BEHAVIOURAL ACTIVITIES OF LYCAENID BUTTERFLIES AND THEIR SIGNIFICANCE WITH THE RELATED PLANTS

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Abstract

Field investigation was carried out during January–December 2015 to assess the behavioural activities of lycaenid butterflies with their related plants. Lycaenid behaviours, viz. foraging, resting, basking, egg-laying and gene-flow activity were examined. The behaviours were found to synchronize with appearance of flowers and fruits of the plants of ground level, manhight and canopy level. A total of 879 individuals under 29 lycaenid species exhibited the dynamism of behavioural activities. They were recorded on 44 plant species. The same plant could be utilized by the different behavioural activities. It was found that the butterflies utilized 34 plants species for resting and nine species for egg-laying support in the experimental site. Among the observed lycaenids, 396 individuals demonstrated foraging activities, 257 showed resting behaviours, 171 basking and 55 were active in egg-laying behaviour in order. It was found that both biotic factors and physical conditions maintained the significant size of lycaenid populations. The combination of the factors displayed the highest abundance (121 individuals) in November and lowest (38 individuals) in April. The study revealed that the behavioural activities of lycaenid butterflies were deeply related with phenological changes of the experimental plants. This interrelationship produced interesting findings to study the identification of bioresources in a certain ecosystem.

Key words: Lycaenid butterflies, behavioural activities, related plants, gene-flow activity.

INTRODUCTION

Butterflies are considered to be an important bio-resource and pollinating agent for the conservation of natural gene-flow in plant kingdom. Gene-flow mechanism is a dynamic phenomenon in establishing genetic biodiversity to maintain species diversity in any certain ecosystem (Futuyma and Peterson 1985). Richness in gene-flow in any ecosystem is directly proportional for the dimension of successive trophic level (Jermy 1984). Therefore, it requires a strong interaction between plants and animals in order to establish a stable ecosystem (Wiense 1976). This interactive system could be identified by studying the behavioural patterns of animals that are directly associated with plants and plant parts. In this case, butterflies would be the best examples when forest ecosystem and its richness are concerned (Bashar 2015).

Lycaenidae is the second largest family of butterflies under the order Lepidoptera comprising about 6,000 species in worldwide distribution and has the greatest diversity in the tropics (Ackery and Vane-Wright 1984). They are rather small in size, brilliantly coloured showing marked sexual dimorphism that always occurs as a difference on the upper wing surface. But ventrally both are usually similar (Roberts 2001).

Throughout the life, a butterfly exhibits a surprising range of behaviours for its nutrition, reproduction and defense. Behavioural activities are interdependently related with the life stages of

lycaenid butterflies and the phenology of associated plants. They stand in second trophic level that directly depends on some specific plants for completing their every stages of life cycle (from egg to adult). These are host plants, nectar plants, shelter plants, pupating supports, and all together abiotic supports (Bashar 2015).

The success of gene-flow in the plant kingdom is directly dependent on the sound activities of butterflies (Bashar 2015). This system is highly essential in nature for conservations of biodiversity as a whole and at the same time in ensuring healthiness of an ecosystem. Considering the facts importance, present study was undertaken to examine the lycanid butterflies and their activities in relation to the associated plants.

MATERIAL AND METHODS

An extensive study of lycanid butterflies was started from 2010 by the Environmental Biology and Biodiversity Laboratory (EBBL), Department of Zoology, University of Dhaka. The year round (Jan-Dec, 2015) observation on the behavioural activities of some lycaenids have been accumulated in the present paper. The field study was carried out in Butterfly Research Park (BRP) at the premises of Bhawal National Park, Gazipur and Krishibary Butterfly Park (KBP) at Savar, Dhaka. The area of BRP is $100\times42m^2$. The area is situated in between longitude 90˚24′06″E and latitude 24˚05′06″N. The area of KBP is $76\times30m^2$ which is situated in between longitude 90˚31′69″E and latitude 23˚76′74″N. Lycaenid species were identified directly in the field. The identification was done based on wing pattern, venation, colouration, forelegs structure, antennal shape, etc. following the procedure of Bingham (1907), Eliot (1973) and Bashar (2014). Plant species have been identified on the basis of leaf characteristics including arrangement of leaves, leaf structure, leaf shape, leaf margin, leaf tip and leaf base, flower arrangements, and fruit types and fruit shapes following the work of Ahmed *et al.* (2009).

