# WILDLIFE CONSERVATION THROUGH BUTTERFLY COLONIZATION

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**Abstract**

Establishment of butterfly open colonization can create an ecologically 'furnished' open site where species richness becomes enriched. In Bhawal National Park of Bangladesh, a natural butterfly park has been used as the study area to investigate how lively ethological behaviours of butterfly interact. The three-acre area of the park is designed with four area-components as hedge-boundary, canopy-tree area, jungle-bush hedges area and multimorphic beds-area. The areas provide both sheltering plants and host-plants for butterflies. The Jungle-bush ensures safe pupation. The accumulation and well-planned arrangement of these four area-components facilitate the system mechanism of butterfly colonizing process. The colonization process has been made functional by applying some procedural methods and also by safe guarding butterfly-activities in the experimental area. To exercise promoting of butterfly-activities in the assessment of interaction between the phenological stages of related plants and the developmental stages of the butterflies, we have divided the entire experiment into two sections. First one is to examine the criteria responsible for determining the establishment of butterfly colonization process. Second one is to examine the impacts of butterfly colonization on the enhancement of seed production capacity of the target plants in the centre premises. Results of the first and second sections indicated that the butterfly colonizing mechanism enhances the multiplication of plant population and protection of successive trophic levels, means the wildlife.

***Key words*:** Butterfly, colonization, interaction, phenological stages, forest ecosystem.

## INTRODUCTION

Conservation ensures the rational optimum use of the biological resources in accordance to the demand and need to protect them for future use. Insect-plant relationship and host-plant selection strategies are based on insect's plant-recognition abilities and adaptations in an ecological condition suitable for both of them (Jermy 1988). To enhance species assemblage and species richness both for plants (first trophic level) and animals (successive trophic levels) butterfly-colonization stands as an important key factor in a terrestrial ecosystem (Bashar 2013). This hypothesis is much more practicable especially in the tropical rain forests like the forests of Bangladesh (Bashar *et al*. 2006). Butterfly-colonizing process is characterized by some special biotic interactions. Butterflies require species specific host-plants, selective egg-laying supports, pupating and resting plants; they need to remain within the choice of their range of behavioural activities and adaptabilities (Bashar 2012b). But, foraging behaviours are many and highly characteristics in the different families of butterflies (Bashar 2014a). They need large volume of plant variety in connection with suitable ecological conditions. These requirements stand essential for the normal life-building of butterflies (Bashar 2010a). The maintenance of such combinations provides an optimum colonizing environment as "*in-situ*" conditions for the butterflies, i.e. the sound "home-place" for them. The butterfly colonization is a process of establishing butterfly-plant interaction in an open area under the presence of all required necessaries (plants, butterflies, water-channel, optimum humidity, temperature, light and other abiotic factors) in a channel which can play

as a vital role model for the sustenance of an ecosystem. In this ecosystem, the biotic-biotic interactive mechanism (butterfly-plant interaction) maintains a synchronization of coincidences between the life stages of butterfly and the phenological stages of associated plants (Bashar 2012a). Through the establishment of the colonization, the dynamism in it ensures the conservation of biodiversity in an ecosystem. The establishment and sustenance of butterfly open colonization create such an ecologically 'functioned' open 'situ' where the species richness of plant and butterflies becomes enriched (Islam *et al.* 2014).

The butterfly colonization has been established in an open ecosystem in the Bhawal National Park of Bangladesh. The butterfly colonization has been tested by examining different butterfly-activities like foraging, puddling, resting, gene-flow activities, territorialities, pre-mating, mating, egg-laying behaviours, larvae and larval activities, pupating patterns, emerging behaviours, pray-predators activities and life cycle of butterflies. The examination of these activities has proved that the butterfly colonizing process can enrich the wildlife population in its area by strengthening the population of butterfly related plants, their fruiting and healthy seed production (Bashar 2014a).

The present paper deals with some endeavour and experiments on the establishment of butterfly colonization in an open environment system at the Bhawal National Park, Gazipur; these have been chronogically arranged in the chapter of Material and Methods.

## MATERIAL AND METHODS

To establish butterfly colonization in an open environment at the Bhawal National Park the following steps are undertaken.

