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TARGETED SURVEY AND REDISCOVERY EFFORT OF *Papilio lampsacus*, JAVAN ENDEMIC AND ENDANGERED BUTTERFLY SPECIES

Djunijanti Peggie*[1,2], Imti Yazil Wafa[1], Nabila Rahma[1], Lutfi Irwansyah[1], Fariq Izzudien Ash Shidiq[1,3], Yohanes Agus Soenarko[1], Teguh Burhan[4], and Abdul Mutholib Shahroni[1,5]

[1]Kupunesia team, Malang, East Java, Indonesia
[2]Research Center for Biosystematics and Evolution, National Research and Innovation Agency (BRIN), Jl. Raya Jakarta - Bogor Km. 46, Cibinong, Bogor 16911, West Java, Indonesia
[3]Tropical Biodiversity Conservation Study Program, Faculty of Forestry and Environment, IPB University, IPB Darmaga Campus, Bogor 16680, West Java, Indonesia,
[4]Kupunesia affiliate, Demak, Central Java, Indonesia
[5]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Brawijaya, Malang 65145, East Java, Indonesia

*Corresponding author: kupu2indonesia@gmail.com

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ABSTRACT

Based on historical records and current data, this study examined the presence of *Papilio lampsacus*, a rare butterfly species in Java. From January to May 2024, four surveys were conducted at multiple sites in the Greater Bandung region of West Java in effort to rediscover the species. The natural forest edges and nearby agricultural landscape, where possible host and nectar plants are present, may indicate the possibility of finding the species. Despite repeated surveys under various weather conditions, no photographic evidence of *P. lampsacus* was obtained. However, brief visual encounters were recorded that were consistent with the species' appearance and flight patterns. Habitat assessments indicate the adverse effects of ongoing forest degradation and intensive pesticide use in agricultural areas adjacent to natural forests on butterflies. This study does not provide conclusive evidence confirming the existence of *P. lampsacus*. This highlights the importance of targeted long-term surveys, combined with well-managed habitats. These findings may serve as a basis to improve future monitoring approaches and conservation efforts for *P. lampsacus* and other rare butterflies.

Key words: Indonesia, Papilionidae, rare, records, threatened status

INTRODUCTION

Indonesia has many rare and endemic butterfly species. One of them, *Papilio lampsacus*, a very rare Javan endemic butterfly species, has long been considered probably extinct. Only three specimens of this species are being deposited at the Museum Zoologicum Bogoriense, i.e., 1 male individual collected in April 1920 in Pengalengan; 1 female individual on 3 January 1934 in Cibodas, 1100 m asl.; and 1 male individual in February 1937 in Situ Lembang, 1500 m asl. Data on Global Biodiversity Information Facility (GBIF) shows that no more than 60 specimens of *P. lampsacus* are deposited in several museums in the world, including at the Museum of Comparative Zoology, Harvard University, United States; Naturalis Biodiversity Center, Leiden, Netherlands; Denver Museum of Nature and Science, United States; and the

Museum of Natural and Environmental History, Shizuoka, Japan, with collections ranging from the year 1892 to 1937. A specimen of this species was collected in 1979 (Tsukada & Nishiyama, 1982), but it was not deposited at MZB. Since 1979, 45 years ago, there has been no encounter reported for this species. The IUCN Red List classifies this species as endangered (EN) due to habitat loss and commercialization by collectors (Rushbrook et al., 2020).

Currently, there is very limited published information on the ecology, habitat preferences, and larval host plants of *P. lampsacus*. Its distribution has been identified in forest habitats on Mt. Mas and Mt. Gede Pangrango in West Java, Indonesia (Tsukada & Nishiyama, 1982). More hill shades and valleys with river streams on both mountains can become habitats for *P. lampsacus*. The closely related species *Papilio acheron* from Borneo and *Papilio forbesi* from Sumatra share similar habitats, particularly along river streams in highland forests (Tsukada & Nishiyama, 1982). The reference for the *P. lampsacus* larval host plant states that there are currently no updated records.

