

CHAPER 1: INTRODUCTION

Gayal, also known as "hill cow" or "forest cow," is now raised commercially in Chattogram Division. Because of its high meat yield, the heavy-weight hill cow, Gayal has been raised commercially for more than ten years. Gayals were removed from the list of wild animals and classified as cattle in 1964 (Faruque, 2023).

Gayal is an endangered species of feral animal native to Bangladesh, and cattle farmers in Chattogram, Rangamati, and Bandarban have great success on farming it. *Bos frontalis* is its scientific name, but Indian forest dwellers also refer to this species as "Mythun" or "Mithan." It's also known as Chattogram Bison because it may be found primarily in the mountainous forested areas of Chattogram (Seraj, 2019).

The gayal is a member of the Bovidae family specifically the Bovini tribe within Bovina group, categorized under the *Bos* genus, and *Bos frontalis* species. Gayals, also referred to as mithans or mithuns, are a rare breed of cattle with a small geographic range that stretches from eastern Bhutan across the state of Arunachal Pradesh in North-east India, to the Naga and Chin-Hills-Arakan Yomarang, which marks the borders between Bangladesh, India and Myanmar (Payne and Hodges, 1997; Manson, 1988). They prefer a shady and humid environment and spend the day browsing largely on tree leaves or grasses on hill slopes, summits, and valleys higher than 1,000 meters above sea level. Due to inadequate food on slopes throughout the winter, they descended to the hill foot paddy and grass fields. They have a different morphology than domestic cattle. In addition to having white stocking on all four legs, they feature a bony dorsal ridge on the shoulder (Giasuddin *et al.*, 2003a). The gayal population once abundant in Bangladesh's hill districts, but due to human intervention, it has sharply decreased. During the day, gayals typically remain in the forest, but at night, they leave the forest in search of salt and water. The villagers frequently use salt as a trap because salt is one of these animals' favorite foods. In addition, the hill tribes will occasionally gather these animals from the thick forest and domesticate them. Compared to Bangladeshi cattle, their body size is significantly larger. They are primarily used as sacrificial animals in religious festivals and are frequently regarded as expensive animals. They feature distinct beef-type characteristics.

Mostly raised for meat, gayal is a large, rare species of semi-domesticated ruminant. According to Simoons (1984), Mondal *et al.* (2004), Mondal *et al.* (2005a, 2005b,

2005c, 2005d and 2005e), Mondal *et al.* (2006a, 2006b, 2006c, 2006d, 2006e and 2006f), Mondal *et al.* (2008) and Mondal *et al.* (2010), this robust hill animal of Southeast Asia is significant to the socio-economic and cultural lives of the locals. Compared to meat from other species, gayal meat is regarded as being more delicate and better in Bangladesh.

Currently, Gayal farmers raise this animal in its natural environment at elevations between 1000 and 3000 meters above the mean sea level under conditions of free grazing. Recent efforts have been made to popularize economic Gayal farming under semi-intensive conditions with controlled breeding because of the gradual denudation of forests (the natural habitat of Gayal) and the enormous socioeconomic and cultural importance of Gayal in the lives of the local tribal population. Despite the fact that Gayal's ancestor, the wild Indian Gaur, is vulnerable (Baillie and Groombridge, 1996). Gayals are also experiencing non-cyclical population declines and local-regional contractions, which are signs of a species or population that is not yet endangered but may do so soon. Inbreeding can happen as a result of a declining population size, which can then affect reproductive fitness (Nei *et al.*, 1975), including fertility and survivorship (Ralls and Ballou, 1986). Furthermore, the current free-ranging Gayal raising strategy allows for the limited grazing of these livestock in a particular hillside area with no movement to different sites and vice versa, which causes significant inbreeding in this species. Population vitality and flexibility in responding to environmental change are improved when genetic variety is preserved or increased.

When local cattle and Gayal were grazed together in the same forest area, the likelihood of crossbreeding with the local cattle increased. This could lead to a loss of the species' unique adaptive and fitness traits as well as a failure to respond in captivity due to behavioral issues related to confinement (Perumal *et al.*, 2013). Gayal, the sole wild relative of domestic zebu cattle in Bangladesh, can be observed in the Chattogram hilly tract areas, primarily in Bandarban regions along with other feral species of animals including feral fowl, feral pig, and feral quail. A few tribal families raise gayal with native cattle and their cross-offspring as a result of natural mating, which are occasionally available in the neighborhood market by the name "Tang gaur." This animal is mostly utilized in Bangladesh as a sacrifice animal during religious festivals in exchange for a high price (Giasuddin and Islam, 2003b). The female progeny of the gayal have capacity to mate with domestic cattle (*Bos taurus* and *Bos indicus*).

Nevertheless, it's worth noting that the male offspring may not consistently exhibit productive traits, as observed in various studies (Huque *et al.*, 2001; Simoons, 1984; Giasuddin *et al.*, 2003a). The constant killing of Gayal for meat until very recently constituted an additional threat to the species' ability to reproduce.

Gayals were numerous in Bangladesh's hill districts, but due to human involvement, their numbers have drastically decreased. Additionally, the hill tribes may occasionally gather them from the thick forest and domesticate these creatures. Gayals were compelled to migrate into deeper forests further east, toward the country's southern border, as a result of human interactions and biodiversity manipulation affecting their habitats (Uzzaman *et al.*, 2014). In 1990, the Bangladesh Livestock Research Institute (BLRI) established an artificial breeding center for gayals in Bandarban district (Naikhangchhari). Two bulls and a couple female gayals were the center's initial animals. Physical characteristics, physiological traits, habits, development patterns, and capacity of reproduction of gayal within semi-captive system of management have been documented in research to date (Giasuddin *et al.*, 2003a; Giasuddin and Islam, 2003b). Gayal is currently one of Bangladesh's threatened animal biological assets, and steps should be done to protect this species by exploiting it as an economic resource. The government is putting forth a lot of effort around the country to fulfill the need for animal protein (Seraj, 2019).

The great majority of the Chattogram Hill Tracts' (CHT's) hilly terrain may be used for raising gayals that browse the plant biomass that is present but may not be palatable or accessible to native cattle. However, the viability of employing gayals as profitable meat-purpose animals needs to be evaluated through analysis of their growth performances, which are frequently seen as a sign of an animal's health and adaptability under conventional management and feeding systems (Haque *et al.*, 2001). Gayal rearing getting popular day by day because of Gayal grow faster than the indigenous cattle and Gayal doesn't need extra feeds. Gayal has a high immune system and doesn't get sick easily.

Therefore, the goal of the current research was to explore the phenotypic characteristics, productive and reproductive performances, and disease incidence of Gayal under captive management.

Objectives of the study:

The overall goal of this study was to look into various aspects of Gayal and Gayal farming in certain areas. The following are the study's particular objectives:

1. To identify phenotypic characteristics of gayal in Bangladesh.
2. To identify the productive and reproductive performances of captive Gayal in Bangladesh.
3. To know the purpose of Gayal rearing.
4. To know about common diseases of Gayal.
5. Determine Gayal's marketing channel.

CHAPTER 2: REVIEW OF LITERATURE

With great potential to improve rural livelihoods and agricultural sustainability, captive gayals (*Bos frontalis*) constitute a distinct and noteworthy aspect of Bangladesh's livestock business. The famous bovine species known as the gayal, or "Mithun" in local dialect, is well-known for its unique morphological features, exceptional productive qualities, and significant contributions to the rural economy. Nevertheless, despite their economical significance, there hasn't been much discussion in the scientific community about the phenotypic traits, reproductive performances, and productive capacities of captive gayals in Bangladesh. In order to close this information gap and provide light on the complex features of gayal husbandry in this area, this literature review will examine previous studies, new findings, and developing patterns, showcasing the many facets of these extraordinary creatures and their crucial role in Bangladesh's agricultural system.

2.1 Scientific Classification

The taxonomy of Gayal is provided below (Ponraj, 2018) considering the research that is currently available:

- Kingdom: Animalia
- Phylum: Chordata
- Sub-phylum: Vertebrata
- Class: Mammalia
- Sub-class: Eutheria
- Order: Ungulate
- Sub-order: Artiodactyla
- Family: Bovidae
- Sub-family: Bovinae
- Genus: *Bos*
- Species: *frontalis*
- Scientific Name: *Bos frontalis*

2.2 Origin

The Indian term for the domestic version of the gaur is "mithun," while in China, it is referred to as "gayal." It has been categorized as a distinct species called *Bos frontalis* and is believed to have originated from its wild gaur ancestors over 8000 years past (Simoons *et al.*, 1984). The wild guar and Gayal both have 58 chromosomes (Winter *et al.*, 1984). There are various theories on the origin of domestic gayal, but recent research has substantially backed the generally held theory that domestic gayal's ancestors were gaur (Mukharjee *et al.*, 2018; Prabhu *et al.*, 2019). The Yunan province of China, Bangladesh, Myanmar, Bhutan, and the Northeastern hilly areas of India are the only places where gayal are found geographically (Mukherjee *et al.*, 2018).

