BUTTERFLY DIVERSITY IN THE THREE SELECTED AREAS IN DHAKA CITY, BANGLADESH

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Abstract: The diversity of butterfly species was studied from January to June 2015 in the three selected areas, viz. Ramna Park, Jagannath University Campus, and Baldha Garden in Dhaka city, Bangladesh. A total 75 species of butterfly belonging to 42 genera under 8 families were recorded from the study areas during the study period. Of them, 52 species (6253 individuals) of 8 families were found in the Ramna Park, 37 species (1430 individuals) of 7 families in the Jagannath University Campus and 20 species (320 individuals) of 6 families in the Boldha Garden. In these three study areas, 17 species, 14 genera and 6 families were in common. At the Ramna Park, the highest species richness included the family Lycaenidae (21.15%, 11 spp.) followed by Papilionidae (17.31%, 9 spp.), Pieridae (17.31%, 9 spp.), Nymphalidae (17.31%, 9 spp.), Hesperiidae (13.46%, 7 spp.), Danaidae (7.69%, 4 spp.), Satyridae (3.85%, 2 spp.), and the lowest was in the family Acriidae (1.92%, 1 spp.). At the Jagannath University Campus the highest number of species were recorded in the family Lycaenidae (21.62%, 8 spp.) and Hesperiidae (21.62%, 8 spp.) followed by Pieridae (18.92%, 7 spp.), Papilionidae (13.51%, 5 spp.), Nymphalidae (10.81%, 4 spp.), Danaidae (10.81%, 4 spp.), and the lowest was in Satyridae (2.70%, 1 spp.). The topmost butterfly species were recorded in the family Pieridae (25%, 5 spp.) followed by Lycaenidae (20%, 4 spp.), Nymphalidae (20%, 4 spp.), Papilionidae (15%, 3 spp.), and the lowest from the family Hesperiidae (10%, 2 spp.) and Danaidae (10%, 2 spp.) at the Baldha Garden. The maximum butterfly species were found in February to June (51 spp.), February (34 spp.), and April (16 spp.), and the lowest were in January (46 spp.), June (21 spp.) and January (8 spp.), respectively for the Ramna Park, Jagannath University Campus and the Baldha Garden. The peak of the population observed in May (n = 1285), March (n = 325), and May (n = 71), and the lowest was in January (n = 662), June (n = 145) and January (n = 21), respectively for the Ramna Park, Jagannath University Campus, and Baldha Garden. The Shanon's Diversity Index (H) and Simpson's Index (λ) indicated high butterfly diversity at the Ramna Park (H = 3.68, λ = 0.03), Jagannath University Campus (H = 3.20, λ = 0.06) and Baldha Garden (H = 2.50, λ = 0.13), respectively. The high Species Evenness in the Ramna Park (E = 0.93), Jaganath University Campus (E = 0.89) and the Baldha Garden (E =0.84) indicated that the species were evenly distributed. The calculated Sorenson's Coefficient (CC) was 0.47, which indicates that these three communities have quite a bit of overlap or similarity.

Key words: Butterfly Diversity, Diversity Index, Species Evenness, Community Similarity, Sorenson's Coefficient.

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INTRODUCTION

Butterflies are scaled wing insects, which belong to the order Lepidoptera, class Insecta and phylum Arthropoda (Nimblkar *et al.* 2011). They are large and diverse group of animals that are a conspicuous part of virtually all the world's terrestrial ecosystems (Singh 2011). There are more than 17,500 butterflies species under 17 families in the world and 90% of them have been documented (Robbins and Olper 1997). Among them, 1501 species have been recorded from India, 651 species from Nepal, 242 species from Srilanka, 237 species from Japan, 1182 species from Malaysia (Gaonkar 1996). A total of 305 butterflies species under 10 families have been reported from Bangladesh (Bangladesh, I. U. C. N. 2015).

Butterflies have been regarded as the sign of beauty and elegance in nature (Rafi *et al.* 2000). They are important aspects of ecosystem for their interaction with plants as pollinators and herbivores. They occupy a vital position or disproportionate effect on other organisms in different ecosystems and their occurrence and diversity has been invoked as an indicator of biological diversity and good health (Aluri and Rao 2002, Schmucki *et al.* 2015). Butterflies are keystone species of environmental changes as they are sensitive to habitat degradation and climate change (Kunte 2000) due to their rapid life cycle than higher animals and hence can be quicker to react to small changes in their environment (Lafontaine 1997).

Butterfly distribution, diversity, and abundance depend upon the key factors such as the greatest diversity of plants, habitats, topography, and climates (Sarder *et al.* 2016). Butterfly species are generally abundant in tropical area means tropical forest, Shal forest, and tropical rainforest. In Bangladesh very insufficient and limited works have been done on butterfly species diversity, species composition and its distribution pattern (Bashar 2014). Hence, in various ecological pockets of primary and disturbed (human dominated) habitat of butterfly fauna, it requires proper exploration (Sarder *et al.* 2016). Many species of butterflies depend on relic vegetation for survival, especially in urban areas (Blair 1999). Dhaka is the capital of Bangladesh and its climate is very favorable for butterfly species diversity having a tropical Savanna climate. However, no detailed work has done on the diversity of butterfly in Dhaka city. The aim of the present study was to evaluate the diversity, species richness and evenness and community similarity of butterfly fauna of the three selected places of the Dhaka city.

MATERIAL AND METHODS

Study area: The study was conducted in the following 3 selected areas in Dhaka city:

Ramna Park: It is located at the center of the Dhaka city. The geological coordinates are Latitude: 23°44'14.70" N Longitude: 90°24'03.4" E. The total area is 68.50 acres. There are 71 species of flowering trees, shrubs, perennials, and annuals, 41 species of forestry, 36 species of fruit-bearing plants, 33 species of medicinal plants, and 11 other species.