Observations were made twice in a month during the time between 9.30 a.m. and 4.30 p.m. The behavioural activities of lycaenids in the study sites were recorded through a "constant walk" for 10-15 minutes over the experimental field. This record was made by using transect method followed by Pollard and Yates (1993). The behavioural activities of lycaenids have been examined by following the procedure of Jones (1983) and Price *et al.* (1991). The observed lycaenid butterflies have been categorized in different symbolic 'potentials' according to "*The EBBL-modulated formula for category-determining*" followed by Bashar (2015); and it stands for Bangladesh context only.

In the present text, the EBBL has formulated four categories of plants for studying the butterflies and their interacting activities in Bangladesh context. Four types of behavioural activities (viz. foraging, resting, basking and egg-laying) were selected to formulate the category of plants. The categories are stated below–

1. **Excellent biotic resource potential:** The plant(s) belongs to this category has no sub-category, but includes all types of behavioural activities on it. The activities are arranged as foraging-resting-basking-egg laying (F-R-B-El)
2. **High biotic resource potential:** In this category, plant(s) provides three types of behavioural activities on it, and it is divided into four sub-categories. The sub-categories are foraging-resting-basking (F-R-B), foraging-resting-egg laying (F-R-El), foraging-basking-egg laying (F-B-El), and resting-basking-egg laying (R-B-El).

3. **Mid biotic resource potential:** The plants belonging to this category contain two types of behavioural activities on it, and it is divided into six sub-categories. The sub-categories are foraging-resting (F-R), foraging-basking (F-B), foraging-egg laying (F-El), resting-basking (R-B), resting-egg laying (R-El), and basking-egg laying (B-El).
4. **Poor biotic resource potential:** The plants belonging to this category maintain a single activity of butterflies on it and it is divided into four sub-categories. The sub-categories are foraging (F), resting (R), basking (B) or egg laying (El). The results of the present study have been accumulated by following the procedures adopted in the methodology.

RESULTS AND DISCUSSION

A total of 879 individuals under 29 species of Lycaenidae was found in foraging, resting, basking, egg-laying and gene-flow movement. Among them 15 species hold the status 'Available', seven species are 'Rare', two and five species are 'Near threatened' and 'Threatened', respectively (Table 1). The status was given in the context of their availability and vulnerability stages followed by Bashar (2015).

Table 1. Behavioural activities and status of lycaenid butterflies in the Butterfly Research Park (BRP), Gazipur and in the Krishibari Butterfly Park (KBP), Savar during the period of January-December 2015. Activities are expressed as present (+) and absent (-) round the research period.

Sl. no	Lycaenid butterfly	Butterfly activities					Status
		Foraging	Resting	Basking	Egg-laying	Larval/Pupal support	
1	*Pseudozizeeria maha*	+	+	+	+	+	Available
2	*Zizina otis*	+	+	+	-	-	Rare
3	*Neopithecops zalmora*	+	+	+	-	-	Near threatened
4	*Megisba malaya*	-	+	-	-	-	Threatened
5	*Chilades lajus*	+	+	+	+	+	Available
6	*C. pandava*	+	+	+	-	-	Available
7	*Catochrysops strabo*	+	+	+	+	+	Available
8	*Tarucus callinara*	+	+	+	+	+	Rare
9	*Castalius rosimon*	+	+	+	+	+	Available
10	*Discolampa ethion*	+	+	+	-	-	Threatened
11	*Caleta decidia*	+	+	+	-	-	Near threatened
12	*Jamides alecto*	-	+	+	-	-	Threatened
13	*J. celeno*	+	+	+	-	-	Available
14	*Lampides boeticus*	+	+	+	+	+	Available
15	*Euchrysops cnejus*	+	+	+	+	+	Available
16	*Anthene emolus*	+	+	+	-	-	Rare
17	*Arhopala amantes*	+	+	+	-	-	Available
18	*A. pseudocentaurus*	+	+	+	-	-	Available
19	*Loxura atymnus*	+	+	+	-	-	Available
20	*Deudorix epijarbas*	+	+	+	-	-	Rare
21	*Rapala manea*	+	+	+	-	-	Available
22	*R. pheretima*	+	+	+	-	-	Available
23	*R. iarbus*	+	+	+	-	-	Rare
24	*Spindasis syama*	+	+	+	-	-	Available
25	*S. lohita*	-	+	-	-	-	Threatened
26	*S. nipalicus*	+	+	-	-	-	Threatened
27	*Remelana jangala*	+	+	+	+	+	Available
28	*Hypolycaena erylus*	+	+	+	-	-	Rare
29	*Tajuria cippus*	+	+	-	-	-	Rare

