

Occurrence of *Borearctia menetriesii* (Eversmann, 1846) (Erebidae: Arctiinae) in Northern European Russia: a new locality in a disjunct species range

Ivan N. Bolotov*, Mikhail Yu. Gofarov, Yulia S. Kolosova & Artyom A. Frolov

Institute of Ecological Problems of the North, Ural Branch of the Russian Academy of Sciences, Northern Dvina Emb., 23, 163000 Arkhangelsk, Russian Federation

* corresponding author; inepras@mail.ru

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Abstract. Disjunctive distribution is typical for the transpalaearctic tiger moth *Borearctia menetriesii* (Eversmann, 1846) (Erebidae: Arctiinae) at the present time. The new discovery at the East European (Russian) Plain modifies the previously known distribution pattern of this species. A specimen of this moth was recorded on a small patch of a humid mixed-herb meadow on the forest karst landscape of the White Sea-Kuloi Plateau. Its location is in the upper part of the Sotka River Valley and is surrounded by northern primary forest of spruce with inclusions of larch patches. It is characterised by a cold microclimate. This paper summarises data on previously known localities of *B. menetriesii* that are situated mainly within the Russian Federation and analyses the species distribution using Bailey's Ecoregions system.

Introduction

The Menetries's Tiger Moth *Borearctia menetriesii* (Eversmann, 1846) (Erebidae: Arctiinae) is one of the rarest species of Palaearctic tiger moths and disjunctive distribution is typical for it (Dubatolov 1984, 2010; Kurentzov 1965, 1973). Contemporary data include the following areas in this species range: Europe: Middle-Finland; European Russia: Karelia and Ural Mountains; Siberia: lower Ob river, the Altai and Sayan Mountains, Baikal, Transbaikalia, Evenkia and Yakutia; Kazakhstan: northeastern region; Far Eastern Russia: northern region of Amur basin, Sikhote-Alin Mountains and Sakhalin Island (Dubatolov 1996, 2010; Dubatolov & Gordeeva 2005; Ermakov 2006; Nupponen & Fibiger 2012; Saarenmaa 2012).

Single specimens were found in most of the listed localities (Dubatolov 1984, 2009, 2010; Koshkin 2010; Krogerus 1944; Marttila et al. 1996; Shodotova et al. 2007; Silvonen 2010). Sometimes, the records are separated from each other by decades, for example in Finland (Fabritius 1914; Krogerus 1944; Marttila et al. 1996; Lappi et al. 2004; Silvonen 2010) and Sakhalin Island (Hori 1926; Klitin 2009). In recent times (i.e. 21st century) species records are known for Finland (Lappi et al. 2004; Silvonen 2010) and Russia: Yamal-Nenets District (Gorbunov & Olschwang 2012), North Ural Mountains (Ermakov 2006; Nupponen & Fibiger 2012), Kuznetsky Alatau Mountains (Sutchev & Skalon 2012), Transbaikalia (Saarenmaa 2012), Sikhote-Alin Mountains (Silvonen 2010) and Sakhalin Island (Klitin 2009).

The largest gap in the species range is situated in the territory of north-eastern Europe: in the West there are only a few localities in East Fennoscandia and in the East

we know only of North Ural and Western Siberian records (Dubatolov 2004, 2010; Ermakov 2006; Nupponen & Fibiger 2012).

Larval development of *B. menetriesii* was described for the first time by Krogerus (1944) and was recently illustrated in detail via in vitro observations (Saarenmaa 2012). The aim of the present paper is to analyse the distribution range of *B. menetriesii* in the light of the first species record from the White Sea-Kuloi Plateau, Northern European Russia.

Material and methods

The White Sea-Kuloi plateau is the largest karst region of Northern European Russia, with an area of approximately 24,000 km^2. The average plateau altitude varies from 70 to 140 m.a.s.l. (Gofarov et al. 2006). Lower Permian gypsum and anhydrite rocks form the eastern part of the plateau and intensive karst processes occur in this area.

