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Cover: A Warty Hammer Orchid *Drakaea livida* gets pollinated by a male thynnine wasp through 'sexual deception' — a colour pencil reproduction of photos by ron_n_beths (flickr.com) and Rod Peakall; Water colour reproduction of Flame Lily *Gloriosa superba* -- photo by Passakoran_14; and a bag worm and its architectural genius (source unknown). Art work by Pannagasri G.

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SHORT COMMUNICATION

Habitat-specific distribution and density of fireflies (Coleoptera: Lampyridae): a comparative study between grassland and woodland habitats

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Abstract: Habitat plays a crucial role in the survival of insect species, with many restricted to or thriving in particular environments. This study examines the population densities and flight heights of fireflies across different habitats. Firefly density was estimated using the point count method along randomly placed 100 m transects in two distinct habitats: grassland and woodland. Results revealed that the average density of *Abscondita chinensis* and *Asymmetricata circumdata* was significantly higher in grassland than in woodland. Firefly vertical distribution also varied by flight height, with a greater density observed below 1.5 m in grassland ($z = 13.90$, $n1 = 99$, $n2 = 99$, $p < 0.05$), while in woodland, higher densities were found above 1.5 m ($z = 2.29$, $n1 = 38$, $n2 = 38$, $p < 0.05$). These findings emphasize habitat-specific preferences & behaviours, highlighting the need for targeted conservation & management strategies to preserve firefly populations, and their diverse environments.

Keywords: *Abscondita chinensis*, *Asymmetricata circumdata*, conservation, glowworms, transects, vertical distribution.

The Neotropics and the Asian south-east harbour the highest diversity of fireflies within the family Lampyridae (Lawrence & Newton 1995; Hu & Fu 2018; Lewis et al. 2021; Poukin et al. 2023). According to Lloyd (2008), the Lampyridae family is renowned for its bioluminescent courtship signalling traits. Research suggests that the flashing behaviour observed in male fireflies serves purposes such as mate choice and predation (Buck & Buck 1968; Lewis & Cratsley 2008).

Abscondita chinensis (Kiesenwetter, 1874) and *Asymmetricata circumdata* (Motschulsky, 1854) are two firefly species with distinct but overlapping distributions in Asia. *Abscondita chinensis* is primarily found across eastern and southeastern Asia, with documented occurrences in countries such as India, China, Japan, Taiwan, Vietnam, and Thailand (Wattanachaiyingcharoen et al. 2011; Ballantyne et al. 2013; Chatragadda 2020; Chaiwongsaen et al. 2024). In India, its distribution includes Assam, Uttarakhand, Doon Valley, and western Himalaya (Ballantyne et al. 2009; Ghosh et al. 2023; Rana et al. 2024). The bioluminescent behaviour of *Abscondita chinensis* fireflies is well-studied in northeastern India (Rabha et al. 2017). This species thrives in moist, lowland habitats, including rice paddies, wetlands, and forested areas (Fu et al. 2012). On the other hand, *Asymmetricata circumdata* has a broader distribution across the Oriental region, reported from southeastern Asia, including India, Sri Lanka, Myanmar, Thailand, parts of China (Lloyd et al. 1989; Ballantyne & Lambkin 2009), and in Assam India (Rabha & Barua 2016).

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Despite extensive research on firefly diversity, bioluminescence, and ecological roles, the significance of flight height in relation to their behaviour, and habitat preferences remains understudied. Most previous research has focused on flashing behaviour for mate selection, but little is known about how flight height impacts firefly behaviour, and survival across habitats. As human-induced threats such as habitat loss and light pollution increase, understanding factors like flight height, and density is essential for conservation (Shen et al. 2022). This study addresses the gap by investigating the density and flight height of two firefly species in grassland, and woodland habitats in & around Bodoland University.

