Species

To Cite:
Devi SB, Sharma T, Rai RK, Irungbam JS, Manish K, Sharma K. Initial Colonization of Red Pierrot *Talicada nyseus nyseus* (Guérin-Méneville, 1843) (Lepidoptera: Lycaenidae: Polyommatinae) in Sikkim, Eastern Himalaya, India. *Species* 2025; 26: e7s1763 doi: https://doi.org/10.54905/disssi.v26i77.e7s1763

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Peer-Review History
Received: 05 October 2024
Reviewed & Revised: 09/October/2024 to 13/January/2025
Accepted: 18 January 2025
Published: 27 January 2025

Peer-Review Model
External peer-review was done through double-blind method.

Species
pISSN 2319–5746; eISSN 2319–5754

Initial Colonization of Red Pierrot *Talicada nyseus nyseus* (Guérin-Méneville, 1843) (Lepidoptera: Lycaenidae: Polyommatinae) in Sikkim, Eastern Himalaya, India

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ABSTRACT

Sikkim forming part of the Himalaya biodiversity hotspot harbors more than half of the butterfly diversity of India. Since its first records from Uttarakhand two decades ago, Red Pierrot *Talicada nyseus nyseus* (Guérin-Méneville, 1843) have been reported from other parts of the Indian Himalayan region and Bhutan. We report new distribution records of *T. n. nyseus* from May 2002 to August 2024 and its initial colonization in Sikkim, Eastern Himalaya, India. We have reviewed past studies on its distribution, habitat, autecology, and colonization. The study also provides future research perspectives to understand better the sub-species, distribution, colonization, and autecology of *T. nyseus* and their population monitoring within the Himalaya, NE India and elsewhere in its geographical range.

Keywords: Biodiversity hotspot, Butterfly, Indicator species, Indian Himalayan Region, Population monitoring, Range expansion.

1. INTRODUCTION

The monotypic oriental genus *Talicada* Moore, 1881, is represented by the species *Talicada nyseus* (Guérin-Méneville, 1843) with nine recognized subspecies (Lo et al., 2017). The nominal sub-species *Talicada nyseus nyseus* (Guerin-Meneville, 1843) is distributed in India (Maharashtra to Kerala, eastward to Andhra Pradesh; Himachal Pradesh; Uttarakhand; Uttar Pradesh; Delhi), Sri Lanka, Bhutan, Pakistan, and Bangladesh (Evans, 1925; D'Abrera, 1986; Varshney and Smetacek, 2015; Lo et al., 2017; Van-Gasse, 2021). *T. n. khasiana* Swinhoe, 1893 is distributed in NE India (Meghalaya, Mizoram, Manipur, and Nagaland) and N. Myanmar (Swinhoe, 1893; Evans, 1925; Varshney and Smetacek, 2015; van Gasse, 2021). *T. n. metana* Riley and

Godfrey, 1921 is distributed in N. Thailand, S. Vietnam (Riley and Godfrey, 1921; Ek-Amnuay, 2006; Inayoshi, 2024).

T. n. assamica Seitz, 1924 is distributed in Assam, NE India (Seitz, 1924). *T. n. annamitica* Seitz, 1924 is distributed in Indochina (Seitz, 1924; Saito, 2014; Inayoshi, 2024). *T. n. burmana* Evans, 1925 is distributed in the Shan States of Myanmar to W. Thailand (Evans, 1925; Inayoshi, 2024). *T. n. macbethi* Riley, 1932 is distributed in E. Thailand (Riley, 1932; Inayoshi, 2024). *T. n. delhiensis* Kumar, 2009 is distributed in Delhi, N. India (Kumar et al., 2009). *T. n. lami* Lo, Li and Ding, 2017 is distributed in Hainan Island, China (Lo et al., 2017). Among them, four subspecies (*T. n. nyseus, T. n. khasiana, T. n. assamica, and T. n. delhiensis*) have been reported in India (Kumar et al., 2009; Varshney and Smetacek, 2015; Lo et al., 2017). However, recent studies have reported only two sub-species *T. n. nyseus* (=*T. n. delhiensis*) and *T. n. khasiana* (=*T. n. assamica*) for India (Varshney and Smetacek, 2015; Van-Gasse, 2021; Anonymous, 2024).

