



A NEW SPECIES OF *NEMOURA* (PLECOPTERA: NEMOURIDAE) FROM KYUSHU, JAPAN, WITH NOTES ON MALE VIBRATIONAL SIGNALS

Satoko Hanada

Nishijin, Sawara Ward, Fukuoka City, Fukuoka Prefecture 814-0002, Japan

E-mail: s.hanada@email.plala.or.jp

ABSTRACT

A new species of *Nemoura* from Japan is described from male and female adults. In addition, the male vibrational signals under solitary condition are described. The new species, *N. sefuriensis* sp. n. is similar to *N. stratum* Kawai, 1966 in adult habitus with somewhat shortened wings, but can be distinguished from *N. stratum* by lacking large sclerotized prolongation on hind margin of male tergum 8, and by having membranous female sternum 8 with a pair of weakly sclerotized small areas.

Keywords: *Nemoura sefuriensis* sp. n., stonefly, Insecta, drumming

INTRODUCTION

A new species of the genus *Nemoura* was discovered from northern Kyushu, western Japan in winter and early spring. It is similar to *Nemoura stratum* Kawai, 1966 distributed in Honshu and Shikoku, Japan, in adult habitus with somewhat shorten wings, which are unique for nemourid adults. In this paper, I describe the new species on the basis of morphological features of both sexes and the male vibrational call signals.

MATERIAL AND METHODS

Morphological observation. Adults were hand-collected and preserved in 80% ethanol. Specimens were studied and drawn using a Leica MZ12 stereomicroscope (magnifications up to 100×) equipped with a drawing tube. The epiproct used for illustrations was removed from a paratype specimen and macerated in a solution of KOH for 10 hours at 28°C. Female vaginal sclerites were observed and drawn after female abdomens were

cleared in a solution of KOH for 8.5 hours at 27°C.

All examined materials were collected by Mr. H. Maruyama and the author, and collector's names were omitted in the lists. The holotype male and paratypes will be deposited in the Lake Biwa Museum, Shiga Prefecture, Japan, and additional specimens remain in the private collection of the author.

Recordings of vibrational signals. Wild males were collected from the following four locations in the Sefuri Mountains: Iiba, Sawara Ward, Fukuoka City, Fukuoka Prefecture (1♂, 27.II.2016; 1♂, 5.III.2016; 1♂, 27.III.2016), Magaribuchi, Sawara Ward, Fukuoka City, Fukuoka Prefecture (1♂, 21.II.2016), Raizan, Itoshima City, Fukuoka Prefecture (1♂, 27.II.2016); and Kamiose, Fuji Town, Saga City, Saga Prefecture (2♂, 27.II.2016; 1♂, 5.III.2016). The eight males were kept individually in plastic cylinders with a piece of wet absorbent cotton and lichens from their habitat until tested for signal recordings.

