Morphological Variation of Idea blanchardii (Lepidoptera: Nymphalidae) in the Palaes Ecotourism Area and Gunung Tumpa Grand Forest Park, North Sulawesi

Denny Christian Putra Setiawan

Department of Biology, Faculty of Mathematics and Natural Sciences, Sam Ratulangi University. Jl Kampus Unsrat Bahu- Manado 95115, North Sulawesi, Indonesia

Received: June 23, 2026
Revised: June 30, 2026
Accepted: July 01, 2026
Published: July 01, 2026

Corresponding Author:
Denny Christian Putra Setiawan
dennysetiawan102@student.unsrat.ac.id

Abstract: *Idea blanchardii* (Lepidoptera: Nymphalidae) is an endemic butterfly of Sulawesi inhabiting tropical forest ecosystems from lowland to montane zones. This study aimed to analyze the morphological variation of *I. blanchardii* between populations in the Ecotourism Area of Palaes Village (92–121 m asl) and Gunung Tumpa Grand Forest Park (383–391 m asl), North Sulawesi. A total of 12 specimens were used, consisting of 3 males and 3 females from each location. Thirty-five morphometric characters were measured, comprising 12 body morphology characters, 13 forewing venation characters, and 10 hindwing venation characters. Data were analyzed using descriptive statistics, independent sample t-test, Ward's method cluster analysis, and Principal Component Analysis (PCA) using SPSS version 16.0. The independent sample t-test revealed that in male individuals, 3 out of 35 characters (8.6%) differed significantly between populations, namely the forewing subcosta (Sca), forewing media 2 (M2a), and forewing media 3 (M3a). In female individuals, 8 out of 35 characters (22.9%) showed significant differences, including forewing length (PSD), mid-leg length (PKk2), forewing cubitus anterior 1 (CuA1a), forewing cubitus anterior 2 (CuA2a), forewing anal veins 1 (A1a), forewing anal veins 2 (A2a), hindwing cubitus anterior 2 (CuA2b), and hindwing anal veins 1 (A1b). Cluster analysis showed that male individuals from both locations were intermixed without a clear geographical pattern, whereas female individuals formed completely separate clusters based on location. PCA results supported these findings, where female individuals from Gunung Tumpa generally exhibited higher PC1 values compared to those from Palaes, although overlap between the two populations was still observed. Overall, 91.4% of male characters and 77.1% of female characters showed no significant differences, indicating that environmental differences between the two locations — including elevation, temperature, light intensity, humidity, and wind speed — have not yet resulted in strong morphological differentiation in *I. blanchardii.*

Keywords: *Idea blanchardii; morphometrics; morphological variation; Nymphalidae, North Sulawesi*

Introduction

Intraspecific morphological variation is often associated with geographical differences among habitats, as spatially separated populations may respond differently to local environmental pressures, resource availability, and selective forces (Herdiana et al., 2018). Butterflies (Lepidoptera) are ecologically significant as pollinators and environmental bioindicators, and their morphology is strongly influenced by genetic factors and environmental conditions including temperature, humidity, and altitude (Peggie, 2014; Leksono et al., 2025). Morphometric analysis provides a quantitative framework for examining such variation in body shape and size (Zahara et al., 2022).

Idea blanchardii (Nymphalidae: Danainae) is a large, endemic butterfly of Sulawesi characterized by transparent wings with black patterning and a slow gliding flight (Peggie &