The karst landscape environment on White Sea-Kuloi Plateau has specific ecological conditions and the most important are the following: (1) high relief heterogeneity: alternating karst craters and ravines, deep incised river valleys, rock outcrops, slide-rocks and caves with perennial subterranean ice; (2) high levels of stream flow and low levels of waterlogging; (3) significant microclimate variability, from very cold to warm conditions, which is determined by a high complexity of vegetation cover; (4) high mineralisation of ground waters and domination by carbonate-rich soils in the soil coverage; (5) high activity of exogenous geological processes (karst formation) and soil erosion (Puchnina et al. 2000; Shvartsman & Bolotov 2008).

Siberian spruce (*Picea abies* ssp. *obovata* (Ledeb.) Domin, Pinaceae) and larch (*Larix sibirica* Ledeb., Pinaceae) primary forests dominate the vegetation cover. According to data from Pinega meteorological station (for the period 1903–2003), the annual mean air temperature is 0.1°C, annual precipitation is 554 mm, the mean air temperature of the coldest month (January) is –15.0°C and of the warmest month (July) is 15.5°C; the summarised daily means above 10°C equal 1216°C.

We were conducting our entomological research on the Sotka River shore (Kuloi River drainage) during the periods 7–17.vi.2000, 13–20.vii.2000, 21–28.viii.2000, 26.vii.2001, 26–31.viii.2004, 8–11.vii.2005, 21–22.vii.2007. We collected mainly butterflies (Papilionoidea), but several individual moths were caught selectively. Butterfly nets were used for collecting.

Data on other *B. menetriesii* localities were obtained from different studies (see Appendix). We included only reliable references where species identification was verified by specialists; for the majority of Russian localities identification was performed by Dr. V. V. Dubatolov (Siberian Zoological Museum of the Institute of Animal Systematics and Ecology, Siberian Branch of the Russian Academy of Science, Novosibirsk city). The arrangement of the localities was digitised and mapped using ESRI ArcGIS 10. We mapped only those data pertaining to collected specimens in order to avoid including several visual and non-specific records (Appendix). The presumed error of determination of the locality coordinates is around ± 1–2 km, because published records of moths are usually ascribed to approximate locations (for example, near a certain vil-

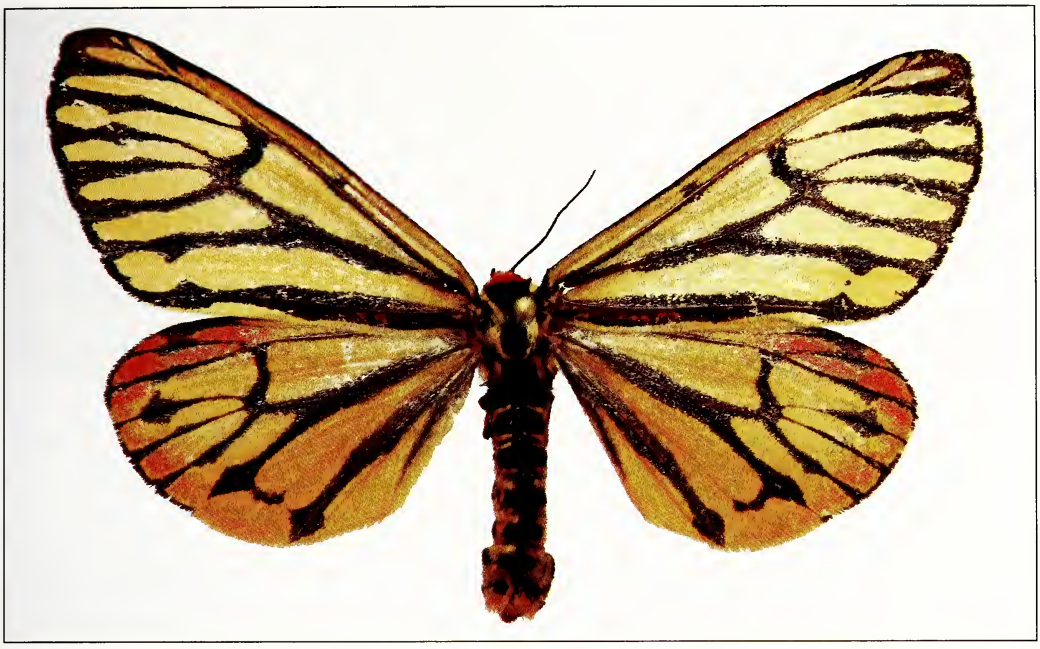

Fig. 1. *Borearctia menetriesii* specimen (female) from the Sotka River valley, Arkhangelsk Oblast, Northern European Russia (photo by Yu. Kolosova).

