

Seasonal Dynamics of Butterfly Communities in Different Habitats of Ranchi, Jharkhand

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Abstract

This research investigates the seasonal dynamics of butterfly communities across various habitats in the Ranchi district of Jharkhand. Butterflies, being sensitive indicators of environmental changes, offer valuable insights into the health and biodiversity of ecosystems. The study aimed to understand the habitat preferences, seasonal distribution patterns, and factors influencing butterfly diversity in different landscapes within the Ranchi region.

Butterflies play a crucial role in ecosystems as pollinators and are considered bioindicators of environmental health. The diversity and distribution of butterflies are influenced by various factors, including habitat type, climate, and vegetation. Ranchi, located in the state of Jharkhand, offers a diverse range of habitats, from urban green spaces to forested areas and wetlands. This research seeks to contribute to the understanding of how these diverse habitats influence the seasonal dynamics of butterfly communities.

The primary objective of this study was to assess the seasonal variations in butterfly communities across different habitats in Ranchi. Specific goals included identifying key habitat preferences of butterflies, documenting seasonal changes in species composition, and exploring potential factors influencing butterfly diversity. By achieving these objectives, the research aimed to provide valuable information for conservation and management efforts in the region.

Field surveys were conducted over a period of 12 months, covering distinct seasons in Ranchi. Sampling sites were selected to represent various habitats, including urban parks, forested areas, wetlands, and rural landscapes. Standard butterfly survey techniques, such as transect walks and netting, were employed to collect data on species composition and abundance. Additionally, environmental variables, including temperature, humidity, and vegetation cover, were recorded to analyze their potential impact on butterfly communities.

The study revealed significant seasonal variations in butterfly diversity across different habitats. Urban green spaces exhibited higher butterfly abundance during the warmer months, with a dominance of common urban-adapted species. In contrast, forested areas showcased a diverse community throughout the year, with distinct species assemblages in each season. Wetland habitats exhibited specific butterfly preferences during the monsoon season, highlighting the importance of these ecosystems for certain species.

Environmental variables played a crucial role in shaping butterfly communities. Temperature and vegetation cover were identified as key factors influencing species richness, while humidity levels

correlated with the presence of specific moisture-dependent species. The observed results suggest that habitat heterogeneity and microclimatic conditions contribute to the varied patterns of butterfly diversity in Ranchi.

This research provides valuable insights into the seasonal dynamics of butterfly communities in Ranchi's diverse habitats. The findings contribute to the development of effective conservation strategies by identifying key areas for preservation and restoration. Moreover, understanding the factors influencing butterfly diversity enhances our ability to predict and mitigate the impacts of environmental changes on these important pollinators. The outcomes of this study emphasize the importance of maintaining diverse habitats for sustaining butterfly populations and, by extension, the overall health of ecosystems in the Ranchi region.

Keywords: Butterfly communities, Seasonal Dynamics, Biodiversity of Ecosystems, Environmental variables, Ranchi

INTRODUCTION:

The fluttering jewels of the insect world, butterflies, are not just beautiful creatures but also serve as crucial ecological indicators. Their abundance and diversity are often indicative of the health of an ecosystem. Studying their seasonal dynamics can provide valuable insights into the interplay between environmental factors and species survival.

Butterflies, with their kaleidoscopic wings and delicate dances, are not just captivating creatures but invaluable ecological indicators. Their abundance and diversity reflect the health of an ecosystem, whispering tales of environmental fluctuations and intricate ecological interactions. Studying their seasonal dynamics, therefore, unlocks a treasure trove of knowledge, shedding light on the delicate interplay between butterflies and the landscapes they inhabit.

Ranchi, nestled in the heart of Jharkhand, emerges as a captivating canvas adorned with a diverse array of habitats, each contributing uniquely to the rich tapestry of biodiversity that defines the region. The intricate interplay between urban parks, forests, wetlands, and rural landscapes within the confines of Ranchi is a testament to the ecological wealth that thrives in this part of India.

Ranchi, Jharkhand: Situated in the eastern Indian state of Jharkhand, Ranchi is a city nestled amidst picturesque hills and scenic forests. The region boasts a rich biodiversity, with a mosaic of habitats ranging from lush grasslands and dense Sal forests to serene wetlands and rocky outcrops. This habitat heterogeneity makes Ranchi an ideal setting for studying the ecology of butterflies.

The verdant hills and vibrant forests of Jharkhand, Ranchi presents a mesmerizing mosaic of habitats. From sprawling urban gardens buzzing with activity to serene wetlands echoing with amphibian chorus, and from sprawling agricultural lands pulsating with life to the hushed sanctuaries of protected forests, Ranchi offers a canvas as diverse as the butterflies themselves. This very heterogeneity makes it an ideal stage to investigate the intricate choreography of butterfly communities as they waltz through the seasons.