Materials and Methods

We conducted the research in the Bodoland University Campus, Assam, India (26.469° N, 90.294° E, 100 m), covering an area of 49.6 acres for six consecutive months from January through June 2022 (Figure 1). We studied in two primary habitats: predominantly grassland and woodland, interspersed with perennial and deciduous plants. The closest water source, the Gaurang River, flows along the easternmost boundary of the campus. The density of fireflies was assessed by point count method, separated by 20 m distance between two successive points along stratified, randomly placed 100 m transects in both grassland, and woodland habitat. We counted fireflies within a 20 m radius during 1930–2100 h. Prior to the data collection, we had done a pilot study, and observed that during this period, the activity of the fireflies was more. We surveyed 99 points in the grassland habitat and 34 points in the woodland habitat. In comparison to the grassland habitat, in the study area, the woodland was smaller, and hence, the number of points surveyed was less, following a stratified random

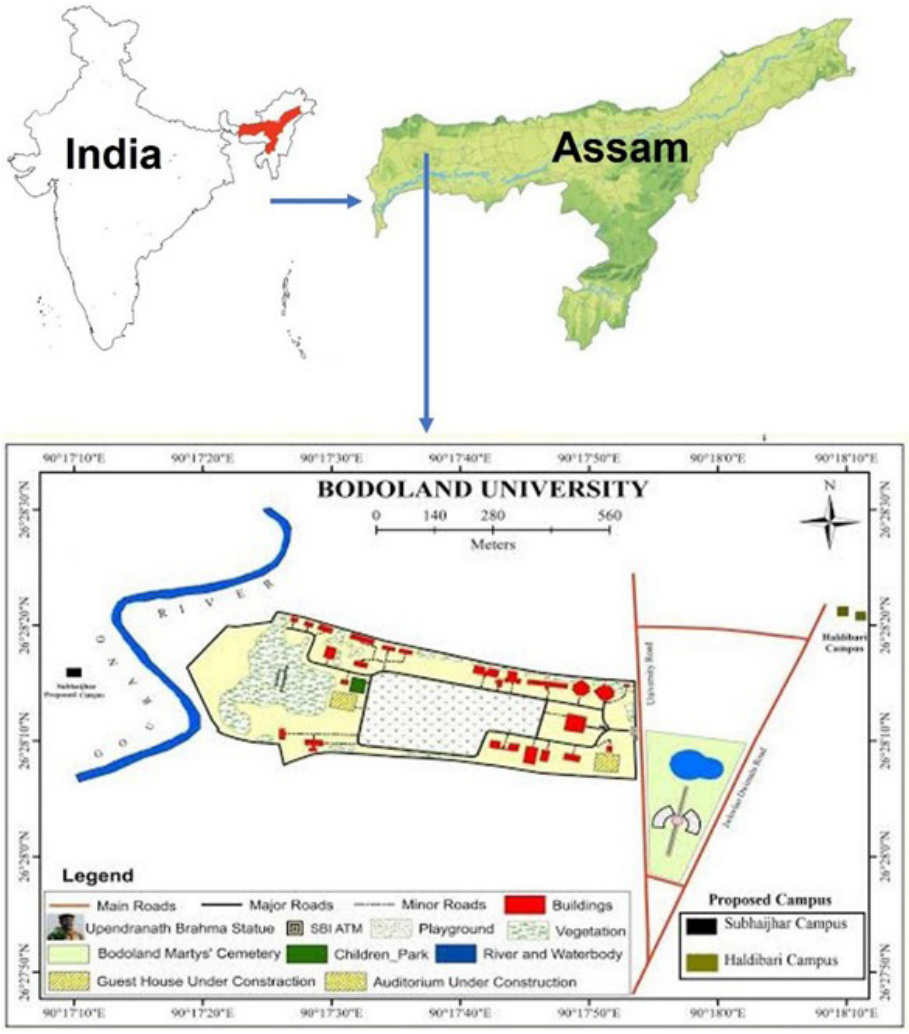

Figure 1. Study area map of Bodoland University campus, Assam, India, showing grassland and woodland habitats.

sampling. The flight height of the fireflies is categorised into two categories: up to 1.5 m from the ground and above 1.5 m, based on the height of the observer, i.e., up to eye level and above. All data were analyzed using Microsoft Excel 2007 and PAST statistical software (version 4.03). To compare firefly densities between the grassland and woodland habitats, a z-test was conducted at a significance level of 0.05.

