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Two new species of *Satonius* Endrödy-Younga from China and notes on the wing polymorphism of *S. kurosawai* Satô (Coleoptera: Myxophaga: Torridincolidae)

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Abstract

Two new species of Torridincolidae from China, *Satonius fui* **sp. nov.** (Hubei) and *S. jaechi* **sp. nov.** (Fujian) are described, illustrated and compared with other species of the genus. The polymorphism of metathoracic wings was studied in the Japanese *S. kurosawai* (Satô, 1982), which macropterous form is presented here for the first time. In addition, new records of *S. stysi* Hájek & Fikáček, 2008 in China are also briefly mentioned.

Key words: taxonomy, new species, wing polymorphism, hygropetric habitats, China, Japan, Palaearctic region

Introduction

The genus *Satonius* Endrödy-Younga, 1997 originally described to accommodate a single Japanese species (*Delevea kurosawai* Satô, 1982), belongs to the family Torridincolidae. Members of the family are known predominantly from the Neotropical and southern Afrotropical zoogeographical regions (Beutel & Vanin 2005). Together with *Sphaerius* Waltl, 1838 (Sphaeriusidae) and *Hydroscapha* LeConte, 1874 (Hydroscaphidae), they represent the only representatives of the suborder Myxophaga in the eastern Palaearctic and Oriental regions (Hájek & Fikáček 2008, Fikáček & Šípková 2009, Falamarzi *et al.* 2010). Apart of the fact that the larvae and adults of *Satonius* live in hygropteric habitats (e.g. on the wet surface of rocks or on seepages) and that adults of several species possessed reduced metathoracic wings, the biology of *Satonius* remains largely unknown. The genus was revised by Hájek & Fikáček (2008) who described three new species from China, compared larval morphology of two species, illustrated the structure of metathoracic wing of the macropterous *S. stysi* Hájek & Fikáček, 2008, and discussed briefly adaptations of the genus for hygropetric habitats.

Recent extensive findings of *Satonius* in south-eastern China enable us to describe two additional species of the genus (both mentioned as unidentified species by Hájek & Fikáček (2008)) and provide additional data on the occurrence of *S. stysi* Hájek & Fikáček, 2008 previously known from the type locality only. The revision of the available material of the Japanese *S. kurosawai* (Satô, 1982) revealed the co-existence of macropterous and micropterous forms in this species. The macropterous form of *S. kurosawai* is recorded here for the first time and the observed patterns in the occurrence of both forms are briefly summarized.

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Material and methods

In the descriptions, we follow the style used in the revision of the genus by Hájek & Fikáček (2008), mentioning only the characters useful for identification and those in which the respective species differs from the general description of the genus. The taxonomic classification is based on males only as the diagnostic characters concern mainly male genitalia.

Male genitalia were mounted in dimethyl hydantoin formaldehyde resin (DMHF, water-soluble) on a clear celluloid label pinned under the beetle or on the same card as the beetle, or in Euparal resin (alcohol soluble) on a small piece of glass attached under the beetle. Drawings of male genitalia were prepared using a drawing tube attached to Olympus BX40 compound microscope. Exact label data are cited for the type material; a forward slash (/) separates different lines and a double slash (//) different labels of data; additional remarks are found in square brackets. Holotypes of the newly described species are provided with one red label with the following printed text: "HOLOTYPE / SATONIUS / "name of the species" **sp. nov.** / J. Hájek et al. det. 2010". Each paratype is provided with a red label similar to that of the holotype, except "PARATYPE" instead of "HOLOTYPE", and the respective tag number.

For the statistical testing of the differences in body size and proportions between micro- and macropterous forms of *S. kurosawai*, we used the Student's *t* test for equality of means; the statistics was calculated in the PAST programme (Hammer *et al*. 2001).

Material studied is deposited in the following institutional collections:

BMNH	The Natural History Museum [former British Museum], London, Great Britain (Maxwell V. L. Barclay);
CNCO	Canadian National Collections, Ottawa, Canada (Pat Bouchard);
EUMJ	Ehime University Museum, Matsuyama, Japan (Hiroyuki Yoshitomi);
USNM	National Museum of Natural History, Smithsonian Institution, Washington, DC, USA (Warren Steiner);
NHMW	Naturhistorisches Museum Wien, Austria (Manfred A. Jäch);
NMPC	Národní muzeum, Praha, Czech Republic (Jiří Hájek, Martin Fikáček);
SYSU	Institute of Entomology, Sun Yat-sen University, Guangzhou, China (Feng-long Jia);
ZSMC	Zoologische Staatssammlung, München, Germany (Michael Balke).

Systematics

Satonius fui sp. nov.

(Fig. 1)

Satonius sp. 2: Hájek & Fikáček 2008: 666 (note).

Type locality. China, Hubei province, Dabie Shan Mts., 31°07'06"N, 115°48'57"E, 640 m.

Type material. 41 specimens — Holotype: male (SYSU): "CHINA: Hubei province / Dabie Shan [Mts.], 640 m / 31°07'06''N, 115°48'57''E / V. Grebennikov leg. 11.–21.iv.2008 [printed]". Paratypes: 8♂♂ 6♀♀ and 26 unsexed specimens, same label data as holotype (BMNH, CNCO, EUMJ, USNM, NHMW, NMPC, ZSMC).

Additional material examined. 1♀, CHINA: Anhui, Huang Shan, 60 km NNW Tunxi, nr. Tang Kou, 900–1000 m, 31.x.1997, H. Schönmann leg. (CWBS 292) (NHMW).

