A new species of the East Asian endemic subgenus Sadonebria Ledoux et Roux (Coleoptera: Carabidae: Nebria) ground beetles from Japan

Nовый вид жужелиц эндемичного восточно-азиатского подрода Sadonebria Ledoux et Roux (Coleoptera: Carabidae: Nebria) из Японии

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ABSTRACT. Ground beetles in the East Asian endemic subgenus Sadonebria (Coleoptera: Carabidae: Nebria) show marked differentiation in the Japanese Archipelago, but their diversity has not been fully elucidated. Based on specimens from localities in western Chubu district, Honshu, Japan, Nebria hakusana Sasakawa, sp.n., is described. Comparison of male genital structures with the known consubgeners, and previously reported morphological and molecular phylogenies of this subgenus, suggest that N. hakusana Sasakawa, sp.n. is the most ancestral of the known Japanese endemic Sadonebria.

KEY WORDS: biogeography, comparative morphology, cryptic species, endophallus, male genitalia, new species, phylogeny, taxonomy.
described based on specimens obtained from the Fukui, Ishikawa, and Gifu Prefectures in the western part of Chubu district.

Materials and methods

Information on related species was obtained from Sasakawa [2008, 2009, 2010, 2016], Sasakawa and Kubota [2006], and Sasakawa and Toki [2011], who described key characters of the species, such as the male endophallus, based on their type specimens (species described key characters of the species, such as the male endophallus, based on their type specimens (species described key characters of the species, such as the male endophallus, based on their type specimens (species described key characters of the species, such as the male endophallus, based on their type specimens (species). Photographs of the holotypes of *N. kiso* Sasakawa, 2009 and *N. mikawa* Sasakawa, 2009, which were taken during my previous study [Sasakawa, 2009], were also used for comparisons. Two taxa, *leechi* Bates, 1889 and *ohdaiensis* Nakane, 1963, are treated as distinct species, not as subspecies of *N. sadona*, based on their non-monophyletic relationship in morphological phylogeny [Sasakawa, Kubota, 2006]. The endophallus was everted by injecting toothpaste from the basal end of the aedeagus [Berlov, 1992]. The terminology of endophallus structures follows Sasakawa [2016]. The following abbreviations are used for the collections to which specimens are deposited and for morphological characters: EUM — Ehime University Museum, Matsuyama, Japan; and KS — the K. Sasakawa collection deposited in the Laboratory of Zoology, Department of Science Education, Faculty of Education, Chiba University, Chiba, Japan; PL — pronotum length along the median line; PW — pronotum width at the widest part; PAW — width of the anterior margin of the pronotum; PPW — width of the posterior margin of the pronotum; EL — elytral length from the level of the shoulder tip to the apices; EW — elytral width at the widest part.

Taxonomy

*Nebria (Sadonebria) hakusana* Sasakawa, sp.n.

Figs 2–7.

**TYPE MATERIALS.** Holotype, ♀ (KS), Shinmata Pass, Nokuchi, Katsuura, Fukui Prefecture, Japan, 1.vi.2020, S. Inoue leg.; paratypes, 1♂ (KS), Mt. Sanbokuzure, ca 1,200 m, Shirakawa City, Gifu Prefecture, Japan, 23–24.vi.2005, H. Ikeda leg.; 1♂2♀ (EUM), “KAGA-Hakusan Nakahanba – Bettonozoki (1,500–1,750 m) 1 VIII. 1973 M. Miyatake” [Nakahanba (1,500 m) – Bettonozoki (1,500 m), Mt. Hakusan, Shizume, Hakusan, Ishikawa Prefecture, Japan].

