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Research Article

Variation in butterfly species diversity and seasonality in the agricultural and agro-forest land type of Rayagada district, southern Odisha, India

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ABSTRACT

This is the maiden study conducted from January, 2020 to December, 2020 to document the changes in butterfly assemblages and their seasonality in two experimental sites i.e., (a) agricultural land of Kutigam (AGL) and (b) agro-forest land of Chamarjodi (AGF) of Rayagada district, Odisha. A total of 1534 individuals belonging to 75 butterfly species, 58 genera, 14 subfamilies under five families was recorded. Mostly Nymphalidae butterfly species were found in both AGF and AGL, where the least abundant family was Hesperiidae. AGF was found to be more species diverse (n=73 species) than AGL (n=50) but the species abundance was found more in AGL (629 individuals; 41% of total individuals). than AGF (905; 58.99%). Diversity indices like Shannon-Wiener index (H'), Simpson's index (γ) and evenness (J) was found to be higher in AGF. Overall, most species were observed during summer season (n=63 species), followed by monsoon (n=62) and winter (n=56). Main cause of this variation in butterfly community of these two sites was species dispersal, resource availability, predation and habitat disturbances. Current threats and conservation measures for the butterfly fauna of these two agriculturally important areas of Rayagada district was also discussed.

Key words: **:** Lepidoptera, Butterflies, Abundance, Occurrence, South Odisha, Eastern India

INTRODUCTION

Study on the diversity pattern of any important taxa and change in their species composition can give us an unblemished impression about the environmental disturbances (Sala *et al*. 2000). These studies are the vital element to understand the functioning of any ecosystem (Tiwari and Saxena, 2011). Modification of any natural habitat, increase the chances of affecting climatic conditions, local biodiversity, natural resources and thus the complete change in ecosystem of that region (Carl Sagan, 2013). The butterflies are considered as one of the main ecological indicator taxa to detect conservation status of any region, which was proved by several environmental investigations (Larsen, 1988; Gunathilagaraj, Kumar & Ramesh, 1997; Kocher & Williams, 2000; Kunte, 2000; Sawchik, Dufrêne & Lebrun, 2005; Hayes *et al*. 2009; Marini *et al*. 2009; Munyuli, 2013a).

There are numerous publications regarding butterfly species diversity in agricultural landscapes in different parts of our world (Rands & Sotherton, 1986; Aviron *et al*. 2007; Francesconi *et al*. 2013; Munyuli, 2013b; Remini & Moulaï, 2015). Study related to the variation in the butterfly species composition found in different agricultural land types revealed several causes of changes at spatial as well as temporal scale (Foley *et al*. 2005). Because these changes in the agricultural land can directly affect small insect diversity (Tscharntke *et al*. 2019). Nonetheless, the butterflies are also very sensitive to different types of agricultural practices (Meehan, Glassberg & Gratton, 2013; Pleasants & Oberhauser, 2013). Being the hub for several host plants, both agricultural and agro-forestry lands are important habitats for butterfly to thrive upon (Munyuli, 2013a). Interestingly the changes are not only limited to agricultural land types but also these scenarios have been reported in disturbed urban areas too (Blair & Launer, 1997; Blair, 1999; Hogsden & Hutchinson, 2004; Marchiori & Romanowski, 2006; Rajagopal *et al*. 2011).

In India, Nilgiri of Western Ghats region was assessed for butterfly diversity of agro-forestry land (Keerthika & Parthiban, 2021). Moreover, in Odisha, although the studies related to butterfly diversity were carried out by lots of researchers but those studies were sporadic (Mandal & Nandi, 1991; Das & Sahu, 2011; Mohapatra *et al*. 2012; Palei & Rath, 2014; Payra *et al*. 2016; Boruah *et al*. 2018; Paria *et al*. 2018). Most of these studies were conducted either in reserve forest, or several protected areas of eastern, northern and southern side of Odisha. Only a single research paper could be reviewed on the butterfly diversity of agro-forestry plantations in Koraput district, in which species richness of three different agro-forest plantation site was estimated and the reasons for variation in species richness was also discussed (Mahata *et al*. 2019). While the butterflies of Rayagada district of southern Odisha have never received attention by any researcher. Hence the butterfly diversity of Rayagada lacks the baseline information. In order to fulfil this knowledge gap, this maiden study was conducted to document the diversity and

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composition of butterfly fauna of two different agricultural land types in Rayagada district of Odisha. Furthermore, diversity indices viz. Shannon's diversity index (H'), Simpson's index (λ) and Evenness index (J) was calculated for both agricultural land type in order to get the important information about rarity and commonness of butterfly species. The reason for the changes in diversity pattern of butterflies are also discussed in this paper.

MATERIALS AND METHODS

Study sites

The present study was carried out from January, 2020 to December, 2020 in two different agricultural land types of Rayagada district, Odisha. Rayagada lies in between 19.1712° North longitude, 83.4163° East latitude having an area of 7073 sq. km. and considered as one of the most fertile districts of southern Odisha (Nayak & Kumar, 2019). The hot, moist and sub-humid climate along with brown-forest, red alluvial and black soil group are the main reason for this (www.rayagada.nic.in). Our two experimental sites fall under the Northern Eastern Ghats (NEG) agro-climatic zone of Odisha (www.agriodisha.nic.in). Among the two sites, one is Kutigam. This area is mostly characterized by the monotypic agricultural crop i.e., *Oryza sativa* (Rice) along with matrix of naturally grown vegetation cover. Whereas hills with few perennial steams and heterogenous wild vegetation cover are present in the second site which is Chamorjodi. The details and the map of these two study localities are provided in Table 1 and Figure 1. Three seasons are prominent in our study areas i.e., summer (March to June), monsoon (July to October), and winter (November to February). The average annual rainfall is 1285 mm since last ten year, the average minimum and maximum temperature was recorded as 19.8°C and 38.7°C respectively.

