Research article

Ecology Journal

ISSN (Print): 2957-4471, ISSN (Online): 2957-448X, Website: https://journal.esbangladesh.org
Ecol. J. (2025) 7 (3) : 201-210

Effect of soil mineral composition on butterfly puddling in Kaptai National Park, Bangladesh

Selina Sultana and Md. Monwar Hossain*

Department of Zoology, Jahangirnagar University, Savar, Dhaka, Bangladesh.

***Corresponding email:** monwar@juniv.edu

Received: 03 November 2025, revised: 06 December 2025, accepted: 08 December 2025, DOI: https: //doi.org/10.59619/ej.7.3.4

Abstract

Butterfly puddling, a behavior typically exhibited by male butterflies, involves aggregating on moist or muddy surfaces to ingest mineral-rich fluids essential for obtaining vital minerals and salts required for various biological functions. This study explores the relationship between butterfly puddling activity and soil mineral composition in Kaptai National Park (Kaptai NP), Bangladesh. Forty-four butterfly species, representing eight families (Papilionidae, Pieridae, Lycaenidae, Danaidae, Nymphalidae, Satyridae, Hesperiidae and Acraeidae), were observed puddling at eight sites (S1-S8) across the Ram Pahar and Sita Pahar regions of Kaptai NP. Soil samples collected from each puddling site were analyzed to assess the relationship between butterfly species abundance and soil mineral content. The analysis revealed 21 distinct soil minerals corresponding to six key nutrient elements, such as sodium, calcium, magnesium, potassium, phosphate and iron. Significant correlations were observed between soil mineral content and butterfly abundance during puddling across all study sites. The findings demonstrated that sites with higher mineral diversity, such as Shilchori (S3) in Ram Pahar and Jamai Chora (S8) in Sita Pahar, which contained 18 distinct minerals, supported 40 and 44 butterfly species, respectively. In contrast, Ronir Chora (S6) in Sita Pahar, with 11 mineral types, supported only 10 species. Furthermore, the study found that puddling activity was more prevalent during the Wet season and Post-monsoon season than in the Dry season. These results emphasize the critical role of soil mineral content in influencing butterfly abundance and diversity, highlighting the importance of mineral-rich habitats for sustaining butterfly populations in Kaptai NP and emphasizing the need for conservation efforts to protect this biodiversity hotspot.

Keywords: Butterfly, soil minerals, puddling, kaptai national park

Introduction

Butterflies, with their vibrant colors and delicate wings, are not only aesthetically captivating but also play vital roles in ecosystems. They are among the most effective pollinators, contributing to the reproductive success of numerous plant species (Erhardt 1985, Thomas 2005). Besides, the role of butterflies as bioindicators is well-demonstrated in studies of habitat disturbance. For instance, research has shown that the diversity and abundance of butterfly communities directly correlate with the level of environmental disruption, offering a clear measure of ecosystem integrity (Kocher and Williams 2000). Among their various behavioral patterns, puddling is a critical activity that significantly influences their physiology and reproductive success (Molleman 2010, Ankola *et al*. 2021). Butterflies puddle to obtain essential minerals like sodium and calcium, which are crucial for reproduction. During puddling, butterflies congregate at moist soil or water sources to absorb essential minerals such as sodium, calcium, and magnesium, which are vital for their development and overall fitness (Nijhout 1994, Smedley and Eisner 1995, Molleman 2010). These minerals are transferred from males to females as a nuptial gift, enhancing fertility and egg quality (Beck *et al.* 1999, Boggs and Dau 2004). A deficiency in these soil minerals can negatively impact their reproductive success and health, affecting species distribution and behavior. Experimental studies have shown that sodium-deprived male butterflies produce smaller spermatophores, leading to a direct reduction in the number and quality of eggs laid by their mates (Pivnick and McNeil 1987). This paternal investment of minerals is so crucial that offspring from deficient males can exhibit poorer health, such as reduced larval growth rates (Smedley and Eisner 1995). Accordingly, mineral availability directly impacts individual health and reproductive success, influencing broader species distribution and population dynamics (Arms *et al.* 1974). Moreover, these essential minerals are gathered through targeted puddling behavior, the availability of mineral-rich sites becomes a key factor in habitat quality (Beck *et al.* 1999). Therefore, landscapes lacking these resources can support fewer healthy individuals, thereby influencing local population density and potentially limiting species distribution (Boggs and Dau 2004).