1. Procedure of butterfly colonizing centre frame-work;
    a. Land preparation and plantation (plantation through organic farming practices);
    b. Colonization process-success and butterfly activities;
2. Enhancement of plant population;
3. Butterfly colonization and successive trophic levels (wildlife) conservation.

1. *Procedure of butterfly colonizing centre frame-work*

The Forest Department of the Government of Bangladesh has allotted ten-acres of land to the Department of Zoology, University of Dhaka for forest conservation technique innovation. Three-acres area of the allotted ten acres have been selected for doing research experiments on the establishment of an open butterfly park. This area is designed with four area-components as *hedge-boundary* (10%), *canopy-tree area* (30%), *jungle-bush hedges* (30%) and *multimorphic beds-area* (30% of total experimental area) (Fig. 1). The hedge boundary has been prepared with the composition of approximate 30±5 essential different natural floral species. The Canopy-tree area has been designed and prepared with tall-trees and their associated vines and climbers. It is a typical area with canopy-covering and man-height supportive bushes. The Jungle-bush hedge is a bushy area that has been prepared with biotic composition of vines, herbs, shrubs, climbers, trees, grasses and also with the canes population. The area ensures safe pupation and quick sheltering (due to sudden extreme changes in weather) for the butterflies. Different kinds of soil beds have been prepared for the growth and maintenance of host, nectar and shelter plants. The plantation in these areas

provides with various blooming flowers in relation to the seasonal variation. In addition to that, the area components show a decorative value that attracts social visitors also. The above biotic conditions constitute a suitable assemblage for the survival of considerable number of fecund butterflies in the park area. This type of biotic mechanism creates vital factors for butterfly colonizing system.

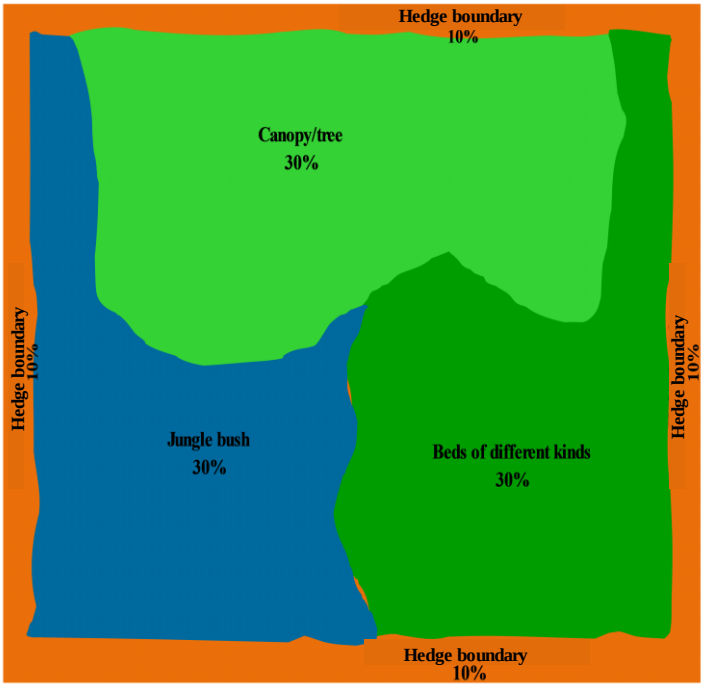


Fig. 1. Butterfly colonization centre frame-work with demarcated biotic component-parts.

a. *Land preparation and plantation by organic farming practices*

An accommodation of plants in the colonizing centre has been exercised by following some techniques to provide nutrition, sheltering, safe pupation and egg-laying support during the developmental stages and for the life cycle of butterflies. These techniques consisted of various successive stages for land preparation, viz. i. Bed modeling preparation; ii. Sand analysis, sand collection and application; iii. Organic manure preparation and application; and iv. Plant culture and plantation.

*i. Bed preparation:* Different sizes and shapes of beds have been prepared for plantation in the colonization centre. The bed preparation depends on the type of plants. Normally three types of plants are planted for butterfly colonization; these are host-plants, nectar-plants and shelter-plants. The bed preparation techniques for different types of plants varied from one type to another.

*ii. Sand analysis, sand collection and application:* Sand analysis is dealt with accommodation and mixing of sand with hard soil in the forest area for making the soil ecology-aerable for seedlings and plantation. The collection of sand and its application have been maintained continuously for five years till the colonizing centre was made suitable for the target uses.