On January 22, 2024, a photographic record was submitted to iNaturalist featuring this species, taken in April 2014. The photograph was identified as a female *P. lampsacus*, resting on a fern. To follow up on the rediscovery, a survey is required to track the species and obtain new evidence that it still exists. Efforts were made to track the population in the vicinity of an "undisclosed location" to confirm the occurrence of the species. Furthermore, habitat assessments were conducted upon rediscovery of 2014 to identify habitat preferences.

MATERIALS AND METHODS

Observation points in Greater Bandung, West Java, Indonesia, were selected to monitor the possible occurrence of this species. These observation points were considered potential locations (Fig. 1), referring to information from the photo contributor who uploaded a photo of the species to iNaturalist (Fig. 2). To avoid irresponsible collection by traders, the exact localities are not mentioned here.

An exploratory survey method was implemented to cover most potential areas (Fig. 3) and increase the probability of finding target species. In addition to observing adult individuals, observations included searching for possible host plants and the early stages of the butterfly. Observations were conducted when the weather conditions met acceptable criteria, such as the absence of rain and high wind speeds (follow van Swaay et al., 2008). Notes on the occurrence of other butterfly species were also made, with a primary focus on *P. lampsacus*.

Personnel were divided into small groups of 1-2 persons to maximize surveillance at the selected sites. Small groups conducted daily observations from morning until afternoon, adjusting for weather conditions. Observations were conducted in areas bordering natural forests and around plantations, such as citrus and tea (Fig. 3). Surveys were conducted four times: (1) the first survey from January 30 to February 6, 2024, around an "undisclosed location"; (2) the second survey from February 26 to March 2, 2024, at the same location plus several other potential points; (3) the third survey from March 13-19, 2024, at the same location with the addition of two observation points and one exploration point; and (4) the fourth survey from May 20-24, 2024, at the same location with limited personnel to suffice the remaining research fund.

This selected survey period covers the earliest available records of specimen collection information in GBIF (GBIF, 2023) and from Tsukada & Nishiyama (1982). The species might be more readily detected early in the year, between January and May. We also considered that this targeted survey should be conducted soon after the photo record.

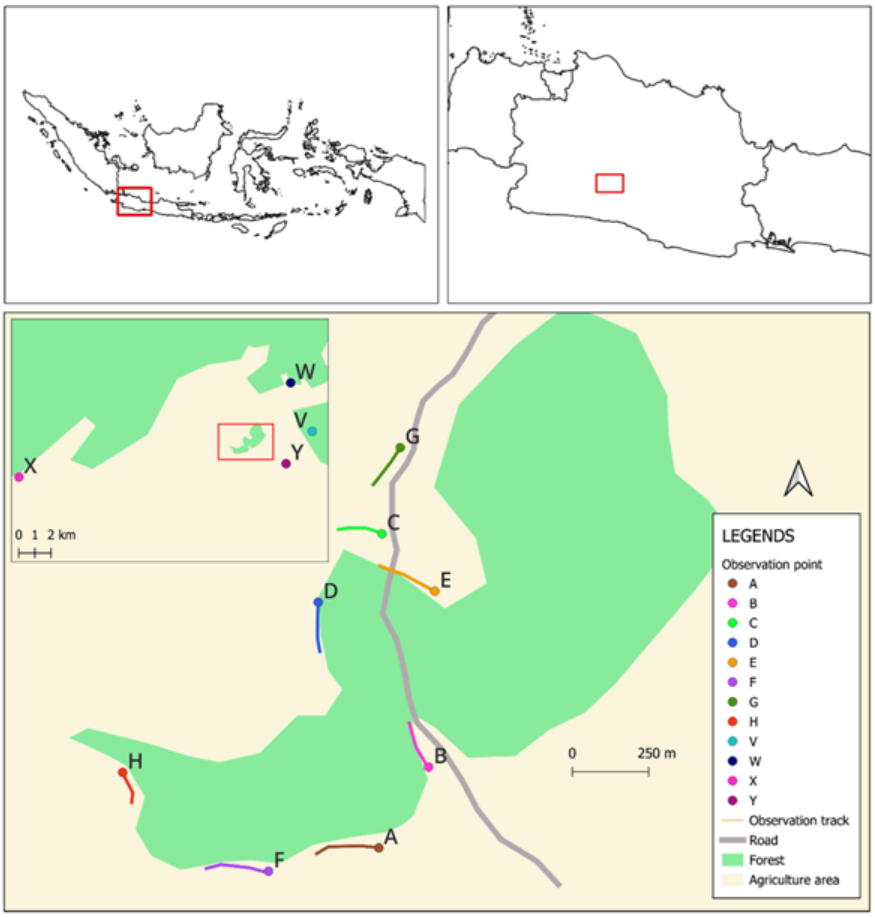

Figure 1. Main observation points (A-H) and additional observation points (V, W, X, Y) used in the surveys.