Table 1. Details of the sampling localities

Sl. No.	Locality	Land type	Latitude (°)	Longitude (°)	Elevation	Temp.(°C)	Precipitation (mm/ month)	Vapour Pressure (hPa)
1	Chamorjodi	Agro-forestry (AGF)	N19.4095	E83.2480	559 m	25.35	147.34	22.94
2	Kutigam	Agricultural (AGL)	N19.3657	E83.2093	516 m	24.75	150.74	23.06

*Note: All the weather-related data are the mean annual value. Abbreviations used in this table: ° – degree, m – metre, °C – degree celsius, mm – milimetre, hPa – hectoPascals.

Field work

Regular survey was carried out twice in a week in both of these localities from January to December 2020. Field survey was done in between 8.00 AM to 11.00AM and 03:00PM to 06:00PM along the trails present inside the localities following Pollard walk sampling technique (Pollard, 1977; Pollard & Yates, 1993). The butterflies were photographed using NIKON D5300 DSLR camera with kit lens of 18–55mm and Vivo y93 smart phone with 20x mobile macro lens. Unidentified butterflies were caught using sweeping net 40 cm diameter and released them into the same habitat after identification without causing any harm. If possible, efforts were made to instantly identify the butterflies in the field using photographs following available field guide and books (Kehimkar, 2008; Mohapatra *et al*. 2012) and the classification was followed upon (Heikkilä *et al*. 2012). Abundance of each species were recorded and noted for further analysis. Later, the relative abundance (RA) was calculated for each species by using the formula below.

Relative abundance (RA) = (Abundance of the species/ total abundance of all the species) × 100.

Based upon the value of RA butterfly species were categorized into Common (C): if the species sighting frequency is more than 70 percent and encountered in every field visit; Fairly Common (FC): if the sighting frequency was less than 70 percent and more than 10 percent and lastly Rare (R): if the species sighting frequency was less than 10 percent. Abundance data for butterfly species are provided as supplementary information (Supplementary file 1). Schedule of the Indian Wildlife (Protection) Act, 1972 of each butterfly was accessed according to the IWPA 1972. Random sightings of the butterflies were avoided and only confirmed identification were included in the final checklist (Table 2).

Data analysis

Species richness (S), species abundance (N) and diversity indices like Shannon's diversity index (H'), Simpson's index (λ), Evenness index (J) (Shannon, 1948; Simpson 1949; Smith & Wilson, 1996) were calculated using 'vegan' package of Rstudio statistical software version1.4.1106 (Oksanen *et al*. 2020; Rstudio, 2021) from the abundance data (Supplementary file 1)

1. Shannon-Wiener index (H'): H' is defined by Species richness (S) in the community and their evenness in abundance. It is the sum of total species number within a locality with the relative abundance of each species (Magurran, 1988). Higher values of H' represent higher diversity.

$H' = - \Sigma\, pi \ln pi$. Here pi is the proportion of ith species in the total sample.

2. Simpson's index (λ): This index is the probability that if two individuals are drawn randomly from a large community, those two individuals won't be same (Simpson, 1949). It is less sensitive to rare species than the H'. The value of λ always ranges from 0 to 1.

$\lambda = \Sigma\, pi\,(pi-1)/N\,(N-1)$. Here pi is the proportion of ith species in the total sample and N is the total number of individuals for the locality.

3. Evenness index (J) or Smith and Wilson's index: it is used to check the evenness of species diversity of a particular locality. The value of J ranges from 0 to 1. Less variation means higher value of J in communities between the species and vice versa.

J = H'/ ln (S). Here 'H'' is Shannon-Wiener index and 'S' is species richness

Dissimilarity among seasonality of AGF and AGL

Month-wise and season-wise abundance datasets are checked by ANOVA at $p < 0.05$ level of significance (see supplementary file 1). Month-wise abundance data in AGL was found to be statistically significant (F=3.37, p=0.00015*, where '*' means statistically significant) but statistically insignificant in AGF (F=9.10, p=1.57). Season-wise abundance data of AGL was found to be statistically significant (F=6.18, p=0.002*) and statistically insignificant in AGF (F=0.32, p=0.72). But the overall dataset of season-wise abundance was found to be statistically significant (F=3.34, p=0.003*). We performed non-metric multidimensional scaling (nMDS; a mostly two-dimensional diagram) analysis in PAST software version 3. 22 (PAST, 2020) to show the dissimilarities between season and species assemblages between the two sites. The nMDS was based on the species composition and abundance of each species found in each season. Bray-Curtis similarity was used while running the nMDS plot in PAST because this is the most commonly used similarity index to study similarities among several taxa (Hoque *et al*. 2015).

