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Butterfly diversity in agriculture zones of Malshiras Tehsil, Maharashtra State, India

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Abstract
Butterflies serve as sensitive bioindicators of habitat quality and environmental change due to their close association with vegetation structure and microclimatic conditions. The present study assessed butterfly diversity in agricultural landscapes of Malshiras Tehsil, Solapur District, Maharashtra. A total of 32 species belonging to four families were recorded, with Nymphalidae emerging as the most dominant group. Seasonal variations in diversity and abundance were prominent, with peak richness observed during the monsoon and early winter months and a noticeable decline during summer, likely due to reduced moisture and floral availability. Species richness correlated positively with habitat heterogeneity and green cover, highlighting the role of vegetative diversity in sustaining butterfly populations. The findings are consistent with earlier studies conducted in similar agro-ecological regions of India and underscore the ecological value of maintaining habitat complexity within agricultural zones for pollinator conservation.

Keywords: Butterfly, Nymphalidae, diversity, agricultural zone

Introduction

The order Lepidoptera is one of the most recognized and popular insect orders which includes butterflies and moths, and is amongst four most species diverse orders along with Coleoptera, Diptera and Hymenoptera. The Lepidoptera fauna varies greatly depending upon altitude (Sidhu 2023) [23]. The order Lepidoptera includes moths and butterflies. The butterfly is a diverse insect, found in many colours and sizes. Worldwide, there are more than 28,000 species of butterflies, with about 80 percent in tropical regions. Butterflies require food in liquid form (Larson *et al*. 2001) [12]. Butterfly is considered as a flagship fauna (Tiple *et al*. 2005) [28].

Butterflies are sensitive indicators of environmental change, playing an important role in monitoring climate variations and habitat degradation. They are vital ecological components, serving as both key pollinators and links in the food chain. Due to their sensitivity to environmental fluctuations and habitat structure, butterflies respond quickly to disturbances and changes in habitat quality and landscape structure (Kocher and Williams 2000; Aneesh *et al*. 2013) [1, 9].

Butterflies have been studied for their numerous aspects, such as biodiversity, abundance, food preferences, population dynamic, distribution and bioindicators of environmental health, managed and degraded ecosystems, also used in monitoring programs (Nganso *et al*., 2012; Sawchik *et al*., 2003; Suwarno *et al*., 2010b, 2010a) [15, 20, 25, 26]. They are well-studied, easily observed, sensitive to changes in vegetation and management practices, and they are tightly intertwined with ecological systems as both primary consumers (herbivores) and as food items (Nganso *et al*. 2012) [15]. Butterfly populations can show large natural fluctuations. These are mainly due to environmental features, especially weather conditions. Longterm changes in abundance and distribution have been linked to a range of factors including habitat loss and fragmentation, land use changes, and climate change (Schulze *et al*. 2004; Suwarno *et al*. 2010) [21, 25, 26]. Seasonal fluctuations of butterflies covering a particular area are influenced by environmental factors *viz*., temperature, photoperiod, rainfall, humidity and availability of food resources, types of vegetations *viz*., herbs, shrubs and trees (Shanthi *et al*. 2009; Tiple and Khurad 2009; Anu *et al*. 2009) [2, 22, 29].

Malshiras Tehsil is one of the eleven tehsils in Solapur district, which is part of the Pune division of Maharashtra State in Western Maharashtra. It is located in the northwestern part of Solapur district and lies approximately between 17°46′N 74°52′E and 18°10′N 75°18′E. The total geographical area of Malshiras Tehsil is around 1,563 square kilometers, of which 35.02 square kilometers is classified as hilly terrain. The Malshiras Block has no recorded saline land, indicating that its soils are generally non-saline, which can impact both agricultural productivity and vegetation type in the area (Hajare *et al*. 2014) [4].

The average annual rainfall for the period 2000–2019 in Malshiras Block was
439.73 mm (standard deviation = 181.99), which is below the normal rainfall level of
530 mm, suggesting minor annual variability over the two decades (Patil and Toradmal 2020) [17].

In the present study, butterfly diversity was assessed across agricultural landscapes of Malshiras Tehsil to understand seasonal patterns and habitat associations. This investigation highlights the ecological role of butterflies as bioindicators and emphasizes the importance of habitat heterogeneity in sustaining pollinator diversity in agro-ecosystems.

Material and methods

Study Site

The village Neware (Latitude 17.836028 and Longitude 75.180853) was selected as agricultural zone of Malshiras tehsil. Neware is situated centrally within Malshiras tehsil and is surrounded by cultivated land and small water reservoirs used for irrigation. The area is dominated by sugarcane and horticultural crops, which may influence butterfly composition through pesticide exposure. However, road margins, canal embankments, and uncultivated field boundaries often harbor flowering plants that support pollinators and butterflies.

