

On the fauna of Odonata of Chukotka and other northern regions of the Holarctic

К фауне стрекоз (Odonata) Чукотки и других северных регионов Голарктики

S.N. Borisov*, O.E. Kosterin**, A.Yu. Haritonov*
С.Н. Борисов*, О.Э. Костерин**, А.Ю. Харитонов*

* Institute of Systematics and Ecology of Animals SB RAS, Frunze Str. 11, Novosibirsk 630091 Russia.

* Институт систематики и экологии животных СО РАН, ул. Фрунзе 11, Новосибирск. E-mail: borisov-s-n@yandex.ru

** Institute of Cytology & Genetics SB RAS, Acad. Lavrentyev Ave. 10, Novosibirsk 630090 Russia; Novosibirsk State University, Pirogova Str. 2, Novosibirsk 630090 Russia. E-mail: kosterin@bionet.nsc.ru

** Институт цитологии и генетики СО РАН, пр. акад. Лаврентьева 10, Новосибирск 630090 Россия; Новосибирский Государственный Университет, ул. Пирогова 2, Новосибирск 630090 Россия.

Key words: Chukotka, Far East, Russia, Asia, North, Arctic, Subarctic, dragonflies, damselflies, Odonata.

Ключевые слова: Чукотка, Дальний Восток, Россия, Азия, Север, Арктика, субарктика, стрекозы, Odonata.

Abstract. On the occasion of new data on Odonata from Chukotka (Chukotka Autonomous Okrug), the knowledge of Odonata fauna of this region is summarised. At present 17 species have been reported for Chukotka, of which *Aeshna caerulea*, *Cordulia aenea* and *Somatochlora exuberata* for the first time in this paper. The fauna of Odonata of Chukotka is compared to those of the territories of Yakutia, North America and Europe north of 62° N, and also to that of Kamchatka (containing 32, 34, 53, and 24 species, respectively). Species richness was found to strongly depend on climate mildness.

Резюме. В связи с поступлением новых данных о стрекозах Чукотки (Чукотского Автономного округа), суммированы знания о фауне Odonata этого региона. В настоящее время для него известно 17 видов стрекоз, из которых *Aeshna caerulea*, *Cordulia aenea* и *Somatochlora exuberata* приводятся впервые. Фауна стрекоз Чукотки сравнивается с фауной территорий Якутии, Северной Америки и Европы, расположенных севернее 62° с.ш., а также с фауной Камчатки (насчитывающих, соответственно, 32, 34, 53 и 24 видов). Видовое богатство стрекоз определяется мягкостью климата.

Introduction

The name Chukotka refers both to Chukotka Peninsula (полуостров Чукотка) at the north-east extremity of Eurasia and to a larger area including also a part of the mainland north-eastern Asia and corresponding to Chukotskiy Autonomous Region, or Chukotka Autonomous Okrug (Чукотский автономный округ). The latter was formerly subordinated to Magadan Province but now is an independent federal subject of Russian Federation. In this paper we refer to that broader meaning of Chukotka. Its territory is situated at 62–70° N and 158° E — 170° W, extends (in both

hemispheres!) for ca 1400 x 900 km, and occupies an area of 721,481 km² (more than France and slightly less than Turkey). It has common borders with Sakha-Yakutia Republic and Magadan Province of Russia and is separated by Bering Strait from Alaska, USA. The Arctic Circle divides Chukotka nearly to halves. Situating in the Far North, in half in the Arctic, Chukotka expectedly has a severe climate: the mean temperature of January varies from –39 to –15, that of July from +5 to +10; the average annual precipitation is only 200–500 mm; the vegetation period in southern regions does not exceed 80–100 days; permafrost is omnipresent. The relief is mostly mountainous, with Anadyr' Plateau, Anyuya Mts. in the central part and Chukotka Mts. in the east; elevations above sea level vary from zero to 1887 m. The land below the snow line is occupied by tundras and bush thickets and, at lower elevations in the south but not in the peninsula, by larch (*Larix gmelinii* (Rupr.) Rupr.) forest-tundra; in the southern continental part there are small areas of larch taiga and small riparian forests of poplar (*Populus suaveolens* Fischer) and Korean willow (*Chosenia arbutifolia* (Pall.) A.K. Skvortsov) [Suslov, 1954]. Because of its severe climate, Chukotka is scarcely populated (50.5 thousand people in 2014, that is 0.07 per km²). Expectedly, it is even more hostile to Odonata than to humans.