*iii. Organic manure preparation and application:* A green manure crop was grown for a specific period, and then ploughed under soil and incorporated into the soil. Cow dung was

applied to the soil in an appropriate proportion before plantation and after plantation. The dung was provided and maintained for keeping the plants of the park in a healthy reproductive condition. Compost has been decomposed and recycled as a fertilizer and soil conditioner. The process of composting required simply piling up waste outdoors and waiting for the materials to be broken down in six weeks or more.

*iv. Plant culture and application:* The plant culture has been grossly done by adopting two processes as *Seed bank* and *Vegetative propagation*.

A seed bank or gene bank has been maintained in our experiments. The seed bank has been established for the storage of seeds as a source for planting in case our natural seed reserves are destroyed. The healthy seed production process is innovated in our park premises.

The vegetative propagation is essential for the colonizing of plants to establish the butterfly farming. The EBBL has developed a technique for vegetative propagation and it has been practiced in the target forests. The plant culture and plantation were followed by some steps necessary for the butterfly colonization procedures. These are arrangement and management of plant; phyto-fencing; water-canalization and water bodies' maintenance and target area determination.

b. *Colonization process-success and butterfly activities*

Butterflies require a strong and successful association with their plants, but they stand difficult to examine whether the relationship occurs successfully or not. The establishment of a sound relationship between butterflies and their related plants can be assessed by studying different activities among themselves. The activities of butterflies are: foraging, puddling, resting, gene-flow activities, territorialities, pre-mating, mating, egg-laying behaviours, larvae and larval activities, pupating characters, emerging behaviours, predator activities and life cycle of butterflies.

The behavioural activities in major cases are biotic-biotic interactions, but some cases there are also abiotic-biotic interactions. In the present article, the butterfly behaviours occurring in the colonizing centre have been successfully examined following the methods adopted by Jermy (1984, 1988); Dethier (1970); Ehrlich and Murphy (1988); Slama (1987) and Bashar (2010b, 2014ab).

2. *Enhancement of plant population*

Plant population sustenance and successes in their phenological patterns with seasonal variation in the Butterfly Colonization Centre are highly essential and useful for the colonization of butterflies. On the other hand, for the assurance of plant multiplication and their healthiness, the butterfly colonization can bring its proper application in the field. The application is a useful tool for the conservation of butterfly-plant association and for establishing of a forest ecosystem. The EBBL has examined how butterfly activities are related with the maintenance of plant gene-flow mechanism and seed-banking functioning. The laboratory has also innovated the process of examining seed production and their healthiness by operating a technique called "Cassette–ribbon system for plant population-covering".

The plants that have been selected to cover their flowering period with a view to keep them "not exposed to butterflies" in the experimental plot in the Butterfly Colonization Centre (BCC) were taken under a system called cassette-ribbon system. In this system we have developed a device with the plastic cassette-ribbons which are used in cassette record player. The ribbons were used to make a net-trap. With the net-trap, the experimental plant area was covered in such a way that the plants under the covered-area had every facilities of receiving light, humidity, air flow, water-flow, temperature and the optimum plant-nutrition. These facilities were also equally available to the plants those were not taken under the cassette-ribbon covering system. Under this system where the plants were covered, they (plants) were not visited (not allowed to visit) by butterflies because the butterflies in the field were obstructed by the ribbon-system vibration. In this system, air vibration always produced some sound with the ribbon used. This vibration created disturbance to the flying-butterflies; and then they could not reach to the flowers which were taken under the system. Under this way they were kept as the plants "not visited" by the butterflies; and the plants were designated as the "non-treated plants". On the other hand, the designated "treated plants" were exposed to butterflies, and the butterflies could freely visit the plants without facing any disturbance.

3. *Butterfly colonization and Successive trophic levels conservation*

The BCC provides inter-linkage of various biotic-biotic interactive factors, and also biotic-abiotic interactive factors together. The combination of inter-linkages produced a highly significant ecosystem, and that ecosystem evidenced the increase of population in vertebrate fauna also remarkably. The researchers of the EBBL have observed gradual increase of various vertebrate populations, such as amphibians, reptiles, birds and mammals in the BCC. The innovative technique of the EBBL examined for four years from the year 2010 to 2013. Sampling was made three times per year with an interval of four months in between the two successive samplings. The calculation of the recorded data was made and the successive development of population increase of the vertebrate fauna has been described in the text result.