2.3 Distribution of Gayal

The southern slopes of the Eastern Himalaya are where Mithun is most commonly found. In contrast to other cattle, Mithun is rare. Small populations were reported by Bhattacharyya *et al.*, (2016) in mountainous regions and tracts of Myanmar, Bangladesh, China, Bhutan, and India. Geographically, the Mithun inhabits low- to high-altitude regions, and they favor cool climates with temperatures between 20°C and 30°C. The Yunan province of China, Bangladesh, Myanmar, Bhutan, and the Northeastern hilly areas of India are the only places where gayal are found geographically (Mukherjee *et al.*, 2018).

2.4 Socio-cultural significance of Gayal

In ethnic society, Mithun meat is frequently served at weddings, neighborhood feasts, and other significant social events. Project Maje (2004) highlighted that meat is a significant component of wedding and Christmas celebrations. It is thought to be the most delectable variety of beef and has a marbled texture. Live animals were reportedly given as gifts during weddings and other social and cultural rituals, according to a few authors (Gibji, 2015 and Ponraj *et al.*, 2016). Moyong (age 30) and Chatterjee (age 38) observed the custom of paying a live animal as the bride price for a girl's hand in marriage. The Mithun breeding bulls are highly prized and regarded as a precious gem in Bhutan. An excellent breeding bull is equivalent to "half the herd" because Mithun calves are thought to inherit positive traits from their breeding bulls, according to traditional tradition. The herders are prepared to spend a hefty amount to purchase one for their herd because of this. The value of having Mithun breeding bulls can be shown

in how the bulls are treated by rural Bhutanese households. Sacrifices of this bovine species are said to bring great glory, additional blessings, and placate the house god (Gibji, 2015). As a result, animals undergo slaughter at religious festivals, and the meat of slaughtered animals is highly valued (Giasuddin *et al.*, 2003a). According to Uzzaman *et al.* (2014), the researched information clearly indicates that Mithun is a ritual animal that is important to the social, cultural, and economic elements of the lives of the ethnic communities in Bangladesh's Bandarban hillside and Chattogram areas.

2.5 Appearance

The gayal stands 140-160 cm (55-63 inches) tall at the shoulder, smaller than the gaur and having shorter legs. Bulls can weigh a ton, which is 20–25 percent more than a cow. The gayal lacks the huge shoulder hump of the gaur, has a shorter, wider, and flatter skull, and both sexes have horns that protrude from the sides of their heads and are bigger but shorter than those of the gaur. At the chin and throat, a double dewlap is well formed. Females are brown-black, while bulls are black, and both have white stockings (Estes *et al.*, 1998). In contrast to domestic cattle, the huge semi-domesticated gayal has white stocking on all four legs and a bony dorsal ridge on the shoulder. Typically, it is black. In comparison to the female, the male gayal has a darker coat that turns black or dark brown as it ages. Gayals have larger bodies than Bangladesh's native cattle. Gayal mature males typically weigh 600 to 700 kg, while females typically weigh 400 to 500 kg; (Giasuddin *et al.*, 2003a). At the age of four months, this white stocking began to form in gayal. The newborn calf's coat was crimson or coffee in color. After four months of age, the calf's coat color changed to black (Faruque *et al.*, 2015).

2.6 Feeds and Feeding Behavior

Gayal prefers to browse mostly on incline slopes. During the day, they roam around freely in the forest, and at night, they go back to the owners' home. These creatures like browsing 300 to 400 meters above sea level. These animals are not used to concentrate or silage made from cultivated fodder plants, unless there is a natural feed limited supply. This animal is extremely fond of salt and will follow you wherever if you offer it a piece of rock salt. During the browsing time, they look for open hilly areas and like open forests with lots of bamboo leaves. Gayal always picks natural feed. However, while they are being fed in a stall, they prefer concentrates and feed with extra salt. Gayal spends almost the same amount of time chewing their cud or thinking as they do

browsing and grazing. They only lie down at night and spend very little time walking or standing (Giasuddin *et al.*, 2003a). They stayed in the forest most of the time, even at night. They went to a small canal that ran through the hills for water. They grazed for feed in the morning and afternoon, and drank water from 10 a.m. to 12 p.m. They rested in the afternoon under trees near water sources or near human settlements (Faruque *et al.*, 2015). Due to Gayal's complete reliance on the nearby jungle forage supply, extra care should be taken when providing mineral supplements to ensure better performance (Das *et al.*, 2010). Leaching of minerals occurs frequently on steep hillsides, especially during the rainy season. The soil will therefore be deficient in some significant mineral elements in a particular hilly grazing gradient. In this scenario, a mineral deficiency may result from the vegetation in that region being deficient in some mineral elements. Mineral supplementation is the only way to make things right in this case. The natural method for these animals to meet their need for minerals is to lick salt and drink mineral water from sources in the hills (Prakash *et al.*, 2013).

2.7 Scientific Rearing system

At the moment, farmers raise Gayal in the forest under free-grazing conditions without any additional housing or feeding facilities. The female Gayal is occasionally brought back by farmers just before giving birth and sent back into the jungle after giving birth. However, it is suggested that even under a free-range system, a temporary dwelling structure can be built in a few key sites in the Gayal raising area using materials that are readily available locally. By giving Gayal a tiny quantity of concentrate and salt each day, you can train him to visit the shed at a specific time. Farmers will find it useful to watch over, feed their animals more, and provide them medicine. Additionally, producers will have the chance to constantly monitor each animal for any form of anomaly or disorder. If farmers choose a semi-intensive strategy of animal rearing, they should choose housing structures with supplies for feeding and watering the animals. They can also tie the animals at night once they return from the forest after grazing. It is possible to supervise individual animals there in the late evening or early morning and administer more food, drink, and medication (Mondal *et al.*, 2014).

2.8 Production Performances

Farmers' primary concern with Gayal is its growth rate because it is a meat animal. With sufficient nutrition, this animal grows between 300 and 600 g per day, which is

comparable to the rates of cattle and buffalo. However, Gayal has a much higher plasma growth hormone concentration (30-90 ng/ml) than any other domesticated animal (Mondal *et al.*, 2004, 2005d, 2006a, 2006c, 2006d). Gayal is an efficient converter of forest biomass into high-quality meat. Gayal meat is softer and better than other meat sources. Gayal meat is healthy because it is low in fat. Indigenous tribes have a strong preference for Gayal meat. It is always best to slaughter Gayal at the age of 4-5 years to get the most meat. In general, the dressing percentage in Gayal is 58-62% (Mondal *et al.*, 2014). Gayal mature males typically weigh 600 to 700 kg, while females typically weigh 400 to 500 kg; the daily average milk output of gayal was reported to be 305 ± 30.5 mL/d (Giasuddin *et al.*, 2003a).

Although Gayals produce about 1-1.5 kg of milk per day per animal, drinking Gayal milk is not a common habit (Nath and Verma, 2000). Gayal milk is exceptional from a nutritional standpoint and is utilized to make a variety of delectable milk products since it contains 3.4–17% fat, 6.8–22.2% SNF, and 4.4–9.8% protein. Due to their durability and high quality, Gayal hide and skin are more valuable than cow leather in the tanning business and are used to make items such as footwear, clothing, bags, coats, purses, appealing ornaments, furniture covers, etc (Shisode *et al.*, 2009).

2.9 Reproduction and breeding

Gayal does not display any signs of estrus (Mondal *et al.*, 2008). In contrast to cattle, it is challenging to see signs of heat in Gayal. The best estrus indicator, out of all the behavioral indicators, is the Gayal bull mounting an estrus cow, followed by the estrus cow standing to be mounted by the Gayal bull. Both vulval mucous membrane congestion and vulva swelling are significant indicators of estrus in Gayal cows. However, other symptoms such as mucous discharge, agitation and alertness, tail-raising, frequent urination, and appetite loss were discovered to be less noticeable estrus symptoms in Gayal cows (Mondal *et al.*, 2008). When Gayals are in estrus, bellowing is rarely seen. Gayal cows in estrus have cervixes that are open and relaxed, uteruses that are taut, and ovaries that have visible follicles. The Gayal estrous cycle is reported to have a mean duration of 21.2 ± 0.3 days (19–24 days) (Ponraj, 2018). Use of healthy Gayal bulls is advised instead for the purpose of detecting heat. According to Mondal *et al.* (2006b), between 20 and 31 hours after the onset of estrus, ovulation takes place in the Gayal population. Without sound reproductive qualities, breeding plans cannot

be carried out on the animal. Gayal has a rather high reproductive performance, according to earlier reports (Ponraj, 2018). Polyestrous animals include Gayal. Around the age of 2-3, females reach sexual maturity. At three to four years old, Gayal bulls reach sexual maturity. As reported in the published characteristics related to calving, study by Faruque *et al.* in 2015, the following statistics were recorded: calving interval was approximately 402.85 days, gestation length averaged around 296.25 days, and the birth weight was approximately 20.85 kg. Gayal cows have a high reproductive efficiency and can have one calf per year. The Gayal productive life span is 16 to 18 years.