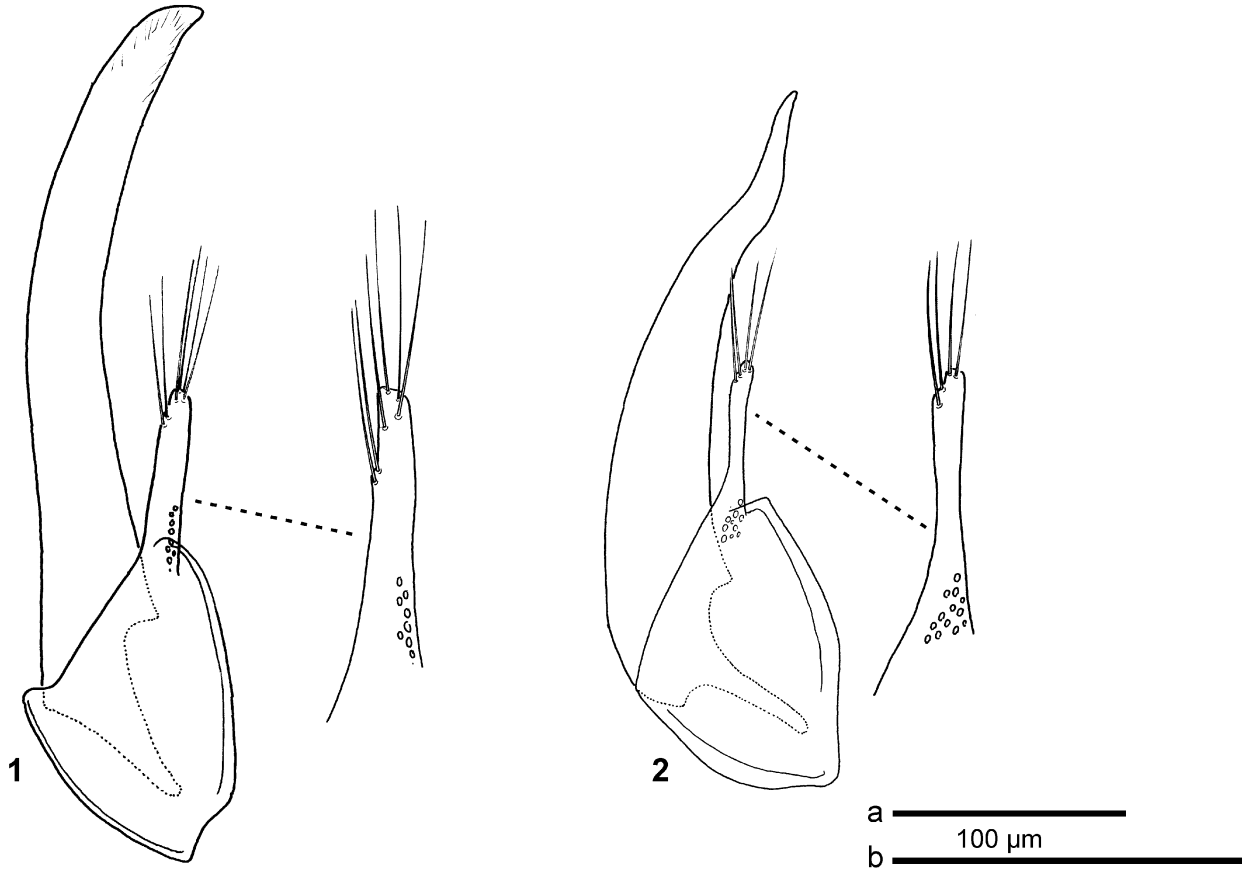
Diagnosis. Small, broad and moderately convex species; body length 1.6–1.7 mm, width 1.0–1.1 mm. Sides of pronotum slightly rounded, distinctly and broadly bordered; pronotum with longitudinal impressions between sides and disc. Lateral margin of elytra visible throughout elytral length except for apex. All above specimens are macropterous.

Male genitalia. Median lobe of aedeagus rather thin, almost parallel-sided subbasally, slightly bent ventrad at midlength, and indistinctly attenuating in apical part; apex with minute hook. Median lobe with minute pores subapically. Parameres short and stout, with four setae on apex and two located subapically, base with long field of pores along ventral surface (Fig. 1).

Bionomics. Collected in hygropetric habitats, in a thin film of water flowing on rock covered with a macroscopic algal mat (Figs 3–4).

Distribution. So far known from two localities in Hubei and Anhui provinces, China. The distance between localities is ca. 250 km (Fig. 7). The record from Anhui province needs to be confirmed by a male.

Etymology. The new species is dedicated to Professor Fu Xinhua (College of Plant Science and Department, Huazhong Agricultural University, Wuhan, P.R.China), for facilitating the V. Grebennikov's fieldwork during which this new species was collected.



FIGURES 1–2. Aedeagus and details of parameres of *Satonius* in lateral view. 1—*S. fui* **sp. nov.**; 2—*S. jaechi* **sp. nov.** Scales: a—aedeagus; b—detail of paramere.