The researchers of the EBBL also have noticed that in addition to butterflies, the members of other insect orders, such as odonates, orthopterans, hemipterans, homopterans, coleopterans, dipterans, hymenopterans, gradually appearing in the BCC premises and thereby increasing their population size. These insects were, however, sampled but the data have not yet been calculated.

## RESULTS AND DISCUSSION

*Establishment of butterfly colonizing centre frame-work*

The plant accommodation procedure that has been adopted in the present experiment, has brought some success in building the butterfly colonizing centre frame-work (Figure 1). The greater area of the BCC has been framed by dividing into four major vegetation areas. Each of the areas has been developed with characteristic plant species in rich status and it took years to accomplish it. The species richness in each of the four different vegetative areas has brought the entire BCC premise into a suitable ecosystem for the maintenance of butterfly-populations. The characteristic floral arrangements together with the proportional abiotic

supports (availabilities of water, air and sunlight) have been enabled the ecosystem of the BCC to provide good required services for the butterflies. The services from the respective divisions were very vital and fruitful for the establishment of butterfly colonization. Services provided by the hedge boundary (10% of the total area) were to protect the butterflies and the vegetation of entire planned butterfly park premises. Canopy tree area (30%) provides both sheltering plants and host plants for the colonizing butterflies in the centre. The jungle bush area (30%) ensures safe pupation and sudden sheltering for butterflies. Bed areas (30%) gave services to provide various flowers in relation to seasonal variation. These services were biotically convenient to butterflies because the successful accommodation of the plants were made by taking them from different forest areas of Bangladesh (Fig. 2). More than 50 forest areas have been studying in our grant project on "Butterflies and their related plants". Required plants have been collected from different forest areas (as shown in Fig. 2) of the country for accommodation in the BCC.

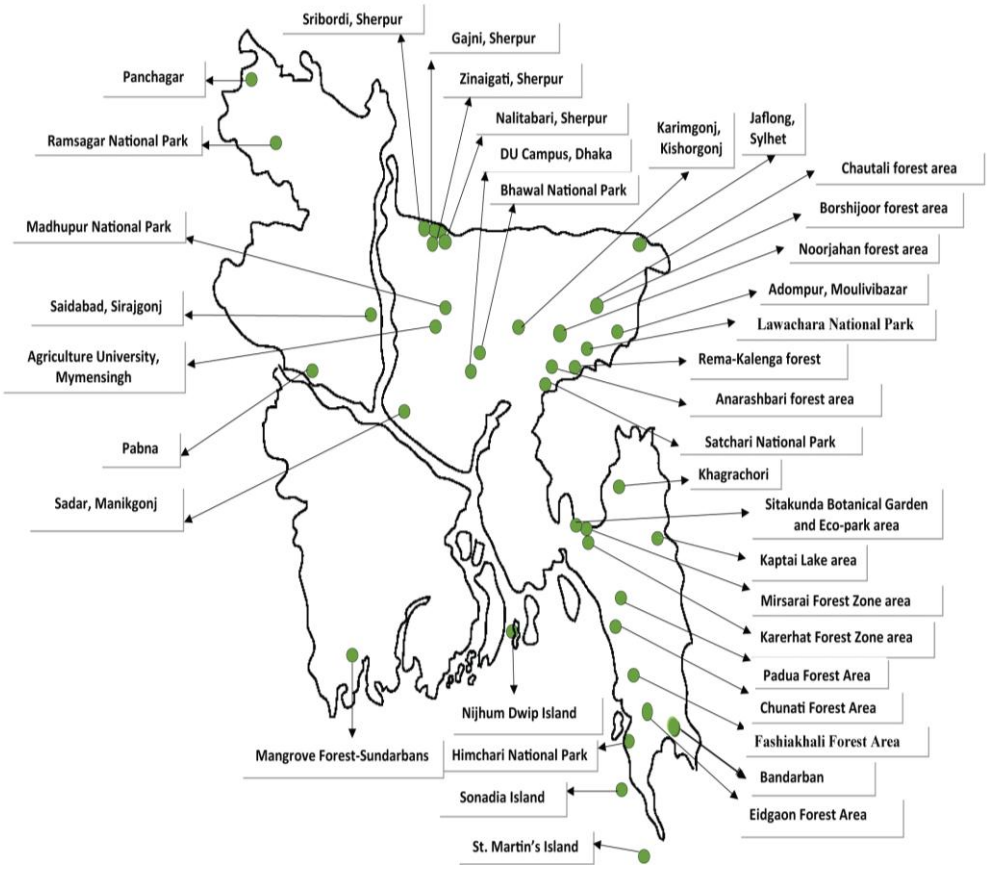


Fig. 2. Forested areas where from the butterflies were collected and their behaviours were recorded, and plants were collected for their accommodation in the BCC.

