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# Rapid assessment of diversity and conservation of butterflies in Rowa Wildlife Sanctuary: An Indo-Burmese hotspot - Tripura, N.E. India

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**Abstract:** The Rapid Biodiversity Assessment (RBA) method was used in Rowa Wildlife Sanctuary (WLS) in Tripura, northeast India to prioritize areas for conservation in remote and threatened habitats. Butterflies were used as indicator taxa to estimate species richness and diversity in three habitat types of the sanctuary: regenerated secondary forest, a botanical garden and bamboo bush. Fifty-three species from 36 genera and 5 families were recorded. The Jacknife 1 estimator provided the most accurate estimate of expected butterfly species richness, which statistically supports the reliability of the RBA. Eight of the recorded species are protected under the Indian Wildlife Protection Act, Red Data Book of Indian butterflies, IUCN Red List and CITES. Occurrence of potentially threatened and endangered species and new records of eight species to Tripura state, during a three-day study, highlights the conservation importance of Rowa WLS (0.85 sq. km) as well as the efficiency of the RBA for conservation biodiversity.

**Key words:** Butterflies, indicator taxa, Rapid Biodiversity Assessment, Rowa Wildlife Sanctuary, threatened habitat.

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## Introduction

Worldwide, humid tropical regions are known for high biodiversity and high endemism of flora and fauna (Hamer & Hill 2004), which are under increasing threat of species extinctions due to deforestation and habitat loss caused by increasing demands of human populations. It is estimated that about 140000 species become extinct every year from the world (Frezina & Rojarina 2012). Despite several explorations of tropical regions in the past, much work on documenting basic biodiversity remains to be done (Sewlal & Hailey 2014); there are immediate needs for conservation and the lack of data has often been a barrier to effective planning and implementation of conservation actions in highly diverse tropical ecosystems, particularly in remote areas. Conservation International (CI) introduced the Rapid Assessment Programme (RAP) in 1990 for species rich areas, to create baseline data which includes species checklists, records of habitat structure, vegetation type and records of disturbance and anthropogenic pressures in a short time (Alonso *et al*. 2011). This programme has proven to be useful in making decisions about conservation or remediation measures for remote ecosystems and threatened areas. Many of the biodiversity-rich areas in remote locations of hot and humid tropics in northeast India are yet to be explored for records of fauna and flora; this is especially true for insect diversity, which represent a major proportion of the faunal diversity of tropical forests (Clark & May 2002; Leather *et al.* 2008; Lewis & Basset 2007; Putz *et al.* 2001). To address this, Rapid Biodiversity Assessment (RBA) is considered

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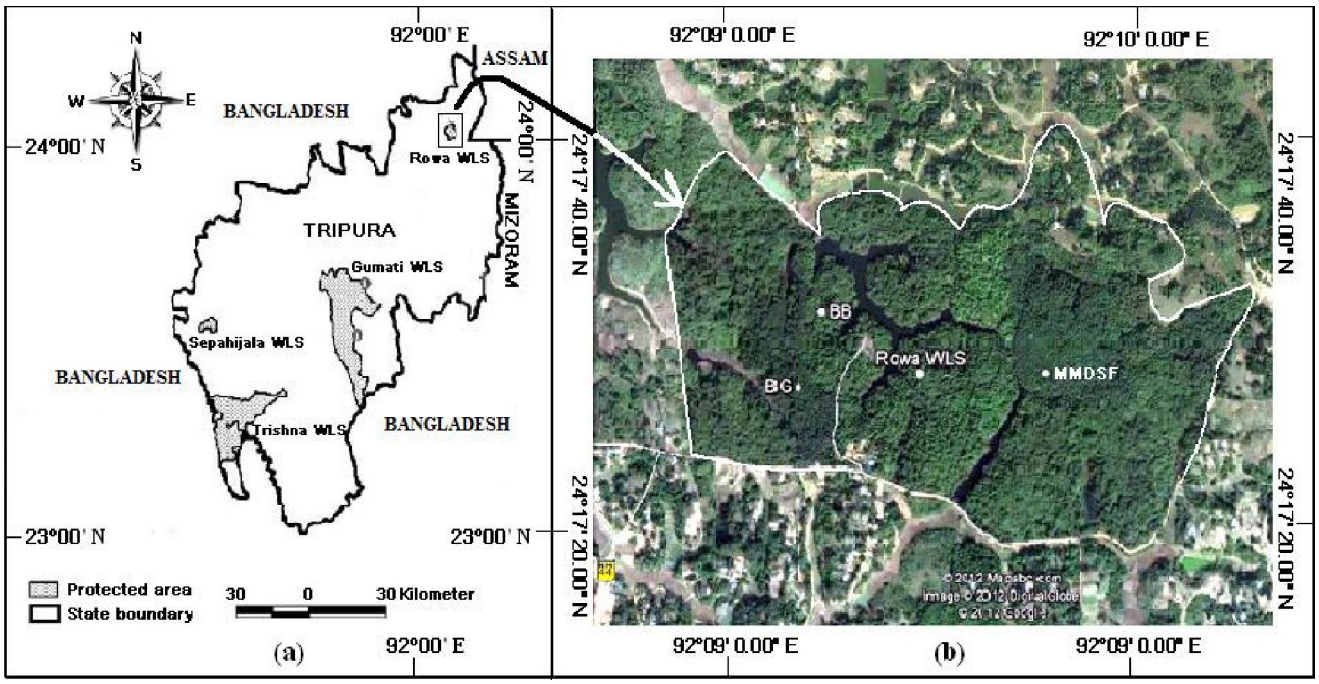