The history of investigation of the Odonata fauna of Chukotka is fairly short. The first report of 1987 contained three species collected by S. Bobrova at Lamutskoe settlement on the Anadyr' River [Belyshev et al., 1987]. Later one of the authors of this report, the late A.Y. Haritonov, identified 12 species collected by M. Danilevskaya at Markovo settlement on the same river and kept in the collection of Zoological Museum of Moscow State University (ZMUM) and listed them

in a manuscript providing no information of the number and sex of specimens and dates. These data were included into two works summarising data on the Russian Far East by Malikova [1995] and Haritonov and Malikova [1998], totally providing for Chukotka 16 species, without localities (Table 1). Recently A.V. Barkalov and V.K. Zinchenko, entomologists of the Institute of Systematics and Ecology of Animals (ISEA) of Siberian Branch of the Russian Academy of Sciences (Novosibirsk) kindly offered to our treatment a number of dragonfly and damselfly specimens collected by them in 2013–2014 in two localities on the same Anadyr' River. The collection included many imagines and some larvae of 3–4 zygopteran and 2 anisopteran species. Identification of imagines was doubtless. We found it possible to identify the larvae of Anisoptera basing on reliable characters provided by Belyshev [1973] but abstained from attempts of identification of Zygoptera larvae.

Besides, two specimens from Chukotka were kindly provided by P.Y. Gorbunov (Ekaterinburg).

With this new material, it seemed useful to summarise all the data available from Chukotka, which would facilitate analysis of the arctic and subarctic fauna of Odonata in general

List of localities

Loc. 1. Lamutskoe (Lomutskoe) settlement, 65°31' N, 168°50' E, 177 m a.s.l., S. Bobrova; at present partly in ISEA; the data published in [Belyshev et al. 1978]).

Loc. 2. Markovo settlement, 64°39' N, 170°25' E, 20 m a.s.l., 12–25.07.1980, M. Danilevskaya; in ZMUM, identified by A.Y. Haritonov (a manuscript).

Loc. 3. 100 km W of Anadyr' Town, 64°43' N, 175°13' E., 4 m a.s.l., 18.07–3.08.2014, A.V. Barkalov, V.K. Zinchenko, in ISEA.

Loc. 4. 73 W of Anadyr' Town, 64°50' N, 175°58' E, 3 m a.s.l., 27.06–17.07.2013, A.V. Barkalov, V.K. Zinchenko, in ISEA.



Fig. 1. Localities where Odonata were collected in Chukotka.
Рис. 1. Места сборов стрекоз на Чукотке.

Loc. 5. Aviagorodok settlement 15 km E of Anadyr' Town, 10–12.07.2004. P. Gorbunov, in ISEA.

All the localities are situated at the major Anadyr' River. Coordinates for localities 1 and 2 were inferred from Google Earth. Situation of the localities is shown in Fig. 1.

Annotated list of species

For each species, all published information is reproduced (including the number of specimens and dates, if provided, but the localities are abbreviated as above), and followed by a list of known localities and specimens examined by the first author (sex is indicated for imagines only). In case of Loc 1, those specimens are listed which are presently in ISEA collection. In case of Loc. 2, the number and sex of specimens and dates are not available. In cases of Loc. 3 and 4, all specimens are in ISEA collection.

Lestes dryas Kirby, 1890

Malikova, 1995; Haritonov, Malikova, 1998.

Records. Loc. 2.

Coenagrion glaciale (Selys, 1872)

Haritonov, Malikova, 1998: (*C. glaciale orientale* Belyshev et Haritonov).

Records. Loc. 2.

Coenagrion hylas (Trybom, 1889)

Belyshev et al., 1978: loc. 1 (*Agrion hylas* Trybom), 28.06.1968, 2♂♂; Malikova, 1995: (*C. hylas ussuriense* Belyshev).

Records. Loc. 1 29.06.1968, 1♂, 3♀♀; Loc. 2; Loc. 3 (14.07.2014, 1♀).

Coenagrion johanssoni (Wallengren, 1894)

Belyshev et al., 1978: Loc. 1 (*Agrion concinnum concinnum* Johanssen), 30.06.1966, 1♂; 29.06.1968, 1♂, 3♀♀; Malikova, 1995: (*C. concinnum bartenevi* Belyshev); Haritonov, Malikova, 1998: (*C. johanssoni* (Wallengren)).

Records. Loc. 1; Loc. 2; loc. 3 (16.07.2014, 1♀).

Coenagrion lunulatum (Charpentier, 1840)

Haritonov, Malikova, 1998.

Records. Loc. 2.

Enallagma cyathigerum (Charpentier, 1840)

Haritonov, Malikova, 1998: (*E. nigrolinium* Belyshev et Haritonov).

Records. Loc. 2; Loc. 3 (05.07., 16.07., 17.07.2014, 1♂, 3♀♀); Loc. 4 (01–03.07.2013, 3♂♂, 3♀♀).

Remark. All specimens had black stripes at the sides of the abdomen, which are frequently present in northern specimens of *E. cyathigerum* [Dumont et al., 2005].

