

TOWARDS AN APPRAISAL OF BIODIVERSITY IN BANGLADESH

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Abstract

In this paper, the concept of biodiversity has been presented on a historical perspective keeping the visions on Bangladesh via mentioning the primary supporting climatological and physiographic factors of the ecosystems along with their species composition. The total number of microbes, plant, and animal species has been estimated in the range of 10,606-14,913. The varieties of ecosystems present in Bangladesh belong to the broad categories, namely forest, agro-terrestrial, freshwater aquatic, as well as estuarine and marine. Forests cover nearly 17.5% of the total land of Bangladesh having specific categories like tropical wet evergreen and semi-evergreen, tropical moist deciduous, mangrove, freshwater swamp, and homestead forests. Dominant species belonging to those ecosystems were mentioned. The dimension of crop diversity in Bangladesh is very large, but the most common staple food comes from *Oryza sativa*, *Triticum aestivum* and *Zea mays*. The sources of biodiversity for the supply of vegetable and protein have been highlighted. Unique biodiversity in cases of freshwater phytoplankton and aquatic plants has been provided. Results from a case study on butterfly as their qualitative and quantitative biological population dynamics in 34 forest ecosystems of Bangladesh were presented and discussed. The establishment of an open 'Butterfly Park' in a National Park reveals that with due course of time the plant-butterfly-wildlife vertebrate species interaction increases with a concomitant increase in the biodiversity. Dominant plant and animal species together with their status as endemic, endangered, threatened, etc. in variously defined ecosystems of Bangladesh were highlighted. Besides, the ways of biodiversity conservation currently in practice in Bangladesh has been mentioned along with the future plans and programs to be implemented. Bangladesh holds a rich history in the starting of biodiversity teaching via developing curricular activities in different teaching institutions throughout the country. The origin and background of this activity was also highlighted. This review will help researchers to address biodiversity related questions on a scientific perspective.

Key words: Plant lore; Cumulative species; Aquatic species; Butterfly park; Medicinal plants; Herbal diversity.

INTRODUCTION

The origin of photoautotrophism, nearly 3000-2800 million years back, could be the sole foundation of plant biodiversity and based upon which the animal diversity came into existence. To our knowledge, nearly 500 million years back, 1st land plant *Rhynia* did exist and 410 million years back the 1st vascular plant *Cooksonia* did thrive on this earth (Jeffries 1997). According to the information provided in the 'Anthropocentric Botany', the time is not much beyond 1.8 million years before present (BP) and when *Homo erectus* (Dubois, 1893) the most known descendants of the modern intelligent creature the human being (*Homo sapiens* Linnaeus, 1758) did exist. It is the 'Paleolithic Hunter gatherers' who passed information on the food obtained from wild plants and animals as 'plant lore' from generation to generation. This relationship had been continued until the appearance of *H. sapiens* of nearly 0.2 million years BP. Agriculture, via which wild plants and cereals domesticated for the use of earth's population is a very recent activity by men and not more than 10000 years old.

The term 'Biodiversity' is a canopy subject of all the living creatures of the universe. Despite the physical presence of individual species in the biosphere, their response towards an array of physiological, ecological, and genetical factors creates a greater deal of diversities among them, further. However, the precise answer on the total number of species on this universe cannot be made readily available. Some species have already been discovered and some are yet to be worked out, if we are to deal with the species of the prehistoric era of our universe. Estimation indicates that there are about 8.7 million species prevailing on the universe, of which the distribution of discovered species looks: brown algae, diatom and water mould, 13.03, protozoa 8.11, plantae 215.64, fungi 43.27 and animalia 953.43 thousand. This means that 14.18% of the total species of the universe have already been described and the rest of the share are yet to be discovered. Nevertheless, to describe the status of the biodiversity of any geographical area of the earth, first the available information of the described species should be considered.

In a meeting of 2017 in China as organized by ATBC (Association for Tropical Biology and Conservation) and ABCDNet (Asia Biodiversity Conservation and Database Network) in Xishuangbanna Tropical Botanical Garden (XTBG), the documentation of biodiversity for Asia was emphasized. In the meeting, information on the plant and animal diversity from Thailand, Vietnam, Malaysia, Indonesia and the Philippines were available, but it was not significantly presented from Bangladesh. Researches related to the floristic and faunistic works in Bangladesh are available, but those are not yet organized in a system so that people could get access to it. Keeping this in mind, the present task has been attempted.

THE TEXT

Physiographic features of Bangladesh

Bangladesh is a south Asiatic country lying within 20°34' and 26°33'N, and 88°01' and 92°41'E. The country is surrounded from three sides by Indian Territory except a south eastern fringe which is bounded by the border of Myanmar. The Southern part of the country is glorified by the Bay of Bengal (Fig. 1). Bangladesh has a humid tropical type of climate with a clear demarcation of having four distinct climatic seasons (Brammer 2002). The Pre-monsoon season prevails in between March and May, during which both temperature and humidity remain high. It soon follows the Monsoon beset with high rate of rainfall which occurs between the months of June and September. The intensity of rainfall soon weakens in the Post monsoon period which extends from October to November. This time, there exists hot and humid climate. The next is the winter; it is really dry and could be called as coolest. Winter extends from December to February.

The annual mean air temperature ranges from 17-29°C and the average relative humidity from 70.50 - 78.10%. Day length ranges from 10.03-13.60 h with a range of PAR (photosynthetic active radiation) input 714 - 1714 $\mu\text{E}/\text{m}^2/\text{sec}$. Annual total surface water inflow from India is nearly 10,73,147.61 m^3 and the annual mean rate of precipitation is 202.39 mm. The biodiversity of Bangladesh is highly related with the extent of the four climatic seasons along with her soils. The soils are mostly alluvium and nearly 80% of the total area of Bangladesh is consisted of flood plains formed so far due to the fluvial action of three mighty rivers Padma, Jamuna and Meghna. The total territorial mass of Bangladesh is 147,570 km^2 with a population density of 1084 ind./ km^2 .

Biodiversity of Bangladesh

Plants: Bangladesh holds a geographical area known to be a tiny part of erstwhile Bengal Province of British India (1784 - 1947). The area inherits a floristic work which is a glorious continuation of historical past. Nearly 200 years back, the area was rich in vegetation, but without record. During 1760s, the students of Linnaeus and other Europeans started floristic work in Indian sub-continent. In 1793, William Roxburgh began floristic work in Bengal province and after which local researchers showed interest in the exploration of flora in this region of the world. Khan (1991) carried out an excellent review on the historical background of the plant sciences of Bangladesh as well as the British and post British period of this region. He divided the whole period into three phases. Phase 1 of his proposal was described as ‘the period of plant exploration during the British reign (1784-1947)’; Phase 2 had been ‘the studies on plants of the post British period to the emergence of Bangladesh in 1971’ via partition period of the Indian sub-continent (1947-1971), i.e. India and Pakistan from the British rule; and the Phase 3, the beginning of the ‘contribution of Bangladesh Botanists’.

The initiation in the botanical research in Bengal under the British rule was interesting. During that period the transport of essential commercial goods was carried out via water ways using wooden freight vessels or boats. Teak wood would have been necessary to prepare those freight vessels. Considering the essentiality of those woods, it was Robert Kyd, the Secretary to the military department of East India Company, who suggested British Government regarding the necessity of teak plantation in the area. The project was finally materialized in 1787 (Burkill 1965, Panigrahi 1977). Later on, the development of tea, jute, cinchona, teak, and mahogany cultivation had continued in India and the event could be considered as one of the main advances in the botanical exploration of the area. Actually, the flora of the regions of Bengal which are currently known to be within the territory of Bangladesh was previously studied by Prain (1903) and Khan (1991). During the post British period, i.e. the period after the liberation of India and Pakistan, significant works on the plants of the then East Pakistan (now the territory of Bangladesh) was contributed by Datta and Mitra (1953) on the plants in and around Dhaka, and Sinclair (1955) on the flora of Cox’s Bazar. The taxonomic account of the family Acanthaceae, Compositae, and Caesalpinae were contributed by Khan and Arangzeb (1959), Hossain (1964) and Rahman (1964), respectively. Khan and Huda (1970) studied the genus *Euphorbia* of Dhaka.