**Fig. 1.** Map of Tripura state showing the study area (a) and the three habitat types (b): MMDSF = Mixed moist deciduous secondary forest, BG = Botanical garden, and BB = Bamboo bushes.

to be a cost- and time- effective method of exploring the biodiversity of tropical habitats. RBA is considered to be a good tool to predict species richness utilizing indicator taxa (Pearson & Cassola 1992; Pearson 1994). Butterflies are a promising group of insects for rapid assessment because they are widespread, conspicuous and easily recognizable, taxonomically well-known and effective indicators of forest health (Bhardwaj *et al.* 2012; Nordqvist 2009). Also, butterfly diversity serves as a surrogate for biodiversity because these insects are highly dependent on plant diversity (Ferrer-Paris *et al.*2013; Janz *et al.* 2006).

Previous studies from the Tripura state (10492 sq. km) of India have recorded 107 species of butterflies (Agarwala *et al.* 2010; Majumder *et al.* 2012a; Mondal *et al.* 2002). Among other north-eastern states, 104 species are known from Meghalaya (22429 sq. km), 695 species from Sikkim (7096 sq. km) (Haribal 1992), 333 species from Nagaland (16579 sq. km) (Gupta 2006; Gupta & Maulik 2006; Gupta & Majumder 2006), 96 species from Mizoram (21081 sq. km) (Ghosh & Majumder 2007; Gupta 2007; Gupta & Maulik 2007), 134 species from Arunachal Pradesh (83743 sq. km) (Borang *et al.* 2008), and 962 species of butterflies from Assam (78438 sq. km) (Evans 1932; Talbot 1939; Wynter-Blyth 1957) have been recorded. A total of 1501 species of butterfly are known to exist throughout India (Kehimkar 2008). This high diversity of butterflies in northeastern states affirms the floral and faunal richness of this biogeographical region. The aim of the present study was to (i) explore the hitherto unknown butterfly diversity and species composition of Rowa Wildlife Sanctuary (Rowa WLS), (ii) to understand habitat relationship of recorded species, and (iii) to evaluate the efficiency of RBA for diversity exploration in biodiversity rich areas. The results are analysed with regard to conservation importance of the sanctuary and discussed in relation to other short-time studies.

## Methodology

### *Study area*

A three-day RBA study was conducted in May, 2011 in the Rowa WLS (area: 0.85 km$^2$; latitude: N 24° 17′, longitude: E 92° 10′) which is located in the northern district of Tripura and is a part of the western fringe of the Indo-Burma biodiversity hotspot (Fig. 1). The sanctuary is characterized by undulating land with narrow and wide ditches between rising hillocks (maximum height: 77 m above mean sea level), the presence of several perennial water bodies, and the occurrence of sparse clusters

of human habitation dominated by indigenous natives dependent on natural resources. The vegetation complex of the sanctuary is comprised of mixed moist deciduous secondary forests, dry deciduous secondary forests, patches of bamboo bushes, and scattered plants of *Cassia siamea* Lam., *Senna sophera* (L.) Roxb. and *Terminalia arjuna* (Roxb.) (Majumdar *et al*. 2010). The approximate canopy heights of wooded regions range from 5 m to 20 m, and leaf litter of the forest floor ranges from 3 cm to 5 cm in thickness. A botanical garden on a small patch of the sanctuary has been established for the conservation and exhibition of floral diversity for educational purposes and tourism. For this study three different habitats which represent landscape gradients of the Rowa sanctuary were chosen: (i) mixed moist deciduous secondary forest (MMDSF; 24° 17′ 33.64″ N, 92° 09′ 54.54″ E) consisting of deciduous trees like *Tectona grandis* L., *Shorea robusta* Gaertn, *Gmelina arborea* L., *Cassia* spp. with a limited understorey of herbs and shrubs, (ii) botanical garden (BG; 24° 17′ 29.08″ N, 92° 09′ 54.57″ E) represented by a mix of *Toona ciliata* M. Roem, *Albizia procera* (Roxb.) Benth, *Delonix regia* (Bojer) Raf., *Michelia champaca* L., *Trema orientalis* (L.) BI, *Adhatoda vasica* Nees and *Aloe vera* (L.) Brum. f., *Polyalthia longifolia* Sonn., *Citrus medica* L., and *Murraya koenigii* (L.) Sprengel among others, and (iii) bamboo bush (BB, 24° 17′ 36.46″ N, 92° 10′ 04.90″ E) colonised by bushes of several species like *Bambusa affinis* Munro (OHRN), *B. balcooa* Roxb., *B. polymorpha* Munro and *B. tulda* Roxb. A large number of medicinal herbs, aromatic plants, horticulture plants, climbers, colourful orchids, and fruit bearing plants also occur in the sanctuary which is inhabited by numerous species of birds, wild reptiles and primates (Choudhury 2010; Deb 1981; Economic Review of Tripura 2008-2009; Majumder *et al*. 2012b). The province has a tropical climate, with four main seasons: winter (late November to February), summer (March to May), monsoon (June to September) and autumn (October to mid November). The average annual temperature varies from a minimum of 10 °C in winter to a maximum of 35 °C in summer. During the monsoon season, southwestern monsoons bring the majority of the precipitation (65 %) to a province which receives 2000 mm to 2500 mm average annual rainfall and has an average humidity of 50 % to 74 % during the summer and above 85 % in the monsoon season (Keshari 2011).