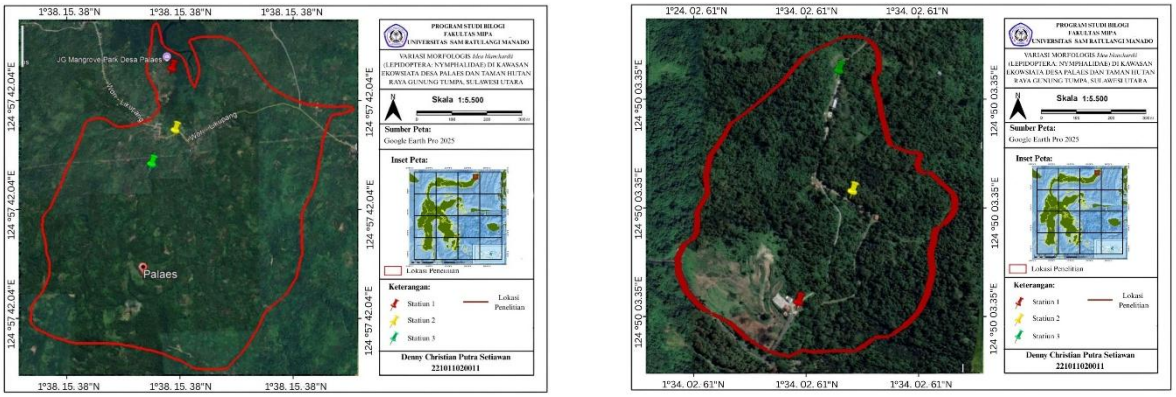
Supadi, 2020). First described by Marchal (1845) from specimens collected in Minahasa and Manado, North Sulawesi, this species holds strategic value for biogeographical and conservation research in the Wallacea region (Vane-Wright & de Jong, 2003; Peggie & Supadi, 2024). Prior studies have documented habitat-associated morphometric variation in butterflies; Bai et al. (2015) reported significant wing size differences in *Pieris rapae* between mountain and lowland populations, while Primadalvi (2009) found smaller body sizes in *Papilio polytes* from isolated island populations.

The Ecotourism Area of Palaes Village (92–121 m asl) represents a coastal lowland ecosystem with high temperatures and open vegetation, while Gunung Tumpa Grand Forest Park (383–391 m asl) reflects a montane forest environment with lower temperatures and dense canopy cover (Desa Wisata Palaes, 2024; Wowor et al., 2014). These contrasting conditions provide an opportunity to examine whether habitat differences drive morphological variation in *I. blanchardii* (Nijhout, 2001; Forister et al., 2016). Despite the ecological significance of this endemic species, morphometric studies of *I. blanchardii* remain extremely limited. This study therefore aims to analyze morphological variation between populations from these two ecologically distinct sites and contribute to the understanding of Wallacean biogeography and endemic species conservation.

Methods

Time and Location

This study was conducted from September to December 2025 at two locations: the Ecotourism Area of Palaes Village and Gunung Tumpa Grand Forest Park, North Sulawesi (**Figure 1**).



(a)Map of the Palaes Ecotourism Area (b) Map of Gunung Tumpa Grand Forest Park

Figure 1. Research location

Tools and Materials

The equipment and materials used in this study consisted of an insect net for capturing butterflies in the field, a Garmin 73 GPS for determining geographical coordinates and elevation of each sampling location, and a Canon EOS 90D digital camera for documenting specimens. Environmental parameters were measured using an LM-8010 thermo-hygrometer to record temperature, humidity, light intensity, and wind speed. Morphometric measurements were performed using a digital vernier caliper with a resolution of 0.1 mm. For specimen preservation, 70% alcohol was applied via syringe and specimens were stored in plastic containers. Supporting materials included label paper for specimen labeling, cotton as a medium for ethyl acetate during narcotization, and stationery for recording field data.

Study Site and Sampling

This study was conducted from September to December 2025 at two locations in North Sulawesi: the Ecotourism Area of Palaes Village and Gunung Tumpa Grand Forest Park. At each location, a 300-meter transect was established using purposive sampling based on habitat representativeness and the confirmed presence of *I. blanchardii*, with positions determined using Google Earth Pro version 7.3.6.10201. Sampling was conducted between 08:00–15:00 WITA (Peggie & Amir, 2006) using the sweeping technique with an insect net. Only individuals with intact and undamaged morphology were retained. Selected specimens were killed by thoracic compression, injected with 70% alcohol, and stored in labeled papilot envelopes (Schmidt et al., 2019). Sampling was conducted weekly for three consecutive weeks, yielding 12 specimens in total (6 per location; 3 males and 3 females each).

Morphometric Analysis

Specimens were analyzed morphometrically using a digital vernier caliper (resolution: 0.1 mm). Twelve body morphology characters were measured as listed in **Table 1**.

Table 1. Morphometric characters measured in this study.