lage). Two localities were digitised from the general range map by Dubatolov (2010) and the obtained coordinates are highly approximated, probably by around ± 5 km. We used Bailey's Ecoregions Map of the Continents (Bailey 1989) for generalised estimation of the species preferences for ecosystem types. On this map, ecosystem units of regional extent (ecoregions) are marked by climate and vegetation. An Arcview shapefile containing ecoregions map data was obtained from the Global Ecosystem Data Base of NOAAs National Geophysical Data Center, Boulder, Colorado, USA.

Results

The record of a female specimen of *B. menetriesii* was made on 9.vii.2005 (Fig. 1). The moth flew at the top of tall mixed-herb vegetation and was caught during the flight (I. N. Bolotov leg.). This specimen is deposited in the collection of the Biological Museum of the Institute of Ecological Problems of the North, Ural Branch of the Russian Academy of Sciences (Arkhangelsk city).

Locality description: Upper part of the Sotka River valley; 64°38′59″ N, 43°04′08″ E; altitude 37 m.a.s.l; 16 km WSW from the Pinega settlement; karst landscape; a small patch of natural humid mixed-herb meadow (Figs 2a, b). The dominant species of the meadow were *Aconitum septentrionale* Koelle and *Thalictrum* sp. (Ranunculaceae), *Geranium sylvaticum* L. (Geraniaceae), *Filipendula ulmaria* (L.) Maxim. (Rosaceae), *Cirsium oleraceum* (L.) Scop. (Asteraceae), *Chamerion angustifolium* (L.) Holub (Onagraceae), *Paeonia anomala* L. (Paeoniaceae) and *Elymus caninus* (L.) L. (Poaceae). The meadow is surrounded by the primary Siberian spruce forest on gypsum soils with

Fig. 2. Habitat of *Borearctia menetriesii*. **A**, the Sotka River valley with karst gypsum outcrop, Pinega region, Arkhangelsk Oblast, Northern European Russia. **B**, forest humid mixed-herb meadow where specimen was collected (photos by Yu. Kolosova).

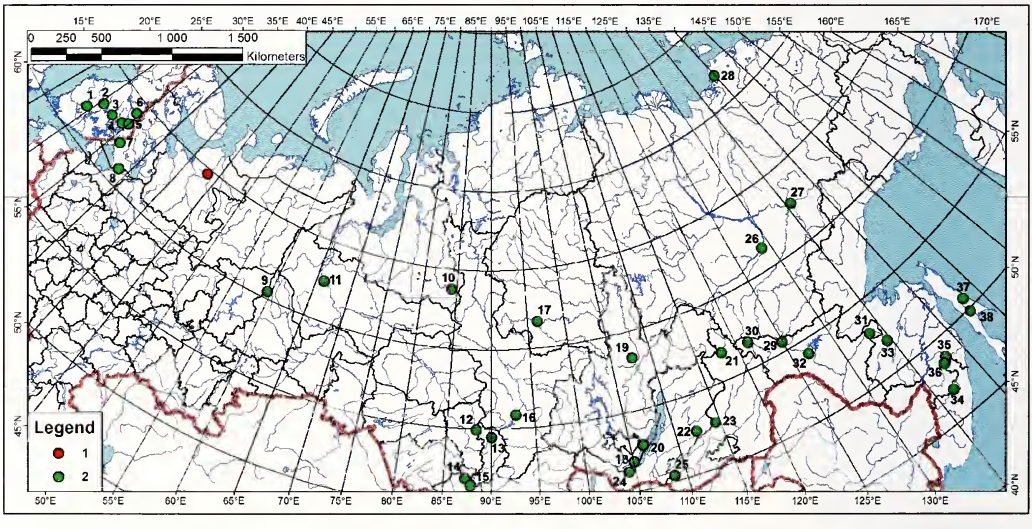

Fig. 3. Distribution range of *Borearctia menetriesii*. Species localities: 1 – our record, 2 – previously published records (see Appendix). Species locality numbers on the map correspond to numbers in the appendix.