Sikkim is one of the most bio-diverse regions in the Himalaya biodiversity hotspot (Mittermeier et al., 2011) including for butterflies (Haribal, 1992); Das et al., 2023), and plants (Gogoi et al., 2021). Haribal (1992) reported 689 species of butterflies in the Sikkim Himalaya. There have been increasing reports on the discovery of new butterfly species (Karmakar et al., 2021), the re-discovery of rare species (Kunte, 2010; Rai et al., 2012; Dewan et al., 2018), and new distribution records (Lepcha et al., 2022) for Sikkim. More focused studies by researchers and citizen scientists during the past two decades have resulted in documenting 40 additional species for the state. A recent study (Das et al., 2023) has reported that Sikkim has the third-highest butterfly diversity (729 species) among India's states and UTs after Arunachal Pradesh (745 species), and West Bengal (731 species). The species is presently reported from more than 25 states and Union Territories (UTs) of India (Das et al., 2023).

The state harbors more than half of the total butterfly diversity of the country (Das et al., 2023; Kunte, 2024). Since its first record in 2002 from Uttarakhand (Singh, 2005; Smetacek, 2011), *T. n. nyseus* has been reported from other parts of the Indian Himalayan region (IHR) such as Himachal Pradesh (Mahendroo and Smetacek, 2011; GBIF.org, 2024), Jammu & Kashmir (Sharma and Sharma, 2017), northern hills of West Bengal (Pradhan et al., 2023, GBIF.org, 2024), Sikkim (Sharma et al., 2023; GBIF.org, 2024), Arunachal Pradesh (GBIF.org, 2024), Manipur (Harmenn H. pers. Obs.; GBIF.org, 2024; Irungbam et al., 2020), and in Bhutan Himalaya (https://biodiversity.bt/observation/show/707340; Van-Gasse, 2021; GBIF.org, 2024). Studies have also reported *T. n. nyseus* in Delhi and North India (Smetacek, 2011; GBIF.org, 2024). Thus, in the past two decades, *T. n. nyseus* has shown range expansion and colonization to the IHR, Bhutan, and northern India.

The species had not been reported in Sikkim (a well-studied region for butterflies), before a recent single photographic record of an individual (from November 2023) in Gangtok district (Sharma et al., 2023). However, our records of the live specimens of *T. n. nyseus* from Pakyong district (May 2022), and Gangtok district (August-October, 2023), precede the specimen record by Sharma et al., (2023) by more than one and half years (for Sikkim state), and up to four months (for Gangtok district), respectively. Our study reports additional distribution records of the species from 2022 to 2024 and its possible colonization in the human-modified ecosystems of two districts (Pakyong and Gangtok) of Sikkim, India. We have also reviewed past studies to understand its distribution, habitat, autecological traits, and colonization in the Himalaya, NE India.

2. PRESENT OBSERVATIONS

On 6 May 2022, at around 13:20 hr on a sunny day, RKR photographed a butterfly individual of *T. n. nyseus* (Figure 1a-b) within an urban habitat at Rangpo town (at 250 m) of Pakyong district, Sikkim, Eastern Himalaya, India (Table 1) which was fluttering slowly and puddling on the ground near the National Highway 10. On 17 August 2023, at around 12:14 hrs, another individual of *T. n. nyseus* was observed near a cloth on the balcony of first floor of a residential building located at Tadong, Gangtok, Sikkim at 1200 m elevation (Table 1). TS photographed the butterfly individual (Figure 1.c) before it fluttered away towards the green space (dominated by *Castanopsis* sp., Bamboos, and ground shrubs such as *Urtica dioica*) through which a small stream flows. It had been drizzling since morning, likely forcing the butterfly to take shelter on the balcony.

After a fortnight, we again sighted the species in the neighbourhood about 100 m away (beyond the small stream) on 4 September between 12:45 to 12:56 pm (Table 1) and photographed it (Figure 1.d). With slightly damaged wings, it was observed flying and sitting on the leaves and flowers of an unidentified ornamental plant. Afterwards, nine more individuals of *T. n. nyseus* were sighted in *Tagetes* spp.- dominated garden of Holy Cross School, Tadong, Gangtok (1130 m) between 10.10.2023 to 13.10.2023; on 16.10.2023, and 18.07.2024 (Figure 1.e-f) during the school break (13:50-14:20 hrs), as well as one individual at Amdo Golai, 5th mile, Tadong, Gangtok (1260 m) on 02.11.2023 at 11:55 hr (Table 1). In 2024, four individuals were also observed flying near the footpaths above the Holy Cross School, 5th mile, Tadong, Gangtok (at 1170 m) on 08.03.2024 at 14:58 hr, and on 27.08.2024 at 08:48 hr.

Table 1 Record of *Talicada nyseus nyseus* in the urban habitats of Pakyong and Gangtok districts of Sikkim, India.