Results

A total of 556 individuals of two species of fireflies, namely, *Abscondita chinensis* (Kiesenwetter, 1874), and *Asymmetricata circumdata* (Motschulsky, 1854) (Image 1), were recorded from the study area. The average density of fireflies was significantly higher (0.0051 ± 0.004, n = 99) in the grassland habitat than in the woodland habitat (0.0031 ± 0.0030, n = 38) ($z = 3.17$, $n1 = 99$, $n2 = 38$, $p < 0.05$) below mid height (BMH) and above mid height (AMH) (Figure 1). The average densities of fireflies were recorded as 0.0000041 /m^2 in the grassland and 0.0000024 /m^2 in the woodland.

The density of *Abscondita chinensis* was higher in the grassland habitat (0.0034 /m^2) than in the woodland habitat (0.0018 /m^2). In contrast, the density of *Asymmetricata circumdata* was also higher in the grassland (0.0017 /m^2) than in the woodland habitat (0.0010 /m^2).

Firefly density was notably higher below 1.5 m from the ground in the grassland habitat ($z = 13.90$, $n1 = 99$, $n2 = 99$, $p < 0.05$) (Figure 2), whereas in woodland habitats, it was more concentrated above 1.5 m ($z = 2.29$, $n1 = 38$, $n2 = 38$, $p < 0.05$) (Figure 3).

Discussion

Firefly density varies across different habitats, likely due to slight variations in environmental factors between the two habitats. Moreover, the presence of vegetation is crucial for fireflies, serving as copulation and resting sites, as documented in *Luciola cruciata* (Yuma & Hori 1990; Wattanachaiyingcharoen et al. 2016). During the night, temperatures typically remain relatively higher in open areas compared to forested areas due to the canopy coverage. Additionally, there may be greater availability of nectar plants in grasslands than in woodlands because the exposure to sunlight in the open grassland habitat results in a higher density of flowering plants compared to the woodland habitat. Another factor contributing to the low density of fireflies in woodland is the scarcity of nectar sources. Asri et al. (2020) found that firefly abundance exhibited a significant correlation with temperature and humidity. Specifically, they observed a positive relationship between firefly abundance and temperature, while noting a negative correlation with humidity. Jusoh (2015) observed that firefly species tend to inhabit a range of environments and may coexist with multiple other species. Their study particularly highlights the coexistence of *Abscondita chinensis* and *Asymmetricata circumdata* in shared habitats, a finding that aligns with our study as well.

In contrast, fireflies may exhibit a preference for higher flight altitudes in woodland habitats for several reasons. Within this habitat, despite still relying on bioluminescence for mating, flying at elevated heights enhances the visibility of their light signals amidst the dense foliage. This heightened visibility extends the range over which potential mates can detect their signals, fostering increased mating opportunities (Lloyd 2008). Furthermore, woodland often harbours intricate vegetation and various obstacles nearer to the ground, such as tree trunks, and branches. By soaring at higher heights, fireflies mitigate the risk of collisions with these obstacles, facilitating better navigation through the forest canopy (Shen 2022). Additionally, given that many

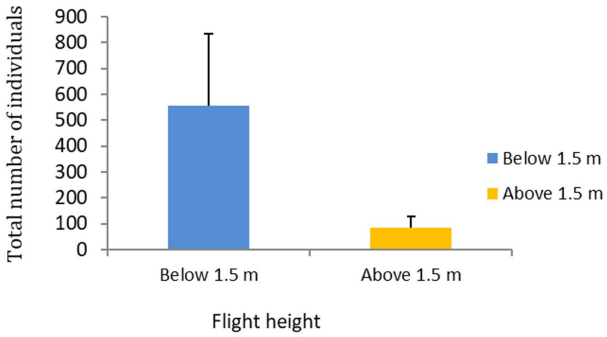

Figure 2. Firefly density distribution in grassland habitat, with significantly higher densities observed below 1.5 m.

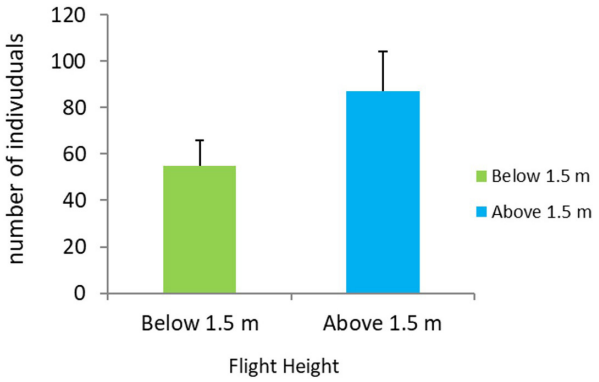

Figure 3. Firefly density distribution in woodland habitat, with significantly higher densities observed above 1.5 m.