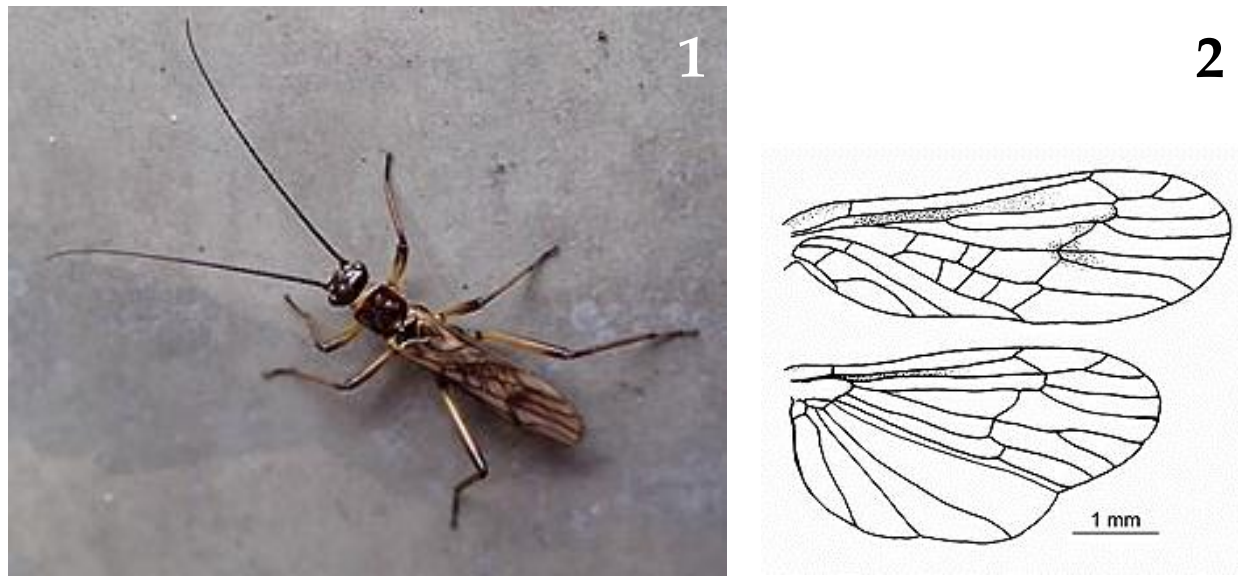


Fig. 1. Habitus of *Nemoura sefuriensis* sp. n. (female). Fig. 2. Right wings of *Nemoura sefuriensis* sp. n., typical venation.

The recording apparatus consisted of a paper box (6W × 12L × 4H cm, divided in two chambers of 6W × 6L × 4H cm by a partition wall) with a clear plastic cover, a contact microphone (Cony Electronics Service, Osaka, Japan) and a digital IC sound recorder (Sony, Tokyo, Japan). A male was placed alone in the chamber under signal recordings. The signals were analyzed using Sound it! 6.0 Basic (INTERNET Co. Ltd., Osaka, Japan). Terminology and signal characteristics follow that of Sandberg (2011) and Sandberg et al. (2015).

DESCRIPTION OF SPECIES

Nemoura sefuriensis sp. n.

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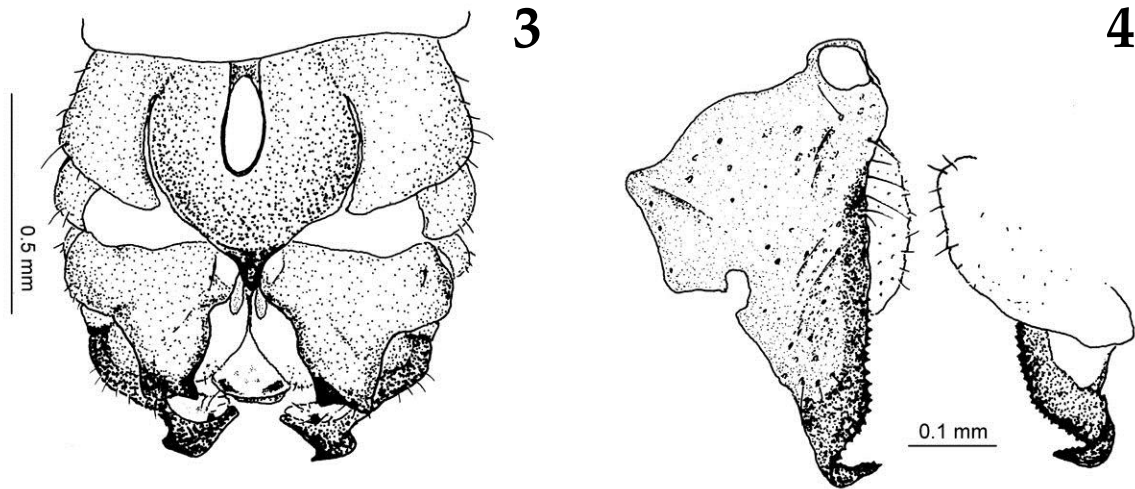
(Figs. 1–14)

Materials examined. Holotype ♂, Japan, Kyushu, Fukuoka Prefecture, Fukuoka City, Sawara Ward, Iiba, 33°28.73'N, 130°17.11'E, alt. 480 m, the Muromi River, 22.II.2014. Paratypes: 2♂, 5♀, collected with holotype; 2♂, Fukuoka Prefecture,

