DISTRIBUTION AND BIOLOGY OF THE GROUND BEETLE *CARABUS* (*DAMASTER*) *BLAPTOIDES RUGIPENNIS* ON KUNASHIR ISLAND, KURILE ISLANDS, RUSSIA

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Based on long-term observations, *Carabus blaptoides rugipennis* is a polytopic, little specialized malacophagous subspecies widespread across Kunashir Island, Kuriles. Its reproduction pattern is autumnal-summer, with low fertility, two larval instars, and hibernation as larvae and adults. The insular population is characterized by considerable variability, sometimes comparable to differences between subspecies. A new synonym is established: *Carabus* (*Damaster*) *blaptoides rugipennis* (Motschulsky, 1861) = *Carabus* (*Damaster*) *blaptoides simushirensis* Obydov, 2008, **syn. nov**. At present there is no direct threat of an abundance drop of this species in the Kurile Islands.

Key words: Carabidae, *Carabus blaptoides rugipennis*, Coleoptera, habitat, Kunashir, Kurile Islands, life cycle, new synonym, rare species, Red Data Book.

Introduction

Carabus (*Damaster*) *blaptoides* (Kollar, 1836) is a polymorphic species ranging from southern Japan in the south to the Middle Kurile Islands in the north (Imura, Mizusawa, 2013). At different times, populations of this species from different parts of the distribution area were allotted different taxonomic statuses (Lewis, 1881; Hauser, 1921; Breuning, 1937), but molecular studies (Su et al., 1996; Su et al., 1998; Kim et al., 1999) have since clearly demonstrated their integrity. As a result, *C. blaptoides* is presently treated as a polytypic species with 8 subspecies (Deuve, 2004; Imura & Mizusawa, 2013). *Carabus blaptoides rugipennis* (Motschulsky, 1861) is the northernmost plesiotypic form (Ishikawa, 1986) which inhabits Hokkaido and the Kurile Islands (Nakane, 1960; Kim et al., 1999, etc.), in Russia being known from the islands of Shikotan, Kunashir, Iturup, Urup, Brat Chirpoev and Simushir (Kanô, 1933; Konakov, 1956; Kuwayama, 1967; Kryvolutskaja, 1973; Kryzhanovskij et al., 1975; Lafer, 1989, 2002; Klitin, 1989, 2008; Su et al., 2000; Obydov, 2008; Sundukov & Makarov, 2013), also included in the red data books of the Russian Federation (2001) and the Sakhalin Region (2001, 2016).

Thanks to our research conducted on the islands of Kunashir and Shikotan in 1990, 2008–2009, 2011–2015, also considering the material provided by a number of specialists, enough information has been accumulated with regards to the distribution and biology of this species to assess the state of its population and the necessary measures of protection.

All measurements in the text are given in mm, with standard error and sample size following the arithmetic mean.

Results and Discussion

DISTRIBUTION. Previously recorded from Mendeleyeva Volcano (Konakov, 1956), the caldera of the Golovnin Volcano, environs of Lake Peshchanoe and Alekhino, Goryachii Plyazh, the village of Sernovodsk (Kryvolutskaja, 1973; Kryzhanovskij et al., 1975), the mouth of Filatova River, capes Rogacheva and Mysovoy (Klitin, 2001). We have mapped it on 43 localities (Fig. 1). The incidence of occurrence of this subspecies is quite high, as it has been found everywhere whence material was collected for at least three days. It probably lives all over the island, with the exception of extensive marshes, solfataric fields and the highest volcanoes. The patchy distribution seems to reflect only the location of the study areas. Literature information is fully consistent with our material (Fig. 1).

BIOLOGY. On the island, it occurs in a wide range of habitats (Fig. 2) such as meadows, *Sasa* sp. thickets, tall grasslands, forests of various types with the exception of closed conifer woodlands. Habitats disturbed by human activities are not avoided either, as it has repeatedly been recorded in small settlements, sometimes even penetrating inside buildings. Based on the records of larvae and adults, it successfully breeds both in forested and non-forested areas.

