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Diversity, Dominance and Evenness of Butterflies in Southern Part of Western Ghats (Palani Hills)

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Abstract The present study has been done in the southern part of Western Ghats of Palani Hills in Tamilnadu. It was conferred as a global biodiversity hotspot that includes Kodaikanal Wildlife Sanctuary is to be proposed. We have studied the Diversity, Dominance and Evenness of butterflies in different habitats (forest area, crop area and river bank,) during the period of December 2018 to March 2019. A total number of 92 species, from 65 genera and 5 families were recorded. The diversity of species and abundance have recorded maximum in March-May and dropped it to the minimum in December 2018-January 2019. Forest area habitats had greater species diversity, while the river bank habitat had a greater number of butterflies; crop area had the least diversity of individuals and abundance present in the studied habitats. We have also been recorded the endemism and the flight period of some of the butterflies and their distribution range within the habitats with their nectar source plants. Analyses were also done to emphasize the importance of butterfly individuals and their need for the conservation.

Keywords Butterfly Communities, Population Dynamics, Species Richness, Climatic Factors, Western Ghats

1. Introduction

Butterflies *(Lepidoptera: Rhopalocera)* are the group of the most plant dependent insects when compared to the other mega diverse group of insects. (Kristensen*et al.,* 1999) Butterflies are the most beneficial as they are serving as a pollinator and the indicator of environmental quality and appreciated for their aesthetic value (Chakravarthy *et al.,* 1997). The holometabolous life history of the butterflies reveals that the family Lepidoptera are exposed to the wide range of environmental influences and are the most sensitive to the climatic changes particularly in temperature, humidity and the light levels (Erhardt 1985; Warren *et al.,* 2001). Nearly 1500 butterflies (Smetacek 1992; Gay 1992) were identified from the Indian sub- continent, constituting 8.33% of 18,000 known species of the globe; most of the Indian butterflies were reported from the Himalayas and from the Western Ghats region (Larsen 1987a; 1988). The population status of butterflies in any study area would help us to understand the status of the ecosystem as they are good indicators of species (Karemen 1992). Nearly 300 species of the butterflies were recorded in a detailed survey of Nilgiri Biosphere Reserve (Larsen 1987a; 1988). At present Nilgiri Biosphere Reserve is one of the 18 hot-spots of the World, conferred as a UNESCO world heritage site.

Butterflies are the good indicators in terms of anthropogenic disturbance and a habitat quality (Kocher *et al.,* 2000). Especially in the forest ecosystem when these habitats are fragmented, butterflies that shift from one habitat to other have been increased chance of exposure to

predators and they are vulnerable to disturbances related with human activity. The effects of the habitat lose can be seen clearly with the decreasing population of butterflies. Moreover, the butterflies are displaced after their habitat loss disappears subsequently.

Climatic changes create a major impact in the diversity of species and they are expected to exacerbate the ecosystems (Scott *et al.,* 2005). The changes in parameters of rainfall patterns, temperature and extreme weather conditions such as heat waves, excessive rainfall, prolonged drought have to be taken it for consideration. Depletion of nectar and desiccation of the host plants cause direct mortality and induce migratory behaviors. Butterflies, being exothermal in nature, they are highly sensitive to climatic variation and a short generation time makes the individuals an appropriate model organisms to study.

The intensification of Agricultural is widely accepted as a cause of declining biodiversity. It is however a broad concept of encompassing many factors, such as loss of semi-natural habitat, ecosystem fragmentation, use of heavy machinery and increased inputs of insecticides, herbicides and pesticides (Tilman *et al.,* 2001). Of these, a chemical pesticide potentially affects the development of butterfly larva and nectar producing plants which adversely affects the adult butterfly diversity. Adult temperate butterfly species feeds primarily on nectar (Scoble 1992), supplemented to varying extents by dung or carrion and mud, (Boggs *et al.,* 2004). The agriculture development field in the forest ecosystem endangered many species throughout the world; at present the extinction rates are estimated to be 100 - 1,000 times the natural rate, depending upon the taxonomic group (Scriber *et al.,* 1995; Virtuosic *et al.,* 1997).

The diversity of butterfly species communities has been studied in different habitat types in different parts of the world including the Indian Great Himalayas Region. However, there are not more studies have done on the diversity of butterfly communities in tropical forests within the different habitat types from southern India especially in Western Ghats. Lien van Vu (2009) reported that the forest edges have greater diversity of butterflies which has more exposure to the open area. The gaps in the forest like the river path or stream have higher diversity of butterflies than the closed forest areas (Spitzer et al., 1997; Lien van Vu *et al.,* 2011).

The present study is to be aimed to examine the diversity, dominance and evenness of butterflies across three different habitats in Palani, namely forest area, river bank, and crop area, located in different altitudes from the southern part of Western Ghats and to correlate with the anthropological activity, availability of hostplants and their nectar source.