Kaptai National Park (Kaptai NP), located in the Chittagong Hill Tracts of Bangladesh, is recognized a biodiversity hotspot, particularly for butterflies, due to its diverse ecosystems including varied vegetation and soil types (Habib *et al*. 2016, Khan *et al*. 2016). As a recognized biodiversity hotspot, its diverse ecosystems and varied soil types create a mosaic of potential mineral resources (Khan *et al*. 2016). However, the specific relationship between soil mineral content and puddling butterfly assemblages in Kaptai NP remains uninvestigated. While the global phenomenon of puddling and its critical role in butterfly reproduction and fitness is well-established (Molleman 2010). While detailed ecological studies, such as those relating butterfly assemblages to environmental gradients, have been conducted in other parts of the Indian subcontinent (Tiple *et al.* 2007). This level of detailed ecological understanding is lacking for Kaptai NP. Addressing this gap is vital for developing evidence-based conservation strategies, as understanding of local mineral requirements is essential to mitigate threats from habitat alteration for Southeast Asian butterflies (Koh 2007). Therefore, this study will correlate the mineral composition of puddling soils with butterfly presence, abundance, and diversity. The results are intended to provide a scientific basis for developing habitat management strategies to sustain healthy butterfly population in this significant region.

Materials and methods

Study area and duration: This study was conducted from March 2023 to April 2025 in Kaptai National Park (Kaptai NP), located in the Chittagong Hill Tracts, Bangladesh. The study was designed to capture topographical and ecological variation by establishing eight sampling sites (S1–S8) across two prominent geographical regions Ram Pahar and Sita Pahar within the Kaptai NP (Fig. 1). The specific study sites were as follows: In Ram Pahar: Wagga Chora (S1), Bazar Chora (S2), Shilchori (S3) and