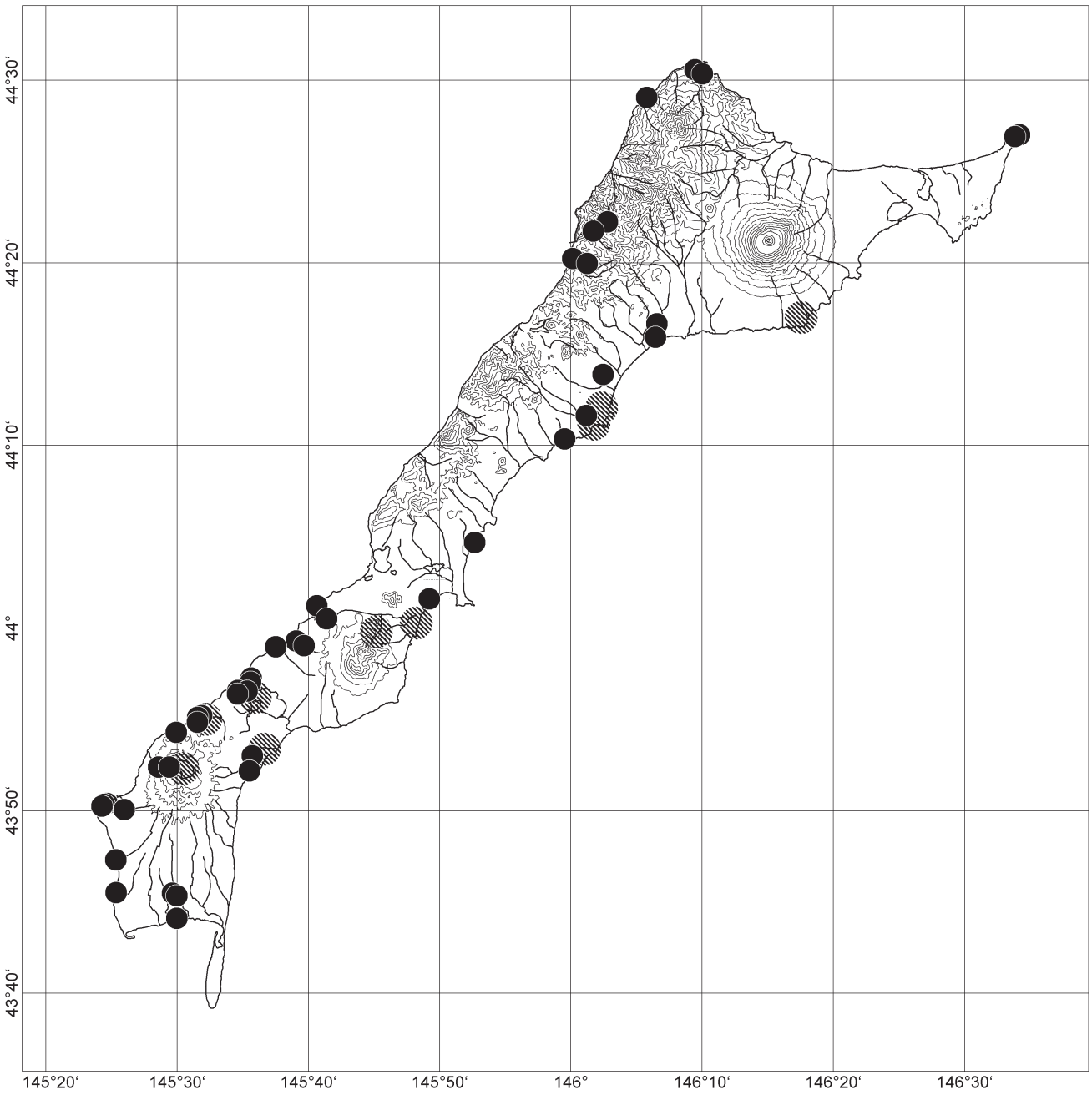

Fig. 1. Distribution of *Carabus blaptoides rugipennis* on Kunashir Island: black dots – our own data; shaded dots – literature data.