No.	Character	Description	Abbreviation
1.	Forewing Length	Distance from wing base to apex	FWL
2.	Hindwing Length	Distance from wing base to hindwing tip	HWL
3.	Forewing Width	Distance between forewing tips in spread position	FWW
4.	Hindwing Width	Distance between hindwing tips in spread position	HWW
5.	Head Length	Distance from head tip to head-thorax boundary	HL
6.	Thorax Length	Distance from head-thorax to thorax-abdomen boundary	TL
7.	Abdomen Length	Distance from thorax-abdomen boundary to abdomen tip	AL
8.	Antenna Length	Total antenna length	AnL
9.	Eye Span	Distance between compound eyes	ES
10.	Foreleg Length	Sum of femur, tibia, tarsus, and claw of foreleg	FL1
11.	Midleg Length	Sum of femur, tibia, tarsus, and claw of midleg	FL2
12.	Hindleg Length	Sum of femur, tibia, tarsus, and claw of hindleg	FL3

Statistical Analysis

Data normality and variance homogeneity were assessed using the Shapiro–Wilk test and Levene's Test, respectively (Shapiro & Wilk, 1965; Levene, 1960). An independent sample t-test was applied to compare morphological characters between populations, with the Mann-Whitney U test used where normality assumptions were not met (Gomez & Gomez, 1984; Walpole, 1995). Analyses were conducted separately by sex to control for sexual dimorphism (Boggs, 2009; Scoble, 1995) at a significance level of $\alpha = 0.05$. All analyses were performed using SPSS version 16.0.

Results and Discussion

Morphological Variation

The independent sample t-test revealed that 11 of 12 body morphology characters in males and 10 of 12 characters in females showed no significant differences between populations ($p > 0.05$; **Table 2**). In males, none of the 12 characters differed significantly. In females,

forewing length (FWL) and mid-leg length (FL2) showed significant differences between populations ($p < 0.05$).

Table 2. Results of independent sample t-test for body morphology characters of *I. blanchardii*.

No.	Character	Code	Male (♂)	Female (♀)
1.	Forewing Length	FWL	–	√
2.	Hindwing Length	HWL	–	–
3.	Forewing Width	FWW	–	–
4.	Hindwing Width	HWW	–	–
5.	Head Length	HL	–	–
6.	Thorax Length	TL	–	–
7.	Abdomen Length	AL	–	–
8.	Antenna Length	AnL	–	–
9.	Eye Span	ES	–	–
10.	Foreleg Length	FL1	–	–
11.	Midleg Length	FL2	–	√
12.	Hindleg Length	FL3	–	–

Note: (√) significant difference; (–) non-significant; (♂) male; (♀) female

The high proportion of non-significant characters indicates that habitat differences between the two locations have not produced strong morphological differentiation in *I. blanchardii*. Characters including thorax length, abdomen length, head length, and leg length were largely similar across populations, suggesting that individuals from both sites develop within comparable morphological ranges despite inhabiting ecologically distinct environments. The significant differences observed in FWL and FL2 in females may reflect the greater morphological sensitivity of females to local environmental conditions. In Lepidoptera, females allocate greater energy toward reproduction, rendering their morphological development more responsive to environmental variation during the growth phase (Boggs, 2009). Forewing length is associated with flight performance and energetic demands during oviposition site selection (Berwaerts et al., 2002), while mid-leg length may reflect microhabitat use differences between structurally distinct vegetation types (Leksono et al., 2025). In contrast, male morphology remained uniform across populations, consistent with the higher dispersal capacity of male Lepidoptera, which facilitates gene flow and homogenizes morphological characters among populations (Plazio et al., 2020; Wahlberg & Rubinoff, 2011).

Environmental Characteristics

Environmental parameters at both locations are presented in **Table 3**. Gunung Tumpa was situated at 383–391 m asl, while Palaes was at 92–121 m asl. Air temperature at Gunung Tumpa ranged from 28.1 to 32.4°C and at Palaes from 28.5 to 34.5°C. The slightly higher temperatures at Palaes are consistent with the environmental lapse rate (Barry & Chorley, 2010). As ectotherms, butterflies depend on ambient temperature for metabolic regulation and activity (Chapman, 2013), yet the temperature difference between locations (1–2°C) was likely too small to drive measurable morphological divergence. Humidity was similarly comparable between sites (Gunung Tumpa: 63.3–83.1%; Palaes: 63.8–86.3%), providing insufficient contrast to trigger significant variation (Halberg & Denholm, 2024). Light intensity differed substantially (Gunung Tumpa: 262–1,548 lux; Palaes: 2,340–11,246 lux), reflecting differences in canopy openness rather than a direct driver of morphological change (Bonebrake et al.,

2010). Wind speed was low at both sites (Gunung Tumpa: 0.2–0.6 m/s; Palaes: 0–1 m/s), suggesting insufficient selective pressure on morphology (Dudley, 2000).