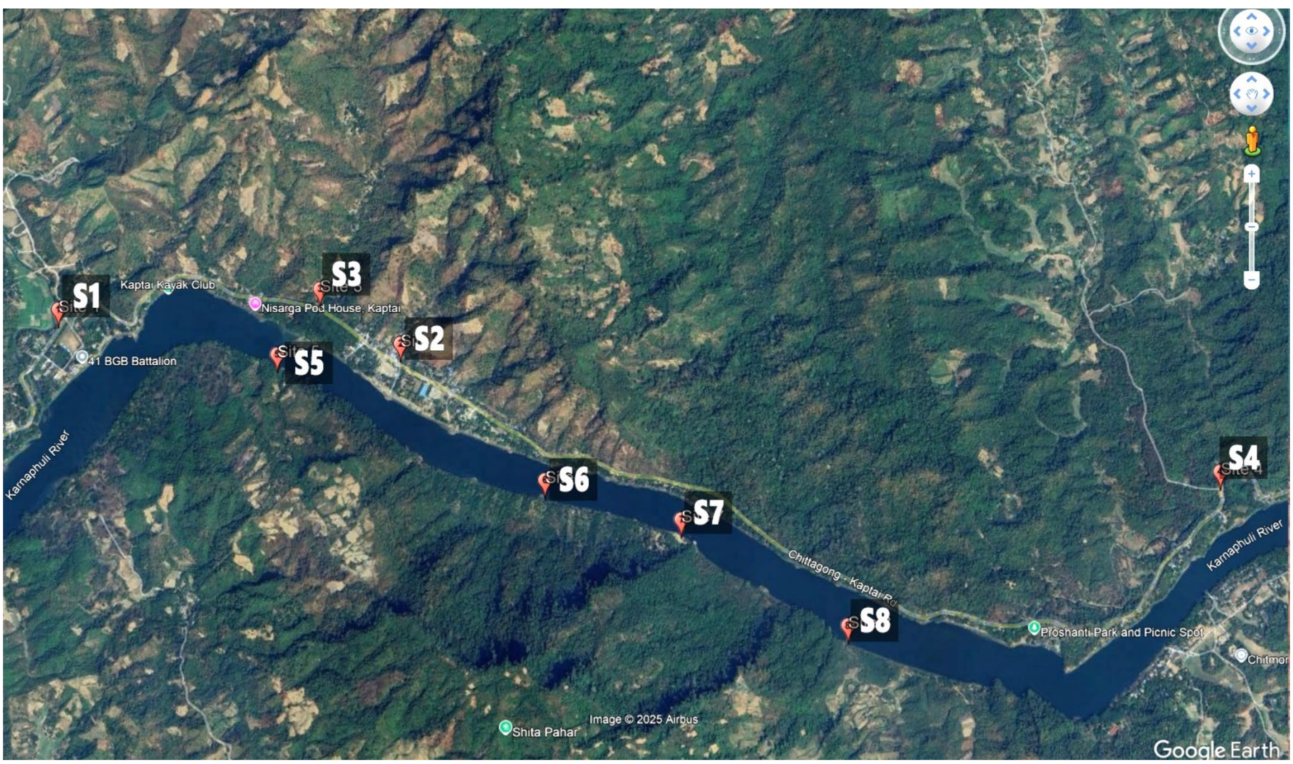


Figure 1. Eight study sites (S1-S8) at Ram Pahar and Sita Pahar in Kaptai national park.

Bangchori (S4); and in Sita Pahar: Thandachori (S5), Ronir Chora (S6), Sita Mondir (S7) and Jamai Chora (S8) (Fig. 1, 2).

Data collection and identification: Soil samples were collected from the eight study sites (S1–S8) across three distinct seasons: the Wet season (May–August 2024), Post-Monsoon (September–December 2024), and the Dry season (January–April 2025). Soil samples were stored in zip-lock bags and plastic jars for transport. Mineralogical analysis was conducted at the Wazed Miah Science Research Centre, Jahangirnagar University, using an X-ray Diffraction (XRD) machine (EXPLORER, GNR Analytical Instruments Group). A semi-quantitative analysis was conducted using the GeoLogynet XRD Database (https://www.geologynet.com/xrd-minerals-db/) and the phases were determined and analyzed using MATCH software. Strict quality control protocols were followed throughout to ensure data reliability.

Butterflies were observed and photographed at the same eight puddling sites (S1–S8) during the study period (Fig. 2). To minimize disturbance, observations were conducted from a short distance using a Canon DSLR camera with a 100mm lens. When necessary for identification, specimens were captured with a sweep net and temporarily stored in labeled containers. Species were identified using standard taxonomic keys from Evans (1927, 1932), Wynter-Blyth (1957) and Talbot (1939, 1947).

Statistical analysis: All statistical analyses for butterfly species richness and its relationship to puddling sites as well as soil minerals were conducted using Microsoft Excel 2019. The study area map was developed in QGIS (version 3.28) while Adobe Photoshop 7.0 was used for processing photographs.

Results and discussion

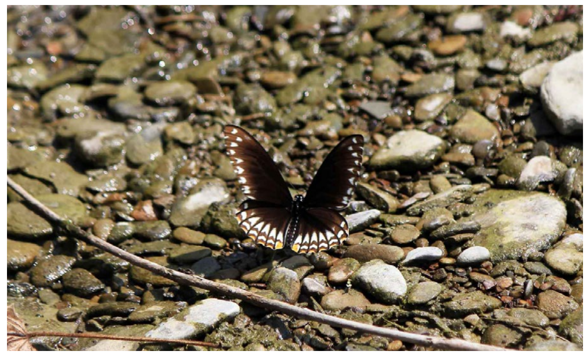
Forty four butterfly species across eight families were recorded engaging in puddling at the study sites (S1–S8) in Kaptai NP (Fig. 3, Table 1). The families represented were Papilionidae (5 sp.), Pieridae (9 sp.), Lycaenidae (8 sp.), Danaidae (3 sp.), Nymphalidae (10 sp.), Satyridae (5 sp.), Hesperiidae (3 sp.) and Acraeidae (1 sp.) (Table 1). In the present result, 9 species are threatened, with 7 classified as Vulnerable (VU) and 2 as Endangered (EN). Additionally, the majority of the 35 species were categorized as Least Concern (LC), according to IUCN Red List of Bangladesh (Table 1). The present study, which observes 44 butterfly species across 8 families, confirms that Kaptai NP supports significant Lepidopteran diversity. This diversity indicates the presence of a

Figure 2. Eight study locations (S1-S8) at Ram Pahar and Sita Pahar in Kaptai national park.

A. *Neptis hylas* (Common Sailer) at Wagga Chora (S1)

B. *Catopsilia pyranthe* (Mottled Emigrant) at Bazar Chora (S2)

C. *Lexias dirtea* (Dark Archduke) at Shilchori (S3)



D. *Chilasa clytia* (Common Mime) at Bangchori (S4)

E. *Pachliopta aristolochiae* (Common Rose) at Thandachori (S5)

F. *Eurema blanda* (Three Spot Grass Yellow) at Ronir Chora (S6)

G. *Papilio nephelus* (Yellow Helen) at Sita Mondir (S7)

H. *Appias libythea* (Striped Albatross) at Jamai Chora (S8)

Figure 3. Puddling activity of different butterfly species across eight sampling sites (S1-S8) in Kaptai national park (A-H).

