

Host plant, Larva and Life History of *Pamphilius brevicornis ibukii* (Hymenoptera, Pamphiliidae) in Honshu, Japan

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Abstract Based on field observations and rearing experiments in Nagano and Gunma prefectures in central Honshu, Japan, we record the host plants and life history of a leaf-rolling sawfly, *Pamphilius brevicornis ibukii* Shinohara, 1995, for the first time. The larva is a solitary leaf-roller on *Betula ermanii*, *B. corylifolia* and *B. platyphylla* var. *japonica* [Betulaceae]. The late-instar and mature larvae are well characterized by the dark chocolate brown head and the richly black-marked thorax and last segment of the abdomen. The egg is laid always on the side vein of upper surface of the leaf, and the larval leaf roll is made always on the upper side of the leaf. The larval leaf-roll is peculiar in that the both ends are equally open with silk threads and the larva consumes the leaf at both ends of the roll.

Key words: host plant, life history, *Pamphilius brevicornis ibukii*, *Betula* spp., Japan.

Introduction

A leaf-rolling sawfly, *Pamphilius brevicornis* Hellén, 1948, was described as a variety of *Pamphilius histrio* Latreille, 1812, from Karelia and Irkutsk, Russia (Hellén, 1948). Kontuniemi (1958) first treated it as a full species and all the subsequent authors (e.g. Beneš, 1972; Shinohara, 1995a) agreed with him. Beneš (1972) recorded the species from huge areas in Eurasia ranging from Belgium to Kamchatka. Shinohara (1995a) recorded the species also from Japan and treated the Japanese populations as a separate subspecies, *P. brevicornis ibukii*. All through its vast distributional range, the species appears rare and only several collection records have been published (Kontuniemi, 1965; Beneš, 1972; Achterberg and Aartsen, 1986; Shinohara and Taeger, 1990; Shinohara, 1995a, b). The immature stages and host plant are unknown, though Achterberg and Aartsen (1986) mentioned “the circumstances of collection in The Netherlands suggest it may feed on *Populus tremula* L.” (p. 38).

On August 8, 2008, H. Kojima discovered a strange pamphiliid larva feeding on *Betula ermanii* Cham. [Betulaceae] on Mt. Motoshiranesan at an altitude of 2020 m in Gunma prefecture, central Honshu, Japan and reared it. The larva was strange not only because of its peculiar color pattern but also because of its peculiar feeding habit as described below. A female pamphiliid emerged on May 13, 2009, and A. Shinohara determined it as *Pamphilius brevicornis ibukii*. As a result of subsequent searches for the larvae on higher mountains of Nagano and Gunma prefectures in 2009 to 2016, H. Kojima found one egg and 58 additional larvae on three species of *Betula* and obtained nine females and three males by rearing them. Here we report on the rearing records and observations on the biology of *P. brevicornis ibukii*.

Materials and Methods

Adult specimens examined are as follows (all kept in the National Museum of Nature and Sci-