Major plants were accumulated in the BCC from the forests of Sylhet (viz. Lawachara, NoorJahan, Anarashbari, Borshijoor, Chautali, Satchori and Rema-Kalenga), Chittogong (viz. Karerhat, Mirsarai, Sitakunda, Chunati, Fashiakhali, Eidgaon) and Madhupur. Some plants were repeatedly collected from several forests at the same time-period in different seasons. The plants were accumulated by plantation, transplantation, cutting and seedling methods. The process was practiced for a long duration (about 8 years) to come to the state of

application in the BCC in the Bhawal National Park. The whole process was divided into two sections viz. "*ex-situ* plantation" and "*in-situ* plantation" for examining the plant-accommodation (Table 1). In the ex-situ plantation process, total 37,500 plants belonging to 50 species were exercised. Out of the experimental plants, 4,500 were planted; 3,000 weretransplanted and 11,000 plants were processed through cutting methods. The seedling process was followed for 19,000 plants. Among the ex-situ accommodation practices, the highest survival rate resulted 80% and lowest 52%. The lowest percentage of survival was focused in cutting plantation and highest survival was noticed in the case of planted plants. Average survival rate was 65% among the plants examined in accommodation process. All the ex-situ plants were brought from long distances and from different remote forest areas of Bangladesh. They were in natural condition while they were collected.

According to the plant survival rate, they were graded as *Excellent*, *Very good*, *Good*, *Average* and *Poor*. In the in-situ accommodation, the plants were collected from the Bhawal National Park premises and also from the adjacent forest areas of the park. In the beds of the BCC area, mainly the ex-situ plants were planted, very few of the plants in beds area were the in-situ plants. But, the in-situ plants were accommodated in all the four other areas of the BCC (Table 1). Total 13,900 plants of 100 species were exercised in the experiment. The survival rate was 95% on an average. The lowest percentage of survival was found in cutting plantation (85%); but in the planted method, the plants survived up to 98%. In the in-situ ecosystem, plantation-methods were found comparatively less troublesome in plantation and on the other hand, highly productive and cost-effective.

**Table 1. Plant accommodation structure in the BCC by plantation, transplantation, cutting and seedling methods in the Bhawal National Park, Bangladesh.**

| | **Number of plants accommodated by different methods in ex-situ plantation (50 species examined)** | | | | | |
|---|---|---|---|---|---|---|
| No. of beds in the BCC | Planted method | Transplanted method | Cutting plantation | Seedling process | Total plants examined | % survived (in average) |
| 27 | 4,500 | 3,000 | 11,000 | 19,000 | 37,500 | 65% |

| | **Number of plants accommodated by different methods in in-situ plantation (100 species examined)** | | | | | |
|---|---|---|---|---|---|---|
| **I**n all four major components in the BCC | Planted method | Transplanted method | Cutting plantation | Seedling process | Total plants examined | % survived (in average) |
| 1. Hedge boundary<br>2. Canopy layer<br>3. Jungle-bush<br>4. Flower-beds | 4,000 | 2,500 | 2,400 | 5,000 | 13,900 | More than 95% |

*Examining the colonization process-success by the butterfly activities*

The success of colonization process in assessing butterfly behaviours was resulted through analyzing some significant stage of their life cycle and functional activities. These behaviours were exposed in such a way that the behaviours made a butterfly capable enough to carry out important roles in the gene-flow process of the entire plant kingdom. They can also show a good sign of microclimatic condition in different ecosystems and indicate presence of the process how it is created. This can easily be determined, especially in the forest ecosystem. Successful moments of performing various ethological behaviours are categorically arranged in the research procedure.