Butterfly activities deal with the determination of status of butterflies in relation to their associated plant-abundance, status of forests and the various aspects of environmental soundness (Bashar 2015). Three types of plants, viz. host plants, nectar plants and shelter/shade plants are pre-requisite for healthy diversity of butterflies. Lycaenid butterflies perform behavioural activities in association with enormous plants species. In the study site (BRP and KBP), 44 plant species have involved fulfilling the requirements of lycaenid activities.

According to plants 'category determining assessment', forty four plants have been grouped into the four categories. Among them, eight plants found under the category 'Excellent Biotic Resource Potential'. The plants are *Ziziphus mauritiana, Ixora coccinea, Eurya acuminate, Oxalis corniculata, Citrus aurantifolia, Cajanus cajan, Lupinus polyphyllus* and *Vigna unguiculata*. The category 'High Biotic Resource Potential' had nine plants of which eight plants (viz. *Shorea robusta, Chromolaena odorata, Mikania cordata, Wedelia chinensis, Panicum repens, Oxalis corymbosa, Senna obtusifolia,* and *Glycosmis pentaphylla*) were categorized under the sub-category foraging-resting-basking (F-R-B) and *Zizyphus oenoplea* alone was categorized under the sub-category resting-basking-egg laying (R-B-El).

Eighteen plants have been labeled in 'Mid Biotic Resource Potential'. Among them five plants (*Madhuka longifolia, Chrysalidocarpus lutescens, Spilanthes calva, Lantana camara,* and *Callistemon citrinus*) were sorted out in the sub-category foraging-resting (F-R); *Cosmos bipinnatus* was placed under the sub-category foraging-basking (F-B); and twelve plants (*Curcuma aromatic, Colocasia esculenta, Melastoma malabathricum, Duranta repens, Paspalum scrobiculatum, Axonopus compressus, Setaria palmifolia, Imperata cylindrica, Urena lobata, Hibiscus rosa-sinensis, Syzygium fruticosum,* and *Cassia tora*) were tagged in the sub-category resting-basking (R-B).

Nine plants (*Ageratum conyzoides, Nelsonia canescens, Asclepias curassavica, Gomphrena globosa, Celosia cristata, C. argentea, Leonurus sibiricus, Leucas aspera,* and *Ocimum tenuiflorum*) were categorized under the sub-category foraging (F) of the category 'Poor Biotic Resource Potential'.

Butterfly-activity study occupies a vast area of research attempts in nature. The different behavioural activities (foraging, resting, flying, egg-laying and gene-flow activity) of lycaenid butterflies are spotted prior to entering the vegetation and then are traced over the course of their activities.

Foraging behaviour

Foraging is a characteristic function in butterfly's life style to take energy directly from the plants especially from the flowers. This behaviour plays a great role in the gene-flow movement of the plants that are visited by the butterflies (Thompson 1988, Jermy 1988). Adult lycaenids commonly seek nectar from flowers of very restricted ranges of food plants (New 1993). They feed nectar from different plants such as ground covers, annuals, perennials, shrubs and trees. Lycaenids have powerful proboscis, they collect nectar from flowers through the proboscis. The natural corelations in between the nectar containing flowers and the nectar-sucking organ (the proboscis) in the butterflies are the most important biotic-biotic adaptabilities (Bashar 2015).