### *Data collection*

A modified Pollard Walk sampling method (Pollard & Yates 1993), was adopted in order to maximize the collection in a short time which is a combination of line-transect distance sampling and a point-count method (Brown & Boyce 1998; Buckland *et al*. 2001). Three 300 × 5 m long transects were laid inside the sanctuary in the three different habitat types (MMDSF, BG and BB). These were separated by a mean distance of about 400 m. The survey routes of transects traversed diverse landscape elements of the sanctuary. The three transects were walked in succession between 0800 h to 1200 h local time on each of the three days of the study. On average, each transect of 300 m length was covered in about 70 minutes with an interval of about 10 - 15 minutes to cover inter-transect distance. The order of succession in time was alternated on the three days so that each of the transect received equal preference of diurnal time. In addition, six fixed canopy traps were used, two in each survey route separated by a distance of 150 m at approximately 5 m -10 m height, baited with a mixture of rotten fruits, to attract active and high flying butterflies. Butterflies captured in traps were recorded every day for each sampling site. Sampling data of canopy traps were incorporated in the transect data of the respective transect. Binoculars (Vista Le 8 × 40 porro prism compact binocular) were used for closer view of butterflies sighted at height.

Point counts were made at 100 m intervals along transects and 10 minute halts were made at every point to collect data and to take photographs. The walking pace was kept steady for recording of butterfly species in maximum numbers. Records of GPS data for each transect, abundance of each butterfly species in transects and traps were also recorded. At least one individual of every species in the field was collected with a sweep net; otherwise butterflies were photographed using high zoom digital cameras. Collected butterflies were identified using field guides (Haribal 1992; Kehimkar 2008; Kunte 2000), and followed the classification by Ackery (1984). All the butterfly specimens are collected, processed and preserve according to Wynter-Blyth (1957). Vouchers of collected butterfly specimens and photographs are maintained in the Ecology and Biodiversity Laboratory, Department of Zoology, Tripura University.

**Table 1.** List of butterfly species and their mean relative abundance recorded in the three habitats of Rowa WLS.

| Zoological name | Family | No. of individuals | Mean Relative Abundance (RA) | Habitat types | | |
|---|---|---|---|---|---|---|
| | | | | MMDSF | BG | BB |
| *Melanitis leda* (Linnaeus, 1758) | Nymphalidae | 12 | 6.49 | X | X | X |
| *Mycalesis perseus* (Fabricius, 1775) | Nymphalidae | 8 | 4.32 | X | X | X |
| *Ypthima baldus* (Fabricius, 1775) | Nymphalidae | 7 | 3.78 | X | X | X |
| *Lethe europa* (Fabricius, 1785)*• | Nymphalidae | 7 | 3.78 | | | X |
| *Papilio nephelus* (Boisduval, 1836) | Papilionidae | 7 | 3.78 | X | X | X |
| *Catopsilia pomona* (Fabricius, 1775) | Pieridae | 7 | 3.78 | X | X | |
| *Euploea core* (Cramer, 1780) • | Nymphalidae | 6 | 3.24 | X | | X |
| *Ypthima huebneri* (Kirby, 1871) | Nymphalidae | 6 | 3.24 | X | X | X |
| *Loxura atymnus* (Cramer, 1782) | Lycaenidae | 5 | 2.70 | X | X | X |
| *Catopsilia pyranthe* (Linnaeus, 1758) | Pieridae | 5 | 2.70 | X | X | |
| *Zizeeria karsandra* (Moore, 1865) | Lycaenidae | 5 | 2.70 | X | X | |
| *Papilio memnon* (Linnaeus, 1758) | Papilionidae | 5 | 2.70 | X | X | |
| *Zizina otis* (Fabricius, 1787) | Lycaenidae | 5 | 2.70 | X | X | |
| *Orsotrioena medus* (Fabricius, 1775) | Nymphalidae | 4 | 2.16 | | X | X |
| *Athyma perius* (Linnaeus, 1758) | Nymphalidae | 4 | 2.16 | X | X | |
| *Patchliopto aristolochiae* (Fabricius, 1775) | Papilionidae | 4 | 2.16 | X | X | X |
| *Eurema hecabe* (Linnaeus, 1758) | Pieridae | 4 | 2.16 | X | X | |
| *Leptosia nina* (Fabricius, 1793) | Pieridae | 4 | 2.16 | | X | |
| *Discolampa ethion* (Westwood, 1851) | Lycaenidae | 4 | 2.16 | X | X | |
| *Ariadne ariadne* (Linnaeus, 1763) | Nymphalidae | 4 | 2.16 | X | X | X |
| *Neptis hylas* (Linnaeus, 1758) | Nymphalidae | 3 | 1.62 | X | X | |
| *Junonia hierta* (Fabricius, 1798) | Nymphalidae | 3 | 1.62 | X | X | |
| *Danaus genutia* (Cramer, 1779) | Nymphalidae | 3 | 1.62 | X | X | |
| *Lethe chandica* (Moore, 1857)* | Nymphalidae | 3 | 1.62 | | | X |
| *Junonia atlites* (Linnaeus, 1763) | Nymphalidae | 3 | 1.62 | X | X | |
| *Junonia almana* (Linnaeus, 1758) | Nymphalidae | 3 | 1.62 | X | | |
| *Papilio polytes* (Linnaeus, 1758) | Papilionidae | 3 | 1.62 | X | X | |
| *Graphium agamemnon* (Linnaeus, 1758) | Papilionidae | 3 | 1.62 | X | | |
| *Pieris canidia* (Sparrman, 1768) | Pieridae | 3 | 1.62 | X | X | |
| *Appias lyncida* (Cramer, 1777 •) | Pieridae | 3 | 1.62 | X | | |
| *Telicota colon* (Fabricius, 1775) + | Hesperiidae | 3 | 1.62 | X | | X |
| *Iambrix salsala* (Moore, 1866) | Hesperiidae | 3 | 1.62 | X | X | |
| *Castalius rosimon* (Fabricius, 1775) • | Lycaenidae | 3 | 1.62 | X | | |
| *Pantoporia hordonia* (Stoll, 1790) • | Nymphalidae | 2 | 1.08 | X | | |
| *Eurema blanda* (Boisduval, 1836) | Pieridae | 2 | 1.08 | X | | |
| *Tanaecia lepidea* (Butler, 1868) | Nymphalidae | 2 | 1.08 | X | | |
| *Parantica aglea* (Stoll, 1781) + | Nymphalidae | 2 | 1.08 | X | X | |
| *Junonia iphita* (Cramer, 1782) | Nymphalidae | 2 | 1.08 | X | | |
| *Junonia lemonias* (Linnaeus, 1758) | Nymphalidae | 2 | 1.08 | X | | |