Gayal is a polyestrous mammal, like cattle. Unless she is pregnant, the healthy adult female Gayal exhibits repeated estrus cycles every 19 to 24 days. The Gayal has no set mating season; they reproduce all year round. In Gayal, the gestation time, service period, and calving interval range from 270 to 290 days, 50 to 100 days, and 350 to 400 days, respectively. The ranges for first calving and puberty are 40 to 48 months and 27 to 36 months, respectively. At three to four years old, Gayal bulls are ready to breed. One bull for every ten breedable females in the herd is introduced as a practical method for selective breeding in the Gayal community under the free-range system, while the undesirable bulls are simultaneously removed. To prevent the depression caused by inbreeding, breeding bulls should be replaced, ideally once every five years. In a semi-captive system, it is possible to detect the heat cycle in a female before she is paired with a high-quality bull for breeding, either through natural mating or artificial insemination, as described by Mondal *et al.* (2014).

2.9.1 Estrous period and estrous signs

Gayal does not display any signs of estrus (Mondal *et al.*, 2008 and Khan *et al.*, 2020). Estrus (heat) is simply the moment when a cow or heifer is sexually receptive and receives a bull. During this period, an egg matures and is ready to be delivered into the genitalia. Estrus can last anywhere from 36 to 72 hours, however standing estrus is usually about 12 to 18 hours. This heating phase is repeated every 19 - 23 days (Khan *et al.*, 2020). The behavioral indicators of estrus that Gayal cows most frequently exhibit willingness to be mounted by a Gayal mature bull, their readiness to stand for mating, as well as vaginal mucosal congestion and vulva enlargement. The relative frequency of behavioral manifestations in Gayal females has been described, and it is

useful in discriminating between main and posterior estrus signals. Bulls sniffed the vulva and stood to be mounted by bulls/other herd members 91.30% of the time. In 82.61% of females during estrus, the frequency of urine increased when the male's chin rested on the buttock. Some Gayal females with estrus, only 65.22% showed signs of restlessness; in 8.70% of cases, this restlessness was severe, while it was not in 56.52%. Hafez *et al.* (1993) reported that 56.52% of Gayal cow exhibited shouting, which was rare in 17.39% of the Gayal cow but common in 39.13% of them. Contrary to cows, Gayal exhibits less overt homosexual behavior during estrus. A majority of Gayal females in estrus (56.52%) were seen to be anxiously scanning the outside for other animals. Only 26.09% of females were found to be mounting herd mates during estrus, while 47.83% were shown to lick the bodies of other animals during the period. Among Gayal females in estrus, only 8.70% reported reduced food intake or appetite loss (Mondal *et al.*, 2006). The vaginal mucosa of female Gayals exhibited varying shades of pinkness during estrus, with 34.78% having a pronounced reddish-pink color, 43.48% displaying a moderate pink hue, and 21.74% showing a slight pinkish tinge. Among the female Gayals in estrus, 82.61% of female had vulvar edema, of which 21.74 and 60.87% had pronounced edema while the remaining 60.87% had just minor edema. Only 78.26% of Gayal females in estrus have had their vaginal mucous spontaneously discharged, and even then, it is not always the case. Rectal palpation was required before the mucus was expelled spontaneously in 39.13% of the animals. 34.78, 43.48, and 21.74% of the females were found to have profuse, little, or no vaginal mucous, respectively. Three distinct hues of vaginal mucous were observed: translucent in 61.11% of instances, metallic blue in 22.22%, and white in 16.67% of cases. Vaginal mucus varied in thickness, being thin in 55.56% of cases and thick in 44.44%. Furthermore, Samad (1996) found that froth was seen in the lips of 30.43% of the animals. The cow will not show behavioral signals of estrus in this scenario, but the physiological symptoms of heat will be there. Although the overall pattern of sexual activity is nearly identical to that of cattle and buffaloes, the intensity with which behavioral signals of estrus are expressed in mithun is noticeably less pronounced. Since there is no behavioral indicator of heat, such as bellowing, the heat is referred to as silent. Additionally, the other behavioral indications of estrus such mounting to other animals and permitting mounting by others may also be present, albeit with considerably less intensity. Mithun's estrus can be identified by parading a teaser bull and/or by trained personnel keeping constant watch in the morning and evening. In

herds that are under stress and kept on a low level of diet, silent heat is shown to occur more frequently (Khan *et al.*, 2020).

2.9.2 Diagnosis of Pregnancy and Parturition

Gayal can be diagnosed with pregnancy using the same transrectal criteria as are used in cows. By the sixth week of gestation, the early signs of fetal membrane slip, uterine horn distension, and CL in the ovary can be seen. After three months of pregnancy, the uterus and ovary of the pregnant animal sink into the abdominal cavity and cannot be palpated, like in the case of cattle. After 4 months, it is possible to distinguish the fremitus of the uterine artery, and from 6 months on, it becomes much more noticeable or powerful. After five months of pregnancy, enlargement of the middle uterine artery is seen. In contrast to cattle, more right horn pregnancies have been recorded (60%) (Bhattacharyya *et al.*, 2006).

Gayal's external pregnancy indicators are similar to cattle's in terms of fetal ballottement, mammary gland development, and abdominal distension. After 5 months, abdominal distension can be noticed, but it is only noticeable in later stages of pregnancy. This is because it results from the gradual accumulation of large uterine contents. When multiparous cows are pregnant, the udder development is visible in the last 1–5 weeks of pregnancy or from 6 months on in Gayal heifers. At 12 hours prior to delivery, the teats engorge. In the final few weeks of pregnancy, there is vulva edema and relaxation caused by the progressive relaxation of the pelvic ligament. The vulvar lips start to sag and flabby three to four days before parturition, and the croup shrinks noticeably. After 6 months of pregnancy, the fetus is balloted in 74% of pregnancies or its movement is visible through the abdominal wall (Ponraj, 2018 and Bhattacharyya *et al.*, 2006).

In Gayal and cattle, the parturition procedure is more or less the same. Just before giving birth, the pregnant mother is anxious and attempts to separate from the rest of the herd. To locate a secret location, they search the surrounding wooded area. They remain in the forest and do not return to the stall (He *et al.*, 2012). The majority of calving in Gayal takes place at night. Restlessness, a rise in urination at intervals of 2 to 5 minutes, and an increase in walking are all indicators of impending parturition in Gayal. Gayal cows give birth while lying down (Ponraj, 2018).

Immediately after birth, Gayal cows begin to lick the calf. 22 minutes after birth, the calf gets up, and 30 minutes later, it takes its first colostrum sucking (Winter *et al.*, 1988). Anybody or any animal that comes close to the infant at this time will face threats from the dam. In order to maintain a close eye on her calf, she grazes and browses around her newborn child. Her customary return to her herd occurs after a day or two. The calf plays with her mother while she watches her from a distance and consumes milk 12 to 15 times per day. The Gayal mother takes great effort to ensure the security of her young during the first week. One week later, she progressively reverts to her previous state, and the calf was observed roaming freely within the herd (Giasuddin *et al.*, 2003a and Giasuddin *et al.*, 2003b).

In the case of bovine species, dystocia is a frequent cause of prenatal calf mortality. In Gayal, dystocia caused by feto-maternal disproportion is uncommon, where neonates usually appear anteriorly during calving. The cow is more likely to experience dystocia or difficult calving when the irregular, misshapen, or narrow pelvic canal is the result of maternal factors (Perumal *et al.*, 2013).

2.9.3 Peripartum Behavior signs

Pregnancy-related behavioral changes included walking in silence and calmness, preferring confinement, and isolating oneself from the rest of the herd. Female Gayal favored a plain area rather than a muddy hill for grazing and browsing during this time period, and they avoided deep forests altogether. The first stage of parturition's behavioral indicators were noted to be restlessness characterized in all animals by a quick change in posture. Up until the time of delivery, it was discovered to gradually grow. In every case, an arched back and occasionally strained abdominal muscles were seen in addition to the raising of the tail. As the parturition process progressed, the amount of straining increased. Occasionally during the early stage of labor, the animals would lie down and then stand up. When compared to pluriparous animals, the signs of the first stage of parturition were more pronounced in primiparous species. All of the animals displayed intense abdominal straining and regularly raised their tails during the second stage of parturition. As the various fetus components protruded through the vulva, the abdominal cramping became more intense and frequent. Although neither position was held for an extended period of time, the animal often switched between standing and lying down. The mother was occupied caring for the newborn immediately

following the birth of the fetus. Animals that are multiparous nurse their calves before those that are primiparous. The placenta used to hang through the vulva, and the female would lick it during this time. Within a typical time frame and on their own accord, all of the animals ejected their placental membranes (Ahmed *et al.*, 2008).

