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Taxonomic revision of the *Dorcus curvidens* and *D. grandis* species groups (Coleoptera: Lucanidae: Lucaninae) in the Indochinese Peninsula

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Abstract: This study clarifies the systematics of the *Dorcus curvidens* and *D. grandis* species groups through integrated morphological and biogeographical analyses across Indochina. Within the *D. curvidens* group, the confirmed sympatry between *D. curvidens babai* Fujita, 2010 and *D. curvidens curvidens* (Hope, 1840) in southern Vietnam—combined with consistent morphological differentiation—invalidates the subspecific status of the former, supporting the elevation of it to species rank, *D. babai* Fujita, 2010 **stat. nov.** Regarding the *D. grandis* group, genitalia morphology between *D. grandis grandis* Didier, 1926 and *Dorcus hopei* (Saunders, 1854) indicates conspecificity. Thus, we reclassify *D. grandis grandis* as *Dorcus hopei grandis* Didier, 1926 **stat. nov.**, and transfer *D. grandis moriyai* to *Dorcus hopei moriyai* Nagai, 2005 **stat. nov.**

Keywords: allopatric speciation, biogeography, Indochina, species delimitation, sympatry

中南半岛弯角大锹与寮国大锹种团分类修订（鞘翅目：锹甲科）

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摘要：本研究通过整合形态学与生物地理学证据，对中南半岛地区的 *Dorcus curvidens* 与 *D. grandis* 种团进行了系统厘定。在 *D. curvidens* 种团中，*D. curvidens babai* Fujita, 2010 与 *D. curvidens curvidens* (Hope, 1840) 在越南南部确认为同域分布，结合二者稳定存在的外部形态差异，否定了前者作为亚种的地位，支持将其提升为独立物种 *Dorcus babai* Fujita, 2010 **stat. nov.**。在 *D. grandis* 种团中，形态学证据表明 *D. grandis grandis* Didier, 1926 与 *Dorcus hopei* (Saunders, 1854)为同种。因此，我们将 *D. grandis grandis* 重新归类为 *Dorcus hopei grandis* Didier, 1926 **stat. nov.**，并将 *D. grandis moriyai* 移入 *Dorcus hopei moriyai* Nagai, 2005 **stat. nov.**。此项修订亦为越南地区 *Dorcus* 属物种提供了一个更新的物种名录。

关键词：异域分布物种形成，生物地理，中南半岛，物种界定，同域分布

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Introduction

The genus *Dorcus* MacLeay, 1819 (Coleoptera: Lucanidae: Lucaninae: Dorcini) encompasses numerous species of stag beetles widely distributed across the Nearctic, Oriental, and Palearctic Realms. Defining stable species boundaries within this genus remains a significant challenge because its taxonomy is consistently complicated by pronounced intraspecific variation and significant character convergence among closely related members. This persistent ambiguity necessitates an integrated approach, combining morphological, genitalic morphology, and biogeographical evidence to establish robust species boundaries. Indeed, the need for integrated systematic study has become critical as new taxa and revisions continue to be published, adding layers of complexity to the group's classification (Bian *et al*. 2025; Huang & Chen 2025; Liu *et al*. 2025; Qi *et al*. 2025; Wang *et al*. 2024; Wang & Zhou 2019).

The taxonomic relationship between the *D. grandis* species group and *D. hopei* exemplifies these challenges. Didier (1926) originally separated *D. grandis* as distinct based on mandibular and pronotal morphology, a classification later complicated by discoveries of extreme morphological variants such as the large-bodied *D. grandis moriyai* from Myanmar/India. Critical insight emerged from Huang & Chen (2013), who documented identical male genitalia between the population of this subspecies *D. grandis formosanus* and *D. hopei* from Taiwan of China, leading to its reclassification. Although they hypothesized mainland *D. grandis* populations were conspecific with *D. hopei*, this remained untested due to insufficient material. Consequently, the status of mainland populations has persisted as a key knowledge gap in *Dorcus* taxonomy.

Parallel systematic issues affect the *D. curvidens* species group (Hope 1840), where compelling distributional evidence now fundamentally challenges existing classifications. The ambiguity originates from the infraspecific status of *D. curvidens babai*, which Fujita (2010) described as a subspecies based primarily on morphological distinctions, thereby implicitly assuming an allopatric distribution (geographical separation). However, our recent fieldwork demonstrates strict sympatry between *D. c. babai* and the nominotypical subspecies in southern Vietnam, with the distinct morphological characters being fully maintained.

This stable sympatric coexistence, characterized by the absence of intermediate forms, directly contradicts the fundamental biological requirement for subspecific status, thereby suggesting the current infraspecific classification is taxonomically untenable and requires elevation to species rank.