Contd...

**Table 1.** Continued.

| Zoological name | Family | No. of individuals | Mean Relative Abundance (RA) | Habitat types | | |
|---|---|---|---|---|---|---|
| | | | | MMDSF | BG | BB |
| *Sarangesa dasahara* (Moore, 1865)* | Hesperiidae | 2 | 1.08 | X | | |
| *Megisba malaya* (Horsfield, 1828)* | Lycaenidae | 2 | 1.08 | X | | |
| *Sarangesa purendra* (Moore, 1882*) | Hesperiidae | 2 | 1.08 | X | | |
| *Appias libythea* Fabricius, 1775 • | Pieridae | 2 | 1.08 | X | | |
| *Baoris farri* (Moore, 1878)• | Hesperiidae | 2 | 1.08 | X | | X |
| *Papilio demoleus* (Linnaeus, 1758) | Papilionidae | 2 | 1.08 | | X | |
| *Zemeros flegyas* (Cramer, 1780) | Riodinidae | 2 | 1.08 | X | | |
| *Graphium sarpedon* (Linnaeus, 1758) | Papilionidae | 1 | 0.54 | | X | |
| Troides helena (Linnaeus, 1758) • | Papilionidae | 1 | 0.54 | | X | |
| *Hebomoia glaucippe* (Linnaeus, 1758) | Pieridae | 1 | 0.54 | X | | |
| *Notocrypta curvifascia* (C & R Felder, 1862)* | Hesperiidae | 1 | 0.54 | X | | |
| *Spialia galba* (Fabricius, 1793)* | Hesperiidae | 1 | 0.54 | X | | |
| *Papilio castor* (Westwood, 1842*) | Papilionidae | 1 | 0.54 | X | | |
| *Charaxes bernardus* (Fabricius, 1793) | Nymphalidae | 1 | 0.54 | | X | |

* New record of Tripura, • Threatened species, + Singletons, X present in habitat type.

### *Data analysis*

The data of line transects, point counts and vertical traps recorded in three days were pooled for each habitat (MMDSF, BG and BB) for comparison and statistical analysis. The Shannon diversity index ($H_s$) (Shannon 1948), Simpson's Dominance index (*Dm*) (Simpson 1949), and Pielou's Evenness Index (*J'*) (Magurran 1988; Pielou 1969) were determined using the software PAST version 1.89 (Hammer *et al*. 2001). Butterfly species of this study were ranked according to their relative abundance and K-dominance curves were drawn for each habitat as well as for Rowa sanctuary as a whole using the software Biodiversity Pro (Lambshead *et al*. 1997). Non-parametric species richness estimates Chao1 and Jacknife 1 were used to determine the expected number of species in sampling sites. The software Biodiversity Pro (Lambshead *et al*. 1997) was used to predict individual-based rarefaction curves of study sites (MMDSF, BG and BB) as well as a species accumulation curve for Rowa WLS. Community-level analysis among the three habitats using single linkage cluster analysis based on Bray-Curtis similarity was also performed using this package (McAleece 1998). One-way ANOVA was performed at the 5 % probability level to compare butterfly population variance across three different habitats using the software PAST 1.89 (Hammer *et al*. 2001). For this purpose the population data of three days from each habitat, representing random distribution, were used. Thus, a total of nine samples recorded on three days from three habitats were compared for variance to test whether differences in habitats in the study area influenced the populations recorded in the study.