Jagannath University Campus: It is located at the southern part of the Dhaka city. The geological co-ordinates are Latitude: 23°42'32.4" N and Longitude: 90°24'38.16" E. Total area is 7.5 acres. It can be compared with the overall vegetation trend of the Dhaka city. Most of its areas are covered with the concrete buildings while the botanical garden, life, and earth science faculty are the oasis of this area. The variety of species stretches from shrubs to medicinal plant and flower-bearing trees.

Baldha Garden: It is located at the south eastern part of the Dhaka city. The geological co-ordinates are Latitude: 23°43'06" N and Longitude: 90°25'04" E. It is 3.15 acres compact area with variety of vegetation. There is a wide variation of floral species occurred in the Baldha garden especially in the psyche section. There are about 600 species of plants from around the world cultured here.

Materials: Sweep net, camera, collecting jar and polythene bag, forceps and needle, envelopes, permanent ink pen, label paper and magnifying glass were used as physical materials. The biological materials were butterflies and the related plants.

Sampling and Identification: Butterflies were observed during sunny days at a constant speed from 7 am to 2 pm (BST) four days in a month through walking transect (Caldas and Robbins 2003). Butterfly Identification was carried out by using the keys developed and used by Marshall de Niceville (1883), Bingham (1905), Evans (1932), Wynter-Blyth (1957), Talbot (1978), Bashar (2014), and Encyclopedia of fauna (Ahmed *et al.* 2009).

On the basis of abundance the observed butterflies were categorized in five categories in the three study areas. Species which observed a total of abundance exceeding 100 individuals were described as very common (VC: > 100 sightings), common (C: 50–100 sightings), not rare (NR: 15–49 sightings), rare (R: 3–14 sightings), very rare (VR: 1–2 sightings) (Nidup *et al.* 2014).

Diversity Analysis: The study used Shannon's Diversity Index (H) (Shannon and Weiner 1949) and Simpson's Index (λ) (Simpson 1949) as models as a measure of diversity. The equations for the two indices:

Shannon's Diversity Index (H) = $-\sum_{i=1}^{S} pi \ln pi$, Simpson's Index (λ) = $\sum_{i=1}^{S} pi^2$ Where, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations and S is the number of species. Optimum values of H are generally between 1.5 and 3.5 in most ecological researches, and the index is rarely greater than 4. Shannon's Diversity Index is mathematical measurement to define community composition (number of species) and commonness of species in a community. It increases as both the richness and the evenness of the community increase (Shannon and Weiner 1949). Opposite to this, the Simpson's Index (λ) is the mathematical representation of the similarity index. The range of λ is from 0 to 1 (Simpson 1949). Higher the index means lower the diversity. It is the strength of dominance, because it weights towards the abundance of the most common species and varies inversely with species diversity (Whittaker 1972).

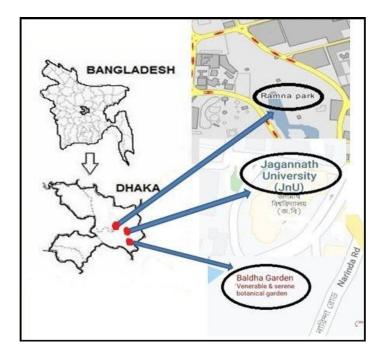


Fig. 1. Map of the Dhaka city in Bangladesh indicating the three study areas.

Simpson's Index of Diversity $(1-\lambda)$: It is a measure of diversity. The probability of two randomly selected individuals in a community belongs to different categories e.g. species. The value of 1- λ ranges between 0 and 1, where, high

scores (close to 1) show high diversity and low scores (close to 0) show low diversity (Simpson 1949).

Simpson's Reciprocal Index $(1/\lambda)$: The relative biodiversity of a community can be measured by it. It can be used to compare communities to identify intrinsic qualities. A high index value indicates a stable site with many different richness and low competition. A low index value shows a site with a few potential niches where only a few species dominate. The index value may alter in response to the ecological interference (MacDonald *et al.* 2017).

Species evenness (E): It refers to how close in number each species an environment is. The equation is: $E = \frac{H}{\ln(S)}$. The range of E is from 0 to 1. The value of E trends to 0 indicates that the species is more dominant in a community, E nears to 1 refers to evenly distributed (Shannon and Weiner 1949).

Community Similarity: It is measured by Sorenson's Coefficient (CC). The equation is: Sorenson's Coefficient (CC) = $=\frac{3C}{S1+S2+S3}$, Where C is the number of species the three communities have in common, S₁ is the total number of species found in community 1, S₂ is the total number of species found in community 3 (Sorensen 1948). Sorenson's coefficient gives a value between 0 and 1, the closer the value is to 1, the more the community dissimilarity is equal to 0 (Sorensen 1948).

RESULTS AND DISCUSSION

A total of 8003 butterflies of 75 species belonging to 42 genera under 8 families were recorded from the Ramna Park, Jagannath University Campus and Baldha Garden in Dhaka city (Table 1, 2 and 3). Of them, 52 species (6253 individuals) under 8 families were found in the Ramna Park (Table 1), 37 species (1430 individuals) belongings to 7 families in the Jagannath University Campus (Table 2) and 20 species (320 individuals) of under 6 families in the Baldha Garden (Table 3). In these three study areas, 17 species, 14 genera and 6 families were in common.