Figure 2. The rediscovery of female *P. lampsacus* was recorded in 2014 by Fachry Nur Mallo.

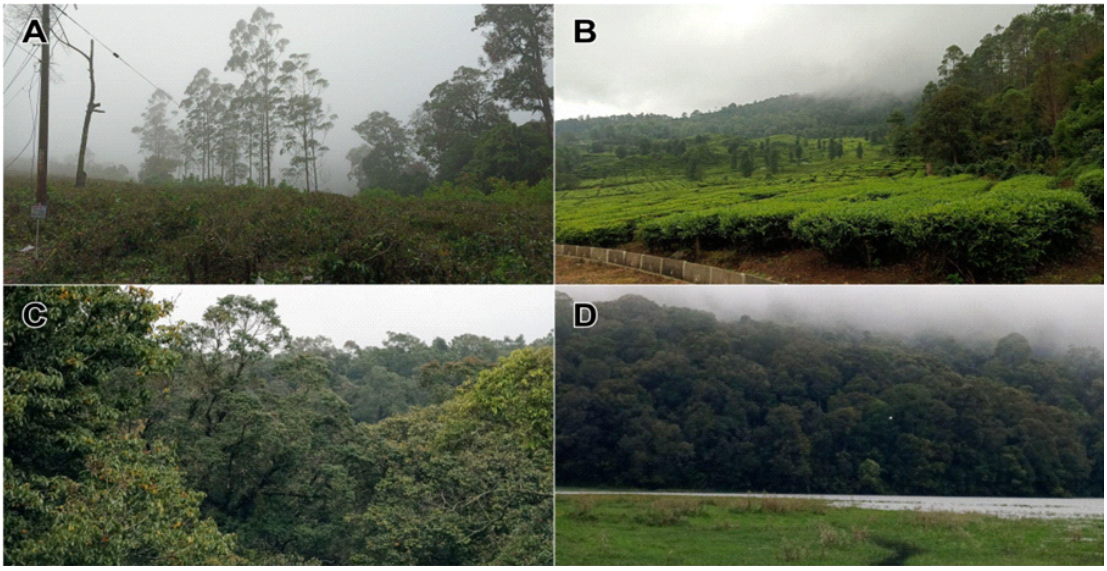

Figure 3. Several potential habitat types for observing the presence of *P. lampsacus* include citrus plantation (A), tea plantation (B), highland natural forest edge (C), and forest edge near the lake (D).

RESULTS

Four surveys were conducted to follow up on the *P. lampsacus* photo record taken in April 2014. A total of 12 sites were surveyed to cover all areas, prioritizing potential habitats for the survey. The potential habitats included citrus and tea plantations near the forest and at the forest edge in the highland primary forest.

In the first survey, two visual encounters provided preliminary indications of the presence of *P. lampsacus*, although these have not yet been verified with photographs. Other species, such as *Troides cuneifera*, a protected species in Indonesia, *Mycalesis sudra,* and *Delias momea,* an endemic species on Java, were also observed. In addition, *Atrophaneura priapus*, a potential mimicry model of the target species, was observed.

Important vegetation identified as potential host plants included *Citrus* sp., *Toddalia* sp., and *Zanthoxylum* sp., while potential nectar plants included *Impatiens* sp., *Begonia* sp., *Lantana camara*, and *Mussaenda* sp. The primary obstacle during this initial survey was poor weather, which was mostly cloudy and drizzly. In addition, signs of intensive pesticide use on plantations near forest edges were frequently observed.