After the liberation of Bangladesh as a sovereign country in 1971, within four years, Bangladesh Agricultural Research Council (BARC, founded in 1973) started nurturing a previously formed plant exploration project leading to the foundation of ‘Bangladesh National Herbarium’ (acronym, DACB, founded in 1975). Research activities and the exploration work on the plant diversities of Bangladesh actually took a new impetus under the active leadership of Professor Dr. M. Salar Khan on the platform of DACB. Dr. Khan published ‘Flora of Bangladesh’ No. 1-53 in between 1972 and 2002. Besides, Dr. Khan also pioneered the publication of the Timber Yielding Plants of Bangladesh in 1986 and the Aquatic Angiosperms of Bangladesh. Parallel to those activities, Islam (1991) published an edited volume titled ‘Two Centuries of Plant Studies in Bangladesh and Adjacent Regions’. The book contained a review of works on almost all the disciplines of plant sciences. The First Red Data Book for Bangladesh edited by Dr. Khan was published in 2001. Dr. Khan expired in 2002 and thereafter his pupils continued the activity and completed the Flora of Bangladesh No. 54-63 in between 2003 and

2016. Altogether 74 families of angiosperms were covered from Bangladesh. The second volume of which was published in 2013. Another Red Data Book was published in 2013 from the Department of Botany, University of Chittagong (Rahman 2013). In between 2005 and 2009, The Asiatic Society of Bangladesh completed a project titled 'Encyclopedia of Flora and Fauna of Bangladesh' (EFFB 2007-2008) and published it in several volumes. The volume included an up to date compilation work using the published records on prokaryotes, algae, fungi, bryophytes, pteridophytes, gymnosperms, angiosperms, and all animals of Bangladesh.

Animals: Unlike the rich history of floristic exploration in Bangladesh, only a few does cover for animals (protozoa to large mammals). The oldest record on plankton made by Begum (1958) could be noteworthy in this discussion. Khan (1982) has made the righteous statement regarding the dearth of studies on the wildlife of the territory, which is currently included under Bangladesh. Husain (1979) carried out studies on the birds of Bangladesh. He commented that during the period of British India, many leading authors studied the avifauna of the Indian sub-continent, but no detail study was ever carried out in this part of 'Bengal'. Khan (1982) published a checklist on the wildlife of Bangladesh which could be considered as one of the pioneer works. The initiative taken by the Asiatic Society of Bangladesh to accumulate all the published information from protists to mammals of Bangladesh in 16 volumes is a gigantic task. Over 12000 species from the biodiversity of Bangladesh have been described in it. The 2nd edition of the checklist by Khan was published in 2015 including some new information on the wildlife of Bangladesh (Khan 2015).

Curriculum on Biodiversity in the Universities of Bangladesh: In between 1978 and 1979, one of the renowned Phycologists of the Indian Sub-continent, the then Professor of Botany, University of Dhaka, Bangladesh Dr. AKM Nurul Islam introduced a course titled 'Plant Diversity' in the 1st year Honours Class of the Department of Botany, University of Dhaka, Bangladesh. The imagination, thoughts, and far sight related to the diversities of plants by Professor Islam were praiseworthy, because, since then, the term 'Biodiversity' had not been even introduced globally. According to Jeffries (1997) the term 'Biodiversity' was first proposed by Walter Rosen in 1986. However, in Bangladesh, since the initiation of the course titled 'Plant Diversity' in 1978, the Department of Botany, University of Dhaka had continued it until the expiry of Professor Islam in 2006. Thereafter, the name of the course was changed to 'Biodiversity' in a meeting of the Academic Committee of the Department of Botany, University of Dhaka and is being taught there until now. The course was later on introduced in the curriculum of other public universities of Bangladesh.

Current analysis on the biodiversity of Bangladesh

Species of plants and animals: The recent trend on the analysis of biodiversity of Bangladesh by different organizations looks quite optimistic in the sense that a new generation of scientists is showing interest and participating in it. But, all those are somehow sporadic and look incomplete. Continuous monitoring system on the dynamics of the components of biodiversity seems to be lacking. The project titled 'The Encyclopedia of Flora and Fauna of Bangladesh' under the platform of the Asiatic Society of Bangladesh, had brought in order, most of the information on biodiversity accumulated from the historical past up to 2008. Their study has shown 13634 species from virus to mammal (Table 1).

Two more studies carried out on the biodiversity of Bangladesh yielded 14913 and 10606 species by DoE (2015) and IUCN (2015), respectively. Among the plants, angiosperms and from animals, arthropoda were the highest. The second highest representation from plants was by algae and from animals by the birds. This information has been revealed in all the recent three analyses carried out in Bangladesh (EFFB 2007-2008, DoE 2015, IUCN 2015).

Table 1. Plant and animal species described in the Encyclopedia of Flora and Fauna of Bangladesh.

Plant Group	Species number	Animal Group	Species number
Bacteria	171	Protozoa to Acanthophora	1923
Fungi	275	Mollusca	475
Blue-green algae (BGA)	300	Arthropoda	2925
Algae	2250	Freshwater fishes	251
Bryophytes	248	Marine fishes	426
Pteridophytes	196	Herpito fauna and reptiles	158
Gymnosperms	7	Birds	650
Angiosperms	3267	Mammals	112

Domestic diversity

In the preamble of this article, we have indicated the development of relationships among plant, animal and men. In those prehistoric periods (1.8 million BP) man's dependency on wild species was beyond any question. In the latter period, the term domestication came into existence which formed the basis of domestic diversity. Though biodiversity bears an essence of full natural origin, the importance of different species for human cultural and social activities and their immediate need as food are inevitable. Based on this the concept of the domestication of biodiversity appeared (Jeffries 1997). The domestication of biodiversity means the species of plants and animals which were wild in habitat, but later on were made pet at domestic premises by the human being to fulfill various needs by the latter. Thus, the essence of domestic diversity is based upon the human needs particularly to fulfill the demand of products as food and as essential commodities to run the daily life. As food, plants yielding cereals, fruits, juices, and vegetables have been domesticated. Plants as the sources of herbal medicines, floriculture, timbers, fibers, drug components, etc. are also seen to be domesticated. Among animals, fishes, chickens, ducks, pigeons, rabbits, cows, buffaloes, goats, sheep, pigs, etc. are most commonly domesticated animals throughout the world. It could be said that the domestic diversity has evolved parallel to the human civilization.

Animals domesticated: The religious belief of common people is a factor which reflects the pattern of animals to be domesticated. Since in Bangladesh the majority (~90%) of population are Muslim, the domestication of animals is mainly done to the species and varieties of cows, buffaloes, goats, sheep, cocks, hens, ducks, geese, turkeys, and pigeons, the so called Halal animals to the Muslims. The species of all those animals have high trading market as well as their meat is popular. Some pigs are also domesticated, but those are localized to the non-muslim ethnic peoples of the country. Pig farming is done only by some selected group of peoples in a very limited scale. Including the large and small ruminants, the total number of domestic animals in Bangladesh may range from 24-28 million. The number of chicken and ducks should be nearly 293 million (DoE 2015). Another indigenous wild species of ruminant animal locally called Goyal (*Bos frontalis*) has now been tried to bring under

domestication, since their population in the habitat has been declining and getting endangered status. *B. frontalis* is a wild species and belong to the jungle habitats of Chittagong Hill Tract forests, namely Naikhang Chhari where few farming establishment for the animal has been in practice.