In the study site, 396 individuals of lycaenids (45.05%) were found on foraging of 34 plant species to collect nectar. They are very fond of the plant species like *Chromolaena odorata, Mikania cordata, Spilanthes calva* and *Wedelia chinensis* of family Asteraceae; *Gomphrena globosa* of family

Amaranthaceae; and *Lantana camara* of family the Verbenaceae. Larger lycaenids such as *Arhopala pseudocentaurus* and *A. amantes* tender in foraging the flowers of *Ziziphus mauritiana*, *Chrysalidocarpus lutescens* and *Ixora coccinea*.

Basking behaviour

Basking is the process of sun-bathing that increases temperature in the wing muscles to bring the insects in a physiological condition which makes the butterflies able for taking off to their flight (Kemp and Krockenberger 2002). Lycaenids take a position for basking on leaves or other plant parts under the direct sunlight. If the temperature gets too hot, they reposition their wings to minimize exposure to the sun. Many lycaenid butterflies absorb maximum heat by basking with closed wings and at an angle to the sun. The dark pigments on the underside of the wings absorb more radiant energy and warm the flight muscles of the thorax efficiently. 171 individuals of lycaenids (19.45%) have been found in basking. It has been observed that lycaenid butterflies bask their wings during 9.30-11.30 am. A very few lycaenids were seen to bask during 2.00-3.00 pm in winter. Some lycaenids have observed to bask when they are engaged in foraging. The plants that situated on direct sun light or where sunlight is available butterflies were found active on basking.

Resting behaviour

Plants under shady areas are preferred for resting. The hedges, vines and bushes are suitable vegetation for serving as resting sites for lycaenid butterflies. In resting condition, the butterflies sit on the upper surface or under surface of plant leaves. Sometimes they take rest on the other parts of plants beside leaves or dry supportive parts. During this resting time they do not move and do not feed anything.

It has been observed that lycaenid butterflies take rest for sometime after foraging, and female lycaenid butterflies take rest for a while between each egg-laying interval time. 257 individuals of lycaenids (29.24%) were found in resting condition. Plants such as *Imperata cylindrica*, *Setaria palmifolia*, *Axonopus compressus* and *Paspalum scrobiculatum* of family Poaceae were seen to use by some small lycaenids only for resting and basking. *Chromolaena odorata*, *Ixora coccinea*, *Shorea robusta*, *Syzygium fruticosum* and *Glycosmis pentaphylla* were found as favourable plants to lycaenids as their resting supports.

Egg-laying behaviour

This behavioural sequence commonly involves searching, orientation, encounter, landing, surface evaluation, and finally acceptance or rejection of a host plant in a given environment (Renwick and Chew 1994). Before egg-laying, the female lycaenids need to have 'found' plant(s') and the perfect site of plant(s) for oviposition. Female vibrates its wings rapidly and repeatedly visits the plants when it searches the host plants. Female usually touches the young shoot, bud or leaves with antennae and then takes a very short flight. It bends its abdomen to touch the plant-parts and moves forward. Finding a suitable place the female lays an egg. The female of lycaenid butterflies lays egg singly on young buds and leaves of host plant. Usually they do not lay huge number of eggs. 55 females of lycaenids have

been found in egg-laying and maximum of them were found to lay between 9.30 am and 12.00 pm; few species laid eggs at afternoon.

Soon after the oviposition is over, the female leaves the place frequently basks or taking rest for a certain period on the leaf of various plants or the host plants or even on other supportive elements. Then she comes back again to the host plant and lays another egg. In this process female lycaenid lays several eggs in a short duration at day light.

Nine plants have been identified as larval host plants. The females of *Pseudozizeeria maha*, *Chilades lajus*, *Catochrysops strabo*, *Lampides boeticus*, *Euchrysops cnejus*, *Castalius rosimon*, *Tarucus callinara* and *Remelana jangala* were observed to lay eggs on host plants *Oxalis corniculata*, *Citrus aurantifolia*, *Cajanus cajan*, *Lupinus polyphyllus*, *Vigna unguiculata*, *Ziziphus mauritiana*, *Z. oneoplea* and *Ixora coccinea*, respectively. It was observed that larvae consume leaves and other plants parts of respective host plants for their development.

Table 2. Examination of mobility of butterflies and bees to the experimental plants to assess their status as pollinators in Krishibari Butterfly Park (KBP), Savar, Dhaka during the year of 2015.