About 430 species of butterfly are known to Bangladesh (Bashar 2014). Out of the above estimated species only 75 species of 8 families were recorded from the three selected areas in the Dhaka city in this study. Present investigation revealed that there were no new species, these areas were excellent for the occurrence of common species availability, Sarder *et al.* (2016) stated that in disturbed habitats and anthropogenic affected sites species richness was

Family name	Scientific name	Common name	Monthly Abundance							Status	Pi	Pi ²	PilnPi
· ····			Jan	Feb	Mar	Apr	May	Jun	Total (n)				
Danaidae	Danaus chrysippus	Plain Tiger	12	14	18	27	24	31	126	VC	0.020150328	0.000406036	-0.0786776
	Danaus genutia	Striped Tiger	8	15	22	19	25	24	113	VC	0.018071326	0.000326573	-0.0725279
	Tirumala limniace exoticus	Blue Tiger	9	12	18	19	16	17	91	C	0.014553015	0.00021179	-0.0615586
	Euploea core	Common Crow	16	14	23	34	28	30	145	VC	0.023188869	0.000537724	-0.0872848
Papilionidae	Pachliopta aristolochiae	Common Rose	7	10	15	12	17	13	74	С	0.01183432	0.000140051	-0.0525059
	Pachliopta hector	Crimson Rose	1	0	3	2	5	1	12	R	0.001919079	3.68286E-06	-0.0120055
	Papilio polytes romulus	Common Mormon	6	11	18	29	24	32	120	VC	0.019190788	0.000368286	-0.0758674
	Papilio polymnestor	Blue Mormon	2	9	14	11	8	13	57	C	0.009115625	8.30946E-05	-0.0428230
	Papilio demoleus	Lime Butterfly	6	10	18	12	16	21	83	C	0.013273629	0.000176189	-0.0573683
	Papilio clytia	Common Mime	1	7	12	9	14	17	60	c	0.009595394	9.20716E-05	-0.0445847
				2		5		8					
	Graphium agamemnon	Tailed Jay	0		6		3		24	NR	0.003838158	1.47315E-05	-0.0213507
	Graphium doson axion	Common Jay	11	10	27	22	25	32	127	VC	0.020310251	0.000412506	-0.0791415
	Graphium sarpedon	Common	2	4	1	6	8	5	26	NR	0.004158004	1.7289E-05	-0.0227971
5 100	1999 B	Bluebottle	120	323	1222	222	1098	1992	1993	22			
ieridae	Catopsilia pyranthe	Mottled Emigrant	8	11	18	14	10	18	79	С	0.012633936	0.000159616	-0.0552275
	Catopsilia pomona	Lemon Emigrant	16	31	38	25	42	36	188	VC	0.030065569	0.000903938	-0.1053610
	Eurema blanda silhetana	Three-Spot Grass	84	90	121	133	98	112	638	VC	0.102031025	0.01041033	-0.2328836
		Yellow											
	Eurema hecabe hecabe	Common Grass	38	44	32	42	128	61	345	VC	0.055173517	0.003044117	-0.1598526
		Yellow											
	Appias libythea	Striped Albatross	18	13	22	31	38	29	151	VC	0.024148409	0.000583146	-0.0899174
				34									
	Leptosia nina	Psyche	48		44	66	47	52	291	VC	0.046537662	0.002165754	-0.142753
	Delias eucharis	Common Jezebel	12	19	28	46	34	31	170	VC	0.02718695	0.00073913	-0.0980094
	Cepora nerissa	Common Gull	0	4	12	7	9	8	40	NR	0.006396929	4.09207E-05	-0.032316
	Artogeia canidia indica	Indian Cabbage	5	3	16	18	8	6	56	C	0.008955701	8.02046E-05	-0.0422303
	ritogola canala malca	White	•		10	10	0	0	00	0	0.000000000	0.020102 00	0.0122.001
ymphalidae	Phalanta phalantha	Common Leopard	12	28	19	22	15	17	113	VC	0.018071326	0.000326573	-0.0725279
	Hypolimnas bolina bolina	Great Earthy	23	26	28	33	21	16	147	VC	0.023508716	0.00055266	-0.088166
		Great Eggfly	11	18	37	32	42	26		VC			-0.0963354
	Ariadne merione tapestrina	Common Castor	11	10		32	42		166		0.026547257	0.000704757	-0.0903354
	Euthalia aconthea	Common Baron	18	14	32	44	47	33	188	VC	0.030065569	0.000903938	-0.1053610
	Junonia atlites	Grey Pansy	7	13	28	31	18	16	113	VC	0.018071326	0.000326573	-0.0725279
	Junonia almanac	Peacock Pansy	19	10	29	33	42	14	147	VC	0.023508716	0.00055266	-0.088166
	Junonia orithya	Blue Pansy	0	6	8	15	4	7	40	NR	0.006396929	4.09207E-05	-0.032316
						28		31		VC			
	Junonia lemonias	Lemon Pansy	16	27	34 39		46		182	VC	0.029106029	0.000847161	-0.1029424
	Neptis hylas	Common Sailor	28	31		31	37	21	187		0.029905645	0.000894348	-0.104960
ycaenidae	Castalius rosimon	Common Pierrot	7	16	21	31	27	23	125	VC	0.019990405	0.000399616	-0.078212
	Jamides bochus	Dark Cerulean	3	18	23	16	27	6	93	С	0.014872861	0.000221202	-0.0625882
	Zizeeria karsandra	Dark Grass Blue	18	23	31	39	12	15	138	VC	0.022069407	0.000487059	-0.084163
	Pseudozizeeria maha maha	Pale Grass Blue	25	33	43	17	21	9	148	VC	0.023668639	0.000560204	-0.088606
	Prosotas dubiosa	Tailless Line Blue	1	8	2	0	3	0	14	R	0.002238925	5.01279E-06	-0.0136613
	FIOSOIAS UUDIOSA	I alliess Line Dide											
	Neopithecops zalmora	Quaker	6	11	9	4	15	7	52	С	0.008316008	6.9156E-05	-0.0398301
	Euchrysops cnejus	Gram Blue	18	16	31	17	13	11	106	VC	0.016951863	0.000287366	-0.0691191
	Chilades lajus	Lime Blue	11	17	12	14	21	8	83	С	0.013273629	0.000176189	-0.057368
	Chilades pandava	Plains Cupid	0	2	7	3	2	1	15	NR	0.002398849	5.75447E-06	-0.0144716
	Lampides boeticus	Pea Blue	28	31	34	43	39	33	208	VC	0.033264033	0.001106496	-0.113206
	Catochrysops strabo	Forget-me-not	17	21	18	27	32	15	130	VC	0.020790021	0.000432225	-0.0805256
esperiidae	Saustrus gremius	Indian Palm Bob	9	7	0	6	4	3	29	NR	0.004637774	2.15089E-05	-0.024921
	Borbo cinnara	Rice Swift	6	11	21	17	14	15	84	C	0.013433552	0.00018046	-0.057898
	Pelopidas conjuncta	Conjoined Swift	15	21	27	12	3	11	89	C	0.014233168	0.000202583	-0.0605219
	Pamara guttatus mangala	Straight Swift	0	2	7	4	19	33	65	C	0.01039501	0.000108056	-0.0474680
	Oriens gola	Common Dartlet	0	3	1	7	3	2	16	NR	0.002558772	6.54731E-06	-0.0152713
	Oriens goloides	Smaller Dartlet	3	11	15	12	19	17	77	C	0.012314089	0.000151637	-0.054145
	Badamia exclamationis	Brown Awl	2	5	3	2	0	7	19	NR	0.003038542	9.23273E-06	-0.0176125
Saturidae													
Satyridae	Elymnias hypermnestra	Common Palmfly	8	14	21	18	25	23	109	VC	0.017431633	0.000303862	-0.0705888
	Melanitis leda	Common Evening	18	21	27	31	46	37	180	VC	0.028786183	0.000828644	-0.1021293
Applid	Aaroos vieles	Brown	22	25	20	24	44	22	474	VC	0.007000040	0.000774000	0.000000
Acriidae Total (Σ)	Acraea violae	TwanyCoster	23 662	35 866	29 1162	24 1202	41 1285	22 1076	174 6253	VC	0.027826643	0.000774322 0.032403906	-0.0996683
	S = 52		002	000	1102	1202	1200	10/0	0203		- 10 C	0.032403906	-3.6823303