2. Methodology

2.1. Transects and Butterfly Data

The sampling is based on standardized “Pollard walk” method (Pollard 1977; Pollard *et al.,* 1993). We have applied line transects of about 1000 Meters in length which has been divided into five segments of 200 meters. Each transect is being observed 3 times and the number of individuals of species as recorded from all the five segments. The butterflies are observed within 2.5 meters to the right and left side and five meters in front of the researcher or observer. Unfamiliar species of individuals were collected for identification and the voucher specimens were deposited at Ecology Research Laboratory, Jamal Mohammad College, Tiruchirappalli – 620020. Details such endemism and mud puddling as habitat of occurrence, behavior were recorded. Also we have examined the vegetation in the transect line area.

2.2. Study Period

The butterfly species were collected using sweeps soft net and, photographed. The collection was done every month from December 2018 to March 2019 at 8.00 AM to 4 PM under perfect weather conditions (temp 18 ℃, (always >13 ℃) cloudless or just few clouds and speed of the wind\5 Beaufort (only leaves and thin branches are moved by wind).

2.3. Study Area

The study has been taken in different regions of the Southern Parts of Western Ghats, in Palani Hills. This Spot is the most important biodiversity hot spot of our Western Ghats. The Palani Hills are the mountain range in the states of Tamil Nadu and Kerala in South part of India. The Palani Hills situated eastward extension of the Western Ghats ranges, which run parallel to the west coast of South India. Palani Hills (Figure – 1) adjoin the high Anamalai range in Kerala on the west, and extend towards east into the plains of South Tamil Nadu, covering in an area of 2,068 square kilometres (798 sq miles). The highest parts of this range are situated in the southwest, and reach into 1,800-2,500 meters (5,906-8,202 feet) elevation; the eastern extension of this range is made up of hills 1,000-1,500 m (3,281-4,921 ft) high. Different climatic gradients with various habitats like tropical moist deciduous forest, evergreen forest, moist deciduous forest, reservoirs, rivers, grass lands have been produced most favorable conditions for greater diversity of insects in Western Ghats.

The Western Ghats receives an annual rainfall of 7600 mm per year; it receives more of its rain from the southwest monsoon during June-September; this region usually gets fairly dry for the rest of the year. Annual mean minimum and maximum temperatures range from 9.6 ℃ to 20.7 ℃ to respectively. Annual relative humidity is 76.9% - 75.8%. A total number of 21 transects (one transect per study site) has been taken for this study

representing three different types of habitats consisting the forest area, crop area (located within fragmented regions in the forest), and the river bank.

2.4. Forest Area

Forest area is being represented by thick canopy with almost shady ground and high relative humidity. Fourteen sites were observed in this habitat seven sites were observed in this habitat. namely Kumbakarai (10˚184883″ N 77.5157″ E Elevation 583m / 1925ft), Kombai (10°2945″ N 77°4370″ E Elevation 1020m / 3341ft), Pethuparai (10˚2820″ N 77˚5303″ E Elevation 1369m / 4490ft), Vellagavi (10°1970″ N 77°4992″ Elevation 1343m / 4408ft), Perumalmalai (10˚2641″ N 77˚5375″ E Elevation 1563m / 5127ft), Vattakanal (10°2153″ N 77°4853″ E Elevation 2080m / 6825ft), Bandichoolai (11°3720″ N 76°8194″ E Elevation 1979m / 6492ft), Shenbaganur (10°2317″ N 77°5030″ E Elevation 1798m/ 5899ft), Vegetation comprised of *Dahlia imperialis, Helichrysum bracteatum, Anaphalis leptophylla, Leucas martinicensis, Physalis peruviana, Rubus ellipticus, Citrus aurantifolia, O.chinensis, Crotalaria pallida, Triumfetta annua, Toddaliaasiatica, Salvia coccinea, Eucalyptus globules, Bidenspilosa, Siegesbeckia orientalis, Erigeron karvinskianus, Calotropis gigantea, Musa paradisiaca, Ficusracemosa, Terminaliapaniculata, Glorio sasuperba, Malvastrum coromandelianum, Osbeckia octandra,* (Chakravarthy *et al.*, 1997).