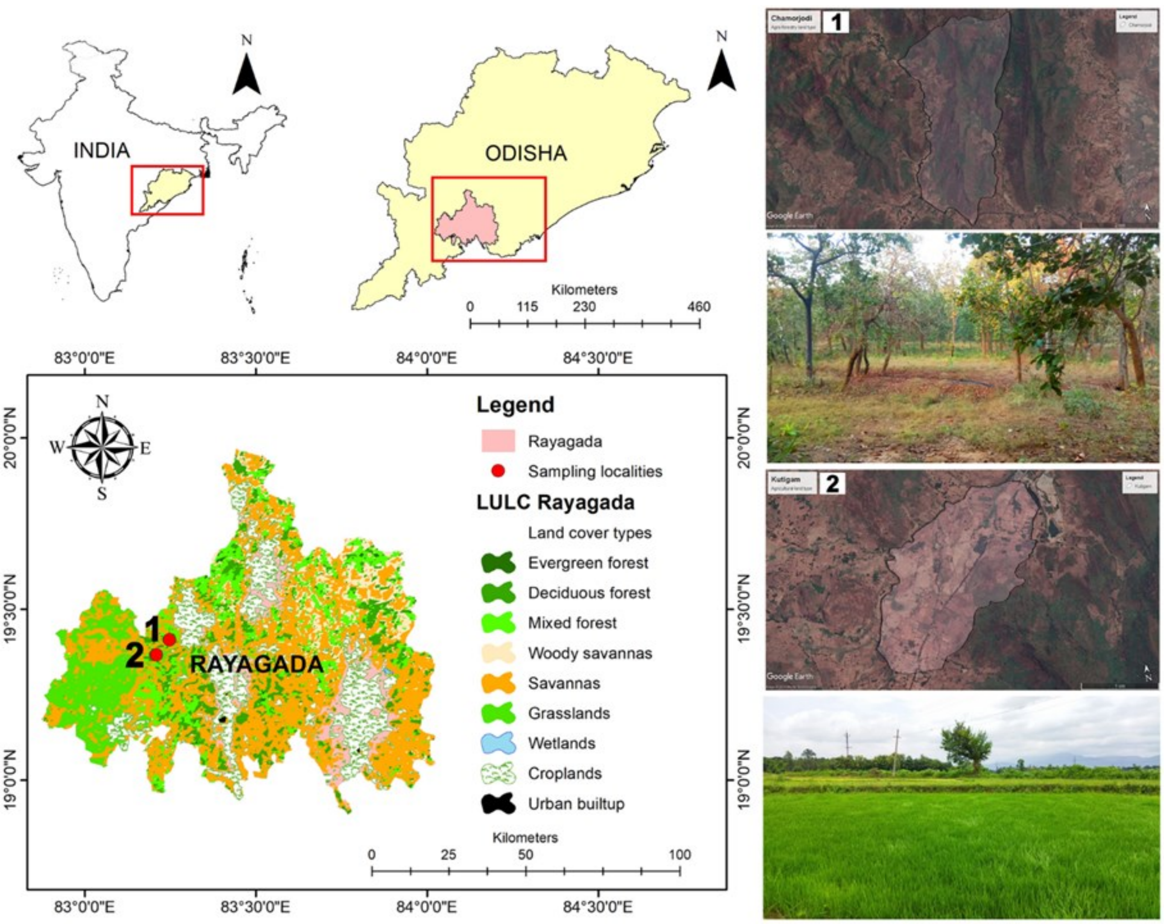

Figure 1. Two study sites of Rayagada district, Odisha, India

RESULTS

Species diversity

A total of 75 species belonging to 58 genera, 14 subfamilies, five families of butterflies documented during the entire study period. Highest number of species belonged to Nymphalidae family (27 species; 36%), followed by Lycaenidae (20 species; 26.6%), Pieridae (11 species; 14.6%), Hesperiidae (9 species; 12%) and the least number of species was documented from Papilionidae (8 species; 10.6%). Higher number of species were observed in AGF i.e., 73 species, whereas only 50 species were recorded in AGL (supplementary file 1). A total of 1534 individuals were recorded during the entire study period. On the contrary, more individuals were found in AGL (905 individuals; 58.99%) compared to AGF (629; 41%). This provide an important information that AGL is less species diverse than AGF but the abundance of butterflies is larger in AGL as compared to AGF. The most abundant species in both AGF and AGL were Common grass yellow *Eurema hecabe* (43 individuals in AGF; 141 individuals in AGL), Lemon emigrant *Catopsilia pomona (*37 in AGF; 46 in AGL) and Common Crow *Euploea core* (35 in AGF; 60 in AGL). However, Common Psyche *Leptosia nina* (44 individuals) and Lime Blue *Chilades lajus* (28) are abundantly found in AGF but less abundantly found in AGL. Similarly, Tiny grass blue *Zizula hylax* (50 individuals), Tawny coster *Acraea terpsicore* (47) and Chocolate pansy *Junonia iphita* (46) were found abundantly in AGL but not abundantly found in AGF.

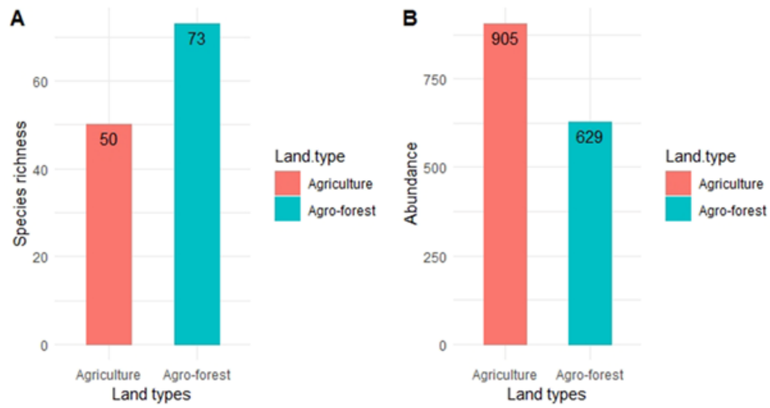

Figure 2. Bar plots of (A) species richness, (B) abundance of two agricultural land types