## Results

### *Butterfly diversity*

A total of 185 individual butterflies representing 53 species from 36 genera and 5 families were encountered (Table 1). Out of these, seven species are listed in the threatened category in south Asia (Gupta & Mondal 2005; IUCN 2007; MoEF 1997) (Table 2), and another species *Troides helena* (L.) is listed by both CITES and IUCN as globally threatened (Collins & Morris 1985; Lonny 2000) (Plate I). Eight butterfly species are reported here as new records to the Tripura state (Table 1). Nymphalidae was recorded to be a species rich family represented by 22 species over 89 individuals, Lycaenidae was found to be a relatively species poor family represented by 6 species over 24 individuals, and Hesperiidae was

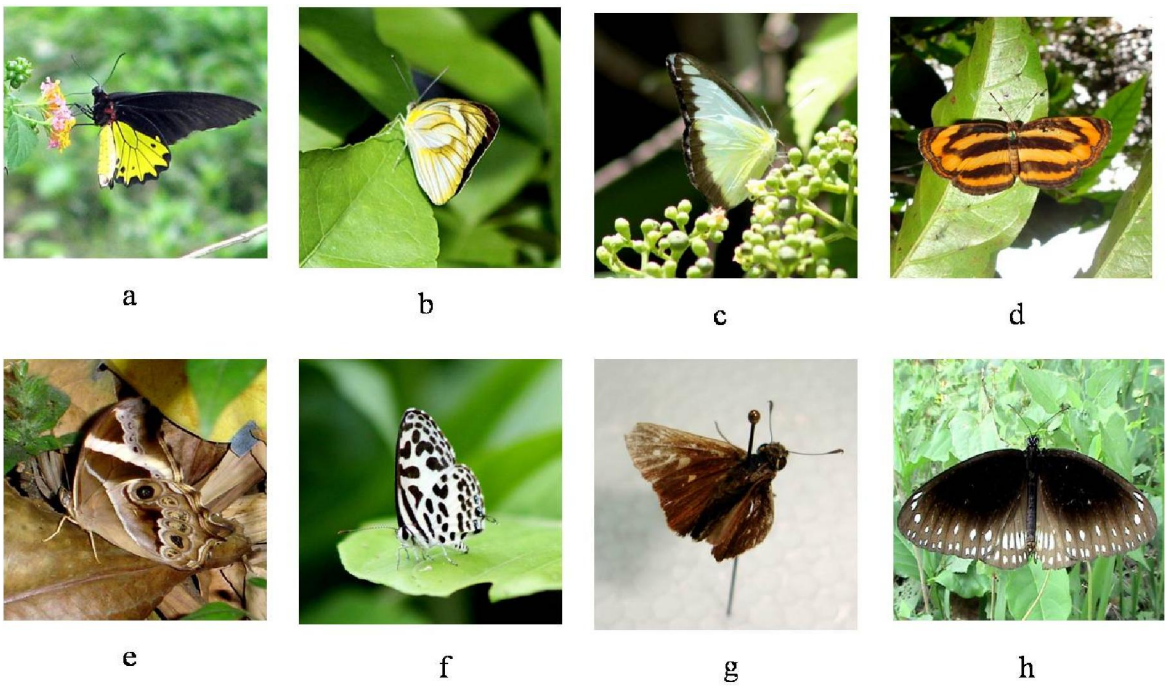


**Plate I.** Photographs of butterfly species recorded as threatened in Rowa WLS: a = *Troides helena*, b = *Appias libythea,* c = *Appias lyncida*, d = *Pantoporia hordonia*, e = *Lethe europa*, f = *Castalius rosimon*, g = *Baoris farri*, h = *Euploea core*.

**Table 2.** List of butterfly species recorded in Rowa sanctuary considered as threatened or endangered by various national and international agencies.

| Zoological name | Source | Status |
|---|---|---|
| *Troides helena* | IUCN Red List / CITES | Vulnerable/ Appendix II G |
| *Appias libythea* | IUCN Red List/ IWPA | Near Threatened/ Schedule IV |
| *Appias lyncida* | IUCN Red List/ IWPA | Near Threatened/ Schedule II |
| *Pantoporia hordonia* | IUCN Red List | Near Threatened |
| *Lethe europa* | Red Data Book | Critically Endangered |
| *Castalius rosimon* | Red Data Book/ IWPA | Vulnerable/ Schedule I |
| *Baoris farri* | IWPA | Schedule IV |
| *Eoploea core* | IWPA | Schedule IV |

Abbreviations: IUCN - International Union for Conservation of Nature and Natural Resources, CITES - Convention on International Trade in Endangered Species of Wild Flora and Fauna, IWPA - Indian Wildlife Protection Act, 1972.

**Table 3.** Diversity assessment parameters of butterflies recorded in Rowa WLS.

| Diversity assessment parameters | BG | BB | MMDSF | Rowa WLS |
|---|---|---|---|---|
| Shannon Diversity Index (*Hs*) | 3.28 | 2.44 | 3.70 | 3.80 |
| Simpson Dominance Index (*Dm*) | 0.04 | 0.10 | 0.03 | 0.03 |
| Evenness Index (*J'*) | 0.96 | 0.92 | 0.97 | 0.96 |
| Chao1 (a) | 32.20 | 45.95 | 54.5 | 54.5 |
| Jacknife1 (b) | 28.12 | 57.35 | 69.66 | 53 |
| Average of (a) and (b) | 30.16 | 51.65 | 62.08 | 53.75 |
| Observed number of species | 30 | 14 | 45 | 53 |
| Sampling completeness (%) | 99.47 | 27.11 | 72.49 | 98.60 |