ence, Tsukuba): HOKKAIDO: 1 ♀ 4 ♂, Asahidake-onsen, 1050 m, 43°38'55"N 142°47'29"E, Higashikawa town, 25–28. VI. 2001, A. Shinohara; 1 ♂, same locality, 25–28. VI. 2002, A. Shinohara; 2 ♂, same locality, 25–28. VI. 2003, A. Shinohara; 3 ♂, Akadake Ginsendai, 1430 m, 43°40'31"N 142°57'39"E, Kamikawa town, 12–14. VII. 2001, A. Shinohara; 1 ♂, same locality, 17–18. VII. 2002, A. Shinohara; 1 ♂ (paratype), Yamada-onsen, 800 m, Tokachi, 21. VI. 1990, A. Shinohara; 1 ♂, Yamada-onsen, 1040 m, 43°19'32"N 143°06'01"E, Shikaoi Town, 22–24. VI. 2000, H. Hara; 1 ♂, Yamada-onsen, 825 m, 43°18'37"N 143°07'31"E, Shikaoi Town, 16. VI. 2011, A. Shinohara; 1 ♂ (paratype), Horoshika-toge, 1100 m, Tokachi, 9. VII. 1994, A. Shinohara; 1 ♂ (paratype), Nakayama-toge, 800 m, Shiribeshi, 26. VI. 1987, A. Shinohara; 1 ♂, Mt. Yokotsudake, 990 m, 41°55'19"N 140°45'52"E, Nanae town, 19–22. VI. 2007, A. Shinohara; 2 ♂, same locality, 20–22. VI. 2007, H. Hara; 5 ♂, same locality, 18–19. VI. 2008, A. Shinohara; 1 ♂, same locality, 18–19. VI. 2008, H. Hara; 1 ♂, same locality, 26. VI. 2009, H. Hara. HONSHU: 1 ♀ (paratype), Utsukushinomori, 1400 m, Mts. Yatsugatake, Yamanashi prefecture, 31. VII. 1973, S. Ibuki; 1 ♀, Fukinotaki, 1860 m, 36°37'24"N 138°27'20"E, Takayama village, Nagano prefecture, 12. VII. 2011, H. Kojima; 1 ♀, Mt. Kasadake, Yamanouchi town, Nagano prefecture, 16. VII. 2012, H. Kojima; 1 ♂, same locality, 8. VII. 2014, H. Kojima; 1 ♀, Yamada-bokujo, Takayama village, Nagano prefecture, 8. VII. 2014, H. Kojima; 1 ♀, Ikenotaira, 2010 m, 36°25'01"N 138°26'23"E, Tomi city, Nagano prefecture, 29. VII. 2016, A. Shinohara; 1 ♀, Mt. Motoshiranesan, Kusatsu town, Gunma prefecture, 19. VII. 2013, H. Kojima; 1 ♀ (holotype), Mt. Hakusan, Ishikawa prefecture, 13. VI. 1975, I. Togashi.

Field observations were made and the egg and larval materials were collected in the following localities: Nagano prefecture: Takayama village: Mt. Kenashiyama, 1830–1840 m (around 36°36'39"N 138°26'55"E); Mt. Omeshidake, 1850–1880 m (around 36°37'24"N 138°27'19"E);

Mt. Oinokuradake, 1910 m (around 36°38'23"N 138°26'50"E). Yamanouchi town: Mt. Kasadake, 1740–1880 m (around 36°40'36"N 138°28'40"E); Okushiga-kogen, 1530–1560 m (around 36°45'41"N 138°32'21"E); Mt. Yokoteyama, 2040–2170 m (around 36°40'14"N 138°31'13"E). Hakuba village: Mt. Kotoomiyama, 1840 m (around 36°39'26"N 137°48'13"E). Tomi city: Ikenotaira, 2000 m (around 36°25'02"N 138°26'18"E). Gunma prefecture: Tsumagoi village/Kusatsu town: Mt. Motoshiranesan, 1980–2150 m (around 36°37'52"N 138°32'05"E). Nakanajo town: Mt. Ikenotoyama, 2170 m (around 36°39'39"N 138°32'07"E).

Rearing experiments were performed by H. Kojima in Kitanagaike, Nagano city, Nagano prefecture, at an altitude of 335 m. In order to count the number of molts during the larval stage, each leaf-roll was examined every day and cast skins were collected when present. On maturity, each larva was released to an individual jar containing ordinary untreated soil. The temperature and day length of the rearing room were not controlled, except that the highest temperature was set at 25°C.

Photographs were taken with digital cameras, Nikon D3200 (Fig. 2A–D), Nikon D70 (E–H), Olympus Stylus TG-4 Tough (Fig. 2I, J), Nikon Coolpix S5100 (Fig. 2K). The digital images were processed and arranged with Adobe Photoshop Elements® 9 and 15 software. For the larval morphological terminology, we followed Viitasaari (2002a, b).

Results and Discussion

Field observations and rearing records.

Tables 1 and 2 and Fig. 1 summarize rearing records of one egg and 58 larvae collected in the field in 2008 to 2016. A total of nine female and three male adults emerged. Besides these, five female and one male adults were collected in the field in 2011 to 2016 (see specimens examined). One female that emerged on May 20, 2012 (8 in Table 1) laid two eggs and one female collected on July 8, 2014 laid one egg in captivity. All the

Table 1. List of individuals of *P. brevicornis ibukii* reared from larvae in Nagano and Gunma prefectures in 2008–2013 by H. Kojima.

