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RESEARCH ARTICLE

Discovery of Firefly Asymmetricity Ovalis (Coleoptera: Lampyridae): A New Record in Phayao Province and Its Morphological Characteristics

Sitthisak Pinmongkhonkul[1], Panupong Chaiwongsaen*, Arthit Nuntakwang[1], Boon Chuang Boonsuk[1], Manas Titayavan[2], Warin Boonriam[3,] Nathawut Thanee[4], Murray Potter[5] and Sorasak Nak-eiam[6]

[1]Department of Biology, School of Science, University of Phayao, Phayao, Thailand

[2]School of Agriculture and Natural Resources, University of Phayao, Phayao, Thailand

[3]Faculty of Environment and Resource Studies Mahidol University, Nakhon Pathom, Thailand

[4]Department of Biology, Institute of Science, Suran Aree University of Technology, nakhon Ratchasima Thailand

[5]School of Food Technology and Natural Sciences, University of New Zealand, New Zealand

[6]Department of Biology, Faculty of Science and Technology Rambha Barni Rajabhat University, Chanthaburi, Thailand

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***Corresponding Author:**

phanuphong.ch@up.ac.th

ABSTRACT

This study reports the first confirmed occurrence of Asymmetricity ovalis in Phayao Province, northern Thailand and to provide a comprehensive morphological characterization to confirm its identity. Field surveys were conducted in Rong Kham Luang Forest Park using sweep netting and visual observations between May and July, during which specimens of both male and female fireflies were collected. Morphological examination followed standard taxonomic procedures and focused on key features, especially the two-part light organ on the seventh segment of the abdomen in males. The male body length ranged from 10.70 to 14.40 mm, and detailed descriptions of the head, thorax, elytra, legs, and genital structures were recorded. In parallel with species identification, this study analyzed the vegetation structure and environmental factors of the firefly's habitat to investigate ecological conditions supporting its presence. Plant surveys and environmental measurements were conducted across five sites to assess shoreline and riparian vegetation, soil and water parameters, and their influence on firefly distribution. Results revealed that A. ovalis was located in a mixed deciduous forest at 538 meters above sea level, where shoreline plants mainly Chromanone odorata, Cryptococcus patens, and Axon opus compresses dominated more than 90% of plant cover. These vegetation patterns are likely linked to reproductive behavior and flash communication. The results confirm the first occurrence of Asymmetricity ovalis in Phayao Province, thereby extending its known geographical range. This finding illustrates the ecological importance of local forest habitats and contributes essential data for future firefly conservation planning in northern Thailand.

NTRODUCTION

Phayao Province is characterized by high environmental diversity due to its complex geology and topography, which includes igneous, sedimentary, and limestone mountains. These diverse landscapes have resulted in a wide variety of habitats that support a rich diversity of organisms, including numerous firefly species. According to Hadley (2009), global firefly populations have declined by approximately 70%, primarily due to environmental degradation and habitat destruction caused by chemical pollution and urbanization. In addition, artificial light from residential and industrial sources disrupts firefly reproduction by interfering with mating behavior, accelerating population decline (Marks, 2009).

Fireflies inhabit a range of ecosystems, including mangroves, riversides, and inland highland forests (Ballantyne et al., 2011). Studies in agricultural areas of Ban Tun Subdistrict, Mueang Phayao District, Thailand, have shown that fireflies are typically found in habitats with high relative humidity near tropical forests (Chaiwongsaen, 2020). Environmental factors, especially artificial lighting from street lamps and community infrastructure, have affected both male and female fireflies (Takeda et al., 2006).

Asymmetricata ovalis is a particularly intriguing firefly species due to its limited but diverse distribution across various natural habitats. It belongs to the same genus as *Asymmetricata circumdata*, which is more widely distributed. The known elevation range of A. ovalis habitats extends from approximately 200 to over 1,200 meters above sea level (Nak-eiam, 2015). Reports of A. ovalis have been documented in Sri Lanka, India, and Thailand. In Thailand, Nak-eiam (2015) recorded this species across northern regions, including forest parks and various forest types (e.g., mixed deciduous, dry evergreen, hill evergreen, and pine forests) in Mae Hong Son, Lampang, Phetchabun, Phitsanulok, Tak, and Chiang Mai provinces. Despite extensive surveys by Nak-eiam (2015), Wattanachaiyingcharoen et al. (2016), and Chaiwongsaen (2020), no records of this species have previously been reported from Phayao Province.