Satonius jaechi sp. nov.
(Fig. 2)

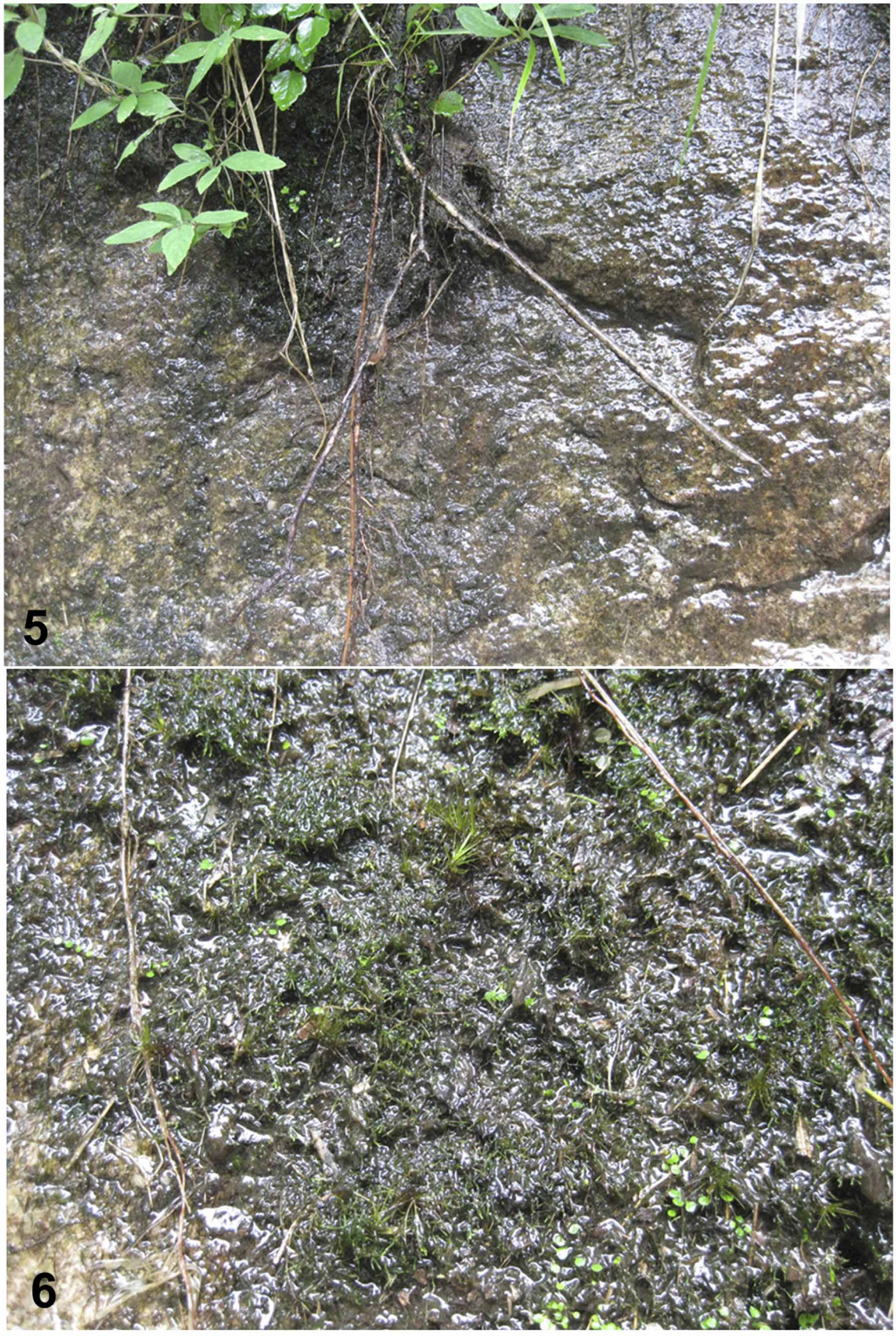
Satonius sp.: Jäch 1998: 51 (note).
Satonius sp. 1: Hájek & Fikáček 2008: 665 (note).

Type locality. China, Fujian province, Wuyi Shan Mts, Da'an, Upper Chongyang river, 27°57'32"N, 117°51'38"E, 444.5 m.

Type material. 63 specimens — Holotype: male (SYSU): "CHINA: Fujian, / Wuyishan, Da'An, Upper / Chongyang River, wet / cliff. Elev. 444.5m // 27°57'32"N, / 117°51'38"E / 15.7.2010 / Leg. F.L. Jia [printed]". Paratypes: 62 specimens, same label data as holotype (SYSU, NMPC, USNM); ♂: "CHINA: FUJIAN, Chong'an / Wuyi Shan, 1 km W Wuyi Gong / 250m, 15.–18.1.1997 / leg. Ji & Wang (CWBS 240) [printed]" (NHMW).

Diagnosis. Very small, broad and convex species; body length 1.2–1.4 mm, width 0.8–0.9 mm. Sides of pronotum slightly rounded, narrowly bordered. Lateral margin of elytra visible only in humeral part. We have studied metahoracic wings in 16 specimens, of which 15 are micropterous and only one macropterous.

FIGURES 3–4. Habitat of *Satonius fui* **sp. nov.** 3—type locality, Dabie Shan; 4—detail of habitat with adults of *S. fui* **sp. nov.** Photos V. Grebennikov.



FIGURES 5–6. Habitats of *Satonius jaechi* **sp. nov.** at the type locality Wuyi Shan Mts. (Fujian). Photos F.-L. Jia.