The colonization-success in the BCC area was determined by recording data on the ethological behaviours, like foraging, puddling, resting, gene-flow activities, territorialities, pre-mating, mating, egg-laying behaviours, larvae and larval activities, pupating characters, emerging behaviours, predator activities and life cycle of butterflies (Bashar 2015). In our context we have come to a stage of success to maintain the population of species ranging about 120 species (±10) in the optimum season favourable for butterflies. But the variation in the size of butterfly population is evident when we analyzed their abundance throughout the year. It depends on the available of variation in the plant phenology and their reproductive appearances in the colonizing centre premises. An experimental record evidences the above statement (Fig. 3).

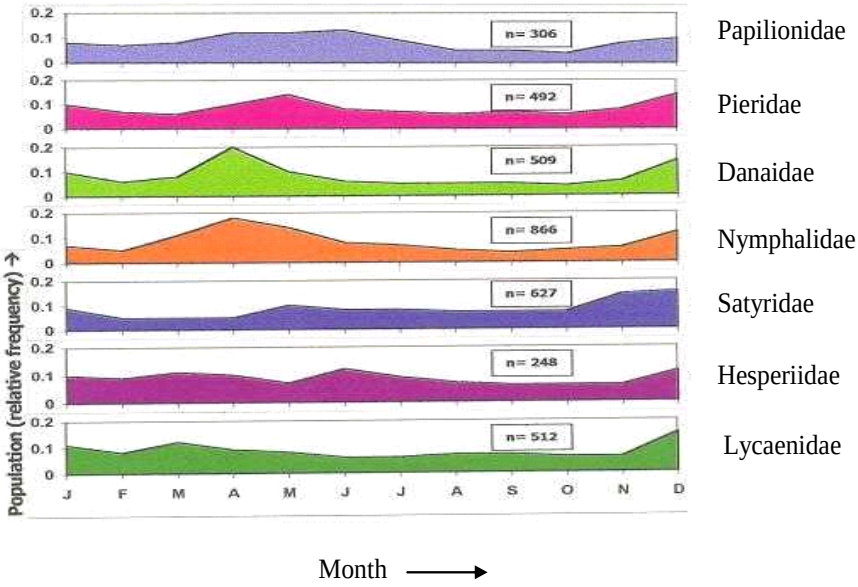


Fig. 3. Successful establishment of butterfly population (colonization): family-wise abundance of the butterflies throughout the year (2010-2011) in the butterfly colonization centre.

*Enhancement of plant population sustenance*

The selected plants were *Asclepias curassavica*, *Aristolochia indica* and *Duranta plumieri*. The productivity and frutiings were found significantly remarkable.

The statement of the importance of butterfly activities in question of floral enhancement in the open butterfly colonizing centre is very much optimistic. The Table 2 shows the experimental results. The *Asclepias* sp. is related with butterflies both as host and nectar

plants. The plants exposed to butterflies are found to produce more fruits and seeds than those of the plants not exposed to butterflies. On the other hand, the non-exposed plants produced seeds with low quality and less weight compared to the seeds produced by the plants exposed to the butterflies. Similar results were also obtained when experiments were conducted with other two plants, viz. *Aristolochia indica* and *Duranta plumieri* (Table 2). From the analysis of the results it is evident that butterflies can bring significant results to the case of healthy seed production. The healthy seed-production can enhance the production of genetically more viable plants also and can sustain good population size in the ecosystem where the colonizing process is practiced. As each of the butterfly species was related with its respective plants for foraging, egg-laying, resting and pupating, and other activities, and if through the activities they (butterflies) bring healthiness to the related plants, they can help in the questions of their conservation in the same ecosystem.

**Table 2. Assessment of fruiting and seed production of three experimental plants in the BCC when these were exposed (Treated) and not exposed (Non treated) to the butterfly activities (Example of 10 samples).**