2.5. River Bank

Rivers create gaps in the forest; the river bank that lies on the open area within the forest supports a variety of fauna including some kinds of insects. They have a microclimate that can be very different from the forest hence we have been considered in this area for this study. With a very thin vegetation of grass and shrubs, damp soil, the river bank was an ideal ground for many nectar containing plants. The present study considered one in this habitat; This was Elephant Valley Cascade (10˚3116″ N 77˚5205″ E Elevation 1148m / 3764 ft) located in 20 Km from the Palani Hills region. The Elephant Valley Cascade is one of the most important hotspots in the Western Ghats region. Dominant nectar source vegetations within the transect lines are *Hibiscus vitifolius, Chromolaenaodorata, Helichrs ysmbracteatum, Hibiscus rosasinensis, Cappariszeylanica, Tecomastans, Osbekiaoctandra, Asystasia sp., Gnidiaglauca. Asclepiascurassavica, Daturastramonium, Hyptis sp., Plum, Sarraceniaalata, Sennatora.*

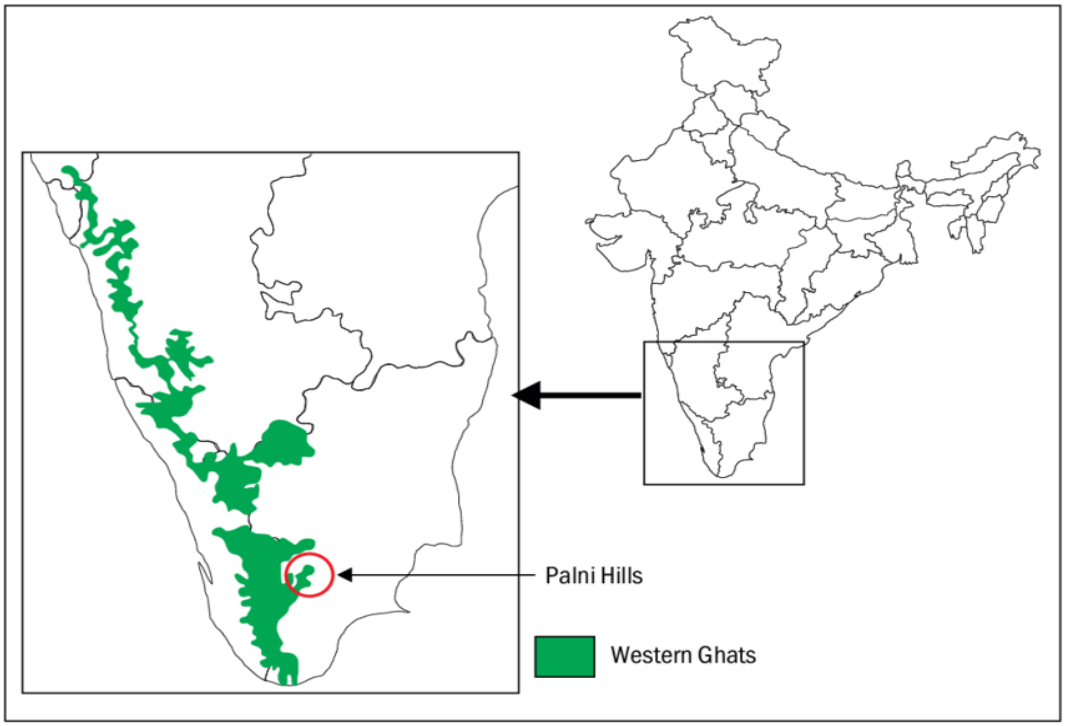

Figure 1. The Map of Western Ghats in India shows biodiversity hotspot includes Palani Hills

2.6. Crop Area

Various agricultural fields are chosen for this study to analyze the butterfly diversity among the fragmented area of the forest as well as to find the impact of pesticides and insecticides in their habitat. Line transect was fixed in the following agriculture fields and the study were conducted in the following sites are Shenbaganur (10°2317″ N 77°5030″ E Elevation 1798m / 5899ft), Pallangi (10°2732″ N 77°4523″ E Elevation 1665m / 5461ft), Poombarai (10°2471″ N 77°4040″ E Elevation 1926m / 6320ft). Dominant nectar plants were recorded *Citrus sinensis, Brassica oleracea, Beta vulgaris, Perseaamericana, Phaseoiuscoccineus, Piper nigrum, Camellia sinensis, Coffeaarabica, Solanumtuberosum, Daucuscarota, pyrussp.*

3. Results

3.1. Diversity Calculation

The total number of butterfly species collected under each identified species in various habitats were recorded and the diversity indices namely dominance index, Shannon's diversity indices (H′), and evenness index (e^H/S) have been calculated by using PAST software (PAST; version=2.02).

3.2. Species Richness

There was a significant variance in number of species between the different types of habitats (Figure 2). The Species Richness was greater in Forest Area (92) than in other two habitats, River Bank Habitat (78) and Crop Area Habitat (61). In all three habitats the maximum richness was recorded in the month of April and the minimum richness has been recorded in the month of December 2018 and January 2019. (Figure-3)

3.3. Species Abundance

In the totally recorded individuals from three different habitats in Forest Area (15927), River Bank Side (19230) and Crop Area (10371), the maximum abundance wasnoted in two seasons, March2018 – May2018 and September2018 – November2018 with the peak in April2018 and October2018 respectively. Maximum abundance within these habitats was observed in River Bank Side (4751) followed by Forest Area Side (3558) and Crop Area Side (2462). Minimum abundance is observed in the month of January (River Bank – 108, CropArea– 79, Forest Area –19).