Sl. no.	Place of sighting (and habitat)	District	Latitude (°N)	Longitude (°E)	Elevation (m)	Dates and time (hr)	N	Reference
1	Rangpo bazaar (roadside)	Pakyong	27.17753	88.5268	250	06.05.2022 (13:20)	1	Present study
2	Samriddhi goan, 6th mile, Tadong	Gangtok	27.311575	88.586339	NA	03.06.2023 (NA)	1	GBIF.org, 2024
3	Gangtok	Gangtok	NA	NA	NA	05.7.2023 (NA)	1	Anonymous, 2024
4	Metro, 5th mile, Tadong (on balcony)	Gangtok	27.30963	88.59342	1200	17.08.2023 (12:14)	1	Present study
5	Metro, 5th mile, Tadong (home garden)	Gangtok	27.308433	88.59352	1210	04.09.2023 (12:45-12:56)	1	Present study
6	Holy Cross School, Tadong (school garden)	Gangtok	27.31133	88.59173	1130	10.10.2023 to 13.10.2023; 16.10.2023; 18.07.2024 (13:50-14:20)	9	Present study
7	Amdo Golai, 5th mile, Tadong (roadside)	Gangtok	27.30008	88.59328	1260	02.11.2023 (11:55)	1	Present study
8	6th mile, Tadong (roadside)	Gangtok	27.31057	88.59759	1600	08.11.2023	1	Sharma et al., 2023
9	6th mile, Tadong	Gangtok	27.308345	88.593152	NA	27.11.2023 (09:25)	1	GBIF.org, 2024
10.	Above Holy Cross School, 5th mile, Tadong (footpath)	Gangtok	27.31055	88.59195	1170	08.03.2024 (14:58) 27.08.2024 (08:48)	4	Present study

The photographed butterfly individuals (Figure 1) were identified as Red Pierrot *Talicada nyseus* nyseus (Guérin-Méneville, 1843) of order Lepidoptera, family Lycaenidae, and subfamily Polyommatinae based on its key identification features (Swinhoe, 1893: Evans, 1932: Smetacek, 2011: Kehimkar, 2016): (a) tailed hindwing (HW); (b) Outer half of underwing forewing having black with white spots; (c) three black bands on forewing underside are joined together, with the outer third black, and two bands having white spots; (d) inconspicuous large orange area present on the HW recto's distal half with ¼ inch or more width; and (e) reduced markings on the HW verso with discal band mostly absent. The Indian subspecies *T. n. nyseus* can be well differentiated from the khasi subspecies *T. n. khasiana* (Table 2).