Table 1. Occurrence of butterfly puddling at Ram and Sita Pahar areas within Kaptai national park

Sl. No	Family/Scientific Name	English Name	Red List Status (2015)	Kaptai NP							
				Ram Pahar				Sita Pahar			
				S1	S2	S3	S4	S5	S6	S7	S8
Family: Papilionidae											
1	*Papilio nephelus* Boisduval, 1836	Yellow Helen	VU (Vulnerable)	√	x	√	√	√	x	√	√
2	*Chilasa clytia* (Linnaeus, 1758)	Common Mime	LC (Least Concern)	√	√	√	√	x	x	x	√
3	*Papilio memnon* Linnaeus, 1758	Great Mormon	LC	√	√	√	√	√	√	√	√
4	*Pachliopta aristolochiae* (Fabricius, 1775)	Common Rose	LC	√	√	√	√	√	x	√	√
5	*Papilio helenus* Linnaeus, 1758	Red Helen	VU	x	√	√	√	x	x	√	√
Family: Pieridae											
6	*Delias eucharis* (Drury, 1773)	Common Jezebel	LC	√	x	√	√	√	√	√	√
7	*Delias hyparete* (Linnaeus, 1758)	Painted Jezebel	LC	√	√	√	√	√	x	√	√
8	*Hebomoia glaucippe* (Linnaeus, 1758)	Great Orange Tip	VU	x	x	√	√	√	√	√	√
9	*Appias lyncida* (Cramer, [1777])	Chocolate Albatross	LC	x	√	√	x	√	x	√	√
10	*Eurema blanda* (Boisduval, 1836)	Three Spot Grass Yellow	LC	x	x	√	√	√	√	√	√
11	*Cepora nerissa* (Fabricius, 1775)	Common Gull	LC	x	x	√	x	√	√	√	√
12	*Leptosia nina* (Fabricius, 1793)	Psyche	LC	x	√	√	√	√	x	√	√
13	*Appias libythea* (Fabricius, 1775)	Striped Albatross	LC	√	x	x	√	√	x	x	√
14	*Catopsilia pyranthe* (Linnaeus, 1758)	Mottled Emigrant	LC	x	√	√	√	x	x	x	√
Family: Lycaenidae											
15	*Zizina otis* (Fabricius, 1787)	Lesser Grass Blue	LC	√	x	√	√	√	x	√	√
16	*Caleta decidia* (Hewitson, 1876)	Angled Pierrot	LC	x	x	√	√	√	x	√	√
17	*Castalius rosimon* (Fabricius, 1775)	Common Pierrot	LC	x	x	√	x	x	x	x	√
18	*Prosotas dubiosa* (Semper, [1879])	Tailless Lineblue	VU	√	√	√	√	√	x	√	√
19	*Loxura atymnus* (Stoll, 1780)	Yamfly	VU	√	x	√	√	x	x	x	√
20	*Neopithecops zalmora* (Butler, [1870])	Quaker	LC	x	√	√	√	√	x	√	√
21	*Chilades lajus* (Stoll, [1780])	Lime Blue	LC	x	√	√	x	√	x	x	√
22	*Euchrysops cnejus* (Fabricius, 1798)	Gram Blue	LC	√	x	√	x	x	x	√	√
Familly: Danaidae											
23	*Euploea core* (Cramer, [1780])	Common Crow	LC	√	√	√	√	√	√	√	√

Table 1. Continue.