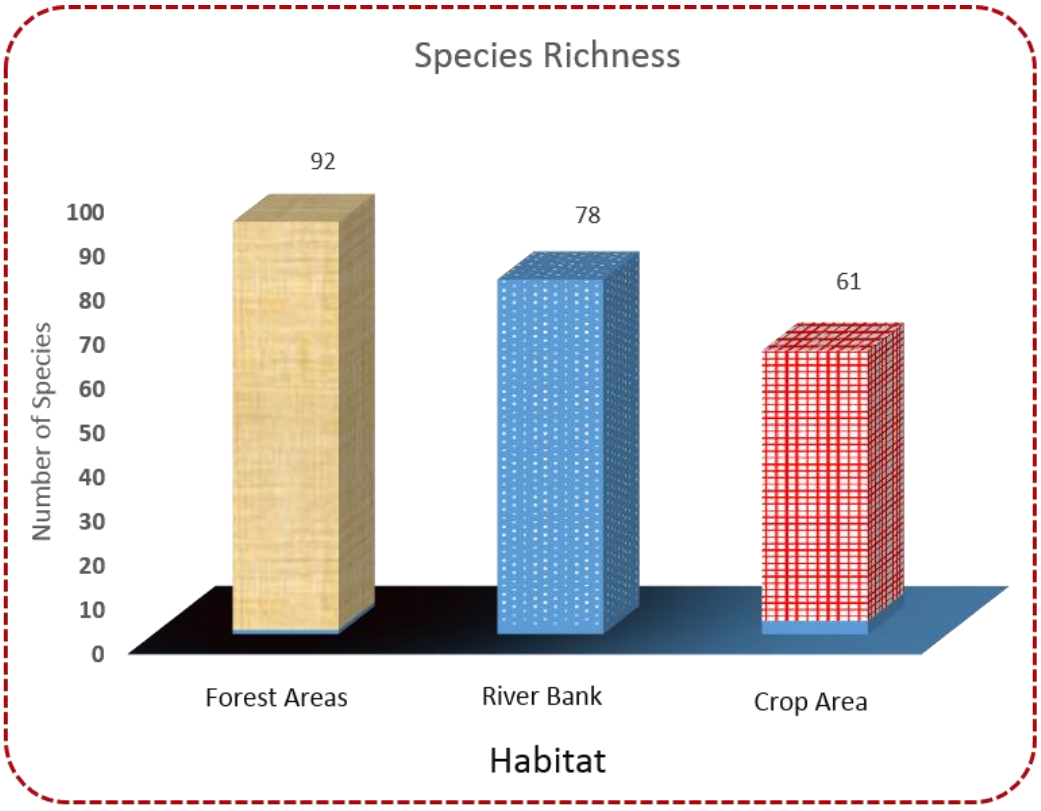

Figure 2. Shows the species richness found in the forest area when compare to riverbank and crop area.