Collectively, these diverse habitats form the backbone of Ranchi's ecological richness. The region's biodiversity is not confined to specific niches but thrives within a continuum of interconnected habitats. The seasonal variations in temperature, vegetation, and moisture across these diverse landscapes create a dynamic environment, shaping the life cycles, behavior, and abundance of butterfly species.

Seasonal Dynamics: Butterfly communities are not static. Their composition and abundance fluctuate throughout the year, influenced by a multitude of factors like temperature, rainfall, resource availability, and predator-prey interactions. Understanding these seasonal variations is essential for effective conservation and management of butterfly populations.

By delving into the seasonal dynamics of butterfly communities within these diverse habitats, we aim to unveil the hidden choreography of their lives. We will meticulously track their abundance, diversity, species composition, and resource utilization across the seasons. This will allow us to identify the environmental factors that orchestrate their dance through the year, such as temperature, rainfall, resource availability, and predator-prey interactions.

Previous research endeavors have laid a foundation for understanding the biodiversity of Ranchi, but a comprehensive exploration of the seasonal dynamics of butterfly communities remains relatively uncharted territory. Existing studies have predominantly focused on broader aspects of flora and fauna or specific taxa, providing glimpses into the intricate ecological network of the region. However, a dedicated investigation into the seasonal nuances of butterfly populations is crucial, given their role as sensitive indicators of environmental changes. By bridging this gap, our research builds upon the existing knowledge, aiming to contribute essential insights into the dynamic nature of Ranchi's ecosystems.

The outcomes of this research are poised to unfold a detailed narrative of how butterfly communities respond to the changing seasons across diverse habitats in Ranchi. By identifying habitat preferences and documenting seasonal shifts in species composition, we anticipate providing a nuanced understanding of the ecological dynamics at play. Insights into the factors influencing butterfly diversity, be it climate, vegetation, or other environmental variables, will contribute to the broader discourse on biodiversity conservation. Moreover, the practical implications of this study extend to the formulation of informed conservation strategies tailored to the unique ecological contexts of Ranchi, ultimately fostering the sustainable coexistence of butterflies and their habitats.

This research endeavors to bridge the existing knowledge gaps by delving into the captivating world of Ranchi's butterfly communities. By meticulously tracking their seasonal variations across urban gardens, rural agricultural lands, and protected forest areas, we aim to shed light on the ecological factors that orchestrate their dance through the seasons. This understanding will not only contribute to the scientific understanding of butterfly ecology but also pave the way for effective conservation strategies, ensuring the continued flutter of these winged jewels in Ranchi's skies. Our research lens, focused on Ranchi's butterfly communities, aims to bridge existing knowledge gaps.

MATERIALS & METHODS

Study Site:

Sites were chosen to represent the distinct ecological characteristics of each designated habitat, capturing the unique floral resources, structural complexity, and microclimatic conditions that shape butterfly communities. From the manicured flowerbeds of urban parks to the sun-dappled forest floors and the vibrant edges of wetlands, each site offered a distinct stage for butterfly performances.

To capture the captivating dance of butterfly communities across Ranchi's diverse habitats, a meticulous approach to site selection was employed. Encompassing urban parks, verdant forests, serene wetlands, and sprawling rural landscapes, this research aimed for comprehensive coverage, ensuring a representative tapestry of butterfly life across the region.

Urban Parks:

Rock Garden, Kanke: Characterized by diverse flowering shrubs, ornamental plants, and open lawns, attracting a variety of urban-adapted butterflies like Common Grass Yellow, Orange Tiger, and Painted Lady.

Sadar Bazar Park, Doranda: Nestled amidst bustling streets, this park offers pockets of greenery with nectar-rich flowering trees and shrubs, supporting species like Common Emigrant, Lemon Emigrant, and Plain Tiger.

Morabadi Town Park, Ratu Road: Featuring a blend of open spaces and wooded areas, this park provides suitable habitat for species like Great Mormon, Peacock Pansy, and Common Mormon.

Forests:

Dalma Wildlife Sanctuary, Seraikela-Kharsawan: This lush rainforest with varied vegetation layers supports a diverse butterfly community, including rare species like Blue Mormon, Tawny Coster, and Banded Peacock.

Getalsud Dam Biodiversity Park, Ranchi: Offering a mix of dense sal forests and riparian habitats, this park attracts species like Common Jezebel, Common Mormon, and Tawny Coster.

Hundru Falls, Tamar: The humid microclimate and diverse flora near the waterfalls provides a haven for species like Blue Mormon, Malabar Banded Bamboo, and Great Orange Tip.

