VISION ON BIODIVERSITY: INDIGENOUS TECHNIQUES OF BIODIVERSITY ASSESSMENT OF BUTTERFLIES IN SOME FORESTS OF BANGLADESH

Bashar, M. A. and H. R. Khan

EBBL, Department of Zoology, University of Dhaka, Dhaka-1000, Bangladesh

Abstract

In the present study few indigenous techniques of the biodiversity assessment of butterflies were practiced in some forest ecosystems of Bangladesh. Butterfly-plant interaction in a forest ecosystem is a dynamic key factor that determines the status of a forest. A research team of the Environmental Biology and Biodiversity Laboratory (EBBL) of the department of Zoology, Dhaka University worked successfully on a population census of butterflies in some forests by using their newly innovated method the "Biotic-epicntre technical model". This method deals with two important points for practicing it in the field condition. These are ethological aspects of the butterflies and application of epicentre-spot-design. In total 202 butterfly species (belonging to seven different families) were studied in the forests experimental stations of Bangladesh. The families are Hesperiidae, Papilionidae, Nymphalidae, Pieridae, Danaidae, Lycaenidae and Satyridae. The 'vulnerability status' comprises'Available (Av)', 'Rare (Rr)', 'Near Threatened (Nt)', 'Threatened (Tr)', 'Critically Threatened (Ct)' and 'Endangered (En)'. The study revealed that the highest number of host-plant families (25 families) was used by lycaenids (45 species). The family Satyridae had the lowest number host-plant families (only 2). The second highest number of host-plant families (24 families) was associated with the family Nymphalidae (34 butterfly species). 38 butterfly species of Hesperiidae were associated with only nine families of the host-plants. The family Papilionidae (19 species) was related to only five host plant families. The butterflies (23 species) of the family Pieridae were found to depend on ten host-plant families. The members of the family Danaidae (12 species) were found on four host-plant families. More than 35 forest-areas of Bangladesh were included in the present investigation. Out of the total studied species (202), six species were found and declared 'Endangered'. Among the examined butterflies, 12, 13, 9, 64 and 98 species hold the status of Critically Threatened, Threatened, Near Threatened, Rare and Available respectively. The population census of the butterflies was carried out in three major forest areas of Bangladesh. The biodiversity assessment methods practiced in the various experimental fields have been illustrated with their respective different figures.

Key words: Biodiversity assessment techniques; Latin squares design; Vulnerability status; Egg-laying plants.

INTRODUCTION

Deforestation remains one of the major environmental issues in South Asia, and the flora and fauna of the region are more threatened now and then even before (UNEP 1997). The countries experiencing the fastest deforestation are: Bangladesh, Pakistan, the Philippines and Thailand (FAO 1995). The rapid deterioration of forest stocks in Bangladesh during the last century caused mainly for shifting agriculture to the forest vegetation. This happened as a result of high population growth. The stocks are also destroyed by the over-exploitation of local pharmaceutical industries (e.g. Ayurbeds and Kabirajs).

The present work is the part of nature conservation where the role of interrelationship between two biotic factors (plants and animals) has been envisaged as the main focus (Bashar 2016). In the present investigation, the author(s) examined some points first on 'where the Plant-Animal association gets to develop'. In connection to get development of such association, we could turn our attention to the explanation of the term "What is Butterfly Park"? Butterfly Park combines the term park in general facts and in scientific facts. Butterfly Park includes plant-animal association. Butterfly Park is rather the most scientific approach and tool for the question of nature conservation. This park does not only give

pleasure to the humans, but also creates some natural tools to maintain the species richness in an ecosystem. Aim of a true butterfly park is to create site for accumulation of new species both of the plant kingdom and in the diversity of butterflies as a whole (Bashar 2012a, Bashar *et al.* 2015a, b).

As butterflies are specific on their host plant selection, they are habituated to be confined to certain forest ecosystems; and are specialized for their characteristic life style. Butterflies are of various shapes and sizes, and they are almost restless in the morning half of the day (Jermi 1988, Akand *et al.* 2016, Akand *et al.* 2017). Generally, in the mid-day they remain in "resting" under shade trees; and that is why they need special type of shade plants (Kamrunnahar *et al.* 2018). They forage on some selective plant-flowers. The flowers are visited by butterflies in the morning and evening. The plant-flowers visited by butterflies are with entomophilous pollen; and pollination is carried out by butterflies (Sultana *et al.* 2017). The larval stages of butterflies have to depend on specific plants as food sources. They are phytophagous and have to depend on respective specific plant. These plants are called host plants. Butterflies have different life-stages; similarly the host plants have different life stages. In insect, life-stages are known as the phases of life cycle; and stages in plants are called phenological stages (Bashar 2012b, Bashar 2018).

There is a synchronization of coincidences between the life stages of butterflies and the phenological stages of their host plants (Alam *et al.* 2017, Rahman 2018). Both plants and animals are wild organisms. Some butterflies are found only in some selected forests as their host plants including other related (nectar and shelter) plants are found there only. Most of the plants are seriously endangered in the forests currently. The coincidence of synchronization between two biotic factors in 'dynamic situation' is the key factor of keeping a forest healthy and makes it sustainable (Bashar 2010). Very recently the EBBL (Environmental Biology and Biodiversity Laboratory), Dhaka University has identified that butterflies need strong species assemblage of wild plants in a forest ecosystem as their host plants, nectar plants and shelter plants. These three different types of plant species are required for their survival in nature. On the other hand, butterflies play a great role in pollination and also in gene-flow activities in plant population. The gene-flow activities are vital for healthy plant population in the forest ecosystem. In this way when plant populations are ensured in a forest ecosystem, the successive trophic levels meaning the availability of different kinds of consumer animals are also ensured. Consequently, the flora and fauna of the forest ecosystem are ensured to have their well-established and stable habitats (Bashar 2014, 2015).