Sl. No	Family/Scientific Name	English Name	Red List Status (2015)	Kaptai NP							
				Ram Pahar				Sita Pahar			
				S1	S2	S3	S4	S5	S6	S7	S8
24	*Danaus genutia* (Cramer, [1779])	Striped Tiger	LC	√	√	√	√	√	x	√	√
25	*Danaus chrysippus* (Linnaeus, 1758)	Plain Tiger	LC	x	x	√	x	x	x	x	√
Family: Nymphalidae											
26	*Junonia atlites* (Linnaeus, 1763)	Grey Pansy	LC	√	√	√	√	√	√	√	√
27	*Junonia almana* (Linnaeus, 1758)	Peacock Pansy	LC	x	x	√	√	√	x	√	√
28	*Junonia lemonias* (Linnaeus, 1758)	Lemon Pansy	LC	x	x	√	x	x	√	√	√
29	*Hypolimnas bolina*	Great Eggfly	LC	√	√	√	√	√	√	√	√
30	*Neptis hylas* (Linnaeus, 1758)	Common Sailer	LC	√	x	√	√	√	x	x	√
31	*Moduza procris* (Cramer, [1777])	Commander	LC	x	√	√	x	x	x	x	√
32	*Ariadne merione* (Cramer, [1777])	Common Castor	LC	x	x	√	√	√	x	x	√
33	*Euthalia aconthea* (Cramer, [1777])	Common Baron	LC	√	√	√	√	√	x	x	√
34	*Athyma perius* (Linnaeus, 1758)	Common Sergeant	LC	√	√	√	√	√	√	√	√
35	*Lexias dirtea* (Fabricius, 1793)	Dark Archduke	EN (Endangered)	x	x	√	x	x	x	x	√
Family: Satyridae											
36	*Elymnias malelas* (Hewitson, 1863)	Spotted Palmfly	EN	x	x	x	x	x	x	x	√
37	*Elymnias hypermnestra* (Linnaeus, 1763)	Common Palmfly	LC	x	x	√	√	x	x	x	√
38	*Mycalesis mineus* (Linnaeus, 1758)	Dark-branded Bushbrown	LC	√	x	√	x	x	x	x	√
39	*Melanitis leda* (Linnaeus, 1758)	Common Evening Brown	LC	√	√	√	√	x	x	√	√
40	*Mycalesis perseus* (Fabricius, 1775)	Common Bushbrown	VU	√	√	√	√	√	x	√	√
Family: Hesperiidae											
41	*Odontoptilum angulata* (Felder, 1862)	Chestnut Angle	LC	x	x	√	x	x	x	x	√
42	*Hyarotis adrastus* (Stoll, [1780])	Tree Flitter	VU	√	√	√	√	√	x	√	√
43	*Udaspes folus* (Cramer, [1775])	Grass Demon	LC	x	x	x	x	x	x	x	√
Family: Acraeidae											
44	*Acraea violae* (Fabricius, 1775)	Tawny Coster	LC	x	x	x	x	x	x	x	√
Total				22	21	40	30	27	10	26	44

Note: **√= present,** x= **absent**

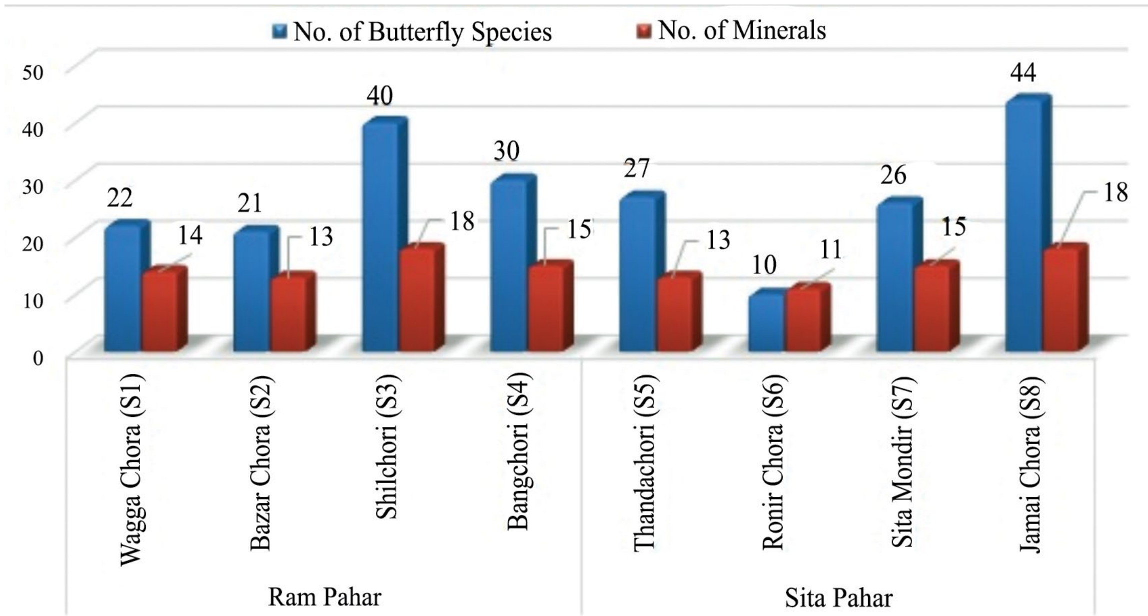


Figure 4. Relationship between soil mineral composition and butterfly species involved in puddling across eight sampling sites (S1-S8) in Kaptai national park.