Methodology

Butterflies sampling was carried out in Summer (March to June), Monsoon (July to October) and Winter (November to February) seasons using the timed, directed, fixed distance transect method depending on the locality and terrain. Samplings were done every week under sunny condition and divided into two period times 8.00 am – 10.00 am and 4.00 pm – 6.00 pm a day and about 90 minutes were spent in each time period. Transects (walk trails) were 200 m in length and stretched every week along the established walk trail. While walking along transect, butterflies seen across 5 m distance from either side of the mid-line were observed and collected. The collected butterflies were identified to the species level using the morphology characters of the specimen such as body size, wing venation and colour on each part of the wing and other specific characters. The identifications were done as per (Kunte 1997) [10], (Kehimkar 2008) [8] and (Kasambe 2018) [7].

The diversity indices were calculated using statistical software PAST version 4.03 (Hammer and Harper 2001) [5].

Result and discussion

Table 1: Butterfly diversity in agricultural zone of Malshiras

Sr. No.	Species	Spring	Summer	Early monsoon	Late Monsoon	Early Winter	Late Winter	Total
A.	**Family Pieridae**							
1	*Appias albina*	1	2	21	18	3	1	46
2	*Appias libythea*	1	3	14	7	1	1	27
3	*Catopsilia florella*	3	4	2	2	2	4	17
4	*Catopsilia pomona*	2	4	21	18	1	1	47
5	*Catopsilia pyranthe*	2	4	17	13	3	2	41
6	*Cepora nerissa*	0	1	11	12	0	1	25
7	*Colotis etrida*	2	2	1	3	4	2	14
8	*Eurema brigitta*	5	2	19	20	5	5	56
9	*Eurema hecabe*	2	5	22	15	4	3	51
10	*Ixias marianne*	2	2	0	3	7	11	25
11	*Pieris canidia*	3	3	0	1	16	13	36
12	*Pieris rapae*	6	4	5	2	2	6	25
B.	**Family Papilionidae**							
13	*Graphium agamemnon*	1	2	6	8	2	0	19
14	*Graphium doson*	2	1	3	5	0	1	12
15	*Graphium sarpedon*	1	0	7	5	0	1	14
16	*Papilio demoleus*	8	10	5	11	5	9	48
17	*Papilio polymnestor*	0	1	16	15	0	0	32
18	*Papilio polytes*	5	1	16	14	4	5	45
C.	**Family Nymphalidae**							
19	*Acraea violae*	1	2	14	11	3	1	32
20	*Danaus chrysippus*	1	1	22	15	3	1	43
21	*Danaus genutia*	1	4	12	15	4	3	39
22	*Euploea core*	3	4	21	22	4	1	55
23	*Euploea klugii*	2	2	3	2	0	1	10
24	*Euploea sylvester*	0	0	5	8	1	2	16
25	*Hypolimnas bolina*	0	0	18	9	0	1	28
26	*Hypolimnas misippus*	0	0	15	10	0	2	27
27	*Junonia almana*	1	4	4	1	13	21	44
28	*Junonia iphita*	1	4	5	5	14	21	50
29	*Junonia lemonias*	2	5	5	2	21	15	50
30	*Melanitis leda*	2	5	10	13	1	4	35
31	*Melanitis phedima*	1	1	6	6	0	1	15
D.	**Family Lycaenidae**							
32	*Chilades parrhasius*	2	1	2	1	15	8	29

Table 2: Diversity indices of butterfly diversity in agricultural zone of Malshiras

	Spring	Summer	Early monsoon	Late monsoon	Early winter	Late winter
Taxa_S	27	28	30	32	24	30
Individuals	63	84	328	292	138	148
Dominance_D	0.057	0.050	0.047	0.045	0.080	0.078
Simpson_1-D	0.943	0.950	0.953	0.955	0.920	0.922
Shannon H	3.076	3.147	3.181	3.220	2.797	2.871
Evenness_e^H/S	0.803	0.831	0.803	0.782	0.683	0.588
Brillouin	2.571	2.714	3.011	3.027	2.539	2.595
Menhinick	3.402	3.055	1.656	1.873	2.043	2.466
Margalef	6.275	6.094	5.006	5.461	4.668	5.803
Equitability_J	0.933	0.945	0.935	0.929	0.880	0.844
Fisher_alpha	17.900	14.710	8.036	9.162	8.396	11.360

Berger-Parker	0.127	0.119	0.067	0.075	0.152	0.142
Chao-1	31.090	30.630	30.000	32.600	25.500	43.200

A total of 32 butterfly species belonging to four families—Pieridae, Papilionidae, Nymphalidae, and Lycaenidae—were recorded from the agricultural zone of Malshiras tehsil during seasonal surveys (Table 1). Among these, the family Nymphalidae was the most dominant in terms of individual abundance (514 individuals), followed by Pieridae (414), Papilionidae (170), and Lycaenidae (29). Species such as *Eurema brigitta* (56), *Euploea core* (55), *Eurema hecabe* (51),

Junonia iphita (50), *Junonia lemonias* (50), and *Papilio demoleus* (48) were among the most frequently encountered butterflies, indicating that both Pierid and Nymphalid species are well-adapted to agricultural landscapes.