inclusions of larch (*Larix sibirica*) patches. Large gypsum outcrops (20–30 m high) are found near the location where the specimen was collected (Fig. 2a). Subterranean solution cavities, caves with cold microclimate and perennial ice are situated in these outcrops. Sparse larch forests and tundra communities with numerous Arctic and Arctic-Alpine vascular plants occur in the outcrops: *Dryas octopetala* L. and *D. o.* ssp. *punctata* (Juz.) Hultén (Rosaceae), *Arctostaphylos alpina* (L.) Spreng. (Ericaceae), *Hedysarum arcticum* B. Fedtsch., *Astragalus norvegicus* Grauer and *Oxytropis campestris* ssp. *sordida* (Willd.) C. Hartm. (Fabaceae), *Salix myrsinites* L., *S. arbuscula* L., *S. recurvigemmis* A. Skvorts. and *S. reticulata* L. (Salicaceae); etc. The study area is situated in the centre of a large primary taiga forest massif, belonging to Pinega State

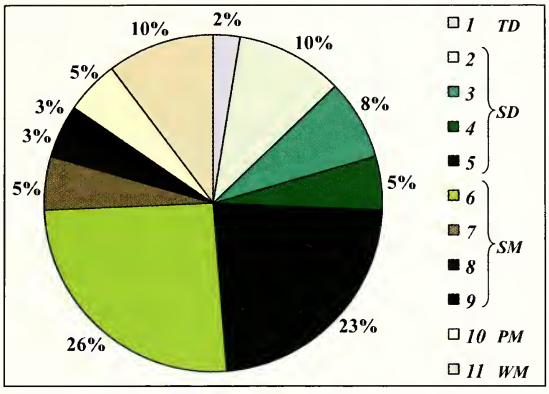

Fig. 4. Proportions of numbers of *Borearctia menetriesii* localities situated in different Bailey's Ecoregions (Bailey 1989). A total data of 39 localities was used (published data in the appendix and our own record). Ecoregions divisions: *TD* – tundra division, *SD* – Subarctic division, *SM* – Subarctic regime mountains, *PM* – prairie regime mountains, *WM* – warm continental regime mountains. Ecoregions provinces: *1* – Arctic tundra, *2* – continental and extreme continental light deciduous taiga, *3* – continental dark evergreen needle-leaf taiga, *4* – eastern oceanic taiga, *5* – moderate continental dark evergreen needle-leaf taiga, *6* – forest-creeping trees-tundra of extreme continental climate, *7* – forest-tundra of moderately and continental climate, *8* – open woodland-creeping trees-tundra, *9* – open woodland-tundra, *10* – continental steppe-forest-tundra and steppe-forest-meadows, 11 – oceanic forest-creeping trees.

Nature Reserve. Anthropogenic activity on the reserve territory has been totally prohibited since 1976 and works are allowed only for reserve staff and several authorised scientists.

Discussion

The new record of *B. menetriesii* in north-eastern Europe significantly reduces the gap between two *Borearctia* derivatives (Fig. 3). In the upper part of the Sotka River valley the karst landscape produces cold microclimate (Puchnina et al. 2000; Shvartsman & Bolotov 2008) by the action of two factors: the cold influence of karst groundwater outpouring and the refrigerant effect of ice caves on the air of the river valley. Boreal karst areas have a more continental climate in comparison to neighbouring territories (Puchnina et al. 2000; Shvartsman & Bolotov 2008). This fact confirms the opinion about the relative continentality of *B. menetriesii* (Kaisila 1947). Another important fact is that larch forest patches are common in the karst landscapes of the White-Sea Kuloi plateau, including the Sotka River valley (Puchnina et al. 2000; Shvartsman & Bolotov 2008), because the *Larix* species are significant food plants in the majority of the *B. menetriesii* range (Saarenmaa 2012).