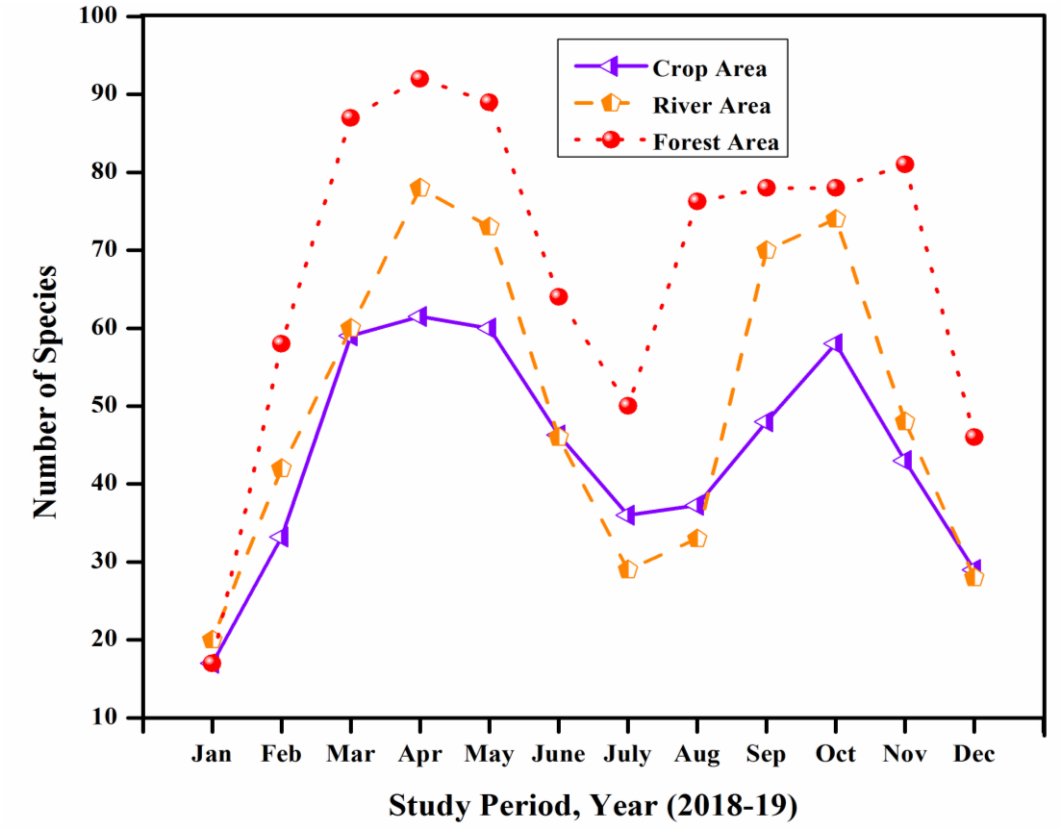

Figure 3. Shows the Species richness found in the forest area in the month of April followed by riverbank and crop area

Dominance, Simpson Diversity and Evenness have been studied using PAST version 2.0. Maximum dominance is recorded in River Bank area (0.11260) in the month of January2019 when compared to other two habitats, Forest Area side (0.09945) and Crop Area side (0.09123). In all three habitats the dominance showed similar kind of trend. Minimum dominance is recorded in the month of April followed by October. The River Bank habitat showed greater dominance among all three habitats.

Maximum Simpson diversity index was recorded in the River Bank (0.9743) in the month of April followed by Crop Area side (0.9819) and Forest Area side (0.9661). Simpson Diversity has showed the peaks in the months of April and October in all three habitats. Minimum Simpson diversity index was recorded in January for River Bank side (0.9088), Crop Area side (0.9005), and Forest Area side (0.9088).

The Trends in the Evenness index showed that there is a considerable dominance by few species in all three habitats. However in crop area the evenness was least modified throughout the whole season. Forest Area had the minimum evenness index with a higher degree of dominance particularly in the months of January (0.7792) and October (0.6128). Highest mean range Evenness has been found in River Bank side (0.6954) habitat followed by Crop Area side (0.6768) and Forest Area side (0.6054).

4. Discussion

Western Ghats is to be considered one of the twelve mega biodiversity hotspots of the world (Larsen 1987a,b,c.); the climatic conditions and the tropical temperature with a very high rainfall throughout the year (Larsen 1988) have made it favorable for the richness of the species. Butterflies *(Lepidoptera: Rhophalocera)* are considered as ecological indicators (McGeoch 1998; Rosenberg *et al.*, 1986; New *et al.*, 1995; Vu 2007). The butterflies help in pollination (Johnson *et al.*, 1994; Johnson *et al.*, 1995). In this study, butterflies from all the families have been recorded; among them, family *Nymphalidae* is outnumbered with the maximum species throughout this period of study; this happens because of their ecological adaptation (Jiggins *et al.*, 1996), speciation and high dispersal ability (Adler *et al.*, 1994). Family *Nymphalidae* is the largest family representing nearly one-third of the known butterfly species of the world. Family *Nymphalidae* has been followed by *Lycaenidae*, *Papilionidae*, *Pieridae*, and *Hesperiidae* in the total number of species were observed. Similar findings have been reported by Mathew and Rahamathulla (1993) from the Western Ghats.

Wynter- Blyth (1956) has identified two seasons, March-April and October are the peak periods in India for the species diversity and abundance. This study observed

the maximum species diversity and abundance in the months of March-May, and October-November (Fig 2&3); and there is a gradual increase in the early summer from the month of March and it has reached the maximum in the month of May; a second peak has been recorded in the month of October, November. Butterfly species in all habitats have flight periods, and their abundance strongly correlates with their different flight periods (Leather 1984; Norris 1935). Almost all butterflies are abundant in very short peak in particular seasons, and may or may not appear in the other seasons. Diversity and abundance of butterfly correlate with the flowering phenology of plants (Gutierrez *et al.,* 1995; Watt *et al.,* 1974; Kunte 2000). Some of the polyphagous species (Larsen 1988) like *Catopsiliaphomona, Neptishylas and Euremaheceba*, were abundant throughout the year in all habitats. Species like *Papiliocrinohas* only short flight period and have been found only in the month of March in the river bank.

Eupolio core and *Papiliopolymnester, Junoniaalmana*, have a long flight period. Species abundance and diversity are declined in two seasons, one in December-January due to the extreme cold and withering of flowers (nectar source) and again in late summer, June-July due to the non-availability of nectar source, over heat, and scarcity of water in the area. Among all the habitats studied, less abundance was recorded in the crop area habitat of the Western Ghats which can be due to non-availability of the host plant. This needs to be studied further.

