass, shrubs and weeds
Common land	Forest Water plants Grass Tree leaves
Homestead	Vegetable, fruits and kitchen waste Weeds

Source: Ly, 1995

2.9.1.2 Agro-industrial by-products

Rice bran, soya bean meal, coconut and ground nut cake belong to the group of agro-industrial by-products. Among these by-products, rice bran is the main by-product of the rice milling industry and is readily available in large quantities in Bangladesh. It is used for cattle as a supplement and is particularly during periods of intensive farm work due to its ease of use. They can be classified into 4 groups:

1. By-products providing essentially easily fermentable energy through digestible cell-walls, starch or sugars. They may constitute the basis or the major part of the diet. They derive mainly from sugarcane, citrus, roots and tubers, bananas, coffee`
2. By-products which are mainly used as a source of supplementary protein: oil-seed cakes, animal wastes from slaughterhouses and fisheries, by- products from pulses, single cell proteins.

3. By-products providing both energy and protein: e.g. cereal milling by-products, brewer's and distiller's grains and whey.
4. Other by-products coming from fruit, bakery and other food industries which provide various kinds of nutrients.

All these by-products have been reviewed by various authors (Chenost and Meyer 1977, IDRC and ICAR 1988). We will therefore restrict to a brief account of the more important ones taken as examples.

2.9.1.3 Molasses

This is a feed which is rapidly and entirely fermented in the rumen. Between 10 and 30% of the diet, as is traditionally the case there is no particular problems with molasses for all types of livestock. However when the diet is based on molasses (e.g. >70%) the behavior of cattle is different and the management of the herd must be more careful (Preston and willis, 1974). A small amount of fibre is vital for ensuring the normal physical function of the rumen. Non protein nitrogen is essential for the development of the micro-organisms of the rumen. Furthermore the animal responds dramatically to small amount of protein like fish meal, which can escape the rumen fermentation (Preston, 1985).

However it has never been possible to incorporate as high levels of molasses in the diet of lactating cows as in the case of fattening cattle. The reason is that diets high in molasses lead to insufficient amount of glucose and glucose precursors (low propionate and high butyrate) in the end products of digestion (Leng and Preston, 1984). Molasses which is an excellent carrier for urea as a source of non protein nitrogen for ruminants can be more easily used as a supplement and distributed to small farmers when is part of solid multi-nutrient blocks (Leng, 1984; Sansoucy, 1986; Sansoucy *et al.,* 1988).

2.9.2 Non-conventional feed resources

Non-conventional feed resources category includes diverse feeds that are not traditionally used in Bangladesh for cattle feeding. In Bangladesh, where WH is abundant, this plant may have a potential as feed for cattle. A better utilization of crop residues and low quality roughages is an important strategy (Devendra *et al.*, 2001) because feed costs dominate animal production, even when household labour is valued at its full cost.

2.10 Feed management

2.10.1 Concentrate

Local cows are fed to a maximum limit of 1 kg concentrate daily, usually rice polish of farmer's own source. The crossbred cows are supplied with concentrate in amount 2-3 times higher than local cows and composed of rice polish, wheat bran, brans of legumes and oil cakes. In an experiment by Kamal *et al.* (2009) the animals were fed basal roughages (straw and green grass) with concentrates (1 kg for 100 kg body weight) made of rice bran, wheat bran, sesame oil cake, molasses, common salt and vitamin-mineral premixes for 30 days before feeding intervention followed by 60 days fed basal roughages with concentrates only after replacing of wheat bran by maize grain after feeding intervention and resulted in increase milk.

2.10.2 Rice straw

The annual world production of cereal straws and stovers is approximately 2 000 million tons, however, the energy contained in this vast bulk of material is on the whole poorly utilized and its nitrogen incompletely returned to the soil. With the rising prices of both energy and nitrogen fertilizer, interest is developing in more efficient ways of utilizing straws, presently used mainly as livestock feed and as compost material (small amounts are used for the manufacture of paper and fibreboards). In the tropical and subtropical areas of the world almost all straw is fed to livestock. Straws are a poor livestock feed, and rice straw is no exception. It contains about 80 percent of substances which are potentially digestible and are therefore sources of energy, but actual digestibility by ruminants is only 45 to 50 percent. Furthermore, the amount an animal can eat is limited to less than 2 percent of body weight because of the slow rate at which it is fermented in the rumen. The net result is an energy intake which provides little or no surplus energy for growth, work or production. The most important consideration in obtaining more animal products from straw in the Asian setting is to improve digestibility and intake so that more energy is available for productive purposes. Protein supplements increase intake, while the alkali treatment of straws increases digestibility and usually voluntary intake as well. The chemistry of straw and its digestion and the chemical changes caused by alkali treatment are receiving increasing attention from animal nutritionists (Jackson, 1977).

Straws contain only 3 to 5 percent crude protein. Animals on an unsupplemented straw diet will usually not gain any weight and very often will actually lose weight. To obtain any production the straw must be supplemented, preferably with nitrogen/ protein and energy. For good growth on straw diets, a level of 8 to 10 percent protein is needed for young stock; this also improves consumption and thus increases energy intake. The level of phosphorus in rice straw (0.02 to 0.16 percent) is less than the level of about 0.3 percent that animals need for growth and normal fertility (Talapatra *et al.,* 1948). Available livestock feed in Bangladesh is given in table 4.4.

Table 2.4. The availability of livestock feed in Bangladesh

Feedstuff	Quantity ($x\ 10^3$ t DM)	Daily availability (kg/head)
Straw		
Rice straw	14955	
Wheat straw	264	
Total	15219	2.01
Grasses	1219	0.20
Concentrates		
Oilcake	168	0.02
Brans	697	0.06
Sugarcane tops	192	0.03
Fodder and forages	81	0.01
Molasses	10	0.001

Source: World Bank (1982).

2.11 The biology of water hyacinth as animal feed

Water hyacinth can be used fresh, ensiled or wilted to animals. Whole plants, chopped or ground can used as feedstuffs for both ruminants and monogastrics. Water hyacinth contains high levels of cellulose and hemicellulose, which could serve as energy sources for cattle. Fresh WH has been utilised as partial replacement of para grass (*Brachiaria mutica*) in diets to cattle (Biswas and Mandal, 1988), and has given better growth than after wilting when fed to goats (Aregheore and Cawa, 2000).Supplementation of wilted WH in a rice straw-based diet had positive effect on intake and growth of beef cattle (Islam *et al.*, 2009). Daily live weight gain was approximately 500 g when 30% dried

WH has been included in the basal diet of wheat straw at a fixed amount of concentrates (Parashar *et al.*, 1999).

As water hyacinth has low dry matter content, wilting is generally preferred to reduce silage losses. Water hyacinth can be successfully ensiled with the addition of molasses, rice bran, cassava root as well as with organic acids, and the silages have been accepted by cattle. An ensiled mixture of WH, rice straw, urea and molasses has been fed to dairy cattle resulting in an increase of milk yield (Chakraborty *et al.*, 1991). Utilization of both wilted and ensiled WH as a feed for sheep has been reported. Although wilted WH has not been recommended as a sole feed for sheep, it can replace up to 50% of the concentrates in complete diets (Abdelhamid and Gabr, 1991).Water hyacinth residues, after mechanical extraction of the juice; can be used in the diet of fattening buffalo calves. Water hyacinth accounted for 35% of diet, while the remaining was concentrates (61%), molasses (2%) and a mineral mixture (1%). Feed conversion efficiency was higher with the WH residues compared to a similar level of Egyptian clover (*Trifolium alexandrinum*).

2.11.1 Description

The family Pontederiaceae has nine genera including *Eichhornia,* which has eight species of freshwater aquatics including water hyacinth (*Eichhornia crassipes*) (Barrett, 1988). Only *E. crassipes* is regarded as a pan-tropical aquatic weed (OEPP/EPPO, 2008). The name water hyacinth refers to its aquatic habitat and the similarity of the flower colour to that of the garden hyacinth (Parsons and Cuthbertson, 2001). Water hyacinth, a free-floating macrophyte, live at the air-water interface and form two distinct canopies: leaf canopies comprising above-water structures and root canopies comprising below water structures (Downing-Kunz and Stacey, 2012).