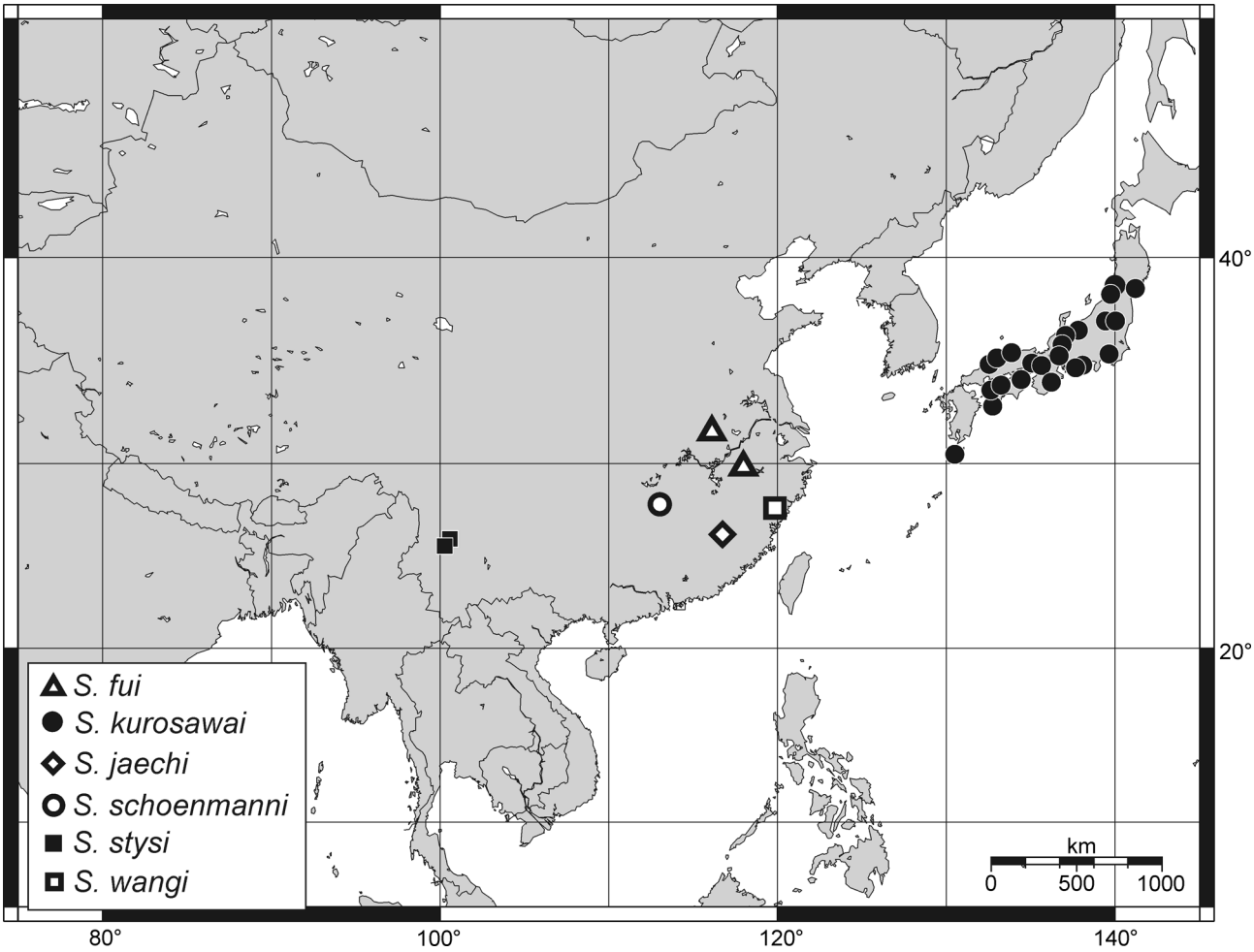


FIGURE 7. Known distribution of *Satonius* species.

Male genitalia. Median lobe of aedeagus with apical portion bent dorsad; paramere narrow, with four apical setae, basal portion with wide field of pores on lateral surface (Fig. 2). We consider differences between presently figured specimen and specimen mentioned by Hájek & Fikáček (2008: Fig. 9) as an intraspecific variability.

Bionomics. All specimens were collected on wet rocks with dense algae mats (Figs 5–6), together with representatives of three genera of the family Hydrophilidae: *Oocyclus*, *Enochrus* and *Coelostoma*.

Distribution. So far known only from two close localities in Wuyi Shan Mts., Fukien province, China (Fig. 7).

Etymology. The new species is dedicated to our colleague Manfred A. Jäch (NHMW), a specialist on Hydraenidae and Dryopoidea.

***Satonius kurosawai* (Satô, 1982)**

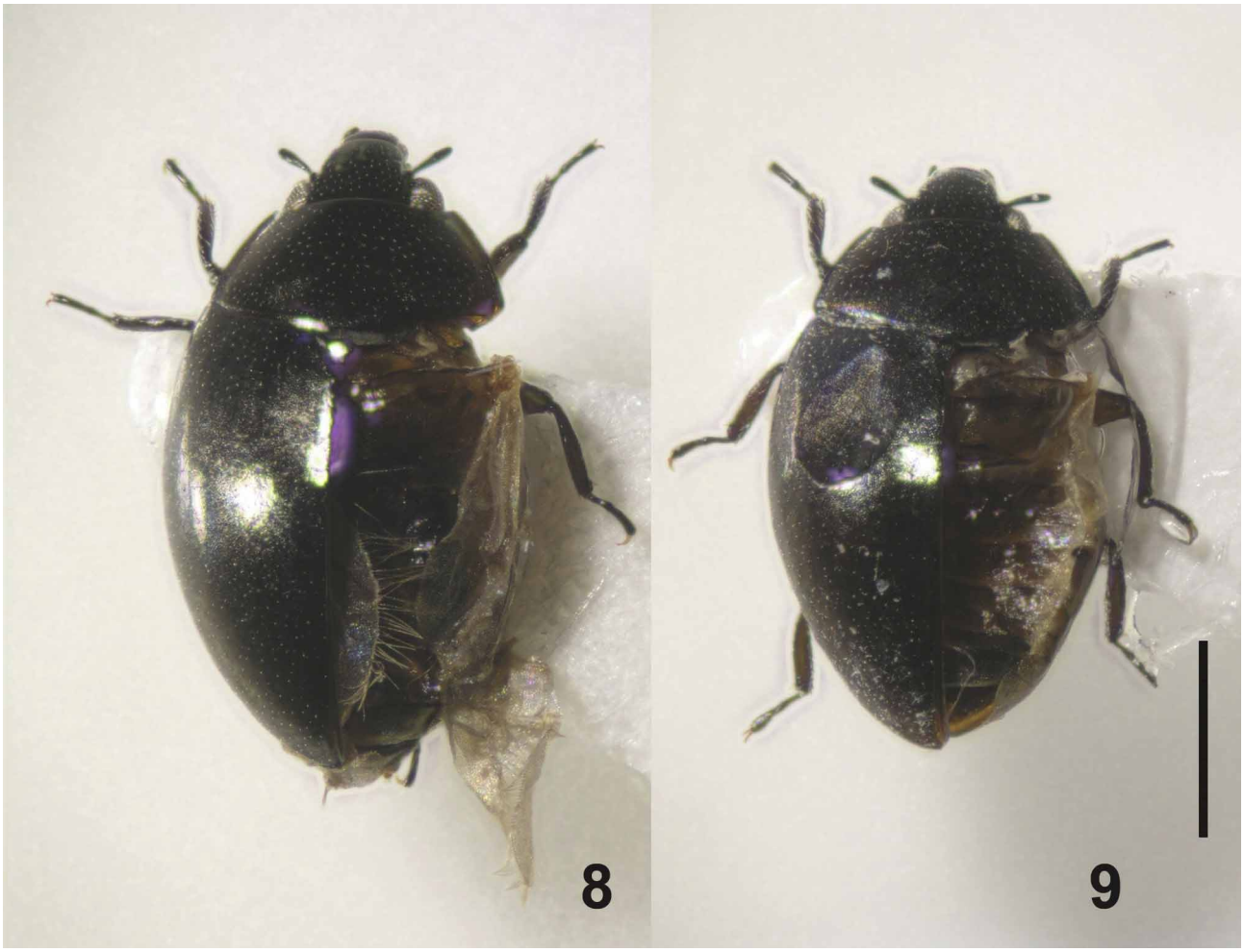
(Figs. 8–11)