2.9.4 Infertility Problem in Gayal

Reproduction-related issues have hardly ever been seen in Gayal. Nonetheless, there have been documented instances of reproductive irregularities in Gayal, including the absence of a consistent estrous cycle, uterine infections, challenging calving experiences, difficulties in expelling the placenta, and behaviors such as placentophagia or postpartum estrus absence (as reported by Perumal *et al.*, 2013; and Faruque *et al.*, 2015). Similarly, on semi-intensive Gayal farms in Bangladesh, the most frequently observed reproductive ailments include uterine infections (16.7%), sporadic heat cycles (25.0%), absence of regular estrus cycles (8.3%), repeat breeding syndrome (8.3%), abortion (16.7%), cervix infections (25%), and calf mortality (24%) (as indicated by Haque *et al.*, 2001).

2.10 Disease incidences of Gayal

According to reports (Giasuddin *et al.*, 2006), research on the prevalence and distribution of gayal (semi-domestic cattle) diseases was done in Bangladesh's Bandarban hill tract. The most common illnesses were non-specific diarrhea, conjunctivitis, skin conditions, non-specific fever, and mastitis. The proportion of FMD cases that occurred during the winter, or 27.38% of all cases, was highest. Due to a scarcity of green grass, gayal occasionally grazed in the ditch when they descended the hill during the summer. Fasciola infection was shown to be spread by these water grasses in the ditch, and monsoon season showed a high incidence. All throughout the year, gastrointestinal nematodes were prevalent. *R. microplus*, *R. appendiculatus*, *H. bispinosa*, and *A. testudinarium*, common cow ticks, were seen all year. The reproductive disorders metritis and cervicitis were more common. All through the year, non-specific diarrhea, skin conditions, gastrointestinal disorders, and external parasite infestations were reported. According to Rajkhowa *et al.* (2003), mithun reared in semi-intensive systems are susceptible to a number of infectious diseases, including brucellosis, tuberculosis, para-tuberculosis, foot and mouth disease (FMD), bovine

viral diarrhea and infectious bovine rhinotracheitis (IBR). These illnesses have a significant negative impact on profitable mithun husbandry practices.

2.11 Prevention of Disease in Gayal

For the purpose of disease prevention, no vaccinations were utilized. According to the recommendations of scientists engaged in the relevant sector, necessary remedies were given for particular disorders. The same set of experts used clinical history, symptoms, and lab tests to pinpoint reproductive issues (Giasuddin *et al.*, 2003a).

2.12 Marketing of Gayal

There was no market for selling or buying gayal in Bandarban Hill district. The owners of gayal did not sell any healthy gayal cow or calf during this study period. They sold only mature gayal bulls and culled cows. The Gayal bulls were sold during the period from December to February and were subsequently utilized as sacrificial offerings during the Muslim religious festival known as "Oros," which was arranged by a Muslim spiritual leader known as a "peer." The price that farmers received and the gayal that was sold in "Oros" varied greatly. One adult bull was sold at the home plot for between Tk 1,20,000 and Tk 1,50,000. Three different kinds of middlemen were involved in the entire marketing procedure. The first set of middlemen purchased the gayal in the neighborhood village. The second set of middlemen bought the gayal from the first middleman and transported it to Chittagong or a nearby area of Chittagong. The third set of middlemen bought the gayal from the second middleman and maintained it in Chittagong or a nearby area of Chittagong until the gayal was sold to "Oros." (Faruque *et al.*, 2015).

In conclusion, this literature review has provided a comprehensive overview of the phenotypic characteristics, productive, and reproductive performances of gayal in Bangladesh. It is evident from the reviewed studies that the gayal, a unique and valuable bovine species, exhibits a distinct set of physical traits that distinguish it from other domesticated cattle. These traits include their large size, distinct hump, and unique coat color patterns, which make them an intriguing subject of study and conservation efforts in Bangladesh.

CHAPTER 3: MATERIALS AND METHODS

3.1 Period of study

This study was conducted for a period of 3 months dated from May 2023 to July 2023. Gayal Farm was visited multiple times during the time period in order to get the essential data.

3.2 Area of Study

The study's locations were Sukhbilas Village, Padua Union, Rangunia Upazilla and Satkania Upazila in Bangladesh's Chattogram District. Rangunia has a Tropical monsoon climate (Classification: Am) and is located at an elevation of 6.46 meters (21.19 feet) above sea level. The yearly temperature in the district is 27.75°C (81.95°F), which is 0.01% higher than the national average. Rangunia gets about 144.71 millimeters (5.7 inches) of rain per year and has 162.62 rainy days (44.55% of the time). This is positioned between latitudes 22° 18' and 22° 37' north and between longitudes 91° 58' and 92° 08' east. Satkania Upazila (Chittagong district) covers an area of 280.99 square kilometers and is located between 22°01' and 22°13' north latitudes and 91°57' and 92°10' east longitudes. It is bounded to the north by Chandanaish upazila, to the south by Lohagara (Chittagong) upazila, to the east by Bandarban Sadar upazila, and to the west by Banshkhali and Anowara upazilas.



Figure 1: Geographical Location of Study Area

3.3 Criteria for farm selection:

For the selection of Gayal farm following criteria were considered.

- Location of farm area
- Number of Gayal populations
- Rearing System
- Objectives of Gayal rearing

Small, Medium and large Gayal farm were selected for the study.

3.4 Sample Selection

The goal of the study was to look at the phenotypic characteristics, reproductive potential, and production capacities of Captive Gayal. Four Gayal farms were chosen. Where 75 Gayal's information was obtained. All data was collected from available Gayal farms in Chattogram division.

Table 1: Study population

Location	No. of the farm	No. of animal	Total
Rangunia upazila	1	57	
Satkania upazila	3	18	75

3.5 Data Collection

A survey with both open-ended and closed-ended questions was created. Then, using a questionnaire, information about Gayal's production and reproduction was obtained from the owner, following the direct interviews and frequent in-person visits (Figure 2 and 3). Typically, interviews took place on the respondent's farm.

The following data were gathered through field visits and animal observation:

- Population of Gayal
- Phenotypic Characteristics
- Production parameter
- Feeds and Feedings
- Breeding and Reproduction
- Housing
- Diseases Prevention and treatment
- Marketing of Gayal

3.6 Phenotypic data

Phenotypic characteristics (Eyeball colour, Body coat colour, Height, Horn type and size) of Gayal was recorded during the time of farm visit by direct observation of animals (Figure 4 and 5).

3.7 Production data

The body was measured with an animal measuring tape (in Inch) (Figure 6, 7, 8 and 9) with the help of farm owner, care taker or workers of the farm.

Animals weight measured by using the following method / formula

$$\text{Animal Weight in pounds} = \frac{l \times G^2}{300}$$

Here, G^2 = heart girth,

L= body length

Animal weight in pounds / 2.2 = Kilogram (Kg).

Table 2: Description of body measurement:

Body measurement (Inch)	Measurement
Head length	Distance from the nape to the rostral end of the muzzle
Height at wither	The vertical distance from bottom of the front foot to the highest point over wither
Body length	The horizontal distance from point of shoulder to pin bone
Heart Girth	Through placing the measuring tape around the animal at the point of smallest circumference just behind the forelegs

3.8 Reproduction data

During the study, various reproductive data were recorded, including the age of puberty (in month), age at first estrous (in days), observations of estrous signs and behaviors, the breeding methods applied, the length of gestation (in days), first calving age (in days), and the number of calf births per conception in natural breeding.

3.9 Data analysis

All of the survey data was entered into Microsoft Office Excel 2019 spread sheet. Appropriate statistical analysis was done using the data analysis tools of Microsoft excel 2019 and SPSS 25.0.

PHOTO GALLERY

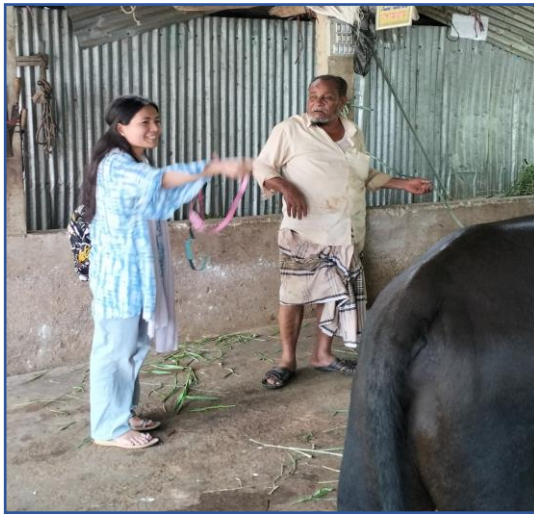


Figure 2: Interview with owner



Figure 3: Interview with worker



Figure 4: Closely observation of Gayal



Figure 5: Data recording



Figure 6: Height measurement



Figure 7: Body length measurement



Figure 8: Heart girth measurement



Figure 9: Head Length measurement



Figure 10: Grazing in nearby forest



Figure 11: Watering nearby forest



Figure 12: Provide straw at farm



Figure 13: Provide green grass and leaves

CHAPTER 4: RESULTS

4.1 Grouping of study populations:

Total 75 Gayals are included in study populations, where there were 18 calves, 07 heifers, 10 bullocks, 15 cows and 25 bulls.