To resolve these systematic ambiguities, we focus on two critical taxonomic questions. First, we test the conspecificity hypothesis for mainland *D. grandis* populations through comparative analysis of male genitalia, assessing whether reclassification as *D. hopei grandis* **stat. nov.** is justified. Second, we evaluate the biological significance of sympatry between *D. c. babai* and *D. c. curvidens* to determine if species elevation to *Dorcus babai* **stat. nov.** is warranted. By addressing these questions through multiple evidence sources, this work aims to establish a more stable taxonomic framework for the economically and ecologically significant *Dorcus* fauna of Indochinese Peninsula.

Material and methods

This study utilized a total of 35 specimens that were examined for this study. All specimens were legally collected and procured in compliance with relevant ethical guidelines and local regulations concerning entomological sampling and trade.

Taxonomic identification was primarily based on Fujita (2010), with subsequent classification and nomenclature adhering to the system proposed by Huang & Chen (2013).

Male genitalia were dissected from selected dry specimens for comparative morphological study.Genitalia were cleared in a 10% solution of Potassium Hydroxide (KOH) for 24 hours (duration adjusted based on sclerotization), rinsed in distilled water, and stored in glycerin microvials pinned beneath the corresponding

specimen. External morphological characters, including the shape of the mandibles, pronotal lateral margins, and body size, were observed using a stereomicroscope. All dry specimens were photographed with a digital camera equipped with a macro lens.

The material examined is deposited in the following private collections:

JZLC: Jing-Zhi Lin Collection, Taipei, Taiwan, China

NMTC: Nguyen-Minh Tuan Collection, Lam Dong Province, Vietnam.

The following specimens of the genus *Dorcus* were used for comparison:

***Dorcus curvidens* (Hope, 1840)** (Figs. 1D–F, 2B; D, 3A–B, 6C–D): 8♂♂, 1♀, Houaphanh Province, northeastern LAOS, vi.2018, local collector (JZLC); 1♂, Daksong, Dakong, VIETNAM.10.vii.2024, N.-M. Tuan leg. (NMTC); 1♂, Di Linh, Lam Dong, VIETNAM. 1283 m, 11.vii.2024, N.-M. Tuan leg. (NMTC).

***Dorcus hopei* (Saunders, 1854)** (Figs. 4 C; F, 5B): 2♂♂, 1♀, Jingzhou - Hunan, CHINA, VI. 2022, local collector (JZLC).

Taxonomy

Genus *Dorcus* MacLeay, 1819 大锹甲属

Dorcus babai Fujita, 2010 stat. nov. 马场氏大锹甲

Figs 1A–C, 2A; C, 3C–D, 6A–B

Dorcus curvidens babai Fujita, 2010: 258, type locality: Da Lat, Vietnam; plate 168, figs 761 (1–2); Tsuchiya 2018: 20, subspecies discussion.

Material examined. VIETNAM: 2♂♂, 4♀♀, Da Lat, 6.ix.2024, bred in captivity (JZLC); 1♂, Daksong, Dakong, 2.vii.2024, N.-M. Tuan leg. (NMTC); 1♂, Lac Duong, 1600 m, 20.xi.2023, N.-M. Tuan leg. (NMTC).

Variation. Body length (including mandibles): Male 30.0–81.5 mm, female 27.5–45.0 mm.

Distribution. VIETNAM: (Da lat, Lac duong, Da knong, Di linh) all specimens recorded from the elevation between 1000−1600 m.

Diagnosis and Discussion. The present study clarifies the taxonomic status of *Dorcus babai* by recognizing it as a distinct species based on integrated morphological and biogeographical evidence. *Dorcus babai* can be reliably distinguished from the sympatric *Dorcus curvidens* by the following suite of stable external characters: 1) Male mandibles are more slender and exhibit a stronger C-shaped curvature; the central major inner tooth points obliquely backwards, with a weakly developed falcate protrusion near the apex; 2) The emargination of the male pronotal lateral margin is positioned more anteriorly; 3) The body surface, particularly the elytra, is dull to strongly matte; the head and pronotum show denser punctation; 4) Females have a wider body profile; 5) Female elytral striae are shallower, with noticeably flatter interstices. Field surveys conducted in the Central Highlands of Vietnam, specifically in Di Linh (Lâm Đồng Province) and Đắk Nông Province, provide the decisive biological evidence for species separation. While Tsuchiya (2018) previously noted anecdotal reports of sympatry, our fieldwork empirically confirms the strict and stable co-occurrence of *Dorcus curvidens* and *Dorcus babai* in these localities. Crucially, despite extensive sampling within this overlapping range, no intermediate forms or hybrid individuals were detected. This maintained morphological discontinuity under sympatry fundamentally invalidates a subspecific relationship—which presupposes allopatry or intergradation—and robustly supports the recognition of *Dorcus babai* as a distinct, reproductively isolated species.