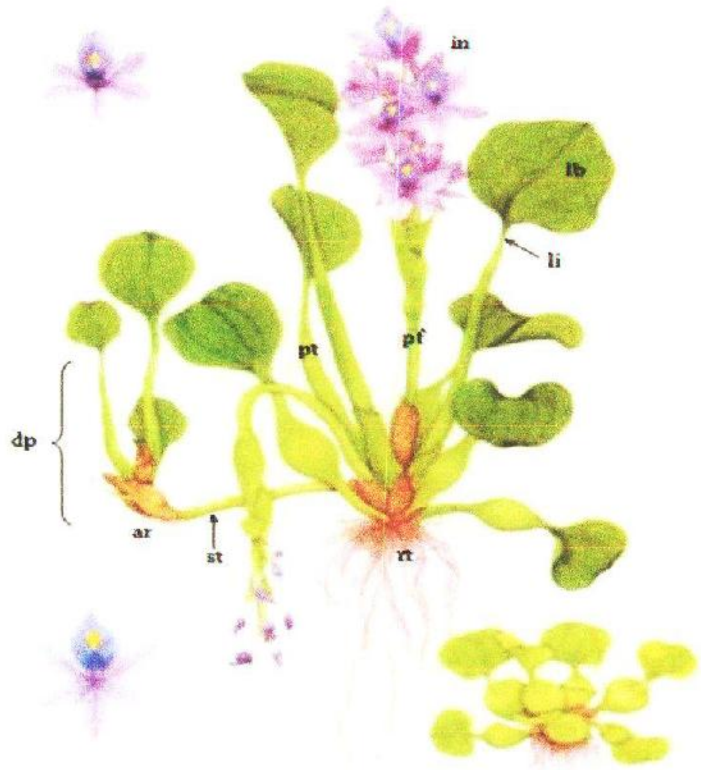

Figure 2.1 **Morphology of water hyacinth plants with stolons.**
ar: adventitious root; dp: daughter plant; in: inflorescence; lb: leaf blade; li: leaf isthmus; pf: peduncle of flower spike; pt: petiole; rt: root; st: stolon.Source: Parsons and Cuthbertson (2001)

The English common names of the plant are water hyacinth, water hyacinth, and water-hyacinth. Water hyacinth is the standardized spelling adopted by the Weed Science Society of America to denote that it is not an aquatic relative of true "hyacinth" (*Hyacinthus* spp.) (Center *et al.*, 2002). Synonyms are *Eichhornia crassipes* (Mart. and Zucc.) Solms, *Pontederia crassipes* (Mart. and Zucc.), *Piaropus crassipes* (Mart. and Zucc.) Britton (Penfound and Earle, 1948).Water hyacinth is an erect, free-floating, stoloniferous, perennial herb (Center *et al.*, 2002). The mature WH consist of roots, rhizomes, stolons, leaves, inflorescences and fruit clusters (Penfound and Earle, 1948) (Figure 1).

Petioles

Water hyacinth petioles are either erect (up to 60 cm long and bearing flowers) or horizontal (stolons), about 10 cm long and producing new plants from terminal buds (Parsons and Cuthbertson, 2001).

Leaves

There are two types of leaves. Some are up to 60 cm long, narrow and stand erect; others are almost round, up to 30 cm diameter and curved upwards with edges somewhat undulate. Both are smooth, glabrous, glossy and with semi19 parallel veins following the curvature of the leaf. Leaf stalks can be 50 cm long with bladder-like swellings, either bulbous or elongated, consisting of large air cells enabling the plant to float on water (Parsons and Cuthbertson, 2001).

Flowers

Water hyacinth flowers are attractive mauve with six lobes or petals. The uppermost petal has a yellow dot in the centre surrounded by darker purple. Each spike consists of about 8 (range from 3 to 35) flowers and individual flowers last only a few days. New plants flower when only 3 or 4 weeks old (Parsons and Cuthbertson, 2001). Under favourable conditions, WH may flower repeatedly throughout the year; although the intensity of flowering may vary with seasonal variation in growth rate (Malik, 2007).

Fruits and seeds

The fruit consists of a narrow 3-celled capsule about 1 to 1.5 cm long, containing up to 300 seeds. Seeds are about 1 to 1.5 mm long with many longitudinal ribs. The seeds can germinate in a few days. In cool temperature areas, they remain dormant for 15 to 20 years in dry mud, germinating when moistened. A temperature of 20 to 35oC usually enhances germination. In other words, rapid growth occurs with increasing summer temperature (Malik, 2007; Parsons and Cuthbertson, 2001).

Roots

The root morphology is highly plastic, fibrous and has one single main root with many laterals, forming colossal root system. Because each lateral root has a root tip, WH may exploit nutrient in a low-nutrient water body (Xie and Yu, 2003). Lateral roots are generally longer and denser at low phosphorus levels than at high phosphorus levels (Xie and Yu, 2003). In shallow water, the roots may become attached to the bottom for several weeks when the water level drops (Parsons and Cuthbertson, 2001). The root-shoot ratio varies inversely with nutrient level, particularly with respect to nitrogen. Purple roots are characteristic of plants when nutrient levels are low in the water (Xie and Yu, 2003).

2.11.2 Distribution and impacts

Water hyacinth originates from the Amazon River basin of South America (Brazil) (Parsons and Cuthbertson, 2001). Water hyacinth has become the major floating water weed of tropical and subtropical regions worldwide because of its rapid growth. Plants were introduced into USA in 1884 (Penfound and Earle, 1948) and reached Europe (Portugal) in the 1930s.In the low land of Narayangonj, the canal and river systems are diverse and creating a favorable environment for WH growth. The ecological and socio-economic impacts of the invasive WH are currently well understood (Villamagna and Murphy, 2010). Water hyacinth mats decrease dissolved oxygen concentrations, one of the most important water quality variables for aquatic fauna, by preventing the transfer of oxygen from the air to the water surface (Perna and Burrows, 2005). Although McVea and Boyd (1975) found a negative relationship between dissolved oxygen and WH coverage, a WH cover of to 25% of 400 m2 experimental ponds did not decrease dissolved oxygen to dangerous concentrations for fish survival.

Water hyacinth is reported to limit the productivity of phytoplankton and submersed vegetation such as *Sagittaria kurziana* by shading of the mats (Villamagna and Murphy, 2010) preventing photosynthesis (McVea and Boyd, 1975). Reduced phytoplankton productivity can in its turn decrease zooplankton growth (Richard *et al.*, 1985). However, from a study in Lake Victoria in Uganda, it was shown that WH enhanced the abundance and diversity of aquatic macro invertebrates at the interface with open water through the provision of a suitable habitat for their colonization.

Finally, the most direct impact of dense mats of WH is on boating access, navigability, water supply systems, drainage canals and on recreation (Villamagna and Murphy, 2010). It can be a serious matter in water-limited areas and small water bodies when water loss through evapo-transpiration from WH is 3.7 times that from open water

(Timmer and Weldon, 1967). Water hyacinth infestations are also known to exacerbate mosquito problems by hindering insecticide application. The socio-economic effects of WH are dependent on the extent of the invasion, the uses of the impacted water body, control methods and the response to control efforts (Villamagna and Murphy, 2010).

2.11.3 Habitat

Water hyacinth rapidly colonizes still or slow moving water, resulting in thick extensive mats. It occurs in estuarine habitats, lakes, urban areas, water courses, and wetlands (Gopal, 1987). It prefers nutrient-enriched waters and can tolerate considerable variation in nutrients, temperature, pH levels and toxic substances (Gopal, 1987). Growth occurs in a wide range of temperature from 1 to 40°C, but is most favourable under warm condition with a maximum growth at 25 to 27.5°C (Wilson *et al.*, 2005). Plants tolerate acidity levels as low as pH 3 but optimum pH for growth is 6 to 8 (Wilson *et al.*, 2005). However, WH does not tolerate salinity above 1.6% and there is no evidence to indicate that this fresh water plant can adjust to saline water (Penfound and Earle, 1948).

2.11.4 Reproduction

Reproduction is rapid under favourable conditions from stolons (asexually) and by seeds (sexually). The major propagation is by means of stolons which form daughter plants at axillary buds (OEPP/EPPO, 2008). The spreading of the daughter plants is also thought to be enhanced by wind and wave action (OEPP/EPPO, 2009). Under suitable conditions, plant numbers can double between 1 to 3 weeks (Parsons and Cuthbertson, 2001; Gopal, 1987). The capacity for vegetative reproduction allows this aquatic plant to quickly occupy all available space.