Despite multiple surveys conducted across several northern provinces of Thailand such as Mae Hong Son, Chiang Mai, Tak, and Phitsanulok the distribution and ecological preferences of *Asymmetricata ovalis* remain poorly documented. Notably, Phayao Province, despite its geographic adjacency and similar ecological profiles, has lacked confirmed records of this species until now. This suggests a potential underestimation of regional firefly biodiversity due to limited site coverage, insufficient nocturnal sampling efforts, and the absence of long-term ecological monitoring in transitional forest zones.Furthermore, while the role of habitat structure, light pollution, and microclimatic conditions on firefly populations has been studied in select regions, comprehensive habitat-based assessments that integrate vegetation composition and environmental variables remain scarce in northern Thailand. There is a particular lack of research linking specific plant communities especially shoreline and riparian vegetation with the presence and behavior of fireflies such as *A. ovalis*. This knowledge gap hampers the development of targeted conservation strategies tailored to the ecological requirements of sensitive insect taxa in this biogeographic region.Therefore, this study not only addresses a critical biogeographical gap in the known range of *A. ovalis*, but also aims to elucidate the ecological factors underpinning its occurrence by integrating taxonomic, botanical, and environmental assessments within a single framework.

This study aims to investigate the occurrence and adaptation of *Asymmetricata ovalis* in Phayao Province's diverse forest ecosystems. It also examines the role of environmental factors in influencing its abundance and distribution. The findings are expected to enhance understanding of the species' ecological preferences and contribute to the development of evidence-based conservation strategies tailored to land use and sustainability in northern Thailand.

MATERIALS AND METHODS

Study area

The study was conducted in Rong Kham Luang Forest Park, located in Ban So, Mae Na Ruea Subdistrict, Mueang District, Phayao Province, Thailand (19.05095°N, 99.86675°E). The specific location where fireflies were observed is indicated by a yellow circle on the satellite image. The site is approximately 3.86 kilometers from the center of Mueang Phayao District. The area comprises mainly mixed deciduous forest and deciduous dipterocarp forest, with some agricultural land along its periphery.

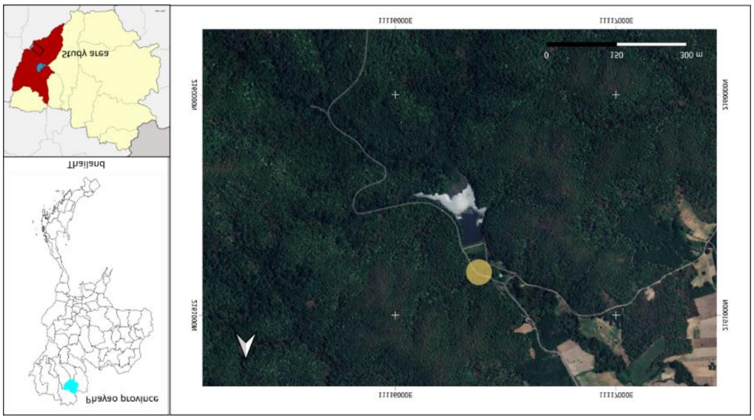

Figure 1. The study area in Rong Kham Luang Forest Park, Ban So, Mae Na Urea Subdistrict, Mueang District, Phayao Province, Thailand.

Sample Collections

Field Observation

Comprehensive observations were carried out from sunset until midnight, covering all life stages of firefly's larvae, pupae, and adults. Visual surveys were conducted across a range of microhabitats, including ground cover, vegetation, and tree trunks. Species identification was based primarily on the distinctive flash patterns exhibited by individuals during flight and at rest, following the methodology of Yuma (2007).