Table 1: Illustration how the various indices change as the relative number of each butterfly species change in the Ramna Park

The maximum population was recorded in the month of May (20.55%) followed by April (19.22%), March (18.58%), June (17.21%), February (13.85%) and the minimum of January (10.59%) (Fig. 6). increased but the uniqueness was less. These results are in good agreement with Padhey *et al.* (2012).

At the Ramna Park, family-wise species richness and butterfly population are shown in Fig. 3 and 5, respectively. The maximum species richness included the family Lycaenidae (21.15%, 11 spp.) followed by Papilionidae (17.31%, 9

Danatase Danatase Danatase Danatase Denatas generalis Plain Tiger 11 15 21 2 0 0 88 C 0.0081988 0.0081988 0.0081988 0.0081988 0.0081988 0.0081988 0.0081988 0.0081988 0.0081988 0.0080955 Papalionidae Dematase penuls Striped Tiger 8 12 9 2 0 0 31 NR 0.001783217 0.00309568 -0.0039957 0.00309577 0.003495505 0.002495157 0.0030957 0.003495505 0.002495157 0.003095295 0.0171458 0.0030957 0.003495505 0.002495157 0.003095295 0.0171457 0.003495505 0.002495157 0.003095295 0.0171581 0.0051988 0.00509295 0.003495505 0.003495505 0.002495155 0.02359514 0.005092958 0.005092958 0.005092958 0.00519544 0.00509356 0.00125714 0.0031768231 0.003495505 0.002495155 0.02378524 0.003295647 0.01258743 0.0031768231 0.003295647 0.011583811 0.002297970 0.003297692 0.	Family	Scientific name	Common name				bundar			Total	Status	Pi	Pi ²	PilnPi
chronipipus Trummale manas genular Trummale manas genular Structuse Stepse Tiger Paglionidae 12 (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	Name	Bussellis		Jan	Feb	Mar	Apr	May	Jun		-			
Timunalis minute Bluis Tiger 2 1 7 5 1 0 16 NR 0.01118811 0.000725189 0.0052085 Papilionidae Explose core Common Rose 12 10 2 1 0 0 24 NR 0.0171425170 0.0052085 0.00745355 0.0023056 0.0023076223	Danaidae		Plain Tiger											
exolicities commo Crow 1 4 1 5 1 0 24 NR 0.01783217 0.00281676 0.00386983 0.0077488 Papilionides Commo Rose 12 10 2 1 0 25 NR 0.01782517 0.00039638 0.0077485 Papilio defide Commo Mine 6 11 14 17 12 11 71 C 0.00485035 0.00245517 0.10030548 Opilio defide Commo Mine 1 3 0 2 7 4 3 16 NR 0.0118811 0.000152443 0.0605076 Opilio defide Common Aing 0 3 8 15 12 6 44 NR 0.01258741 0.000154443 0.050706 Papilo defide Common Aing 0 3 8 15 12 6 44 NR 0.01258741 0.00015447 0.02216415 0.02236722 Catapsilia Common Crose 18														-0.08305924
Papelinindae Papelinipationalise Common Rose 12 10 2 1 7 1 C 0.017482517 0.00306538 0.0074353 Papilio political Common 6 11 14 17 12 11 71 C 0.00495035 0.002465157 0.1409673 Papilio definic Common Mine 1 5 9 2 7 4 3 16 NR 0.01128544 0.00246515 0.00246515 0.00246516 0.00212554 0.0026365 0.00212554 0.0026365 0.00216544 0.00251664 0.00115569 0.000946746 0.00115644 0.000946746 0.00115644 0.000946746 0.00115644 0.000356474			Blue Tiger	2	1	7	5	1	0	16	NR	0.011188811	0.000125189	-0.05026955
aristoliciniar promulus Common 6 11 14 77 12 11 71 C 0.0485503 0.00245157 0.149077 Pienide strunulus Common 6 10 11 8 13 2 50 C 0.034965035 0.00125189 0.00052037 0.00052037 0.		Euploea core	Common Crow	1	4	13	5	1	0	24	NR	0.016783217	0.000281676	-0.06859931
Papilo polyse Papilo define Common Momon Papilo define Common Mise Momon Papilo define Common Mise Molece Common Mise Molece <thcommon mise<br="">Molece Common Mise Molece<td>Papilionidae</td><td>Pachliopta</td><td>Common Rose</td><td>12</td><td>10</td><td>2</td><td>1</td><td>0</td><td>0</td><td>25</td><td>NR</td><td>0.017482517</td><td>0.000305638</td><td>-0.07074394</td></thcommon>	Papilionidae	Pachliopta	Common Rose	12	10	2	1	0	0	25	NR	0.017482517	0.000305638	-0.07074394