found to be the least abundant with 14 individuals only representing 7 species. Members of Nymphalidae were found to be the most abundant in all of the three habitats. Habitat-wise, 6 specialist species of subfamily Satyrinae showed preference

for closed-canopy forests; these included *Melanitis leda* (L.), *Mycalesis perseus* (F.), *Ypthima baldus* (F.) and *Y. huebneri* Kirby found in all habitats, and *Lethe europa* (F.), *L. chandica* (Moore) in BB habitat alone. The study showed the occurrence of high species diversity (*Hs* = 3.80), low dominance (*Dm* = 0.03) and high evenness index (*J'* = 0.96) in Rowa WLS (Table 3). Cluster analysis based on Bray-Curtis similarity values showed that MMDSF and BG habitats formed a pair showing high similarity (44.07 %) but BB habitat is linked to the MMDSF-BG cluster at a similarity of only 25.20 % (Fig. 2). The overall butterfly populations recorded in three habitats for three days showed significant difference (ANOVA: $F_{2, 6} = 82.94$, $P = 0.001$). Variation in species composition and abundance was observed across 3 sampling habitats. Among the three habitats, highest diversity of butterfly species was recorded in MMDSF (45 species and 90 individuals, *Hs* = 3.70) in comparison to 30 species and 55 individuals recorded in BG (*Hs* = 3.28) and 14 species and 40 individuals recorded in BB (*Hs* = 2.44). A Nymphalid species, *Charaxes bernardus* (F.), and three papilionid species *Graphium sarpedon* (L.), *Papilio demoleus* (L.) and *Troides helena* (L.), were found unique to the open forests of BG only. Hesperiidae butterflies showed high species richness in MMDSF but were represented by a single species in the managed BG.

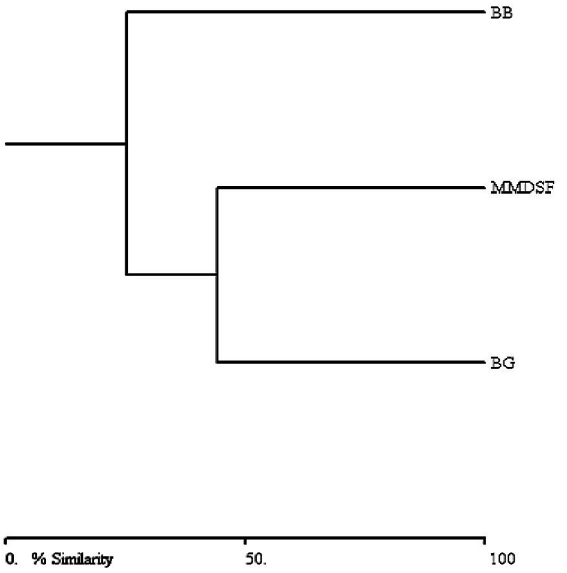


**Fig. 2.** Bray-Curtis single linkage cluster analysis of butterfly diversity in the three habitats: MMDSF = Mixed moist deciduous secondary forest, BG = Botanical garden, and BB = Bamboo bushes.

## *Species richness estimates*

Non - parametric species richness estimators Chao1 and Jacknife1 provided the best average expected species richness which is close to the actual overall richness recorded in the study area (Table 3). Individual-based rarefaction curves in relation to sample size from the three habitats were found to be steep; the curve was steeper for MMDSF than the curves for BG or BB habitats (Fig. 3). The overall species accumulation curve showed an initial sharp rise (28 species from 40 individuals) followed by a gentle rise (next 23 species from 120 individuals), and approached asymptote at 53 species of butterflies (Fig. 4). Sampling completeness was found to be the highest in BG (99.47 %) followed by MMDSF (72.43 %) and BB (27.11 %). Overall sampling completeness for Rowa WLS was recorded to be 98.60 % (Table 3).

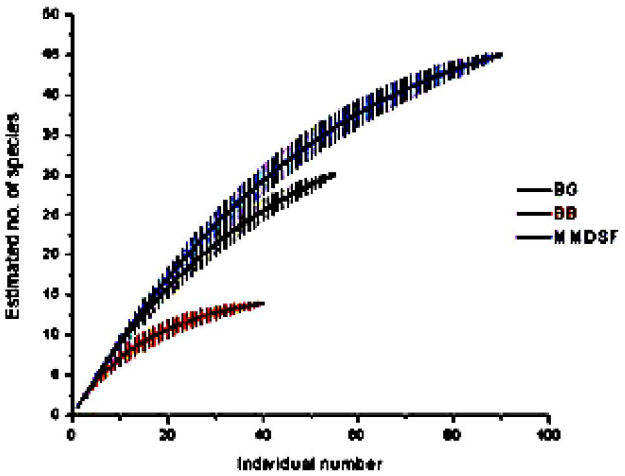


**Fig. 3.** Individual-based rarefaction curves of butterfly samples collected in three habitats: MMDSF (Mixed moist deciduous secondary forest), BG (Botanical garden) and BB (Bamboo bushes).