Collected specimens of *B. menetriesii* inhabited only a few ecoregion types in spite of very broad species range (Fig. 4 and Appendix). Most of the localities (19 sites, 49% of the total known) were situated in two ecoregion provinces: 1) subarctic mountains with forest-creeping trees-tundra of extreme continental climate (Transbaikalia and the Russian Far East); 2) moderate-continental dark evergreen needle-leaf taiga (all northern European localities). The northernmost species record was made at 71° 52′ N in

Arctic tundra of the Yana-Indigirka Lowland of the Northern Yakutia (Appendix), but scarce larch forests in the tundra of Yana-Indigirka can advance very far northwards in the river valleys (including the Muksunuokha River valley where this specimen was collected) and it is possible that *B. menetriesii* ranges as far north as larch forests. The height of the Arsenyeva Mountain (1860 m, the Sikhote-Alin Mountains of the Russian Far East) is the maximum altitude where a specimen of this species has been collected.

According to the aforementioned, one can conclude that the distribution pattern of *B. menetriesii* is primarily connected with ecosystems of primary taiga forests and mountain forest-creeping trees-tundra with elfin forms of coniferous trees. These ecosystem types play the main role in vegetation cover of Northern Eurasia. In spite of the exceptionally low abundance of *B. menetriesii*, we can assume that the scattered transcontinental distribution of this species is determined by preference for specific biomes.

Acknowledgements

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Appendix

List of published localities of *Borearctia menetriesii*. * – The presumable error of determination of the locality coordinates is around ± 1–2 km for most sites excluding localities No. 35 and No. 36 for which the error is around ± 5 km; ** – see categories of the Bailey's Ecoregion system in legend to Fig. 4.

No.	Country	Region	Locality and sample data	Coordinates*		Bailey's Ecoregions**		Reference
				N	E	Division	Province	
1	Finland	Hame	Juupajoki, vi.1920, 1 larva, Carpelan leg.	61°52′04″	24°25′51″	SD	5	Krogerus 1944
2	Finland	Keski-Soumi	Saarijärvi, Pyhä-Häkki National Park, 29.vi.1943, 1♀, Stockmann, Krogerus and Stenius leg.	62°49′27″	25°27′55″	SD	5	Krogerus 1944
3	Finland	Kuopio	Kuopio, Haminanlahti, 8.vii.1913, 1♀, Fabritius leg.	62°50′47″	27°32′11″	SD	5	Fabritius 1914
4	Finland	Pohjois-Karjala	Polvijärvi, Martonvaara, old dark spruce forest, 29.vi.1921, 1♀, Sandström leg.	63°01′36″	29°15′31″	SD	5	Krogerus 1944
5	Finland	Pohjois-Karjala	Lieksa, Kevätniemi, 26.vi–4.vii.2003, 1♀, Hilkkonen leg. [the collecting year was erroneously published as 2002]	63°19′42″	29°58′54″	SD	5	Silvonen 2010
6	Finland	Oulu	Kuhmo, a Natura 2000 site, 6.vii.2009, half-open bog surrounded by coniferous forest, 1♀ (dead)	64°07′48″	29°31′12″	SD	5	Silvonen 2010
7	Russia	Karelia Republic	Salmi, Hiisjärvi, northward from the Ladoga Lake, 8.vii.1939, 1 ex., Valleala leg.	62°08′01″	31°16′25″	SD	5	Krogerus 1944
8	Russia	Karelia Republic	Kuujärvi [recent name is Mikhailovskoe village], 3.5 km SE from Mäkrätjärvi, northward from the Svir River, 3.vii.1943, 1 ex., Grönroos leg.	61°00′43″	33°44′39″	SD	5	Krogerus 1944
9	Russia	Sverdlovsk oblast	North Ural, northern slope of Denezhkin Kamen Mt., 20.vii.2005, taiga forest, 1♀ (dead), Ermakov leg.	60°28′00“	59°40′00“	SM	9	Ermakov 2006; Nupponen & Fibiger 2012
10	Russia	Jamal-Nenets district	Northern boundary of Verkhne-Tazovsky Nature Reserve, 2003, 1 ex. [probably this specimen was cited by Silvonen (2010) as record «Polar Urals near the Jamal Peninsula in 2003»]	63°43′00″	84°14′00″	SD	3	Gorbunov & Olschwang 2012

List of published localities of *Borearctia menetriesii* – continued.