According to Kimoto & Yasuda (1995), in the mountainous part of Shiretoko Peninsula, Hokkaido, *C. b. rugipennis* lives in the forest zone, yet failing to reach high numbers and amounting to 10–15% of ground beetle abundance. On the contrary, on the Sarobetsu plains, on the northwestern coast of Hokkaido, it can be a mass species, accounting for 50–70% of pitfall trap catches (Kimoto & Yasuda, 1995). In addition, it has been noted as rather common in coniferous stands (Kaizuka & Iwasa, 2014). The remaining subspecies of *C. blaptoides* are also characterized by high ecological plasticity (Imura & Mizusawa, 2013).

Although adults are found on the ground, they easily and often climb up large grassy plants as well as standing or half-fallen tree trunks (Fig. 3). Larvae are more closely associated with the soil, only rarely moving onto plants; just a single record has been made of a larva captured by a window trap set at a height of 1.5 m from the soil surface.

In nature, feeding on snails (Bradybaenidae: *Karaftohelix* spp.) has been observed. Although no special studies on the feeding of *C. b. rugipennis* have been conducted, according to literature (Sturani, 1962; Konuma et al, 2011, 2013, 2014) and also taking into account the available information on that of the closely related subgenus *Coptolabrus* Solier, 1842 (Kim & Park, 1999; Berlov O.E. & Berlov E.Y., 1989; our data), it seems highly probable that this species feeds on a wide range of relatively large prey with soft bodies (annelids, molluscs, some insects and their larvae) while its normal development and reproduction require a large proportion of molluscs in the diet.