| **Experimental plants (cluster) (10 Samples)** | | **No. of branches per sample** | | | **No. of effective branches per sample** | | | **No. of fruits /seeds per sample** | | | **Wt. (gm) of 1000 seeds per sample** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Names** | **Expt. type** | **Max.** | **Min.** | **Av.± SD.** | **Max.** | **Min.** | **Av.± SD.** | **Max.** | **Min.** | **Av. ± SD.** | **Max.** | **Min.** | **Av.± SD.** |
| *Asclepias curassavica* | Treated | 17 | 9 | 12.9± 2.601 | 14 | 7 | 10.3± 2.45 | 142 | 85 | 109.1± 18.76 | 4.46 | 4.10 | 4.334± 0.17 |
| | Non treated | 17 | 9 | 13.2± 2.66 | 15 | 7 | 10.2± 2.52 | 89 | 49 | 70.2± 13.62 | 3.68 | 2.56 | 3.046± 0.352 |
| *Aristolochia indica* | Treated | 17 | 9 | 12.8± 2.66 | 14 | 7 | 10.5± 2.368 | 114 | 87 | 105.4± 7.961 | 4.13 | 4.1 | 4.148± 0.026 |
| | Non treated | 15 | 9 | 11.9± 1.852 | 13 | 6 | 8.2± 2.043 | 105 | 75 | 90.3± 12.06 | 4.15 | 3.8 | 3.847± 0.197 |
| *Duranta plumieri* | Treated | 18 | 9 | 14.5± 2.635 | 15 | 8 | 12.0± 2.054 | 2489 | 2377 | 2443.3± 42.06 | 57 | 43 | 50.9± 4.605 |
| | Non treated | 17 | 11 | 13.6± 1.955 | 13 | 8 | 10.2± 1.549 | 2419 | 2309 | 2374.3 ± 44.22 | 50 | 40 | 44.7± 3.233 |

*Wildlife conservation and the butterfly colonization*

Plantation initiation in the BCC has been started since the year 2004 and later in 2007 we started the colonization of 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. The present paper includes the data up to the year 2014 (Fig. 4).

Wild vertebrate population increase was regularly observed from the year 2007 and it was estimated in four groups, such as amphibians, reptiles, birds and mammals. The vertebrate species record was maintained in the BCC during the study period are listed below.

**Amphibians**: Available amphibians in BCC are *Hoplobatrachus tigerinus, Duttaphrynus melanosfictus, Kaloula pulchra, Ichthyophis glutinosus, Fejervarya limnocharis, Microhyla berdmorei, Microhyla rubra, Sylvirana leptoglossa,* and *Polypedates maculates.* 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, Gecko gecko, Typhlops diardii, Scincella reevessii, 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 *Eudynamys 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.

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

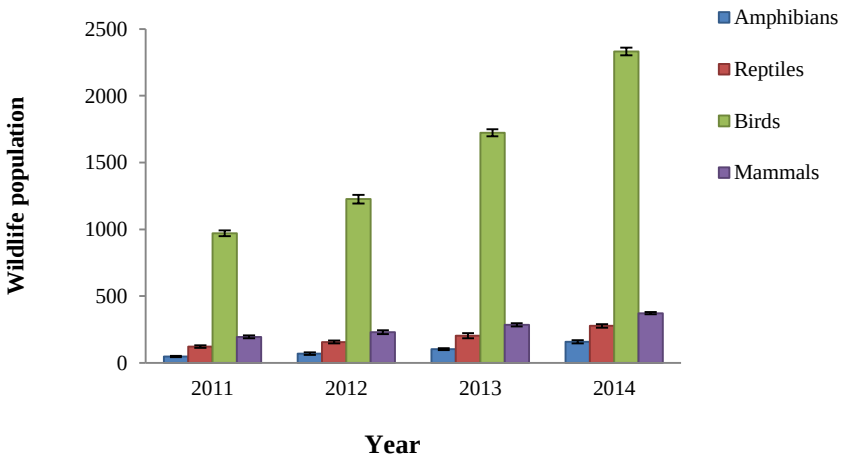


Fig. 4. Concomitant increase of wild vertebrates with the progressive success of the butterfly colonizing mechanism in the butterfly colonization centre (4-years duration of study: 2011-2014).

We observed the concomitant increase of wild vertebrates with the progressive success of the butterfly colonizing mechanism in the BCC from 2011to 2014. It is evident that the insect

interaction with plants (especially the phytophagous pollinating insects and the flowering plants with entomophilous pollens) establishes strong gene-flow mechanism in the forest ecosystem. Then the ecosystem becomes healthy and gave more functional services. Consequently the ecosystem becomes suitable and compact home for the successive trophic levels which provided 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 2011).