Pollinators	No. of plants examined	Counted visits-range/ experimental plants	Foraging-range on the experimental plants	Range of plant species visited	Characteristics of visits	Types of plants/total plants area	Status of pollinators/ relations
Butterflies	60	1-42	1-62(s)	15-46 at a time	Foraging, nectaring, mating, egg-laying, patrolling (diversely)	All types (from grasses to trees) 55 plants of 60 experimental plants	Diverse pollinators: Relations of visits with the plant at almost all the parts of plants like barks, young stems, leaves, buds, flowers, fruits and sometimes with roots even.
Honey bees	60	102-300	300×60(s) together	1-2 mainly 1 at a time	Mainly collection of nectar and pollens (densely)	5 plants out of 60 experimental plants. But one plant more than 90% time of total budget time.	Confined pollinators but densely pollinators: Associated with only the flowers. But on the few or/and on the selective plants; and moreover of the seasonal plants preferably.

Gene-flow activity

In the plants, with the entomophilous pollens, the pollen movement is the major component of gene-flow rather than the movement of seeds (Ehrlich and Murphy 1988). Flower pollens become attached on body parts of butterfly when they visit from flower to flower for sucking nectar; thereby the pollen is transferred onto another flower causing pollination (Gilbert 1972). The visit of butterflies to flowers is more versatile, starts from ground level vegetation to the canopy layer of trees. That is why almost all plants are visited and pollinated by the butterflies in an ecosystem (Bashar 2015).

Pollen transfer among flowers is a fundamental component of gene-flow activity on plants; and the pollen dispersal is happened by the behavioural activities of pollinators (Price and Waser 1979). Insects like bees as well as butterflies are strong and versatile pollinators, respectively. Though bees are densely pollinators, but they are confined to selective plants. On the other hand, butterflies are diverse pollinators because of their diverse and distance covering mobility. EBBL conducted experiments on the mobility of the butterflies and the honey bees to assess their gene-flow activities to the related plants. This experiment was done in Krishibari Butterfly Park (KBP), Savar, Dhaka during the year of 2015. The site is covered with plants of different vegetation layers (Fig. 1).

Fig. 1. (Left to the right) Foraging of *Spindasis nipalicus* on *Chromolaena odorata* plant (Bhawal National Park: 20 January, 2015); *Arhopala pseudocentaurus* is foraging on Kul plant (*Ziziphus mauritiana*); *Tecoma gaudichaudi* flowers are densely being foraged by the honey bee (*Apias dorsata*) (Krishibari Butterfly Park: 22 October, 2015).

During the experiments, 60 plants were selected to study the behavioural activities of butterflies and bees. Out of 60 plant species, 55 plants were visited by butterflies. On the other hand, honey bee visited only 5 plants out of 60 species. But number of visits made by the bees varied on plants (flowers) and it was 102-300 times/individuals per hours. In case of butterflies, number of visits by them varied on plants (both flowers and vegetative parts) from 1-42 times/ individuals per hours. Butterflies visited plant species from 15 to 46 mainly at a time and their foraging time ranges 1-62 seconds; whereas 1-2 plants mainly single plants at a time were visited by bees and their foraging time ranges 300×60 seconds; and continuously occurred the visits by the bees (Table 2).

The butterfly's mobility is distance-covering and more diverse than that of the bee visits (Herrera 1987). Their pollination activities maintain the plant population healthy in an area more than the other animal can do it. The diversity of pollination and diversity in gene-flow in the plant kingdom made by the butterflies are much wider and broadly functional (Bashar 2015, Herrera 1987).

Lycaenids like *Lampides boeticus*, *Arhopala pseudocentaurus* and *A. amantes* have a wide range of flower visiting pattern, and help in pollination for plants. Small lycaenids such as *Pseudozizeeria maha, Zizina otis, Neopithecops zalmora, Caleta decidia* and other species. visit *Spilanthes calva, Ageratum conyzoides, Panica indica* and *Gomphrena globosa* are responsible for the pollination of respective plants.