Presence of the butterflies' in a particular habitat depends upon a wide range of factors; the availability of the food and microclimate are considered to be the most important (Janzen *et al.,* 1968). In these results, the river bank habitat had the greatest abundance of butterflies but lower in species number more than the forest and crop area habitats. The living environment of the river bank habitat is being diversified with the vegetation, animal dung, mud, rocks, sand, with water that attracts more butterflies (Janzen *et al.,* 1968), and thus the river bank habitat had the greatest abundance of the butterflies. The river bank habitat is less in diverse (78 species) than the forest habitat (91 species) probably due to the availability of host plant. Greater abundance (Fig 4) and less diversity (Fig 6) lead to the higher dominance (Fig 5) in the river bank habitat (0.1126) more than the other habitats. *Euremahecabe, GraphiunSarpedon, Catopsilia Pomona,* and *Ypthimaceylonicawere* are observed throughout the year in the river bank habitat.

Evenness index ranged between 0.4237 to 0.8341 in three different habitats (Fig 7). Optimum Evenness was found between June and July in this study, where the diversity and dominance of butterflies were even. Low rain fall, moderate availability of nectar source, and moderate temperature resulted in optimum evenness. High fluctuation in Evenness in crop area is observed because of the different cultivable plants that have been varied in blooming period. In crop area *Lycaenidae* species *(Acytolepispupsa, Amblypodiaanita,)* were dominantly found, because of their varied mechanism of feeding, ability to change their host plant, and symbiotic relationship with ant which are increased their caterpillar survival rate.

The Western Ghats is unique in endemism (Holloway 1974, Sudheendrakumar *et al.,* 2000); each and every habitat has a specific set of microenvironment suitable for the endemic species (Holloway 1974). Seventeen endemic species of butterflies are observed and recorded in the present study. Among them, ten species namely *Papiliopolymnestor, Vanessa indica, Vanessa cardui, Papiliohelenus, Troidesminos, Melanitisleda, Mycalesisanaxias, Cirrochroathais, Cuphaerymanthis, Coliasnilagiriensis, Orsotrioenamedus, letherohrianeelgiriensis, Tagiadeslitigiosaand Loxuraatymnuswere* were observed in the forest habitat, and three other species were found such as *Hebomoiaglaucippe, Phalantaphalantha, Papiliocrinofrom* the river bank habitat. Maximum numbers of endemic species were found in the undisturbed evergreen forest when compared to other habitats; this may be observed due to the availability of host plant and least disturbance. Significantly, we couldn't record any endemic species in the crop area habitat side.

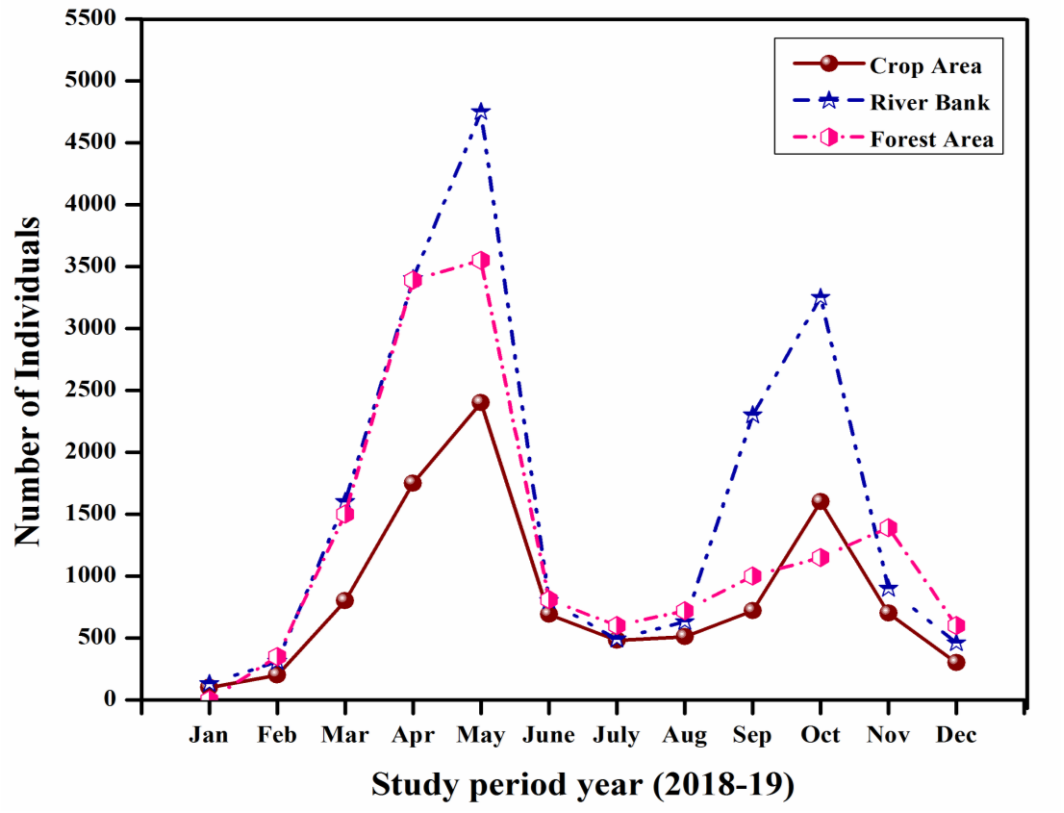

Figure 4. Graph showing the two peaks of abundance of individuals recorded in the month of March-May followed by September-November