This conclusion is further corroborated by fixed genitalic differences: 1) Male median lobe thicker; 2) Medial stalk of male sternite IX thinner; 3) Ventral process of male basal piece slightly wider; 4) Female apical parts of hemisternites with sparser setation compared to the dense vestiture in *D. curvidens*.

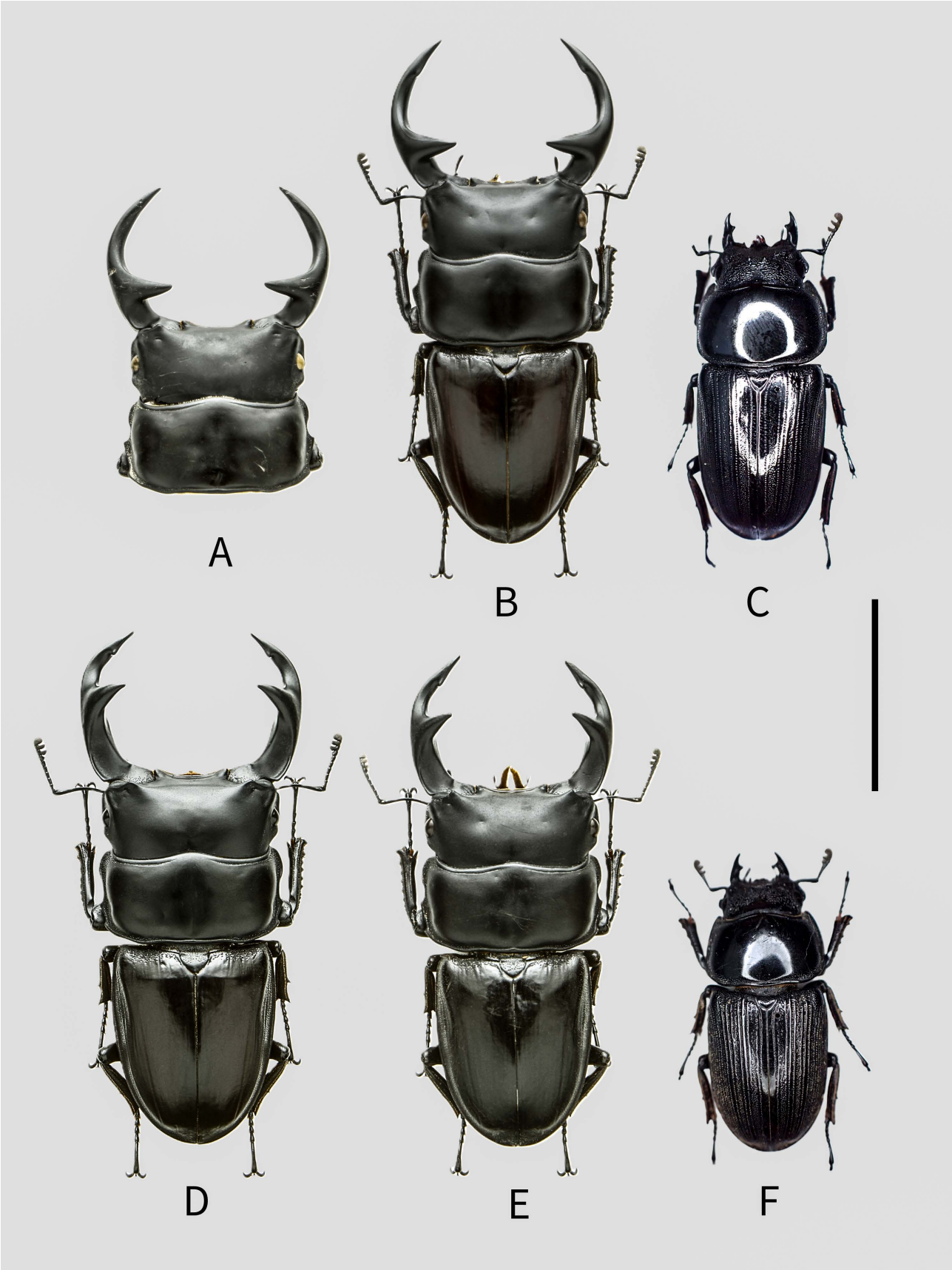

FIGURE 1. Variability of *Dorcus babai* (A–C) and *Dorcus curvidens* (D–F): **A** Lac Duong, male **B** Daksong, male **C** Da Lat, female **D** Lam Dong, male **E** Daksong, male **F** Laos, female. Dorsal views. Scale bar: 30.0 mm.