variety of suitable habitats, along with essential host plants and nectar sources (Das *et al*. 2025, Ruhi 2025). Its conservation importance is prioritized by the presence of 9 threatened species listed for Bangladesh (IUCN, 2015) (Table 1). The threatened species were included in the Papilionidae, Pieridae, Lycaenidae, Nymphalidae, Satyridae and Hesperiidae families is consistent with global trends, where such specialized taxa are more vulnerable to disturbance, highlighting them as specific conservation priorities (Koh *et al.* 2004).

The present study identified 21 soil minerals, corresponding to 6 nutrient elements (sodium, calcium, magnesium, potassium, phosphate and iron) found across the sites (S1-S8) in Kaptai NP (Table 2). The study found that the number of minerals varied by location, where Shilchori (S3) and Jamai Chora (S8) had the highest mineral diversity with 18 types each (Table 2). A moderate diversity of 14-15 minerals was found at Wagga Chora (S1), Bangchori (S4) and Sita Mondir (S7) (Table 2). The lowest diversity (11-13 minerals) was recorded at Ronir Chora (S6), Bazar Chora (S2), and Thandachora (S5) (Table 2). On the other hand, the present results show that Shilchori (S3) and Jamai Chora (S8) recorded the highest butterfly diversity, with 40 and 44 species respectively (Fig. 4) (Table 1). The most abundant butterflies at these sites belonged to the Papilionidae, Lycaenidae, Danaidae, and Nymphalidae families (Table 1). In contrast, Ronir Chora (S6) had the lowest number of butterfly species (10 species) in the families- Papilionidae, Pieridae, Danaidae, and Nymphalidae, as well as the lowest mineral count (11 minerals) (Fig. 4) (Table 1).

Spatial heterogeneity in soil mineral content was observed across Kaptai NP, with mineral counts ranging from 11 to 18 (Table 2). This variation is a common characteristic of natural landscapes shaped by geology and soil formation, which are critical factors in structuring butterfly communities (Weil and Brady 2016). The present study also revealed a positive linked between soil minerals and butterfly diversity, particularly at Shilchori (S3) and Jamai Chora (S8), where geochemistry plays a key role in shaping these insect communities (Fig. 4) (Beck *et al*. 1999). These sites are rich in essential nutrients that compensate for nutritional deficits in insect diets (Fig. 4) (Smedley and Eisner 1995).The abundance of Nymphalidae and Lycaenidae at these mineral-rich sites aligns with their well-documented tendency for puddling behavior (Beck *et al*. 1999). In contrast, the low-diversity community at the mineral-poor site, Ronir Chora (S6), experiences a nutritional bottleneck, where the lack of essential resources constrains Lepidopteran diversity (Fig.

Table 2. Distribution of soil minerals across the eight study sites in Kaptai national park

Sl. No	Nutrient Element	Present Soil Minerals	Study Areas								Seasons		
			S1	S2	S3	S4	S5	S6	S7	S8	Wet	Post Monsoon	Dry
1	Sodium	Sodium-boltwoodite	√	√	√	√	√	√	√	√	√	√	√
2		Sodium-komarovite	√	√	√	√	√	√	√	√	√	√	√
3		Sodium-pharmacosiderite	√	√	√	√	√	√	√	√	√	√	√
4		Albite	x	x	√	x	√	x	√	√	√	√	x
5		Albite Low	√	√	√	√	√	x	√	√	√	√	√
6		Albite Calcian High	√	x	√	√	x	x	x	√	√	√	x
7		Anorthoclase	x	x	√	x	√	√	x	√	√	√	√
8		Oligoclase	√	x	√	√	√	x	x	√	√	√	x
9	Calcium	Muscovite 2M2 Calcium	√	√	√	√	√	√	√	√	√	√	√
10		Calciumcatapleiite	√	√	√	x	x	√	√	√	√	√	x
11		Anorthite Sodian High	√	x	x	√	x	x	√	x	√	√	√
12		Anorthite Sodian low	√	x	x	√	x	x	√	x	√	√	√
13		Anorthite	x	√	√	√	x	x	√	√	√	√	x
14		Probertite	x	x	√	√	x	x	√	√	√	√	x
15		Ettringite	x	x	√	√	√	x	x	√	√	√	x
16	Magnesium	Magnesium-chlorophoenicite	√	√	√	√	√	√	√	√	√	√	√
17		Mcallisterite	√	√	√	x	x	x	x	√	√	√	x
18		Amesite	x	√	x	x	x	√	√	x	√	√	x
19	Potassium	Potassium-alum	√	√	√	√	√	√	√	√	√	√	√
20	Phosphate	Sanidine	x	√	√	x	√	√	x	√	√	√	x
21	Iron	Hematite	√	√	√	√	√	√	√	√	√	√	√
	Total	21	14	13	18	15	13	11	15	18	21	21	11