Delevea kurosawai Satô, 1982: 279 (original description).
Satonius kurosawai: Endrödy-Younga 1997: 318 (redescription); Hájek & Fikáček 2008: 662 (redescription).

New material examined (see Table 1 for all known records). ***Macropterous form:*** **HONSHÛ:** GIFU PREFECTURE: 1 spec., Shagatate-yama, Ibigawa-cho, 30.iv.2006, K. Kitayama leg. HYÔGO PREFECTURE: 2 spec., Aotani-gawa, Maya-san, Kobe-shi, 16.vi.2008, I. Tanaka leg.; 1 spec., same data, but 24.vi.2006, T. Saito leg.; 1 spec., Koujin-gawa, Kiyoshikoujin, Takarazuka-shi, 17ix.2007, I. Tanaka leg. OSAKA PREFECTURE: 2 spec., Minoo, 11.ix.2007, I. Tanaka leg. SHIMANE PREFECTURE: 32 spec., Shakunouchi, Kitsuki-cho, Unnan-shi, 23.xii.2006, M. Hayashi leg.; 10 spec., same data, but 8.i.2007; 1 spec., same data, but 17–29.vi.2006, flight intercept trap. TOTTORI PREFEC-

TURE: 32 spec., Ohuchi, Houki-cho, 4.iv.2008, M. Hayashi leg. **SHIKOKU:** EHIME PREFECTURE: 2 spec., Syukuno, Matsuyama-shi, 5.v.2002, T. Kurihara leg. All specimens deposited in EUMJ.

Micropterous form: **HONSHÛ:** FUKUSHIMA PREFECTURE: 6 spec., Asakusa-dake, Tadami-machi, 19.viii.1999, N. Hikida leg. GIFU PREFECTURE: 1 spec., Hirano, Motosu-cho, 23.x.2004, Y. Kamite leg. SHIMANE PREFECTURE: 10 spec., Hagiwara, Hikimi-cho, 17.ix.2003, T. Ogata leg.; 10 spec., Kawashita, Kawashita-cho, Izumo-shi, 23.xii.2006, M. Hayashi leg. SHIZUOKA PREFECTURE: 2 spec., Sakuma-cho, 3.iii.1999, H. Yoshitomi leg. TOTTORI PREFECTURE: 10 spec., Daimyo-bashi, Daisen-cho, 3.v.2007, M. Hayashi leg. YAMAGATA PREFECTURE: 3 spec., Kaname, Oguni-machi, 14.x.2002, T. Ogata leg.; 9 spec., Kami-tazawa, Tsuruoka-shi, 14.ix. 2007, T. Ogata leg.; 17 spec., Arasawa, Tsuruoka-shi, 14.ix.2007, Y. Kamite leg.; 7 spec., Hokorobi-sawa, Tsuruoka-shi, 14.ix.2007, Y. Kamite & T. Ogata leg. All specimens deposited in EUMJ.



FIGURES 8–9. Habitus of *Satonius kurosawai* (Satô). 8—macropterous form; 9—micropterous form. Scale bar 0.5 mm.

Morphology of micro- and macropterous form (see Satô (1982) and Endrödy-Younga (1997) for detailed description of external characters of *S. kurosawai*).