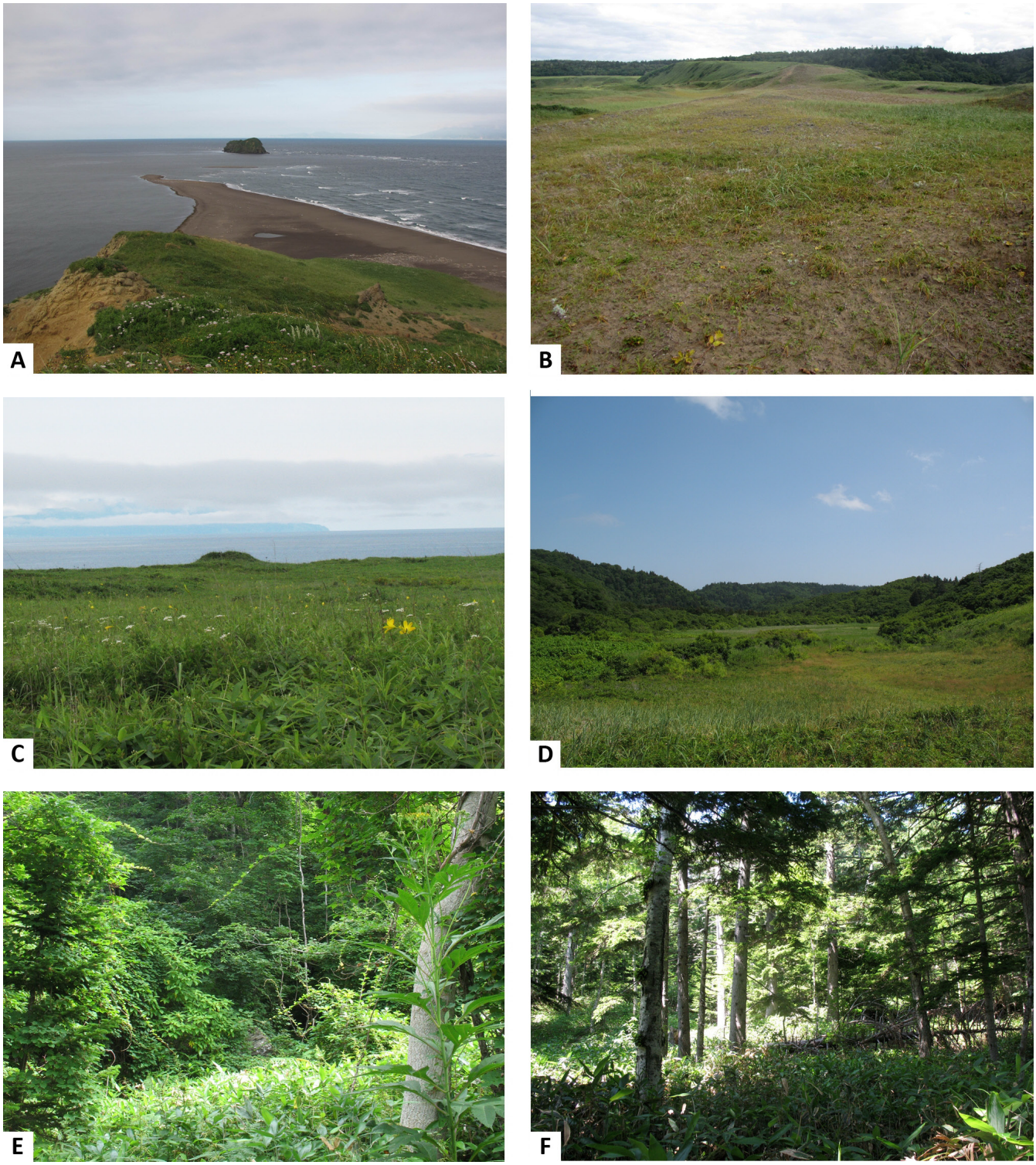

Fig. 2. Habitats of *Carabus blaptoides rugipennis* on Kunashir Island: A – sedge-forb meadow (Cape Lovtsova); B – grass-mixed and grass meadows (western coast of Lake Peshchanoe); C – thicket of *Sasa* sp. and grassy meadow (Cape Ivanovskiy, Grozovoe); D – tall and small-leaved forests (Alekhina River valley); E – deciduous forest (near Dalniy Stream); F – mixed forest (stream valley south of Dokuchaevo).

Adults are found almost all over the season, but in its first half these are relatively rare while most of the captures are confined to the second half of August and to September. Larvae are recorded from July to September, but in the first half of the season they occur more often than adults (Fig. 4). Based on certain structural details (egg teeth on the frontal sclerite and chaetotaxy) and head capsule measurements, development takes place with two larval stages (Fig. 5 E, F), which is consistent with literature (Sturani, 1962; Ishikawa, 1986). The first instar larvae are quite large: head width 2.81±0.03, n = 7, *versus* 3.77±0.03, n = 34 in second stage larvae. Based on the size ratio of the first instar larva to adult (Fig. 5), females lay very large eggs, hence the clutch cannot be bulky. In closely related species, there are usually 10–20 eggs per clutch (Berlov O.E., Berlov E.Y., 1989).

Fig. 3. *Carabus blaptoides rugipennis*: A – male on an oak trunk (photo: A. Matalin); B – larva feeding on a snail.

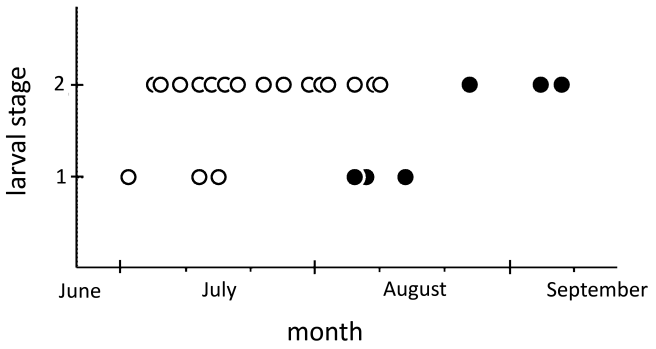

Fig. 4. The occurrence frequency of *Carabus blaptoides rugipennis* larvae during the season: circle – overwintered, dark spot – larvae hatched during this season.

Based on data on larval phenology (Fig. 4) and the information concerning the development of related *Coptolabrus* species (Stiprais 1987; Kim & Lee, 1992; Kim & Park, 1999; Berlov O.E., Berlov E.Y., 1989; our data), the life cycle of *C. b. rugipennis* can be reconstructed as follows. Postgenerative adults (parental generation) and child generation larvae hibernate. The share of overwintered beetles is low (higher in the northern part of the island) while individuals overwintering several times are few. The growth and development of overwintering larvae continue until the second half of August, while pupation and adult appearance occur during August.