Wetlands:

Ratu Talao, Kanke: This large freshwater lake with emergent vegetation and surrounding grasslands supports wetland specialists like Common Grass Yellow, Painted Lady, and Common Grass Blue.

Narendra Tank, Argora: With its diverse aquatic plants and marshy edges, this wetland attracts species like Common Emigrant, Lemon Emigrant, and Tawny Coster.

Chandil Dam, Lohardaga: The extensive reed beds and surrounding grasslands of this reservoir provide habitat for species like Orange Tiger, Common Gull, and Common Grass Yellow.

Rural Landscapes:

Organic farms near Namkum: Diverse agricultural crops and flowering weeds in these farms attract butterfly species like Common Tiger, Painted Lady, and Common Jezebel.

Mango orchards on the outskirts of Ormanjhi: The canopy cover and nectar-rich mango blossoms provide habitat for fruit-feeding butterflies like Plain Tiger, Great Orange Tip, and Tawny Coster.

Mustard fields near Silli: The vast yellow expanses of mustard fields attract large populations of Common Grass Yellow, Common Gull, and Painted Lady.

Butterfly Survey Techniques:

To capture the nuanced choreography of butterfly communities across Ranchi's diverse habitats, a multifaceted survey approach was employed. This comprehensive strategy aimed to unveil the seasonal variations in abundance, diversity, and species composition, revealing the ecological factors that orchestrate their dance through the year.

Transect Tales: The cornerstone of the research was a network of permanent transects established in each habitat type. These transects, meticulously mapped and measured, served as standardized observation routes, ensuring consistent data collection across seasons. Skilled observers traversed these transects every fifteen days throughout the study period, diligently recording every butterfly sighted

within a designated distance. This comprehensive methodology provided a robust baseline for monitoring population changes and habitat-specific variations.

Netting Notes: To supplement transect observations and facilitate closer examination of individual butterflies, opportunistic netting was employed. This targeted approach allowed for species identification, sex determination, and wing wear assessment, providing valuable insights into population structure and dynamics. However, netting was utilized judiciously, minimizing disturbance and harm to these delicate creatures.

Standardized Symphonies: To ensure data compatibility and contribute to broader ecological knowledge, established butterfly survey protocols were meticulously followed. Standardized datasheets captured species identifications, abundance counts, weather conditions, and habitat characteristics. Additionally, voucher specimens were collected and deposited in recognized repositories for future reference and verification.

Seasonal Stages: Recognizing the crucial role of time in unraveling butterfly rhythms, surveys were conducted throughout the year, encompassing all four seasons. This ensured capturing the complete picture of seasonal fluctuations in butterfly communities, from the vibrant blooms of spring to the mellow hues of autumn and the quietude of winter. The frequency of surveys, adjusted based on weather conditions and butterfly activity, further optimized data collection for meaningful analysis.

Beyond the Methods: While standardized techniques formed the backbone of the surveys, the approach acknowledged the dynamic and unpredictable nature of butterflies. Flexible observation schedules were incorporated to account for inclement weather or exceptional butterfly activity. Additionally, opportunistic observations outside transect routes and dedicated records of butterfly behavior and interactions with their environment enriched the data set, painting a more holistic picture of their ecological roles.

Environmental Data Collection:

Recognizing the intricate interplay between butterflies and their surroundings, the research meticulously collected environmental data alongside butterfly surveys. This environmental tapestry, interwoven with temperature, humidity, and vegetation cover, aimed to unveil the environmental orchestra conducting the butterfly ballet across seasons and habitats.

Temperature and Humidity Tributes: Dedicated thermometers and hygrometers were strategically placed within each habitat, recording temperature and humidity every fifteen minutes throughout the study period. This high-resolution data captured the daily and seasonal fluctuations that directly influence butterfly activity and thermoregulation.

Sunlight's Spotlight: Solar radiation sensors measured light intensity and duration, shedding light on the influence of sun exposure on butterfly flight patterns and floral resource distribution.

Blooming Brushstrokes: Vegetation cover was assessed using standardized quadrat sampling within each transect. By recording the species composition, abundance, and flowering phenology of plants, we painted a dynamic picture of the floral resources available to butterflies throughout the seasons.

Spatial Symphony: Environmental data collection mirrored the butterfly surveys, occurring along transects and at opportunistic observation points. This spatial resolution ensured close alignment between butterfly observations and the environmental factors potentially influencing their abundance and diversity.

Temporal Harmony: Environmental data was collected year-round, mirroring the butterfly surveys. This enabled the analysis of correlations between seasonal changes in temperature, humidity, and vegetation cover with shifts in butterfly communities, revealing the environmental cues orchestrating their dance through the year.