Growth is stimulated by inflow of nutrient rich water, such as from runoff of tropical rains, particularly in static water situations. In flowing water, fluctuations in nutrient levels are less important as nutrients are carried to the plants. In moving water, WH can achieve rapid growth by continually taking up nutrients, even at very low concentrations (Howard and Harley, 1998). However, growth is increased by high nutrient levels and temperature (Howard and Harley, 1998). Water hyacinth can double its population every seven days to yield 930 to 2900 tones fresh matter (FM)/ha/year (Lareo and Bressani, 1982), equivalent to approximately 75 to 230 tones DM/ha/year.

2.11.5 Chemical composition of water hyacinth

The composition of WH is characterized by low DM and high CP and ash contents (Table 2.5). Light green leaves and petioles of the immature plant are softer and contain a higher proportion of protein than those of the mature plant (Men *et al.*, 2006). The leaf protein content is higher than sweet potato leaf while the protein content in whole plant is considerable higher than grasses such as elephant grass and can be used as a protein supplement of low quality diets (Khan, 2006).

Table 2.5. Chemical composition (g/kg DM or as otherwise stated) of water hyacinth collected from different habitats.

Items	Young leaf	Young petiole	Whole shoot	shoot†
Dry matter (g/kg)	79	58	87	95
Crude protein	181	76	128	200
Ether extract	43	24	38	35
NDF	606	692	635	623
ADF	350	410	337	290
Hemicellulose/Cellulose	0.9	0.9	1.1	1.7
Lignin	75	94	76	-
Ash	142	134	131	257
Silica 10 19 4 52	10	19	4	52
IVOMD (%)	76	67	69	52
Metabolisable energy for ruminants (MJ/kg DM)	-	-	-	6.4
Oxalic acid‡	-	-	-	58
Tannin‡ - - - 27	-	-	-	27

Sources: Dung (2001) collected water hyacinth from the river in the Mekong Delta of Vietnam.

†Abdelhamid and Gabr (1991) collected from the ditch at Mansoura, Egypt. ‡ Biswas and Mandal (1988) collected from the pond at West Bengal, India. ADF: Acid detergent fibre;DM: Dry matter;IVOMD: in vitro organic matter digestibility;NDF: Neutral detergent fibre.

Chemical composition of WH varies with season, habitat as well as with harvesting frequency (Reddy and D'Angelo, 1990). Under warm weather conditions like in

Vietnam, forages mature more rapidly (Buxton, 1996) and cell walls become highly lignified (Van Soest, 1988). Protein concentration is high in the immature forage but declines with advancing maturity (Buxton, 1996). Lignin, followed by silica and cutin, are the primary limiting factors of digestibility (Van Soest, 1981).

Lignin content of WH in the range from 7 to 10% has been reported while silica has varied widely from 0.5 to 5% (Abdelhamid and Gabr, 1991). As nutrient composition of WH is generally related to nutrient availability in the habitat where the plants are growing, WH grown in sewage has high protein and mineral contents (Wolverton and McDonald, 1978).Protein in leaves contains most essential amino acids and is particularly rich in glutamine, asparagine and leucine (Virabalin *et al.*, 1993) (Table 2.6).

Table 2.6. Amino acid content (g/kg crude protein) and mineral concentration (g/kg DM or as otherwise stated) of the water hyacinth.

Amino acids	Leaf†	Petiole‡	Mineral*	Leaf	Whole shoot
Alanine	34	29	Ca	20	18
Arginine	36	11	P	8	7
Asparagine	51	34	Na	0.6	0.5
Cysteine	4	-	K	66	48
Cystine	8	-	Mg	6	5
Glutamine	59	30	Mn	0.4	0.3
Glycine	30	32	Fe	0.1	0.9
Histidine	11	6	Cu(mg/kg DM)	7	4
Isoleucine	23	14	Zn (mg/kg DM)	31	51
Leucine	51	27			
Lysine	27	16			
Methionine	13	-			
Phenylalanine	34	-			
Phenylalanine + Tyrosine	-	19			
Proline	27	17			
Serine	26	18			
Threonine	26	16			
Tyrosine	22	-			
Valine	28	20			

Sources: †Virabalin *et al.* (1993); ‡Wanapat *et al.* (1985); Khan (2006).

2.11.6 Utilizations of water hyacinth

Water hyacinth has received much attention in recent years due to its potential benefits as animal fodder, aqua feed, water purification, fertilizer, biogas production, even food for human and other products (Wolverton and McDonald, 1976) (Figure 2). Due to the scarcity and cost of forages in Bangladesh, WH has become more interesting for the improvement of cattle production. Therefore, attention has gradually shifted from control to the utilization of WH as a valuable resource (Gopal, 1998).

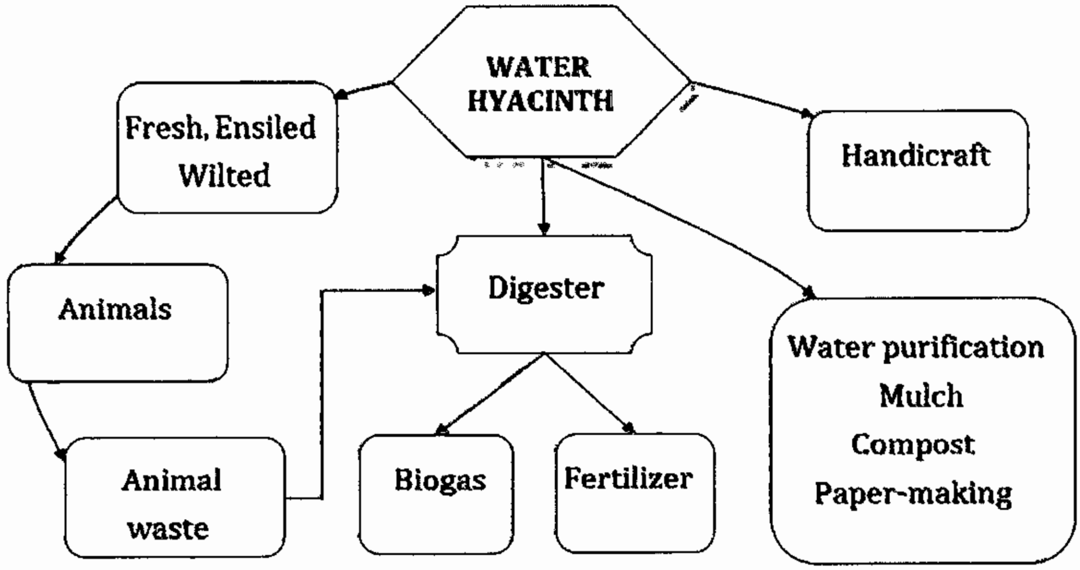

Figure 2.2 **A diagram of possible uses of water hyacinth.**

2.11.7 Toxic elements in water hyacinth

Lead is highly toxic to humans, plants and animals. Lead poisoning (plumbism) causes plant and animal death as well as mental deficiency, anemia, brain damage, kidney dysfunction, and behavioral problems in humans. Varying degrees of lead (Pb) poisoning were recorded in cows and buffaloes near a primary lead-zinc smelter in India; affected animals had history of clinical signs characterized by blindness, head pressing, violent movement and salivation. In another study of lead poisoning in animals grazing near a lead smelter, Hammond and Aronson (1964) reported that a dose of 6 mg lead/kg live weight for 60 days was toxic to young growing cattle. This equates to a daily concentration in feed DM of about 200 mg/kg. In the UK the maximum acceptable limit of lead in feeds is set at 10 mg/kg DM, while in the USA it is 30 mg/kg DM (NRC, 1980).

Abdelhamid and Gabr (1991) reported that the lead (Pb) content in water hyacinth leaves and stems was in the range from 90 to 100ppm and 120 to 146 ppm (DM basis), respectively. These values are intermediate between generally accepted limits of 10 to 30 mg/kg DM) and levels causing toxicity (about 200 mg/kg). Thus it appears likely that the concentrations of lead in water hyacinth leaves (about 100 mg/kg DM) could be close to the toxic levels of this element.