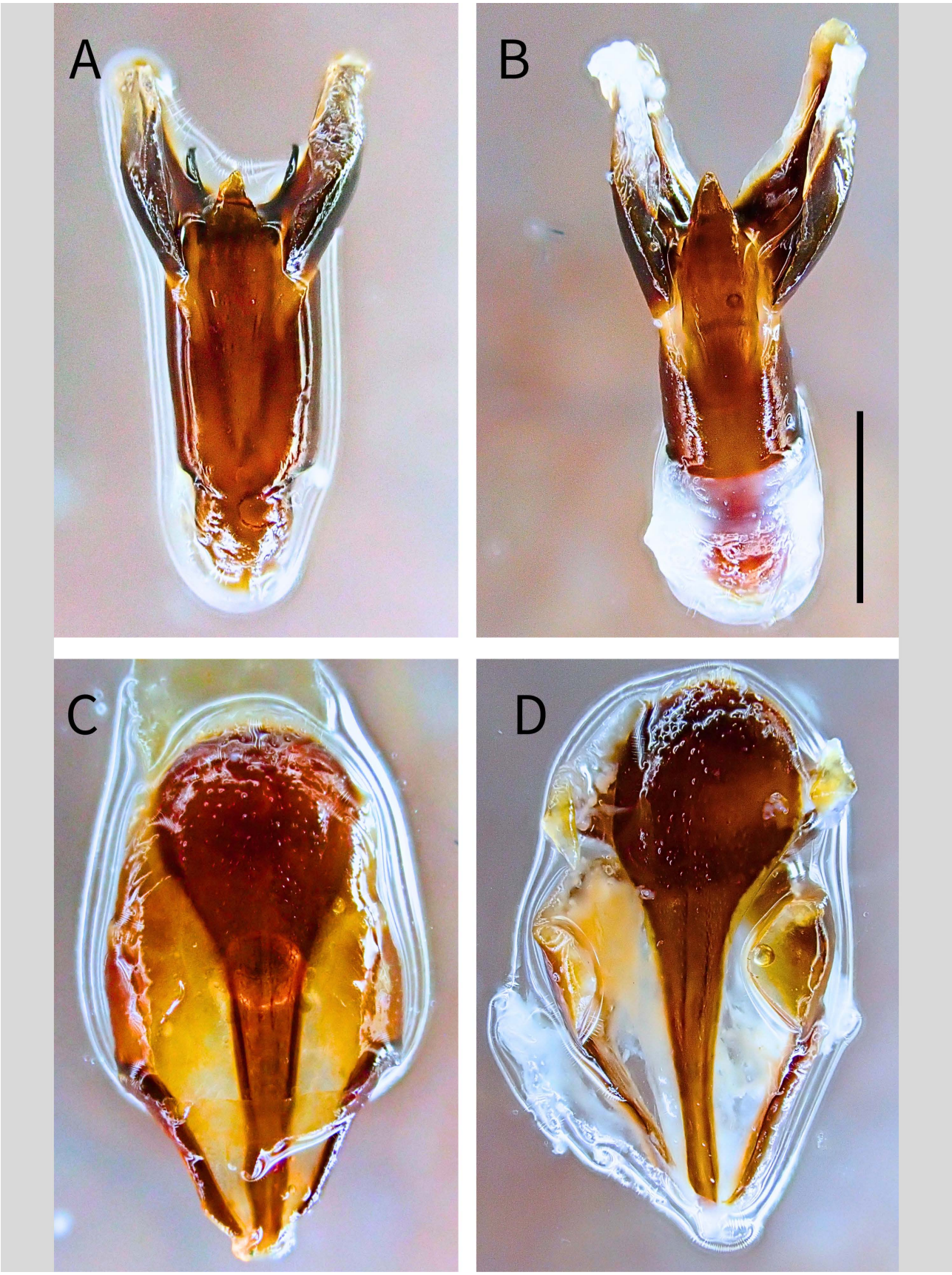

FIGURE 2. Comparative morphology of male terminalia between *Dorcus babai* and *Dorcus curvidens*: **A** aedeagus of *D. babai* **B** aedeagus of *D. curvidens* **C** male abdominal segment IX of *D. babai* **D** male abdominal segment IX of *D. curvidens*. All figures shown in dorsal view. Scale bar: 3.0 mm.