Specimen Collection and Preservation

Adult fireflies were collected monthly using random sampling methods, as outlined by Krebs (1999), and specimens were collected under the scientific research animal use permit number U1-07818-2561. Specimens were immediately preserved in 70% isopropyl alcohol, each stored in individual vials labelled with the date, location, and field reference number. Specimens were pinned after collection for taxonomic identification.

Taxonomic Identification

We identified the specimens using a detailed list of taxonomic references, which included works by Ballantyne and others from various years. Morphological analysis focused on diagnostic features such as the structure of the light organ, antennal segments, and aedeagal morphology.

RESULTS

Taxonomic Identification

Asymmetricata ovalis (Hope, 1831) (Figure 1) was in Mae Na Ruea Subdistrict, Mueang Phayao District, Phayao Province, Thailand. The specimens, one male and one female, were collected at an elevation of 538 meters above sea level (19°02'43.26" N, 99°51'21.42" E) in a mixed deciduous forest. This finding represents the first documented occurrence of *A. ovalis* in Phayao Province.

Diagnostic Characteristics

Asymmetricata ovalis differs from *Asymmetricity circumradii* in that it has a bipartite light organ on abdomen segment V7, whereas *A. circumdata*'s light organ covers the whole V7. Other differentiating characteristics include body size, head shape, antennal structure, pronotal proportions, elytral pigmentation, and complex male genitalia.

Morphological Description of the Male Specimen

The male body length ranged from 10.70 to 14.40 mm, with a width of 4.40 to 6.40 mm. The head was black, featuring a moderately depressed vertex and white antennal sockets. Antennae were filiform, 11-antennomered; labial palps were finger-like. The pronotum was transverse, densely punctate, and had a median groove. Elytra were dark brown to black, with a yellowish-orange margin at the apex and suture. Legs were straight, unmodified, and had darker hind coxae. Abdominal segments V6 and V7 contained well-developed light organs; V7 was bipartite with a longitudinal groove. The aedeagal sheath measured 2.70 mm long and 0.95 mm wide, displaying an asymmetrically emarginated posterior margin. The aedeagus measured 1.90 mm in length and 0.70 mm in width, comprising a cylindrical median lobe and separate lateral lobes.

Distribution and Phenology

A small number of adult males were collected during the rainy season, between May and early July, indicating seasonal emergence linked to rainfall and humidity levels. This evidence suggests a preference for warm, moist conditions.

Habitat Features and Vegetation Structure

Three primary habitat features for A. ovalis were identified: (1) dry tropical forests near water sources, (2) shallow terrain, and (3) elevations from 200 to over 1,200 meters. Vegetation surveys at the collection site showed clear dominance by shoreline plants, which comprised 91.03% of total plant cover, versus 8.97% for riparian species. The most abundant shoreline species were *Chromolaena odorata* (19%), *Cyrtococcum patens* (18%), *Axonopus compressus* (16%), and *Eleusine indica* (13%). In contrast, riparian plants like *Broussonetia papyrifera*, *Croton oblongifolius*, and *Musa acuminata* exhibited much lower relative densities (<3%).

Climatic Conditions

The climate in the study area exhibited a clear seasonal pattern. The dry season extended from November to April, while the rainy season lasted from May to October, peaking in August and September. Relative humidity closely mirrored rainfall trends, increasing significantly during the wet season. Temperature remained relatively stable throughout the year, with slight increases in April and May.