During the second survey, the observers noted two encounters with suspected *P. lampsacus* on two separate occasions. However, these were not successfully documented with photographs. The team could distinguish it from *A. priapus* based on the different flight patterns. However, the suspected individual flew away quickly and entered the forest, making it very challenging to observe them again. Most butterfly activities were quite low because of rainy weather conditions accompanied by fog. Other species, such as *T. cuneifera* and *Papilio memnon*, were also observed in this survey.

In the third survey, more potential observation locations were added to the survey. During the third survey period, the weather was still not conducive to observation activities because of cloudy, foggy, rainy, and strong winds almost every day. There was no indication of the target species, but other butterflies were found and *Zanthoxylum cf. scandens* was detected as a potential host plant.

The fourth survey was conducted in the early dry season, hoping that the weather conditions would be more stable. However, there was still no strong indication of the target species being present. Butterfly activity was higher than that in the previous three surveys, with several important species, such as *T. cuneifera* and *A. priapus,* still being monitored.

DISCUSSION

Papilio lampsacus Tracking

P. lampsacus photo record was taken 10 years prior to the submitted entry to iNaturalist, sparking excitement among butterfly enthusiasts. The primary team handling the Kupunesia App was quick to respond to the need to track down the occurrence of the species and secured the information. Indeed, the team needed to act quickly before commercial insect dealers and foreign butterfly enthusiasts came to look for them as well. The person who submitted the photo was contacted immediately, and agreed that it is in the best interest of the species that we keep the locality information unknown to the general public.

The survey results indicated several visual encounters with individuals suspected to be *P. lampsacus*. The target species were recorded four times, twice in the first survey and twice in

the second survey. Although these observations were not supported by photographic evidence, these notes remain important. The recent photographic evidence from 2014 and these encounters, although unfortunately could not be documented, still gives a hopeful expectation that the species may still survive in its habitat.

The challenges in documenting this species are due to its rapid flight pattern, infrequent resting, and unfavorable environmental conditions. This is consistent with previous reports that this species is difficult to observe directly in the wild. Fast-flying butterflies pose particular difficulties, as observers often only catch brief glimpses of fast flyers, lasting just milliseconds, which reduces the accuracy of their identification and verification (Taron & Ries, 2015). *P. lampsacus* is likely a fast-moving butterfly species which uses vertical habitats such as canopies or cliffs that are beyond the reach of normal observers. The flight behavior of such species makes it hard and almost impossible to detect them (Freitas et al., 2021). Combined methods using active and passive sampling can be applied to complement each other and may increase the potential for detecting target species (Vann, 2008).

Weather conditions during the surveys were generally not conducive. Rapidly changing mountain weather conditions were indeed challenging. Despite the weather, observations were conducted every day during the surveys. The weather conditions in the 4th survey were relatively better than in the 3rd survey. Our main focus is on monitoring the presence of *P. lampsacus*, which unfortunately was not detected in this 4th survey. As in previous surveys, we continued to record the presence of other butterfly species to indicate the activity of other butterflies. Butterflies tend to have longer flight durations and wider dispersal ranges when temperatures increase, compared to when the weather is cloudy (Cormont et al., 2011), with high rainfall and strong wind (Kuussaari et al., 2016).

The presence of *A. priapus* in the same habitat is thought to play a role as a mimicry model. The morphology of *P. lampsacus* is similar to that of *A. priapus*. This strategy is a form of Batesian mimicry, which causes this species to evolve warning signals to predators. Similar to its closest species in the *memnon* group, the female of *Papilio forbesi* mimics *Atrophaneura hageni* in northern Sumatra (Collins & Morris, 1985). In the same family Papilionidae, females of *Papilio polytes* also mimic *Pachliopta aristolochiae* to develop an unpalatable strategy (Iijima et al., 2019; Komata et al., 2020). This mimicry aims to enhance the anti-predatory survival strategy by mimicking the Aristolochiaceae feeder (Sekimura et al., 2017). However, the similar appearances between *P. lampsacus* and *A. priapus* make it challenging for observers to distinguish and visually identify them when they are flying fast.