Seasonal variation in butterfly abundance was evident, with a marked increase during the monsoon periods. The highest numbers were observed during the Late Monsoon (288 individuals) and Early Monsoon (287), reflecting peak activity likely associated with favorable temperature, humidity, and host plant availability. In contrast, Spring (81) and Summer (105) showed reduced butterfly activity, possibly due to harsh dry conditions and limited nectar resources. Winter seasons also supported a moderate diversity, with 231 individuals recorded across Early and Late Winter, particularly among *Junonia* and *Pieris* species. Certain species exhibited strong seasonality; for instance, *Catopsilia pomona*, *Eurema hecabe*, and *Euploea core* were monsoon-dominant, whereas *Junonia almana*, *Pieris canidia*, and *Chilades parrhasius* were primarily observed during the winter months. This seasonal and family-level distribution highlights the ecological responsiveness of butterflies to changing environmental conditions in agroecosystems.

Based on the diversity indices calculated from the butterfly assemblages in agricultural zones of Malshiras Tehsil, clear seasonal variations in community structure and diversity were observed (Table 2). Species richness (Taxa_S) peaked during the Late Monsoon with 32 species and remained relatively high during the Early Monsoon (30 species) and Late Winter (30 species), indicating favorable ecological conditions in these seasons. In contrast, Early Winter showed a noticeable decline in species richness (24 species), despite a relatively higher number of individuals (138), suggesting possible dominance by fewer species.

The Shannon Diversity Index (H') values were highest during the Late Monsoon (3.220) and Early Monsoon (3.181), reflecting high species diversity and evenness during these wet periods. This was further supported by high values of Simpson's Index (1–D) (>0.95), indicating low dominance and more equitable distribution among species. The Dominance Index (D) was lowest in the Late Monsoon (0.045), suggesting minimal influence of any single species on the community. Seasonal trends in Evenness (e^H/S) also revealed that the butterfly community was more balanced in Spring and Summer (0.803 and 0.831 respectively), while Late Winter showed lower evenness (0.588), pointing toward skewed species dominance.

Additionally, richness estimators like Margalef, Menhinick, and Fisher's Alpha all showed higher values during Spring and Summer, but lower during peak monsoon seasons, possibly due to high individual counts diluting per capita richness. The Chao-1 estimator predicted the highest unseen diversity in Late Winter (43.2), suggesting that this season may harbor more undetected species and requires more intensive sampling. Overall, the results suggest that butterfly diversity and community composition in agricultural zones are strongly influenced by seasonal climatic variation, with monsoon periods supporting higher diversity and evenness, while transitional seasons like winter may see greater dominance by specific species.

Butterflies are widely recognized as ecologically significant organisms and serve as reliable indicators of environmental quality and habitat integrity (Stefanescu *et al*. 2004) [24]. Their diversity patterns can provide essential insights into the structure and health of ecosystems, particularly through observed variations in species richness and abundance in relation to vegetation composition and surrounding landscape features (Öckinger *et al*. 2006; Mutmainnah and Santosa 2019) [14, 16]. The findings of the present study reaffirm these observations, demonstrating that butterfly diversity within the agricultural zones of Malshiras Tehsil is notably influenced by the heterogeneity of habitats and the availability of plant resources. Previous studies have similarly noted that landscapes with a higher diversity of vegetation support a richer butterfly fauna (Kuussaari *et al*. 2007; Mukherjee *et al*. 2015) [11, 13], a trend that was evident in the relatively higher diversity and evenness observed during monsoon and early winter seasons in the current study.

Our data also reveal that butterfly species richness and abundance peak during the monsoon months and gradually decline toward the summer. This seasonal trend is consistent with earlier reports suggesting that reductions in soil moisture, floral diversity, and host plant availability during the dry season adversely impact butterfly populations (Gupta *et al*. 2019) [3]. Environmental parameters such as temperature and relative humidity played a significant role in shaping butterfly assemblages, with higher humidity during the monsoon favoring larval development and adult activity. Monthly monitoring indicated a distinct increase in population size from August to December, followed by a decline from January to May, reflecting typical seasonal dynamics of butterfly communities in semi-arid agricultural regions.

The dominance of the family Nymphalidae, as recorded in the present study, corresponds with observations from other regions across India and tropical Asia, where this family often emerges as the most prevalent group (Tiple 2018; Mutmainnah and Santosa 2019) [14, 29]. Furthermore, the species composition observed in the Malshiras agricultural landscape closely aligns with that reported in other parts of India with comparable habitat types, suggesting a consistent pattern of butterfly distribution across similar agro-ecological zones (Roy *et al*. 2012; Saikia 2014; Harsh 2014; Mukherjee *et al*. 2015) [6, 13, 18, 19]. These findings collectively emphasize the importance of maintaining habitat diversity and microclimatic conditions in agricultural landscapes to support and conserve butterfly populations.

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