	Collection date		Locality	Altitude	Host plant	Maturation date	MLL	Emergence date	Sex
1	2008	VIII 8	Mt. Motoshiranesan	2020 m	BE	IX 3	19 mm	2009 V 13	♀
2	2009	VIII 21	Mt. Ikenotoyama	2170 m	BE	D			
3	2011	VII 27	Mt. Ikenotoyama	2170 m	BE	VIII 18	20 mm	2012 V 18	♀
4	2011	VIII 4	Mt. Motoshiranesan	2080 m	BE	VIII 21	20 mm	2012 V 23	♀
5	2011	VIII 4	Mt. Motoshiranesan	2140 m	BE	VIII 25	20 mm		
6	2011	VIII 4	Mt. Motoshiranesan	2140 m	BE	VIII 19	17 mm		
7	2011	VIII 4	Mt. Motoshiranesan	2150 m	BE	D			
8	2011	VIII 4	Mt. Motoshiranesan	2150 m	BE	VIII 20	18 mm	2012 V 20	♀
9	2011	VIII 4	Mt. Motoshiranesan	2150 m	BE	VIII 20	21 mm		
10	2011	VIII 4	Mt. Motoshiranesan	2150 m	BE	D			
11	2011	VIII 5	Mt. Kasadake	1880 m	BE	VIII 14	20 mm	2012 V 13	♀
12	2011	VIII 11	Mt. Ikenotoyama	2170 m	BE	VIII 25	17 mm		
13	2011	VIII 11	Mt. Yokoteyama	2040 m	BE	VIII 25	19 mm	2012 V 18	♀
14	2012	VIII 7	Mt. Motoshiranesan	2150 m	BE	D			
15	2012	VIII 15	Mt. Kasadake	1880 m	BC	VIII 21	17 mm	2013 V 19	♀
16	2013	VII 22	Mt. Kasadake	1870 m	BE	VIII 10	18 mm		
17	2013	VII 22	Mt. Kasadake	1870 m	BE	VIII 10	16 mm		
18	2013	VII 27	Mt. Omeshidake	1850 m	BC	D			
19	2013	VII 30	Mt. Motoshiranesan	2150 m	BE	D			
20	2013	VII 30	Mt. Motoshiranesan	2150 m	BE	D			
21	2013	VIII 8	Mt. Kasadake	1740 m	BE	VIII 18			
22	2013	VIII 8	Mt. Kasadake	1740 m	BE	VIII 21	16 mm	2014 V 1	♂
23	2013	VIII 8	Mt. Kasadake	1740 m	BE	VIII 21	15 mm	2014 V 8	♂
24	2013	VIII 8	Mt. Kasadake	1870 m	BE	VIII 18	13 mm		
25	2013	VIII 8	Mt. Kasadake	1870 m	BE	VIII 23	17 mm		
26	2013	VIII 9	Mt. Motoshiranesan	1980 m	BE	D			
27	2013	VIII 9	Mt. Motoshiranesan	1980 m	BE	D			
28	2013	VIII 9	Mt. Motoshiranesan	2130 m	BE	VIII 23	18 mm		
29	2013	VIII 9	Mt. Motoshiranesan	2130 m	BE	VIII 28	14 mm		
30	2013	VIII 9	Mt. Motoshiranesan	2150 m	BE	D			
31	2013	VIII 20	Mt. Kasadake	1870 m	BE	VIII 30	18 mm	2014 IV 28	♀
32	2013	VIII 26	Mt. Motoshiranesan	1980 m	BE	IX 1	15 mm		
33	2013	VIII 26	Mt. Omeshidake	1880 m	BE	VIII 30	16 mm	2014 V 1	♂
34	2013	VIII 26	Mt. Omeshidake	1880 m	BE	D			

Signs: BE: *Betula ermanii*. BC: *Betula corylifolia*. BP: *Betula platyphylla* var. *japonica*. MLL: Mature larva length. D: Dead before maturation.

attempts to rear the eggs to the adults failed.