## *Rank distribution*

Distribution of ranks according to abundance of individual species showed higher ranks for *M. leda* and *M. perseus* with relative abundances of 6.49 % and 4.32 %, respectively (Table 1). The next 44 species together shared 85.41 % of the total abundance. The remaining 7 species, ranked at 9, were found to be singletons; these represented 3.78 % of total abundance (Fig. 5). K-dominance curves of cumulative abundance against species ranks showed non-overlapping variation in species dominance in the three habitats (Fig. 6). The

dominance curve of MMDSF showed substantial similarity with that of the Rowa sanctuary as a whole. BB habitat stood apart with high dominance (*Dm* = 0.10) in comparison to BG (*Dm* = 0.04) and MMDSF (*Dm* = 0. 0.03) habitats. Thus, for each butterfly species recorded in the three habitats, BB showed higher dominance for 14 species in comparison to lower dominance recorded for 30 species at BG habitat, and the least dominance recorded for 45 species at MMDSF habitat.

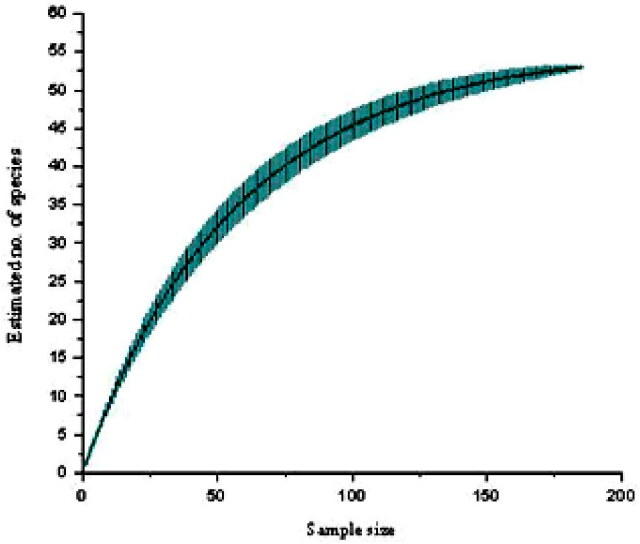


**Fig. 4.** Sample based species accumulation curve of butterfly samples collected in Rowa WLS.

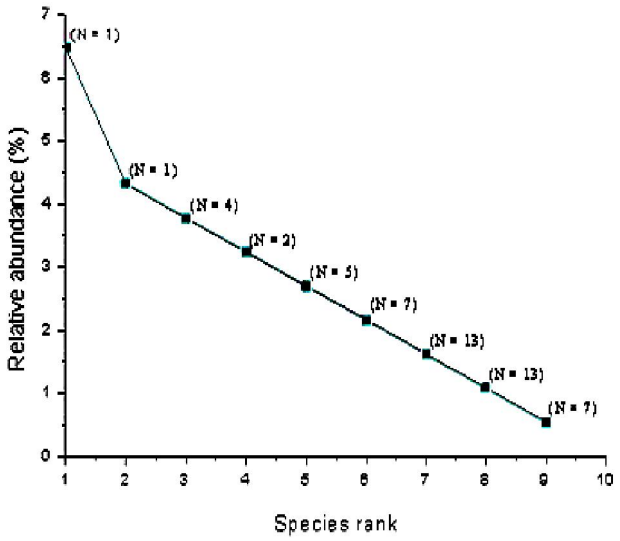


**Fig. 5.** Species rank abundance plot based on mean relative abundance (%) of butterfly species recorded at Rowa WLS.

## Discussion

This is the first RBA study for butterfly diversity in a sanctuary protected by law in Tripura state, northeast India. Records of 53 butterfly species in three days from one of the smallest sanctuaries (0.85 sq. km) including 8 species considered as threatened compares favourably with 59 butterfly species reported from Trishna WLS (194.71 sq. km) in south Tripura district of Tripura during a six month study (Majumder *et al.* 2012a) and 117 butterfly species reported from Keibul Lamjao National Park (40 sq. km) in Manipur during a three year study (Singh *et al.* 2011). An earlier RBA study on butterflies in the western Himalayas across different elevation gradients recorded approximately 77 % of the species richness recorded over a longer period of sampling (Bhardwaj *et al.* 2012). Results of this study showed that a short duration systematic assessment of biodiversity in a wildlife area can yield sufficient information and, therefore, the RBA method is useful in remote and difficult areas (Lawton *et al.* 1998; Roberts 1991). This is particularly so for insect taxa which are important indicators in conservation planning (Hayes *et al.* 2009; Uniyal *et al.* 2007).

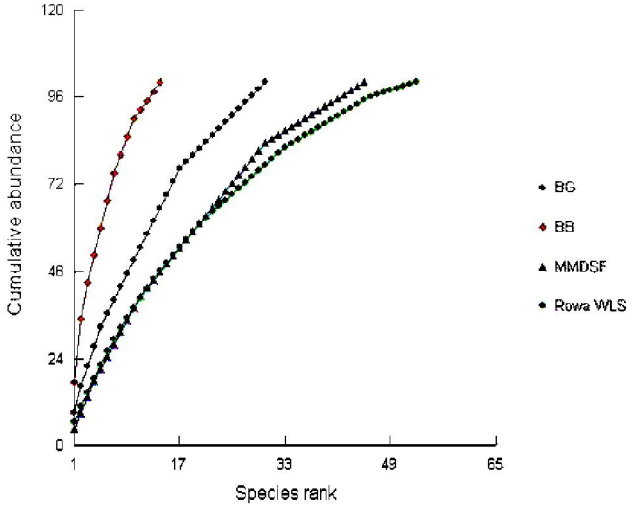


**Fig. 6.** K-dominance curves of butterfly samples collected in three habitats: MMDSF (Mixed moist deciduous secondary forest), BG (Botanical garden) and BB (Bamboo bushes) and Rowa WLS.