Toxicity in goats consuming water hyacinth as the sole feed was reported by Dutta *et al.* (1984) and Mishra *et al.* (1987). The symptoms were stiff legs and cardionephrotic failure. Most of the animals died. Sheep fed on water-hyacinth alone lost live weight and suffered from hepatic failure followed by death in a study reported by Singh *et al.* (1988). In the study reported by Abdelhamid and Gabr (1991), one of the sheep fed only water hyacinth died after a week of tetany and "stiffy" legs without response to Ca-injection.

2.11.8 Competing feeds and water hyacinth

Based upon early indications that water hyacinths could be managed to produce a viable feed product. Comparison with Alfalfa Hay, Coastal Bermudah hay, Corn, Grain corn, silage, Soybean meal, Sugarcane baggage, Cottonseed meal and Molasses shows satisfactory results. Table 2.7 shows competing feeds and water hyacinth nutrient values (dry matter basis).

cows are supplied with concentrate in amount 2-3 times higher than local cows and composed of rice polish, wheat bran, brans of legumes and oil cakes.

The income through dairying was calculated taking into account the feed cost and price incurred from daily milk yield. In case of local cows, the overall incomes of farmers are far below the income in comparison with cross bred cows. In both type of cows maximum milk yield and profit was found in rainy season and low milk yield at the same time low profit was noticed in summer season of the year.

Feeding system can be based on farmer's experience, or on feeding trials in research centre. In order to develop feeding system it is necessary to relate information on the nutritional characteristics of feed resources with requirements for nutrient according to the purpose and rate of productivity of the animal in question. In the industrialized countries, this information has been incorporated in tables of "feeding standards" which interpret chemical analysis of feed resources in term of their capacity to supply the nutrients. These standards are steadily becoming more sophisticated with the aim of improving their effectiveness in predicting rate of performance of intensively-fed livestock to derive least cost formulation. But the relevance of feeding standard for developing countries has been questioned from the socio-economic (Jackson, 1980) and technical (Graham, 1983; Preston, 1985) viewpoints. It has been apparent for many years that feeding standards base on assigned nutritive value (i.e. energy) are misleading when unconventional feed resources are used in formulation (Gaya *et al.*, 1981) and Leng and Preston (1976) because, this often led to the rejection of many feed resources which were too low in DE energy to supply the energy needed for production of the animal.

In Bangladesh most forage consumed by livestock are relatively low in digestibility (40-50%). The metabolizable energy in the dry matter ranges from 4.8-7.5 MJ/kg DM. According to feeding standards, metabolizable energy content in a feed of 7.5 will support a gain of approximately 2g MJ of ME intake in cattle. As a consequence of 4.8 MJ/kg DM, animal are usually in negative energy balance (Webster, 1989). On the other hand, supplying urea with low quality forages growth rate of animal can be attained up to 18 g/MJ of ME intake (Saadullah, 1984).

CHAPTER 3

MATERIALS AND METHODS

CHAPTER THREE
MATERIALS AND METHODS

3.1 Site selection

The study was conducted under three Thanas in Narayangonj District, namely Narayangonj Sadar, Fatulla and Bondor, during December 2013 to May 2014. Twenty three small dairy farms of which six from Sadar Thana, twelve from Fatulla and five from Bondor Thana were randomly selected (Appendix 1) and a total of 92 cows (58 graded and 34 local breeds) were selected from the small holders' farm and surveyed according to objectives. The age of the cows ranged from 4 to 5 years and body weight from 100 to 180 kg. Data were collected through direct interviewing to the farm owners (Appendix 2). To attain accurate and reliable data, care and caution were taken in course of data collection. Data collected from the farmers were compiled and tabulated. Data of cattle management system regarding feeding, housing, breeding, milk production, marketing etc. were arranged as percent value for easy understanding.

3.2 Animal selection and grouping

A total of 92 cows were selected and grouped into three on the basis of their body weight, all of which were in same lactating stage. Number of cows in each group was different. Number of cows and their body weight is given in table 3.1. In group A, body weight of improved local cows ranges from 100 kg to 125 kg and for graded cows ranges from 130 kg to 140 kg. In group B, body weight of local cows and graded cows were 125 kg to 140 kg and 140 kg to 150 kg respectively. In group C, body weights of local and graded cows were ranges from 140 kg to 150 kg and 150 kg to 180 kg respectively.

Table 3.1: Animal selection and grouping

Group	Improved local cows		Graded Cows	
	No. of Cow	Average Body Weight ±SE	No. of Cow	Average Body Weight ±SE
A	12	110 ± 3.5	16	135 ± 1.0
B	08	132 ± 5.0	20	145 ± 1.2
C	14	145 ± 4.0	22	160 ± 1.7

SE= Standard Error

Photo 3.1: Experimental graded cow

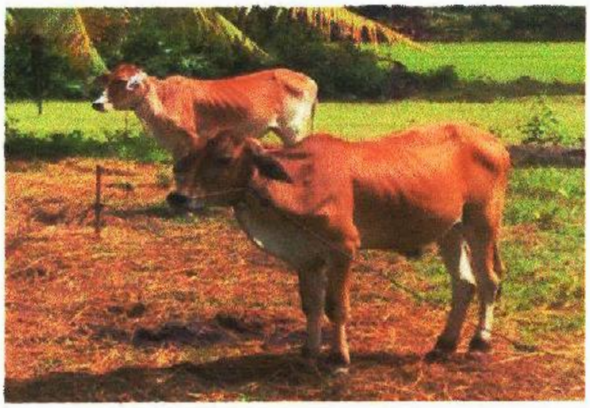

Photo 3.2: Experimental local cow

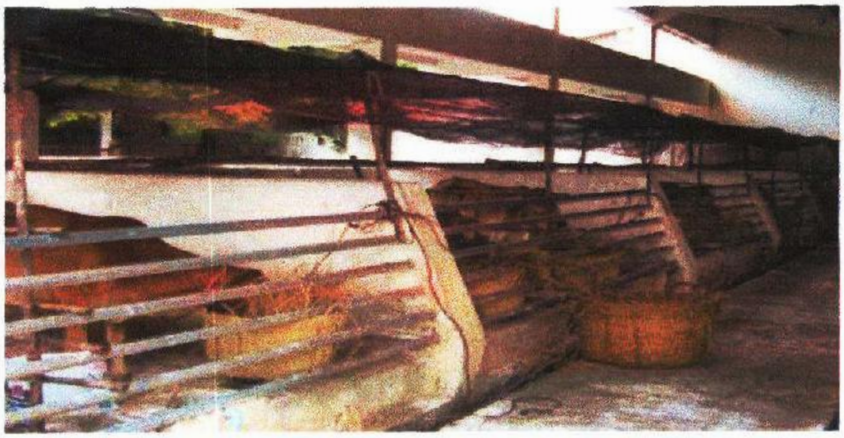

Photo 3.3: Experimental cattle are kept in individual pens

3.3 Experimental animal and feed management

Sources of feed used for feeding of dairy cows are mainly homestead byproducts, non arable land, road side grass, river side, embankment, play ground and low water land. In this experimental procedure, the animals of each group were fed with 3.0 kg concentrated food (2.0 kg in morning and 1.0 kg in evening) made of rice bran, wheat bran, mustard oilcake, molasses, common salt and vitamin-mineral premixes . With this concentrated food, group A, B and C were feed different basal roughages such as untreated straw, untreated straw and water hyacinth at 1:1 ratio and water hyacinth alone respectively. Source of feed, composition and proportion of concentrate mixtures were shown in Table 3.2.

Table 3.2: Source of feed, composition and proportion of concentrate mixtures

Source of feed and feeding system		**Variables**	**Percentage**
Source of feed	Source of feed	**Concentrate**	
	Homestead	Rice bran	50
	Non arable land	Wheat bran	15
	Road side grass	Mustard oilcake	25
	River side	Molasses	08
	Embankment	Salt	1
	Play ground	Vitamins	1
Feeding system		**Roughage**	
	Cut and carry	Untreated straw	According to treatment
	Restricted grazing		
	Tethering	Treated straw	---
	Stall feeding	Water hyacinth	According to treatment

Concentrated feeds were given twice in a day at 06.00 a.m. and 16.00 p.m. after milking and *ad libitum* water was supplied. The cows were milked twice daily with their calves at foot. Each group was maintained under identical management.