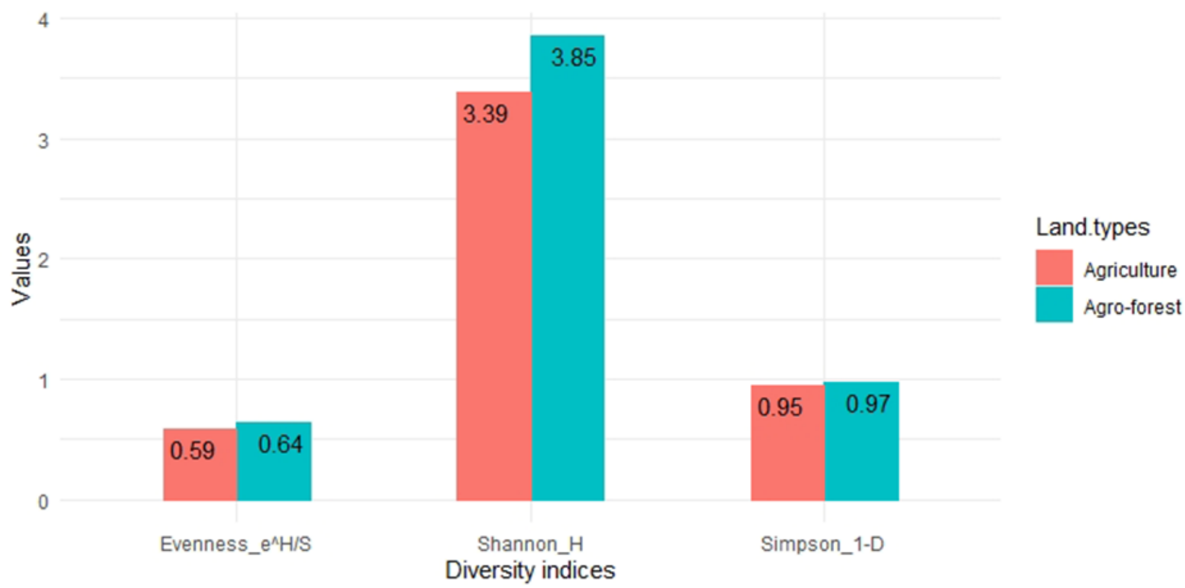

Figure 3. Values of several diversity indices between AGF and AGL.

Based upon the relative abundance data (see supplementary file 1), 36 species were found to be very common (48%), 18 species (24%) were occasional, 15 species (20%) were rare and six species (8%) were found to be very rare during the entire study. This study has revealed that a total of nine species were found to be legally protected under Indian Wildlife (Protection) Act (IWPA, 1972). Among them, four species viz. Crimson Rose *Pachliopta hector*, Common Mime *Papilio clytia*, Common Pierrot *Castalius rosimon* and Danaid Eggfly *Hypolimnas misippus* were under Schedule I; rest four species viz. Gram Blue *Euchrysops cnejus*, Pea Blue *Lampides boeticus*, Blue Spotted Crow *Euploea midamus* and Grey count *Tanaecia lepidea* were under Schedule II. The photographs of the scheduled butterfly species were given in Figure 8.

Diversity indices

The abundance data was taken for the calculation of several diversity indices (see supplementary file 1). Values of Shannon's diversity index (H′), Simpson's index (λ) in AGF was found to be higher as compared to AGL (Fig. 4). Thus, inferring that in terms of species diversity, AGF more diverse and richer as compared to AGL. The value of J was 0.64 in AGF, which is higher as compared to the value of E in AGL i.e., 0.59. The higher value of J is indicating less variation in butterfly community and the lower value of J in AGF as compared to AGL.

Seasonality of butterflies in AGF and AGL

The largest number of species were observed during monsoon season in AGF (n=52 species), followed by summer in AGF (n=50), winter in AGF (n=49), summer in AGL (n=43), monsoon in AGL (n=42) and the least number of species were observed during winter season in AGL (n=38). Overall, the highest number of species were observed during summer season (n=63), followed by monsoon season (n=62) and the least number of species were observed during winter season (n=56) (see supplementary file 1). All these variations are visualized in Figure 4.

Studying the month-wise species occurrence has shown quite interesting facts regarding the butterfly assemblages found in both AGF and AGL of Rayagada (Fig. 6; see supplementary file 1). In AGF, there are two peaks observed in June and October. Only a single species was observed during August. This indicate that the lowest as well as the highest species occurrence was observed during monsoon season in AGF. The observation of higher peak was quite similar in AGL too. Because the two peaks were observed in the same months as that of AGF. But the first peak was higher as compared to AGF in AGL while the second peak was lower than AGF. More species were observed in the month of January in AGL than AGF. The nature of lower peaks is not same in AGL than AGF. Because minimum 12 species were observed in AGL during August, which is larger than the minimum number of species observed in AGF during August.