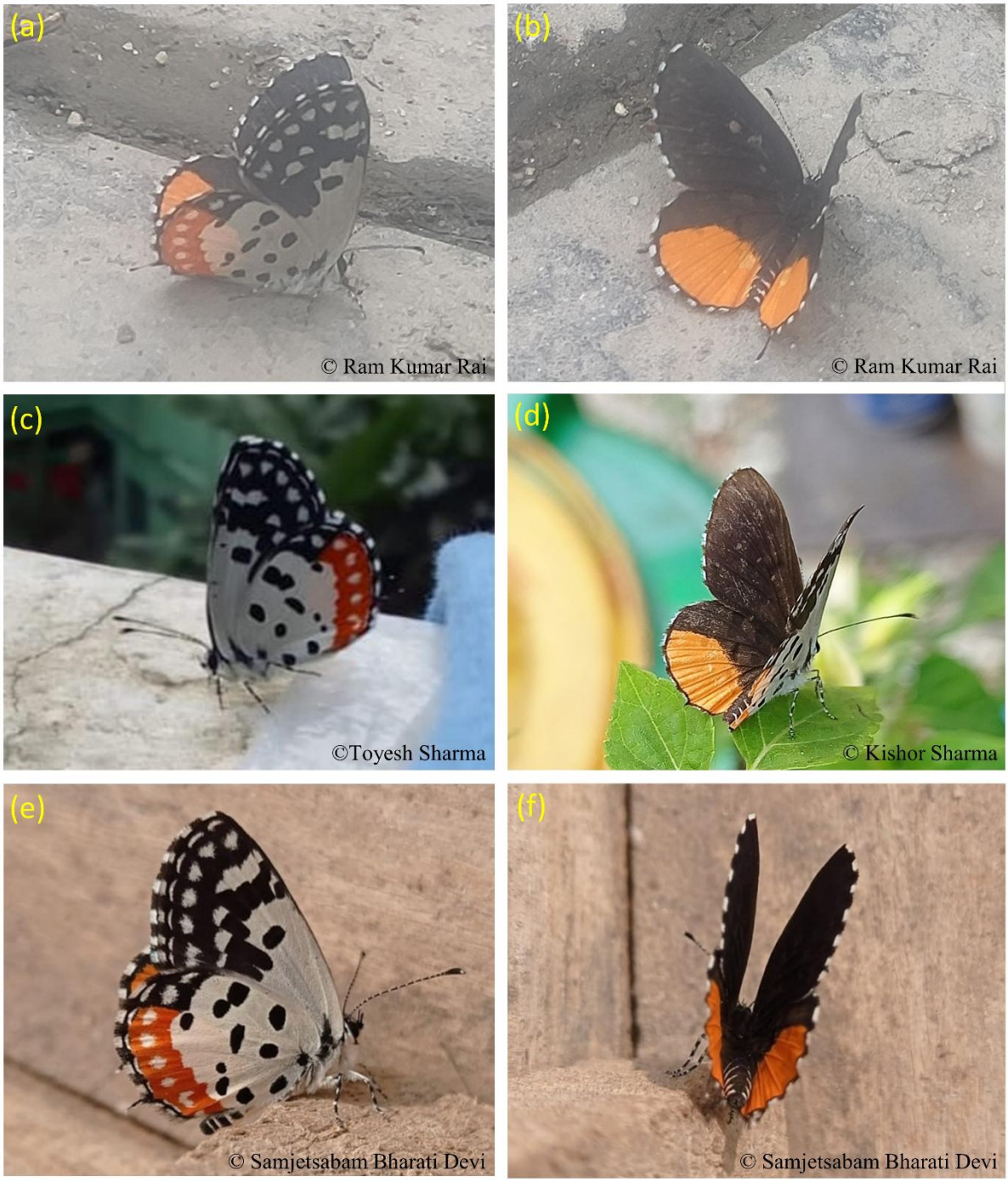

Figure 1 Red Pierrot *Talicada nyseus nyseus* photographed at Rangpo (Pakyong district: a, b), and at Tadong (Gangtok district: c-f) in Sikkim, India.

3. DISCUSSIONS

Distributions of Talicada nyseus in the Himalaya and NE India

The localities of the sightings of *T. n. nyseus* in the two districts of Sikkim are depicted in (Figure 2). An updated distribution map of the species in the Himalaya and NE India is depicted in (Figure 3). We have also summarised the distribution, habitat and morphological traits for the its two sub-species (*T. n. nyseus* and *T. n. khasiana*) found in India (Table 2). Historically, the distribution range of *T. n.*

nyseus was considered to be Peninsular India and Sri Lanka (Evans, 1932), but presently, it is reported from more than 20 Indian states/UTs (Table 2).

The sightings of *T. n. nyseus* in Sikkim, in addition to its recent records in Arunachal Pradesh (27.0803° N, 93.53106° E; GBIF.org 2024) and Bhutan (in Samshe: 26.9190° N, 89.0512° E: https://biodiversity.bt/observation/show/707340; and Phuentsholing, Chukha: 26.8603° N, 89.3938° E https://biodiversity.bt/observation/show/881304) in the Eastern Himalaya, as well as records from Western Himalaya including Jammu and Kashmir, Himachal Pradesh and Uttarakhand (Singh, 2005:Smetacek, 2011: Mahendroo and Smetacek, 2011: Sharma and Sharma, 2017: Das et al., 2023: GBIF.org, 2024) suggests disjointed distribution in the Himalaya and NE India (Figure 3). It also implies a high possibility for its presence and/ or future colonization in hitherto unreported tropical and sub-tropical areas of Nepal (Van-der-Poel and Smetacek, 2022).

Only two decades ago, *T. n. nyseus* was first conclusively reported in the Himalaya from Uttarakhand (Singh, 2005; Smetacek, 2011). However, there existed more than 140-year-old historical records of the species in the Himalaya (Atkinson, 1882 in Smetacek, 2011) albeit inconclusive, which was subsequently validated as the correct distribution record since one of its hostplants *Kalanchoe spathulata* was also native to the region. The distribution and elevation range (300-1500) of *K. spathulata* are within the normal distribution of *T. n. nyseus* in the Himalayan region (Mahendroo and Smetacek, 2011).