3.4 Feeding trials

3.4.1 Improved local cows

Major types of feeds were rice straw, water hyacinth, rice bran, wheat bran, mustard oilcake, molasses and others. Three different diets were fed to three different groups. Group A and B were provided with 7 kg untreated straw, untreated straw and water hyacinth (1:1) respectively and group C were provided with 8 kg water hyacinth (5 kg in morning and 3 kg in evening) shown in table 3.3.

Table 3.3: Roughage offered to dairy cows

Group	Treatment	Improved local cows	Graded cows
		Roughage offered (kg)	Roughage offered (kg)
A	Untreated straw + Concentrate✱	7 kg	10 kg
B	Untreated straw and water hyacinth (1:1) + Concentrate	7 kg	10 kg
C	Water hyacinth + Concentrate	8 kg	10 kg

✱Concentrates 3.0 kg (2.0 kg in morning and 1.0 kg in evening)

One of the advantages of dairy cattle management at farmers level is that they used locally available cattle feed resources. Family members of the farmers are involved in feed processing and offering feed daily to the cattle.

Photo 3.4: Improved Pabna cow

Photo 3.5: Improved Munshigonj cow

Photo 3.6: Water hyacinth in the low land.

Photo 3.7: Water hyacinth collecting from lagoon.

3.4.2 Graded cows

No improved feeding technologies, such as urea treatment of straw and urea molasses block supplement were not used by the small holders'. Indigenous knowledge on cattle feeding like chopping of straw, mixing of water hyacinth with straw, feeding tree leaves etc were practiced by the rural farmers of Narayangonj District of Bangladesh, which were found in this study.

Graded cows of group A, B and C were provided with 10 kg untreated straw, untreated straw and water hyacinth at 1:1 ratio and water hyacinth respectively (6 kg in morning and 4 kg in evening) Table 3.3.

Photo 3.8: Maintenance of Holstein cross.

Photo 3.9: Milking of dairy cow.

3.5 Data collection and statistical analysis

Feed intake and feed refusals were recorded every morning and evening. Milk yield (morning and evening) records were also collected daily. The data were entered into Microsoft Excel worksheet, organized and processed for further analysis. Means, standard errors and correlation were calculated using Statistical Packages for Social Science (SPSS-20.0) computer program. To find out the effect of water hyacinth on milk production between local and graded cows, least significant difference (LSD) was tested with analysis of variance (ANOVA) using SPSS-20.0.

CHAPTER 4

RESULTS AND DISCUSSION

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

This study was conducted at Narayangonj district of Bangladesh, during December 2013 to May 2014. Twenty three small dairy farms were randomly selected from different regions. The data were collected through questionnaire and direct interviewing to the farm owners. Collected data is tabulated and discussed below.

4.1.1 Cattle management by the small holders'

A total of 98 local cattle were found in 11 small holders out of which 34 were lactating cows. On the other hand graded cattle were selected from 12 small holders' that contained 155 cattle, out of which 58 were lactating cows. Among the 23 different small holders' men and women were 13 and 10 respectively. Factors associated with dairy cattle management by the small holders' are shown in table 4.1. The results showed that 22% farm owner had taken dairying as main business and 26% farm owners had business as the principal occupation and the highest percentage (52%) of small holders' had agriculture as principal occupation. Only 17% of the dairy farmers were dependent on bank loan for establishing dairy farms, 61% from their own source and 22% by bank loan as well as own source (Table 4.1).

It was revealed that monthly income of the owners were 0-3,000, 3,000-5,000, 5,000-10,000 and above 10,000 taka for 13, 26, 43 and 18%, respectively. It was observed that average number of milch cow per farm was 4.0, average number of total cattle per farm was 11.0 and percentage of milch cows was 37 and out of 253 cattle dry, heifer, calf and bull were 2%, 20%, 40% and 2% respectively. It was observed that the tendency of rearing crossbred cows at small-scale dairy farms in Narayangonj is increasing day by day (Table 4.1).

Table 4.1: Factors associated with dairy cattle management system at small holders' level.

Parameters	Categories	Percentage
Occupation	Dairy farming	22
	Service	---
	Agriculture	52
	Business	26
Source of money	Bank loan	17
	Own source	61
	Both	22
Monthly income (Tk.)	0-3,000	13
	3,000-5,000	26
	5,000-10,000	43
	Above 10,000	18
Type of cattle	Milch cow	37
	Dry cow	2
	Heifer	20
	Calf	40
	Bull	2
Type of farm houses	Nature of construction	
	Pucca	13
	Kacha	22
	Semi pucca	65
	Housing system	
	Open	---
	Closed	17
	Semi closed	83
	Ventilation	
	Proper	90
	Improper	10
	Drainage	
	Proper	61
	Improper	39
Breeding practice	Artificial insemination	90
	Both AI and natural	10
	Only natural	---

Among 23 small dairy farmers, 83% small holders' had semi-closed house and 17% had closed house. Among these houses, 65%, 22% and 13% houses were semipucca, Kacha and Pucca, respectively. Proper ventilation and drainage were 90% and 61%, respectively (Table 4.1).

It was observed that very little number of indigenous cattle found in this study. Because, most of the farm-owners used artificial insemination technique for breeding purposes which makes the availability of huge number dairy crossbred cows. For this reason, a good number of Holstein Friesian, Shahiwal and Sindhi crossbred stock found in this area. The data showed that 90% cows were inseminated artificially and 10% by both naturally and artificially (Table 4.1).

4.1.2 Milking of cows

From the observed data, all farmers milked their cows manually and milking done by 43% male, 35% female and 22% both male and female. Milking was carried out twice a day, morning and evening, in most of the cases. 44%, 26% and 30% of the farms disposed their milk by window delivery, home delivery and both window and home delivery system respectively. Container used for milk carrying to consumers and market was small drum in most of the cases. 17% respondents sold their milk to neighbors and restaurants, 13% to neighbors and sweet makers, 26% to neighbors and vendors and 17% to vendors (Table 4.2).

Table 4.2: Milking of cows and marketing

Parameters	Categories	Percentage
Milking system	Manual	100
	Mechanical	----
Type of milker	Female	35
	Male	43
	Both	22
Number of milking/day	1	----
	2	100
	3	----
Milk delivery system	Window delivery	44
	Home delivery	26
	Both	30
Container for carrying	Bucket	23
	Drum	70
	Jug	2
	Poly-pack	5
Marketing system	Vendors	17
	Neighbors + Vendors	26
	Neighbors + Restaurants	17
	Neighbors + Sweet makers	13
	Sweet makers + Vendors	17
	Neighbors	10

4.1.3 Feed intake and milk yield by local and graded cows

A total of 92 cows (50 graded and 42 local) were grouped into three, namely group A, group B and group C. Water hyacinth was provided to observe feed intake, feed refusal and milk production. The performance of local and graded cows on feed intake and milk yield is discussed below:

4.1.3.1 Feed intake by local and graded cows

There were marked differences in feed intake by local and graded cows. All the concentrated offered (2 kg in morning and 1 kg in evening) to the cows was consumed. Average amount of untreated straw consumed by local and graded cows was 5.60 ± 0.04 and 7.46 ± 0.03 respectively. It is interesting to note that when water hyacinth was given along with straw at 1:1 ratio in the diet, the graded cows selectively ate the straw. It may be appeared due to the preference of straw by the cows. When untreated straw and water hyacinth was offered at 1:1 ratio, average amount of feed intake by local and graded cows was 6.41 ± 0.04 and 7.64 ± 0.03 respectively. Intake of feed was increased when water hyacinth was given to the cows at fresh. It was observed that at an average 7.12 ± 0.03 and 8.22 ± 0.03 kg of water hyacinth was consumed by local and graded cows respectively (Table 4.3). Descriptive analytical sheets are included in Appendix 3 and 4.