No.	Country	Region	Locality and sample data	Coordinates*		Bailey's Ecoregions**		Reference
				N	E	Division	Province	
10	Russia	Khanty-Mansiysk district	Near Oktjabryskoe village, 12.vii.1964, 1♀, Shubina leg.	62°27′38″	66°01′59″	SD	3	Dubatolov 1984, 1996
12	Russia	Kemerovo oblast	Kuznetsky Alatau Mts., Nature Reserve, Bezymaynka River, 12.vii.2010, 1 ex., Budaev leg.	54°56′00″	88°22′00″	SD	3	Sutchev & Skalon 2012
13	Russia	Khakassia Republic	Itkul Lake	54°27′42″	90°05′13″	SM	7	Kozhanchikov 1923 (cited from Dubatolov 1985)
14	Russia	Altay Republic	Altay Mts., Teletskoye Lake, near Artybash village, 20.vi.1969, 1♀	51°47′26″	87°15′30″	PM	10	Dubatolov 1985
15	Russia	Altay Republic	Altay Mts., near Chiry village, 2.vii.1964, 1♀, Korshunov leg.	51°21′41″	87°50′19″	PM	10	Dubatolov 1985
16	Russia	Krasnoyarsk district	East Sayan Mts.,"Stolby" Nature Reserve, 15.vii.1966, 1♀, Korshunov leg.	55°49′48″	92°51′19″	SD	2	Dubatolov 1985
17	Russia	Krasnoyarsk district	Podkamennaya Tunguska River, near Baykit village, 9.vii.1929, 1♀	61°40′48″	96°22′48″	SD	2	Dubatolov 1984
18	Russia	Irkutsk oblast	Baikal Lake, Bolshie Koty Gulf, 13.vii.1970, 1♀, Drakin leg.	51°53′55″	105°04′58″	SM	6	Dubatolov 1985
19	Russia	Irkutsk oblast	Near Kirensk city, Chechui River near Rassokha River, 22.vii.1969, 1 ex., Pleshanov leg.	58°19′25″	107°37′15″	SD	2	Berlov & Berlov 2012
20	Russia	Irkutsk oblast	Near Elantsy village, Aya bay, vii.1971, 1 ex., Berlov leg.	52°47′14″	106°22′53″	SM	6	Berlov & Berlov 2012
21	Russia	Transbaikalia district	Ingamakit Stream mouth, near Chara settlement, open and light larch forest, 3.vii.2011, 1♂, Korsun leg.	56°43′57″	118°02′05″	SM	6	Saarenmaa 2012
22	Russia	Transbaikalia district	Yabloneviy Mt. Ridge, Saranakan Mt., 21.vi.1951, 1♀ and 2.vii.1955, 1♀, Kurentzov leg.	52°40′35″	112°15′58″	SM	6	Dubatolov 1990

List of published localities of *Borearctia menetriesii* – continued.