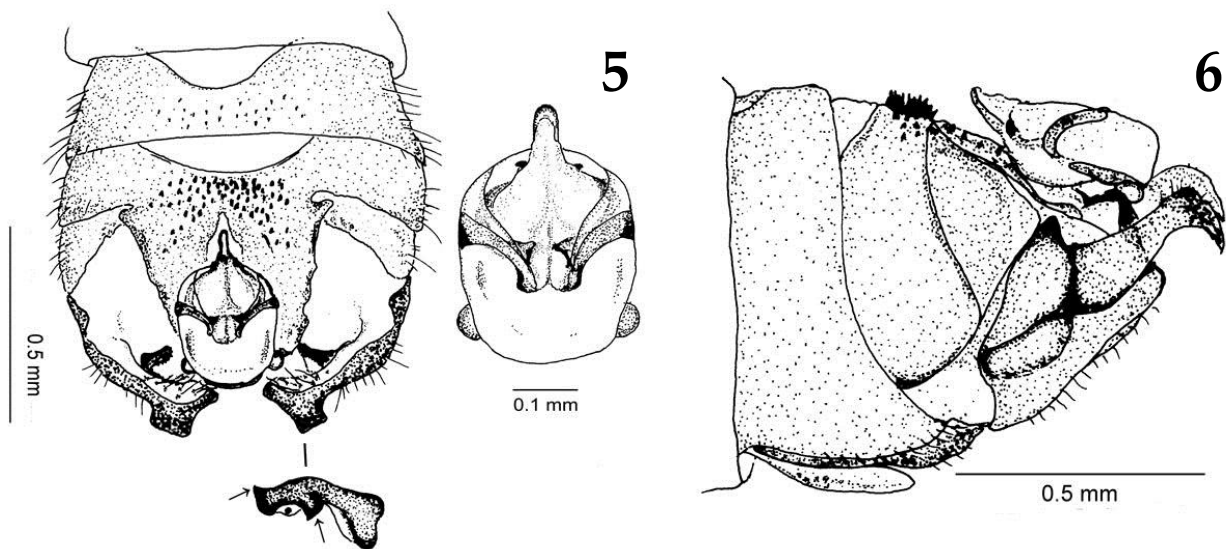
Itoshima City, Raizan, 33°29.63'N, 130°13.76'E, alt. 330 m, the Raizan River, 22.II.2015.

Additional materials. Japan, Kyushu: Iiba, Sawara Ward, Fukuoka City, Fukuoka Prefecture (type locality), the Muromi River, 21.II.2015, 5♂, 1♀; same locality, 22.II.2015, 3♀; same locality, 26.II.2015, 1♂; same locality, 15.III.2015, 2♂; same locality, 28.III.2015, 1♂; same locality, 27.II.2016, 2♂; same locality, 28.II.2016, 4♂, 3♀; same locality, 5.III.2016, 2♂; same locality, 13.III.2016, 1♀; same locality, 20.III.2016, 2♀; same locality, 27.III.2016, 1♂; same locality, 28.II.2017, 1♂ same locality, 4.III.2017, 1♀; Magaribuchi, Sawara Ward, Fukuoka City, Fukuoka Prefecture, 33°28.97'N, 130°17.34'E, alt. 410 m, the Muromi River, 22.II.2015, 2♂, 1♀; Raizan, Itoshima City, Fukuoka Prefecture, the Raizan River, 3.III.2012, 1♂, 1♀; same locality, 2.II.2015, 2♂; same locality, 2.III.2015, 1♂, 1♀; same locality, 13.II.2016, 1♂, 1♀; same locality, 27.II.2016, 1♂; same locality, 13.III.2016, 1♂, 1♀ (copulating pair); Hirogoura, Hoshino Village, Yame City, Fukuoka Prefecture, 33°13.34'N, 130°49.26'E, alt. 456 m, the Kumado River, 28.II.2016, 1♂; Kamiose, Fuji Town, Saga