Aeshna caerulea (Ström, 1764)

Records. Loc. 3 (05–17.07.2014, 4♂♂, 5♀♀, series of larvae); Loc. 4 (18–20.07.2013, 6♂♂, 3♀♀, series of larvae); Loc. 5 (10–12.07.2004, 1♂, 1♀).

Remark. The first record for Chukotka. The larvae were identified on the basis of combination of such characters as

Table 1. Checklist of the Odonata species recorded in Chukotka (including two doubtfully recorded species).
Таблица 1. Список видов стрекоз (Odonata), отмеченных для Чукотки (включая два сомнительных вида).

Species	B	H	M	HM	tp
1. <i>Lestes dryas</i> Kirby, 1890		+	+	+	
2. <i>Coenagrion glaciale</i> (Selys, 1872)		+		+	
3. <i>C. hylas</i> (Trybom, 1889)	+		+		+
4. <i>C. johanssoni</i> (Wallengren, 1894)	+	+	+	+	+
5. <i>C. lunulatum</i> (Charpentier, 1840)		+		+	
6. <i>Enallagma cyathigerum</i> (Charpentier, 1840)		+		+	+
7. <i>Aeshna caerulea</i> (Ström, 1764)					+N
8. <i>A. crenata</i> Hagen, 1856		+		+	
9. <i>A. juncea</i> (Linnaeus, 1758)	+	+	+	+	+
10. <i>A. subarctica</i> Walker, 1908		+		+	
11. <i>Cordulia aenea</i> (Linnaeus, 1758)					+N
12. <i>Somatochlora arctica</i> (Zetterstedt, 1840)		+		+	+
13. <i>S. exuberata</i> Bartenev, 1911					+N
14. <i>S. graeseri</i> Selys, 1887		+		+	
15. <i>S. sahlbergi</i> (Trybom, 1889)		+	+	+	
16. <i>Leucorrhinia (dubia) orientalis</i> Selys, 1887		+		+	+
17. <i>L. (rubicunda) intermedia</i> (Bartenev, 1911)			+	+	
? <i>Sympetrum danae</i> (Sulzer, 1776)			?		
? <i>S. flaveolum</i> (Linnaeus, 1758)			?	?	
Total	3	12	6 + 2?	13 + 1?	9

The sources are encoded as follows: B — Belyshev et al., 1978; H — A.Y. Haritonov, the manuscript with a species list from Loc. 2; M — Malikova, 1995; HM — Haritonov, Malikova, 1998; tp — new data in this paper. Species new for Chukotka recorded during this study are marked with N.

Источники информации сокращены следующим образом: B — Belyshev et al., 1978; H — А.Ю. Харитонов — рукопись со списком видов из местобитания 2; M — Malikova, 1995; HM — Haritonov, Malikova, 1998; tp — новые данные. Виды, впервые приводимые для Чукотки, помечены буквой N.

small lateral spines on S9 and a hardly noticeable terminal (not movable) hook on the labial palpus [Belyshev, 1973].

Aeshna crenata (Hagen, 1856)

Haritonov, Malikova, 1998.

Records. Loc. 2.

Aeshna juncea (Linnaeus, 1758)

Belyshev et al., 1978: Loc. 1. (*Ae. juncea angustyla* Oguma), 29.06.1968, 1♀; Malikova, 1995: (*Ae. juncea angustyla* Oguma); Haritonov, Malikova, 1998: (*Ae. juncea orientalis* Bartenev).

Records. Loc. 1; Loc. 2; Loc. 3 (05–17.07.2014, 9♀♀); Loc. 4 (18–28.07.2013, 3♀♀).

Aeshna subarctica Walker, 1908

Haritonov, Malikova, 1998: (*Ae. subarctica elisabethae* Djakonov).

Records. Loc. 2.

Cordulia aenea (Linnaeus, 1758)

Records. Loc. 3 (16.07.2014, 1♂).

Remark. The first record for Chukotka. It is unknown if this specimen belongs to the Euro-Siberian or Far Eastern branches of the genus, revealed by Jödicke et al [2004] and associated with the names *C. aenea* and *C. amurensis*, respectively, since they do not differ in any external character and were recognised on molecular level only. Anyway, their specific status is doubtful [Kosterin, Zaika, 2010], so we use the name *C. aenea*.

Somatochlora arctica (Zetterstedt, 1840)

Haritonov, Malikova, 1998.

Records. Loc. 2; Loc. 3 (24–28.06.2014, 3 larvae); Loc. 4 (04.08.2013, 1 larva).

Remark. The larvae was identified by the following combinations of characters [Belyshev, 1973]: a very haired

body, absence of dorsal and lateral spines, the labial palpus with 8 teeth.

Somatochlora exuberata Bartenev, 1911

Records. Loc. 3 (13.07.2014, 1♀).