A single plant species can provide materials to perform different activities for lycaenids. Among 44 plant species, 31 species were found as nectar producers. At the same time, those plants utilized as resting and basking support and other support plant also involved in above mentioned behaviours. In the same way, 34 and 30 plant species were found to visit by the butterflies for resting and basking support,

respectively. Only nine species were identified as host plants for oviposition and as larval-pupal supports. As lycaenids utilized same plants for different-activity performance, plants were counted separately in different number on butterfly-activity basis but the total number of plants was fixed in forty four species. It was assessed that lycaenid butterflies were more abundant on flowering plants than other plants. In the experimental site, the population of lycaenids was focused to vary in different activities, maximum (396) lycaenids were busy in foraging and minimum (55) in egg-laying, whereas, 257 and 171 butterflies were found in resting and basking condition, respectively (Fig. 2).

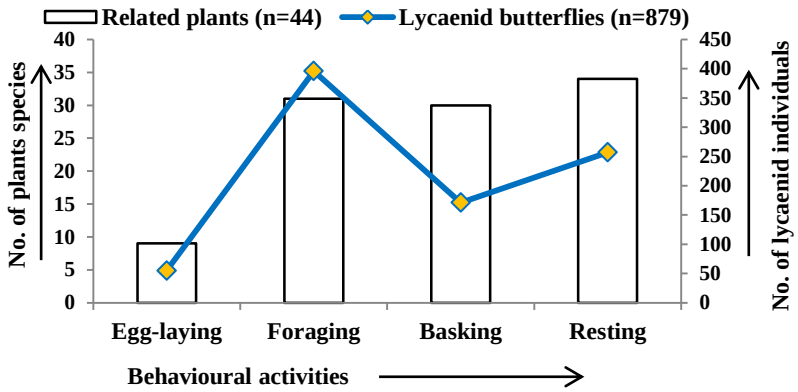

Fig. 2. Lycaenid individuals and their exploited plants species in the experimental site BRP, Gazipur and KBP, Savar during January-December, 2015.

Seasonal availability of plants has a marked correspondent in the abundance of lycaenid butterflies (Fig. 3). The highest number, 121 individuals were recorded in November and the lowest 38 individuals in April through the year round observation. The experiments reveal that the butterflies show two peaks of abundance in a year; once in November and another during the months of June-July of the year. Of the two peaks the November-peak shows always with the greater in number of butterflies than that of the June-July peak. But the greater duration of the peak was recorded in the second peak (June-July) time. This study reveals that the behavioural activities of lycaenid butterflies are deeply related with plant-phenological changes and seasonality.

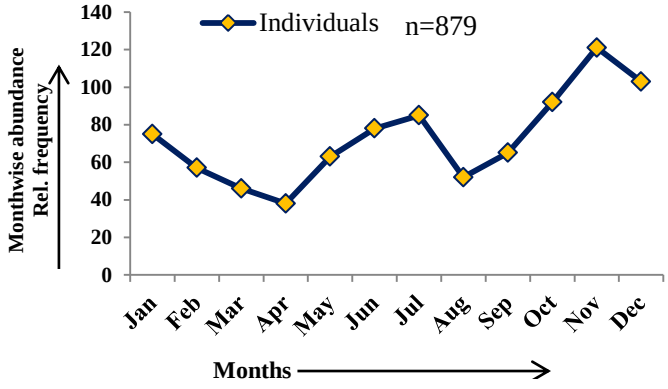

Fig. 3. Monthwise abundance of lycaenid butterflies during January-December, 2015 in the experimental site BRP, Gazipur and KBP, Savar.

Almost all butterflies require specific plant species to sustain their life style and larval development. Three types of plants (host, nectar and shelter plants) have been assessed. These plants are found all the layers of vegetation (canopy, man-height and soil surface forest) in a forest ecosystem (Bashar *et al.* 2006). Lycaenid butterflies show diversified activities and behaviours with different phenological stages of the related plants. This interactive process is important in the field of bio-resource identification. Lycaenids carry important role in the gene-flow mechanism of the plant kingdom and create good microclimatic condition in different ecosystem, especially in the forest ecosystem. The biotic interaction between lycaenid butterflies and their related plants can play a significant role in the conservation of biodiversity and other bioresources in its own way.

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