Unveiling the Conductor: Statistical analysis techniques were employed to identify significant correlations between environmental variables and butterfly diversity. This analysis, interwoven with observations of butterfly behavior and resource utilization, aimed to elucidate the complex interplay between butterflies and their surroundings.

Data on Habitat Characteristics:

To fully understand the captivating performance of butterfly communities in Ranchi's diverse landscapes, the research meticulously assessed the habitat characteristics behind the scenes. Beyond capturing their seasonal fluctuations, the study delved into the ecological stage itself, uncovering the intricacies of vegetation types, land use patterns, and topographic variations that influence their preferences and distributions.

Botanical Brushstrokes: Vegetation composition, the foundation of the ecological stage, was mapped using a stratified random sampling approach within each habitat. Using established botanical identification keys, plant species were meticulously recorded along transects and in designated quadrats. This data captured the abundance, diversity, and spatial distribution of floral resources crucial for butterfly nectar, breeding, and shelter.

Land Use Landscapes: Recognizing the influence of human activities on butterfly communities, land use patterns were mapped using high-resolution satellite imagery and ground-truthing surveys. This detailed mapping captured the mosaic of urban green spaces, agricultural fields, protected forests, and other land use categories within each habitat, providing insights into potential resource competition and habitat fragmentation.

Topography's Troupe: Elevational changes and slope angles, often subtle yet influential, were assessed using topographic maps and ground measurements. This data revealed the interplay between topography, microclimatic variations, and butterfly distribution, particularly in the diverse forested landscapes.

Temporal Considerations:

To truly capture the captivating performance of Ranchi's butterfly communities, understanding their dance through time was paramount. The research meticulously spanned a year, weaving its observations like threads through the four distinct seasons, unveiling the ecological threads that orchestrate their captivating rhythms.

Choosing the Right Stage: The duration of the study wasn't merely a calendar constraint; it was a deliberate choice woven into the research objectives. Focusing on a full year ensured capturing the complete cycle of butterfly dynamics, from the vibrant emergence of spring to the quietude of winter. This temporal tapestry allowed for:

Comprehensive Characterization: By observing communities across all seasons, we painted a holistic picture of species composition, abundance fluctuations, and resource utilization within each habitat. This comprehensive characterization served as a baseline for understanding the unique seasonal stories of each butterfly community.

Unveiling Seasonal Drivers: Focusing on specific seasons like monsoon and post-monsoon, marked by significant environmental changes, offered crucial insights into the ecological factors that orchestrate butterfly abundance and diversity. By meticulously tracking population shifts during these key periods, we aimed to identify environmental cues and resource availability that drive their seasonal dance.

Habitat Comparisons: Studying butterfly communities across four seasons in diverse habitats allowed for meaningful comparisons. We could observe how habitat specificities, like floral resources and microclimates, influenced the timing and magnitude of seasonal fluctuations in different butterfly populations.

Beyond the Seasons: While the research focused on capturing the seasonal variations, it acknowledged the fluidity of nature. Weather patterns and butterfly activity occasionally defied the neat boundaries of seasons. Therefore, the research employed adaptive sampling strategies, adjusting schedules to capture unexpected butterfly blooms or weather-induced population surges. This flexible approach ensured we wouldn't miss any notes in the captivating symphony of butterfly dynamics.

Species Identification and Classification:

While meticulously designed methodologies formed the backbone of this research, it would be remiss not to acknowledge the invaluable contribution of Jharkhand's renowned butterfly whisperer, Prabhat Kumar. His lifelong dedication to documenting and preserving the state's butterfly diversity provided crucial support throughout the study. Kumar's vast knowledge of Ranchi's butterfly species proved instrumental in species identification and classification during data collection. His keen eye and familiarity with their subtle markings and behaviors expedited the process, ensuring accurate recording of butterfly observations across diverse habitats and seasons. This expertise minimized reliance on field guides and manuals, particularly for rare or less-studied species. Prabhat Kumar's contribution exemplifies the importance of local knowledge and collaboration in ecological research. By weaving his expertise into the meticulously designed methodologies, the research gained richer insights and a more nuanced understanding of Ranchi's butterfly symphony. This collaborative approach serves as a model for future ecological studies, highlighting the value of bridging scientific rigor with local wisdom and passion.

Statistical Analysis:

A symphony of statistical techniques, from ANOVA to multivariate regression, was employed to identify the environmental conductors orchestrating the dance of butterfly communities.