Table 2. Annotated checklist of butterfly diversity of two agricultural land types of Rayagada district, Odisha, India

Sl. No.	Family	Subfamily	Species name	Scientific name	IWPA
1	Hesperiidae	Coeliadinae	Common Banded Awl	*Hasora chromus* (Cramer, [1780])	–
2		Pyrginae	Indian Skipper	*Spialia galba* (Fabricius, 1793)	–
3		Hesperiinae	Straight Swift	*Parnara guttatus* (Bremer and Grey, [1852])	–
4			Grass Demon	*Udaspes folus* (Cramer, [1775])	–
5			Restricted Demon	*Notocrypta curvifascia* (C. & R. Felder, 1862)	–
6			Chestnut Bob	*Iambrix salsala* (Moore, [1866])	–
7		Pyrginae	Golden Angle	*Caprona ransonnetti* (Felder, 1868)	–
8			Asian Grizzled Skipper	*Spialia galba* (Fabricius, 1793)	–
9			Suffused Snow Flat	*Tagiades gana* (Moore, [1866])	–
10	Papilionidae	Papilioninae	Blue Mormon	*Papilio polymnestor* Cramer, 1775	–
11			Common Banded peacock	*Papilio crino* Fabricius, 1793	–
12			Common Mormon	*Papilio polytes* Linnaeus, 1758	–
13			Common Mime	*Papilio clytia* Linnaeus, 1758	I
14			Lime Swallowtail	*Papilio demoleus* Linnaeus, 1758	–
15			Common Rose	*Pachliopta aristolochiae* (Fabricius, 1775)	–
16			Crimson Rose	*Pachliopta hector* (Linnaeus, 1758)	I
17			Tailed Jay	*Graphium agamemnon* (Linnaeus, 1758)	–
18	Pieridae	Coliadinae	Common Grass Yellow	*Eurema hecabe* (Linnaeus, 1758)	–
19			One-spot Grass Yellow	*Eurema andersonii* (Moore, 1886)	–
20			Lemon Emigrant	*Catopsilia pomona* (Fabricius, 1775)	–
21			Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus, 1758)	–
22		Pierinae	Indian Jezebel	*Delias eucharis* (Drury, 1773)	–
23			Common Gull	*Cepora nerissa* (Fabricius, 1775)	–
24			Indian Wanderer	*Pareronia hippia* (Fabricius, 1787)	–
25			Common Psyche	*Leptosia nina* (Fabricius, 1793)	–
26			Eastern Striped Albatross	*Appias olferna* Swinhoe, 1890	–
27			White Orange-tip	*Ixias marianne* (Cramer, [1779])	–
28			Pioneer	*Belenois aurota* (Fabricius, 1793)	–

Table 2 continued in next page

29	Lycaenidae	Polyommatinae	Gram Blue	*Euchrysops cnejus* (Fabricius, 1798)	II
30			Lime Blue	*Chilades lajus* (Stoll, [1780])	–
31			Forget-me-not	*Catochrysops strabo* (Fabricius, 1793)	–
32			Dusky Blue Cupid	*Everes hugelii* (Gistel, 1857)	–
33			Indian Cupid	*Everes lacturnus* (Godart, [1824])	–
34			Common Hedge Blue	*Acytolepis puspa* (Horsfield, [1828])	–
35			Common Pierrot	*Castalius rosimon* (Fabricius, 1775)	I
36			Orange-spotted Grass Jewel	Freyeria trochylus (Freyer, 1845)	–
37			Pea Blue	*Lampides boeticus* (Linnaeus, 1767)	II
38			White Hedge Blue	*Udara akasa* (Horsfield, [1828])	–
39			Pale Grass Blue	*Pseudozizeeria maha* (Kollar, [1844])	–
40			Lesser Grass Blue	*Zizina otis* (Fabricius, 1787)	–
41			Tiny Grass Blue	*Zizula hylax* (Fabricius, 1775)	–
42			Common Cerulean	*Jamides celeno* (Cramer, [1775])	–
43		Theclinae	Purple Leaf Blue	*Amblypodia anita* Hewitson, 1862	–
44			Monkey Puzzle	*Rathinda amor* (Fabricius, 1775)	–
45			Large Oakblue	*Arhopala amantes* (Hewitson, 1862)	–
46			Common Silverline	*Spindasis vulcanus* (Fabricius, 1775)	–
47			Plains Blue Royal	*Tajuria jehana* Moore, [1884]	–
48			Yamfly	*Loxura atymnus* (Stoll, 1780)	–
49	Nymphalidae	Biblidinae	Common Castor	*Ariadne merione* (Cramer, [1777])	–
50			Angled Castor	*Ariadne ariadne* (Linnaeus, 1763)	–
51		Danainae	Common Crow	*Euploea core* (Cramer, [1780])	–
52			Blue-spotted Crow	*Euploea midamus* (Linnaeus, 1758)	II
53			Striped Tiger	*Danaus genutia* (Cramer, [1779])	–
54			Plain Tiger	*Danaus chrysippus* (Linnaeus, 1758)	–
55			Glassy Tiger	*Parantica aglea* (Stoll, [1782])	–
56			Blue Tiger	*Tirumala limniace* (Cramer, [1775])	–
57		Heliconiinae	Tawny Coster	*Acraea terpsicore* (Linnaeus, 1758)	–
58			Common Leopard	*Phalanta phalantha* (Drury, [1773])	–
59		Limenitidinae	Baronet	*Symphaedra nais* (Forster, 1771)	–
60			Commander	*Moduza procris* (Cramer, [1777])	–
61			Grey Count	*Tanaecia lepidea* (Butler, 1868)	II
62			Common Sailer	*Neptis hylas* (Linnaeus, 1758)	–
63			Yellow Sailer	*Neptis ananta* Moore, [1858]	–