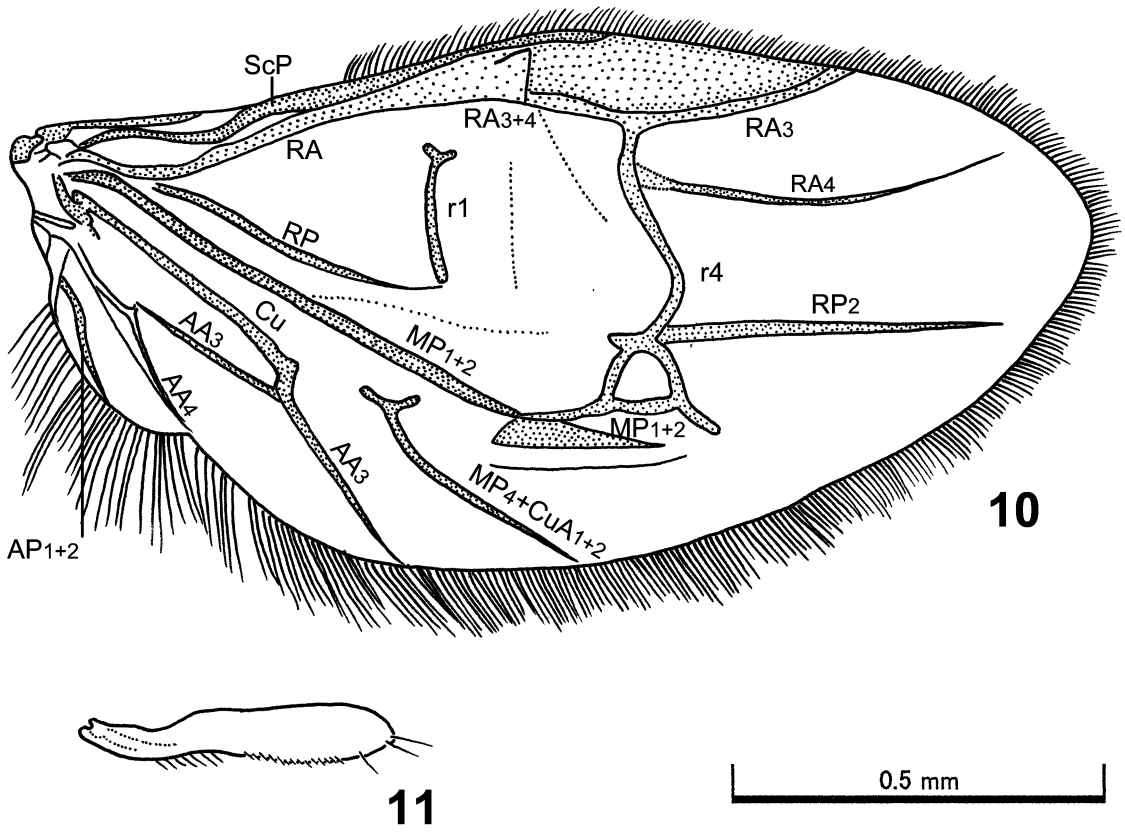
Macropterous form. Generally bigger than micropterous form (Fig. 8), see Table 2 for measurements. Maximum length of the metathoracic wing ca 1.5 mm, maximum width ca. 0.8 mm; the wing (Fig. 10) is similar to that of *Satonius stysi* in shape and venation, but differs in the following characters: length/width ratio = ca 0.52 (ca 0.46 in *S. stysi*); RP long, reaching r1 (not reaching r1 in *S. stysi*); RP_{3+4} absent.

Micropterous form. Smaller than macropterous form (Fig. 9), see Table 2 for measurements. Metathoracic wing scale-like (Fig. 11), only ca 0.4 mm long and 0.1 mm wide. Specimens with intermediate sized metathoracic wing were not observed.

Bionomics. The species lives in hygropetric habitats, e.g. on wet surfaces of natural rocks and artificial concrete walls near small streams or roadsides.

TABLE 1. List of all known records of *Satonius kurosawai* (Satô).

Hind wing	Locality	Latitude (N)	Longitude (E)	Environment	Reference
micropt.	Atsumi-cho, Yamagata	38.373959	139.35275	natural rock	Satô (1982)
micropt.	Yakurai-onsen, Miyagi	38.343151	140.42187	natural rock	Satô (1982)
micropt.	Hokorobi-sawa, Tsuruoka-shi, Yamagata	38.324092	139.553422	concrete wall	present paper
micropt.	Kami-tazawa, Tsuruoka-shi, Yamagata	38.311716	139.474075	concrete wall	present paper
micropt.	Maya-san, Yamagata	38.31125	139.434	natural rock	Satô (1982)
micropt.	Arasawa, Tsuruoka-shi, Yamagata	38.30305	139.473461	concrete wall	present paper
micropt.	Momogawa-toge, Niigata	38.085562	139.313544	natural rock	Satô (1982)
micropt.	Kaname, Oguni-machi, Yamagata	38.053067	139.481457	natural rock	present paper
micropt.	Asakusa-dake, Tadami-machi, Fukushima	37.205259	139.141145	unknown	present paper
micropt.	Minami-aizu, Fukushima	37.120688	139.462528	natural rock	Satô (1982)
unknown	Ohsawano-cho, Toyama	36.335856	137.124221	concrete wall	Takai (1999)
micropt.	Hakusan, Ishikawa	36.093619	136.46049	natural rock	Satô (1982)
micropt.	Izumi-mura, Fukui	35.554294	136.412678	natural rock	Satô (1982)
MACROPT.	Syagatate-yama, Ibigawa-cho, Gifu	35.453465	136.211907	concrete wall	present paper
micropt.	Yokoyama-dam, Fujihashi-mura, Gifu	35.362639	136.274462	concrete wall	Yoshitomi (1997)
micropt.	Hirano, Motosu-shi, Gifu	35.353807	136.375514	river	present paper
micropt.	Kawashimo-cho, Izumo-shi, Shimane	35.264531	132.443834	natural rock	Hayashi (2007)
micropt.	Gakuenji, Besso-cho, Izumo-shi, Shimane	35.252365	132.445879	natural rock	Hayashi (2007)
micropt. MACROPT.	Daisen, Tottori	35.23279	133.315104	natural rock, concrete wall	Hayashi & Kadowaki (2007)
MACROPT.	Kitsuki-cho, Unnan-shi, Shimane	35.172164	132.544631	concrete wall	Hayashi (2007)
micropt.	Sakuma-cho, Shizuoka	35.045755	137.473268	concrete wall	present paper
MACROPT.	Kenashi-yama, Shobara-shi, Hiroshima	35.012135	133.021681	unknown	Akiyama (2008)
micropt.	Hourai-ko, Hourai-cho, Aichi	35.00384	137.390138	natural rock	Yoshitomi (1997)
micropt.	Yumesaki-cho, Hyogo	35.000648	134.400368	natural rock	Satô (1982)
MACROPT.	Minoo, Osaka	34.510078	135.28198	concrete wall	present paper
MACROPT.	Kiyoshikoujin, Takarazuka-shi, Hyogo	34.484662	135.211183	concrete wall	present paper
MACROPT.	Maya-san, Kobe-shi, Hyogo	34.440414	135.120831	concrete wall	present paper
MACROPT.	Kobe-shi, Hyogo	34.433079	134.58435	natural rock	Saito (2006)
micropt.	Hagiwara, Masuda-shi, Shimane	34.343729	132.013935	natural rock	present paper
unknown	Chichigatani, Miyagawa-mura, Mie	34.12436	136.094694	unknown	Saito & Narukawa (1986)
MACROPT.	Daisenzan, Mannou-cho, Kagawa	34.072845	133.563708	concrete wall	Kamite (2003)
unknown	Tamatani-cho, Matsuyama-shi, Ehime	33.535429	132.5017	natural rock	Kamite (2003)
MACROPT.	Syukuno, Matsuyama-shi, Ehime	33.521764	132.494019	unknown	present paper
micropt.	Namerikawa, Ehime	33.471518	133.000298	natural rock	Satô (1982)
unknown	Omogodam, Omogo-mura, Ehime	33.430188	133.015855	natural rock	Kamite (2003)
micropt.	Shiratani, Yakushima, Kagoshima	30.234471	130.335624	natural rock	Hayashi & Fujiwara (2007)
micropt.	Shakagatakeyama, Asahigawa valley, Nara	34.114398	135.903046	natural rock	Hájek & Fikáček (2008)