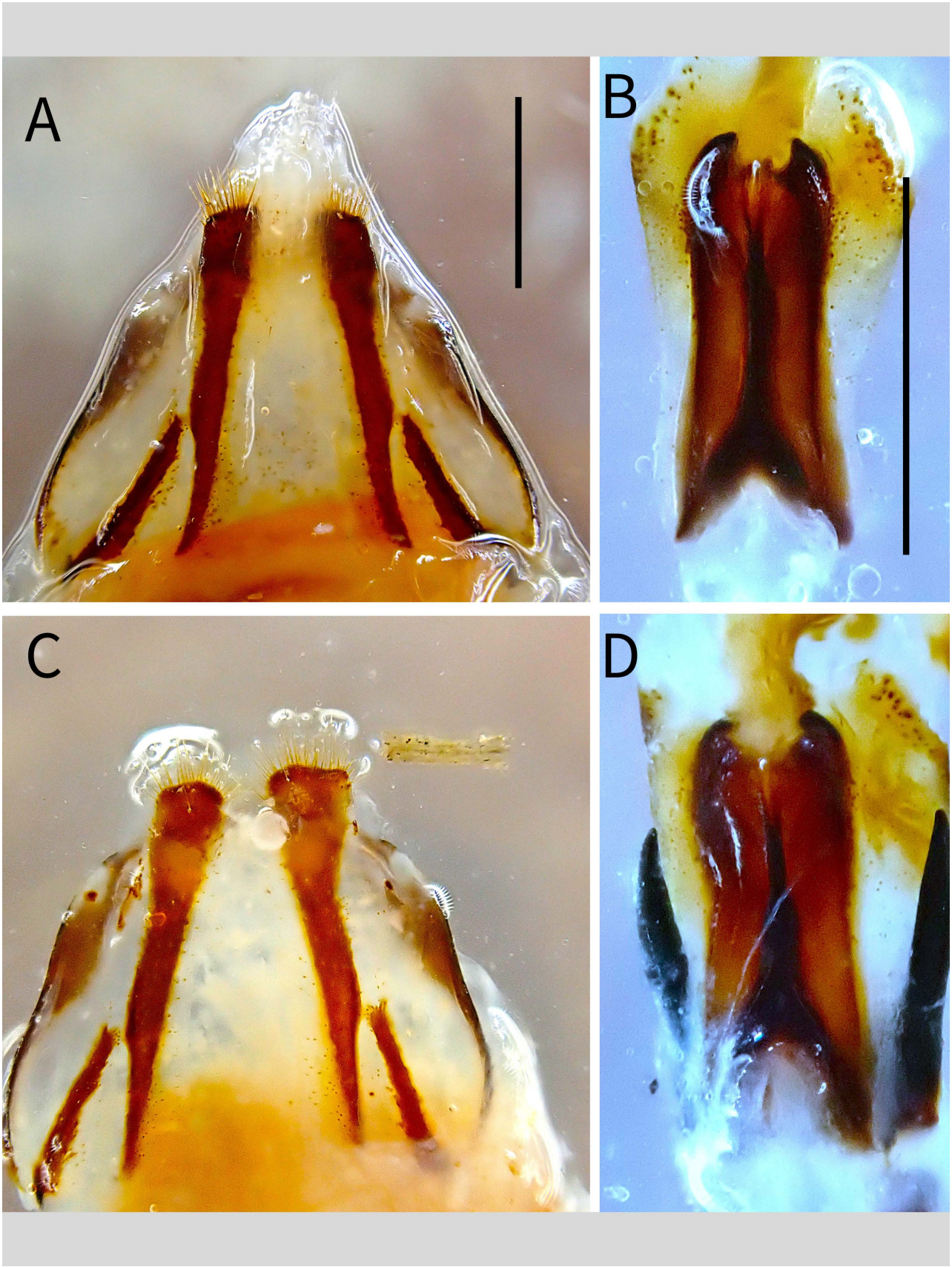

FIGURE 3. Detailed comparison of diagnostic genitalic structures between *Dorcus curvidens* and *Dorcus babai*: **A** female hemisternites (Segment X) of *D. curvidens* **B** male median lobe of aedeagus of *D. curvidens* **C** female hemisternites (Segment X) of *D. babai* **D** male median lobe of aedeagus of *D. babai*. All figures shown in dorsal view. Scale bar: 2.0 mm.

Together, the evidence from confirmed sympatry, discrete external morphology, and clear genitalic discontinuity supports the presence of a definitive species boundary. Consequently, we formally elevate *Dorcus babai* Fujita, 2010 to full species rank and propose the new status.

Remark. *Dorcus babai* is endemic to the Central Highlands of Vietnam, with confirmed populations in the type locality of Da Lat Plateau and adjacent areas of Lac duong and Da knong provinces. All documented specimens originate from elevations between 1000-1600 m, indicating specific adaptation to intermediate montane forests. While unverified commercial records from Laos and Cambodia have recently emerged in Japanese beetle markets, these extralimital reports require field confirmation due to potential mislabeling in trade networks. Field studies reveal notable ecological differences between sympatric species. *D. babai* exhibits a relatively short adult activity period, primarily during May and June. In contrast, *D. curvidens* shows extended seasonal occurrence from March to October. Sampling methods further demonstrate behavioral divergence: light traps effectively capture only smaller males and females of *D. babai*, suggesting larger males maintain cryptic habits in tree hollows and sap flows. This size-dependent microhabitat preference represents a significant factor in sampling bias and resource partitioning. The elevational specialization and distinct phenology of *D. babai* reinforce its ecological separation from co-occurring congeners. These biological characteristics, combined with its restricted distribution, support its recognition as an independent evolutionary lineage adapted to the unique conditions of Vietnam's Central Highlands.