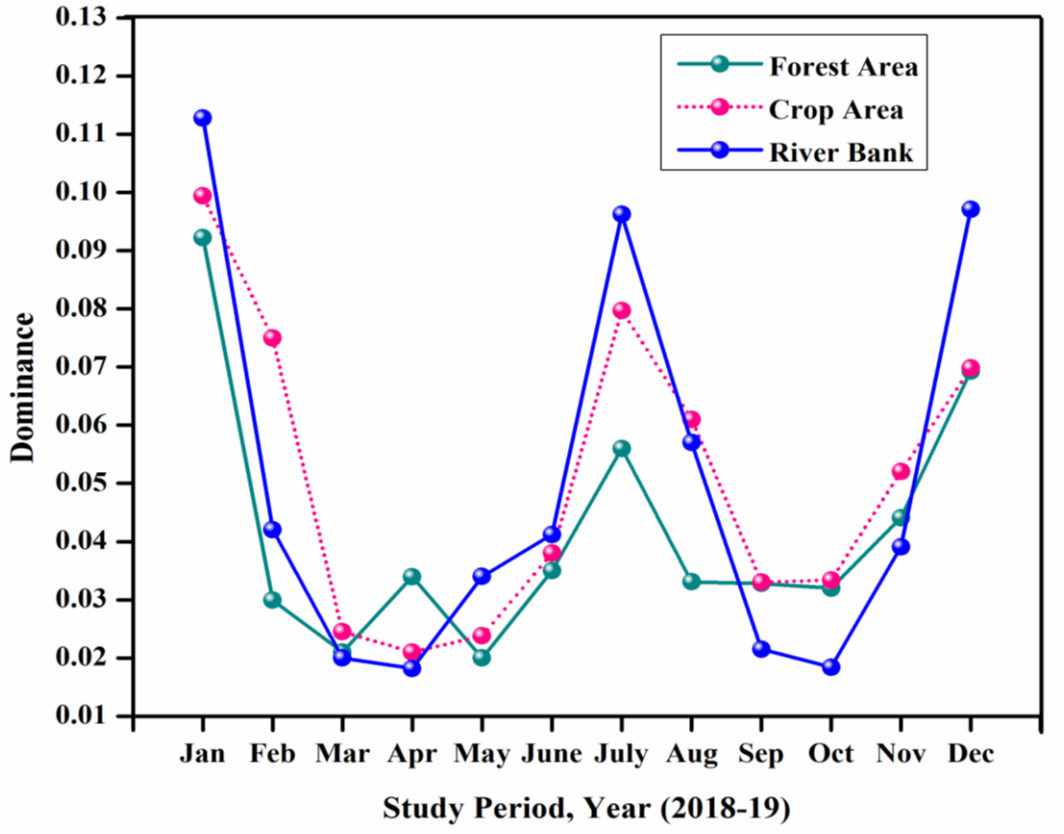

Figure 5. Shows the maximum dominance of Butterflies in river bank habitat than the other study area