MATERIAL AND METHODS

The present research project deals with butterfly census and butterfly behavioural strategies for evaluating the essential points of biodiversity conservation as a whole. Almost all butterflies require their respective host plant (species) to maintain their life style and larval development. Plant species richness contributes not only to butterfly species richness, but also to the richness of other animals in the same ecosystem (Akand *et al.* 2015b). This biotic mechanism (plant-butterfly interaction) establishes a spectacular situation in a forest ecosystem. Butterfly colonization and "biotic indicators" assessment in the forest ecosystems need to conduct some experiments and their applications (Aich *et al*. 2016). This is necessary for piloting a developed monitoring system for biodiversity conservation in the forest

ecosystem (Bashar and Khan 2015). To reach these objectives, five indigenous methods were adopted to study butterfly census in some selected experimental stations (forest areas). The methods were:

1. Random-plain count-method; 2. **Biotic-epicentre model**; 3. **EBBL model for the assessment of biodiversity status**; 4. **Practice of Latin squares design (LSD) sampling**; and 5. **Practice of Butterfly-Plant assessment indigenous model**.

All the above five methods were used in the grand programme of biodiversity study in the forests of Bangladesh as a whole. In addition, the present part of the research work was dealt with the procedures followed mainly by the method no. 3, 4 and 5.

Method no. 3 - EBBL model for assessment of biodiversity status

The Environmental Biology and Biodiversity Laboratory (EBBL), Dhaka University had started research work on butterflies since 1998 as a team work. During the course of the working tenure, the research team (of the EBBL) delivered endless efforts and immense contributions to study the status of butterflies in the selected forest ecosystems of Bangladesh. Focusing on the study, the team constructed a framework to assess the status of butterflies in Bangladesh designated as "EBBL Model". This was based on the results obtained from their field data. Additionally, the research team of the laboratory prepared a model by using 'indigenous' procedure. The indigenous procedure model-exercise has been processed in the present investigation (Table 1).

Table 1. The EBBL-modulated formula for the category determination of 'vulnerability status'.

Conservation Status	Number of forest station(s)	Number of butterfly(s) per station
Available	>5	>5
Rare	≤5	≥5
Near Threatened	>5	≤5
Threatened	≤5	≤2
Critically Threatened	<5	1
Endangered	1	≤3

Note: >5 = more than '5'; ≤5 = equal or, less than '5'; ≥5 = equal or, more than '5'; ≤2 = equal or, less than '2'; <5 = less than '5'; ≤3 = equal or, less than '3'

Six categories in the Table 1 have been suggested by the EBBL in the context of categorizing 'vulnerability status' to prepare the 'assessment process' by using all the collected and identified species of the experimental stations in the forest areas studied. The model-exercise is stated below. In the exercise, 32 experimental stations (forest areas) were selected as the model's experimental units. Total experimental butterfly species were 16. The butterfly individuals of the 16 species were recorded in the selected 32 stations (forest areas). The records were made on the individual butterfly numbers per species per station as adopted by the procedures of Latin squares design (Fig. 1).

Method no. 4 - Practice of Latin squares design (LSD) sampling

LSD is a very helpful and applicable method for assessing biodiversity monitoring and biodiversity sampling application. This design produces data accumulation for numerous small-sized organisms like butterflies in the wild state. This design has got some advantages in taking measures for analyzing data statistically. Data recording was made by following a group-wise pattern. There are 4 groups. All the four groups started recording butterflies from 8.30 hours and ended by 11.30 hours. They completed recording as per schedule time period (8.30-11.30 hours) simultaneously (Fig. 1). The groups followed

their recording operation in a cyclic order by using the blocks in A-B-C-D chronology. A block means an unit area for butterfly recording in a region of the forests (North, South, East or West).