Table 2. Cumulative species of plants and animal and total biodiversity of Bangladesh as reported by different organizations.

Sources	Plant species	Animal species	Total Biodiversity
Encyclopedia of Flora and Fauna of Bangladesh (EFFB 2007 - 2008)	6714	6920	13634
Department of Environment, Government of the People's Republic of Bangladesh (DoE 2015)	6967	7946	14913
International Union for Conservation of Nature and natural products (IUCN 2015)	2764	7842	10606

Fishes: From time immemorial, the presence of a pond in the house of a farmer happens to be a common practice in Bangladesh. The domestication of different fish species has grown up based on this very fundamental habit of the inhabitants. The aquatic ecosystem characteristics of each pond were prevalent by then and the species of fishes were mainly dependent on the naturally occurring food chain. The principal and highly popular fish species domesticated was rui (*Labeo rohita*), catla (*Catla catla*) and mrigel (*Cirrhinus mrigala*). Nile perch, the so called tilapia fish (*Oreochromis niloticus*) was first introduced in the present territory of Bangladesh around nineteen sixties because of its high multiplication capacity. However, within the recent one or two decades due to the increasing demand of fish protein, the commercial concept in the domestication of fishes has been added. Nowadays, most of the ponds are fertilized and stocked with a number of high yielding fish species. Large scale aquaculture is now most common in Bangladesh. The fishes mostly stocked there are *Macrobrachium rosenbergii*, *Cyprinus carpio*, *Labeo rohita*, *L. calbasu*, *Catla catla*, *Cirrhinus mrigala*, *Clarias batrachus*, *Pangasius pangasius*, *Puntius sarana*, etc. The total species of fishes currently domesticated in Bangladesh is more than 20 (DoE 2015).

Non-conventional animal species: A few animal species are brought under domestication in Bangladesh targeting the foreign markets only. Among those are crocodiles, tortoises, crabs, frogs, mud eels, and snakes are the main. All those species are farmed in different places of Bangladesh and exported.

Plants of homestead: The domestication of plants in Bangladesh is mainly done to fulfill the needs of food and fodder, biomass fuel, medicine, fruits and vegetables, lumber, building and house construction materials, etc. Bangladesh is the center of the origin of rice crop and the country inhabits one species of wild rice, namely *Porteresia coarctata*, growing in saline estuaries. The domesticated species of rice is *Oryza sativa* L. which is the most common staple food for the inhabitants of Bangladesh. Therefore, the domestication and cultivation of this species with hundreds of cultivars have been wide spread throughout the country. Rice, wheat, maize, millet, potato, sugarcane, etc. are extensively cultured in the vast agricultural fields of Bangladesh. Besides, most of the farmers' house does have fruit trees like mango, litchi, jackfruit and berries, and medicinal plants like *Adhatoda vasica*, *Ocimum sanctum*, *Terminalia arjuna* as well as many vines and lianas of medicinal interest. Tribal peoples of Bangladesh

do also practice herbals for the cure of their diseases. This demand is met from the plants grown in their homestead.

Lumber and fuel wood species: *Shorea robusta*, *Tectona grandis*, *Swietenia mahagoni*, *Albizia procera*, *Gmelina arborea* and *Sygygium cumini* are mainly planted in the domestic premises because of their values as wood. In the recent time some exotic trees have also attracted the farmers because of their fast growing properties. These are *Eucalyptus*, *Accacia moniliformis* and *Leucaena leucocephala*. Sometimes large-scale cultivation of these species for commercial purposes is also supported in this country.

Cultural biodiversity

Since past, relationship between men and biodiversity has developed ethical, cultural, and religious values among societies. The values of biodiversity are affected by the differences in culture among the people. To many societies' intrinsic need of using some selected species of biodiversity for their social and religious belief sometimes poses threat to the conservation of biodiversity (Jeffries 1997). Therefore, the plant and animal components of biodiversity which are associated with the cultural history and religious purposes could be categorized under this. Many species of plants, flowers and fruits are used by the worshippers for performing their prayer to the God or Goddess.

Sacrificial animals for ritual purposes: The second largest religious festival for Muslims of the world is Eid-ul-Azha, i.e. the feast of the sacrifice, during which the holy Hajj is performed in Mecca. In Bangladesh, during Eid-ul-Azha a significantly large number of cattles and other domestic animals are traded. In 2018, 11.56 millions of livestock resources were used. These include mainly cows, buffaloes, goats and sheep. This happens to be the biggest supply of leathers to the tanning industries and the total trading involved worth Tk. 160 billion.

Sacred plants: To Muslims there are few sacred plants. The most spectacular plant of this category is the Agarwood (*Aquilaria agallocha*). The plant is a tree and usually grows in the Sylhet district of Bangladesh. Small scale industrial set up is available in those areas to extract agar from the plant. The wood of the plant is infected by a fungus which produces scent materials. The materials after extraction are crushed and pasted onto a thin stick and dried to harden. When the sticks are ignited from the top it glows very slowly emitting a kind of smoke which smells elegant giving a religious gathering a good environment. These sticks are so called 'Agar Bati'. Sometimes alkaloids called 'Atar' are extracted from the plant. It is a kind of perfume which a Muslim uses when going to the mosque for prayer and/or attending mass religious congregation. Invariably dipping some individual leaves of a plum tree (*Ziziphus jujuba*) in the warm water which is made ready to give bath to a dead body of a Muslim is also practiced in many areas of Bangladesh. However, there are unknown valid reasons to this practice available. Hindu worshippers use lotus (*Nelumbo nucifera*) flower, green coconut (*Cocos nucifera*), grass (*Cynodon dactylon*), banana and banana tree (*Musa sapientum*) in their worship. Besides, two sacred trees are usually planted at the premises of temples by the Hindus. These are *Ficus religiosa* and *F. benghalensis*. The flower of *N. nucifera* is also holy to the Buddhists. Hassan (2016a) reported 40 species of plants as sacred to the Muslim, Hindu, Christian, and Buddhists of Bangladesh.

Medicines

On this earth, plant and people have a good tie owing to a number of reasons. Of these, demand for food, fodder, clothing, housing and finally medicine to get cured from ailments are the principal reasons. The concept of 'Herbals' is based mainly on the use of plants, plant-parts for the cure of diseases for the human. So, the use of plants as a disease curing agent to men is a century old system. Though, in the modern world various extracts from different plants form the base of modern pharmaceutical industries, still there are peoples who would simply use just a raw leaf extract to cure their diseases which they know from their families or from some herbals. Sometimes oils extracted from animals or eating different organs of animals and/or extracting ingredients from different animal organs are also used to cure diseases for mankind. Nearly 80% of the global rural population uses this kind of practice to meet their primary healthcare requirements. All these have formed the bases for biodiversity study of herbal origin and of animal origin.

Herbal origin: In Bangladesh the plants of medicinal origin were first highlighted by Khan and Huq (1975) who reported 182 species. Another survey carried out on the plants used by the native and tribal peoples of Sylhet district, Bangladesh confirmed the existence of 61 species in Jointiapur, Tamabil and Jaflong areas dominated by the Khasya tribe (Mia and Huq 1988). Later on, a comprehensive edition of the medicinal plants of Bangladesh was published by Ghani (2003) which included more than 440 plant species belonging to 124 botanical families and their uses for the cure of various ailments. The highest number of species of medicinal plants was represented by the family Papilionaceae (30) followed by Euphorbiaceae (22), Compositae (21), Labiatae (17), Rubiaceae and Cucurbitaceae (each 14), Verbenaceae and Solanaceae (each 13), Rutaceae, Gramineae and Caesalpinae (each 10). Recently some more publications on herbal medicines have become available in Bangladesh (Hassan 2016b, 2017a, 2017b, Chowdhury and Hassan 2017). Most of these publications covered the plants description, their habitats and plant parts used for the cure of specific diseases. Information provided there are quite useful for the common people of the country since those are composed in Bangla language. Considering the spread and severity of Diabetes mellitus, Hassan (2017b) listed 101 antidiabetic plants of Bangladesh. Description present therein indicates the paths of curing and controlling this disease through using herbals.