Table 3. Environmental parameters recorded at each sampling location.

Location	Elevation (masl)	Temperature (°C)	Humidity (%)	Light Intensity (Lux)	Wind Speed (m/s)
Gunung Tumpa	383–391	28.1–32.4	63.3–83.1	262–1,548	0–0.6
Palaes	92–121	28.5–34.5	63.8–86.3	2,340–11,246	0–1

Overall, the measured environmental parameters at both sites fell within the ecological tolerance range of *I. blanchardii*, such that prevailing conditions were insufficient to elicit pronounced morphological responses. This is consistent with developmental canalization, whereby species morphology maintains phenotypic stability under moderate environmental variation (Waddington, 1942). The absence of clear morphological differentiation further aligns with findings in other Nymphalidae species with high dispersal capacity (Wahlberg & Rubinoff, 2011) and in *Danaus chrysippus* (Danainae), where high inter-population connectivity prevented geographic clustering of morphological variation (Negi et al., 2018).

Conclusion

Idea blanchardii populations from Palaes and Gunung Tumpa exhibit low morphological differentiation. Among the 12 morphometric characters analyzed, males showed no significant differences in all traits, while females showed significant differences only in forewing length and mid-leg length. The overall high proportion of non-significant traits indicates strong morphological similarity between populations despite differences in habitat type and elevation. This pattern suggests that environmental variation between the two sites remains within the species' ecological tolerance range and is insufficient to drive pronounced morphological divergence. The results are also consistent with the role of developmental canalization and the likely dispersal ability of *I. blanchardii*, which may promote gene flow and maintain morphological uniformity across populations. In conclusion, geographic and environmental differences between Palaes and Gunung Tumpa have not led to strong intraspecific morphological differentiation, although minor sex-specific variation in females indicates that subtle environmental responses may still occur.

References

Bai, Y., Ma, L. B., Xu, S. Q., & Wang, G. H. (2015). A geometric morphometric study of the wing shapes of *Pieris rapae* (Lepidoptera: Pieridae) from the Qinling Mountains and adjacent regions: An environmental and distance-based consideration. *Florida Entomologist*, 98(1), 162–169. https://doi.org/10.1653/024.098.0128

Barry, R. G., & Chorley, R. J. (2010). *Atmosphere, Weather and Climate* (9th ed.). Routledge.

Berwaerts, K., Van Dyck, H., & Aerts, P. (2002). Does flight morphology relate to flight performance? An experimental test with the butterfly *Pararge aegeria*. *Functional Ecology, 16*(4), 484–491. https://doi.org/10.1046/j.1365-2435.2002.00650.x

Boggs, C. L. (2009). Understanding insect life histories and senescence through a resource allocation lens. *Functional Ecology, 23*(1), 27–37. https://doi.org/10.1111/j.1365-2435.2009.01527.x

Bonebrake, T. C., Ponisio, L. C., Boggs, C. L., & Ehrlich, P. R. (2010). More than just indicators: A review of tropical butterfly ecology and conservation. *Biological Conservation, 143*(8), 1831–1841. https://doi.org/10.1016/j.biocon.2010.04.044

Chapman, R. F. (2013). *The Insects: Structure and Function* (5th ed.). Cambridge University Press.

Desa Wisata Palaes. (2024). *Profil Desa Wisata Palaes*. https://desawisatapalaes.com

Dudley, R. (2000). *The Biomechanics of Insect Flight: Form, Function, Evolution*. Princeton University Press.

Forister, M. L., Pelton, E. M., & Black, S. H. (2016). Declines in insect abundance and diversity: We know enough to act now. *Conservation Science and Practice*, 1(8), e80.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical Procedures for Agricultural Research* (2nd ed.). John Wiley & Sons.