Papilo denotusis Line Butterfly 6 10 11 8 13 2 50 C C 0.004865035 0.001222564 0.0022056 0.0022056 0.0020056 Brighiand doson axion axion axion pyrrenthe consol Mottled Emigrant 1 5 9 2 0 1 18 NR 0.012567413 0.000946746 0.000151443 -0.0502066 pyrrenthe consol Lemon Emigrant 0 3 8 15 12 6 44 NR 0.000750231 0.000947746 -0.0171502 pyrrenthe consol Three-Spott 28 35 44 42 31 33 213 VC 0.149951049 0.022196415 -0.2373202 pyrenthe consol Consol field Abatoss 11 13 0 0 1 2 27 NR 0.018951149 0.00025455 -0.012937 pilos inheiran consol Striped Abatoss 11 13 0 0 1 2 27 NR 0.018951149		Papilio polytes		6	11	14	17	12	11	71	С	0.04965035	0.002465157	-0.14908758
Papilo cythe Common Mime 1 3 0 0 1 2 7 R 0.004895105 2.3921-50 0.0052089 Preindae Common Jay 0 0 2 7 R 0.004895105 2.3921-505 0.0052089 Preindae Common Lingrant 0 3 8 15 12 6 44 NR 0.017587413 0.00018443 -0.0550762 Common Emigrant Dimens Emigrant 0 3 8 15 12 6 44 NR 0.0015857413 0.0004746 -0.1011150 Common Grass 18 24 23 31 28 27 151 VC 0.105594406 0.011150178 -0.2373922 Appils silvina Preyche 8 14 18 1 0 0 41 NR 0.02861319 0.000862445 -0.1018344 Delies eucharis Common Tag 2 0 0 1 0 3 R 0.0208				6	10	11	8	13	2	50	C	0.034965035	0 001222554	-0 11725198
axion pyranthe gyranthe pyranthe cabpellia pyranthe Euroma bacada silhetana silheta														-0.02603960
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Junonia almanac Peacock Pansy 1 0 4 7 10 1 23 NR 0.01603316 0.00025682 -0.0664252 Lycaenidae Jamides bochus Dark Cerulean 3 1 7 10 0 0 21 NR 0.016485315 0.00025682 -0.0664955 Zizeeria Dark Grass Blue 0 2 5 9 7 9 32 NR 0.022377622 0.00050758 -0.0664955 Pseudozizeeria Pale Grass Blue 5 13 11 6 8 7 50 C 0.034965035 0.00122554 -0.1172515 maha Prosolas dubiosa Tailless Line 0 3 5 9 12 0 29 NR 0.02027972 0.000411267 -0.0790530 Euchrysops Gram Blue 5 7 11 6 3 2 34 NR 0.021678322 0.0004695 -0.0800592 Chilades lajus Lampides		Junonia atlites	Grey Pansy	4	3	12	7	2	2	30	NR	0.020979021	0.000440119	-0.08106781
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Tagiade sjapetus Pied Flat 0 1 2 0 0 3 R 0.002097902 4.40119E-06 -0.0129373 Oriens gola Common Dartlet 1 3 3 2 0 0 9 R 0.006293706 3.96107E-05 -0.0318977 Oriens goloides Smaller Dartlet 3 2 3 0 1 0 9 R 0.006293706 3.96107E-05 -0.0318977 Badamia Brown Awl 0 4 7 15 13 5 44 NR 0.030769231 0.000946746 -0.0171150 exclamationis Common 3 8 7 2 0 1 21 NR 0.014685315 0.000215658 -0.0619853 Satyridae Mycalesis Common 3 8 7 2 0 1 21 NR 0.014685315 0.000215658 -0.0619853		Pamara guttatus	Straight Swift	2	4	2	1	2	0	11	R	0.007692308	5.91716E-05	-0.03744257
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Badamia Brown Awl 0 4 7 15 13 5 44 NR 0.030769231 0.000946746 -0.1071150 exclamationis exclamationis sexclamationis Satyridae Mycalesis Common 3 8 7 2 0 1 21 NR 0.014685315 0.000215658 -0.0619853 perseus blasius Bushbrown Satyridae Mycalesia Satyridae Saty		Oriens goloides	Smaller Dartlet	3	2	3	0	1	0	9	R	0.006293706	3.96107E-05	-0.03189779
Satyridae <i>Mycalesis</i> Common 3 8 7 2 0 1 21 NR 0.014685315 0.000215658 -0.0619853 <i>perseus blasius</i> Bushbrown		Badamia		-	_	_	-		-	-				-0.10711508
	Satyridae	Mycalesis		3	8	7	2	0	1	21	NR	0.014685315	0.000215658	-0.06198535
	Γotal (Σ)	perseus blasius S=37	Bushbrown	184	261	325	301	214	145	1430		1	0.058477187	-3.19854660