Table 4.3: Feed intake by local and graded cows

Group	Treatment	Local improved cows	Graded cows
		Average feed intake ± SE (kg)	Average feed intake ± SE (kg)
A	Untreated straw + Concentrate	5.60 ± 0.04	7.46 ± 0.03
B	Untreated straw and water hyacinth (1:1)+ Concentrate	6.41 ± 0.04	7.64 ± 0.03
C	Water hyacinth + Concentrate	7.12 ± 0.03	8.22 ± 0.03

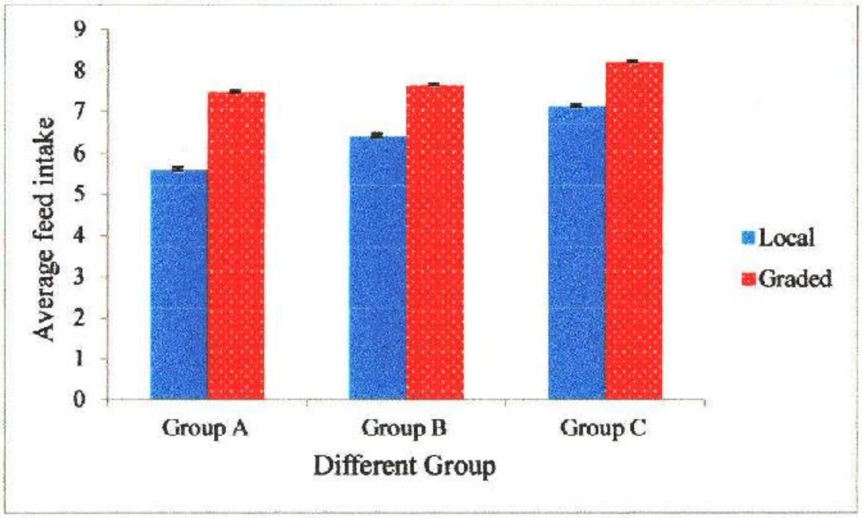

Fig 4.1: Average feed intake by local and graded cows

4.1.3.2 Feed refusal by local and graded cows

The major differences were observed in feed refusal between two types of dairy cattle. In case of group A, the feed refusal was 20% and 25.3% for local and graded cows respectively. It was 8.29% and 23.5% for group B and 7.87% and 17.8% for group C. It indicates that the graded cows of all groups had more feed refusal tendency than the local cows. But in case of group B, this difference was very high (Table 4.4). Analytical sheets are provided in Appendix 3 and 4.

Table 4.4: Feed refusal by local and graded cows

Group	Treatment	Local improved cows	Graded cows
		Feed refusal (%)	Feed refusal (%)
A	Untreated straw + Concentrate	20.00	25.3
B	Untreated straw and water hyacinth at 1:1 ratio + Concentrate	8.29	23.5
C	Water hyacinth + Concentrate	7.87	17.8

4.1.3.3 Milk yield by local and graded cows

Milk yield of local and graded cows of different genotypes is presented in table 4.5. It was found that the average milk yield of local breed was 3.45 ± 0.03, 3.73 ± 0.03 and 3.77 ± 0.02 liter/day for group A, B and C respectively. On the other hand, average milk production of graded cows was 11.29 ± 0.04, 11.67 ± 0.04 and 11.73 ± 0.05 liter/day for group A, B and C respectively. It was interesting to record that average milk yield was increasing when untreated straw was substituted with fresh water hyacinth (Table 4.5). Descriptive analytical sheets are included in Appendix 3 and 4.

Table 4.5: Average milk yield of local and graded cows

Group	Treatment	Local cows	Graded cows
		Average milk yield (liter ± mean)	Average milk yield (liter ± mean)
A	Untreated straw + Concentrate	3.45 ± 0.03	11.29 ± 0.04
B	Untreated straw and water hyacinth at 1:1 ratio + Concentrate	3.73 ± 0.03	11.67 ± 0.04
C	Water hyacinth + Concentrate	3.77 ± 0.02	11.73 ± 0.05

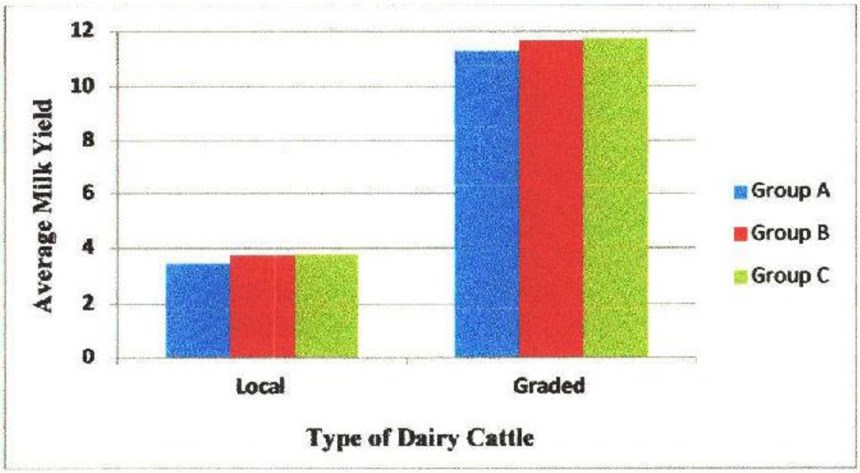

Fig 4.2: Average milk yield by local and graded cows

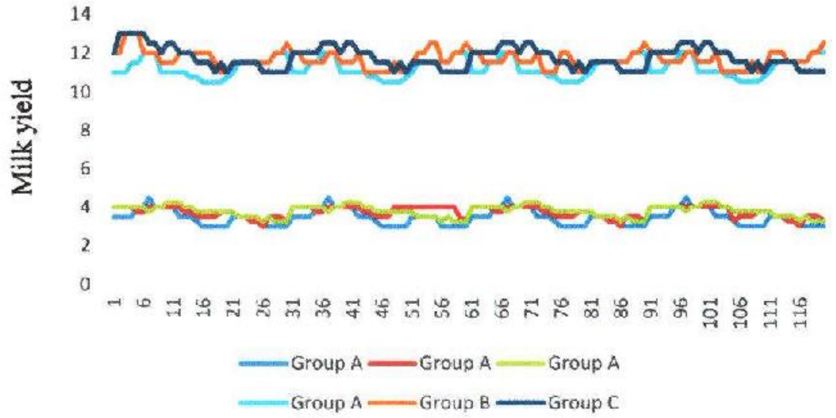

Fig 4.3: Milk yield by local improved and graded cows

4.1.3.4 Correlation between feed intake and milk yield

It was observed that the local cows consumed untreated straw along with concentrates at fixed ratios caused increase milk yield at 5% level of significance (Table 4.6). When fresh water hyacinth was substituted for untreated straw or provided with untreated straw at 1:1 ratio resulted in increased milk yield significantly ($P<0.01$). On the other hand, graded cows fed with fresh water hyacinth or untreated straw+ water hyacinth at 1:1 ratio lead to significantly increased milk yield ($P<0.01$).Original analytical sheets are included in Appendix 5.

Table 4.6: Correlation between feed intake and milk yield

Group	Treatment	Local cows	Graded cows
A	Untreated straw	$3.45 \pm 0.03^{*}$	11.29 ± 0.04^{NS}
B	Untreated straw and water hyacinth at 1:1 ratio	$3.73 \pm 0.02^{**}$	$11.67 \pm 0.04^{**}$
C	Water hyacinth	$3.77 \pm 0.02^{**}$	$11.73 \pm 0.05^{**}$

NS = Non significant
** = Significant at 1% level
* = Significant at 5% level

4.1.3.5 Analysis of variance (ANOVA) of feed intake and milk yield for local cows

Milk yield by the experimental cows depend on feed intake. In statistical analysis milk yield is dependent variable and feed intake is the factor. Sum of Squares, degree of freedom (df), mean squares, F-value and level of significance of local cows is given in table 4.7. Analytical sheets are included in Appendix 6.

Table 4.7: Statistical analysis of variance (ANOVA) of feed intake and milk production for local cows

Group	Treatment	Milk yield	Sum of Squares	df	Mean Square	F	Sig.
A	Untreated straw	Between Groups	4.340	13	.334	2.254	.012
		Within Groups	15.702	106	.148		
		Total	20.042	119			
B	Untreated straw and water hyacinth at 1:1 ratio	Between Groups	1.480	4	.370	5.158	.001
		Within Groups	8.251	115	.072		
		Total	9.731	119			
C	Water hyacinth	Between Groups	1.517	3	.506	6.403	.000
		Within Groups	9.158	116	.079		
		Total	10.675	119			

4.1.3.6 Analysis of variance (ANOVA) of feed intake and milk yield for graded cows

Statistical analysis of milk yield with in groups and between groups is presented in table 4.8 when feed intake is factor and milk yield is the dependent variable. Sum of Squares, degree of freedom (df), mean squares, F-value and level of significance of graded cows is given in table 4.8. Statistical analytical sheets are included in Appendix 7.