Larval host and nectar plants

The species is known to lay eggs singly, with its larvae being monophagous, and feeds exclusively on the leaves of its host plants belonging to Crassulaceae family: Native Himalayan species *Kalanchoe integra* (synonym: *Kalanchoe spathulata*) and other cultivated ornamental species i.e., *K. blossfeldiana, K. laciniata, K. pinnata* (synonym: *K. calycinum*), *K. delagoense* (Kehimkar, 2008; Smetacek, 2011; Bais, 2015; Anonymous, 2024). Many other species of the Crassulaceae family, such as *K. lanceolata, K. lanceolata var. glandulosa, K. grandiflora, K. olivacea, K. tubiflora, K. bhidei,* and *K. cherukondensis* are widely used as ornamental plants in north India (Bais, 2015), some of which could be hitherto unreported host plants for *T. n. nyseus*. Past studies have reported that the adult individuals of the species feed on the flower nectar of *Lantana camara, Sida rhomboidei, Cosmos sulphurous, Croton bonplandianum, Gomphrena globosa, and Tridax procumbens* (Singh, 2005: Nimbalkar et al., 2011), and on lichen *Leproloma sipmanianum* (Karunaratne et al., 2002). In the present study, we observed it feeding on the flower nectar of *Bidens pilosa.*

Habitat preference

T. n. nysuus is reported as a habitat specialist, preferring moist, sheltered habitats in deciduous to evergreen forests and urban gardens (Kehimkar, 2016: Singh, 2005: Smetacek, 2011), and we observed it within human-modified ecosystems (Urban, and agricultural ecosystems) across different habitats such as roadsides, footpaths, residential spaces, school gardens, and home gardens in Sikkim. Similar to the slow fluttering flight reported in the past (Kehimkar, 2016), the individuals of *T. n. nyseus* were observed flying slowly close to the ground or around the flowering plants in Sikkim.

Flight period and elevation range

In Sikkim, *T. n. nyseus* was sighted from March and May to November within 250 m to 1260 m in the present study. A recent study (Sharma et al., 2023) recorded a single sighting of the species in Tadong (of Gangtok district) during November at 1600 m. *T. n. nyseus* is a multivoltine species, and it is known to fly year-round (Singh, 2005; Kehimkar, 2016; Anonymous, 2024). During the first documented colonization events in the Kumaon Himalaya (i.e., in Haldwani, Chandradevi, and Jone estate) from 2002 to 2004, the species was observed to fly during January to February, June to September, and November across 400 to 1500 m elevation (Smetacek, 2011).

Singh (2005) documented the initial colonisation of the species in Dehradun valley (average elevation: 485 m) during 2003-2004 reporting year-round sightings but primarily from March to November, and occasionally during December to February. In Sikkim, the species is yet to be recorded during the winter season (December to February), likely due to its less abundance during this season Singh, (2005) as the majority of butterflies in the Himalaya (Sharma et al., 2020). *T. n. nyseus* may also migrate to the lower tropical belt during the winter season to overcome the unfavourable climate and scarcity of larval and nectar plants.