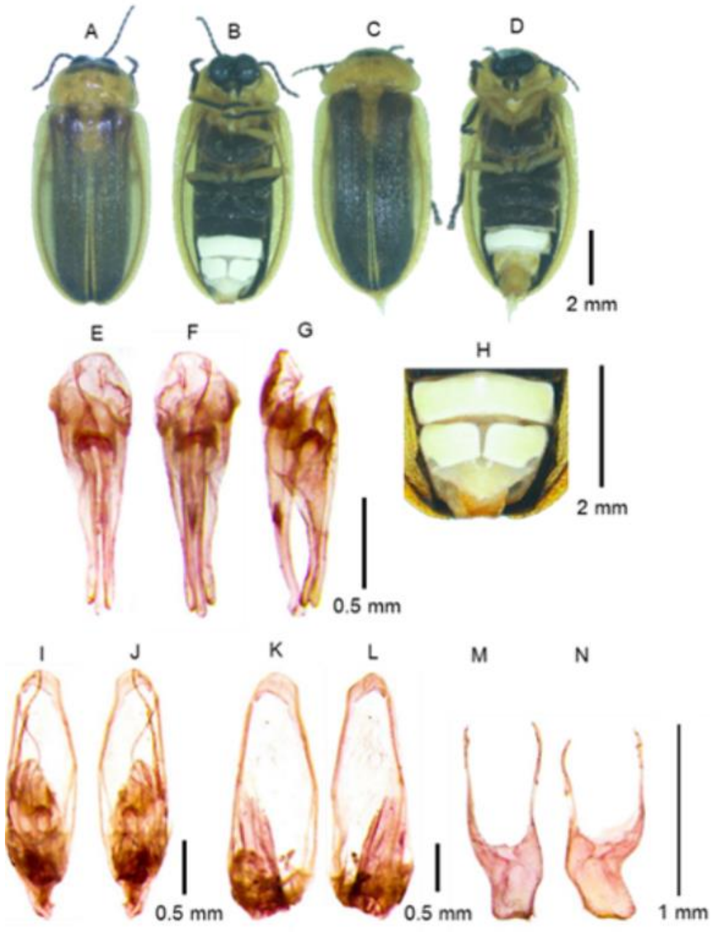

Figure 2. Morphology of *Asymmetricata ovalis* sp. nov. A-D: Dorsal and ventral views of habitus. A, B: A. ovalis male. C, D: A. ovalis female. E-G: aedeagus (E: dorsal, F: ventral, G: lateral). H: abdominal segments V6-V7 showing light organs. I-L: aedeagus (I: dorsal, J: ventral, K: lateral, L: unknown view). M, N: aedeagal sheath (M: ventral, N: lateral). Scale bars: 2 mm for A-D and H; 0.5 mm for E-G and I-L; 1 mm for M-N.

Biophysical information

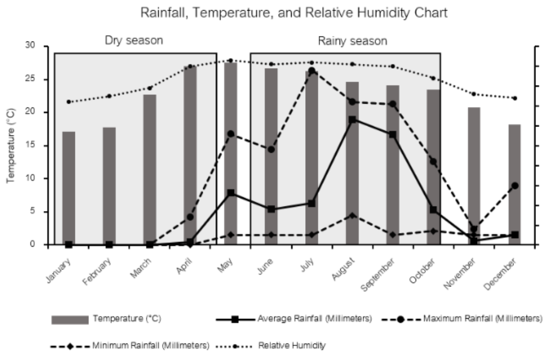

Figure 3. Annual climatic trends with separate dry season (January–May) and rainy season (June–December) periods, displaying monthly temperature (°C), rainfall (mm), and relative humidity (%).

The yearly temperature trend is very stable, with a slight rise in April and May signifying an elevated level of warmth. There is a separate wet season that runs from May to October and is marked by heavy rainfall that peaks in August and September. On the other hand, November through April is the dry season, which is characterized by little precipitation. With higher levels during the wet season and lower levels during the dry season, relative humidity closely reflects changes in rainfall. The dry season, which runs roughly from November to April, and the rainy season, which runs from May to October, are clearly marked on the chart. This graphic gives a comprehensive picture of the local climatic patterns by skillfully illustrating the seasonal dynamics of temperature, precipitation, and relative humidity as shown in Figure 3.

Table 1. Plant Species (Riparian Plant) and Distribution Across the Study Sites

No.	Family	Scientific Name	Site 1	Site 2	Site 3	Site 4	Site 5
1	FABACEAE	*Albizia chinensis*	2				6
2	GRAMINEAE	*Bambusa nutans*				27	
3	FABACEAE	*Bauhinia variegata*	2		6		1
4	PHYLLANTHACEAE	*Bischofia javanica*	2		2		2
5	MORACEAE	*Broussonetia papyrifera*	12				7
6	TILIACEAE	*Colona winitii*		72		21	13
7	EUPHORBIACEAE	*Croton oblongifolius*	8		5	1	
8	SAPINDACEAE	*Dimocarpus longan*			8		2
9	EBENACEAE	*Diospyros castanea*			8		
10	COMBRETACEAE	*erminalia bellirica*	1		5		1
11	MORACEAE	*Ficus hispida*			4		3
12	EUPHORBIACEAE	*Mallotus barbatus*		38			
13	ANACARDIACEAE	*Mangifera caloneura*					5
14	FABACEAE	*Mimosa pigra*					15
15	MUSACEAE	*Musa acuminate*	8			69	66