Herbal biodiversity- a resource for Bangladesh: In Bangladesh, from the wild nearly 500 species of plants have been recognized as possessing herbal values. Local Ayurvedic, Unani and pharmaceutical industries all collect raw materials from the wild. This process has been creating a severe threat to the biodiversity of herbal plants. So, the cultivation of herbal plant is essential to protect the wild flora of herbals in Bangladesh. Currently the cultivation of nearly 40 species of herbal plants is practiced in different districts of Bangladesh. To promote this as well as to show the herbal plants as a resource, Sarker and Shamsuddin (2018) published an excellent encyclopedia on medicinal plants. They have listed the medicinal plants required by many purposes. The number of species required by different group of users is, by local herbal medicinal products: 91, preparation of homeopathic medicine: 81, and for exportable medicinal plants: 61. For expediting commercial cultivation of medicinal plants in Bangladesh WHO has recommended 25 species. In Bangladesh so far 28 species of medicinal plants have been recognized as threatened and/or rare (Sarker and Shamsuddin 2018). Bangladesh has a demand of approx. 33340 MT of herbal plants and plant parts in the form of whole plant, barks,

rhizomes, leaves, etc. annually. Nearly 67 species have been supplying this product (Sarker and Shamsuddin 2018).

Diversity in the ecosystems

The driving forces for the ecosystems of Bangladesh are its adequate sunlight, rainfall, alluvium deposition, siltation and hot humid climate. Its soil as well as inland water system contains nutrients from the alluvium deposition and the territorial river flow mainly from India. Considering the physiographic and biogeographic conditions, the ecosystem diversity of Bangladesh could be classified as i. Forest ecosystems, ii. Agroecosystems, iii. Wetland ecosystems, and iv. Coastal and marine ecosystems.

i. Forest ecosystems

The distribution of principal forest ecosystems of Bangladesh covers nearly 17.5% of the total area of Bangladesh (Alam 2008) (Fig. 2). Depending upon the dominant species of plants together with the regional climate, soil and altitude the forest ecosystem could be subdivided into (a) Tropical wet evergreen and semi-evergreen, (b) Tropical moist deciduous, (c) Mangrove, (d) Freshwater swamp and (d) Homestead forests (DoE 2015). A brief description is followed.

(a) Tropical wet evergreen and semi-evergreen: This constitutes the forests of Chittagong Hill Tracts which is bounded in the north by the Tripura state of India and in the south the Akyab region of Myanmar and in the east by Lushai Hills of India. The principal plant diversity in the region is composed of large trees whose canopy height may range from 30-50 m. The dominant species are *Dipterocarpus turbinatus*, *Artocarpus chama*, *Swintonia floribunda*, *Protium serratum*, *Toona ciliata*, *Hopea odorata*, *Swintonia floribunda*, etc. Besides, shrubs, climbers, ferns and mosses are also there (Alam 2008, DoE 2015). The forests of Sylhet region are also hilly, but composed of trees characteristic to evergreen and deciduous type. The major evergreen plants of this area are: *Artocarpus chama*, *A. lacucha*, *Eleocarpus robustus*, *Holigarna caustica*, etc. Of the deciduous types *Bombax ceiba*, *Adina cordifolia*, *Hymenodictyon orixense*, *Spondias pinnata* and some species of *Ficus* do belong to this category (Alam 2008).

(b) Tropical moist deciduous: The so called Sal forests of Bangladesh belong to the districts under Mymensingh Division extending along the foot hill regions of Garo Hills where the patches of semi evergreen type of forests could be seen (Alam 2008). These kinds of forests are also seen in Lalmai Pahar in Cumilla district and in the Northern part of Bangladesh, namely the district of Dinajpur. The dominant tree species of this region is *Shorea robusta* commonly called Sal tree. Among the other trees *Adina cordifolia*, *Albizia procera*, *Bombax ceiba*, *Butea monosperma*, *Lagerstroemia parviflora*, *Dillenia pentagyna* etc. are the main (Alam 2008).

(c) Mangrove: The Sundarbans is the largest mangrove of Bangladesh situated in the greater Khulna district. Some small-scale mangrove vegetation is also present in the district of Chittagong (Chokoria Sundarban) and Patuakhali (Fattrar Bon). The Sundarbans is the largest continuous mangrove forest comprising 10000 km² in total of which 62% belong to Bangladesh and 48% belong to the 24-Pargana district, West Bengal, India. The forest is not more than 7000 years old. Siddiqi (2001) listed 65 species

of trees, shrubs and herbs from the Bangladesh part of the Sundarbans. Of these, *Avicenia officinalis*, *Bruguiera sexangula*, *Ceriops decandra*, *Cynometra ramiflora*, *Excoecaria agallocha*, *Heritiera fomes*, *Lumnitzera racemosa*, *Nypa fruticans*, *Phoenix paludosa*, *Sonneratia apetala*, *Xylocarpus granatum* and *Xylocarpus mekongensis* have been considered as commercially important species from the forest (Siddiqi 2001). The Sundarbans also supports a very rich faunal composition including mammals (50 spp.), birds (300 spp.), reptiles (50 spp.), fishes (177 spp.), 24 species of shrimps, 7 species of crabs, and 3 species of turtles (Siddiqi 2001). The famous Royal Bengal tiger *Panthera tigris* is well known from the Sundarbans of Bangladesh. From the other animals, spotted deer (*Axis axis*), wild boar (*Sus scrofa*), Rhesus Macaque (*Macaca mulatta*) and otter (*Lutra perspicillata*) are main. Their population size may vary from 40-80 k (Siddiqi 2001). The Sundarbans is also well known for the ideal habitat of the estuarine crocodile *Crocodylus porosus*. Besides, a good number of cobra, the king cobra, green pit viper, rock python and sea snakes do occur also in the estuaries of the Sundarbans (Rashid *et al.* 1994).



Fig. 1. Geographical location of Bangladesh (Source: <https://www.infoplease.com/atlas/asia/bangladesh-map>).

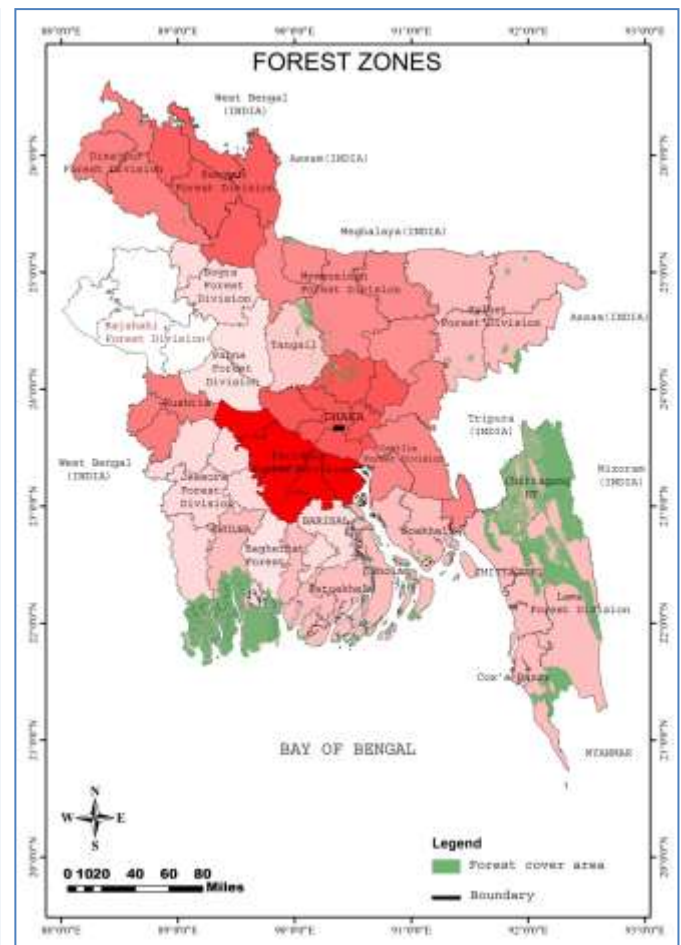


Fig. 2. Showing the distribution of principal forest ecosystems of Bangladesh (Source: Bangladesh Forest Department, 1990).