Table 2 continued in next page

64	Nymphalinae	Danaid Eggfly	*Hypolimnas misippus* (Linnaeus, 1764)	I
65		Lemon Pansy	*Junonia lemonias* (Linnaeus, 1758)	–
66		Chocolate Pansy	*Junonia iphita* (Cramer, [1779])	–
67		Grey Pansy	*Junonia atlites* (Linnaeus, 1763)	–
68		Peacock Pansy	*Junonia almana* (Linnaeus, 1758)	–
69		Blue Pansy	*Junonia orithya* (Linnaeus, 1758)	–
70		Yellow Pansy	*Junonia hierta* (Fabricius, 1798)	–
71	Satyrinae	Common Four-ring	*Ypthima huebneri* Kirby, 1871	–
72		Common Bushbrown	*Mycalesis perseus* (Fabricius, 1775)	–
73		Dark-branded Bushbrown	*Mycalesis mineus* (Linnaeus, 1758)	–
74		Common Evening Brown	*Melanitis leda* (Linnaeus, 1758)	–
75		Common Palmfly	*Elymnias hypermnestra* (Linnaeus, 1763)	–

The MDS plot, suggesting two distinct groups of species assemblages across three seasons (Fig. 7). The two agricultural land types i.e., AGF and AGL have occupied separately in the plot showing the dissimilarity among the butterfly abundance between two land types. The stress value of nMDS was calculated to be 0.1448 indicate that this nMDS is fair in determining the dissimilarity but not strong enough.

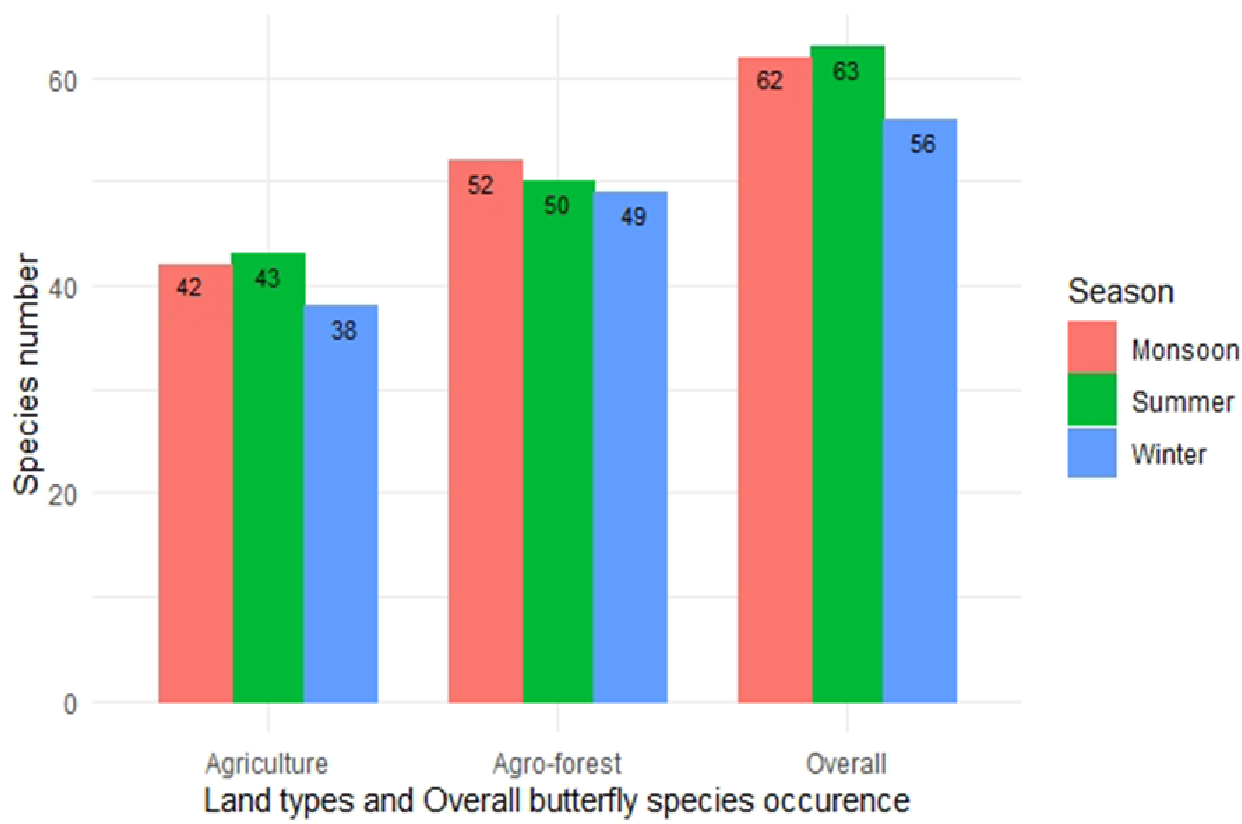

Figure 4. Values of several diversity indices between AGF and AGL

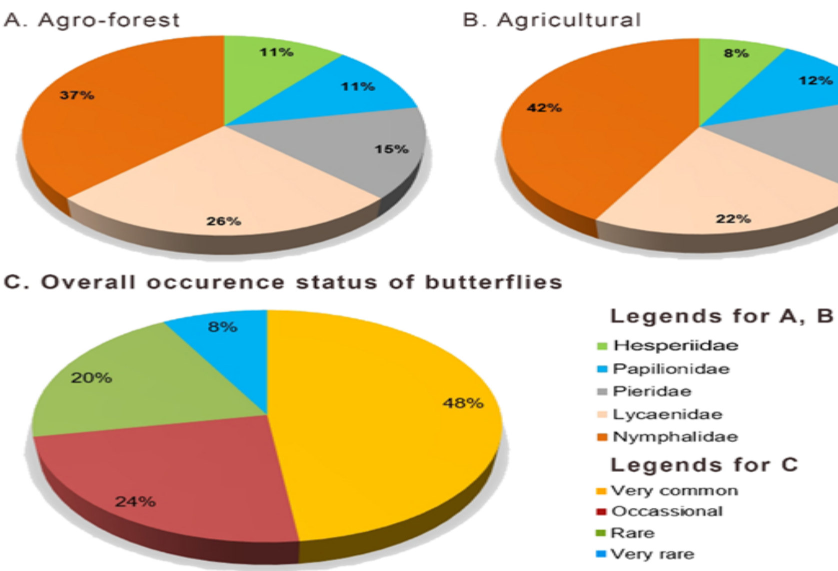

Figure 5. Pie-chart of family-wise species composition of butterflies. (A, B) in two land types, (C) overall occurrence status