Percentage of calf, heifer, bullock, cow and bull are showed in bellow Chart (Figure 14):

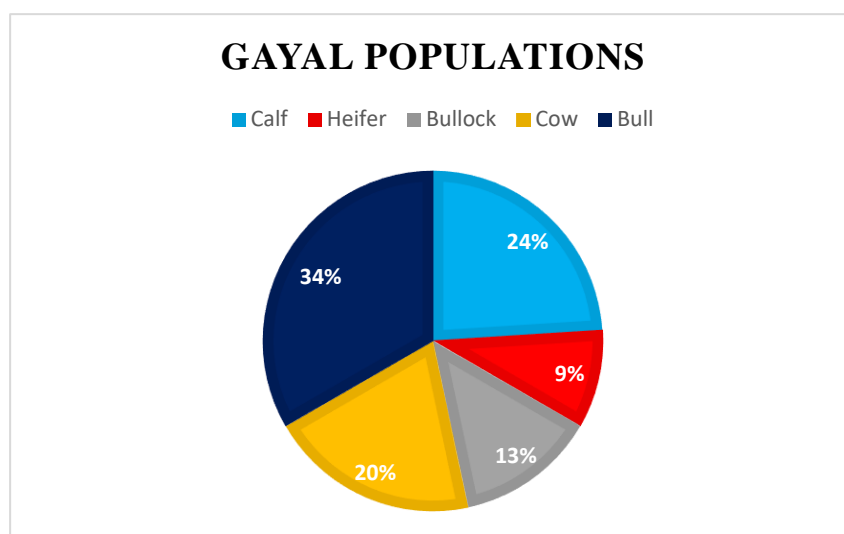


Figure 14: Percentage of gayal in study area

4.2 Coat colour of Gayal

The gayal is not native to Bangladesh, although there are initiatives on to introduce and breed them in particular areas. Gayal breeds in Bangladesh may not have been adequately documented. The available coat colour of Gayal are as bellow:

1. Black
2. White
3. Black and white

The available Gayal crossbreeds in Bangladesh are as bellow:

1. Gayal (Male) x RCC (Female) = Tang guar
2. Gayal (Male) x Tang guar (Female)



Figure 15: Pure Black Gayal



Figure 16: Black and White Gayal



Figure 17: Pure White Gayal



Figure 18: Tang guar



Figure 19: Tang Guar x Gayal

Table 3: Available genotypes of gayal in study area

Genotypes	Frequency
Gayal x Gayal	70
Gayal x RCC	3
Gayal x Tang guar	2
Total	75

4.3 Phenotypic Characteristics of Gayal

Gayal have a distinctive look that is a cross between domestic cattle and wild bison. They have an athletic build, a well-defined hump over the shoulders, and a short, thick tail. Their coat can be any color from dark brown to black, and they occasionally have white markings on their body, legs, and face. One phenotypic trait that stands out is the variety in coat color. Gayals' coat colors can change as they get older, although the particular alterations might vary from person to person and may be impacted by genetics, diet, and environmental factors. Gayals typically have a different coat color at birth than they have as adults. The calf coat has distinctive patterns or markings and is frequently lighter in color (Figure 20). Gayals mature into the typical adult coat color for their breed or population as their coat color tends to darken with age. From two and a half to three months old, the gayal calf's coat color started to change. Gayals, like other cattle, have brown or black eyes. Gayal eyes are not distinguished from those of other domesticated cattle species. Their eye color varies slightly through individuals, although it is frequently within the spectrum of ordinary cattle eye colors, which are brown or black. Both stout and upwardly curving horns are present on both sexes. Horn size and shape can vary between individuals, and horn length and curvature can be influenced by heredity and age. These impressively long horns are utilized for social interaction and defense. The tail switch color vary from black to white depending on their coat color. Gayal are larger than the majority of domestic cattle breeds. Males can weigh up to 800 kilograms as adults, while females normally weigh 400 to 600 kilograms.



Figure 20: Gayal calf

Table 4: Phenotypic characteristics of gayal (Coat color, lower leg color and muzzle color)

Variables	Color	Frequency	Percentage
Coat Color	Black	33	44
	Black and White	12	16
	Brown	4	5.3
	Brown and White	2	2.7
	Dark Brown	6	8.0
	Dark Grey	7	9.3
	Greyish Black	10	13.3
	White	1	1.3
Muzzle Color	Black	38	50.7
	Brown	4	5.3
	Dark Brown	4	5.3
	Dark Grey	6	8
	Greyish Black	10	13.3
	White	13	17.3
Lower Leg Color	Black	12	16
	Brown	2	2.7
	White	61	81.3

4.3.1 Phenotypic characteristics of cross breeds

Cross breed of Gayal (male) and RCC (female) known as “Tang Guar”. The coat of the Tang guar is a deep brown color (Figure 18). They have a face that resembles a cow. The Tang guar is almost RCC in size. Black can be seen on the legs and faces of adult tang guar. Their horn has a distinctive curve. The male and female of the hybrid between a gayal and a tang guar virtually seem like gayals, but their faces look more like cattle (Figure 19). Adult crossbred animals are black in color. They have a bright brown upper head and tail switch. Their lower leg is white mixed with slightly reddish tone. Horns have a little curvature. Their size larger than the Tang guar.

4.4 Gayal Production

4.4.1 Weaning age and weight of Gayal calves

Gayal is well-known for its high-quality meat that is lean and high in protein. Their meat is popular due to its flavor and nutritional content. While gayal cattle produce less milk than typical dairy cow, their milk is still not consumed in Bangladesh. Calves have been allowed to consume milk. In average, male gayal calves can be born weighing 25 to 30 kilograms, while female gayal calves can be born weighing 20 to 30 kilos. These figures are approximations that may differ between individuals and populations. Gayal calves, like other cattle, should be fed colostrum as soon as they are born. Colostrum is the mother cow's (or gayal's) first milk produced after giving birth. It is high in antibodies and vital nutrients that are required for the development of the calf's immune system. Colostrum supplies the calf with passive immunity, protecting it from a variety of illnesses and infections. It also contains proteins, vitamins, and minerals that are required for the calf's growth and development. To reap the most benefits from colostrum, a calf should be given it within the first few hours after life. If a gayal calf does not receive colostrum or receives insufficient colostrum intake, it is more vulnerable to health problems and may require further veterinarian treatment to address any health issues.

Table 5: Weaning of Gayal calves

Content	Description
Age at weaning	2-3 months
Weaning weight of calf	40-60 kg
Weight gain after weaning	0.5-1 kg/day

Gayal's weaning age can range from 2 to 3 months. However, it is crucial to note that the weaning age can be influenced by factors like as food availability, calf health, and cultural customs of those who raise them. Some people wean their calves sooner, while others wait until they are a little older. Another reason for weaning sooner (within 2-3 months) is that the gayal or mother cow enters heat sooner after calving. Weaning weights can differ greatly across individual gayal and herds. Some gayal may have weaning weights of 200-300 kg or more. Gayal weigh between 40 and 60 kilograms when weaned. A healthy calf may gain between 250-900 g every day before to weaning for various breeds of cattle, including gayals. This is just a basic range, and growth rates can vary widely between individual. Gayals, the post-weaning weight growth may range from 0.5 to 1 kg per day on average. Individual growth rates can differ from this basic range. After weaning, it's critical to maintain optimum nutrition, availability to high-quality hay or pasture, clean water, and the appropriate feed additives if required. In addition to immunization and parasite control, good herd management techniques are essential for ensuring the health and development of gayals.

4.4.2 Meat and milk production

Gayals are mainly reared for meat production. The weights of mature male and female gayals differ. Male gayals are heavier than female gayals, with mature male gayals weighing 700-800 kg and adult female gayals weighing 400-600 kg.