Beetles of the parental generation start breeding in mid-August while those of the child generation mostly in September. A considerable duration of the reproductive period results in the wintering of an uneven-aged group consisting of freshly hatched larvae of the first instar to fully developed larvae of the second stage and adults. In the studied species *Coptolabrus* (*C. smaragdinus* Fischer, 1823; *C. jankowskii* Oberthür, 1833 – Berlov O.E., Berlov E.Y., 1989; our data) larval overwintering is not obligate and some individuals may pupate in autumn. A similar multivariant pattern of development cannot be ruled out for *C. b. rugipennis* either. Very likely it also has some mechanisms of development synchronisation recorded in ground beetles (Matalin, 2007).

Hence the life cycle of *C. b. rugipennis*, according to the classification of A.V. Matalin (2007), can be referred to as summer-autumnal iteroparous.

VARIABILIY. On Kunashir, *C. b. rugipennis* varies considerably in size and colour. Typically, the upper side of the body is blue, with the elytra being blue-green to dark blue while the head and pronotum are bronze or copper red. This pattern is well-expressed in young individuals, but it grows dull with time so that 2- or 3-year old beetles are almost black (Fig. 5 A–C).

Although different parts of the island support very different combinations of temperature, precipitation and insolation rates, the sizes of the beetles from the warmest and coldest habitats, be they from the southern or northern parts of the island, from the Sea of Okhotsk or Pacific coasts, fail to vary significantly. Local habitat conditions thereby significantly affect some other characters, sometimes leading to the appearance of individuals which are phenotypically similar to other subspecies. For example, during the unusually warm summer of 2011, the warmed grasslands on the western shore of Lake Peshchanoe revealed large beetles with green elytra, a red head and a red pronotum; superficially, these resembled *C. b. viridipennis* Lewis, 1880, but without apical processes on the elytra so characteristic of the latter subspecies.

The shape of the elytral apices appears to be quite variable in Kurile individuals. They can be either jointly rounded or separately pointed to form two short caudal spines. Variations in the sculpture of abdominal sternites are noteworthy. Although the subgenus *Damaster* is generally characterized by the presence of sternal sulci (Ishikawa, 1986; Imura & Mizusawa, 2013), a little more than half of the *C. b. rugipennis* specimens studied had well-developed sulci on all three apical visible sternites, whereas in the remaining beetles the sulci were poorly-developed at least in some of the segments. As a result, the population of *C. b. rugipennis* from Kunashir shows in miniature all clinal variations in morphological characters generally known in *Damaster* (Lewis, 1880; Ishikawa, 1986).

Sexual dimorphism is well-developed (Fig. 5 A, D; Fig. 6). The elytra of females are 18.0–23.5 (20.3±0.4, n = 17) mm long, *versus* 17.0–21.5 (18.3±0.3, n = 17) in males. In addition to the larger size and structural differences, females have relatively wide elytra and a relatively short pronotum, the elytral apices are usually jointly rounded (*versus* often pointed in males) while the head is often thickened.

In 2008, based on a single female from the island of Simushir, D. Obydov described a local subspecies, *C. b. simushirensis*. The grounds for the erection of this taxon were said to be the considerable distance from the distribution area *C. b. rugipennis* and a number of external features such as a dark colour, the proportions of the pronotum and the absence of abdominal sulci (Obydov, 2008). However, since *C. b. rugipennis* is also known from the island of Brat Chirpoev (Kryzhanovskij et al., 1975; Klitin 1989; Su et al, 2000; Lafer, 2002), the isolation of the Simushir population is not stronger than that of populations from other islands of the Middle and southern Kuriles. As soon as the above features defined in Obydov's (2008) original description fail to surpass the variation range of *C. b. rugipennis*, we consider it necessary to synonymize *Carabus* (*Damaster*) *blaptoides rugipennis* (Motschulsky, 1861) with *Carabus* (*Damaster*) *blaptoides simushirensis* Obydov, 2008, **syn. nov**.