(d) Freshwater swamp forests: These forests are characterized by occasional inundation because of overflowing from the nearby river or from the nearby hillocks during monsoon. Characteristic tree

species which can withstand freshwater logging are adapted there. In Bangladesh two well-known swamp forests are (i) Ratargul and (ii) Tanguar Haor. (i) Ratargul swamp forest- Ratargul swamp forest is situated in the Surma-Kushiyara floodplain of the greater Sylhet district. The forest remains dry in winter, but becomes inundated to a water depth of 2.44 m during monsoon. A total of 73 plants and 230 animals were recorded from it. The dominant flora of Ratargul consists of *Barringtonia acutangula*, *Pongamia pinnata*, *Crateva religiosa*, *Salix tetrasperma*, *Phyllanthus reticulatus*, etc. One species of wild rose (*Rosa clinophylla*) and a kind of wild rice (*Oryza rufipogon*) are also present there. Among animals nine amphibians, 4 snakes, 175 species of birds and 26 species of mammals have been recorded from the forest (DoE 2015). (ii) Tanguar Haor- It is a special kind of water body which is very similar to large shallow lakes. During dry season water remains only in the scattered shallow tectonic basins, but during rainy season water accumulates and all those basins merge together giving a very large shape of the Haor. The Haor is a Ramsar site and currently under conservation state. The Tanguar Haor is a good spot for migratory birds and nearly 60000 bird populations belonging to 60 species visit the haor annually. The fish fauna comprised of 140 species. Among trees *Barringtonia acutangula*, *Pongamia pinnata*, *Crateva religiosa* are most common. Besides, aquatic angiosperms like *Nymphaea nouchali*, *Trapa maximowickzii*, *Ceratophyllum demersum*, etc. are also present in this waterbody. The wild rose species *Rosa clinophylla* also grow here (Fig. 3).



Fig. 3. Tanguar Haor (swamp forests ecosystem) showing the stands of *Barringtonia acutangula*, *Pongamia pinnata* and *Crateva religiosa* (Source: MAH Bhuiyan and M Khondker).

(e) **Homestead forests:** This kind of forest prevails in Bangladesh centering the house of the villagers and farmers. Species composition fully depends upon the needs of the inhabitants. Typically, it may contain a small pond for aquaculture, shed for pet animals, small vegetable garden, planted trees for fruits, lumber and fuel wood and a jungle containing shrubs and vines for herbal use. The number of vegetable species cultured in the village groves may vary from 20-70 in different areas of Bangladesh.

ii. Agroecosystem

Agriculture is the main domain to the inhabitants of Bangladesh and previously the farming practice was mainly dependent on the seasonal cycles of rainfall, drying and wintering of the fields. But in recent times, creation of mass irrigation facility has enabled farmers to go for high yielding varieties of crops having short production duration. At present more than 300 crop plants are cultivated throughout the 88 agroecological zones of Bangladesh. The main staple crops are rice, wheat and maize. Among others,

jute, sugarcane, tobacco, potato, sweet potato, tomato and various other kinds of vegetables and spices are grown. There are two main cropping seasons namely monsoon (Kharif) and winter (Rabi) in Bangladesh. A special kind cultivation called 'Jhum cultivation' is practiced by the ethnic peoples of the hilly area in Bangladesh. In those areas nearly 1000 species of medicinal herbs together with different varieties of rice, cotton, banana, gourd, jackfruit, pineapple, etc. are cultured. Peoples inhabiting the low lying areas, namely haor basins and floodplains do practice hydroponic system for growing their essential crops.

Aquatic

Bangladesh is blessed with river ecosystems and nearly 50% of the total territories belong to wetland. The country has 310 rivers having a total length of 16,889 km and a total catchment of 181635 km² (DoE 2015). The other aquatic ecosystems belong to 3 small natural lakes, more than 3.4 million ponds and 6300 ox-bow lakes and 47 major *Haors*. Including the seasonal floodplain the total aquatic surface area in Bangladesh becomes 36,663 km². A good diversity of plankton and aquatic macrophytes is present in those aquatic ecosystems leading to a substantial amount of freshwater fish production (Bhuiyan *et al.* 2019a, b, 2021). The diversity of some rare fresh water phytoplankton from Bangladesh (with one new species) is *Microcrocis granulata*; *Paulinella chromatophora*; *Aphanothece clathrata*; *Strombomonas acuminata* var. *deflandreana*; *Pandorina cylindricum*; *Achnanthes lacunarum*; *Chlorogonium metamorphum*; *Lepocinclis spahgnophila*; *Strombomona islamii*, *Raphidiopsis mediterranea* and *Colacium ovale* (Khondker *et al.* 2009). A few mammals and a good number of bird and reptile species do inhabit those ecosystems.

Table 3. An account of aquatic flora of Bangladesh.

Group	Species number	Group	Species number
Freshwater phytoplankton (Total)	1136	Marine phytoplankton (Total)	126
Bluegreens	112	Diatoms	91
Greens	841	Dinoflagellates	35
Chrysophytes	183	Seaweeds (algae)	133
Freshwater aquatic bryophytes	2	Freshwater aquatic ferns	7
Freshwater aquatic angiosperms	~100	Seagrasses	2

(Source: EFFB 2007-2008)

Aquatic invasive species

Bangladesh is well known about the invasion of water hyacinth (*Eichhornia crassipes*) during the British India from Brazil. It is known that this species was brought to the undivided territory of Bengal during the rule of British Emperor from Brazil because of its beautiful pinkish flower. The plant is so much well adapted in the aquatic habitats of Bangladesh that it has now become a serious pest causing economic loss to the aquaculture, navigation, carrier of diseases, rice fields, *etc.* The eradication of *E. crassipes* from different habitats of Bangladesh is usually done via manual processes. The harvested biomass could sometimes be used in mulching and production of organic fertilizer by mixing with cow dung.

Recently, a few more species have also been reported from different aquatic habitats of Bangladesh (Fig. 4). These are aquatic angiosperm (*Egeria densa*, collected from Lake Bogakine of Bandarban district) and fern (*Salvinia molesta*, collected from a small pond of National Botanic Garden, Mirpur,

Dhaka) a pest in Lake Kariba, Africa have been identified and reported to occur in Bangladesh (Alfasane *et al.* 2010, Hadiuzzaman and Khondker 2005). One chaetophoralean alga (collected from a *Beel* ecosystem of Manikganj district) endemic to Lake Baikal of Russia has been reported from Bangladesh (Khan and Islam 1996). It is assumed that the alga (*Ireksokonia formosa*) might have been transported from Siberia to Bangladesh via migratory birds since the ox-bow lake from where the alga was collected and identified is visited by migratory bird population every year.