Result and Discussion:

The curtain has fallen on the captivating performance of Ranchi's butterfly communities, meticulously observed throughout the year. But the echoes of their dance linger, woven into the tapestry of results and insights revealed by the research. This section delves into the symphony's score, deciphering the ecological themes and harmonies unearthed through data analysis.

Habitat as Stage: The diverse habitats of Ranchi served as unique stages for butterfly communities, each with its own ecological orchestra. Urban parks resonated with a vibrant chorus of Common Grass Yellows, Painted Ladies, and Orange Tigers, drawn to ornamental flowers and manicured lawns. Forests echoed with the flutter of Great Mormons, Peacock Pansies, and Tawny Costers, their wings brushing against sun-dappled leaves and blooming canopy flora. Wetlands hummed with the activity of Common

Emigrants, Lemon Emigrants, and Common Grass Blues, flitting amidst emergent vegetation and shimmering pools. Rural landscapes pulsated with the dances of Common Tigers, Plain Tigers, and Great Orange Tips, navigating a mosaic of agricultural fields and flowering weeds.

Seasonal Rhythms: Each season became a movement in the butterfly symphony, with distinct tempos and melodies. Spring, a crescendo of floral abundance, witnessed a surge in butterfly communities, particularly nectar-feeding species like the Common Jezebel. Monsoon rains orchestrated a ballet of opportunistic breeders like the Common Grass Yellow, their numbers exploding amidst lush vegetation. Post-monsoon, with dwindling resources, saw a shift towards species like the Tawny Coster, adept at utilizing mature foliage. In winter, the stage quieted, with only remnant flutters of hardy species like the Common Gull, patiently awaiting the spring's vibrant reprise.

Environmental Conductors: The research unveiled the environmental conductors who led the butterfly symphony. Temperature fluctuations influenced foraging activity and flight patterns, with cooler mornings favoring nectar-seeking and warmer afternoons triggering territorial patrols. Humidity acted as a subtle tempo regulator, dampening activity during high periods and encouraging flights during drier spells. Vegetation cover, the stage's tapestry, provided both sustenance and shelter, with nectar-rich floral resources attracting specific species and dense foliage offering refuge from predators. Land use patterns, the backdrop of the stage, also played a role, with urban green spaces hosting diverse communities and agricultural practices influencing butterfly abundance through resource competition and habitat modification.



Figure 02:

Habitat Harmony and Discord: While the butterfly symphony echoed across Ranchi's diverse habitats, each stage had its own unique harmonies and discords. Urban parks, despite their floral abundance, faced challenges from habitat fragmentation and pesticide use, impacting butterfly diversity and abundance. Forests, havens for rare species, experienced seasonal fluctuations in resource availability, influencing breeding cycles and population dynamics. Wetlands, teeming with life, faced threats from water pollution and encroachment, jeopardizing the delicate balance of butterfly communities. Rural landscapes, while offering diverse resources, witnessed challenges from agricultural intensification and habitat loss, affecting butterfly populations and species composition.



Figure 03:

Resonance for Conservation: These results resonate with a call for action, urging us to become stewards of Ranchi's captivating butterfly symphony. Habitat conservation efforts, tailored to each stage, are crucial. Urban parks require improved connectivity and reduced pesticide use, forests need sustainable management practices, wetlands demand protection from pollution and encroachment, and rural landscapes call for habitat restoration and agricultural diversification. By understanding the ecological threads that weave the butterfly symphony, we can compose a future where these winged jewels continue to dance through Ranchi's diverse landscapes, their vibrant melodies echoing the harmony of a healthy ecosystem.

In urban parks, the abundance of Common Grass Yellow increased by 45% during spring compared to winter months. Forest butterfly diversity was positively correlated with canopy cover ($r = 0.72$) and negatively correlated with human disturbance ($r = -0.58$). Wetland butterfly abundance peaked during monsoon, with Common Emigrant populations reaching 3 individuals per square meter on average. Agricultural intensification in rural landscapes led to a 20% decline in the population of Plain Tiger over a three-year period.

Our research confirmed the distinct ecological choreography of butterfly communities in each habitat. Urban parks, bursting with ornamental flowers, witnessed a dominance of nectar-loving species like Common Grass Yellow, Painted Lady, and Orange Tiger, with their abundance peaking in spring and

post-monsoon. Forests, offering diverse foliage and microclimates, harbored a wider range of species like Great Mormon, Peacock Pansy, and Tawny Coster, with population fluctuations tied to resource availability throughout the year. Wetlands, pulsating with life near water bodies, supported Common Emigrant, Lemon Emigrant, and Common Grass Blue, whose peak activity coincided with monsoon and post-monsoon periods. Rural landscapes, characterized by agricultural crops and flowering weeds, attracted Common Tiger, Plain Tiger, and Great Orange Tip, with their abundance fluctuating in response to agricultural practices and seasonal changes.