No.	Family	Scientific Name	Site 1	Site 2	Site 3	Site 4	Site 5
16	BURSERACEAE	*Protium serratum*		49	58	44	23
17	FABACEAE	*Samanea saman*			12		4
18	MIMOSOIDEAE	*Xylia xylocarpa*	3		15		
Total			38	159	123	162	148

Table 2. Plant Species (Shoreline Plants) and Distribution Across the Study Sites

No.	Family	Scientific Name	Site 1	Site 2	Site 3	Site 4	Site 5
1	POACECE	*Axonopus compressus*	66	61			
2	ASTERACEAE	*Bidens pilosa*		67		44	
3	POACEAE	*Bothriochloa ischaemum*		565	239	443	291
4	POACEAE	*Brachiaria mutica*		89		34	
5	ASTERACEAE	*Chromolaena odorata*	81			5	
6	COMMELINACEAE	*Commelina bengalensis*				28	72
7	GRAMINEAE	*Cyrtococcum patens*	78	71		45	26
8	ATHYRIACEAE	*Diplazium esculentum*				45	
9	POACEAE	*Eleusine indica*	54				
10	ARACEAE	*Lasia spinosa*				27	
11	FABACEAE	*Mimosa diplotricha*	36	18	69	32	45
12	FABACEAE	*Mimosa pudica*		49			
13	POLYGONACEAE	*Persicaria hydropiper*	39	4			
14	PIPERACEAE	*Piper sarmentosum*				18	
15	SELAGINELLACEAE	*Selaginella argentea*				3	
16	ASTERACEAE	*Synedrella nodiflora*	32	47			
17	GRAMINEAE	*Thysanoleana maxima*			45		
Total			386	971	353	724	434

Data on 38 plant species from 5 study sites are presented in Table 1 and 2, organized into two primary categories: riparian plants and waterside plants, with comprehensive taxonomic details. The analysis shows that Site 2 boasts the highest plant diversity with 1,130 individuals, followed by Site 4 with 886 individuals, whereas Site 1 has the lowest count at 424 individuals. The original Thai common names are retained in this table, which presents the data in a professional English format that is appropriate for research and analysis.

The vegetation survey reveals a distinct ecological pattern at Station 1. The site demonstrates a strong dominance of shoreline plants, which constitute 91.03% of the total plant coverage. In contrast, riparian plants represent only 8.97% of the vegetation. These two plant groupings differ significantly, according to the data. With *Chromolaena odorata* (Siam weed) leading at around 19% and *Cyrtococcum patens* following closely after at about 18%, shoreline plants exhibit noticeably higher relative density values. *Axonopus compressus* (about 16%), *Eleusine indica* (about 13%), and *Persicaria hydropiper* (about 9%) are other notable beach species. Riparian plants, on the other hand, show significantly lower relative density levels. The remaining riparian plants, such as *Croton oblongifolius*, *Musa acuminata*, *Xylia xylocarpa*, and others, have relative density values below 2%, while the most prevalent riparian species, *Broussonetia papyrifera*, only reaches roughly 3%. The biological dominance of shoreline plants in this specific habitat is evident from the visualization, which also suggests that these plants are more suited to the study area's environmental circumstances than riparian species. This information may help guide conservation and management plans for these areas and provide insightful information about the composition of the plant community as shown in Figure 4.