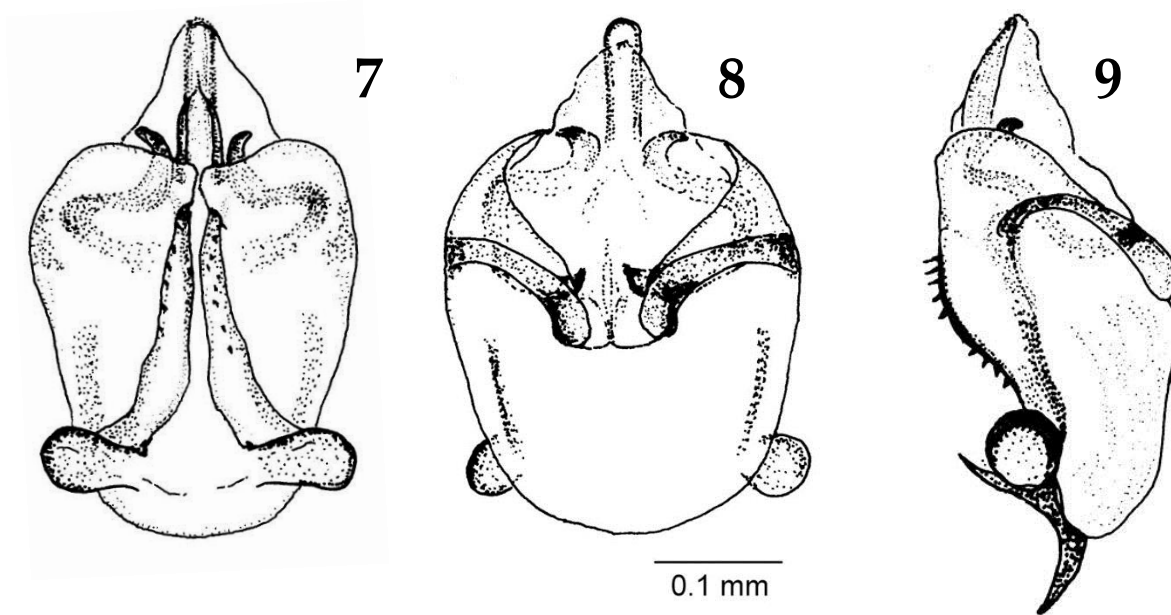
City, Saga Prefecture, 33°28.22'N, 130°16.21'E, alt. 515 m, the Hatsuse River, 2.II.2015, 6♂; same locality, 7.III.2015, 1♂, 1♀; same locality, 15.III.2015, 1♀; same locality, 13.II.2016, 3♂; same locality, 27.II.2016, 2♂, 2♀; same locality, 28.II.2016, 3♂, 1♀; same locality, 5.III.2016, 1♂; same locality, 20.III.2016, 1♂, 1♀ (copulating pair); same locality, 3.IV.2016, 1♀; same locality, 4.III.2017, 1♂.



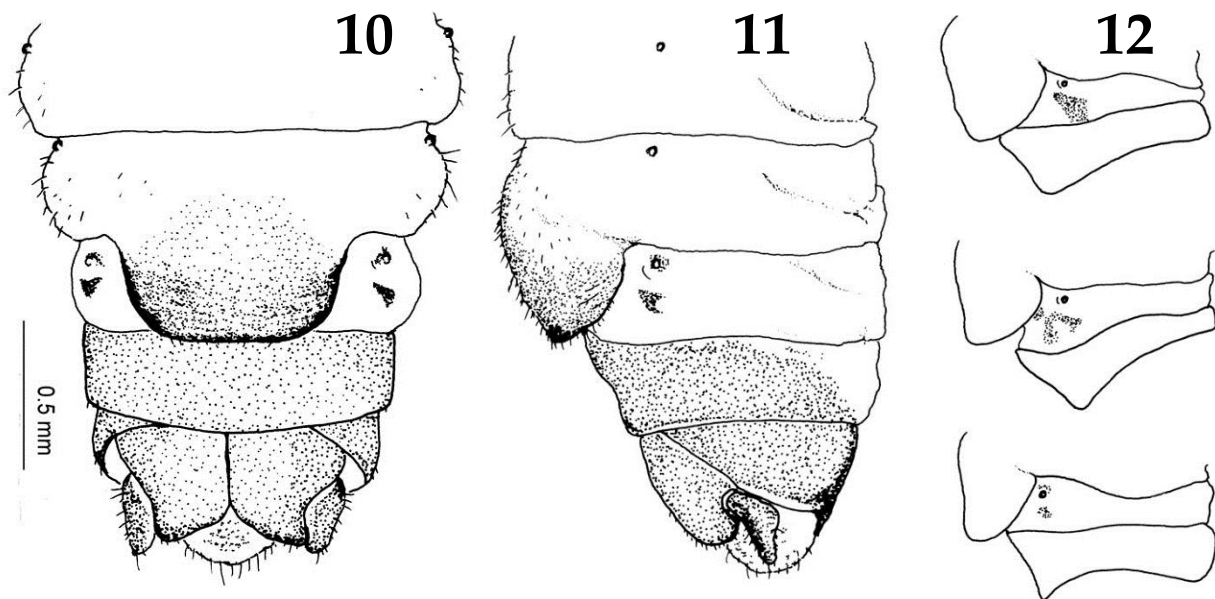
Figs. 3–4. *Nemoura sefuriensis* sp. n., male. 3. Terminalia, ventral view. 4. Outer lobe of right paraprot, ventral view (left) and dorsal view (right).