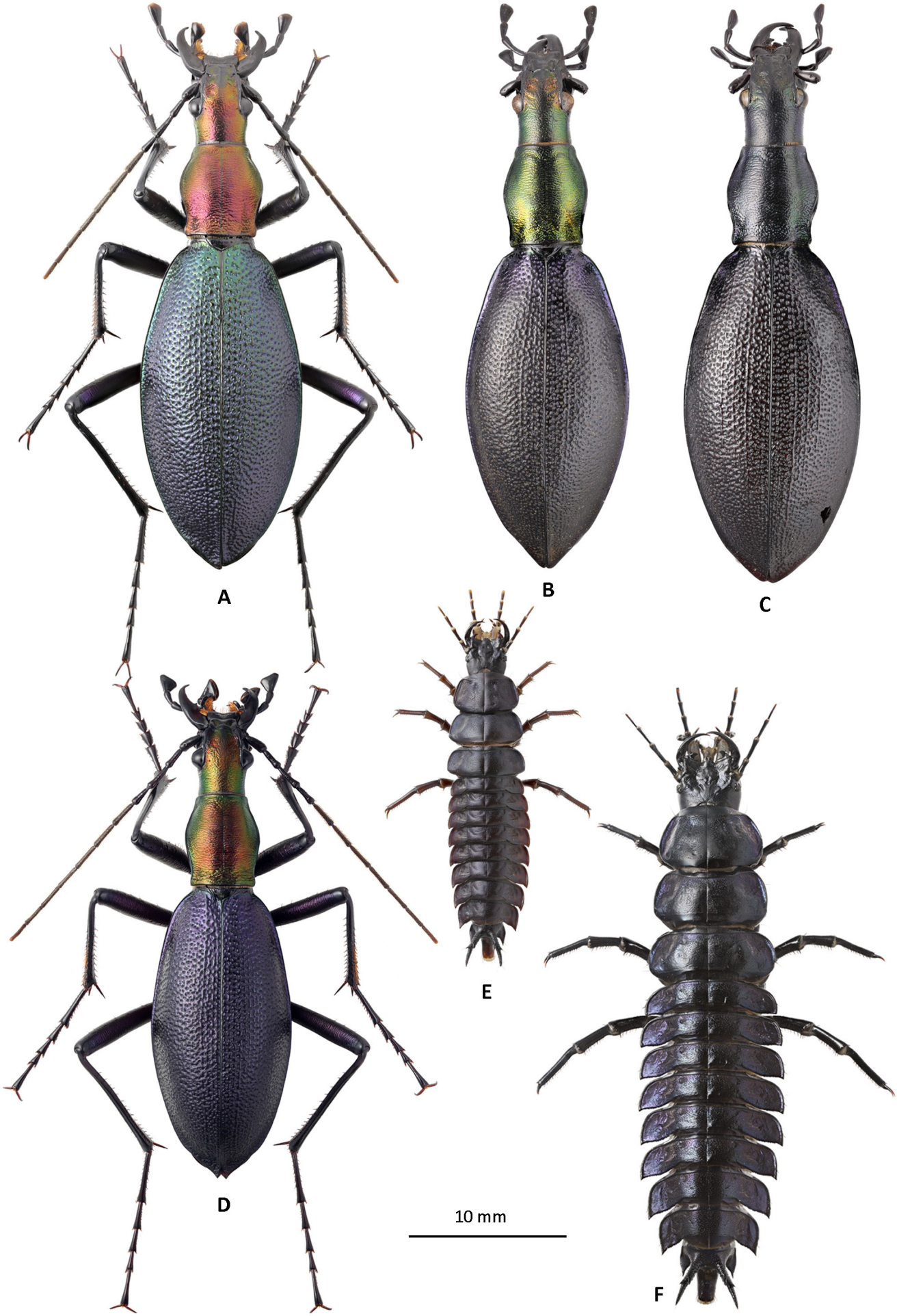

Fig. 5. Habitus of *Carabus blaptoides rugipennis*: A–C – female, colour variability; D – male; E – stage 1 larva; F – stage 2 larva.