The analysis of site features and the grouping of biotic and physical elements are depicted in Figure 5. The study areas are separated into three major groups according to different ecological characteristics, using Principal Component Analysis (PCA) with PC-ORD version 5.10 software. Site Classifications and Environmental Elements. Specialized Environmental Group (Sites 2 and 4): These areas exhibit low conductivity, water temperature, and total dissolved solids (TDS), making them suitable for specialized plants like *Bambusa nutans*, *Colona winitii*, and *Mallotus barbatus*, which are effective at absorbing minerals and water. Moderate Environmental Group (Site 1): This site shows a balanced range of environmental parameters, including ideal pH and humidity. This balance supports a wide variety of species, such as *Musa acuminata* and *Broussonetia papyrifera*, reflecting the region's biological equilibrium. High Mineral Content Environmental Group (Sites 3 and 5): These areas have high water temperatures and mineral content. Site 5 is dominated by *Mangifera caloneura and Mimosa pigra*, while Site 3 is characterized by *Diospyros castanea* and *Xylia xylocarpa*. The analysis also highlighted that physical water characteristics (TDS, conductivity, and water temperature) are the most crucial factors influencing plant species distribution. While pH and humidity have a minor impact, especially on Site 1, these parameters are highly interconnected and have the greatest effect on Site 3.

Distribution Patterns of Plant Species

The study identified three categories of plant species distribution patterns. Generalist Species: Located at the center of the PCA plot, these species including *Albizia chinensis*, *Bischofia javanica*, *Broussonetia papyrifera*, *Croton oblongifolius*, *Ficus hispida*, *Musa acuminata*, and *Protium serratum* can adapt to a range of conditions. Locally Adapted Species: These species are confined to specific areas. For example, *Mangifera caloneura* and *Mimosa pigra* are primarily found in Site 5, whereas *Diospyros castanea* and *Xylia xylocarpa* are exclusive to Site 3. Water-Specialized Species: Found near Sites 2 and 4, these species such as *Bambusa nutans*, *Colona winitii*, and *Mallotus barbatus* show a preference for particular aquatic environments.

Figure 7 shows a Principal Component Analysis (PCA) of 17 riparian plant species from five study sites. This analysis finds intriguing correlations between plant species, environmental conditions, and the study area classification. Overall, the data show that riparian plants have unique adaptations to changing environmental conditions, as evidenced by an analysis of site groups and associated environmental parameters. Site 1 is distinguished by its unique environmental circumstances, including *Eleusine indica* and *Chromolaena odorata* as dominating species. Site 2 stands out from other areas due to the presence of *Bidens pilosa*. High humidity and pH levels at Site 3 favor *Thysanoleana maximum* and a diverse plant community. TDS, conductivity, and water temperature (TempW) all have a significant impact on Site 4. These highly connected characteristics promote the dominance of species such as *Synedrella nodiflora*, *Diplazium esculentum*, and *Piper sarmentosum*. Site 5 has moderate environmental conditions and hosts a varied range of species, including *Commelina bengalensis*.

Plant Species Distribution

The analysis divides plant species into two major categories. Generalist species: These are *Axonopus compressus*, *Cyrtococcum patens*, and *Mimosa diplotricha*. Their extensive dispersion on the PCA plot demonstrates their resilience to a variety of environmental circumstances. Specialist/Locally Adapted Species: Found only in specified locations. *Eleusine indica* and *Chromolaena odorata*, for example, are restricted to Site 1; *Bidens pilosa* to Site 2; *Thysanoleana maximum* to Site 3 (which prefers high humidity and pH); and *Synedrella nodiflora*, *Diplazium esculentum*, and *Piper sarmentosum* to Site 4 (which prefers mineral-rich water).

The Function of Environmental Factors in Riparian Ecosystems

This study emphasizes the importance of water salinity (TDS, Conductivity) and temperature in differentiating riparian plant groups. Simultaneously, humidity and pH levels have a substantial impact on the species composition of any riparian habitat. These findings are extremely helpful for future research and conservation of riparian habitats.