Table 6: Productive Parameters of Gayal

Physio-logical stage	Age (Month)	Sex	N	Head length (Inch) Mean±SD	Height at wither (Inch) Mean±SD	Body Length (Inch) Mean±SD	Heart girth (Inch) Mean±SD	Weight (Kg) Mean±SD
Calf	1-4	M	4	12.75±0.50	33.00±1.15	28.25±1.5	33.75±2.63	49.26±10.09
		F	1	11.00±0.00	29.00±0.00	26.00±0.00	28.00±0.00	30.88±0.00
	5-8	M	5	14.80±0.84	39.80±1.09	38.60±0.55	49.60±0.89	143.96±6.53
		F	4	14.25±0.50	37.50±1.73	37.50±0.58	46.00±1.83	120.47±11.32
	9-12	M	3	16.00±0.00	42.00±1.73	40.33±0.58	53.33±3.21	174.12±19.77
		F	1	16.00±0.00	41.00±0.00	39.00±0.00	49.00±0.00	141.88±0.00
Bullock	13-24	M	3	17.00±0.00	43.33±0.58	38.33±0.58	58.67±0.58	199.87±0.95
	25-36		7	17.42±0.53	44.00±0.58	41.86±3.33	67.86±7.43	299.16±84.60
Bull	37-72	M	18	20.50±1.10	54.72±1.60	55.67±1.85	83.94±4.11	596.63±69.42
	73-84		5	22.00±0.00	57.00±0.71	59.60±0.55	88.20±0.84	702.51±12.80
	180-192		2	23.00±0.00	58.50±0.71	60.50±0.71	90.00±0.00	742.50±8.68
Heifer	24-36	F	4	17.25±0.50	43.50±0.56	39.00±1.41	61.75±4.99	227.32±44.38
	37-42		2	18.00±0.00	44.50±0.71	43.00±0.00	71.00±1.41	328.49±13.08
Cow	48-72	F	7	18.86±0.69	53.14±2.27	50.86±3.89	79.71±2.36	491.75±64.17
	73-84		3	20.00±0.00	55.33±0.58	55.33±0.58	82.67±0.58	572.98±12.13
	180-192		5	20.20±0.45	55.20±1.64	54.40±2.07	85.00±1.00	595.84±33.38

Here, N = Total number of animals, M= Male and F= Female

Table 7: Milk production in female gayal

Parameters	Productive Performance
Milk production/day	N/A (Milking is not done)
Length of lactation	N/A (Milking is not done, so actual length of lactation is unknown)

Although the quality of both meat and milk of Gayal is excellent but milking is still not practiced. Farmers are preferred for meat purposes due to the rapid growth of gayal. Gayal cows usually yield less milk than indigenous cows. Gayal's udder is invisible from the outside. Unlike indigenous cows, gayals' udders do not swell even during pregnancy. Female cow teats are also smaller than those of indigenous cows. Gayal calf is permitted to consume all of mother gayal's milk.

4.4.3 Crossbred Gayal production

Gayal may be crossed with other cattle species or breeds to introduce or improve particular features like disease resistance, climatic adaptability, or meat and milk output. Cattle with favorable traits for regional or commercial goals may result from this. Crossbreeding may also be done for commercial or cultural purposes, such as to produce animals with qualities that are in demand in a particular area. In Bangladesh Gayal crossbreds are mostly raised for meat. Tang guar weighs more than RCC cattle. The body weight of a three-year-old Tang guar heifer was 250 kg, whereas that of a three-year-old Gayal heifer was 279 kg. Tang guar hybridization improves growing characteristics. The four-year-old male Gayal X Tang guar weighed between 464 and 473 kg.

4.5 Feeds and feeding

There are various methods of Gayal feeding. Grass is often the forage that makes up the majority of the diet of pastured animals. Straw is fed to cattle raised in feedlots. Farmers provide grass/straw and occasionally rice polish or wheat bran combined with salt under confined conditions. Female gayals, calves, and one breeding bull are permitted to graze from morning to afternoon (Figure 10). Water is provided from natural sources during grazing (Figure 11). In case of captive gayals, water is provided in containers for drinking. Other confined animals are fed straw (Figure 12). Farmers

offer rice polish or wheat bran with salt in the evening. Gayals have special fascination to salt. Some farmers supply green leaves or grass in captivity without any concentrate feed or salt (Figure 13). The quantity of rice polish and wheat bran is increased even before Eid-al-Adha. Farmers sometimes plant Napier grass. When it is time to harvest paddy, the farmers feed Napier grass to the gayal.

Table 8: Types of feed that are provided to Gayal

Types of feed		Name of feeds
Roughage	Succulent	Pasture forages
	roughage	Napier Banana leaves
	Dry roughage	Straw
Concentrate		Rice Polish Wheat bran
	Mixed feed	Mixture of rice polish and salt or wheat bran and salt.

4.6 Breeding and Reproduction:

Gayal, like many other mammals, undergo a series of distinct reproductive stages throughout their life. These stages encompass puberty, when sexual maturity is reached, the estrous cycle, during which females exhibit receptivity to mating, pregnancy, which involves the development of offspring within the female, and gestation periods, which are the durations of pregnancy leading to the birth of offspring. These reproductive stages play a crucial role in the natural life cycle of gayal and have significant implications for their population management and breeding programs.

Table 9: Stages of reproduction in Gayal cow

Stage	Description	Time
Prepubertal	Non-cycling, growing heifers	Birth to 12-24 months
Puberty	First estrus (begin normal cycling)	12-24 months
Estrus cycle	Continued cycles with even intervals	19-21 days
Length of estrus	Duration of estrus lasting	12-18 hours
Gestation	Pregnancy not cycling	280-290 days
Parturition	Calving	3-3.5 years
Postpartum	Recovery after calving (not cycling)	Up to 45 days

The age of puberty come earlier in female gayal than male gayal. The age of puberty of female and male are 12-24 months (average 547.5 days) and 36-48 months (average 1277.5 days). Gayal heifer have their first estrous cycle when they reach puberty. Estrus can last anywhere between 36 and 72 hours, however the standing estrus lasts about 12 to 18 hours on average. The length of the estrous cycle in gayal cow is 19-21 days. Gayal females typically exhibit silent heat. When a female gayal is in the period of estrus she shows sexual receptivity symptoms such as enhanced vocalization, mounting other animals, and behavioral changes. This is the most likely moment for her to mate. Female gayal allows male to mount during estrous. Female gayal try to stick close to male gayal. Vulva that is slightly enlarged may be present. There is no such technique applied for heat detection. Detection of heat by clinical symptoms is difficult in female gayal. In a natural breeding scheme, the bull determines when a cow is in heat. Natural breeding is preferred for reproduction in Bangladesh. All female gayal are permitted to graze outside along a selective breeding bull. If a female gayal is in heat, the male animal mounts her. During first conception the age of gayal is 727.5 days. The farmer or caretaker of gayal routinely observes the animal that is supposed to be in heat. Female gayal usually returns to heat 45 days after calving. If a female animal allows a male to mount her or if mating occurs naturally, the female gayal is considered a concept. In late pregnancy abdominal ballottement is prominent (Figure 21). Gayal has a gestation

period similar to cattle. The gestation period lasts between 280 and 290 days. Female gayal give birth to their first calf at the age of 3-3.5 years (1095-1277 days). Gayal naturally comeback to estrous within 45-60 days after calving. Duration of calving interval in gayal is 1 year (360-400 days) typically. Calving difficulties are less visible in gayal. Injuries to female gayal are occasionally recorded. A gayal female gives birth to one calf at a time. In Bangladesh, calf mortality was also documented. Farmers claim that the calf gave birth naturally, but died after a few days. Because of the mother cow's small teat, the calf cannot properly suck milk. Mother cows exhibit less pain before giving birth to a calf than heifer cow. Mother cow exhibits less maternal behavior. In most circumstances, they give delivery without agitation. The mother cow is unaware of her youngster (Figure 22). However, when heifer gayal gives birth for the first time, they are aware of their calf. After birth, calves are given colostrum. Female gayals, like other cattle, supply milk for their calves, which is the principal source of nutrition throughout the early stages of life, and they often nudge or encourage their calves to nurse. After a few days, the calf is free to roam the farm. Mothers normally take care of calves, which can begin grazing a few weeks after birth.



Figure 21: Pregnant Gayal



Figure 22: Calf with mother cow

4.6.1 Reproduction in crossbred gayal

Gayals are permitted to graze in dense forest among cattle, increasing the possibility that they may breed together. The reproduction of crossbreeds almost similar to native gayals.