**DESCRIPTION.** External characters (Figs 2–3). Body length (including mandibles): ♀, 12.5–13.6 mm; ♂, 12.6–12.8 mm. PL/PW: 0.73–0.76; PAW/PW: 0.73–0.76; PPW/PW: 0.64–0.68. EL/EW: 1.59–1.71. Habitus slender. Hind wings atrophied. Dorsal surface shiny and almost black; head with a dark-brown patch between eyes; pronotal and elytral margins dark-brown; mouth appendages and antennae red-
dish to dark brown; legs dark brown except for femora, which are blackish brown. Pronotum cordate and convex; lateral margins reflexed throughout; hind angle acute; laterobasal impression large and deep; median line distinct in the middle, absent near the anterior margin, rudimentary near the posterior margin; surface of central part and near the anterior

Figs 2–9. Nebria (Sadonebria) spp.: 2–7 — N. hakusana sp.n.; 8 — N. kiso; 9 — N. mikawa; 2–3 — habitus; 4 — aedeagus; 5–6 — endophallus; 7–9 — pronotum; 2–3, 7–9 — dorsal view; 4–5 — right lateral view; 6 — ventral view; 2, 5–9 — holotype, male; 3 — paratype, female; 4 — paratype, male from Mt. Sanpôkuzure. Abbreviations: da — dorsoapical lobe; db — dorsobasal lobe; go — gonopore; lb — laterobasal lobe; va — ventroapical lobe. Scales: 5.0 mm for 2–3; and 0.5 mm for 4–9.

Рис. 2–9. Nebria (Sadonebria) spp.: 2–7 — N. hakusana sp.n.; 8 — N. kiso; 9 — N. mikawa; 2–3 — габитус; 4 — эдеагус; 5–6 — эндофаллус; 7–9 — пронотум; 2–3, 7–9 — сверху; 4–5 — справа; 6 — снизу; 2, 5–9 — голотип, самец; 3 — паратип, самка; 4 — паратип, самец с горы Санпокудзурэ. Сокращения: da — дорсоапикальная доля; db — дорсобазальная доля; go — гонопор; lb — латеробазальная доля; va — вентропапикальная доля. Масштаб: 5,0 мм для рис. 2–3; 0,5 мм для рис. 4–9.
margin almost smooth; surface near the posterior margins very sparsely punctate; surface of the lateral margins very sparsely punctate and/or shallowly, transversely wrinkled; two marginal setae on each lateral side, anterior setae near the widest pronotal point, and posterior setae near hind angles. Elytra oblong, widest behind the middle; 7–10 setigerous pores on interval 3. Abdominal sterna 4–7 usually with a pair of setae, but in the male from Mt. Sannōkazure, additional setae on left side of sternum 4 and on both sides of sternum 7. Male genitalia (Figs 4–6). Aedeagus slender and strongly bent at apical 2/5; ventral contour of subapical part from lateral view arcuate ventrally; apex simple and widely rounded. Endophallus straight, elongate, directed posterodorsally; laterobasal lobes large, hemispherical; lateroapical lobes absent; dorsobasal lobe bifid from lateral view, with the subapex of basal one smaller than that of apical one; dorsoapical lobe widely swollen, and smaller than the laterobasal and dorsobasal lobes; ventroapical lobe barely swollen. Both right and left parameres spatulate, with the former larger than the latter.

**DIAGNOSIS.** Distinguished from *N. quinquelobata* Sasakawa, 2016, *N. kiso*, and *N. mikawa*, which are relatively closely distributed (Fig. 1), by the following characters: from *N. quinquelobata* by dark brown legs [versus yellowish brown legs in *N. quinquelobata*; Sasakawa, 2016], and from *N. kiso* and *N. mikawa* by less cordate and less punctate pronotum (Figs 7–9).