Figs. 5–6. *Nemoura sefuriensis* sp. n., male. 5. Terminalia, dorsal view, magnified epiproct, dorsal view, and right cercus, caudal view. 6. Terminalia, lateral view. Arrows = apical spines on cercus.



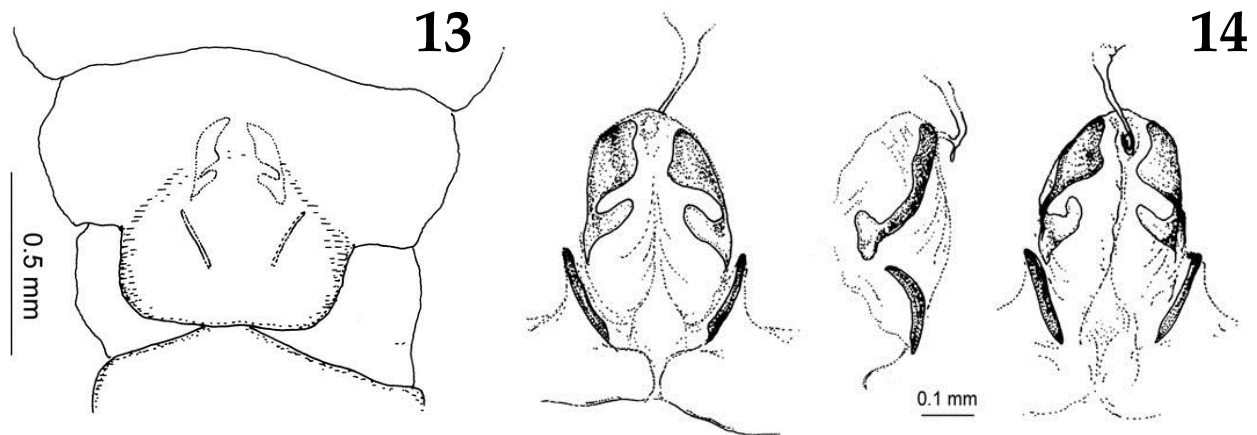
Figs. 7–9. *Nemoura sefuriensis* sp. n., male. 7. Epiproct, ventral view. 8. Epiproct, dorsal view. 9. Epiproct, lateral view.



Figs. 10–12. *Nemoura sefuriensis* sp. n., female. 10. Terminalia, ventral view. 11. Terminalia, lateral view. 12. Variation of a pair of weakly sclerotized areas on sternum 8, lateral view.

Diagnosis. This new species is macropterous, but has somewhat shorted wings in both sexes. The male is characterized by the following morphological features: oval epiproct with a slender

apical projection, tergum 10 bearing 40-80 blackish short bristles, and cerci having two sclerotized spines at the apices. The female has a pair of distinctive sclerites in the vagina and near the vulva.



Figs. 13–14. *Nemoura sefuriensis* sp. n., female. 13. Cleared terminalia, ventral view. 14. Inner vaginal sclerites, ventral view (left), lateral view (middle) and dorsal view (right).

Adult habitus. Macropterous, but wings somewhat shortened (Fig. 1). Wings subhyaline and slightly brownish, veins thick and dark brown, but basal part sometimes pale. Apical parts of both wings without the distinct X-patterns in venation; anal veins typical of the family (Fig. 2). General color dark brown. Legs yellowish, but coxae, basal and distal areas of femora and tibiae, and tarsi dark brown.