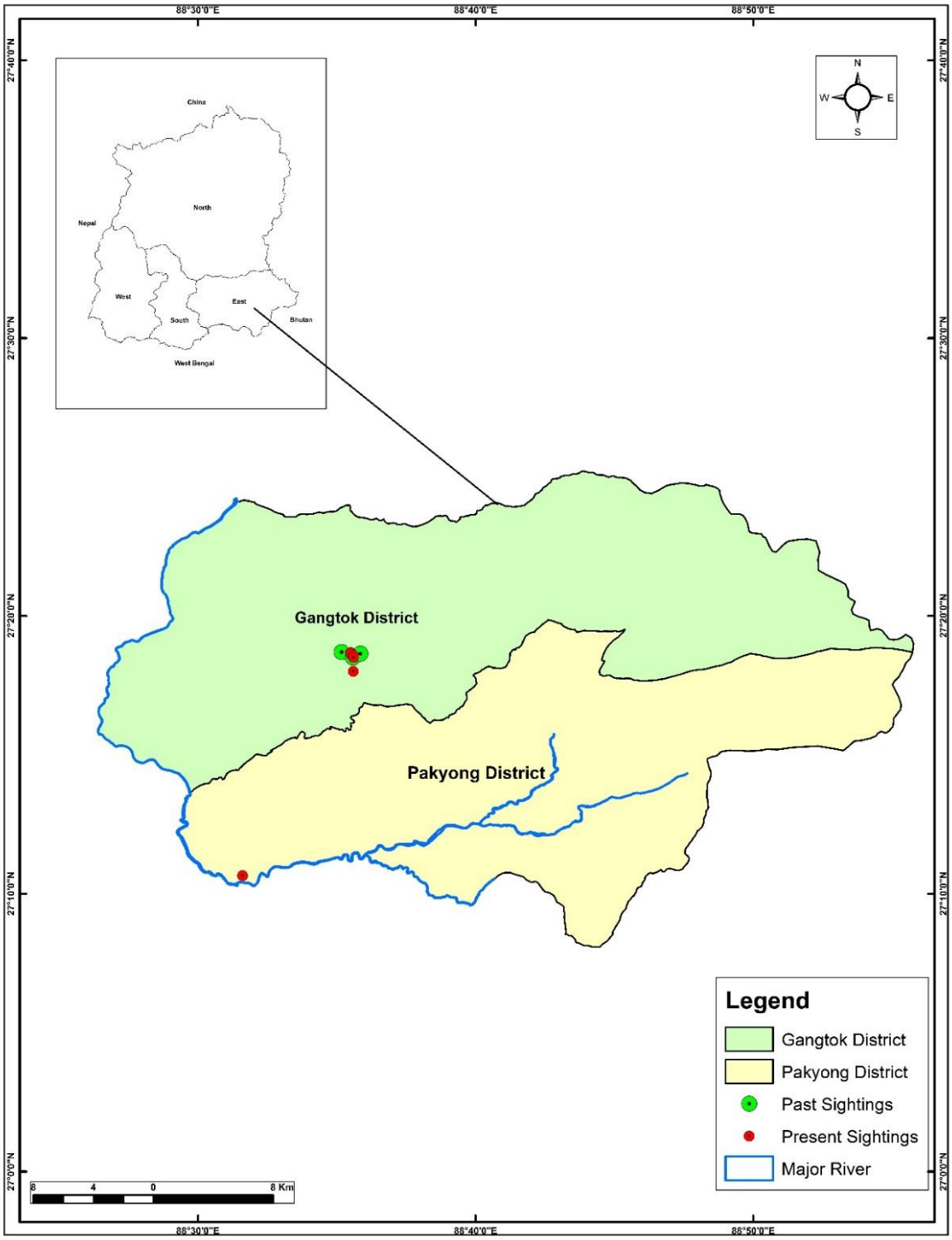

Figure 2 Map showing the sites of sightings of *Talicada nyseus nyseus* in Gangtok and Pakyong districts of Sikkim, India.