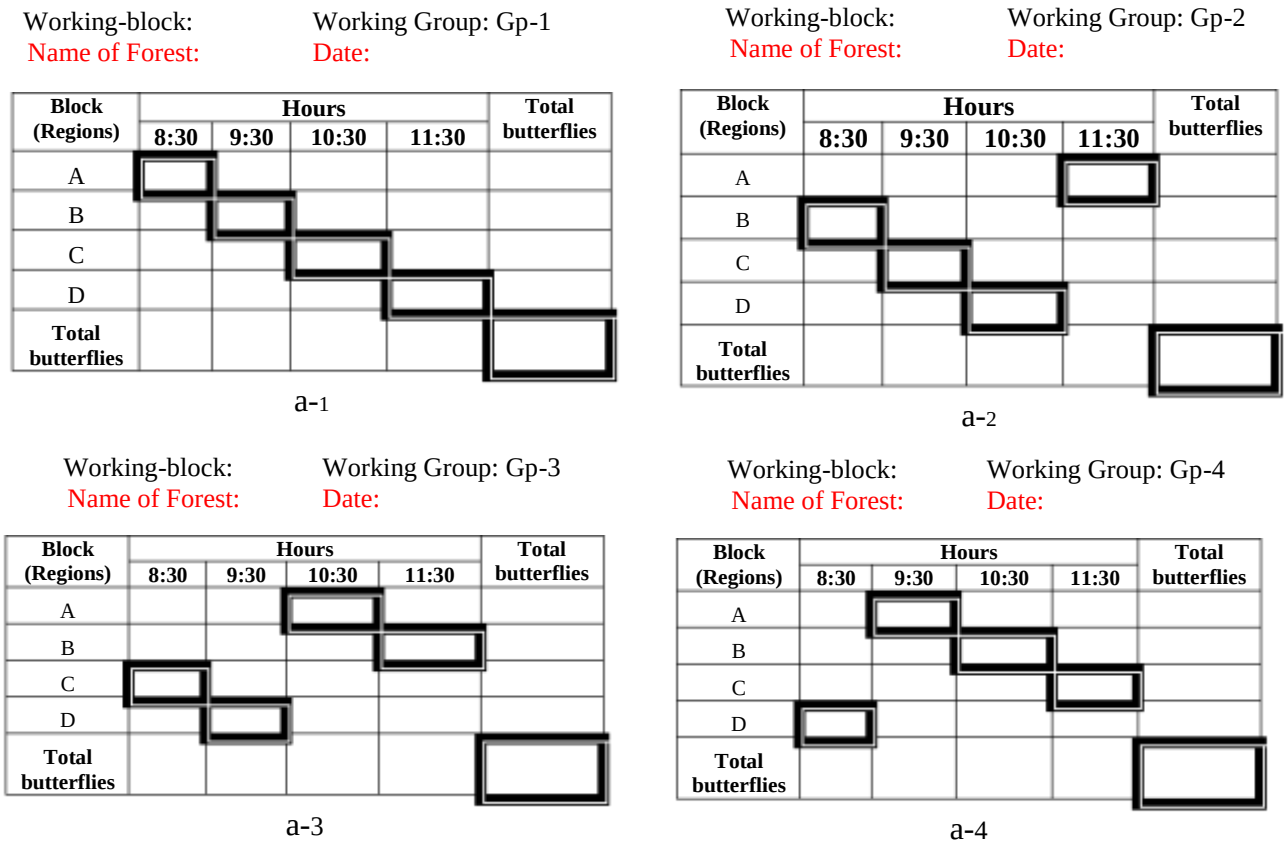

Fig. 1. Modulation of 'Latin squares design of sampling'. a-1. exercise of Gp-1; a-2. exercise of Gp-2; a-3. exercise of Gp-3; and a-4. exercise of Gp-4.

Method no. 5 - Practice of Butterfly-Plant assessment model

The 'butterfly-plant assessment model' was dealt with the practice to record butterflies and the number of plant species in each experimental square area. The sampling procedure of the butterfly plant assessment practice in the field was exercised in the way as shown below. In this practice, four assessors were assigned in the field (100m^2 area) as shown on the working pattern. In this procedure assessor-1

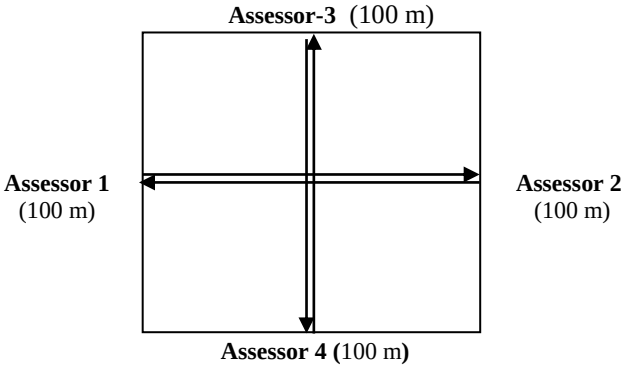

Fig. 2. Practice of Butterfly-Plant assessment model. a. four assessors-modeling.

counted the butterfly as well as the number of plants species in the target area and continued from this standing point to the next standing point of the assessor-2 and vice versa. Similarly the assessor-3 did the same to the next assessor-4 and vice versa. The total number of the assessor of the assessment is shown in Fig. 2.

RESULTS AND DISCUSSION

Results are presented under two heading like A. Assessment of 'Vulnerability status' and B. Population census.

A. Assessment of 'Vulnerability status'

In studying 'Vulnerability status' of butterflies, it was found that some of the experimental species were presented in the field with a large size of population, some of them were with a moderate population size; and others were found with a very small population size. In the present investigation, six categories were exercised as the EBBL model of vulnerability study of the butterfly population on Bangladesh context. These 'Vulnerability categories' practiced in the present method is processed as shown in the Table 2 (Bashar 2015).

**Available (Av)*

A species is designated as 'Available' in Bangladesh at that case when it was recorded in more than 16% of total (5) forest stations as well as the recorded butterfly-individuals belonging to the species per station were more than 16% of total (5) number. For example, 114 butterfly-individuals of 8 Species were recorded in 26 number of forest stations. More than five individuals per forest experimental station were recorded eight times during the field-record period. This accomplishes the status of availability. As a result, the species available in the context of Bangladesh (Table 2) will be recorded (Bashar 2015).

**Rare (Rr)*

When a species was found in not more than 16% of total (five or, less than five) stations; but on the other hand, the butterfly-individuals of the species per station were recorded not less than 16% of total (five or, more than five) in number; then it is termed as 'Rare'. For example, 7 Species was recorded in four experimental forest stations and the number of recorded butterfly-individuals of that species per station were 'five' (once) or, more than 'five' (three times). According to the EBBL modulated formula (Table 1), the species holds the 'Rare' conservation status (Bashar 2015).

**Near Threatened (Nt)*

The status 'Near Threatened' is applied in case of those species which might be found available in more than 16% of total (five) forest stations, but the butterfly-individuals per species per station were not exceeded more than 16% of total (five) in number. For example, in case of one species in the forest, it was recorded available in nine of total experimental forest stations. On the other hand, the recorded individuals of that species per forest station were not more than 'five' in number. Therefore, the species reach 'Near Threatened' status (Bashar 2015).

**Threatened* (*Tr*)

A species is said to hold the status 'Threatened' when the number of butterfly-recorded from forest stations did not exceed more than 16% of total (five). And the butterfly-individuals belonging to that

species per station also did not exceed more than two (6%) of total (two) in number. For example, 13 species was found in five forest stations and the recorded individuals belonging to the species was not more than two (three times). Hence, the no. 13 Species holds the conservation status 'Threatened' (Bashar 2015).