Male. Body 5.0–7.5 mm ($n = 30$) long. Forewing 5.0–6.0 mm ($n = 30$) long. Sternum 9: subgenital plate round and tapered subapically, with small triangular apex; vesicle slender, nearly half as long as subgenital plate (Fig. 3). Paraproct: inner lobe simple and small; outer lobe large and subtriangular, its apex extending dorsally and forming a dark sclerotized spine bent inward (Figs. 3–5); posterior inner margin and the apical spine of outer lobe minutely indented (Fig. 4). Terga 7–10 with membranous field oriented antero-mesally (Fig. 5). Tergum 10 concave below epiproct, with longitudinal membranous area in the midline; 40–80 blackish short bristles located mainly on the antero-mesal area (Figs. 5 & 6). Cercus strongly sclerotized on outer side, elongated and slightly bent inward with two-forked apex, each of which forming a strongly sclerotized spine (Figs 3 & 5); inner spine which is produced from cercus body minute and slightly

curved dorsally with a pointed end; outer spine having flat, subquadrilateral plate-like base extending ventrally, the end of which is pointed and bent inward (Figs. 5 & 6). Epiproct somewhat flattened dorsoventrally, oval in dorsal aspect, having a delicate membranous apical projection without scales or spines, which is supported ventrally by paired, slender sclerites (Figs. 5–9); short apico-ventral horns without spines and scales extending from inner arms to either side of the apical projection, and its apices curved outward (Figs. 7–9); keel-shaped ventral sclerites on both sides of the midline of the epiproct bearing spines (Figs. 8 & 9).

Female. Body 7.0–9.1 mm ($n = 15$) long. Forewing 6.0–7.0 mm ($n = 15$) long. Pregenital plate large, rectangular and bulging ventrally; posterolateral margins slightly bent (Figs. 10 & 11). Sternum 8 membranous with a pair of weakly sclerotized areas located postero-laterally; size and shape of the sclerotized areas variable (Figs. 10–12). Vagina membranous with a pair of sclerites; each sclerite consisting of broad, dark brown colored anterior part, narrow middle part and transverse, pale colored posterior part which is curved inward (Figs. 13 & 14). A pair of slender sclerites, which are slightly curved ventrally, located near the vulva (Fig. 14).

Larva. Unknown.