Habitat Condition and Anthropogenic Pressure

The areas surveyed have undergone quite a change when comparing conditions in 2014 with conditions in 2024. Forest cover in the distribution area of *P. lampsacus* has gradually degraded, such as the forests on the slopes of Mount Gede Pangrango (Hansen et al., 2013). This might negatively impact the range and availability of food and host plants in the area. The use of pesticides in plantation areas bordering the forests may affect the survival of this species. During the surveys, pesticides were sprayed quite heavily within the agricultural areas neighboring the forest (Fig, 4). Therefore, *P. lampsacus* and other butterflies may be distracted due to the presence of insecticides, which are frequently applied by farmers. In fact, insecticides can affect the development and reproduction as well as the metabolism, physiology, and behavior of butterflies as non-target insects (Braak et al., 2018).

With the short life cycle of butterflies in the tropics, it is of course necessary to carry out regular observations, so that we can obtain accurate data, especially regarding this rare and thought to be extinct species that was documented 10 years ago. Subsequent surveys need to be conducted to ensure that the coverage in terms of temporal and spatial distribution will be sufficient before any conclusion can be drawn as to the status of the species. Further surveys are needed in the recorded areas and other possible locations where specimens were deposited in museums.

Figure 4. Preparations for pesticide spraying by farmers in gardens near natural forests.

Ecology and Implications for Future Surveys

There is no specific information in scientific literature indicating the use of host plant species by *P. lampsacus*. However, as with other members of the genus *Papilio*, *P. lampsacus* likely primarily uses host plants from the Rutaceae family (Murata et al., 2011). Based on the survey, the presence of potential host plants from the Rutaceae family (*Citrus*, *Toddalia*, and

Zanthoxylum) in their habitat could attract them. Citrus plants are used as host plants by *Papilio memnon* (Zulnawati et al., 2018), *Toddalia asiatica* is used by *P. polytes* (Murakami et al., 2003), and *Zanthoxylum* is commonly used by swallowtails. Moreover, Citrus plantations in the area can serve as host plants. However, it is yet to be discovered whether *Papilio* spp. prefer to use natural host plants found in forests or at forest edges.

Nectar plant observations were also recorded to expand the detection of the target species. *Impatiens* spp., *Begonia* spp., *Lantana camara*, and *Mussaenda* sp. were identified as nectar sources in the habitat. Additionally, some flowering trees provide nectars for canopy-visiting butterflies, as observed for *T. cuneifera*. Notes from observations of *P. forbesi* in Sumatra indicated that individuals were observed sucking nectar from *Mussaenda* plants while flying along rivers (Tsukada & Nishiyama, 1982). In addition, the flowers of coffee plants in coffee plantations attract butterflies to feed on nectar. Rubiaceae, Verbenaceae, Apocynaceae, Asteraceae, and Malvaceae are a group of nectar source plants that the swallowtails mostly use. This selection can be based on the long shape of the funnel, wide petals, and high nectar content to suit the needs of this group of butterflies. Furthermore, the visual coloration and olfactory attributes of each flower type also affect nectar preferences (Yoshida et al., 2015). This important factor should be considered during observations by focusing on nectar plant preferences that are likely to be visited.

Overall, this study indicates that *P. lampsacus* might still exist. However, its presence could not be definitively verified, and any existing population is probably very small and susceptible to environmental threats and disturbances. Therefore, efforts to conserve natural forest habitats and manage pesticide-free buffer zones are crucial in this regard. Other research employing various methods, such as passive sampling, extended surveys across wet and dry seasons, and monitoring at the early stages (eggs and larvae) on host plants, is strongly recommended to obtain more definitive evidence of the species' presence.

Further investigation of this species should be expanded to include riverine habitats within the forest, as this species may fly along rivers or streams, as indicated by Tsukada & Nishiyama (1982). It is important to include some other areas of its historical range in Java to rediscover this species.

CONCLUSION

Targeted surveys in potential habitats of *P. lampsacus* found unverified encounters but no photographic evidence of the species current presence. This suggests standard survey methods

may not effectively detect fast-flying butterflies. Ongoing habitat loss and pesticide use near forests may further reduce suitable habitats. To assess *P. lampsacus* conservation status, long-term surveys with improved monitoring, focusing on host plants and river areas, are essential.

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