Life history. The field observations and rearing records given above indicate that *P. brevicornis ibukii* has a univoltine life cycle as in other *Pamphilius* species. The subspecies has been found at an altitude of 800 to 1430 m in Hokkaido and 1400 to 2170 m in central Honshu (see Materials and Methods and Tables 1, 2). The adults were collected in mid June to late July, the larvae were found in mid July to late August, and they matured in early August to early September (Tables 1, 2).

Eggs. We have examined four living eggs (three deposited by a female in captivity and one found in the field) and 45 egg shells. In all cases, one egg or egg shell each was found on the side vein of upper surface of the leaf, never situated in the other parts of the leaf. Three eggs, which were just deposited, were greenish and covered with thick layer of yellowish sticky substance. One egg found in the field (No. 48 in Table 2 and Fig. 1 and Fig. 2A) just before hatching (Fig. 1) was yellowish and covered with thin layer of sticky substance. Of the 45 egg shells examined,

Table 2. List of individuals of *P. brevicornis ibukii* reared from an egg (n. 48) or larvae (all others) in Nagano and Gunma prefectures in 2014–2016 by H. Kojima.

	Collection date		Locality	Altitude	Host plant	Maturation date	MLL	Emergence date	Sex
35	2014	VIII 21	Mt. Kasadake	1870 m	BE	VIII 31	14 mm		
36	2014	VIII 21	Mt. Kasadake	1870 m	BC	IX 2	19 mm	2015 V 7	♀
37	2015	VIII 4	Mt. Kasadake	1870 m	BC	D			
38	2015	VIII 4	Mt. Kasadake	1870 m	BE	VIII 20	18 mm		
39	2015	VIII 8	Mt. Kotoomiyama	1840 m	BC	D			
40	2015	VIII 19	Mt. Kenashiyama	1830 m	BE	VIII 25	20 mm		
41	2015	VIII 19	Mt. Kenashiyama	1830 m	BE	IX 1	18 mm		
42	2015	VIII 22	Mt. Kasadake	1870 m	BE	VIII 25	20 mm		
43	2016	VII 17	Okushiga-kogen	1530 m	BE	D			
44	2016	VII 17	Okushiga-kogen	1530 m	BE	D			
45	2016	VII 17	Okushiga-kogen	1530 m	BE	D			
46	2016	VII 20	Okushiga-kogen	1560 m	BE	D			
47	2016	VII 27	Mt. Omeshidake	1860 m	BE	D			
48	2016	VII 23	Mt. Kenashiyama	1840 m	BE	D			
49	2016	VII 26	Mt. Kenashiyama	1840 m	BE	D			
50	2016	VII 27	Mt. Omeshidake	1860 m	BE	VIII 6	21 mm		
51	2016	VIII 5	Mt. Kasadake	1770 m	BE	D			
52	2016	VIII 5	Mt. Kasadake	1870 m	BE	D			
53	2016	VIII 5	Mt. Kasadake	1870 m	BE	VIII 15	12 mm		
54	2016	VIII 5	Mt. Kasadake	1870 m	BE	D			
55	2016	VIII 5	Mt. Kasadake	1870 m	BE	D			
56	2016	VIII 5	Mt. Kasadake	1870 m	BE	D			
57	2016	VIII 11	Ikenotaira	2000 m	BP	VIII 28	18 mm		
58	2016	VIII 19	Mt. Oinokuradake	1910 m	BE	IX 2	20 mm		
59	2016	VIII 24	Mt. Yokoteyama	2170 m	BE	IX 1	15 mm		

Signs: BE: *Betula ermanii*. BC: *Betula corylifolia*. BP: *Betula platyphylla* var. *japonica*. MLL: Mature larva length. D: Dead before maturation.