No.	Country	Region	Locality and sample data	Coordinates*		Bailey's Ecoregions**		Reference
				N	E	Division	Province	
23	Russia	Trans-baikalia district	Yablonevіy Mt. Ridge, Chingikan Mt., 1 ex.	52°46′12″	114°29′32″	SM	6	Dubatolov & Gordeev 2000
24	Russia	Buryatia Republic	Khamar-Daban Mt. Ridge, 1 ex.	51°17′26″	104°19′11″	SM	6	Dubatolov & Gordeeva 2005
25	Russia	Trans-baikalia district	Malkhanskiy Mt. Ridge, near Krasniy Chikoy village, cedar forest, 1 ex.	50°22′12″	108°44′60″	SM	6	Dubatolov & Gordeev 2000
26	Russia	Sakha-Yakutia Republic	Near Bestyah village, 24.vi.1907, 1♀, Naumov leg.	61°22′06″	128°52′04″	SD	2	Dubatolov 1984
27	Russia	Sakha-Yakutia Republic	Suntar-Khayata Mt. Ridge, East Khandyga River headstream, vii.1986, 1 ex.	62°33′04″	135°41′50″	SM	8	Dubatolov & Kaymuk 2003
28	Russia	Sakha-Yakutia Republic	Yana-Indigirka Lowland (Muksunuokha River), 1 ex.	71°52′00″	139°52′00″	TD	1	Dubatolov & Kaymuk 2003
29	Russia	Amur oblast	Near Mogot village, 25.vi.1975, 1♀, Bogdanova leg.	55°36′14″	124°55′14″	SM	6	Dubatolov 1985
30	Russia	Amur oblast	Near Mostovoy village, 1 ex.	56°36′00″	121°24′00″	SM	6	Dubatolov 2009
31	Russia	Amur oblast	Near Zlatoustovsk settlement, 1 ex., Streltzov leg.	52°57′50″	133°35′48″	SM	7	Dubatolov 2009
32	Russia	Amur oblast	Zeya Nature Reserve, Bolshaya Erakingra River, cordon "52 km", 11.vii.1979, 1♀, Murzin leg.; Bolshaya Erakingra River, 9–14. vii.1977, 2♀ & 1♂, Sviridov and Murzin leg.; Motovaya River, 14–18.vii.1977, 1♀, Sviridov leg.	54°05′15″	126°52′14″	SM	6	Dubatolov 1984
33	Russia		Bureya Nature Reserve; the middle course of Levaya Bureya River, 15.vii.1984, 1♀, Nebaykin leg.; Verkhne-Bureya Region, vii.1984, 1♀, Nebaykin leg.	51°55′46″	134°35′44″	SD	4	Koshkin 2010

List of published localities of *Borearctia menetriesii* – continued.

No.	Country	Region	Locality and sample data	Coordinates*		Bailey's Ecoregions**		Reference
				N	E	Division	Province	
34	Russia	Primorye district	Sikhote-Alin Mts., Arsenyeva Mt., at height of the mountain, rocky alpine tundra, 1860 m.a.s.l., 20.vii.1948, 1 ex., Kononov and Kurentzov leg.	46° 50′ 41″	136° 42′ 13″	WM	11	Kurentzov 1973
35	Russia	Primorye district	Sikhote-Alin Mts.	48° 45′ 46″	138° 07′ 22″	WM	11	Dubatolov 2010
36	Russia	Primorye district	Sikhote-Alin Mts.	48° 30′ 20″	137° 36′ 26″	WM	11	Dubatolov 2010
37	Russia	Sakhalin Island	East slope of Nabilskiy Mt. Ridge, 850 m.a.s.l., karst landscape, mountain slope with high-herb sprouts and shrubs, 22.vii.2002, 1 ex., Klitin leg.	50° 42′ 27″	143° 18′ 01″	SD	4	Klitin 2009
38	Russia	Sakhalin Island	Poronay River valley, peat bog, in the early 1920s, 1 ex.	49° 50′ 27″	142° 57′ 45″	WM	11	Hori 1926
—	Finland	Pohjois-Karjala	Juuka, Polvela-Petrovaara, 21.vi.1961, a flying specimen seen by a M. Kononen	63° 09′ 14″	29° 39′ 16″	SD	5	Silvonen 2010
—	Finland	Oulu	Kuhmo, Kuusijärvi, Havukka, 22.vii.1939, one specimen seen and drawn by maiden	63° 53′ 47″	30° 13′ 53″	SD	5	Silvonen 2010
—	Russia	Irkutsk oblast	Baikal Lake, 3.vii.1958, 1♀	No data	No data	No data	No data	Dubatolov 1985
—	China	Heilongjiang	V. V. Dubatolov noted that *Callimorpha principalis* Fang (1982) might belong to *B. menetriesii*	No data	No data	No data	No data	Dubatolov 1996, 2010
—	Kazakhstan	East Kazakhstan Region	"Songoria", 1♀ (holotype)	No data	No data	No data	No data	Dubatolov 1996; Krogerus 1944