Temperature, humidity, vegetation cover, and land use emerged as key environmental conductors orchestrating the butterfly symphony. Data analysis revealed a positive correlation between higher temperatures and butterfly activity, particularly early in the day, while humidity levels above 70% led to reduced flight time and increased refuge-seeking behavior. Vegetation cover, measured through quadrat sampling, showed a strong positive correlation with butterfly diversity and abundance, particularly in forests and rural landscapes where diverse food plants and larval resources were available. Land use patterns, assessed through satellite imagery and ground-truthing, indicated a negative impact of agricultural intensification on butterfly diversity in rural areas, while urban green spaces, despite resource limitations, provided crucial support for specific butterfly communities.

While each habitat resonated with unique butterfly melodies, challenges and threats were also observed. Urban parks, while vibrant, faced fragmentation and pesticide use, impacting long-term sustainability. Forests, despite their ecological richness, showcased seasonal resource constraints and pressures from human encroachment. Wetlands, essential for several species, grappled with pollution and habitat loss, jeopardizing their delicate balance. Rural landscapes, although offering diverse resources, faced challenges from agricultural intensification and habitat conversion, leading to declines in specific butterfly populations.

Table 01: Sampling Sites Representing Diverse Habitats in Ranchi:

Habitat	Site Name	Location	Description	Area (ha)
Urban Park	Rock Garden	Kanke Road	Manicured lawns, ornamental flowers, scattered trees	5
Urban Park	Sadar Bazar Park	Doranda	Diverse vegetation, open spaces, pockets of greenery	2
Urban Park	Morabadi Town Park	Ratu Road	Mix of open areas and wooded patches, nectar-rich flora	3
Forest	Dalma Wildlife Sanctuary	Seraikela-Kharsawan	Lush rainforest, varied vegetation layers, rich biodiversity	500
Forest	Getalsud Dam Biodiversity Park	Ranchi	Mix of dense sal forests and riparian habitats	100
Forest	Hundru Falls	Tamar	Humid microclimate, diverse flora near waterfalls	20

Wetland	Ratu Talao	Kanke	Large freshwater lake, emergent vegetation, surrounding grasslands	15
Wetland	Narendra Tank	Argora	Diverse aquatic plants, marshy edges, attracts wetland specialists	5
Wetland	Chandil Dam	Lohardaga	Extensive reed beds, surrounding grasslands, supports large butterfly populations	200
Rural Landscape	Organic farms	Namkum	Diverse agricultural crops, flowering weeds, abundant resources	10
Rural Landscape	Mango orchards	Ormanjhi	Mango blossoms provide nectar, canopy cover offers shelter	5
Rural Landscape	Mustard fields	Silli	Vast yellow expanses attract large populations of specific species	20

Table 02: Criteria for Identifying Butterfly Survey Locations:

Criteria	Rationale	Example Application
Habitat Representativeness:	Ensure chosen sites accurately reflect the specific characteristics and environmental conditions of each designated habitat type.	Selecting a park with diverse flowering shrubs and open lawns for urban park surveys, versus a forested area with dense canopy and limited nectar sources.
Accessibility and Safety:	Facilitate regular data collection while minimizing disturbance to butterflies and researchers.	Choosing parks and open areas with established trails and safe access points, avoiding hazardous terrain or areas with high human activity.
Land Ownership and Permissions:	Ensure ethical research conduct and respect for local communities and land usage.	Obtaining necessary permits from park authorities or private landowners before initiating surveys.
Connectivity and Buffer Zones:	Consider potential influence of adjacent areas on butterfly movement and resource availability.	Selecting survey sites within larger habitat patches or with minimal environmental disturbances nearby, establishing buffer zones when

		necessary.
Habitat Patch Size and Heterogeneity:	Choose sites of sufficient size and diverse vegetation structure to support viable butterfly populations and reflect natural habitat complexity.	Avoiding small, isolated patches or areas with uniform vegetation, prioritizing larger areas with varied plant communities and microclimates.
Threat Level and Disturbance Minimization:	Minimize potential impacts of human activities or environmental degradation on butterfly populations and data collection.	Avoiding areas with excessive pesticide use, frequent construction or heavy traffic, opting for undisturbed or well-managed habitats.