Note: S1: Wagga Chora, S2: Bazar Chora, S3: Shilchori, S4: Bangchori, S5: Thandachori, S6: Ronir Chora, S7: Sita Mondir, S8: Jamai Chora. √= present, x= absent

4). This bottleneck may act as a limiting factor, preventing these areas from supporting diverse butterfly populations (Bonebrake *et al*. 2010). Moreover, the clear correlation between soil mineral content and butterfly diversity establishes soil minerals as a fundamental, bottom-up factor that structures butterfly communities in this forest, a role consistent with its impact on other insect populations (Prudic *et al*. 2005).

The present study also investigates the relationship between the three different seasons (Wet, Post-monsoon, and Dry) and the mineral content across eight studied sites. The results indicate that both the Wet and Post-monsoon seasons were characterized by the presence of all 21 recorded soil minerals, creating a highly favorable environment abundant in essential elements (Table 2). In contrast, the Dry season showed a significant decrease, with only 11 soil minerals remaining, signifying a period of resource insufficiency (Table 2) (Bonebrake *et al*. 2010). Thus, the Wet and Post-monsoon seasons are clearly the most favorable for butterfly abundance in puddling, as rainfall mobilizes these soluble nutrients, facilitating butterfly behavior (Smedley and Eisner 1995). Nonetheless, these findings establish that the spatial distribution and temporal stability of soil minerals are key drivers of meta-population structure, defining essential source habitats and refugia within the landscape

(Hanski 1999). Finally, this study concludes that the preservation of soil mineral hotspots is integral to the conservation of butterfly diversity in Kaptai NP, with particular implications for threatened specialist species. Protecting these geochemically unique areas is essential for sustaining lepidopteran community resilience in the face of environmental change.

Conclusion

This study identifies spatial and temporal variations in soil mineral availability as a key driver of butterfly diversity in Kaptai NP. A positive linked was observed between species richness and the availability of mineral contents. Mineral-rich sites such as Shilchori (S3) and Jamai Chora (S8) supported the highest diversity of butterflies, while the mineral-poor Ronir Chora (S6) showed markedly lower species richness, indicating a nutritional bottleneck. Mineral availability proved highly seasonal, with greater puddling activity during the Wet and Post-monsoon seasons than in the Dry season. These findings highlight the importance of conserving mineral-rich habitats to sustain butterfly biodiversity and ecological stability in Kaptai NP. Future research should examine the long-term effects of soil mineral depletion and habitat degradation on butterfly populations to inform conservation planning.

Acknowledgement

The authors acknowledge the Wazed Miah Science Research Centre at Jahangirnagar University (JU), Bangladesh, for providing laboratory facilities. They also extent their sincere thanks to Mohammad Khairul Islam, Senior Scientific Officer (X-Ray Crystallography), Wazed Miah Science Research Centre, Jahangirnagar University, for his assistance in the analysis of soil minerals.

Author's contribution

Selina Sultana was responsible for data collection and sampling. Selina Sultana and Md. Monwar Hossain conducted data analysis and initial drafting. Md. Monwar Hossain supervised the process and made edits to the final manuscript. All authors reviewed and approved the final version.

References

Ankola K, Aishwarya D, Anusha R, Vaishnavi N, Supriya VK and Puttaraju HP. 2021. Ecological significance of puddling as a behavioural phenomenon in the life history of butterfly Papilio polytes Linn. (Lepidoptera: Papilionidae). Journal of Asia-Pacific Entomology. 24: 1-6.

Arms K, Feeny P and Lederhouse RC. 1974. Sodium stimulus for puddling behavior by tiger swallowtail butterflies, *Papilio glaucus*. Science. 185: 372-374.