Among the three habitats of Rowa WLS, the MMDSF showed the lowest dominance value (*Ds* = 0.03) and high diversity (*Hs* = 3.70) compared to the other habitats. The high diversity, low domi-

nance, and lower abundance of the majority of the recorded butterfly species - including several taxa belonging to the threatened category and seven singleton species - makes Rowa WLS a primary area for taking adequate scientific measures for the conservation of its existing flora and fauna. The study also resulted in the reporting of eight species as new records from the state, which was once part of the undivided Assam in pre-independent India when Evans (1932) reported a number of butterfly species from this region without regard to their exact location of collection. Some of the species reported here are reported to be common in south Asia (IUCN 2007; Kehimkar 2008) and are supposed to be also present in India, but this study has revealed that *Sarangesa purendra* Moore - hitherto known from southern and central India, parts of northwestern Himalaya and Gujarat - is now also found in Tripura.

Habitat preference and abundance of butterfly species in a habitat is directly related to the availability of larval host plants and adult nectar sources (Denis *et al*. 2006; Thomas 1995). This is also true of other ecosystems (Flauzino Pires 2015). Nymphalidae was found to be the most species rich and abundant family in Rowa WLS; this is in accord with results of earlier studies in tropical habitats (Mathew & Rahamathulla 1993; Sudheendrakumar *et al.* 2000). Nymphalid butterflies are polyphagous and most of them are active fliers which enables them to exploit diverse habitats, cover a wide dispersal area, and maintain large population sizes (Raut & Pendharkar 2010; Sreekumar & Balakrishnan 2001). Hesperiidae was found to be least abundant, and Lycaenidae was the most species poor family, possibly due to their host specificity and niche preferences. The lower abundance and poor species richness of these two families may be attributed to the small body size of these butterflies which restrain their wide dispersal. Among the three study sites, MMDSF habitat showed the high species diversity (*Hs* = 3.70) but members of Lycaenidae and Hesperiidae, which prefer low herbs and grasses (Kehimkar 2008), were recorded to be much lower in number of species as well as in their abundance. Such a contrast can be attributed due to the dense canopy of the MMDSF that restricts entry of sun radiation inside the forest resulting in the lack of understorey and grass species. *M. leda*, *M. perseus*, *Y. baldus*, *Y. huebneri*, *Ariadne ariadne* (L.), *Loxura athymnus* (Stoll), *Atrophaneura aristolochiae* (F.) and *Papilio nephelus* L. were found to be present in all of the three habitats. Among these, *M. leda* was found to be the dominant and is known as a generalist species in tropical habitats (Nordqvist 2009) where *P. nephelus* is known as a specialist forest species (Barua *et al.* 2010). Two unique species, *Lethe europa* (F.) and *L. chandica* (Moore), were found in BB only because both these species prefer bamboo as their host (Kehimkar 2008) and are well adapted to camouflage in bamboo bush forest floor which protects them from predators. Saikia (2011) recorded similar habitat preferences of nymphalid butterfly species in tropical forests of Assam. A nymphalid species, *C. bernardus*, and three papilionid species (*G. sarpedon*, *P. demoleus* and *T. helena*) were unique to BG only, and these are considered to be the forest species (Barua *et al.* 2010; Nordqvist 2009). Four singleton species, *Hebomoia glaucippe* (L.), *Notocrypta curvifascia* (C & R Felder), *Spialia galba* (F.) and *Papilio castor* Westwood, were confined to MMDSF habitat alone (Table 1) among which *P. castor* is a forest dweller endemic species with restricted geographical range and considered to be rare in northeast India (Barua *et al.* 2010). *L. europa*, considered to be a critically endangered species according to Red Data Book (Gupta & Mondal 2005), showed high rank abundance in Rowa WLS. However, several other species not categorized as threatened from other areas, were found to be rare in this sanctuary. Those are *G. sarpedon*, *H. glaucippe*, *N. curvifascia*, *S. galba*, *P. castor* and *C. bernardus*.

Rowa sanctuary is inhabited by indigenous people dependent on forest resources. In addition, frequent infringement of natural resources through wood cutting and animal poaching by external elements are not uncommon. Results of this study bring to the fore vital biological and ecological resources that are present in Rowa sanctuary and these needs to be conserved on a long-term basis for healthy sustenance of the wildlife. This study demonstrates the usefulness of information statistics Indices (*Hs*, *J'* etc.) in determining the conservation value of place in terms of rare species that occur in the community. Low species diversity (*Hs* = 2.44) and a very steep dominance curve recorded in BB shows the negative impacts of vegetative propagation of bamboo on butterfly diversity. The species accumulation curve showed asymptote at 53 estimated species for 185 individual which implies 100 percent sampling completeness, and there was a least chance to get more species in small sized Rowa WLS with further sampling effort. Overall high species richness and diversity signify the occurrence of

pristine condition of Rowa WLS. Results of this 3-day study on family-wise species richness and their abundance in Rowa WLS prove equal to the results of long term studies in other parts of India (Eswaran & Pramod 2005; Krishnakumar *et al.* 2007; Majumder *et al*. 2012a; Padhye *et al.* 2006; Raut & Pendarkar 2010) and hold promise for exploration of several un-explored areas for fauna and flora.

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