Dorcus hopei grandis Didier, 1926 stat. nov. 寮国大锹甲

Figs 4 B; E, 5C; F

Dorcus grandis Didier, 1926: 146–148 type locality: Xiang khouang, Laos; Ikeda & Nishimura 1995, 292: 17–21; Fujita 2010: 256; plate 165, figs 759 (1–5); Tsuchiya 2018: 21.

Material examined. VIETNAM: Lao Cai Province: 2♂♂, Sa Pa, ix.2014, local collector (JZLC). 1♂♂, Van chan Yen Bai, 20. VIII.2021, N.-M. TUAN LEG. (NMTC). **LAOS:** Xieng Khouang Province: 1♂, 1♀, ix.2014, local collector (JZLC). Houaphanh Province: Xam Neua, 1♂, vii.2017, local collector (JZLC).

Variation. Body length (including mandibles): Male 39.5–88.5 mm, female 32.5–54.5 mm.

Distribution. Vietnam (Yen Bai, Ha Giang, Sapa), Laos (Xam Neua, Xieng Khouang).

Dorcus hopei moriyai Nagai, 2005 stat. nov. 守谷氏大锹甲

Figs 4 A; D, 5A; D, 3C–D, 7A

Dorcus grandis moriyai Nagai, 2005: 413:2–3 type locality: Chin, Myanmar; Fujita 2010: 257; plate 165, figs 759 (10–14); Huang & Chen 2013: 401-402, subspecies discussion; Tsuchiya 2018: 21.

Material examined. MYANMAR: Chin Hills: 1♂, 1♀, 20.ix.2018, local collector. **INDIA:** Manipur: 3♂♂, 2♀♀, 1.ix.2022, local collector. All specimens deposited in JZLC unless otherwise specified.

Variation. Body length (including mandibles): Male: 36.9–95.5 mm, female:30.5–56.0 mm.

Distribution. W. Myanmar (Chin Hills), NE. India (Manipur)

Taxonomic note. The taxonomic distinction between *Dorcus hopei* (Saunders, 1854), *D. grandis* Didier, 1926, and its allied forms has been historically problematic due to the genus's pronounced intraspecific variation and morphological convergence. While Fujita (2010), in his definitive monograph, relied on external characters to maintain the specific separation of *D. hopei* and *D. grandis*, the underlying genetic relationship remained questionable. Fujita (2004) previously noted the close genetic affinity among these taxa based on molecular phylogenetic tree analysis, suggesting they form a single monophyletic cluster. Despite this molecular evidence, Fujita preserved the species separation, though he presciently hypothesized that *D. grandis* might represent a relict southern population of *D. hopei*, indicating the necessity for further clarification regarding their subspecific

relationship.