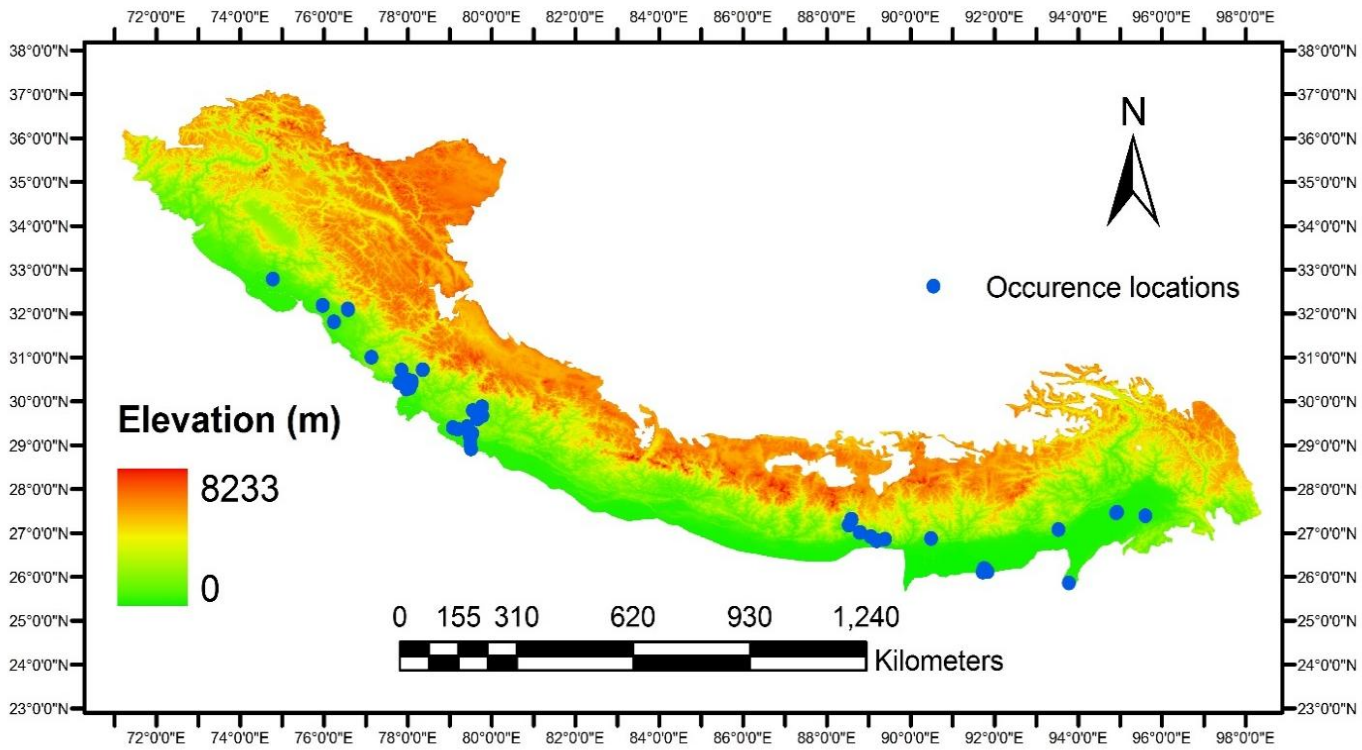

Figure 3 Figure showing the distribution map of *Talicada nyseus* in the Himalaya and NE India.

Table 2 Table showing the comparison of morphological and autecological characteristics for the two subspecies of Talicada nyseus (Guérin-Méneville, 1843) found in India.

Characters	**Subspecies**		**Reference**
	T. n. nyseus **(Guérin-Méneville, 1843)**	***T. n. khasiana*** **Swinhoe, 1893**	
Subspecies type	*Indian subspecies*	*Khasi subspecies*	Evans, (1932); Smetacek, (2011)
Wingspan	30-36 mm	30-36 mm	Singh, (2005); Kehimkar, (2016)
Orange area on the distal half of the hindwing recto	Extensive, with a width of ¼ inch or more.	Restricted, well under ¼ inch width.	Evans, (1932); Smetacek, (2011)
Markings on the hindwing verso	Reduced, with most of the discal band absent.	Large and complete.	Evans, (1932); Smetacek, (2011)
Three black bands on the underside of the forewing	Joined together, making the outer third black, with two bands of white spots.	The third band is well separated.	Swinhoe, (1893)
Geographic range	India (Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Assam- north of Brahmaputra, Manipur, Andhra Pradesh, Bihar, Chandigarh, Delhi, Goa, Gujrat, Jharkhand, Karnataka, Kerala, Madhya Pradesh,	NE India (Assam- south of Brahmaputra, Manipur, Meghalaya, Mizoram, and Nagaland), and N. Myanmar.	Kehimkar, (2016); Varshney and Smetacek, (2015); Lo et al., (2017); Irungbam et al., (2020); Van-Gasse, (2021); Das et al., (2023);

	Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, West Bengal), Sri Lanka, Bhutan, Pakistan, and Bangladesh.		Sharma et al., (2023); Present study
Elevational range	up to 2400 m;	up to 1800 m	Singh, (2005); Van-Gasse, (2021)
Flight period	January to December	January to December	Singh, (2005); Kehimkar, (2016); Anonymous, (2024)

Colonization

In Sikkim, we recorded *T. n. nyseus* from Pakyong district in May 2022 (at 250 m), and in Gangtok district from July to November 2023, and in March, July and August 2024 (within the elevation of 1130 m to 1260 m). It was previously recorded from Gangtok in June, October and November of 2023 (Sharma et al., 2023: Anonymous, 2024: GBIF.org, 2024) up to 1600 m elevation. Comparatively higher sightings of *T. n. nyseus* in Sikkim during the post-monsoon (September to November) than other seasons may be attributed to the higher abundance of butterfly communities during this season due to the availability of favorable climate, larval and nectar plants (Sharma et al., 2020).

Past studies have attributed the burst in population and surge in colonization rate of *T. n. nyseus* in the Himalaya and northern India to the large-scale introduction of its larval hostplants belonging to the Crassulaceae family (predominantly non-native species) originating from peninsular India as ornamental plants in the urban habitat, whereas its population crash and local extinction to the habitat loss of its native/ introduced larval hostplants (Singh, 2005: Smetacek, 2011: Bais, 2015), and predation by Asian yellow wasps *Polites hebraeus* (Bais, 2015). *T. n. nyseus* has been reported to show some interesting behaviors, including being attracted to light Usman, (1956) and associated with lichen *Leproloma sipmanianum* (Karunaratne et al., 2002). It is also well-known for its ability to colonize fast and for being an indicator of environmental change (Singh, 2005).