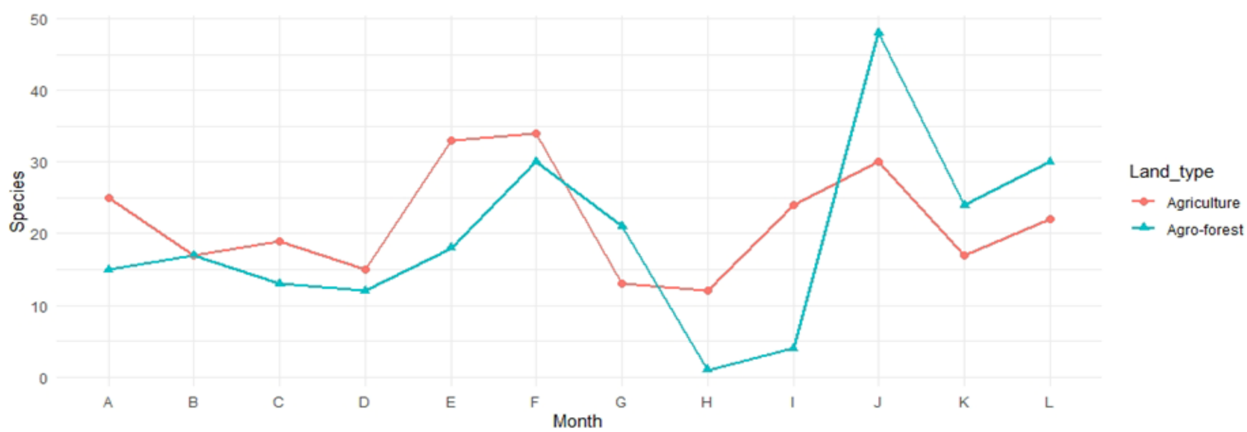

Figure 6. Month-wise species occurrence in both land types (A–L: representing months of a year chronologically)

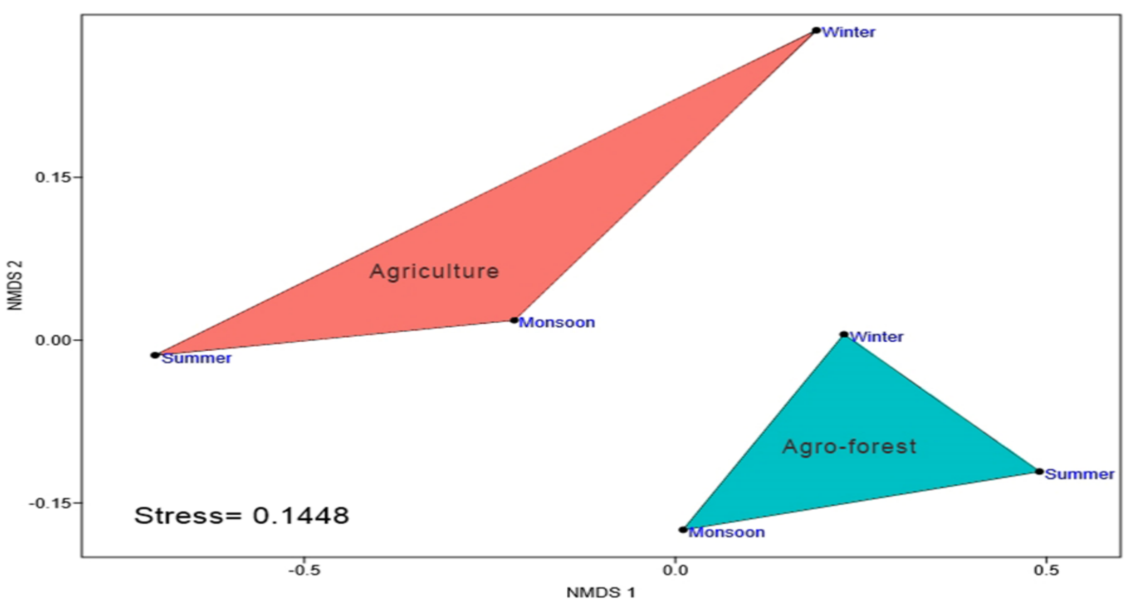

Figure 7. Non-metric multidimensional scaling (NMDS) of Bray-Curtis dissimilarities between three seasons and two land types (stress=0.1448)

Figure 8. Scheduled butterfly species (A-I) found in AGF and AGL of Rayagada district

DISCUSSION

The present study revealed the presence of 1534 individuals and 75 species under five families, 14 subfamilies and 58 genera of butterflies. Between the two sites, more species were observed under Nymphalidae family. Similarly, Nymphalids were found to be in greater number in other studies conducted in several studies due to the disturbance resistant nature of Nymphalids (Fermon *et al*. 2005; Khan & Rastogi, 2015; Payra *et al*. 2016; Boruah *et al*. 2018; Mohanta & Behera, 2018; Mahata *et al*. 2019). The species richness and diversity are not the strong indicator of richer and diverse region rather a small population of Nymphalids along with other butterfly families present at lower spatial scale can act as indicators for giving numerous information in assessing the ecosystem health and implication of management policies (Thomas & Mallorie, 1985; Spitzer *et al*. 1997; Fermon *et al*. 2000, 2005; Thomas, 2005; Mahata *et al*. 2019). Rutaceae and Annonaceae plant families are the larval host plant for Papilionidae butterflies, but in the other hand Moraceae, Malvaceae, Acanthaceae, Fabaceae and Poaceae plant families are the host plants of Nymphalidae, Pieridae, Lycaenidae and Hesperiidae butterflies (Deepika, Atluri & Sowmya, 2014; Anand, Rufus & Vivekraj, 2016; Khyade & Jagtap, 2017). The habitat heterogeneity is higher in AGF as compared to AGL which is supported by the availability of variety of plants which is higher in AGF.