Table 2. EBBL model for the assessment of biodiversity status (Example of EBBL model-exercise for the assessment of butterfly vulnerability-status).

Forest	Number of species (individual)																IPF
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	-	-	12	8	-	-	-	9	-	-	3	-	-	-	-	7	39
2	-	-	4	2	12	2	-	2	3	-	-	1	-	-	-	12	38
3	-	-	10	3	-	-	-	4	8	-	-	-	-	-	-	9	34
4	-	-	3	8	-	-	5	-	13	-	2	-	-	-	-	2	33
5	-	1	-	2	-	-	-	7	2	-	-	-	-	-	-	5	17
6	-	-	14	10	-	-	-	11	4	-	-	-	-	-	-	-	39
7	-	-	10	7	-	3	-	6	3	-	-	-	1	-	-	4	34
8	1	-	7	-	2	-	-	4	7	-	1	-	-	-	-	-	22
9	-	-	5	6	-	-	8	1	-	-	2	-	-	9	-	4	35
10	-	-	5	10	-	-	-	1	3	-	5	-	-	-	-	-	24
11	-	1	9	12	-	-	-	3	-	-	-	-	-	-	1	3	29
12	-	-	1	2	-	-	-	-	10	-	2	-	-	-	-	5	20
13	2	-	1	-	-	-	-	-	-	-	-	-	2	-	-	9	14
14	-	-	2	-	-	4	-	7	13	2	-	-	-	-	-	13	41
15	-	-	-	2	-	1	-	2	9	-	-	-	-	-	-	-	14
16	2	-	-	3	-	-	-	2	7	-	1	-	-	-	1	-	16
17	1	-	4	-	-	3	-	4	-	-	2	-	-	-	-	11	25
18	-	-	3	2	-	-	-	3	-	-	-	-	1	-	-	8	17
19	-	-	11	7	-	-	-	15	6	-	-	-	-	-	-	2	41
20	4	1	-	-	-	-	-	2	10	-	4	-	-	-	-	6	25
21	-	-	-	2	-	-	-	1	2	-	-	-	-	-	-	-	05
22	2	-	5	-	-	-	-	-	12	-	-	-	-	-	-	11	30
23	-	-	2	-	-	-	11	8	-	-	2	-	1	1	-	7	32
24	3	-	10	2	-	-	-	3	-	-	-	-	-	-	-	3	21
25	-	-	11	3	-	-	-	8	7	-	3	-	-	-	-	9	41
26	-	-	15	4	-	5	-	2	-	-	-	-	-	-	-	-	26
27	-	-	2	-	-	2	-	1	9	-	-	-	2	-	-	-	16
28	2	-	3	1	-	-	9	-	-	-	5	-	-	-	-	-	20
29	1	-	4	2	-	-	-	-	8	-	-	-	-	13	-	1	29
30	-	-	8	5	-	-	-	5	5	-	-	-	-	-	-	2	25
31	-	-	2	-	-	-	-	2	1	-	4	-	-	-	-	1	10
32	-	-	8	4	-	-	-	1	-	-	1	-	-	-	-	5	19
TI	18	3	71	107	14	20	33	114	142	2	37	1	7	23	2	139	
TFE	9	3	25	23	2	7	4	26	21	1	14	1	5	3	2	23	

Note: TI = Total individuals; TFE = Total forest examined; IPF = Individual(s) per forest

*Critically Threatened (Ct)

When only a single butterfly-individual of a species was recorded per station in less than 16% of total (five) forest stations, but in more than one station, then it is designated as 'Critically Threatened' species. For example, only a single individual of no. 15 species was found in two of total experimental forest stations. That's why the species is critically threatened in the forest station of Bangladesh (Bashar 2015).

***Endangered (En)

When less than 11% of the total (three or, less than three) butterfly-individual(s) of a species was recorded only in 3% of total (one) experimental station, then the species is designated as 'Endangered'

species in Bangladesh perspectives. The species is expected to be no longer existed in Bangladesh if immediately measure(s) for its conservation is not considered. For example, two butterfly-individuals of no. 10 species were noted only in one of total forest stations. Therefore, the species holds the 'Endangered' conservation status (Bashar 2015).

B. Population census

In the present investigation total seven major families were examined in the field experiments. In total 202 butterfly species were studied in the experimental stations (forests). The families are: Hesperiidae, Papilionidae, Nymphalidae, Pieridae, Danaidae, Lycaenidae and Satyridae. The 'vulnerability status' are 'Available (Av)', 'Rare (Rr)', 'Near Threatened (Nt)', 'Threatened (Tr)', 'Critically Threatened (Ct)' and 'Endangered (En)'. Analytical description on the application of 'Red List preparation model' has been made as follows:

Table 3. 'Vulnerability status' of the experimental butterflies in Bangladesh context. Percentage of the examined butterflies (relative frequency) (as per model no. 4: Latin squares design).