The species has exceptional adaptation for anti-predation through the mining behavior of its larvae (that feed inside the leaves of its host plant), allowing it to stay undetected during the transportation of its hostplants as ornamental plants and ultimately promote colonization by the species to newer urban and human-modified habitats (Bais, 2015). All of its host plants (except *Kalanchoë integra*) are cultivated ornamental plants affecting the stability of the natural population, and its slow fluttering flight during its adult stage renders it vulnerable to attack by predators, e.g. *Polistes hebraeus* that caused its sudden population decline in Delhi during 2009 (Bais, 2015).

The successful colonization of the species in the Himalaya is also linked to the availability of its native host plant, *K. integra* in the tropical and subtropical zones (i.e., across 300 to 1800 m) of the Himalaya (from Jammu and Kashmir to Bhutan, Lushai hills including in Sikkim), and Deccan Peninsula (Smetacek, 2011; Bais, 2015; (https://efloraofindia.com/2012/07/26/kalanchoe-integra/; Hassler, 1994 - 2024). Another host plant, *K. laciniata*, is also native/ naturalised to the Himalaya (including in Uttarakhand, Sikkim, Arunachal Pradesh), NE India (Meghalaya, Nagaland), and Deccan peninsular region (Hassler, 1994 - 2024) which might have further helped in the population explosion and colonization of *T. nyseus* in the IHR.

4. CONCLUSIONS AND FUTURE RESEARCH PERSPECTIVES

We recorded *T. n. nyseus* in Sikkim in March and from May to November at elevations ranging from 250 m to 1260 m, aligning with its known flight period (January to December) and elevation range (up to 2400 m) (Wynter-Blyth, 1957; Singh, 2005; Kehimkar, 2016; Van-Gasse, 2021). With this record of *T. n. nyseus* in Pakyong and Gangtok districts, the total butterfly diversity for Sikkim has increased to 730 species, up from the 729 species recorded in a recent study (Das et al., 2023). Therefore, it is essential to enhance partnerships between researchers and citizen scientists further to conduct focused long-term studies on butterflies covering both natural and human-modified ecosystems of the state.

In the future, incorporating molecular tools such as DNA barcoding (to complement taxonomic studies) and implementing long-term monitoring programs can help accurately decipher the subspecies and population fluctuations/colonization of *T. nyseus* in both natural and human-modified ecosystems of the Himalaya and Northeast India. It is also necessary to further investigate whether the colonization of *T. n. nyseus* is driven by the introduction of its non-native larval host plants as ornamental plants, or environmental

changes. Despite not being protected under Schedule I, II, or IV of the Indian Wildlife (Protection) Act 1972 (Anonymous, 2024), there is still a need to prevent the local extirpation of natural population of *T. n. nyseus* in the Himalaya by conserving the habitat of its native host plants (*K. integra, K. laciniata*) (Smetacek, 2011).

There is also a need to carry out ecological niche modeling of the indicator butterfly species for urbanization and environmental change such as *T. n. nyseus* (Singh, 2005), and other indicator species of land use change (Sharma et al., 2020) in the Himalayan region. Better understanding of the present and future distribution of these indicator butterfly species and their host plants can assist the scientific community and policymakers in mitigating environmental change in the Himalayan region.

Acknowledgements

For guidance and support, SBD is grateful to Prof. Ch. Satish Kumar (Hon'ble Vice Chancellor, SRM University). TS conveys his gratitude to the respected Principal and Teachers of Holy Cross School for the encouragement and support to study butterflies in the school garden. KS is grateful to Prof. Bhoj Kumar Acharya and Kalsang Nyima for their support and encouragement. For providing research facilities and support, KS, and SBD extend their gratitude to Sikkim University and SRM University Sikkim, respectively.

Ethical approval

An opportunistic sampling of the Red Pierrot butterfly was done in the human-modified habitats at two locations (Rangpo in Pakyong district and Tadong in Gangtok district) of Sikkim during the present study. We followed ethical guidelines for butterfly observation, photography and identification. The Animal ethical guidelines are followed in the study for species observation, identification & experimentation.

Informed consent

Not applicable.

Conflicts of interests:

The authors declare that there are no conflicts of interests.

Funding:

The study has not received any external funding.

Data and materials availability

All data associated with this study are embedded in the paper. The additional secondary data used for preparing the distribution map (Figure 3) are available in gbif (https://www.gbif.org/).

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