It is found that when almost all the dominating plants species in a forest are found with entomophilous pollens, they are densely pollinated by a single species of insect like the honey bee. The single species (*Apis dorsata*) becomes responsible in greater extent for the healthiness of the forest like the Sundarbans. Because this insect species is dominating pollinator on the dominating plant populations (Bashar 2011). Though butterflies are not dense pollinators, but they are pollinating the forest plants of almost all kinds. The butterflies are related with the plants of all the forest-layer vegetations without any reservation whatever is the height level of the trees or vegetation in the forests is concerned. They can forage the vegetation of the soil surface layer, undergrowth layer and also the plants of the canopy layer. Forest conservation may have some percentage of dependence on the colonization of butterflies as it is hypothesized in the present paper. We have a plan in mind to conduct further researches in the field and explore the possibilities of their uses.

The results and observations of the present research has brought some ideas as to how to deal with the fact of using "butterfly-colonization" as a biotic tool for nature conservation as well as forest conservation. It is indicated that ecotourism industry could be framed by keeping practice of the colonizing process as a biotic epicentre (especially in tropical forest ecosystem). The present paper brings some evidences that species richness and assemblage are highly related with the sustainability of the colonizing process. In connection with the above conclusive statement in brief, the following recommendations may be made.

The production and fruiting enrichment of the plants are only the very symbolic ones. There are many other plants under the natural phenomenon that could be protected and enhanced for their species richness. Bangladesh ecology is so favourable for establishing the mechanism that the newly experimental idea could be taken into practice to go for further study. This could be applied in discovering a device to protect the plant population (first trophic level) and successive trophic levels (animals). Under the technique of the establishment of open butterfly park, conservation of nature and conservation of biodiversity could be attempted in a new step to be materialized.

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## REFERENCES

Bashar, M. A. 2015. *Butterflies of Bangladesh, Vol-2 (EBBL Red-List and butterfly activities)*. 1st ed. BCTF publications.182 pp.

Bashar, M. A. 2014a. *Butterflies of Bangladesh, Vol-1 (A broad approach for nature lovers*). BCTF publications. 514 pp.

Bashar, M. A. 2014b. Butterfly Colonization, Farming and Ecotourism Industry. *Ministry of Education, GoB, Final Report (2011-2014).* 137 pp.

Bashar, M. A. 2013. Assemblage of flora and fauna. *The Daily Independent.* (Science & Technology) May 27, 2013.

Bashar, M. A. 2012a. Butterfly colonization, biodiversity conservation and ecotourism. *The Daily Independent.* (Science & Technology) June 22, 2012.

Bashar, M. A. 2012b. Evaluating services of forest (Biodiversity contributes considerably to economy and environment). *The Daily Star.* (Environment) December 29, 2012.

Bashar, M. A. 2011. Honey collection and biodiversity loss in mangrove ecosystem. *The Daily Independent.* (Science & Technology) June 17, 2011.

Bashar, M. A. 2010a. Sustainable use of biodiversity: Bracing the change. *The Daily Star*. (Environment) April 10, 2010.

Bashar, M. A. 2010b. Innovating biotic technique for conservation of forest and wildlife. *The Daily Independent.* (Science & technology) April 21, 2010.

Bashar, M. A., M. A. Mamun, A. F. M. Aslam and M. A. K. Chowdhury. 2006. Biodiversity Maintenance and Conservation of Butterfly-Plant Association in some Forest of Bangladesh. *Bangladesh J. Zool.* **34**(1): 55-67.

Dethier, V. G. 1970. Chemical interactions between plants and insects. In: E. Sondheimer, and J. B. Simeone (eds.). *Chemical Ecology*. Academic Press, New York, London., pp. 83-103.

Ehrlich, P. R. and D. D. Murphy. 1988. Plant chemistry and host range in insect behaviores. *Ecology*. **69**: 908-909.

Islam, M. A., N. Parven, M. S. Islam, and M. A. Bashar. 2014. Butterfly abundance in relation to abiotic-biotic factors of forest ecosystem of the butterfly research park, Gazipur, Bangladesh. *Bangladesh. J. Zool.* **41**(2): 247-255.

Jermy, T. 1984. Evolution of insect/host relationship. *Amer. Nat.* **124**: 609-630.

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

Slama, K. 1987. Insect hormones and bioanalogues in plants. International Symposium on Insect-Plant Relationships (6th: 1986: Pau: France), *Insects-Plants*. **41**: 9-17.