Butterfly family	Total species examined (N)	Vulnerability status					
		Available (Av)	Rare (Rr)	Near Threatened (Nt)	Threatened (Tr)	Critically Threatened (Ct)	Endangered (En)
Hesperiidae	38 (18.81%)	21(55.26%)	12(31.16%)	--	4(10.53%)	--	1(2.63%)
Papilionidae	19 (9.41%)	7(37%)	6(31%)	3(26%)	--	2(10.5%)	1(5.3%)
Nymphalidae	34 (16.83%)	20(58.82%)	10(29.4%)	--	--	2(5.88%)	2(5.88%)
Pieridae	23 (11.39%)	13(56.52%)	8(34.8%)	1(4.34%)	--	1(4.34%)	--
Danaidae	12 (5.94%)	7(58.33%)	4(33.33%)	--	--	--	1(8.33%)
Lycaenidae	45 (22.27%)	15(33.33%)	12(26.66%)	3(6.66%)	9(2%)	6(13.33%)	--
Satyridae	31 (15.35%)	15(48.4%)	12(38.71%)	2(6.45%)	--	1(3.22%)	1(3.22%)
Total	202 (100%)	98(48.51%)	64(31.68%)	9(4.46%)	13(6.44%)	12(5.94%)	6(2.97%)

Among the total 202 examined butterfly species from the seven mentioned families the family Lycaenidae occupied top position in the volume of species number. In the relative frequency (fr) analysis, it is revealed that the family Lycaenidae contained 22.27% species of the total species recorded (Table 3). The minimum number of species was found in the family Danaidae. It was only 5.94% of the total species recorded. The examined butterfly species of the family Hesperiidae, Papilionidae, Nymphalidae, Pieridae and Satyridae were 18.81%, 9.41%, 16.83%, 11.39% and 15.35%, respectively. Among the examined butterflies 48.51% species held the 'Available' status. 22.28% butterfly species were recorded in the 'Rare' status whereas, 4.46%, 6.44% and 5.94% species were in the 'Near Threatened', 'Threatened' and 'Critically Threatened' status, respectively. Only 2.97% butterfly species were recorded in the 'Endangered' status in Bangladesh.

In the family Hesperiidae, 55.26% species were recorded as available species whereas 31.16%, 10.53% and 2.63% species were recorded as rare, threatened and endangered species, respectively. No species of the family was recorded in the status 'Near Threatened' and 'Critically Threatened'. 37% species of the family Papilionidae held the status 'Available'. Recorded butterfly species of the Papilionidae were 31%, 26%, 10.5% and 5.3% in the status 'Rare', 'Near Threatened', 'Critically Threatened' and 'Endangered', respectively. No species of the family was recorded as 'Threatened' species. In case of family Nymphalidae, 58.82% butterfly species were recorded as 'Available'. 29.4%

species of the family held the status of 'Rare'. On the other hand, 5.88% species was recorded both in the 'Critically Threatened' and in the 'Endangered' status. No butterfly species belonging to the family was found in the status 'Near Threatened' and 'Threatened'. In the family Pieridae 56.52% species were recorded as 'Available' species, whereas 34.8% species were rare status. Only 4.34% of species were both in 'Near Threatened' and 'Critically Threatened' status. No species of the family was recorded as 'Threatened' and also as 'Endangered'. 58.33% species of the family Danaidae were recorded as 'Available' species, whereas 33.33% species were in the 'Rare' status. 8.33% species were recorded as the status 'Endangered' under the family. In this family, no species was found in 'Near Threatened', 'Threatened' and in 'Critically Threatened' status. In case of family the Lycaenidae, 33.33% and 26.66% species held the status 'Available' and 'Rare', respectively. Species was recorded 6.66%, 2% and 13.33% as 'Near Threatened', 'Threatened' and 'Critically Threatened', respectively. No butterfly was found as 'Endangered' belonging to the family Lycaenidae. In the family Satyridae 48.4% species were examined as 'Available' status, whereas 41.93% and 6.45% species were in the 'Rare' and 'Near Threatened', respectively. 3.22% species of the family held the status of both as 'Critically Threatened' and 'Endangered'. No butterfly species of the family Satyridae was found as 'Threatened' species.

The total 79 families of host-plant with a considerable number of other associated plant species were found 'related' with the butterflies studied. The host plant association with the butterflies is found in the developmental stages (larval stages) (Akand *et al.* 2015a). Not only the host-plants are essential to maintain the population status of the butterflies in an ecosystem, but also they need other more plant species for maintaining their life activities including foraging, nectering, mating and egg laying etc. So, 'population census' study needs a thorough investigation of the plant-assemblage in the vicinity of the population-census sampling areas of the ecosystem. The plant assemblage related with the butterfly families are shown in Table 4.

The butterflies of seven major families were considered to study the population census in different forest areas of Bangladesh. In the study of seven different families it was revealed (Table 4) that the highest number of host-plant families (25) was observed in the case of Lycaenidae (Akand *et al.* 2015a). The butterflies of the families (Lycaenidae) are found to depend on the host-plants belonging to 25 different families. The total species number of the butterfly family was 45. In the case of the family Satyridae the lowest number host-plant families (2) were found associated with this butterfly. In this case almost all the butterflies of the family were found to depend on two host-plant families; they were Poaceae and Palmae (Rahman 2018). The second highest number of host-plant families was associated with the family Nymphalidae. 34 butterfly species of the family Nymphalidae were found to depend on 24 different families of host-plants. 38 butterfly species of the family Hesperiidae were associated with only nine families of host-plant. It was found that 19 butterfly species of the family Papilionidae were related to five host plant families. 23 butterfly species of the family Pieridae were found to depend on the host-plants belonging to ten different families. In case of the family Danaidae, twelve butterfly species were found to depend on only four host-plant families (Table 4). Recently, some research works have been carried out to provide data in the field conditions. The investigations were done in some forest areas (Bhawal and Madhupur forests) near the Dhaka city which produced harmonious supports to the present works of the 'population census' (Chowdhury 2020, Chowdhury and Bashar 2021).

Table 4. Butterfly families and their respective associated host-plant families (as per the model no. 4: butterfly-plant assessment model).