4.7 Housing

Types of Housing available in study area are (Figure 23, 24)

1. Conventional barn / Stanchion barn

a. Face-in-system

b. Face- out-system

Gayal require shelter to defend themselves from adverse conditions such as rain, cold, and heat. It is essential to have a robust and well-ventilated barn or shelter. Chittagong division has both intensive and semi-intensive housing systems. The floor is easy to clean and provide good drainage to prevent the buildup of moisture and waste. Concrete floors are common at study area. Floor space for each animal (Table 10) mentioned below:

Table 10: Floor space for each Gayal

Type of animal	Space for each (m ²)
Calf	1-2
Heifer or Cow	4-5
Bull	12



Figure 23: Face-in Housing system



Figure 24: Face-out Housing system

4.8 Disease prevention and treatment

Gayals are susceptible to FMD, Anthrax, LSD, Black Quarter, mastitis, parasitic infestations and Diarrhoea. For disease prevention, farmers often provide FMD vaccine at the age of 6 months, followed by a booster at a one-year interval (Table 11). Deworming is done to prevent parasite illnesses; initially at the age of 6 months, then at 6 months intervals thereafter (Table 11). Gayal animals have great immunity and are less prone to sickness. When gayals are unwell, they tend to graze freely outside of the farm. According to farmers, Gayal consume forest leaves when they are unwell and recover quickly.

There were no diseased animals in the selected farms during the study period.

Table 11: Deworming and Vaccination schedule

SL no.	Prevention/ disease	Name	of	Age	at	first	Boaster dose
				dose			
1	Deworming			6 months			6 months interval
2	FMD (Vaccine)			6 months			6 months after first dose then every 6 months interval

4.9 Marketing of Gayal

As Eid-ul-Adha approaches, Gayal shopkeepers are observing an increase in demand for wild bovine meat, which was already a popular dish on many Chattogram dining tables. Gayal bulls are sold between December to February and used as sacrificed animals for the Muslim religious festival called “Oros” and “Eid e Miladunnabi” organized by the Muslims. Gayals can now be seen in cattle sale markets such as Keranihat. Farmers from many districts gather Gayals from the Chattogram division for rearing. Gayal demand increased after Eid-ul-Adha as farmers expressed interest in gayal farming. A customer who purchased a Gayal for the first time for Eid sacrifice explained that he chose the animal since it is a free-range cow that only grazes on natural food. Gayal meat is presently selling for an average of 1000 Tk per kilogram. Pricing system of Gayal vary depends on size of animal, location, availability and transport system. According to the size of animal following pricing system (Table 12) is available in Bangladesh:

Table 12: Pricing system of Gayal based on size

Size of animal	Price (Lakh)
Small	2-2.5
Medium	3-4
Large	6-7

All of the gayals are sold except selective breeding bulls. The price rate of breeding bull is higher than others.

4.9.1 Marketing channel of gayal

The process by which these animals are transferred from producers to consumers in Bangladesh's gayal (*Bos frontalis*) marketing channel is multistage. For their flesh, gayals are highly prized.

These crucial procedures are usually followed by the gayal marketing channel in Bangladesh:

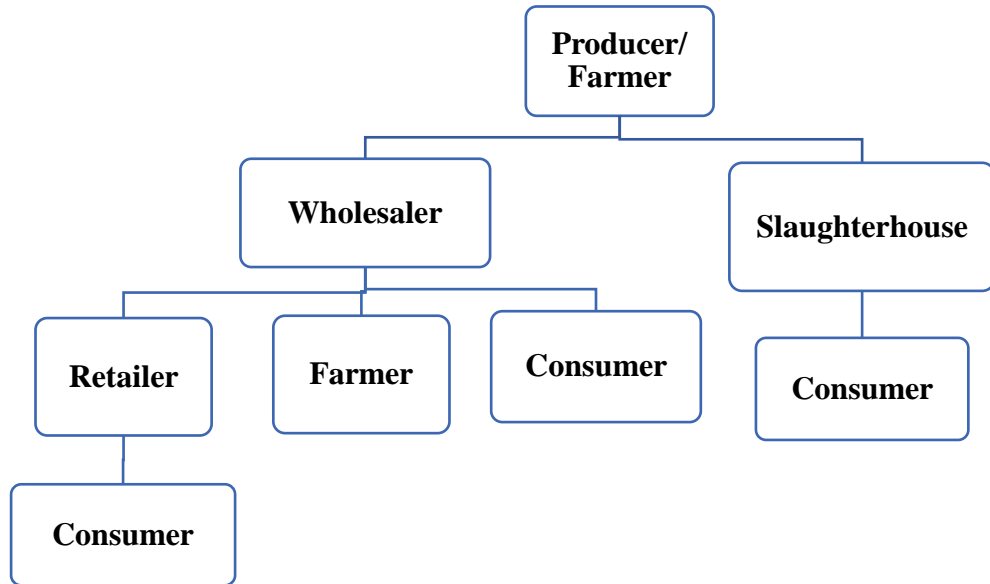


Figure 25: Marketing Channel of Gayal in Bangladesh

CHAPTER 5: DISCUSSION

The goal of the current study is to investigate the phenotypic traits, reproductive abilities, and productivity of captive gayal in Bangladesh. The structure and morphology of the gayal used in this investigation show that the majority of it is original. Gayal's coat color varies with age. The coat color of adult gayals ranges from dark black to grayish black. Gayals also had coats that mixed white and black. Crossbred gayal crossing with RCC commonly known as Tang guar are also present in the studied farms. Tang guar possessed coats dark brown and shaded black. Faruque *et al.* (2015) stated that the adult gayal carried a black coat and white stockings were quite common. Gayal resembles Bhutanese, Chinese, and Burmese animals in terms of body shape and coat colour. White is the predominant colour of the gayal in Arunachal, India (Arora, 1998).

Gayal's birth weight and body weight in the current study were 25-30 kg in male and 20-25 kg in female. According to Haque *et al.* (2001), the average birth weights of the male and female Gayals were 24.30 ± 6.99 kg and 20.20 ± 4.08 kg, respectively. According to Faruque *et al.* (2015), the average birth weights of the male and female Gayals were 21.67 ± 0.15 kg and 19.63 ± 0.21 kg, respectively.

At present gayal calves are weaned at the age of 2-3 months. Weight of gayal during weaning 40-60 kg. Haque *et al.* (2001) reported that gayal calves are weaned at the age of 6 months. Gayal's weaning weight was 83.9 ± 17.7 kg (dry season).

In the current study, the male gayal's (37-72 months or 4-6 years) average body length, height at the wither, head length and weight were 55.67 ± 1.85 inch, 54.72 ± 1.60 inch and 20.50 ± 1.10 inch and 596.63 ± 69.42 kg. According to Faruque *et al.* (2015), the male gayal's (5-6 years) average body length, height at the wither, head length and body weight were 132.00 ± 1.02 cm, 132.50 ± 1.42 cm and 50.00 ± 00 cm and 510.00 ± 16.71 kg respectively. Adult male and female gayals in India have the body lengths of 138.75 cm and 126.75 cm, respectively, according to Gupta *et al.* (1996).

The body weight of a three-year-old Tang guar heifer was 250 kg, whereas that of a three-year-old Gayal heifer was 279 kg. The four-year-old male Gayal x Tang guar weighed between 464 and 473 kg. According to Hoque *et al.* (2001) the weight of one year female (50% Gayal x 50% Friesian) was 226 kg and male (50% Gayal x 50% Jersey) was 212 kg.

Farmers are given green grass or straw for intensive farming in the study area. Gayals are permitted to graze from early in the morning until late in the afternoon when farming is semi-intensive. In the evening, salt and wheat or rice polish are offered. According to Shisode *et al.* (2009) the availability of jungle forage and pasture land are Mithuns' only sources of food. In hilly regions during monsoon season, salt feeding and licking of mineral water sources are common practices to prevent mineral deficiency in these animals. In contrast to the lean season, when there is a lack of feed and much concentration is needed to feed the concentrate ration with 15% crude protein (C.P.) and 70% total digestible nutrient (TDN), fortified with salt and mineral mixture, the flush season is when they have an abundance of green grass, fodder, herbs, and shrubs. Shun-li *et al.* (2011) stated that Yunnan Gayals have distinctive dietary habits that include alfalfa, barley straw, rice straw, bamboo leaves, and bamboo twigs and bamboo stems.

In study area Gayal milking was not performed due to low milk output and tiny teats. Bangladesh exclusively uses gayals as meat animals since they produce relatively little milk. Farmers mostly raise cows for slaughter or breeding purposes in the study area, not for milking. Gayal provides a small amount of milk that is allowed to be consumed by the calf. Gayal produce about 1-1.5 kg of milk per day per animal (Nath and Verma, 2000). The duration of lactation, lactational production, and daily milk output were found to be 116.7 ± 8.1 days, 305 ± 30.5 ml/day and 35.7 ± 6.2 kg/lactation respectively based on data from Giasuddin *et al.* (2003a). Mondal *et al.*, 2014; Phanchung and Roden, 1996 reported that the female gayal hybrids have shown to be excellent milk producers and are widely employed in Bhutan and the northeastern mountainous regions of India. However, in Bangladesh, such hybrids were unable to provide any positive outcomes (Haque *et al.*, 2001).