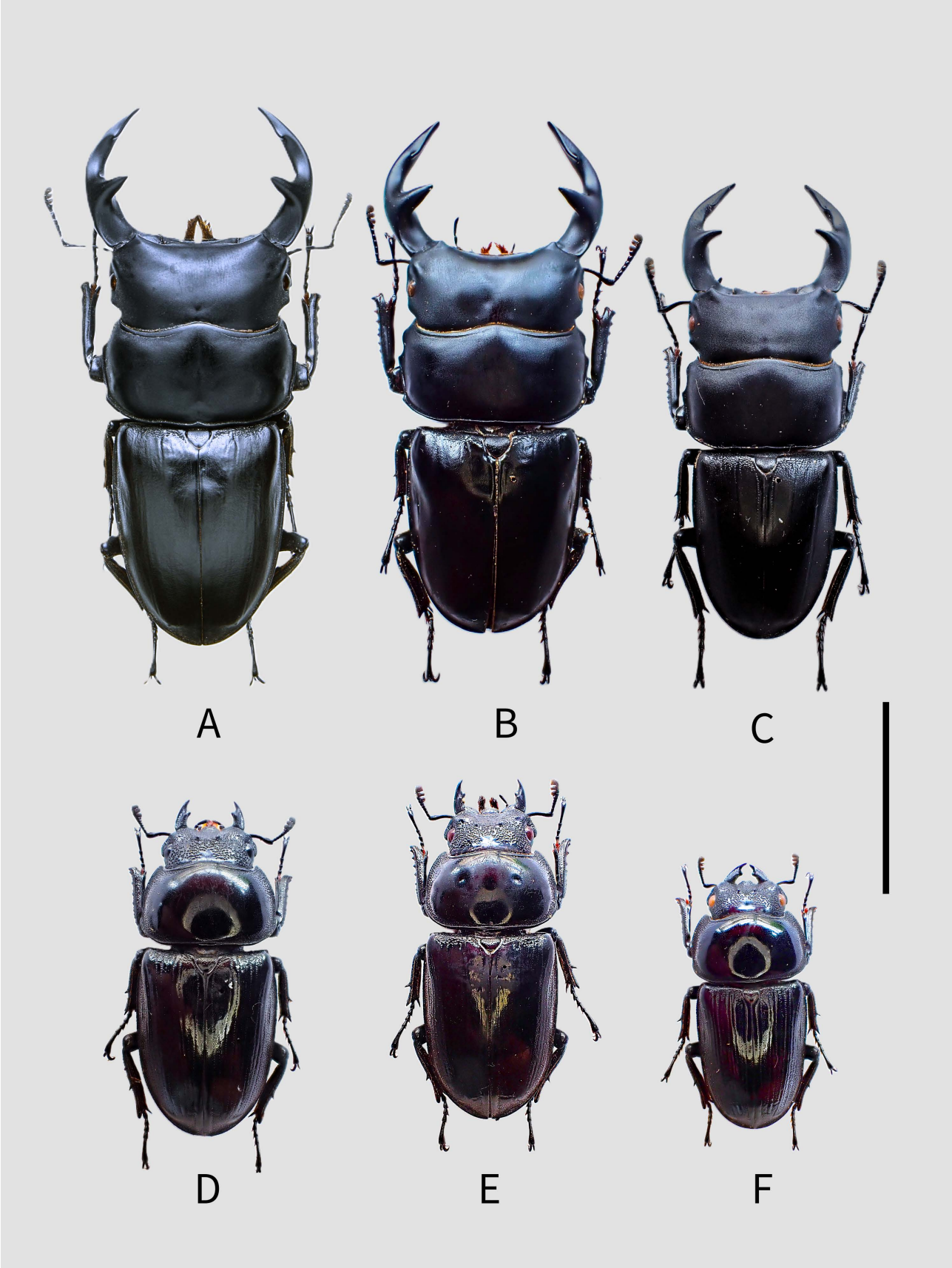

FIGURE 4. Variability of *D. hopei* species groups: **A** ssp. *grandis*, male **B** ssp. *moriyai*, male **C** ssp. *hopei*, male **D** ssp. *grandis*, female **E** ssp. *moriyai*, female **F** ssp. *hopei*, female. Dorsal view. Scale bar: 40.0 mm.

FIGURE 5. Aedeagus and abdominal segment IX of *D. hopei* species groups: **A, D** ssp. *grandis* **B, E** ssp. *hopei* **C, F** ssp. *moriyai*. Dorsal view. Scale bar: 3.0 mm.

FIGURE 6. Living specimens of *Dorcus* species photographed in their natural habitats in Vietnam, illustrating morphological stability in sympatry: **A** *Dorcus babai* from Dak Nong Province **B** *Dorcus babai* from Lam Dong Province **C** *Dorcus curvidens* from Dak Nong Province **D** *Dorcus curvidens* from Lam Dong Province.

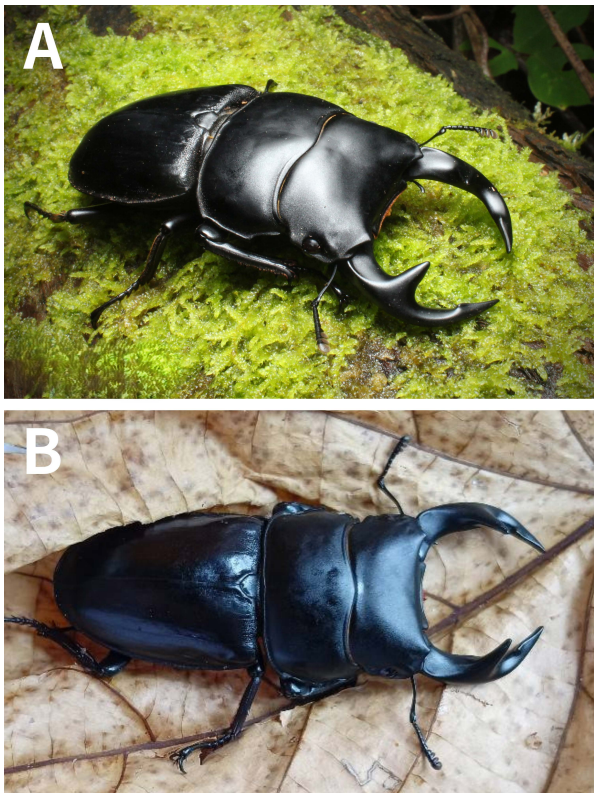

FIGURE 7. Living specimens of *Dorcus*: **A** *Dorcus hopei grandis* from Yen Bai **B** Artificial hybridization individual (F1) resulting from a cross between *D. hopei* × *grandis*, confirming reproductive compatibility.