Table 4.8: Statistical analysis of variance (ANOVA) of feed intake and milk production for graded cows.

Group	Treatment	Milk yield	Sum of Squares	df	Mean Square	F	Sig.
A	Untreated straw	Between Groups	9.328	7	1.333	7.312	.000
		Within Groups	20.413	112	.182		
		Total	29.742	119			
B	Untreated straw and water hyacinth at 1:1 ratio	Between Groups	5.800	8	.725	4.247	.000
		Within Groups	18.948	111	.171		
		Total	24.748	119			
C	Water hyacinth	Between Groups	8.969	10	.897	3.313	.001
		Within Groups	29.512	109	.271		
		Total	38.481	119			

4.2.2 Feed intake

Average feed intake by local and graded cows were 6.41 ± 0.04 and 7.64 ± 0.03 respectively when untreated straw and water hyacinth was offered at 1:1 ratio. It was observed that at an average 7.12 ± 0.03 and 8.22 ± 0.03 kg of water hyacinth was consumed by local and graded cows, when untreated straw is substituted with water hyacinth. Group B and group C, both local and graded cows significantly (*P<0.01*) increase feed intake, thus improved feed efficiency. Water hyacinth (*E. crassipes*) has been fed extensively in a series of studies in Thailand (Wanapat, 1986). The feeding value of this forage is similar to that of *leucaena* forage when fed in urea-treated rice straw diet Feeding water hyacinth to urea treated rice straw significantly increased live weight gain and also improved feed efficiency (Sriwattanasombat and Wanapat, 1985). According to Department of Animal Nutrition College of Veterinary Science, Assam Agricultural University Khanapara, Guwahati-22, Assam 'The feed efficiency ratio can be improved in feeding of 100% silage or 100% fresh form of water hyacinth as also 50% silage or 50% fresh water hyacinth with 50% grasses or 50% hay plus concentrate mixture.'An inclusion level of fresh water hyacinth in the diet should not exceed 30% for growing cattle (Ho Thanh Tham, 2012).

Water hyacinth contains high levels of cellulose and hemicellulose, which could serve as energy sources for cattle. Fresh WH has been utilised as partial replacement of para grass (*Brachiaria mutica*) in diets to cattle (Biswas and Mandal, 1988), and has given better growth than after wilting when fed to cattle (Aregheore and Cawa, 2000). Supplementation of wilted WH in a rice straw-based diet had positive effect on intake and growth of beef cattle (Islam *et al.*, 2009). Daily live weight gain was approximately 500 g when 30% dried WH has been included in the basal diet of wheat straw at a fixed amount of concentrates (Parashar *et al.*, 1999).

4.2.3 Milk production

Average milk yield of local and graded cows were 3.45 ± 0.03, 3.73 ± 0.03, 3.77 ± 0.02 and 11.29 ± 0.04, 11.67 ± 0.04, 11.73 ± 0.05 liter/day respectively for group A, B and C. Milk production was significantly (*P<0.01*) increase by both local and graded cows when water hyacinth was supplied to the animals as a source of roughage in group B and C.

Whereas, only local cows showed increased (*$P<0.05$*) milk production when untreated straw was provided. It may be due to concentrate feed (3 kg) supplied to the cattle.

Cowan *et al.* (1974) reported that there were significant differences in daily milk production by the local and graded cows. However, the treatment produced a greater quantity of milk over the period. Average production per cow from tropical pastures is in the range of 10 to 12 kg/day for Friesian cows, 7 to 9 kg/day for Jersey and 6 to 10 kg/day for crossbred cattle. The result of present study agrees with the work of Kabir *et al.* (2009) who showed that the average milk yield Holstein cross, Sindhi cross, Sahiwal cross and local cow were 12.03±3.73, 7±1.58, 5.16±0.8 and 2.1±0.41litre/ day respectively.

It was also found in an experiment by Nahar *et al.* (1992) who reported that average daily milk yield of Sindhi x Deshi, Sahiwal x Deshi, Jersey x Deshi and Holstein x deshi graded animals were 3.0±0.1, 2.9±0.1, 3.8±0.1, and 5.5±0.1 kg, respectively. Halim (1992) who found that average milk yield of crossbreed dairy cow was 11.09 litre/ day. According to Department of Animal Nutrition College of Veterinary Science, Assam Agricultural University Khanapara, Guwahati-22, Assam'' Feeding of water hyacinth silage and para hay (50:50) with concentrate showed best performance in daily milk yield. Next best is *ad libitum* fresh water hyacinth with concentrate.''

CHAPTER 5

SUMMARY AND CONCLUSION

CHAPTER FIVE
SUMMARY AND CONCLUSION

The management condition of small dairy farms in Narayangonj is more or less traditional. Some important steps like subsidy on animal feed, cultivation of fodder, providing milk marketing facilities and financial support, expansion of veterinary service, reasonable price of milk, giving managemental training etc. are essential for the improvement of small dairy farms.

Water hyacinth can be used effectively as a source of carbohydrate, crude protein, high levels of cellulose and hemicellulose for growing cattle. In a situation where basal roughage (rice straw) is relatively limited, water hyacinth can substitute for the roughage with satisfactory results. Because of the scarcity of green fodder; water hyacinths could meet a part of the requirement of green roughages. Supplement of water hyacinth to untreated rice straw and substitution of rice straw significantly increased feed intake and reduce refusal of feed thus improved feed efficiency. Milk production is also increased in both local and graded cows when fresh water hyacinth was supplied as sole source of roughage.

Although the experiments have done over short periods of time and with a small number of animals, water hyacinth was useful for local and graded cows in combinations with feeds of poorer quality rice straw.

5.1 Future research

1. Depending on household conditions and animal species, to ensure an acceptable range of intake and to increase labor efficiency, it seems that ensiling of WH may offer a better alternative for feeding. Both these aspects require further studies.
2. Long-term effects on animal productivity of feeding fresh or ensiled water hyacinth to cattle should be investigated in the future with respect to growth rate as well as feed conversion efficiency.
3. It appears that the constraint to the use of water hyacinth as live stock feed may be related to sub-clinical concentrations of heavy metals, especially lead. So, before providing as the sole feed throughout the year further investigated is necessary.

CHAPTER 8

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Appendix 1: Summary of the small holders, total cows, lactating cows and provided treatment

Serial	Name of the small holder	Address	Total cow	Type	Lactating cow	Provided treatment
1	Mr. Motaleb	Shah Suza Road, Narayangonj	11	Local cow	4	Untreated straw
2	Mr. Rafique	College Road, Narayangonj	8		3	
3	Mrs. Rahima	North Casara, Narayangonj	6		2	
4	Mrs. Asia	North Casara, Narayangonj	8		3	
5	Mrs. Khodeza	North Casara, Narayangonj	5		2	Untreated straw and water hyacinth at 1:1 ratio + Concentrate
6	Mr. Alam	Dhaka-Chittagong Link Road, Narayangonj	8		3	
7	Mr. Hafiz	Dapa Idracpur, Fatulla, Narayangonj	9		3	
8	Mr. Kalam	Dapa Idracpur, Fatulla, Narayangonj	15		5	Water hyacinth
9	Mrs. Farida	Police Line, Gabtoli, Fatulla, Narayangonj	9		3	
10	Mr. Mamun	Police Line, Gabtoli, Fatulla, Narayangonj	11		4	
11	Mrs. Ambia	Police Line, Gabtoli, Fatulla, Narayangonj	8		2	
12	Mr. Zakir	Dewbogh, Fatulla, Narayangonj	12	Graded cow	4	Untreated straw
13	Mr. Mozibor	Dewbogh, Fatulla, Narayangonj	18		8	
14	Mr. Sahin	Dewbogh, Fatulla, Narayangonj	11		4	
15	Mr. Reza	Gabtoli,West Izdair, Fatulla, Narayangonj	10		4	Untreated straw and water hyacinth at 1:1 ratio + Concentrate
16	Mrs. Rina	Gabtoli,West Izdair, Fatulla, Narayangonj	14		5	
17	Mrs. Roymon	Gabtoli,West Izdair, Fatulla, Narayangonj	14		5	
18	Mr. Kader	Gabtoli,West Izdair, Fatulla, Narayangonj	9		4	
19	Mr. Rokon	Sonakanda, Bondor, Narayangonj	7		2	
20	Mr. Babu	Sonakanda, Bondor, Narayangonj	18		7	Water hyacinth
21	Mrs. Farida	Ecrampur, Bondor, Narayangonj	16		6	
22	Mrs. Aklima	HM Shen Road, Bondor, Narayangonj	14		5	
23	Mrs. Merin	HM Shen Road, Bondor, Narayangonj	12		4	