All these factors are can be suggested as the main reason of AGF being the most specious site than AGL. But the lower abundance, higher species richness in AGF and higher abundance, lower species richness in AGL can be explained by the following reasons (a) variation in species dispersal patterns (dispersal is an ecological process that mainly involve the movement of an individual or multiple individuals from the main population to another location), (b) resource availability, (c) predation and (d) habitat disturbance The species dispersal happens in lower rate in AGF as compared to AGL.

Because the availability of nectar and larval host plants is higher in AGF than AGL (as AGL is a monotypic land with less variety of vegetation). Including this AGF provide good place to butterflies for fulfilling their non-consumable resources (roosting, basking, mate location). The perennial streams present inside AGF provide good puddling areas for butterfly fauna found there while the AGL lack proper place for mud-puddling. Hence the butterflies which were observed in AGL disperse to various locations due to relatively lower resource availability. Numerous predators are present in AGF such as birds, reptiles, amphibians who prey on butterflies for their survival. But in AGL, they were less abundant. Except all of this, the agricultural site has a monotonous vegetation than the forest site could be a main reason behind the greater number of individuals but lower number of species. Availability of tree plant shade (direct sunlight inhibits butterfly activity) in AGF due to the presence of more perennial plants than AGL may be another reason for more species diversity in AGF. Studies conducted in various agro-forest lands close to natural habitats exhibited richer species diversity and abundance similar to the present study (Dolia *et al*. 2008; Munyuli, 2013b; Mahata *et al*. 2019). All of this information is supported by the quantified diversity indices of both agricultural land types i.e., higher Shannon-Wiener index (H′) and Simpson's index (λ) in AGF and lower values of diversity indices in AGL.Overall, the habitat heterogeneity, resource availability of Agro-forest lands can be regarded as the major complementary factor to landscape enhancement of any ecosystem (Turner, 1989; Danielson, 1991; Dunning, Danielson & Pulliam, 1992; Mahata *et al*. 2019). Hence it may be suggested to understand the importance of agro-forest landscapes in a greater manner by using butterfly as an indicator taxon. Because the role of agro-forest lands in biodiversity conservation is well understood (Estrada, Cammarano & Coater-Estrada, 2000; Beecher *et al*. 2002; Wezel & Bender, 2003; Harvey & González Villalobos, 2007; Bhagwat *et al*. 2008; Scales & Marsden, 2008; Philpott *et al*. 2008). In contrast the agricultural land can also give some importance insight into the health of an ecosystem (Elsen *et al*. 2017; Decaëns *et al*. 2018). Here in our study AGL was found less specious, less resource area than AGF. This can also be explained by the usage of chemical pesticides in AGL by the locals. Because the effects of chemical use on agriculture is greatly influence the butterfly diversity of agricultural lands (Pekin, 2013). Human intervention can be seen frequently in AGL due to their livelihood practices. While in the other hand logging is a major problem in AGF. Logging in forest negatively effects on its biodiversity and the effect is temporarily irreversible. This creates disturbances among local biodiversity instantly and spread at larger scale if practiced consistently. Logging can also lead to forest loss, reduction in insect diversity (Struhsaker, 1997; Willott *et al*. 2000). Along with this habitat disturbance, alteration, landscaping might be the main reasons of butterfly declination in these areas.

Studying seasonality among butterfly species assemblages is a common practice among researchers to know the temporal occurrence of butterfly fauna in a region (Saikia, 2014; Ansari, Ram & Nawab, 2015; Singh, Gogoi & Sebastian, 2015; Boruah *et al*. 2018; Arya, Dayakrishna & Verma, 2020; Harisha & Hosetti 2021). Our study shows highest number of species in summer season. While the least number of species were observed during winter season. This may be related to the pattern of rainfall here but it cannot be proved. The peaks in month-wise species occurrence were also been reported in a study conducted in Gibbon Wildlife Sanctuary, Assam (Singh *et al*. 2015). In their study, post-monsoon season was the most specious season along with two peaks in month-wise species occurrence observation. Similarly in the present study two peaks in species occurrence observation was seen during June and October. All this variation in seasonality was supported by the nMDS ordination.

In conclusion, this study provides baseline information regarding the butterfly fauna found in Rayagada district of southern Odisha. The butterfly fauna of both agricultural land types varied significantly across seasons. The findings of this study may expose new directions in exploring butterfly fauna of agricultural and agro-forest lands found in other regions. Besides richer diversity, strong seasonality both land types exhibited potentiality in the survival of butterflies. But the threats are also looming around it. So, it is advisable to implicate the conservation measures in these areas. Awareness among local villagers, students, people can be created via various nature-oriented programs, photography exhibition, drawing competitions. Furthermore, plantation of larval as well as nectar host plants are also required to recover the degraded areas of these regions.

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