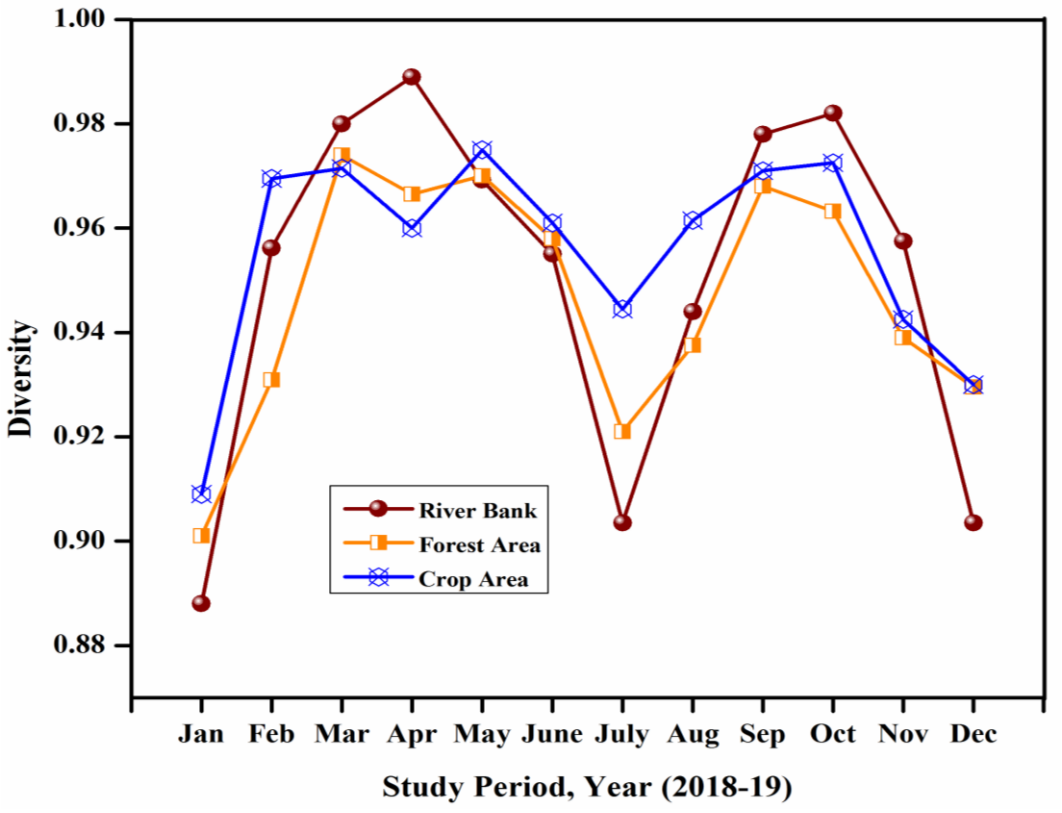

Figure 6. Shows the greater diversity of butterflies in forest area followed by river bank and crop area in the month of April

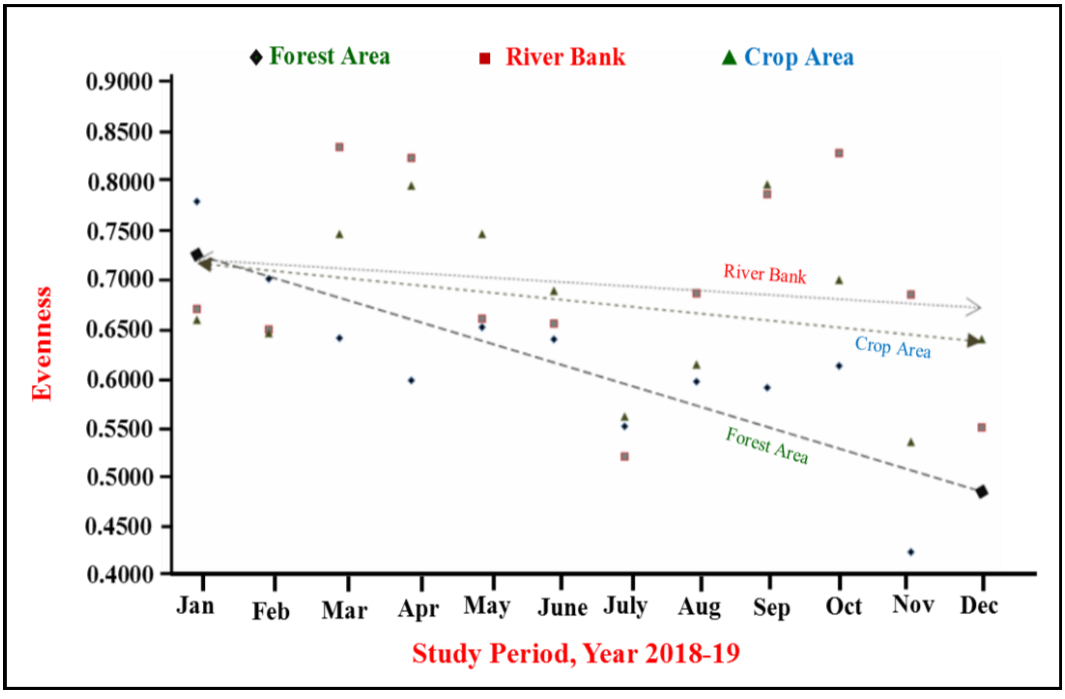

Figure 7. shows the high degree of Evenness fluctuation throughout our study period

5. Conclusions

The statistical comparison of results in three different habitats shows that butterflies' diversity and abundance have significantly declined in the crop area habitats than the other two habitats, - river side and forest habitat. This is observed probably due to the destruction of host plant in the crop area habitat, usage of chemical pesticides, and

human disturbance. Fragmentation of the forests for crop area could certainly destroy the host plant and could greatly influence the biodiversity of butterflies. Biodiversity laws alone cannot create an awareness and conserve the butterflies. It is most important to understand the relation between the host plants and the butterflies to protect them as they have co-evolved. Western Ghats being conferred as one of the biodiversity heritage sites needs more attention for effective conservation of butterflies.

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