Appendix 2: Questionnaire for interviewing farm owners

1. Small holders Name:				
2. Address:				
3. Number of cows:				
4. Number of lactating cows:				
5. Occupation:	A. Dairy farming	B. Service	C. Agriculture	D. Business
6. Source of money:	A. Bank loan	B. Own source	C. Both	
7. Monthly income:	A. 0-3,000	B. 3,000-5,000	C. 5,000-10,000	D. Above 10,000
8. Type of cattle:				
A. Milch cow	B. Dry cow	C. Heifer	D. Calf	E. Bull
9. Nature of construction:		A. Pucca	B. Kacha	C. Semi Pucca
10. Housing system:		A. Open	B. Closed	C. Semi closed
11. Ventilation:	A. Proper	B. Improper		
12. Drainage:	A. Proper	B. Improper		
13. Breeding practice:				
	A. Artificial insemination (AI)	B. Both AI and natural	C. Only natural	
14. Milking system:	A. Manual	B. Mechanical		
15. Type of milker:	A. Female	B. Male	C. Both	
16. Number of milking/day:				
	A. 1	B. 2	C. 3	
17. Milk delivery system:				
	A. Window delivery	B. Home delivery	C. Both	
18. Container for carrying:				
	A. Bucket	B. Drum	C. Jug	D. Poly-pack
19. Marketing system:				
A. Vendors	B. Vendors	C. Restaurants	D. Sweet makers	E. Neighbors

Appendix 3: Descriptive Statistics of Local improved cow

Appendix 3.1: Local improved cow treated with untreated straw

Group A: Untreated straw

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
feed intake	120	5.00	6.50	671.85	5.5988	.03705	.40581
Refusal	120	.50	2.00	167.65	1.3971	.03671	.40216
Milk yield	120	3.00	4.50	415.00	3.4583	.03746	.41039
Valid N (list wise)	120						

Appendix 3.2: Local improved cow treated with untreated straw and water hyacinth at 1:1 ratio

Group B: Untreated straw and water hyacinth at 1:1 ratio

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Feed intake	120	5.50	7.00	769.75	6.4146	.03795	.41568
Refusal	120	.00	1.50	69.75	.5813	.03779	.41399
Milk yield	120	3.00	4.00	448.50	3.7375	.02610	.28596
Valid N (list wise)	120						

Appendix 3.3: Local improved cow treated with water hyacinth

Group C: Water hyacinth

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Feed intake	120	6.50	8.00	855.00	7.1250	.03513	.38485
Refusal	120	.00	1.50	105.00	.8750	.03513	.38485
Milk yield	120	3.25	4.25	453.00	3.7750	.02734	.29951
Valid N (list wise)	120						

Appendix 4: Descriptive Statistics of graded cow

Appendix 4.1: Graded cow treated with untreated straw

Group A: Untreated straw

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Feed intake	120	7.00	8.00	895.70	7.4642	.03017	.33053
Refusal	120	2.00	3.00	304.30	2.5358	.03017	.33053
Milk yield	120	10.50	12.00	1349.00	11.2417	.04564	.49993
Valid N (list wise)	120						

Appendix 4.2: Graded cow treated with untreated straw and water hyacinth at 1:1 ratio

Group B: Untreated straw and water hyacinth at 1:1 ratio

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Feed intake	120	7.00	8.00	917.30	7.6442	.03210	.35160
Refusal	120	2.00	3.00	282.70	2.3558	.03210	.35160
Milk yield	120	11.00	13.00	1400.50	11.6708	.04163	.45603
Valid N (list wise)	120						

Appendix 4.3: Graded cow treated with water hyacinth

Group C: Water hyacinth

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Feed intake	120	7.50	9.00	986.50	8.2208	.03560	.38992
Refusal	120	1.00	2.50	214.50	1.7875	.03503	.38377
Milk yield	120	11.00	13.00	1408.50	11.7375	.05191	.56866
Valid N (list wise)	120						

Appendix 5: Correlation between feed intake and milk yield of Local and graded cows

Appendix 5.1: Correlation between feed intake and milk yield of local cows treated with untreated straw

Group A: Untreated straw

Correlations

		feed intake	Production
feed intake	Pearson Correlation	1	-.190*
	Sig. (2-tailed)		.038
	N	120	120
Production	Pearson Correlation	-.190*	1
	Sig. (2-tailed)	.038	
	N	120	120

*. Correlation is significant at the 0.05 level (2-tailed).

Appendix 5.2: Correlation between feed intake and milk yield of local cows treated with untreated straw and water hyacinth at 1:1 ratio

Group B: Untreated straw and water hyacinth at 1:1 ratio

Correlations

		Feed intake	Production
Feed intake	Pearson Correlation	1	.340**
	Sig. (2-tailed)		.000
	N	120	120
Production	Pearson Correlation	.340**	1
	Sig. (2-tailed)	.000	
	N	120	120

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 5.3: Correlation between feed intake and milk yield of local cows treated with water hyacinth at 1:1 ratio

Group C: Water hyacinth

Correlations

		Feed intake	Production
Feed intake	Pearson Correlation	1	.319**
	Sig. (2-tailed)		.000
	N	120	120
Production	Pearson Correlation	.319**	1
	Sig. (2-tailed)	.000	
	N	120	120

**. Correlation is significant at the 0.01 level (2-tailed).

GRADED COW

Appendix 5.4: Correlation between feed intake and milk yield of graded cows treated with untreated straw

Group A: Untreated straw

Correlations

		Feed intake	Production
Feed intake	Pearson Correlation	1	.054
	Sig. (2-tailed)		.557
	N	120	120
Production	Pearson Correlation	.054	1
	Sig. (2-tailed)	.557	
	N	120	120

Appendix 5.5: Correlation between feed intake and milk yield of graded cows treated with untreated straw and water hyacinth at 1:1 ratio

Group B: Untreated straw and water hyacinth at 1:1 ratio

Correlations

		Feed intake	Production
Feed intake	*Pearson Correlation*	1	.238**
	Sig. (2-tailed)		.009
	N	120	120
Production	Pearson Correlation	.238**	1
	Sig. (2-tailed)	.009	
	N	120	120

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 5.6: Correlation between feed intake and milk yield of local cows treated with water hyacinth

Group C: Water hyacinth

Correlations

		Feed intake	Production
Feed intake	*Pearson Correlation*	1	.256**
	Sig. (2-tailed)		.005
	N	120	120
Production	Pearson Correlation	.256**	1
	Sig. (2-tailed)	.005	
	N	120	120

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 6: Anova for local improved cows

Appendix 6.1: Anova for feed intake and milk yield treated with untreated straw

Group A: Untreated straw

ANOVA

Production

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.340	13	.334	2.254	.012
Within Groups	15.702	106	.148		
Total	20.042	119			

Appendix 6.2: Anova for feed intake and milk yield treated with untreated straw and water hyacinth at 1:1 ratio

Group B: Untreated straw and water hyacinth at 1:1 ratio

ANOVA

Production

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.480	4	.370	5.158	.001
Within Groups	8.251	115	.072		
Total	9.731	119			

Appendix 6.3: Anova for feed intake and milk yield treated with water hyacinth

Group C: Water hyacinth

ANOVA

Production

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.517	3	.506	6.403	.000
Within Groups	9.158	116	.079		
Total	10.675	119			

Appendix 7: Anova for graded cows

Appendix 7.1: Anova for feed intake and milk yield treated with untreated straw

Group A: Untreated straw

ANOVA

Production

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.328	7	1.333	7.312	.000
Within Groups	20.413	112	.182		
Total	29.742	119			