Butterfly families examined	Number of associated host-plant families recorded (N=79)	Name of the associated host-plant families
Hesperiidae	09	Oleaceae, Dioscoreaceae, Zingiberaceae, Arecaceae, Poaceae, Malvaceae, Combretaceae, Sterculiaceae, Marantaceae.
Papilionidae	05	Magnoliaceae, Annonaceae, Lauraceae, Aristolochiaceae, Rutaceae.
Nymphalidae	24	Mimosaceae, Flacourtiaceae, Euphorbiaceae, Fabaceae, Acanthaceae, Verbenaceae, Tiliaceae, Myrtaceae, Anacardiaceae, Loranthaceae, Urticaceae, Ulmaceae, Caesalpiniaceae, Meliosmaceae, Menispermaceae, Portulacaceae, Rhamnaceae, Moraceae, Passifloraceae, Violaceae, Melastomaceae, Bombaceae, Malvaceae, Oleaceae
Pieridae	10	Caesalpiniaceae, Fabaceae, Mimosaceae, Capparaceae, Viscaceae, Loranthaceae, Lamiaceae, Crucifera, Euphorbiaceae, Cleomaceae.
Danaidae	04	Asclepiadaceae, Rubiaceae, Apocynaceae, Moraceae.
Lycaenidae	25	Fabaceae, Acanthaceae, Rutaceae, Sapindaceae, Cycadeae, Orchidaceae, Sterculiaceae, Rhamnaceae, Mimosaceae, Zingiberaceae, Myrsinaceae, Coesalpiniaceae, Combretaceae, Myrtaceae, Fagaceae, Dioscoreaceae, Euphorbiaceae, Punicaceae, Moraceae, Connaraceae, Melastomataceae, Verbenaceae, Dioscoreaceae, Terntroeniceae, Rubiaceae.
Satyridae	02	Poaceae, Palmae.

The above statements (Table 1 and Table 2) detail the 'vulnerability status' of butterflies in Bangladesh context. The study was conducted throughout the forest areas of Bangladesh. More than 35 forest-areas of Bangladesh were included in the present investigation. Total 202 species were taken under consideration of the study. Out of the total species, six species were found and declared 'Endangered'. Among the examined butterflies, 12, 13, 9, 64 and 98 species hold the status of Critically Threatened, Threatened, Near Threatened, Rare and Available, respectively (Bashar 2015). Keeping ideas (obtained from the statement) in front, the population census of the butterflies was carried out in three major forest areas of Bangladesh. The three examples of 'population census' study-model are described below (model no. 1, 2 and 3).

Statements of the example Model no. 1 of Kalenga

In the Kalenga forest, there were three regions (North, South and Centre) to conduct the population census record study. In each of the regions 5 spots were randomly selected and examined ($100\times100m^2$) by counting butterflies. In each spot, there were 4 assessors to record the population census. Example of only spot (Kalenga: spot-1; Centre) is demonstrated here.

In the Kalenga forest, total conducted spots were 15 ($3\times5=15$) in number. In the final analyses, the cumulative figure (obtained from the calculations) of the 15 experimental spots represented the butterfly population size of the forest Kalenga. In addition to that, the calculations were also made on the records maintained on the related plant species population and the record of the dominated plants in the forest.

Identification and practice of Butterfly-Plant assessment model 1
(Data recording method in the stations)

Station: Kalenga (Spot-1) (dt: 27/05/17) Sampling Area: Central (T: 35°C RH: 77%)

SN	Plants-Species in number	Butterfly numbers in the family wise pattern										
		Hes	Pap	Nym	Pie	Dan	Lyc	Sat	Minor			Total
									Ama	Acr	Rio	
1	40	2	9	13	13	9	15	6	--	--	--	67
2	40	5	10	13	17	7	12	9	--	--	--	73
3	40	5	9	12	13	5	7	7	--	--	--	58
4	39	4	9	12	14	7	12	8	--	--	--	66
Total	40	16	37	50	57	28	46	30	--	--	--	264
Av.±SD		**4±1.41**	**9.25±0.5**	**12.5±0.5**	**14.25±1.8**	**7±1.63**	**11.5±3.32**	**7.5±1.29**				**66±6.16**
Remarks	**Main activities:** Foraging, basking, resting, puddling, egg-laying, pre-mating and mating, territoriality activities. **Dominating plants:** Chapalish, Mango, Shati, Shagun, Grasses.											

SN= Serial number, Tr= Transect (100m^2: 50m^2), Hes= Hesperiidae, Pap= Papilionidae, Nym= Nymphalidae, Pie= Pieridae, Dan= Danaidae, Lyc= Lycaenidae, Sat= Satyridae, Ama= Amathusiidae, Acr= Acraeidae, Rio= Riodinidae, T= Temperature, RH= Relative humidity, DP= Dominating plant (s); and (Area: North, South, East, West, Mid or central)

Statements of the example Model no. 2 of Satchori

In the Satchori forest, there were three regions (West, East and Centre) to conduct the population census study. In each of the regions 5 spots were randomly selected and examined (100×100 m^2) by counting butterflies. In each spot, there were 4 assessors to record the population. Example of only spot (Satchori: spot-2; West) is demonstrated here.

It is to be noted that in the Satchori forest, total conducted spots were 15 (3×5=15) in number. In the final analyses, the cumulative figure (obtained from the calculations) of the 15 experimental spots represented the butterfly population size of the forest Satchori. In addition to that, the calculations were also made on the records maintained on the related plant species population and the record of the dominated plants in the forest.