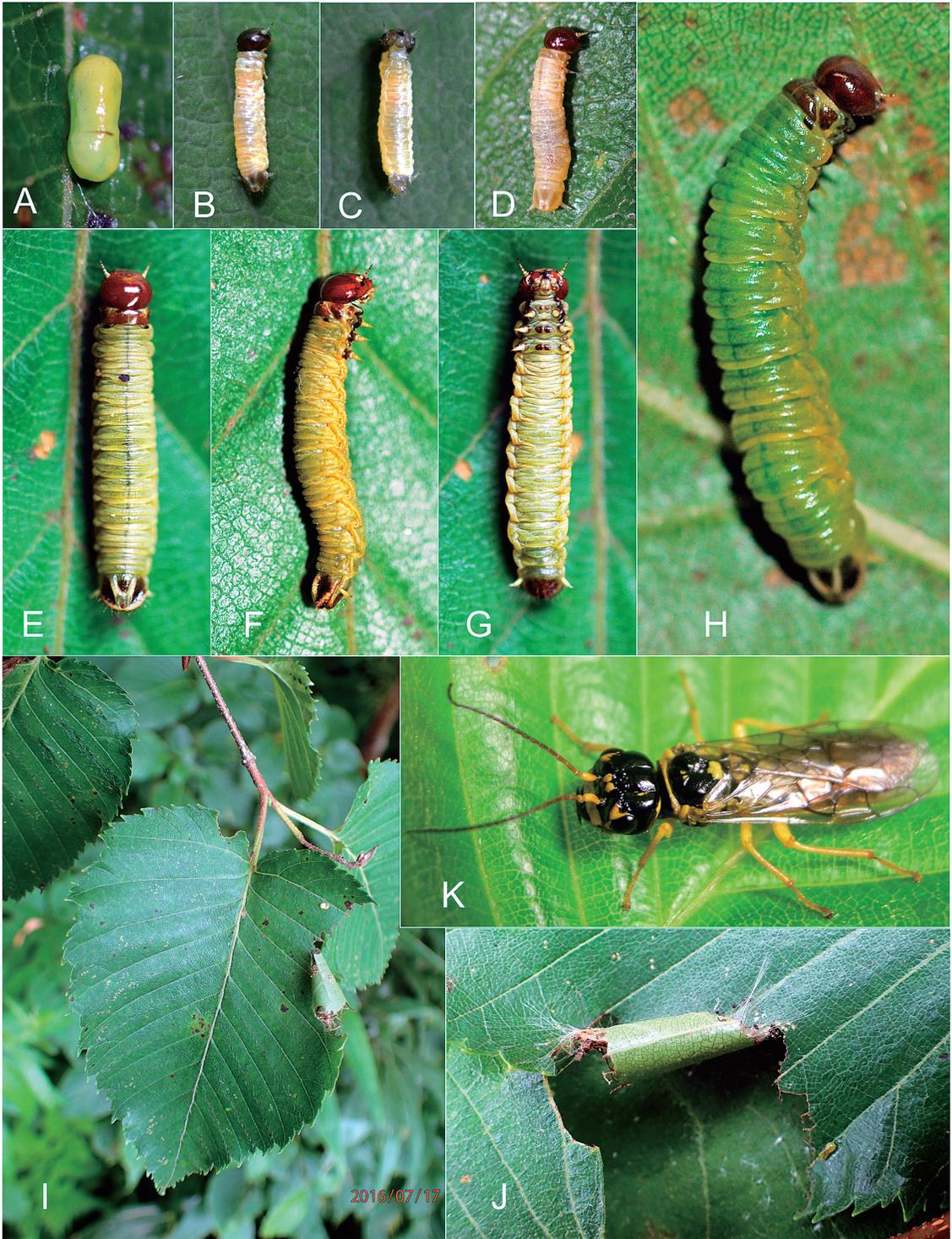
25 were more or less yellowish and 20 were whitish.

Larva. *Early instars* (Fig. 2B–D): Head black; trunk creamy white; terminal segment darkened. *Late instar* (Fig. 2E–G): Head dark chocolate brown; mandible dark chocolate brown with black apex; stemmatum black; antenna dark brown, areas between antennomeres creamy white; trunk pale greenish yellow; prothoracic shield large, concolorous to head, covering most of ventral and lateral parts of prothorax, broken into very large dorsal plate and smaller three pairs of lateral plates; small elongate spot on last lateral annulet of prothorax, cervical sclerite, large lateral spot at base of each leg and spot between them, each coxa, and paired median spots on each thoracic sternum black; thoracic legs, except for coxae, and subanal appendage (except for blackish apical segment) concolorous

to trunk; three depressed areas of suranal plate mostly and most of subanal plate black. *Mature larvae* (Fig. 2H): Length about (12–)15–16 mm in male, 17–20(–21) mm in female; similar to the preceding, but trunk vivid pale green, with lateral margins, last annulet of each segment and caudal part yellowish.