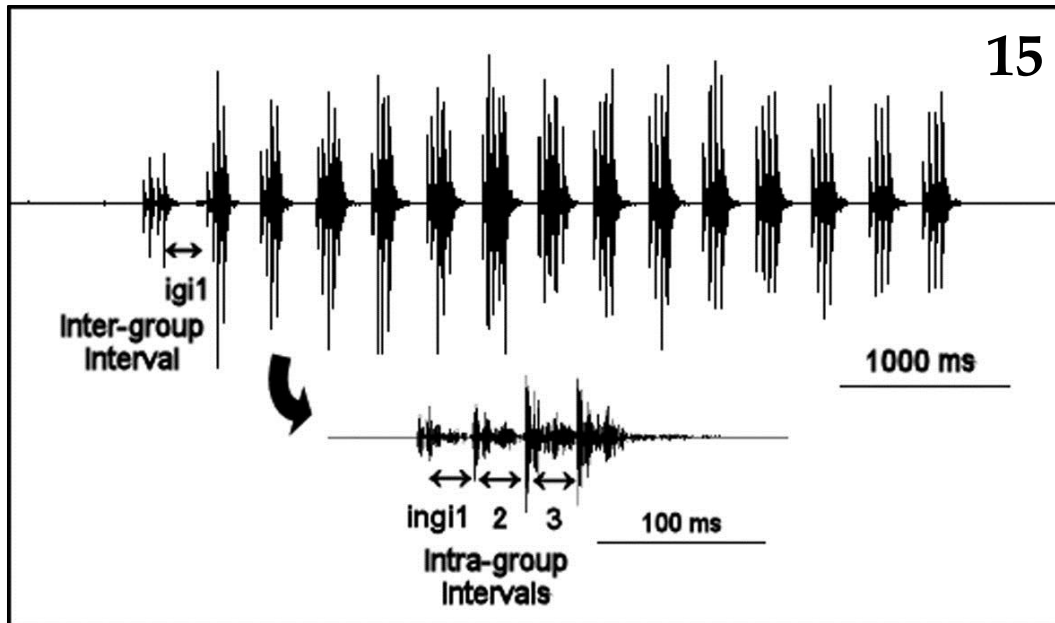


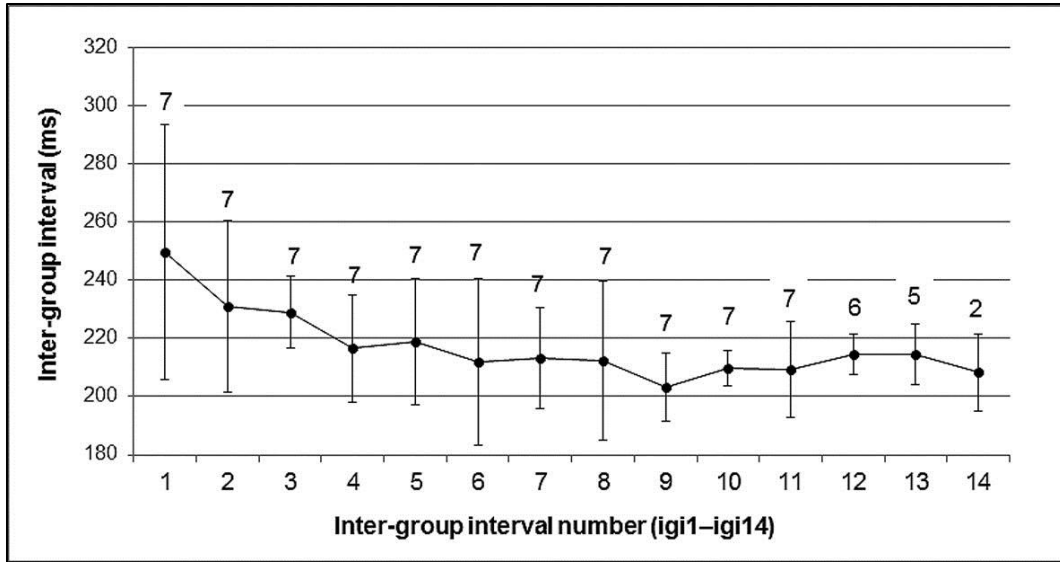
Fig. 15. *Nemoura sefuriensis* sp. n. male call signal composed of 15 beat groups (above) and the magnified third beat group consisting of four beats (below). igi = inter-group interval, ingi = intra-group interval.

Vibrational signals. Only seven signals were recorded from two males (three-day-old and four-day-old post-capture) at 16–17°C; female answer signals were highly variable and omitted from this preliminary description. The males produced grouped call signals (Fig. 15) using the ventral abdominal vesicle. Table 1 includes descriptive characters of male call signals under solitary condition. The male call signals were composed of

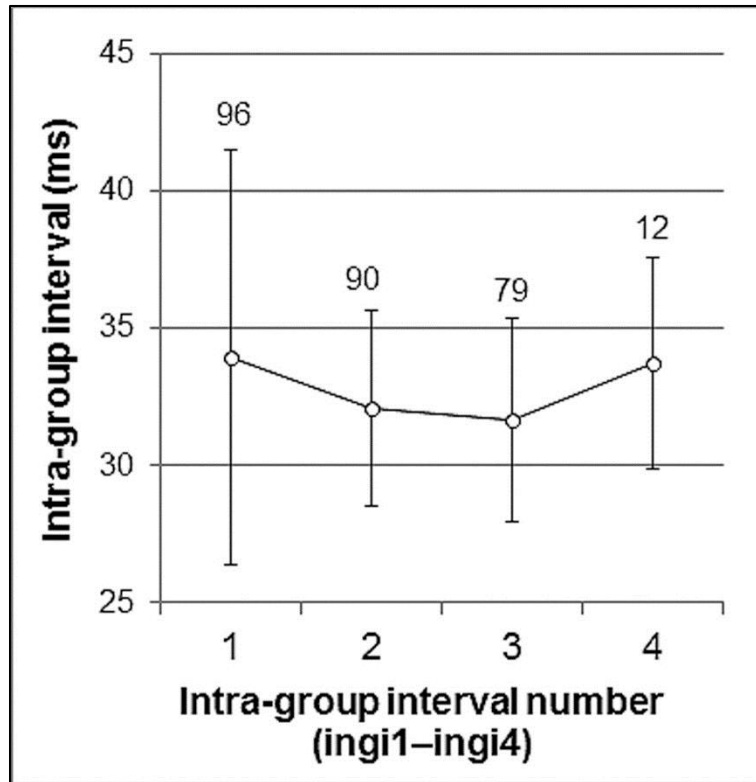
10–15 beat groups per signal (mean \pm SD = 13.4 ± 1.8) with 217.9 ± 23.7 ms inter-group intervals (Fig. 15, Table 1). The beat group had 1–5 beats (mean \pm SD = 4 ± 0.7) with 32.7 ± 5.4 ms intra-group intervals (Fig. 15, Table 1), and the beat group duration was 94.3 ± 19.7 ms (range = 30.48–135.33, $n = 96$). Total signal duration and total number of beats per signal were averaged 4094.8 ± 346.9 ms (range = 3508.4–4510.1, $n = 7$) and 53.4 ± 6.7 beats