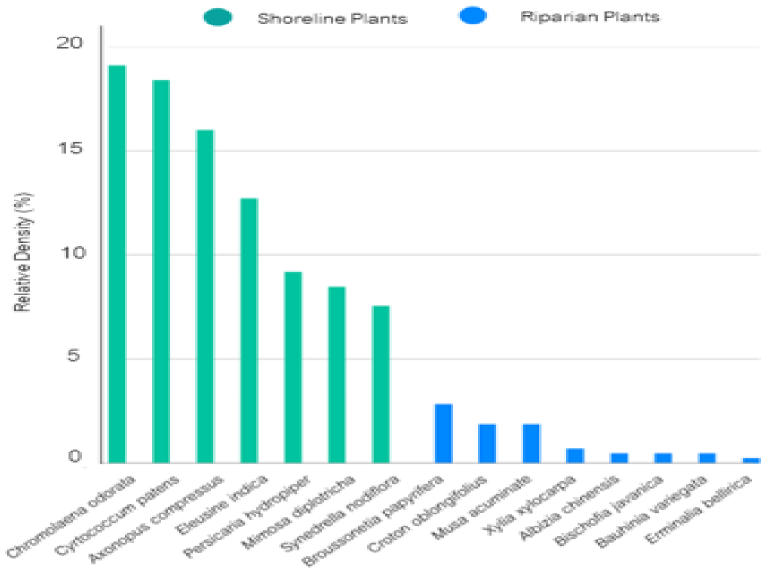

Figure 4. shows the relative density (%) of coastal plants (teal bars) and riparian plants (blue bars) across different plant species, demonstrating that shoreline vegetation is more diverse and abundant than riparian vegetation.

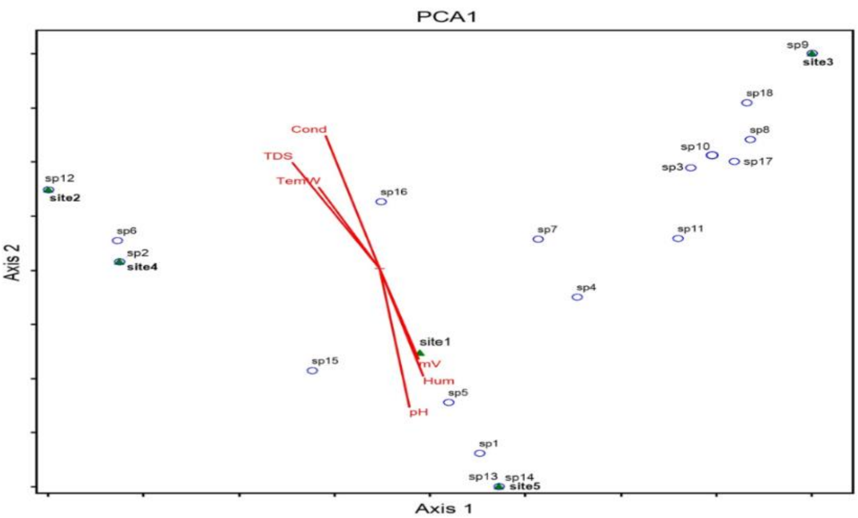

Figure 5. shows a Principal Component Analysis (PCA) biplot of the relationship between riparian plant species (sp1-sp18), sample sites (site1-site5), and environmental parameters (Cond: conductivity, TDS: total dissolved solids, TemW: water temperature, Hum: humidity, pH: pH, mV: millivolt).