Table 2. Illustration how the various indices change as the relative number of each butterfly species change in the Jagannath University Campus

spp.), Pieridae (17.31%, 9 spp.), Nymphalidae (17.31%, 9 spp.), Hesperiidae (13.46%, 7 spp.), Danaidae (7.69%, 4 spp.), Satyridae (3.85%, 2 spp.), and the minimum was in the family Acriidae (1.92%, 1 spp.). The highest butterfly

population was in the family Pieridae (1958 individuals) followed by Nymphalidae (1283 individuals), Lycaenidae (1112 individuals), Papilionidae (583 individuals), Danaidae (475 individuals), Hesperiidae (379 individuals), Satyridae (289 individuals), and the lowest was in the family Acriidae (174 individuals) (Fig. 5). Among them, *Eurema blanda silhetana* (n=638) was the most dominant species followed by *Eurema hecabe* (n=345) and *Leptosia nina* (n=291) (Table 1). On the other hand, *Pachliopta hector* (n=12) was in the lowest population followed by *Prosotas dubiosa* (n=14) *Chilades pandava* (n=15), *Oriens gola* (n=16) and

Table 3. Illustration how the various indices change as the relative number of each butterfly species change in the Baldha Garden

Family name	Scientific	Common	Monthly Abundance						Total	Status	Pi	Pi ²	PilnPi
	name	name	Jan	Feb	Mar	Apr	May	Jun					
Danaidae	Danaus chrysippus	Plain Tiger	0	2	4	4	12	4	26	NR	0.08125	0.006601563	-0.20395573
	Euploea core	Common Crow	1	3	0	0	1	0	5	R	0.015625	0.000244141	-0.06498254
Papilionidae	Pachliopta aristolochiae	Common Rose	0	0	2	3	0	2	7	R	0.021875	0.000478516	-0.08361523
	Papilio polytes romulus	Common Mormon	0	2	1	1	0	2	6	R	0.01875	0.000351563	-0.07456052
	Papilio demoleus	Lime Butterfly	0	0	0	0	2	0	2	VR	0.00625	3.90625E-05	-0.03171983
Pieridae	Catopsilia pomona Eurema	Lemon Emigrant Three-Spot	0	3	2	7	4	3	19	NR	0.059375	0.003525391	-0.16766799
	blanda silhetana	Grass Yellow	0	5	3	10	12	9	39	NR	0.121875	0.014853516	-0.25651754
	Eurema hecabe hecabe	Common Grass Yellow	1	4	3	7	9	4	28	NR	0.0875	0.00765625	-0.21316019
	Lepto sianina	Psyche	5	4	4	6	0	1	20	NR	0.0625	0.00390625	-0.17328679
	Delias eucharis	Common Jezebel	2	0	0	0	1	0	3	R	0.009375	8.78906E-05	-0.04377851
	Hypolimnas bolinabolina	Great Eggfly	1	2	0	3	1	0	7	R	0.021875	0.000478516	-0.08361523
Nymphalidae	Junonia atlites atlites	Grey Pansy	1	2	1	3	2	4	13	R	0.040625	0.001650391	-0.13013697
	Junonia almanac	Peacock Pansy	0	0	0	3	2	3	8	R	0.025	0.000625	-0.09222198
	Neptishylas	Common Sailor	2	0	1	3	4	0	10	R	0.03125	0.000976563	-0.10830424
Lycaenidae	Zizeeria karsandra	Dark Grass Blue	0	2	1	3	3	0	9	R	0.028125	0.000791016	-0.10043708
	Pseudozizeer iamaha	Pale Grass Blue	8	11	15	18	15	24	91	С	0.284375	0.080869141	-0.35759061
	Zizula hylax	Tiny Grass Blue	0	0	3	1	1	0	5	R	0.015625	0.000244141	-0.06498254
	Euchrysops cnejus	Gram Blue	0	3	5	1	0	2	11	R	0.034375	0.001181641	-0.11585838
Hesperiidae	Parnara guttatus mangala	Straight Swift	0	3	2	1	2	0	8	R	0.025	0.000625	-0.09222198
	Tagiades japetus	Pied Flat	0	1	2	0	0	0	3	R	0.009375	8.78906E-05	-0.04377851
Total(Σ)	S=20		21	47	49	74	71	58	320		1	0.125273438	2.50239251

VC-Very Common (> 100 sightings), C - Common (50–99 sightings), NR - Not Rare (15–49 sightings), R - Rare (3–14 sightings), VR - Very Rare (1–2 sightings) (Nidup *et al.* 2014).

Badamia exclamationis (n=19) (Table 1). Among observed species, 28 were very common, 14 were common, 8 were not rare, and 2 were rare (Table 1). An analogous study was carried out by Koirala *et al.* (2020) at Gidakom Forest

management Unit, Thimpu, Bhutan that revealed a total of 90 species under 52 genera and 5 families. Nymphalidae was dominant with 38 species followed by Lycaenidae with 19, Pieridae with 15, Papilionidae with 11, and Hesperiidae with 7 species.