FIGURES 10–11. Metathotracic wings of *Satonius kurosawai* (Satô). 10—macropterous; 11—micropterous.

Distribution. Widely distributed in the Japanese islands of Honshû (prefectures Aichi, Fukui, Fukushima, Gifu, Hiroshima, Ishikawa, Hyôgo, Mie, Miyagi, Nara, Niigata, Osaka, Shizuoka, Shimane, Tottori, Toyama, Yamagata), Shikoku (prefectures Ehime and Kagawa) and Yakushima (Fig. 12). The distribution of the macropterous form seems to be limited to western (west from 137°E) or southern (south from 36°N) parts of Honshû and Shikoku.

TABLE 2. Measurements of *Satonius kurosawai* (Satô). EL—length of elytra in suture, EW—maximum width of elytra, PL—length of pronotum, PW—maximum width of pronotum in posterior angles, TL—total body length (EL+PL). *—statistically significant difference in the mean values.

	Macropterous form (n =20)	Micropterous form (n = 20)	Student's *t* test *p*-value
TL (mm)	1.21–1.52 (1.39)	1.15–1.44 (1.28)	<0.001*
PW (mm)	0.65–0.80 (0.73)	0.63–0.73 (0.69)	<0.001*
PL (mm)	0.23–0.32 (0.29)	0.23–0.31 (0.28)	<0.001*
EL (mm)	0.97–1.20 (1.10)	0.90–1.13 (1.00)	<0.001*
EW (mm)	0.85–1.02 (0.95)	0.75–0.98 (0.89)	<0.001*
PW/PL	2.34–3.00 (2.56)	2.32–2.91 (2.51)	0.36
EL/EW	1.05–1.24 (1.16)	1.00–1.27 (1.13)	0.06
EL/PL	3.50–4.48 (3.88)	3.21–4.13 (3.63)	<0.01*
EW/PW	1.25–1.37 (1.31)	1.12–1.34 (1.28)	0.08
TL/EW	1.35–1.56 (1.46)	1.31–1.57 (1.44)	0.27