Fig. 4. Some invasive aquatic species of Bangladesh. Left: A-F. different stages of *Egeria densa*; middle: *Ireksokonia formosa*; right: *Salvinia molesta* (Alfasane *et al.* 2010, Hadiuzzaman and Khondker 2005, Khan and Islam 1996).

Some researches on butterflies in Bangladesh

Recently, a research team of Environmental Biology and Biodiversity Laboratory (EBBL), Department of Zoology, University of Dhaka has made an important study under the ‘Biodiversity and Biodiversity Conservation’ (BBC) grand programme. Under the programme, a vital research was conducted on the ‘Biodiversity of Butterflies’. As a part of the grand programme, monitoring and data recording were carried out on the ‘distribution and activities’ of butterflies throughout different forest ecosystems of Bangladesh. The whole study on the butterflies was carried out under the guidance of an expert, Professor Dr. M. A. Bashar (Co-author of this paper) in more than 35 forests of Bangladesh (Fig. 5).

The study demonstrates butterfly distribution patterns and shows numerical database with illustrations of the butterflies. The research team has identified taxonomically more than 300 species from Bangladesh (Bashar 2014, 2015). But it is reported that, in Bangladesh the species of butterflies may exceed 600, if a rigorous scientific investigation would have been given. An updated world information reveals that the total family of butterflies would be 17. In Bangladesh, so far 10 families have been reported, out of which 7 are reported as ‘major’ and 3 as ‘minor’ (Fig. 6).

The major families with key characters: **Hesperiidae**- small and stout bodied; front legs are much reduced; colour usually brownish or gray with white, yellowish or silvery spot and oblique band. **Papilionidae**- medium to large size; hind wing often with tail-like prolongation; dark, white or gray coloured. **Nymphalidae**- small, medium and large size; front legs are much reduced; brightly coloured. **Pieridae**- small to medium size; front legs are well developed; usually white or yellowish with black marginal markings. **Danaidae**- generally medium to large size; front legs are much reduced; brightly

coloured. **Lycaenidae**- small or medium size; males are usually smaller than the females; purple, green, orange, brown or even white coloured and **Satyridae**- small or medium size; front legs are much reduced; usually grayish or brown and generally have eyelike spots.

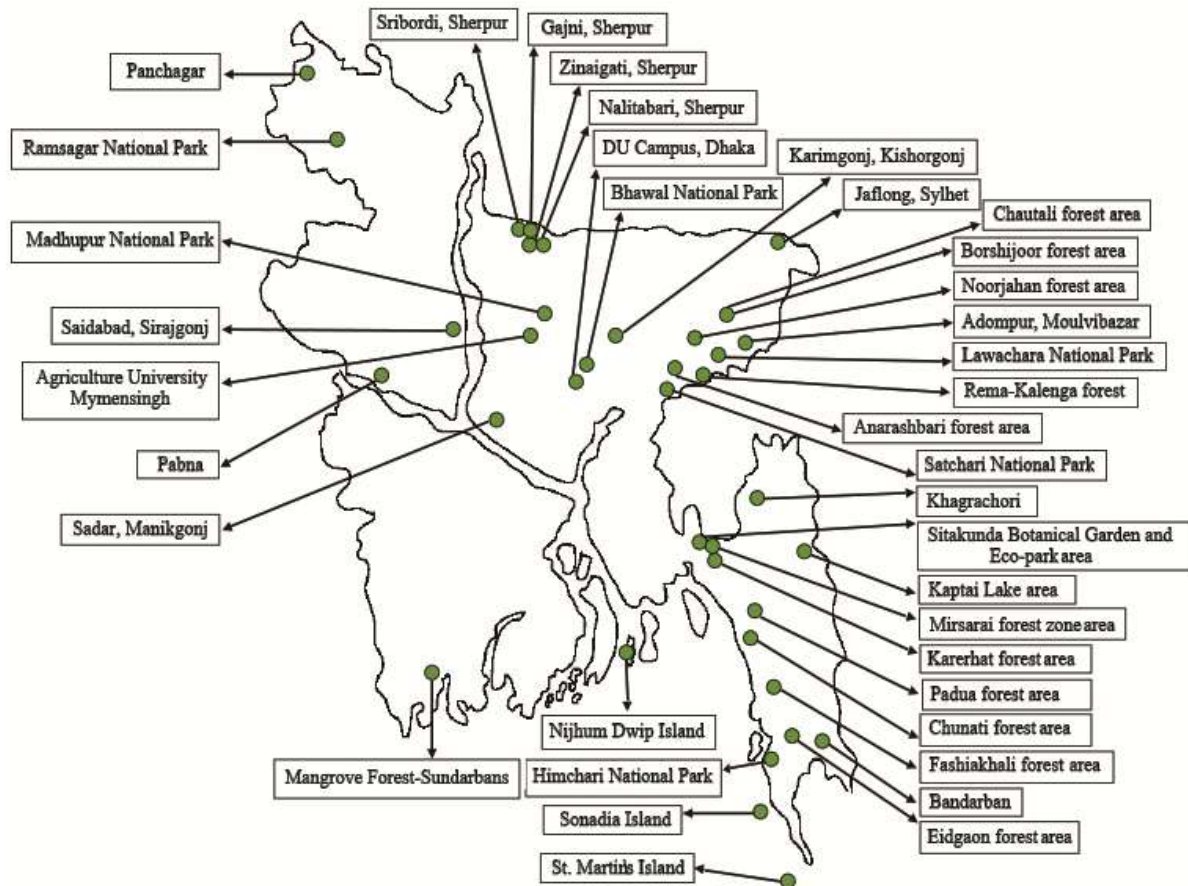








Fig. 5 . Forests where butterfly collections are made and butterfly behaviours are recorded (after Bashar 2015).

The minor families with key characters: **Amathusiidae**- medium to large in size with compact body; front legs are undeveloped in male; both wings are broad and tinted with brilliant colours. The markings of eye-like ocelli are large and frequently present on the wings underside. **Acraeidae**- adults with having a leathery body; cells of both wings are closed by tubular veins; the butterflies are poisonous in all stages and **Riodinidae**- forelegs in male are incomplete, but in female these are fully developed; antennae are longer than half of the forewing costa; adult prefers semi-shaded areas and remains not far from water body in the forest.

Butterfly species distribution in 24 forests among the 35, studied in Bangladesh, are presented herewith their respective species number (Bashar 2014, 2015). These are: Bhawal National Park (about 300 spp.); Madhupur National Park (more than 300 spp.); Lawachara National Park (more than 300 spp.); Satchari National Park (more than 300 spp.); Rema-Kalenga (more than 200 spp.); Anarashbari (more than 90); Noorjahan (about 140 spp.); Phoolbari (more than 200 spp.); Chautalii (about 150 spp.); Borshijoor (less than 100); Gajni (does not exceed 100 spp.); Karerhat (does not exceed 90 spp.); Mirsarai (more than 250 spp.); Fashiakhali (about 200 spp.); Chunati (does not exceed 200 spp.); Eidgaon (about 200 spp.); Kaptai Lake (more than 200 spp.); Himchari National Park (less than 150

spp.); Nijhumdweep (does not exceed 100 spp.); St. Martin's island (may not exceed 20 spp.); Sitakunda Botanical Garden and Eco-park (about 200 spp.); Sundarbans (does not exceed 200 spp.); Ramsagar National Park (does not exceed 100 spp.); and Sonadia Island (below 100 spp.) (Bashar 2014, 2015).