Family-wise species richness and butterfly population are shown in figure 3 and 5, respectively at the Jagannath University Campus. The maximum species were recorded in the family Lycaenidae (21.62%, 8 spp.) and Hesperiidae (21.62%, 8 spp.) followed by Pieridae (18.92%, 7 spp.), Papilionidae (13.51%, 5 spp.), Nymphalidae (10.81%, 4 spp.), Danaidae (10.81%, 4 spp.), and the minimum was in Satyridae (2.70%, 1 spp.). The highest butterfly population was in the family Pieridae (497 individuals) followed by Lycaenidae (257 individuals), Nymphalidae (208 individuals), Papilionidae (169 individuals),

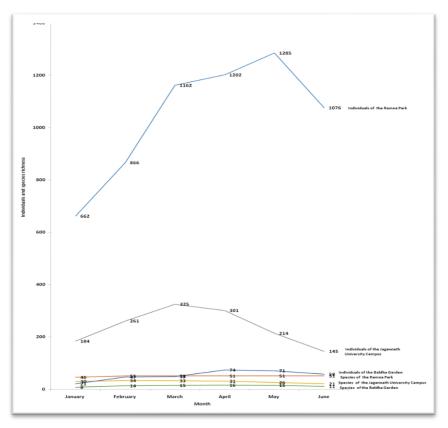


Fig. 2. Species richness and individuals curves for pooled data over six months.

Danaidae (157 individuals), Hesperiidae (121 individuals), and the lowest was in the family Satyridae (21 individuals). The maximum population was recorded in

the month of March (22.73%) followed by April (21.05%), February (18.25%), May (14.97%), January (12.86%) and the minimum of June (10.14%) (Fig. 6). Among them, *Eurema blanda silhetana* (n=213) was the most dominant species followed by *Eurema hecabe* (n=151) and *Phalanta phalantha* (n=113). On the other hand, *Tagiades japetus* (n=3) and *Delias eucharis* (n=3) were in the lowest

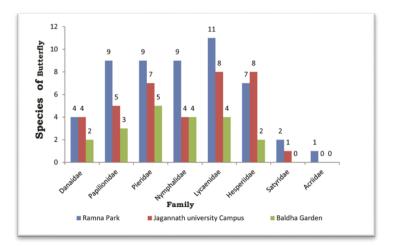


Fig. 3. Family-wise species at the three selected areas of the Dhaka city.

population followed by Papilio claytia (n=7), Lampides boeticus (n=8), Pelopidas conjuncta (n=8), Oriens gola (n=9), Oriens goloides (n=9), Parnara guttatus mangala (n=11), Graphium doson (n=16), Trirumala limniace (n=16), Catopsilia pyranthe (n=18), Borbo cinnara (n=18) and Saustrus gremius (n= 19) (Table 2). Among observed species, 3 were very common, 5 were common, 21 were not rare and 8 were rare (Table 2). Similar work of Sarder *et al.* (2016) recorded 42 species under 8 families at Keranigonj, out of the recorded families, Pieridae (36.59%) was in the highest population, then Nymphalidae (24.08%), Lycaenidae (16.49%), Dainaidae (13.89%), Hesperiidae (6.45%), Acriidae(1.29%), Satyridae (0.73%) and Papilionidae (0.45%).

At the Baldha garden, family-wise species richness and butterfly population are shown in Fig. 3 and 5, respectively. The topmost species were recorded in the family Pieridae (25%, 5 spp.) followed by Lycaenidae (20%, 4 spp.), Nymphalidae (20%, 4 spp.), Papilionidae (15%, 3 spp.), and the lowest from the family Hesperiidae (10%, 2 spp.) and Danaidae (10%, 2 spp.) at the Baldha Garden. The highest butterfly population was in the family Lycaenidae (116 individuals) followed by Pieridae (109 individuals), Nymphalidae (38

individuals), Danaidae (31 individuals), Papilionidae (15 individuals), and the lowest was in the family Hesperiidae (11 individuals). The maximum population was recorded in the month of April (23.12%) followed by May (22.19%), June (18.12%), March (15.31%), February (14.69%) and the minimum of January (6.56%) (Fig.6). Among them, *Pseudozizeeria maha* (n=91) was the most dominant species followed by *Eurema blanda silhetana* (n=39), *Eurema hecabe* (n=28) and *Danaus crysippus* (n=26). On the other hand, *Papilio demoleus* (n=2) was in the lowest population followed by *Delias eucharis* (n=3) *Tagiades japetus* (n=3), *Euploea core* (n=5), *Zizula hylax* (n=5) and *Papilio polytes* (n=6) (Table 3). Among observed species, 1 was common, 5 were not rare, 13 were rare, and 2 were very rare (Table 3). Nidup *et al.* (2014) recorded 91 species belonging to 5 major families of which 1 species was new in Royal Monas National Park, Bhutan. Nymphalidae was the most common (33%, n = 30), and the lowest was hesperiidae (12%, n=11).

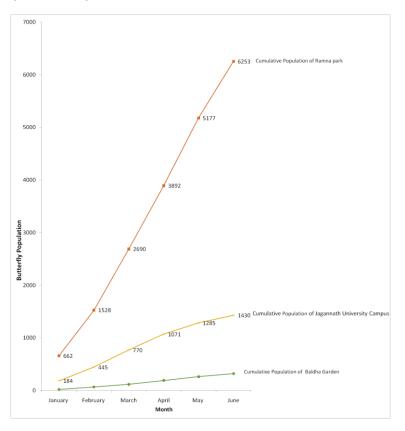


Fig. 4. Month-wise population cumulative curve of faunal assemblage of butterfly at the three selected areas of the Dhaka city.