Identification and practice of Butterfly-Plant assessment model 2
(Data recording method in the stations)

Station: Satchori (Spot-2) (dt: 03/06/17) Sampling Area: West (Temp: 32.4°C RH: 89%)

SN	Plants-Species in number	Butterfly numbers in the family wise pattern										
		Hes	Pap	Nym	Pie	Dan	Lyc	Sat	Minor			Total
									Ama	Acr	Rio	
1	41	5	9	8	5	5	7	2	--	--	--	41
2	41	6	11	5	6	4	7	3	--	--	--	42
3	41	7	11	7	6	4	12	9	--	--	--	56
4	40	6	11	7	6	5	9	5	--	--	--	49
Total	41	24	42	27	23	18	35	19	--	--	--	188
Av.±SD		**6±0.81**	**10.5±1**	**6.75±1.26**	**5.75±0.5**	**4.5±0.6**	**8.75±2.4**	**4.75±3.1**				**47±6.98**
Remarks	**Main activities:** Foraging, basking, resting, puddling, egg-laying, pre-mating and mating, territoriality activities. **Dominating plants:** Chapalish, Bet, Shagun, Motkila, Ciz, Grasses.											

SN= Serial number, Tr= Transect (100m^2: 50m^2), Hes= Hesperiidae, Pap= Papilionidae, Nym= Nymphalidae, Pie= Pieridae, Dan= Danaidae, Lyc= Lycaenidae, Sat= Satyridae, Ama= Amathusiidae, Acr= Acraeidae, Rio= Riodinidae, T= Temperature, RH= Relative humidity, DP= Dominating plant (s); and (Area: North, South, East, West, Mid or central)

Statements of the example Model no. 3 of Madhupur

In the Madhupur forest, there were three regions (South, North and West) to conduct the population census record study. In each of the regions 5 spots were randomly selected and examined ($100\times100m^2$) by counting butterflies. In each spot, there were 4 assessors to record the population. Example of only one spot (Madhupur: spot-3; North) is demonstrated here.

It is to be noted that in the Madhupur forest, the total conducted spots were 15 (3×5=15) in number. In the final analyses, the cumulative figure (obtained from the calculations) of the 15 experimental spots represented the butterfly population size of the Madhupur forest. In addition to that, the calculations were also made on the records maintained on the related plant species population and the record of the dominated plants in the forest.

Identification and practice of Butterfly-Plant assessment model 3

(Data recording method in the stations)

Station: Madhupur (Spot-3) (dt: 10/06/17) Sampling Area: North (Temp: 33.7°C RH: 80%)

SN	**Plants-Species in number**	**Butterfly numbers in the family wise pattern**										
		Hes	Pap	Nym	Pie	Dan	Lyc	Sat	Minor			Total
									Ama	Acr	Rio	
1	21	1	2	10	18	1	70	13	--	--	--	115
2	23	3	2	6	15	3	75	10	--	--	--	114
3	23	2	3	3	5	2	64	9	--	--	--	88
4	23	2	1	6	13	2	69	10	--	--	--	103
Total	23	8	8	25	51	8	278	42	--	--	--	420
Av.±SD		**2±0.82**	**2±0.82**	**6.25±2.8**	**12.8±5.6**	**2±0.82**	**69.5±4.5**	**10.5±1.7**				**105±12.7**
Remarks	**Main activities:** Foraging, basking, resting, puddling, egg-laying, pre-mating and mating, territoriality activities. **Dominating plants:** Shal, Sonalo, Monkat, Motkila, Bankuch and Grasses.											

SN= Serial number, Tr= Transect ($100m^2$: $50m^2$), Hes= Hesperiidae, Pap= Papilionidae, Nym= Nymphalidae, Pie= Pieridae, Dan= Danaidae, Lyc= Lycaenidae, Sat= Satyridae, Ama= Amathusiidae, Acr= Acraeidae, Rio= Riodinidae, T= Temperature, RH= Relative humidity, DP= Dominating plant (s); and (Area: North, South, East, West, Mid or central)

It is already stated that, the present part of the study was based on the practices of three models (no. 3, 4, 5) only out of the five models (no. 1, 2, 3, 4, and 5) innovated. At the beginning of start of our grand project on biodiversity assessment, we had to practice all the five models in together. When we had 'analyzed' the results of that study, the results showed some interesting findings.

More than 35 forest areas were taken under the first practical trial. The EBBL showed a clear picture on the experimental forest areas with their respective number of butterfly's record. Of the studied forests, some of them are presented here with their respective number of butterfly species-recorded by the EBBL (Bashar 2014 and 2015). They 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.); Nijhum dweep (does not exceed 100 spp.); St. Martin's island (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.).

The above detail works (done in more than 35 forests) have encouraged us to a new concept to go for further researches that, "only the greenness of a forest does not show species richness of butterflies but the plant-species richness maintains butterfly species richness in a forest ecosystem. But random plant species richness generally showed butterfly host-species abundance in an ecosystem. This random species richness of plants stands as additional factor for species richness and species assemblage in an ecosystem as a whole. Because of the fact that, the richness of non-host plant species provide shelter, nectar supplying, mating surface, egg-laying substrate and various other behavioural support providers for the butterflies. The above situations detail the 'vulnerability status' of butterflies in Bangladesh forest context".

A glorious information is including in the present article on the butterfly exploration in Bangladesh contest that, a butterfly belonging to the species *Papilio distantianus* has been recorded from Kalenga forest (near the city of Sylhet) for the first time in Bangladesh. No record was found before, but only one specimen is available to us in our laboratory. The single specimen is not enough to declare its position in the 'Vulnerability status'. We are eagerly searching more specimen of the butterfly in the different forests of Bangladesh where we have conducted our researches in the past.

ACKNOWLEDGEMENTS

Present article is a part of the grand research programme "Butterflies of Bangladesh". The research programme is financially supported by the Ministry of Education, Government of the People's Republic of Bangladesh. The EBBL, Department of Zoology, University of Dhaka acknowledges the support with thanks. The authors are grateful to Dr. Shahanaz Rahman and Kritee Chowdhury for compiling data and for composing text of the article sincerely.