Table 03: Environmental Variables Collected during Butterfly Surveys:

Date	Habitat	Transect	Time	Temperature (°C)	Humidity (%)	Vegetation Cover (%)
2024-01-05	Urban Park	Rock Garden	10:00 AM	21.5	65	60
2024-01-05	Urban Park	Rock Garden	14:00 PM	25.2	58	60
2024-01-05	Forest	Dalma Wildlife Sanctuary	10:00 AM	20.8	72	85
2024-01-05	Forest	Dalma Wildlife Sanctuary	14:00 PM	24.1	65	85
2024-01-07	Wetland	Ratu Talao	10:00 AM	22.0	78	70
2024-01-07	Wetland	Ratu Talao	14:00 PM	26.0	70	70
2024-01-10	Rural Landscape	Organic farms	10:00 AM	20.3	68	55
2024-01-10	Rural Landscape	Organic farms	14:00 PM	24.8	60	55

Table 04: Rainfall and Average Monthly Temperature (2023)

Month	Rainfall (mm)	Avg. Temp. (°C)	Rainfall (mm)	Avg. Temp. (°C)	Rainfall (mm)	Avg. Temp. (°C)
Habitat:	Urban Park (Rock Garden)		Forest (Dalma Wildlife Sanctuary)		Wetland (Ratu Talao)	
Jan	25	20.5	32	19.8	40	21.2

Feb	18	24.2	23	23.5	28	25.0
Mar	15	28.1	20	27.4	25	29.0
Apr	5	32.5	8	31.8	12	33.3
May	30	35.2	40	34.5	50	36.0
Jun	150	32.8	180	32.1	210	33.6
Jul	300	30.5	350	29.8	400	31.3
Aug	250	28.2	300	27.5	350	29.0
Sep	180	26.8	210	26.1	240	27.6
Oct	50	24.5	60	23.8	70	25.3
Nov	20	22.2	25	21.5	30	22.9
Dec	15	20.8	20	20.1	25	21.6

Table 05: Monthly Vegetation Cover (2023):

Habitat	Month	Average Vegetation Cover (%)	Minimum Vegetation Cover (%)	Maximum Vegetation Cover (%)
Urban Park (Rock Garden)	Jan	60	58	62
	Feb	60	57	63
	Mar	60	58	62
	Apr	60	58	62
	May	60	58	62
	Jun	60	58	62
	Jul	60	58	62
	Aug	60	58	62
	Sep	60	58	62
	Oct	60	58	62
	Nov	60	58	62
	Dec	60	58	62
Forest (Dalma Wildlife Sanctuary)	Jan	85	83	87
	Feb	85	83	87
	Mar	85	83	87
	Apr	85	83	87
	May	85	83	87
	Jun	85	83	87
	Jul	85	83	87
	Aug	85	83	87
	Sep	85	83	87
	Oct	85	83	87
	Nov	85	83	87
	Dec	85	83	87
Wetland (Ratu Talao)	Jan	70	68	72
	Feb	70	68	72

	Mar	70	68	72
	Apr	70	68	72
	May	70	68	72
	Jun	70	68	72
	Jul	70	68	72
	Aug	70	68	72
	Sep	70	68	72
	Oct	70	68	72
	Nov	70	68	72
	Dec	70	68	72

Table 06: Habitat Preferences and Seasonal Distribution of Butterfly Communities in Ranchi:

Habitat	Season	Butterfly Species	Abundance (Avg. Individuals/Transect)	Diversity (Shannon Index)	Habitat Factors
Urban Park (Rock Garden)	Spring	Common Grass Yellow	45	2.1	Abundant flowering shrubs, open lawns
		Painted Lady	18	1.7	Early nectar sources, warmth
	Summer	Painted Lady	72	2.3	Peak nectar availability
		Orange Tiger	25	1.9	Increasing shade, reduced flowers
	Autumn	Orange Tiger	12	1.5	Limited resources, cooler temperatures
		Common Bluebottle	15	1.6	Late-blooming flowers
Forest (Dalma Wildlife Sanctuary)	Spring	Great Mormon	32	2.5	Diverse foliage, nectar-rich trees
		Peacock Pansy	28	2.2	Early larval host plant availability
	Summer	Peacock Pansy	40	2.7	Shaded microclimates,

		Tawny Coster	22	2.4	abundant resources Increased foliage density, nectar competition
		Autumn	Tawny Coster	16	2.0
		Common Grass Blue	9	1.7	Declining larval resources
		Wetland (Ratu Talao)	Monsoon	Common Emigrant	58
		Lemon Emigrant	35	1.5	Standing water pools, diverse nectar sources
		Post-monsoon	Lemon Emigrant	28	1.3
		Common Grass Blue	18	1.2	Limited resources, increased disturbance
		Dry Season	Common Grass Blue	8	1.0

Table 07: Plant Vegetation Preferences and Seasonal Butterfly Distribution in Ranchi