Huang & Chen (2013) pioneered the definitive breakthrough, their rigorous examination revealed that the male genitalia of *D. hopei* (nominotypical form) and *D. formosanus* were anatomically indistinguishable, leading to the reclassification of the latter as a subspecies of *D. hopei*. Crucially, based on external morphology, Huang & Chen hypothesized that the mainland *D. grandis* was also conspecific, although this could not be verified due to the lack of representative Indochinese material at the time.

The present study resolves this remaining systematic ambiguity. Examination of specimens from multiple Indochinese localities (Vietnam, Laos, Myanmar, E. India) confirms that the male genitalia of the *grandis* populations are structurally identical to those of *D. hopei*. Furthermore, biological evidence strongly supports this finding: artificial hybridization experiments between *D. hopei* and *D. grandis* yielded fertile F1 offspring, effectively ruling out the presence of pre- or post-zygotic reproductive isolation barriers (Fig. 7B). This combined evidence corroborates the hypothesis put forth by Huang & Chen (2013).

Given the consensus from anatomical and biological data regarding conspecificity, the retention of *D. grandis* as a valid species is unwarranted. However, we propose that *grandis* and *moriyai* are retained as valid subspecies of *Dorcus hopei* due to stable phenotypic divergences maintained across geographic distance: 1) Indochinese populations exhibit consistent differences in the shape of the pronotal lateral margins compared to the Sino-Japanese populations; 2) A pronounced and stable difference in maximum body size is evident; *D. grandis* can reach 85 mm (and *moriyai* up to 95 mm), contrasting sharply with the typical maximum size of 60–75 mm observed in the nominotypical *D. hopei* populations. This size difference reflects allometric responses to local environmental factors across their vast distribution.

Notably, the broad morphological variation observed in ssp. *formosanus* holds particular significance. The subspecies distributed in Taiwan of China, exhibits a mosaic of pronotal characteristics intermediate between the grandis, moriyai, and hopei types. This intermediate phenotype, which bridges the morphological extremes between these forms, further supports their status as a single species and explains the long-standing taxonomic confusion surrounding the entire *D. hopei* complex. Based on robust evidence from genitalic morphology and reproductive compatibility, the reclassification of *Dorcus grandis* as a geographical subspecies of *Dorcus hopei* is formally justified. We therefore propose *Dorcus hopei grandis* Didier, 1926 **stat. nov.** and *Dorcus hopei moriyai* Nagai, 2005 **stat. nov.**

Checklist of the genus *Dorcus* MacLeay, 1819 from Vietnam

Incorporating taxonomic data from recent studies (Fujii& Okuda 2020; Fujita 2010; Huang & Chen 2013, 2017, 2025; Tsuchiya 2018,2025; Qi *et al*. 2025) and the present work, a total of 19 taxa (species and subspecies) are currently recorded from Vietnam.

1. *Dorcus antaeus miyashitai* Fujita, 2010
2. *Dorcus arrowi lieni* Maeda, 2012
3. *Dorcus arrowi magdeleinae* (Lacroix, 1972)
4. *Dorcus babai* Fujita, 2010 **[species rank confirmed by present study]**
5. *Dorcus branaungi* Nagai, 2000
6. *Dorcus cervulus* (Boileau, 1901)
7. *Dorcus curvidens* (Hope, 1840)
8. *Dorcus daedalion* (Didier & Seguy, 1953)
9. *Dorcus fujiii* Nagai, 2010
10. *Dorcus hirticornis* ssp. **[taxonomic status unresolved]**
11. *Dorcus hopei grandis* Didier, 1926 **[reclassified as subspecies in present study]**
12. *Dorcus kamijoi* Fujita, 2009

13. *Dorcus katsurai* Ikeda, 2000
14. *Dorcus kentai* Tsukawaki, 1999
15. *Dorcus laevidorsis* Fairmaire, 1888
16. *Dorcus linwenhsini conjunctus* Qi, Bian, Xin & Dang, 2025
17. *Dorcus tanakai* Nagai, 2002
18. *Dorcus tatsuhikoi* Fujii & Okuda, 2020
19. *Dorcus yaksha tonkinensis* Fujita, 2010

FIGURE 8. Typical habitat of *Dorcus babai* in Vietnam. The photograph shows the intermediate montane forest environment in Daksong, Dak Nong Province, near Nam Nung National Park. This site is confirmed for the strict sympatric co-occurrence of *D. babai* and *D. curvidens*.

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Additional information

Author contributions: Conceptualization: J-Z Lin & N-M Tuan. Project administration: J-Z Lin. Resources: N-M Tuan. Supervision: J-Z Lin. Visualization: N-M Tuan. Writing–original draft: J-Z Lin. Writing–review and editing: J-Z Lin & N-M Tuan.

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