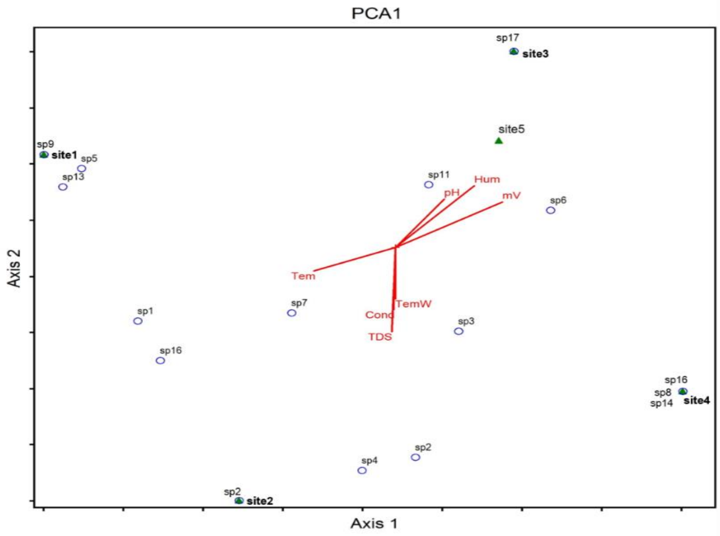

Figure 6. shows a Principal Component Analysis (PCA) biplot of the relationship between Shoreline Plant Species (sp1-sp17), sampling sites (site1-site5), and environmental parameters (Cond: conductivity, TDS: total dissolved solids, Teems: water temperature, Hum: humidity, pH: pH, mV: millivolt).

DISCUSSION AND CONCLUSION

The habitat of Asymmetricity ovalis in Phayao Province is predominantly characterized by shoreline vegetation, which appears to play a critical role in sustaining local firefly populations. The dominant plant species observed in this habitat include Chromanone odorata (19.10%), Cryptococcus patens (18.40%), and Axon opus compresses (15.57%), collectively accounting for over 53% of the total vegetation cover. This high proportion of shoreline vegetation likely reflects the presence of distinct ecological conditions—such as periodic disturbance regimes, unique edaphic factors, and localized moisture availability—that preferentially support shoreline flora over riparian plant communities.

Vegetation structure is closely linked to firefly reproductive ecology, particularly in relation to bioluminescent courtship signaling. The efficiency of such signaling is influenced by vegetation height and density, which directly affect visual communication and mating success (Viviani & Bechara, 1997). Dense shoreline vegetation provides critical microhabitats, including perching sites for males and oviposition substrates for females. Additionally, these habitats serve as refugia for larval development and buffers against environmental stressors.

The observed association between A. ovalis and vegetated areas adjacent to water sources is consistent with previous studies that emphasize the importance of specific vegetative structures coupled with favorable environmental conditions for sustaining firefly populations (Wong & Yeap, 2012). Herbaceous and shrubby vegetation, in particular, enhance larval development and prey availability, thereby contributing to population persistence and stability (Ohba & Sim, 1994).

With respect to elevational distribution, A. ovalis appears to prefer mid-elevation forest zones (approximately 200–1,200 m a.s.l.), which offer moderate temperatures, elevated humidity, and reduced anthropogenic disturbance. This pattern aligns with the findings of Wattanachaiyingcharoen et al. (2016), who reported that lower montane rainforests within similar elevation ranges (700–1,900 m) support the greatest diversity and abundance of firefly species in northern Thailand. These data suggest that A. ovalis is ecologically adapted to cooler, humid, and structurally complex environments that provide essential resources such as food, shelter, and mating opportunities.

Several abiotic and biotic factors have been identified as key determinants of firefly aggregation and persistence, including proximity to aquatic habitats, canopy stratification, and the presence of sap-producing trees (Chey, 2004; Jusoh et al., 2010a, 2010b). The present study reinforces these findings, demonstrating that well-structured shoreline vegetation adjacent to water bodies supports critical microhabitats for firefly reproduction and population maintenance.

This study documents the first confirmed occurrence of *Asymmetricata ovalis* in Phayao Province, thereby filling a notable biogeographical gap in the known distribution of this species across northern Thailand. Previous surveys in adjacent provinces had reported the species' presence, but the absence of records in Phayao had left a discontinuity in its range. The confirmation of A. ovalis in this location not only extends its distributional boundaries but also highlights the underexplored biodiversity of transitional forest zones in this region.

From a conservation perspective, these findings underscore the ecological importance of mixed deciduous forests and shoreline vegetation as essential habitats for fireflies. They also suggest that fragmented or semi-natural forest patches, when located near water bodies and containing specific vegetation structures, may serve as viable refuges for sensitive insect taxa. Protecting these habitats is crucial, particularly in light of ongoing threats such as land-use change, agricultural expansion, and light pollution. A more comprehensive understanding of firefly ecology, including their habitat preferences and distribution patterns, is necessary to inform conservation planning, ecosystem restoration, and biodiversity monitoring programs in northern Thailand and beyond.

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