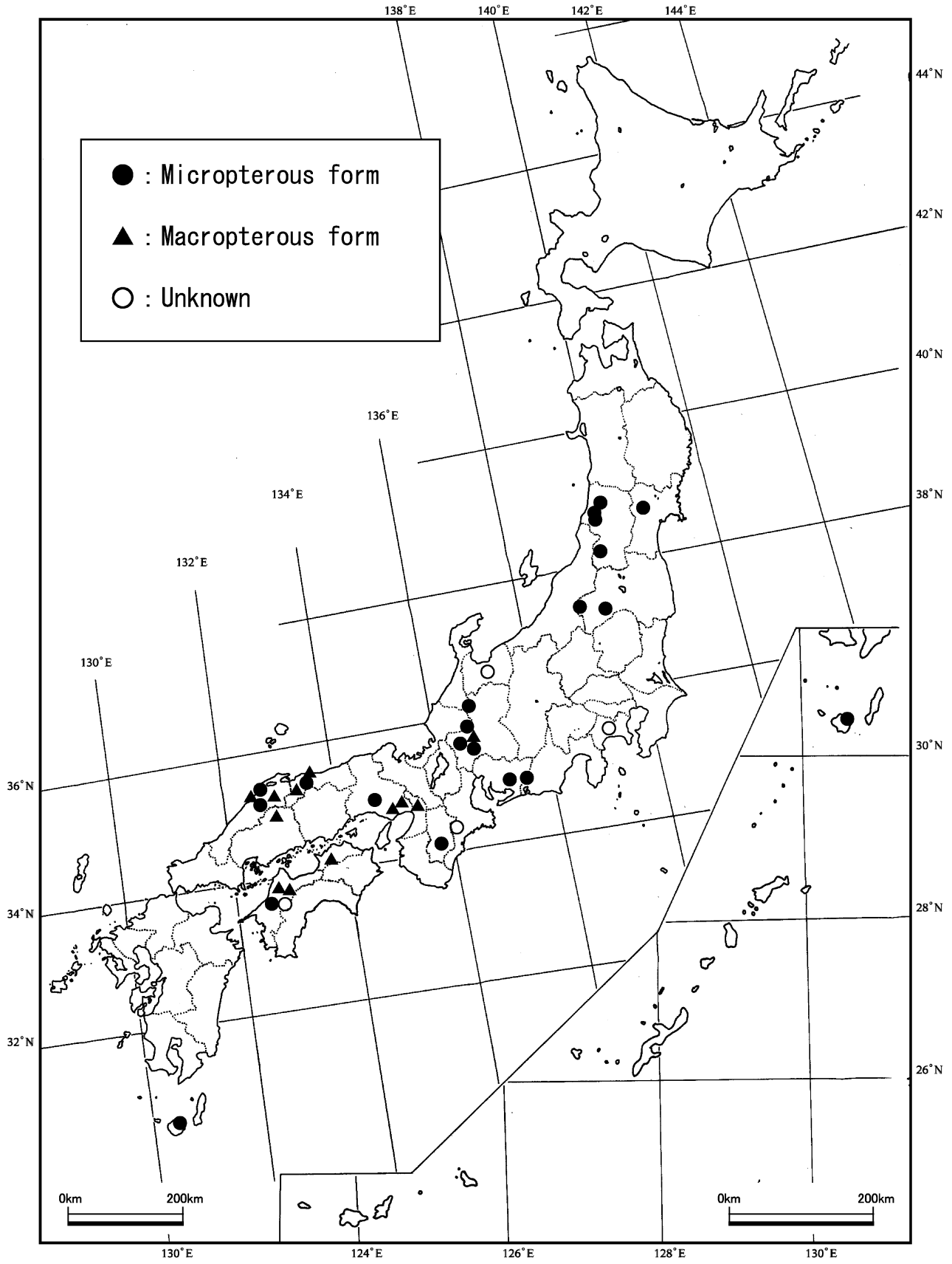


FIGURE 12. Distribution of macro- and micropterous forms of *Satonius kurosawai* (Satô).

Satonius stysi Hájek & Fikáček 2008

Satonius stysi Hájek & Fikáček, 2008: 663 (original description).

Additional material examined. 27 spec., China, Yunnan prov., Cang Shan Mts, 25°41'N, 100°08'E, 2600 m, V. Grebennikov leg. (CNCO, EUMJ, NMPC, SYSU, ZSMC).

Remarks. This species was previously known only from the type locality in Jizu Shan Mt., Yunnan province, China. The locality from which the species is recorded here is situated in a different mountain range ca. 40 km SW from Jizu Shan.

Discussion

The specimens of *S. kurosawai* examined for this study were not collected with the intention to analyse the biology of the species and mostly bear only very basic data on the collecting circumstances. This prevents us from an exhaustive analysis of the wing polymorphism of the species, but still allows us to trace some patterns, which are worthy to be mentioned and further studied.

Hájek & Fikáček (2008) found that both micropterous and macropterous species exist in the genus *Satonius* and suggested that a low number of macropterous specimens should be present even in micropterous species to make their dispersal to new habitats possible. We find support for this hypothesis here for the Japanese species *S. kurosawai* and can moreover document that the macropterous specimens are actually capable of flight, based on a macropterous specimen collected by a flight intercept trap in Shakunouchi (Shimane Pref.). However, in contrast to the expectations by the above authors, the macropterous specimens are rather frequent in *S. kurosawai* and were not collected at the same locality as micropterous specimens in most cases—the only exception is the locality of Daisen, Tottori (see Table 1). In addition, body size differs significantly between macro- and micropterous forms. All this indicates that the importance of the wing morphology and body size for species recognition may be more limited than originally supposed (Hájek & Fikáček 2008).

Based on our data, the micropterous form prevails in relatively permanent and stable habitats represented by waterfalls on streams and rivers and flowing over natural rocks (77% of localities). In contrast, the macropterous form was found more frequently in temporary artificial habitats, typically represented by wet concrete walls along roads (86% of localities). This pattern seems to be, however, limited to the southern part of the species range as no macropterous specimens are known north of 36°N and only micropterous beetles were collected from both types of habitats (waterfalls and concrete road walls) in the north. The absence of winged *S. kurosawai* from northern areas resembles the latitudinally delimited flightlessness reported for various insect groups (e.g., Roff 1990) including some Japanese beetles (Ohta *et al.* 2009) and usually interpreted as a result of the trade-off between the flight capability (dispersal) and reproduction under climatic conditions at higher latitudes (Zera & Denno 1997, Ohta *et al.* 2009). More data are necessary to reveal if the same is the case of *S. kurosawai.*

Both macro- and micropterous forms were collected throught the season (from March to November), but each locality listed was sampled only once and no data on the wing morphology at a single locality throughout a year are available. Hence, although we may possibly exclude a simple seasonality in wing morphology over the whole range of *S. kurosawai*, we cannot exclude the wing polymophism to be locally seasonal or co-driven by seasonality and other factors.

In conclusion, we present the first set of data showing that the dispersal ability and the related wing polymorphism may play an important role in the biology of the myxophagan beetles. It is also evident that the problem deserves further and more detailed studies, possibly including more species of *Satonius* and incorporating the data on the immatures on the sampled sites.

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