MAJOR FAMILIES WITH SOME MORPHOLOGICAL CHARACTERS IN BANGLADESH

Hesperiidae		<ul style="list-style-type: none"> # Small and stout bodied # Front legs much reduced # Colour usually brownish or gray with white, yellowish or silvery spot and oblique band
Papilionidae		<ul style="list-style-type: none"> # Medium to large size # Hind wing often with tail-like prolongation # Dark, white or gray coloured
Nymphalidae		<ul style="list-style-type: none"> # Small, medium and large size # Front legs much reduced # Brightly coloured
Pieridae		<ul style="list-style-type: none"> # Small to medium size # Front legs well developed # Usually white or yellowish with black marginal markings
Danaidae		<ul style="list-style-type: none"> # Generally medium to large size # Front legs much reduced # Brightly coloured
Lycaenidae		<ul style="list-style-type: none"> # Small or medium size # Males usually smaller than the females # Purple, green, orange, brown or even white coloured
Satyridae		<ul style="list-style-type: none"> # Small or medium size # Front legs much reduced # Usually grayish or brown and generally have eye-like spots

MINOR FAMILIES WITH SOME MORPHOLOGICAL CHARACTERS IN BANGLADESH




Amathusiidae		<ul style="list-style-type: none"> # Medium to large in size with compact body # Front legs undeveloped in male # Both wings broad and tinted with brilliant colours. The markings of eye-like ocelli large and frequently present on the underside of wings.
Acraeidae		<ul style="list-style-type: none"> # Adults with a leathery body. # Cells of both wings closed by tubular veins # Poisonous in all life stages.
Riodinidae		<ul style="list-style-type: none"> # Forelegs in male incomplete, but in female fully developed # Antennae longer than half of the forewing costa # Adult prefers semi-shaded areas and remains not far from water body in the forest

Fig. 6. Some recorded butterfly species belonging to the 'major' and 'minor' families.

Accordingly, a 'Butterfly Red list' has also been prepared highlighting their 'vulnerable status' from Bangladesh. The BBC research team has prepared an expert (Professor Dr. M. A. Bashar) opinion based on 'Red list' by following a local method for the assessment of biodiversity of butterflies. In the study, a total of 202 species was taken under consideration and six categories were suggested to explain the 'vulnerability stages'. The categories are as follows: Available (Av); Rare (Rr); Near Threatened (Nt); Threatened (Th); Critically Threatened (Ct); and Endangered (En) (Bashar 2015). Based on this, out of the total species, six were declared 'Endangered'. Among the examined butterflies 12, 13, 9, 64, and 98 species were assigned to the status of Critically Threatened, Threatened, Near Threatened, Rare, and Available, respectively (Bashar and Khan 2022).

Furthermore, an open Butterfly Colonization Centre (BCC) as Butterfly Park in Bhawal National Park, Gazipur, Dhaka was established. The BCC was created through increasing species richness of various plants which are deeply and occasionally associated with four different life stages of the butterflies. The butterfly colonization process increased the plant-species, as well as animal species assemblages. The results of the butterfly colonization supported not only the sustainability of butterfly population, but also enhanced the environmental soundness of the forest ecosystem significantly. It is found that after establishing the butterfly colonization in the open butterfly park, increase of wildlife species population occurred significantly. In a four-year duration monitoring, the wildlife population of some groups of animals remarkably increased (Fig. 7). The open Butterfly Park in Bhawal National Park has revealed interesting research results related to the balancing of the ecosystem biodiversity (Bashar 2015, 2018).

Wildlife conservation and the butterfly colonization

Plantation has been started in the BCC since the year 2004, and later in 2007, the plant colonization was started by butterflies after accommodating the plants related to butterflies. The gradual assemblage of the wild vertebrates in the BCC has been recorded regularly from the year 2007. However, the wildlife vertebrate population dynamics from 2011-2014 has been presented in Fig. 7. From Fig. 7, it is evident that the wild vertebrate population increased regularly from 2007 and it was divided into four groups, e.g. amphibians, reptiles, birds, and mammals. The vertebrate species record maintained in the BCC during the study period are listed below.

Amphibians: Available amphibians in the BCC are *Hoplobatrachus tigerinus*, *Duttaphrynus melanostictus*, *Kaloula pulchra*, *Ichthyophis glutinosus*, *Fejervarya limnocharis*, *Microhyla berdmorei*, *Microhyla rubra*, *Sylvirana leptoglossa*, and *Polypedates maculatus*. In 2011, the size of population was 47 ± 5 and it stood 158 ± 12 in 2014.

Reptiles: Reptiles habited in the BCC are *Varanus bengalensis*, *Ptyas mucosa*, *Xenochrophis piscator*, *Calotes versicolor*, *Gekko gecko*, *Typhlops diardii*, *Scincella reevesii*, *Calotes versicolor*, *Mabuya carinata*, *Naja naja*, *Lycodon aulicus*, and *Dendrelaphis tristis*. The size of reptilian population was 122 ± 9 in 2011 and it increased up to 277 ± 13 in 2014.

Birds: The available birds in the BCC are *Eudynamis scolopaceus*, *Hierococcyx varius*, *Centropus sinensis*, *Streptopus chinensis*, *Corvus macrorhyncho*, *Dicrurus macrocercus*, *Copsychus saularis*, *Acridotheres tristis*, *Sturnus malabaricus*, *Sturnus contra*, *Orthotomus sutorius*, *Turdoides straitus*,

Pycnonotus cafer, *Passer domesticus*, *Halcyon smyrnensis*, *Merops orientalis*, *Athene brama*, *Psittacula krameri*, *Cuculus micropterus*, *Cebtrapus bengalensis*, *Copsychus malabaricus*, and *Milvus migrans*. In 2011, the size of population was 970 ± 21 and it stood 2333 ± 21 in 2014.

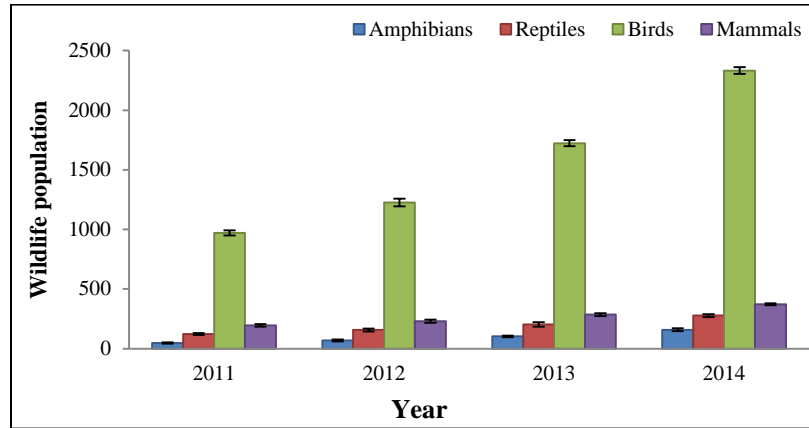


Fig. 7. Concomitant increase of wild vertebrates with the progressive success of the butterfly colonizing mechanism in the butterfly colonization centre (4-year duration of study: 2011- 2014) (After: Bashar *et al.* 2015).

Mammals: The mammals found in the BCC are *Suncus murinus*, *Pteropus giganteus*, *Macaca mulatta*, *Herpestes edwardsii*, *Manis crassicaudata*, *Bandicota bengalensis*, *Callosciurus pygerythrus*, *Vandeleuria oleracea*, *Felis viverrinus*, *Herpestes auropunctatus* and *Canis aureus*. The mammalian population was 194 ± 11 in 2011 and it increased upto 372 ± 9 in 2014.

The results reveal that the concomitant increase of wild vertebrates with the progressive success of the butterfly colonizing mechanism occurred in the BCC from 2011-2014. It is, therefore, evident that the insect interaction with plants (especially the phytophagous pollinating insects and the flowering plants with entomophilous pollens) establishes a strong gene-flow mechanism in the forest ecosystem. Then the ecosystem becomes healthy and gives more functional services. Consequently, the ecosystem becomes suitable and converted to a compact home for the successive trophic levels which provide fruitful services to all the wild animals living in the forest ecosystem. The fact remains that the forest can serve as a home of *in-situ* conservation site for wildlife fauna (Bashar *et al.* 2015, Bashar 2018).