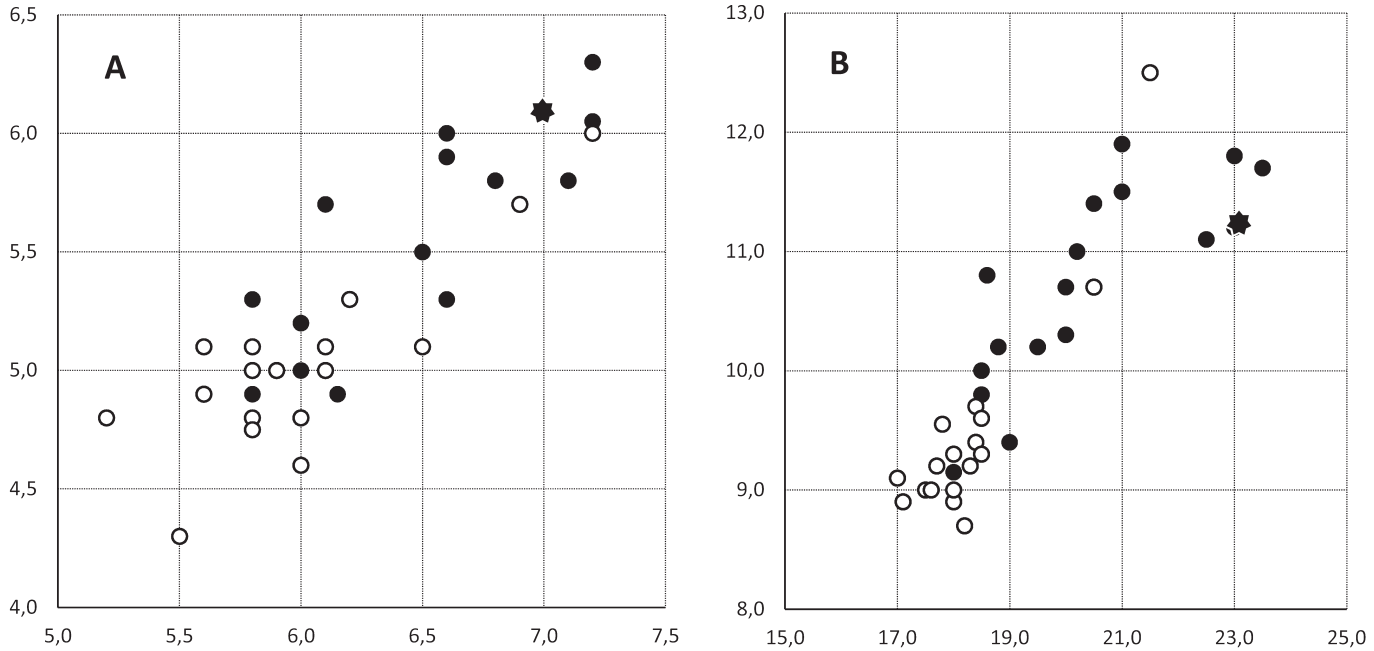

Fig. 6. Size variations of pronotum (A) and elytra (B) in *Carabus blaptoides rugipennis* on Kunashir. Black spots – female, circles – male; the asterisk denotes the holotype of *Carabus blaptoides simushirensis*. Abscissa – the length, Ordinate – the width.

POPULATION STATE, VULNERABILITY. In the Red Data Book of the Russian Federation (2001) and those of the Sakhalin Region (2001, 2016), *C. b. rugipennis* was described as a taxon of low and constantly decreasing numbers; it was also incorrectly stated to be confined to forests, showing a one-year long generation, a summer development of the larvae and the overwintering in the adult stage. The exception was the first edition of the Red Book of the Sakhalin Region (2001), in which A.K. Klitin provided a brief, but in general reliable account.

The above information makes it possible to draw a number of conclusions that are important for assessing the population *C. b. rugipennis* from Kunashir Island.

(a) This is a polytopic, ecologically plastic subspecies that can also exist in anthropogenically modified habitats.

(b) It has a broad nutritive base while its only specific food source (Bradybaenidae snails) is common and shows no tendency to any decrease.