Average first estrous age and first conception age were, 547.5 days and 727.5 days respectively. Giasuddin *et al.* (2003a) reported that average first estrous age and first conception were 598.2 ± 168.4 and 723.9 ± 169.9 day. In gayal, the average body weight at first estrous was 227.32 ± 44.38 days. In a report Gayal average body weight was 247.8 ± 35.1 kg, the weight is between 205 kg to 330 kg (Giasuddin *et al.*, 2003a). In gayal, the average estrous cycle lasted 20 days, and the average heat period was 52 hours. Almost similar results about the length of the estrous cycle in Gayal was published by Giasuddin *et al.* (2003a).

The gestation period of gayal lasts between 280 and 290 days. According to Giasuddin *et al.* (2003a), the average gestation duration of gayal was 296.1 ± 3.9 days and Faruque *et al.* (2015), the average gestation period was 296.25 ± 0.77 days.

The average at age first calving and postpartum estrous were 1095-1277 days and 45-60 days respectively. The average age at first calving and postpartum estrous according to Giasuddin *et al.* (2003a) was $1,014.4 \pm 266.3$ days and 96.2 ± 24.1 days, respectively. The average calving interval of Gayal was 1 year (360-400 days). Faruque *et al.* (2015), who reported a gayal's average calving interval 402.85 ± 3.04 days. The recent study shows less maternal behavior in Gayal cows. However, according to Giasuddin *et al.* (2003a) and Giasuddin and Islam (2003b), cows exhibit maternal behavior during the first week after giving birth, then revert to their prior status.

In Bangladesh's Chattogram division diseases under intensive and semi-intensive management were studied. The most common diseases were FMD, Anthrax, LSD, Black Quarter, mastitis, parasitic infestations and Diarrhoea. Farmers provide vaccine as a disease prevention measure even though they are now conscious of disease. All animals received deworming as well. According to Giasuddin *et al.* (2006), Shisode *et al.* (2009) and Haque *et al.* (2011) the most common conditions were FMD, non-specific diarrhea, conjunctivitis, skin conditions, non-specific fever, and mastitis.

Gayal is always marketed in the study area, but it is especially sold for animal sacrifice on Eid-ul-Adha, Oros, and Eid-e Miladunabi. Farmers are starting to take an interest in growing gayal, and some of them are buying it from the research area. Gayal meat is becoming more expensive day by day, followed by other species. Now gayal meat are sold at 1000tk per kg. Seraj (2019) reported that gayal sold during Eid-ul-adha, with price ranging from 2-3.5 lakh. Gayal prices vary depending on region.

CHAPTER 6: CONCLUSION

Gayals are significant culturally and economically in Bangladesh, especially because of the exceptional caliber of their meat. Male gayals are heavier than female. Gayals can be distinguished from other animals by their phenotypic characteristics. Despite having diverse morphological traits and various productive advantages, they have relatively high reproduction rates and short calving intervals. Male gayals are heavier than female and female. For those who looking to quickly expand their herd, calf mortality can be restricting issues. However, on-going initiatives to increase breeding and management techniques are anticipated to boost their reproductive success. Gayals marketing still underdeveloped. Overall, gayals may continue to be an important part of Bangladesh's agricultural environment, enhancing the livelihoods and traditions of numerous communities.

LIMITATIONS

While doing the research, a significant amount of issues were encountered. These could be successfully used for further research.

1. Location of farm: There are no gayal farms close to the CVASU campus. Due to the farm's distance, regular animal monitoring is not possible. If there was an established gayal farm close to the institution, the task would be simple.
2. Scarcity of gayal: Gayal communities in Bangladesh are tiny and scattered. They are mainly found in hilly and forested areas, making them difficult to find and research.
3. Data collection challenges: Gayal are notorious for their evasive behavior, which makes them difficult to monitor and research. Gathering data on their ecology, behavior, and reproduction was time-consuming and required long hours of observation in difficult terrain.
4. Weather and climate: The environment was unfavorable when doing the research. Research work is disrupted by constant rain.
5. Semi-intensive farming systems: Farmers are permitted to browse gayals from early in the morning until late in the day, which has an impact on data collecting.
6. Frequent selling of gayals: The demand for gayal increases during and following Eid ul-Adha. Farmers this time sell a lot of gayals. which has interfered with the data collection.

RECOMMENDATIONS

It is critical to understand the distinct phenotypic features, production capacity, and reproductive performance of captive gayals in Bangladesh, given the increasing interest in using them for sustainable agriculture and conservation initiatives.

- To maintain genetic diversity, avoid excessive inbreeding within the captive gayal population. Maintain records of lineage and consider periodic introductions of new individuals to the breeding program.
- Select individuals for breeding that display desirable physical traits, such as a robust body structure, strong limbs, a well-proportioned head, and good horn development.
- Pay attention to the coat color and pattern, as these can vary among gayal individuals. While coloration may not directly impact production, it's essential to maintain the natural diversity of these traits.
- Provide a balanced and nutritionally adequate diet for captive gayal. Their diet should include good-quality forage, fresh water, and supplementary feed if necessary.
- Implement a weaning program at the appropriate age to ensure the health and well-being of both calves and mothers.

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Appendix

Dept. of Dairy and Poultry Science
Chattogram Veterinary and Animal Sciences University (CVASU)
Survey Questionnaire

Phenotypic characteristics, Productive and Reproductive performances of Captive Gayal in Bangladesh

Name of Farm: Year of establishment:

Name of farm owner:

Location of farm:..... Cell phone:.....

Objectives: 1. Meat purpose 2. Ornamental purpose 3. Research purpose 4. Milk Purpose 5. Conservation purpose 6. Dual purpose (-----) 7. Crossbreeding purpose (breed(s) crossing with)

Section A: General information

1. Educational status of the farmer/entrepreneur
I) Primary II) Secondary III) Higher secondary IV) Tertiary
2. Family members
3. Main occupation
4. Annual income per year Bdt.

Section B: Gayal population of the farm

Calf: Heifer: Cow: Dry
cow:

Bullock: Bull: Steers:

Crossbreed:

Section C: Phenotypic Characteristics

1. Colour

Eye ball colour: Body Coat colour:

2. Height at wither

3. Shape

4. Size

5. Horn type:

Section D: Information on Gayal Production

1. What was the weight of calf at birth (male/ female)?

Tag no. male	Weight(kg)	Tag no. of female	Weight(kg)
a.		a.	
b.		b.	
c.		c.	
d.		d.	
e.		e.	

2. Colostrum feeding:

Yes No

If Yes, what is the amount and how long?

3. Weaning weight

4. Weaning age

5. Body weight gain/day up to weaning-----

5. Body weight gain after weaning (g/day)

Male	Female

6. Mature body weight (kg)

Male	Female

7. Amount of milk production (liter/ day) in different lactation.....

8. No. of lactation in productive life.....

9. Length of lactation (lactation period) in different lactation.....

10. Length of Peak of lactation (days) in different lactation.....

Section E: Feeds and feeding

1. Any special feeding habit(s)

2. Type of feeds offered

Green Roughage	Dry Roughage	Concentrate
a.	a.	a.
b.	b.	b.
c.	c.	c.
d.	d.	d.

3. Feeding schedule:

4. Offered ration of the farm

Ingredients	Amount(%)

5.Amount of offered ration (per animal/day)

Calf	Feed consumption (kg)	Roughage+ Concentrate	Heifer	Feed consumption (kg)	Roughage+ Concentrate

Milking cow	Feed consumption(kg)	Roughage+ Concentrate	Bull	Feed Consumption (kg)	Roughage+ Concentrate

6. Do you supply any additional vitamin and mineral premix?.....

If yes, what are those?.....

7. Is salt supplement mandatory for your animals?

If yes, why?

8. Source of feed

9. Do you have enough grazing land and how many acres?

Section F: Breeding and Reproduction

1. Age of puberty

Male:

Female:

2. Age at breeding

Male:

Female:

3. First estrous age(days)

4. Estrous cycle interval (days).....

5. Length of heat period (hours)

7. Estrous behavior and sign

.....

6. Technique of heat detection

BIOGRAPHY

I am Sushama Chakma, daughter of Hemaranjan Chakma and Mrs. Appeima Chakma. My permanent address is Upper Perachara village of Khagrachhari upazila, Khagrachhari. I passed my Secondary School Certificate (SSC) examination from Varateswhari Homes High School, Mirzapur, Tangail in 2012 and Higher Secondary Certificate (HSC) examination from Bharateswari Homes, Mirzapur, Tangail in 2014. I have completed my graduation on Doctor of Veterinary Medicine (DVM) from Chattogram Veterinary and Animal Sciences University (CVASU) in 2019. Currently I am a Master of Science (MS) in Dairy Science candidate under the Department of Dairy and Poultry Science, Faculty of Veterinary Medicine, Chattogram Veterinary and Animal Sciences University (CVASU). I intend to pursue my future research on dairy product marketing and dairy microbiology.