The value of various indices of species diversity in the Ramna Park, Jagannath University Campus and Baldha Garden are shown in Table 1, 2 and 3, respectively. The values of Shannon's Diversity Index (H), the Simpson's Index (λ), Simpson's Index of Diversity (1- λ), Simpson's Reciprocal Index (1/ λ) and the Species Evenness (E), are 3.68, 0.032, 0.97, 30.86 and 0.93, respectively for the Ramna Park (Table 1). The values of Shannon's Diversity Index (H), the Simpson's Diversity Index (λ), Simpson's Index of Diversity Index (H), the Simpson's Diversity Index (λ), Simpson's Index of Diversity (1- λ), Simpson's Reciprocal Index (1/ λ) and the Species Evenness (E) are 3.20, 0.058, .094, 17.1 and 0.89, respectively for the Jagannath University (Table 2). The values of Shannon's Diversity Index (H), the Simpson's Index (λ), Simpson Reciprocal Index (1/ λ) and the Species Evenness (E) are 3.20, 0.058, .094, 17.1 and 0.89, respectively for the Jagannath University (Table 2). The values of Shannon's Diversity Index (H), the Simpson's Index (λ), Simpson Index of Diversity (1- λ) and Simpson Reciprocal Index (1/ λ) and the Species Evenness (E) are 2.50, 0.13, 0.87, 7.98 and 0.84, respectively for the Baldha Garden (Table 3).

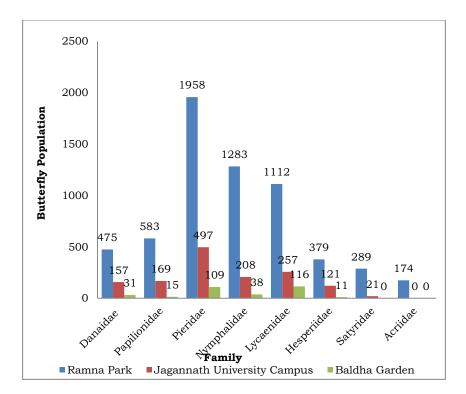


Fig. 5. Family-wise population of butterfly at the three selected areas of the Dhaka city.

The diversity indices H and λ appear useful as it incorporates species richness (Ganeshaih *et al.* 1997). In this study Shanon's Diversity Index appears to have high value (H=3.68 for the Ramna Park, H=3.20 for the Jagannath University Campus and H=2.50 for the Baldha garden) and Simpson's Index (λ) gave the

low value (λ = 0.03 for the Ramna park, λ =0.06 for the Jagannath University and λ =0.13 for the Baldha garden) indicating plenteous diversity richness for butterfly species in these three selected areas. These also indicate

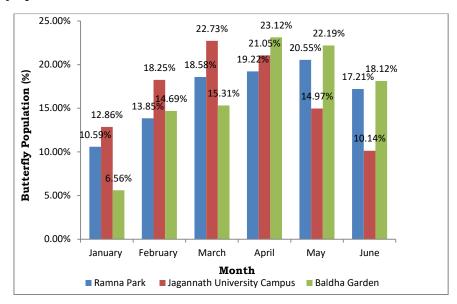


Fig. 6. Month-wise population of butterfly (%) at the three selected areas of the Dhaka city.

Table 4. Community Similarity among the Ramna Park, Jagannath University Campus and Baldha Garden

Community Similarity is measured by Sorenson's Coefficient (CC). The equation is: Sorenson's Coefficient (CC) = $=\frac{3C}{S1+S2+S3}$ Where, The number of species in the three communities (Ramna Park, Jagannath University Campus and Baldha Garden) have in common (C) = 17, The total number of species found in the Ramna Park (S₁) = 52, The total number of species found in the Jagannath University Campus (S₂) = 37, and the total number of species found in the Baldha Garden (S₃) = 20. Sorenson's Coefficient (CC) = $=\frac{3C}{S1+S2+S3} = \frac{3x17}{52+37+20} = \frac{51}{109} = 0.47.$

that the highest diversity of these three areas is in the Ramna Park, and the lowest is in the Baldha Garden, since the value of λ decrease with the increasing diversity (Ludwing and Reynolds 1988). The Shannon-Wiener Index of diversity has demonstrated some sort of contradictory outcome, interference habitat or forest gaps have higher butterfly diversity than that in closed canopy or dense forests (Wood and Gillman 1998). Nidup *et al.* (2014) described Shannon's Diversity Index 3.16 indicated high butterfly diversity in Royal Monas National Park, Bhutan. Simpson's Index of Diversity of these three areas indicated high

butterfly diversity of which the topmost diversity was in the Ramna Park, and the lowest was in the Baldha Garden.The Simson's Reciprocal Index is also shown high butterfly diversity of these areas. According to the index values the maximum and minimum diversity was found as same as Simpson's Index of Diversity

Evenness index provides and insight into the relative abundance of the species in the community. The value of E tend to be zero indicates that the species become more dominant in a community (Sanjayan *et al.* 1995). In this study, the value of E (0.93) for the Ramna Park is so high while the Jagannath University (E=0.89) and Baldha Garden (E=0.84) also have high value of E that indicates the species are evenly distributed.

Community Similarity among the Ramna Park, Jagannath University Campus and Baldha Garden is shown in Table 4. The value of Sorenson's Coefficient (CC) of these communities is 0.47. The range of it is from 0 to 1, the closer the value is to 1, the more the communities have in common (Sorensen 1948). According to Sorenson's Coefficient these three communities have quite a bit of overlap or similarity.

CONCLUSION

The present research has revealed butterfly biodiversity and prepared checklists in the study areas. This study revealed 75 butterfly species belongings to 42 genera under 8 major families. On the basis of the data, conservation of wide range of indigenous butterfly fauna in these small human dominated landscapes might be a good model for maintaining most favourable habitat within fragments.

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