Tables 1 and 2 show that the mature larvae 15–16 mm long were males and those 17–20 mm long were females. This agrees with Shinohara *et al.*'s (2016) observation that the male mature larvae were smaller than the female mature larvae in *Pamphilius ishikawai* Shinohara, 1979, and the length of the mature larvae can be used for identifying the sex of the mature larvae. We suppose, among the mature larvae which did not become adults, those 12–14 mm long were males and those 17–21 mm long were females.

Larval leaf rolls. The larval leaf rolls were



1, 2). *Betula ermanii* is apparently preferred as a host of *P. brevicornis ibukii*.

For the nominotypical subspecies, Achterberg and Aartsen (1986) mentioned “the circumstances of collection in The Netherlands suggest it may feed on *Populus tremula* L.” (p. 38). This is a simple speculation without relevant evidence. *Pamphilius brevicornis* belongs to the *P. histrio* group (Shinohara, 1995a), whose members are, as far as is known, associated with the Salicaceae, *Salix* or *Populus* (Shinohara, 2002). The newly found host plant relationship of *P. brevicornis ibukii* with *Betula* spp. (Betulaceae) was therefore unexpected and it has shown that the host spectrum of the *P. histrio* group includes at least two plant families, Salicaceae and Betulaceae.

Comparison with the other species in larval stage. The late instar and mature larvae are well characterized by the dark chocolate brown head, the large dark chocolate brown prothoracic shields, which cover most of the prothorax, the elongate black spot on each side of the last annulet of the prothorax, the paired black spots on the sternum of each thoracic segment, and the largely black terminal abdominal segment. These characters will easily separate the larvae of *P. brevicornis ibukii* from the other known larvae of *Pamphilius*. The late instar larva of *P. montanus montanus* Shinohara, 1985, has a similar color pattern of the head, thorax and caudal part of the abdomen, but the head and dark area of the thorax are black, not dark chocolate brown. The larvae of *P. montanus montanus* are gregarious web-spinners on *Sorbus commixta* Hedl. [Rosaceae] (Shinohara and Kojima, 2011), whereas those of *P. brevicornis ibukii* are solitary leaf-rollers on *Betula*.

Three other *Pamphilius* species are known to feed on *Betula*, *P. varius* (Serville, 1823), *P. pallipes* (Zetterstedt, 1838) and *P. masao* Shinohara, 2005. Of these, the late-instar larvae of two species, *P. varius* and *P. pallipes*, are pale-colored, having no dark brown or black areas on the head and trunk (Viitasaari, 2002b). The larva of *P. masao* has not been described, but a published monochrome photograph (fig. 33B in Shinohara, 2005) shows that the head is black and the black areas on the thorax are small and the black marks on the last abdominal segment are missing or inconspicuous.

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Fig. 2. *Pamphilius brevicornis ibukii*, egg (A), larvae (B–H), larval leaf-rolls (I, J) and female adult (K) on *B. ermanii*; numbers in parentheses refer to the individual numbers in Table 1. A, Mt. Kenashiyama, 23 VII 2016 (no. 48); B, C, first instar, Mt. Omeshidake, 29 VII 2013 (no. 18); D, third instar, 1 VIII 2016 (no. 48, dead on 31 VII); E, F, G, late instar, Mt. Ikenotoyama, 1 IX 2009 (no. 2); H, mature larva, Mt. Motoshiranesan, 3 IX 2008 (no. 1); I, J, larval leaf-roll, Okushiga-kogen, 17 VII 2016; K, female adult, reared from larva collected on Mt. Motoshiranesan (no. 8, emerged on 20 V 2012), 4 VI 2012. Photographed by H. Kojima (A–H, K) and A. Shinohara (I, J).

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