(c) The population living on Kunashir, although isolated from the main distribution area, is not situated at the range limit of the taxon.

(d) At the moment, there seems to be only one biological feature of *C. b. rugipennis* that can cause a decrease in the population, i.e. its low individual fertility.

In relation to the latter circumstance, it seems appropriate to provide an example, concerning two hygrophilous species of *Carabus* which live in Europe: *C.* (*Carabus*) *granulatus* Linnaeus, 1758 and *C.* (*Limnocarabus*) *clathratus* Linnaeus, 1761. The former species lays relatively small eggs and is highly fecund, being widespread and common everywhere. The latter species is less prolific (the clutch size averages 9–10 large eggs: Huk & Kühne, 2000), is much rarer while its numbers are usually low. Such a low reproductive potential of *C. clathratus* considerably increases the risk of extinction. For example, the spreading crayfish *Procambarus clarkii* (Girard, 1852) acclimated in Italy, which among others feeds on near-water beetles, during the last few years has put *C. clathratus* on the brink of extinction (Casale & Busato, 2008).

Conclusions

During our studies (1990–2015), as we have detected no signs of a drop in the numbers of *C. b. rugipennis*, we believe that the current state of its population on the island of Kunashir can be considered as stable. It seems noteworthy that the overall area of the Kurile Islands, which support *C. b. rugipennis*, amounts to ca 6900 km^2, with much of the territory being suitable for its living (Atlas of the Kurile Islands, 2009). Formally, the Kurile part of this subspecies' range can be considered fragmented, but the formation of the island populations seems to have happened in the Late Wurm, 15000–20000 years ago (Su et al., 2000; Bogatov et al., 2006), and has since not been accompanied by extinction. Hence, marking a superficial match of the distribution data of *C. b. rugipennis* to certain criteria of IUCN (2014) which correspond to the «vulnerable species» category (VU), we believe that its more realistic assessment is NT, i.e. «in a state near to

threatened». In terms of the Red Data Book of the Russian Federation which roughly correspond to the category of «rare species which do not require the adoption of additional security measures» (III priority conservation measures), *C. b. rugipennis* seems better to be moved to the «List of species in need of special attention to their status in the natural environment».

Of course, the low individual fertility can cause a rapid decline of this subspecies due to various biotic reasons, habitat transformations and/or yield. In this regard, regularly monitoring the population of *C. b. rugipennis* as a potentially vulnerable subspecies is required. An adequate assessment of the population size for most of the growing season (June – August) takes into account not only adults, but also larvae. An exception can only be the breeding season, when it is possible to get confined to counting the adults. In either case, conventional pitfall traps without fixative can be used, set for 3–5 days and checked at least once a day. Adults and larvae of this species are easy to identify, with some practice the sex and age of live specimens can be determined even with the naked eye before returning them to nature.

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РАСПРОСТРАНЕНИЕ И БИОЛОГИЯ ЖУЖЕЛИЦЫ *CARABUS* (*DAMASTER*) *BLAPTOIDES RUGIPENNIS* НА ОСТРОВЕ КУНАШИР, КУРИЛЬСКИЕ ОСТРОВА, РОССИЯ

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На основании многолетних наблюдений показано, что *Carabus blaptoides rugipennis* – политопный, мало специализированный моллюскоед, широко распространенный на о. Кунашир. Обладает осенне-летним размножением, малой плодовитостью, двумя личиночными возрастами, зимовкой на стадии личинки и имаго. Островная популяция характеризуется значительной изменчивостью, иногда сравнимой с различиями подвидов. Установлена новая синонимия: *Carabus* (*Damaster*) *blaptoides rugipennis* (Motschulsky, 1861) = *Carabus* (*Damaster*) *blaptoides simushirensis* Obydov, 2008, **syn. nov.** В настоящее время нет прямой угрозы сокращения численности этого вида на Курильских островах.

Ключевые слова: Coleoptera, Carabidae, *Carabus blaptoides rugipennis*, жизненный цикл, Красная книга, Кунашир, Курильские острова, местообитания, новый синоним, редкие виды.