**ETYMOLOGY.** Named after the Hakusan Mountains, where the type materials were collected.

**Table 1. Character states of the endophallus structures of *Nebria* (Sadonebria) spp.**

| Taxa               | Lateoapical lobe size | Dorsobasal lobe shape | Dorsoapical lobe size | Endophallus length |
|--------------------|-----------------------|-----------------------|-----------------------|--------------------|
| *N. chinensis*     | absent                | bifid                 | small                 | > 1.5 mm           |
| *N. niitakana*     | absent                | slightly bifid        | small                 | > 1.5 mm           |
| *N. asahina*       | large                 | simple                | large                 | < 1.5 mm           |
| *N. chichibuensis* | absent                | simple                | large                 | < 1.5 mm           |
| *N. hakusana*      | absent                | bifid                 | small                 | > 1.5 mm           |
| *N. jakachisana*   | absent                | simple                | small                 | < 1.5 mm           |
| *N. kiso*          | small                 | simple                | large                 | < 1.5 mm           |
| *N. mikawa*        | small                 | simple                | large                 | < 1.5 mm           |
| *N. nasuensis*     | large                 | simple                | large                 | < 1.5 mm           |
| *N. quinquelobata* | large                 | simple                | large                 | < 1.5 mm           |
| *N. kechi*         | absent                | simple                | large                 | < 1.5 mm           |
| *N. ohdaiensis*    | small                 | hook-shaped           | small                 | > 1.5 mm           |
| *N. saeviens*      | large                 | simple                | large                 | < 1.5 mm           |
| *N. shikokauen*    | absent                | simple                | large                 | < 1.5 mm           |
| *N. tencaulis*     | absent                | simple                | small                 | < 1.5 mm           |
| *N. trifida*       | absent                | simple                | large                 | < 1.5 mm           |
| *N. yatsugataensis*| small                 | simple                | large                 | < 1.5 mm           |

**NOTE.** Except for *N. sadona*, for which no specimens other than the lectotype have been obtained since its original description. Two species, *N. chinensis* and *N. niitakana*, which were determined to be placed in the basal lineages in both morphological [Sasakawa, Kubota, 2006] and molecular [Kavanaugh et al., 2021] phylogenies, are marked with asterisk. The sizes of the lateoapical and dorsoapical lobes are compared against the laterobasal lobes: if the lobe is larger (smaller) than the laterobasal lobe, it is classified as “large” (“small”). The endophallus length is measured from base to gonopore. Boxes in black, grey, and white indicate presumed ancestral, intermediate, and derived character states, respectively.

**ПРИМЕЧАНИЕ.** Не включена *N. sadona*, для которой момент первоописания не было найдено ни одного экземпляра, кроме лектотипа. Два вида, *N. chinensis* и *N. niitakana*, которые были отнесены к базальным линиям как в морфологической [Sasakawa, Kubota, 2006], так и в молекулярной [Kavanaugh et al., 2021] филогении, отмечены звездочкой. Размеры латероапикальной и дорsoapICAL лопастей сравниваются с латеробазальными долями: если доля крупнее (меньше) латеробазальной доли, её классифицируют как “большую” (“маленькую”). Длина эндофаллуса измеряется от основания до гонопора. Ячейки чёрного, серого и белого цвета обозначают предполагаемые предковые, промежуточные и производные состояния признаков, соответственно.

**Discussion**

The new species is currently known only from the Hakusan Mountains, on the border of the Fukui, Ishikawa and Gifu Prefectures (Fig. 1). Specimens of *Sadonebria* from the Hakusan Mountains have been repeatedly recorded as *N. sadona* [Hiramatsu, Usio, 2018 and references therein], and these specimens are also most likely *N. hakusana*.

A comparative morphology revealed that *N. hakusana* shares most of the endophallus character states with the widely distributed *N. chinensis* and Taiwanese endemic *N. niitakana* (Table 1), which split from the Japanese endemic taxa at the basal node(s) within *Sadonebria* phylogeny [Sasakawa, Kubota, 2006; Kavanaug et al., 2021]. This suggests that *N. hakusana* is the most ancestral of the known Japanese endemic *Sadonebria*. This result is not surprising, because *N. ohdaiensis*, which is distributed relatively close to *N. hakusana* (Fig. 1), also has endophallus with many presumed ancestral character states (Table 1). These patterns suggest that the initial differentiation of the flightless *Sadonebria* from Japan occurred around the known localities of *N. hakusana* and *N. ohdaiensis*. 

**Таблица 1. Признаки структура эндофаллуса *Nebria* (Sadonebria) spp.**
Interestingly, a similar result has been reported based on a comparative morphology for \textit{N. reflexa} Bates, 1883 and its related species that belong to a different \textit{Nebria} subgenus (\textit{Falcinebria}), inhabit a similar environment, and have almost the same distribution in the archipelago. That is, the basal lineages of these species are also distributed in the western part of the Chubu District [Sasakawa, 2020]. This concordance may indicate that the ancestors of \textit{Sadonebria} and \textit{Falcinebria} colonized the Japanese Archipelago at the same time. These hypotheses regarding the region and timing of the initial differentiation could be tested by future molecular phylogenetic analyses of the two groups.

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