Table 1. Male call signal data of *Nemoura sefuriensis* sp. n. at 16–17°C. The values are represented as mean \pm standard deviation (n = number of samples) and range. Interval patterns were determined by mean ID (a maximum – minimum interval difference): Horizontal (H) and varied beat interval (VB-I) patterns were determined by interval difference (ID) results less than or equal to 10 ms or greater than 10 ms, respectively (Sandberg 2011).

Num. of beats per group	Intra-group interval (ms)	Intra-group mean ID (ms) & interval pattern	Num. of beat groups per signal	Inter-group intervals (ms)	Inter-group mean ID (ms) & interval pattern
4 ± 0.7 ($n = 97$)	32.7 ± 5.4 ($n = 277$)	2.3 H	13.4 ± 1.8 ($n = 7$)	217.9 ± 23.7 ($n = 90$)	46.5 VB-I
1–5	20.3–68.2		10–15	178.5–330.2	



16



17

Figs. 16–17. Inter-group and intra-group interval patterns of grouped male call signals of *Nemoura sefuriensis* sp. n. 16. Varied inter-group interval pattern (inter-group mean ID = 46.5 ms > 10 ms mean ID). 17. Horizontal intra-group interval pattern (intra-group mean ID = 2.3 ms ≤ 10 ms mean ID). Circles and solid line = means, vertical solid lines = standard deviation, number above the standard deviation = number of intervals, igi = inter-group interval, ingi = intra-group interval.

(range = 43–64, $n = 7$), respectively. The inter-group mean interval difference was 46.5 ms ($249.7 - 203.2 = 46.5$ ms), and therefore the inter-group intervals were classified into varied interval pattern (Table 1). Initial inter-group intervals were decreased irregularly between beat groups 1–5 (igi1–igi4) with a 33.2-ms inter-group interval difference ($249.7 - 216.5 = 33.2$ ms), and the 4–14th inter-group intervals had a 15.7-ms inter-group interval difference ($218.9 - 203.2 = 15.7$ ms) (Fig. 16). The intra-group mean interval difference was 2.3 ms ($33.94 - 31.66 = 2.3$ ms), and therefore the intra-

group interval patterns were horizontal or even (Table 1, Fig. 17). The call description was a grouped call pattern with horizontal intra-group interval pattern and initially decreasing, then nearly even, varied inter-group interval pattern.

Ecological notes. *Nemoura sefuriensis* adults were collected from the upper reaches of rivers around 330–540 m above sea level. Adults were usually collected on the parapets of bridges and guard rails (Fig. 18), and sometimes on snow near the rivers from early February to early April in the Sefuri Mountains.



Fig. 18. Habitat of *Nemoura sefuriensis* sp. n.

Distribution. Japan (northern Kyushu).

Etymology. The specific name *sefuriensis* refers to the Sefuri Mountains where the new species was found.

Remarks. This new species is very similar to *Nemoura stratum* in adult habitus, but can be easily distinguished from *N. stratum* by the absence of a large sclerotized saddle-like prolongation on the hind margin of male terga 7 and 8, and by having a

mostly membranous female sternum 8 with a pair of small, weakly sclerotized areas. Sternum 8 on the female of *N. stratum* is mostly sclerotized (Kawai 1966). In addition, males of this new species have cerci with strongly sclerotized spines at their two-forked apices, paraprocts with darkly sclerotized spines at their apices in dorsal aspect, and the epiproct with a slender apico-mesal projection and a pair of horns extending from the

inner arms. On the other hand, male of *N. stratum* presents the cerci with mushroom-shaped tubercles at posterior tips and with hook-shaped anterior apices, simple paraprocts with blunt apices, and the epiproct with a simply tapered apex, lacking additional projections. The male terminal features of this new species are also similar to those of other *Nemoura cercispinosa* complex members, especially in following features: cerci enlarged bearing spines at apices; tergum 10 with large spines; and apical membranous projection of epiproct having a pair of longitudinal sclerites ventrally (Baumann 1975, Shimizu 1997).

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