Expert (Professor Dr. M. A. Bashar) remark has therefore been made that only the greenness of an ecosystem (even of a forest ecosystem) does not show the species richness of butterflies. But, the 'plant-species' richness maintains the species richness of butterflies in an ecosystem (Bashar and Khan 2015). It is also found that not only random plant species richness shows the result as said before, but the butterfly host species (plants) richness shows the butterfly species richness in an ecosystem principally. The random species richness acts as an additional factor for maintaining species-richness in an area as a whole. Because of the fact that the species richness of the non-host plants of butterflies act as shelter, nectar, mating, and egg-laying plants and sometimes sources of various other behavioural supporting - plants (Bashar 2016).

Genetic diversity

Genome interacting with the ecological processes over time produces the genetic diversity among population (Jeffries 1997). Genetic diversity could be very large even within a single species. Among

the species of flora and fauna, i.e. the so called taxonomic diversity, the occurrence of genetic diversity may be very high. Bangladesh happens to be one of the centers of the origin of rice plant (*Oryza sativa* L.) and because of her unique climatic conditions such as day length, humidity, rainfall, soil condition, prolonged desiccation, etc. a high genetic segregation of rice biodiversity has come into existence (DoE 2015). In Bangladesh Rice Research Institute (BRRI), the total number of the accession of rice germplasm is 8044 (DoE 2015). Of this, 4600 germplasms are native and others might have come from different other sources. Each of these germplasms has unique characteristics in terms of production, taste, grain size and many more of commercial importance. Some are tolerant to different ecological and environmental conditions, e.g. cold, drought, flooding, disease resistant and salinity. Not only rice, but also in case of tuber crops, cereals, pulses, oilseeds, fruits and vegetables one finds enormous genetic diversity. The total number of accessions for all those mentioned above goes upto 9,975 (DoE 2015). At least four indigenous and three cross breed genotypes of cow are present in Bangladesh. Among others four genotypes in each of duck and pigeon, three from chicken, two from each of sheep, horse and dog and one genotype from each of buffalo, goat (Black Bengal), pig and goose are available (DoE 2015).

Endemic plants

When the occurrence of a particular species is restricted naturally to some geographical areas due to its response to some specific ecological factors it is termed endemic. The dispersal of endemic species to other geographical regions may not be successful because of their infertility to a newer habitat or the means of dispersal is blocked by harsh environmental conditions. In Bangladesh, so far 34 species of angiosperms have been recorded as endemic (Pers. comm. Professor Dr. M Oliur Rahman, Department of Botany, University of Dhaka). Of these, nearly 15 have been described as new by the local taxonomists and 11 species have already gone extinct. Some of the endemic species of Bangladesh are *Cyperus pilosus* Vahl var. *polyantha* C. B. Clarke, *Dalbergia confertiflora* Benth. var. *listeri* Thoth., *Flemingia fluminalis* C. B. Clarke ex Prain, *Hedyotis thomsonii* Hook. f., *Iodes thomsoniana* Baill., *Knema bengalensis* W. J. de Wilde, *Lagenandra gomezii* (Schott) Bogner and N. Jacob., *Limnophila cana* Griff. and *Rotala simplisiuscula* (Kurz) Koehne.

Endangered plants and animals

In Bangladesh, growing population pressure, urbanization, industrialization, over exploitation, deforestation, new agricultural land accretion, strong pollution, and climate change might have caused eradication of a number of plant and animal species from their natural habitats. So far 486 species (12.75% of the total) of plants are threatened. From this, 36 species belonged to pteridophytes (fern and fern allies), one species to gymnosperms (naked seeded plant) and 449 to angiosperms (DoE 2015). Among the angiosperms *Anisoptera scaphula*, *Swintonia floribunda*, *Corypha taliera*, etc. are main. The lone threatened gymnosperm is *Podocarpus neriifolius*.

Recently IUCN (2015) prepared the Red List of Threatened animals of Bangladesh. So far 13 large mammal wildlife species have been facing critical threats from the inhabitants. Among those *Panthera tigris* (the Royal Bengal Tiger of Sundarbans), Eurasian otter (*Lutra lutra*), Burmese python (*Python bivittatus*) and Elongated tortoise (*Indotestudo elongata*) happen to be the most threatened animal species of Bangladesh. From riverine fish population nearly 25 species have so far been recorded as

extinct (DoE 2015). Among the other threatened animals Asian elephant (*Elephus maximus*), Primates (*Rhesus macaques*) and Gangetic dolphin (*Platanista gangetica*) have also been considered to remain under risks.

Conservation and monitoring

This is an important task that every nation must undertake to safeguard its biodiversity. So far, the *ex situ* and *in situ* conservation strategies are recommended for the conservation of biodiversity. By declaring fragile ecosystems as a conservation zone the *in situ* protection of organisms could be ensured. On the other hand, establishing botanical gardens, zoos, gene bank, seed bank, etc. the *ex situ* conservation could be carried out. Besides, concepts related to the establish of national parks, wildlife sanctuaries, ecotourism, safari park, game reserves and reserve forests are also found successfully to protect the species of biodiversity. In Bangladesh, so far 21 protected areas have been declared for biodiversity conservation. These include 7 National Parks, 12 Wildlife sanctuaries, 1 Marine and 1 Special Biodiversity conservation area. The total area covered under this program is 339.15 km² (DoE 2015). To protect the marine biodiversity, particularly fishes, the ‘Swatch of No Ground’ and the ‘Middle Ground and South Patches’ of the Bay of Bengal have been declared as protected marine areas by the Government of the People’s Republic of Bangladesh (DoE 2015). The total number of protected areas from inland terrestrial and freshwater ecosystems is 40. Besides, the Government of Bangladesh via the Department of Environment has declared 13 Ecologically Critical Areas (ECA) covering 2845.29 km² in different areas of Bangladesh (DoE 2015). In some of those conserved ecosystems, a significant improvement in the ‘health’ of the biodiversity has been observed. For example in Tanguar Haor within the span of a decade conservation results a 23% increase of the total plant species in the ecosystem (DoE 2015).

Bangladesh, a densely populated (1084 ind./km²) South Asiatic Nation contains 10,606-14,913 species of microbes, plants and animals in her Biodiversity. Most recent compilation on the Biodiversity of Bangladesh could be obtained from DoE (2015), IUCN (2015) and EFFB (2007-2008). The ecosystems of Bangladesh are fragile, because more than 160 million people of the country are dependent on the constant supply of living components from different ecosystems to run their daily life. Besides, the growing urbanization, industrialization and agriculture are creating the burden of pollution on the structure and function of the ecosystems. So far, 486 species of plants, 13 species of large mammals and 25 species of riverine fishes have been recognized as threatened. Scientists from the Universities, Non-governmental organizations (NGO’s) and from the relevant governmental agencies are quite aware about the sustainable use of the biodiversity and their conservation. The government of Bangladesh has been strengthening and advancing the program of National Biodiversity Safety and Action Plan (NBSAP) via the Department of Environment, the Government of the People’s Republic of Bangladesh (DoE 2015). By declaring several ecosystems as reserves, sanctuaries, eco-parks, etc., the Government of Bangladesh has been taking initiative to safeguard the biodiversity. Scientists have been carrying out explorative works to find the autecological conditions of the species in the wild. Some researchers are also going on to find the effect of climate change on the overall biodiversity. But the most recent and severe problem are to put a control on the release of pollutants in the nature by the ever increasing industries and the illegal occupation of wetlands, forests, hills and other natural grounds.

Environmental law makers are suggesting the government and their relevant agencies to materialize their proposals.

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