REFERENCES

Aich, U., S. Chowdhury, S. Akand, S. Rahman, K. Chowdhury, Z. Sultan and M. A. Bashar. 2016. Synchronization of coincidences between the life stages of *Pachliopta aristolochiae* and the phenological stages of its host plant *Aristolochia indica*. *J. biodivers. conserv. bioresour. manag*. **2**(2): 61-68.

Akand, S., M. A. Bashar and H. R. Khan. 2015a. Biology of the gram blue butterfly, *Euchrysops cnejus* (Fabricius) (Lycaenidae: Lapidoptera) and its relationship with the phenology of host-plant, Vigna unquiculata (L.). *J. Bangladesh Acad. Sci*. **39**(2): 241-248.

Akand, S., M. A. Bashar, S. Rahman and H. R. Khan. 2017. Morphometric variation in the species of two subfamilies of lycaenid butterflies (Lepidoptera: Lycaenidae) of Bangladesh. *J. biodivers. conserv. bioresour. manag*. **3**(1): 9-16.

Akand, S., M. A., Bashar, H. R. Khan and S. Rahman. 2016. Abundance and some behavioural aspects of lycaenid butterflies in the Butterfly Research Park at the Bhawal National Park, Gazipur. *J. biodivers. conserv. bioresour. manag*. **2**(2): 39-46.

Akand, S., S. Rahman, K. Chowdhury, M. M. Alam, G. Moula, H. R. Khan and M. A. Bashar. 2015b. Behavioural activities of lycaenid butterflies and their significance with the related plants. *J. biodivers. conserv. bioresour. manag*. **1**(2): 57-66.

Alam, S., M. A. Bashar, U. Aich, S. Akand and S. Rahman. 2017. Colonization and strategic stratification of butterfly *Pachliopta aristolochiae* (Lepidoptera: Papilionidae) and its relationship withthe host plant *Aristolochia indica* (Piperales: Aristolochiaceae). *J. biodivers. conserv. bioresour. manag*. **3**(1): 45-54.

Bashar, M. A. 2010. Butterflies: Best 'biotic-indicators' of climatic change. *The Daily Star* (*Environment*). **23**(19): 13.

Bashar, M. A. 2012a. Butterfly colonization, biodiversity conservation and ecotourism. *The Independent* (*Science & Technology).* **19**(325): 28

Bashar, M. A. 2012b. Making a butterfly park for conservation of nature. *The Independent* (*Science & Technology*). **17**(291): 20.

Bashar, M. A. 2014. *Butterflies of Bangladesh: A broad approach for nature lovers*. Vol. 1. 1st ed. BCTF Publications, Dhaka-1000. 515 pp.

Bashar, M. A. 2015. *Butterflies of Bangladesh: A broad approach for nature lover.* (*EBBL Butterfly Red List and Butterfly Activities*). Vol. 2. BCTF Publications. 177 pp.

Bashar, M. A. 2016. Vision on biodiversity: example of ecosystem services in Bangladesh. J.biodivers. conserv. bioresour. manag. 2(1): 1-6.

Bashar, M. A. 2018. Vision on biodiversity: ecotourism and biodiversity conservation in Bangladesh. *biodivers. conserv. bioresour. manag.* **4**(1): 1-10.

Bashar, M. A. and H. R. Khan. 2015. Vision on bioresource recognition and bioresource management: Bangladesh perspectives. *J. biodivers. conserv. bioresour. manag*. **1**(1): 1-14.

Bashar, M. A., H. R. Khan, S. Rahman, Eftesum, K. Chowdhury, M. M. Alam and G. Maula. 2015a. Wildlife conservation through butterfly colonization. *J. biodivers. conserv. bioresour. manag*. **1**(1): 71-82.

Bashar, M. A., S. Rahman, E. Eftesum, K. Chowdhury, M. M. Alam, G. Moula and M. A. Islam. 2015b. Conservation of Plants and Successive Trophic levels by Butterfly Colonization in an open forest ecosystem of Bangladesh. XIV WORLD FORESTRY CONGRESS, Durban, South Africa., pp. 1-10.

Chowdhury, M. A. K. 2020. Foraging behaviour of some papilionid butterflies in Bhawal and Madhupur Sal forests of Bangladesh. *J. biodivers. conserv. bioresour. manag.* **6**(2): 55-68.

Chowdhury, M. A. K. and M. A. Bashar. 2021. Diversity and abundance of insect fauna in the Bhawal and Madhupur Sal forests of Bangladesh. *J. biodivers. conserv. bioresour. manag.* **7**(1): 11-24.

FAO. 1995. *Global Forest Resources Assessment 1990*. Global Synthesis. FAO Forestry Paper, FAO, Rome. 124 pp.

Jermi, T. 1988. Can predation lead to narrow food specialization in phytophagous insects? *Ecology*. **69**: 902-904.

Kamrunnahar, S. Akand, S. Rahman, H. R. Khan and M. A. Bashar. 2018. Basking behaviour in some nymphalid butterflies of Bangladesh. *J. biodivers. conserv. bioresour. manag*. **4**(1): 63-72.

Rahman, S. 2018. Seasonal polyphenism of selected satyrid butterflies in some forest ecosystems of Bangladesh. Ph. D. Thesis. Department of Zoology, University of Dhaka. 388 pp.

Sultana, S., S, Rahman, S. Akand, M. F. Hoque, M. S. Miah and M. A. Bashar. 2017. Butterfly probosces and their functional relations with the nectar plants in some selected forests. *J. biodivers. conserv. bioresour. manag.* **3**(1): 93-101.

UNEP. 1997. Global Environment Outlook. New York, Oxford University Press, Nairobi. 264 pp.