Halberg, K. A., & Denholm, B. (2024). Insect water balance and environmental adaptation. *Current Opinion in Insect Science, 63*, 101157. https://doi.org/10.1016/j.cois.2024.101157

Herdiana, L. (2018). Keragaman Morfometrik dan Genetik Gen COI Belut Sawah (*Monopterus albus*) Asal Empat Populasi di Jawa Barat. Jurnal Ilmu Pertanian Indonesia, 22(3): 180–190. https://doi.org/10.18343/jipi.22.3.180

Leksono, A. S., Yanuwiadi, B., Millah, N., & Abdullah, S. A. (2025). Butterfly diversity along an altitudinal gradient and land uses in East Java, Indonesia. *Biodiversitas*, 26(2), 551–563. https://doi.org/10.13057/biodiv/d260204

Levene, H. (1960). Robust tests for equality of variances. In I. Olkin (Ed.), *Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling* (pp. 278–292). Stanford University Press.

Marchal, P. (1845). Description d'une nouvelle espèce du genre *Idea*. *Annales de la Société Entomologique de France, 3*, 251–255.

Negi, H. R., Kumar, R., & Sondhi, S. (2018). Altitudinal variation and population structure of *Danaus chrysippus* (Linnaeus, 1758) in the western Himalaya. *Journal of Asia-Pacific Biodiversity, 11*(3), 403–410. https://doi.org/10.1016/j.japb.2018.05.001

Nijhout, H. F. (2001). *The Development and Evolution of Butterfly Wing Patterns*. Smithsonian Institution Press, Washington, D.C.

Peggie, D. (2014). *Mengenal kupu-kupu Indonesia*. Pusat Penelitian Biologi LIPI.

Peggie, D., & Amir, M. (2006). *Practical Guide to the Butterflies of Bogor Botanic Garden*. Center for Biology, Indonesian Institute of Sciences (LIPI).

Peggie, D., & Supadi, W. (2020). Diversity and taxonomy of Sulawesi butterflies. *Treubia, 47*, 23–45.

Peggie, D., & Supadi. (2024). Adult longevity of *Idea blanchardii* (Lepidoptera: Nymphalidae) captive bred at LIPI butterfly breeding facility, Cibinong, Indonesia. *Treubia*, 51(1), 51–72. https://doi.org/10.14203/treubia.v51i1.4774

Plazio, E., Hill, J. K., & Dennis, R. L. H. (2020). Sex-specific dispersal and mobility patterns in butterflies: Implications for population structure and adaptation. *Ecological Entomology, 45*(6), 1241–1250. https://doi.org/10.1111/een.12918

Primadalvi, I. (2009). *Kupu-kupu (Butterflies) di Pulau Marak Kabupaten Pesisir Selatan Sumatera Barat* [Skripsi]. Universitas Andalas, Padang.

Schmidt, O., Schmidt, S., Häuser, C. L., Hausmann, A., & Vu, L. V. (2019). Using Malaise traps for collecting Lepidoptera (Insecta), with notes on the preparation of Macrolepidoptera from ethanol. *Biodiversity Data Journal, 7*, e32192. https://doi.org/10.3897/BDJ.7.e32192

Scoble, M. J. (1995). *The Lepidoptera: Form, Function and Diversity*. Oxford University Press.

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika, 52*(3–4), 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Vane-Wright, R. I., & de Jong, R. (2003). The butterflies of Sulawesi: Annotated checklist for a critical island fauna. *Zoologische Verhandelingen Leiden, 343*, 1–267.

Waddington, C. H. (1942). Canalization of development and the inheritance of acquired characters. *Nature, 150*, 563–565. https://doi.org/10.1038/150563a0

Wahlberg, N., & Rubinoff, D. (2011). Vagility across Vanessa butterflies and other Nymphalidae: Implications for phylogeography and population structure. *Systematic Entomology, 36*(1), 12–23. https://doi.org/10.1111/j.1365-3113.2010.00557.x

Walpole, R. E. (1995). *Introduction to Statistics* (3rd ed.). Macmillan Publishing Company.

Wowor, M. M., Langi, M. A., Saroinsong, F. B., & Nurmawan, W. (2014). Kondisi Biofisik Gunung Tumpa sebagai Taman Hutan Raya (Tahura). *COCOS*, 4(2).

Zahara, I., Fahri, F., Lamerkabel, J. S. A., Qashiratuttarafi, Q., Juliandi, B., & Raffiudin, R. (2022). Landmark-based geometric morphometric of *Apis dorsata* and A. d. binghami wing venation in Indonesian archipelagos. *HAYATI Journal of Biosciences*, 29(5), 658–668. https://doi.org/10.4308/hjb.29.5.658-668