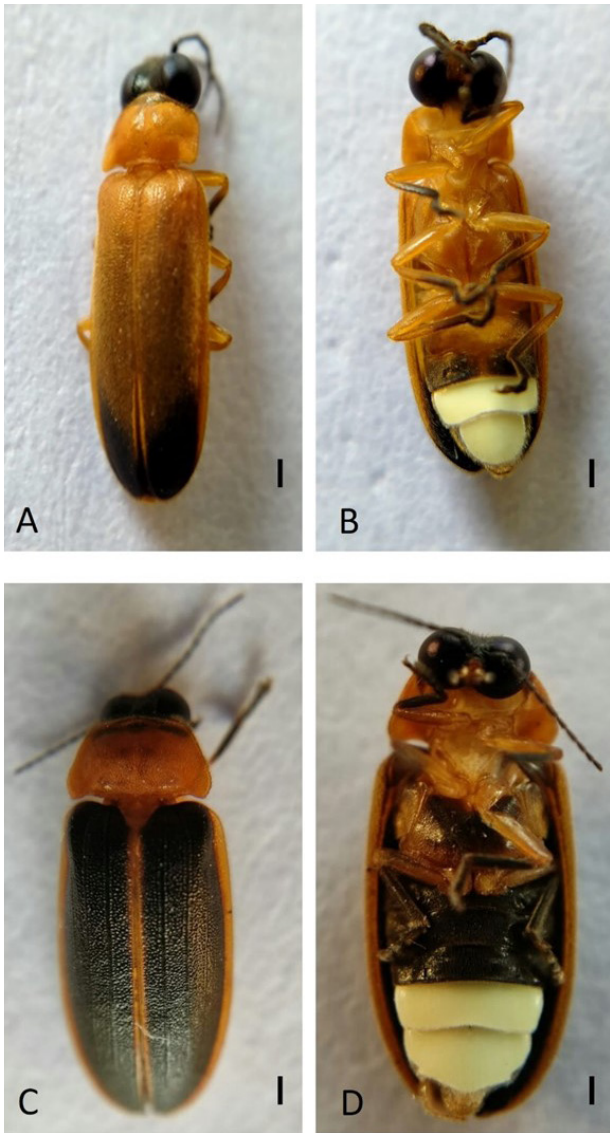

Image 1. Morphological views of two firefly species: A—dorsal view (male) | B—ventral view of *Abscondita chinensis* | C—dorsal view (male) | D—ventral view of *Asymmetricata circumdata*. (Scale in 2 mm). © Kushal Choudhury.

firefly species seek refuge and forage for sustenance in the canopy during daylight hours, elevated flight allows easier access to these critical resources, and habitats during their active periods. While this behavior may expose fireflies to aerial predators like bats, the advantage lies in the enhanced visibility of oncoming threats, enabling more effective evasion strategies compared to lower-altitude flights where ambushes by predators within dense vegetation pose a greater risk (Barbosa & Castellanos 2005). In addition, some specific features of plant leaves, for example, broader leaves, may be a crucial factor in enabling fireflies to escape the attention of predators.

Conclusion

From a conservation perspective, understanding habitat preferences and flight height is crucial for firefly survival, as these factors directly impact their ecological roles, reproductive success, and vulnerability to threats. Habitat type influences food availability, larval development, and mating behaviours, while flight height can affect how fireflies interact with their environment, find mates, and avoid predators. Fireflies that fly close to the ground may be more vulnerable to habitat disturbance, such as land-use changes or pesticide exposure, whereas, those flying at higher altitudes could be more affected by artificial lighting (Costin & Boulton 2016). Since light pollution interferes with their bioluminescent signalling (Owens et al. 2022), critical for mating, knowing flight height can inform strategies to minimize artificial light at key levels in specific habitats. The present research explicitly highlights how these objectives are addressed from both behavioural and ecological perspectives. Thus, conservation efforts must integrate both habitat protection and an understanding of species-specific flight heights to ensure effective firefly preservation amidst growing environmental threats.

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