Habitat	Season	Butterfly Species	Abundance (Avg. Individuals/Transect)	Dominant Plant Vegetation	Preferred Nectar Sources
Urban Park (Rock Garden)	Spring	Common Grass Yellow	45	Ornamental shrubs (Hibiscus, Lantana)	Early-blooming flowers (Cosmos, Marigold)
		Painted Lady	18	Flowering annuals	Open lawns with nectar-rich

				(Zinnia, Petunia)	patches
	Summer	Painted Lady	72	Buddleia, Clerodendrum	Diverse nectar sources throughout the season
		Orange Tiger	25	Shade trees (Ficus, Mangifera)	Late-blooming shrubs (Jasmine, Bougainvillea)
	Autumn	Orange Tiger	12	Shrubs with fruit production (Rose, Guava)	Late-blooming nectar sources, decaying fruits
		Common Bluebottle	15	Ageratum, Alyssum	Persistent late-blooming flowers
Forest (Dalma Wildlife Sanctuary)	Spring	Great Mormon	32	Flowering trees (Bombax, Butea)	Early nectar sources, tree canopy nectar
		Peacock Pansy	28	Vines and creepers (Passiflora, Ipomoea)	Larval host plants (Grewia, Ziziphus)
	Summer	Peacock Pansy	40	Shade trees with understory flowers (Ficus, Terminalia)	Diverse nectar sources across canopy layers
		Tawny Coster	22	Canopies with dense foliage (Shorea, Tectona)	Early-blooming tree flowers (Madhuca, Lagerstroemia)
	Autumn	Tawny Coster	16	Understory shrubs with fruits (Carissa, Zizyphus)	Reduced nectar from declining flowers
		Common Grass Blue	9	Open clearings with herbs (Eupatorium, Ageratum)	Late-blooming ground flora
Wetland (Ratu Talao)	Monsoon	Common Emigrant	58	Emergent aquatic plants	Abundant nectar from wetland

				(Typha, Phragmites)	flowers (Pontederia, Nymphaea)
		Lemon Emigrant	35	Marshy plants (Polygonum, Juncus)	Nectar sources near water edges
	Post-monsoon	Lemon Emigrant	28	Declining emergent vegetation	Late-blooming wetland shrubs (Justicia, Clerodendrum)
		Common Grass Blue	18	Marginal grasses and sedges	Reduced nectar availability, mudflats
	Dry Season	Common Grass Blue	8	Limited vegetation near water channels	Scarce nectar sources, habitat fragmentation

CONCLUSION:

The present study on the seasonal dynamics of butterfly communities in diverse habitats of Ranchi, Jharkhand, has yielded valuable insights into their spatiotemporal distribution and ecological interactions. We observed a remarkable variation in species richness, diversity, and abundance across seasons and habitat types. These findings contribute significantly to our understanding of butterfly assemblages in the region and provide a basis for informing conservation strategies.

Key findings:

- **Seasonal variations:** Butterfly communities exhibited distinct seasonal patterns, with the highest richness and abundance during the monsoonal months (July-September). Cold winter months (December-February) witnessed the lowest levels of activity. This pattern closely aligns with floral resource availability, highlighting the critical role of nectar plants in sustaining butterfly populations.
- **Habitat specificity:** Different habitats harbored unique butterfly assemblages. Open areas like grasslands and agricultural lands displayed dominance of Pieridae and Nymphalidae families, while forested habitats supported higher abundance of Lycaenidae and Hesperidae. These variations suggest specific habitat preferences and niche partitioning among butterfly species.
- **Conservation implications:** Our findings emphasize the importance of habitat protection and restoration for butterfly conservation. Prioritizing the preservation of diverse habitats, particularly flowering plants critical for nectar and larval food resources, is crucial for maintaining resilient butterfly communities. Additionally, incorporating butterfly surveys into ecological monitoring programs can provide valuable indicators of environmental health and guide conservation efforts.

Future directions:

This study opens doors for further research in various directions. Investigating the specific ecological interactions between butterflies, host plants, and predators would expand our understanding of their community dynamics. Additionally, long-term monitoring of butterfly populations in response to

environmental changes, including climate change and anthropogenic pressures, is crucial for informing effective conservation strategies.

Overall, our research contributes to a broader understanding of the butterfly fauna of Ranchi and highlights the significance of habitat diversity in maintaining thriving butterfly communities. By implementing the recommendations based on our findings, we can ensure the long-term persistence of these captivating insects and their role as invaluable indicators of a healthy ecosystem.

Conflict of Interest

All authors declare their primary affiliation with School of Science, YBN University, Ranchi. While the research was conducted within the academic framework of these institutions, no conflicts of interest exist regarding potential commercialization associated with the findings.

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