Beck J, Mühlenberg E and Fiedler K. 1999. Mud-puddling behavior in tropical butterflies: in search of proteins or minerals? Oecologia. 119: 140-148.

Boggs C and Dau B. 2004. Resource specialization in puddling Lepidoptera. Environmental Entomology. 33: 1020-1024.

Bonebrake TC, Ponisio LC, Boggs CL and Ehrlich PR. 2010. More than just indicators: A review of tropical butterfly ecology and conservation. Biological Conservation. 143: 1831-1841.

Das S, Ruhi M, Abedin MS and Hossain MM. 2025. Checklist of butterfly larval host plants and their spatial distribution on the campus of Jahangirnagar University, Bangladesh. Asian Australasian Journal of Bioscience and Biotechnology. 10: 22-33.

Ruhi M. 2025. Interactions between butterflies and their wild nectar plants on the campus of Jahangirnagar University. Thesis submitted a to the Department of Zoology, Jahangirnagar University. Bangladesh. Pp 62.

Evans WH. 1927. The Identification of Indian Butterflies. Bombay Natural History Society. Pp 302.

Evans WH. 1932. The Identification of Indian Butterflies (2nd ed.). Bombay Natural History Society. Pp 454.

Erhardt A. 1985. Diurnal Lepidoptera: sensitive indicators of cultivated and abandoned grassland. Journal of Applied Ecology. 22: 849-861.

GeoLogynet XRD Database. 2025. http://www.geologynet.com/xrd-minerals-db/.

Habib MS, Rima N, Akter F, Islam MS and Hossain MM. 2016. Checklist of butterfly fauna of Kaptai National Park in Bangladesh. Journal of Taxonomy and Biodiversity Research. 7: 19-28.

Hanski I. 1999. Metapopulation Ecology. Vol. 232, Oxford University Press, Oxford. Pp 313.

IUCN Bangladesh. 2015. Red List of Bangladesh Volume 7: Butterflies. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh. xvi+400.

Khan MMH, Begum S, Feeroz MM, Kabir MM, Hasan MK, Khan B, Rahman T, Prodhan MMH, Khan MNS, Khaledin S and Basak R. 2016. Wildlife of Kaptai National Park of Bangladesh. Bangladesh Forest Department, Dhaka Bangladesh. Pp 108.

Koh LP, Sodhi NS and Brook BW. 2004. Ecological correlates of extinction proneness in tropical butterflies. Conservation Biology. 18: 1571-1578.

Koh LP. 2007. Impacts of land use change on south-east Asian forest butterflies: a review. Journal of Applied Ecology. 44: 703-713.

Kocher SD and Williams EH. 2000. The diversity and abundance of north American butterflies vary with habitat disturbance and geography. Journal of Biogeography. 27: 785-794.

Molleman F. 2010. Puddling: from natural history to understanding how it affects fitness. Entomologia Experimentalis et Applicata. 134: 107-113.

Nijhout HF. 1994. Insect Hormones. Princeton University Press. Pp 79.

Prudic KL, Oliver JC and Bowers DM. 2005. Soil nutrient effects on ovipositon preference, larval performance, and chemical defense of a specialist insect herbivore. Oecologia. 143: 578-587.

Pivnick KA and McNeil JN. 1987. Puddling in butterflies: sodium affects reproductive success in Thymelicus lineola. Physiological Entomology. 12: 461-472.

Smedley SR and Eisner T. 1995. Sodium uptake by puddling in a moth. Science. 270: 1816-1818.

Thomas JA. 2005. Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. Philosophical Transactions of the Royal Society B: Biological Sciences. 360: 339-357.

Tiple AD, Khurad AM and Dennis-Macfie RLH. 2007. Butterfly diversity in relation to a human-impact gradient on an Indian university campus. Nota Lepidopterologica. 30: 179-188.

Talbot, G. 1939. The Fauna of British India including Ceylon and Burma. Butterflies. Vol. I. Taylor & Francis, London (Reprinted by Today and Tomorrow's Printers and Publishers, New Delhi). Pp 600.

Talbot, G. 1947. The Fauna of British India including Ceylon and Burma. Butterflies. Vol. II. Taylor & Francis, London (Reprinted by Today and Tomorrow's Printers and Publishers, New Delhi). Pp 506.

Weil RR and Brady RR. 2016. The Nature and Properties of Soils. Fifteenth Edition, Pearson, Columbus. Pp 110.

Wynter-Blyth MA. 1957. Butterflies of the Indian region. Bombay Natural History Society. Pp 523.