Remark. The first record for Chukotka.

Somatochlora graeseri Selys, 1887

Haritonov, Malikova, 1998.

Records. Loc. 2.

Somatochlora sahlbergi (Trybom, 1889)

Malikova, 1995; Haritonov, Malikova, 1998: (*S. s. sahlbergi* Tribom).

Records. Loc. 2.

Leucorrhinia (dubia) orientalis Selys, 1887

Haritonov, Malikova, 1998.

Records. Loc. 2; Loc. 3 (27.06.2014, 1♂); Loc. 4 (26.07.2013, 1♀).

Leucorrhinia (rubicunda) intermedia
(Bartenev, 1911)

Malikova, 1995; Haritonov, Malikova, 1998: (*Leucorrhinia intermedia* Bartenev).

Records. Loc. 2.

Two more species were mentioned for Chukotka in literature: *Sympetrum danae* (Sulzer, 1776) by Malikova [1995] and *Sympetrum flaveolum* (Linnaeus, 1758) by Malikova [1995] and Haritonov and Malikova [1998]. In both cases they were present in a summarising table only. While the second work is a brief survey, the former is a large detailed dissertation, and it is noteworthy that both species were not mentioned among specimens studied. The list of references in this work also does not contain additional papers which could contain information from Chukotka. Most probably, indication of these species was an extrapolation, so we abstain from including them into our checklist.

Discussion

The here presented current checklist of Odonata of Chukotka, all collected only in four localities along the Anadyr' River. (Fig. 1), is of course very preliminary and is to increase with further studies. So far, there is no data from Chukotka Peninsula (although presence of any Odonata is not guaranteed there). However, some preliminary comparative notes may be done.

The checklist includes 17 species (Table 1). They belong to 7 genera (*Lestes*: 1; *Coenagrion* 4; *Enallagma*: 1; *Aeshna*: 4; *Cordulia*: 1; *Somatochlora*: 4; *Leucorrhinia*: 2) and five families (Lestidae: 1; Coenagrionidae: 5; Aeshnidae: 4; Corduliidae: 5; Libellulidae: 2). The two richest females have 5 species, and one of them being Corduliidae is a peculiar northern feature of the fauna.

Because of a strong dependence of the Odonata biodiversity on the climate and the geographical position of Chukotka, the latter is scarcely comparable in this respect to some other well-defined and named re-

gions. First, it seems reasonable to compare the fauna of Odonata of Chukotka with some conventionally outlined areas which would be equally northerly situated. Let us take the 62° N parallel as their southern limit and consider the so defined «northern Yakutia» and «northern Alaska» which are Chukotka's western and eastern neighbours, respectively.

The fauna of «northern Yakutia» in the here accepted sense may be subtracted from Kosterin and Sivtseva [2009], namely, with respect to the geographical subdivision of Yakutia accepted in that paper, for the North, North-West, West, East Yakutia and northern part of Central Yakutia and excluding the southern part of the latter, South-West and South Yakutia. The fauna of «northern Yakutia» appears to count 32 species. All the species recorded in Chukotka occur in «northern Yakutia» as well. Besides, the following 15 species have been reported for the latter: Calopterygidae: *Calopteryx japonica* Selys, 1869; Lestidae: *Lestes sponsa* (Hansemann, 1823), *Sympecma paedisca* (Brauer, 1877), Coenagrionidae: *Coenagrion armatum* (Charpentier, 1840), *C. ecornutum* (Selys, 1872), *C. hastulatum* (Charpentier, 1825), *C. lanceolatum* (Selys, 1872), *Erythromma najas humerale* (Selys, 1877); Aeshnidae: *Aeshna serrata* (Hagen, 1856); Gomphidae: *Ophiogomphus obscurus* Bartenev, 1930; Corduliidae: *Epitheca bimaculata* (Charpentier, 1825); Libellulidae: *Libellula quadrimaculata* Linnaeus, 1758, *Sympetrum danae* (Sulzer, 1776), *S. flaveolum* (Linnaeus, 1758), *S. vulgatum* (Linnaeus, 1758). Hence, the known Odonata fauna of Chukotka is just a half of that of «northern Yakutia». Note, there is no any biogeographical border between Chukotka and Yakutia to be evaluated.

The fauna of «northern Alaska» as defined here as north of 62° N can be inferred from distributional maps in Paulson [2009] and occurrence in main parts of Alaska provided by Hudson and Armstrong [2005] (the here considered area occupies the Northern, Central and most of Western Alaska as defined in the last cited book). The fauna of «northern Alaska» includes 30 species, that is almost identical to the species number in «northern Yakutia». Four species, *L. dryas*, *A. juncea*, *A. subarctica* and *S. sahlbergi*, are in common with Chukotka. The other species are: Lestidae: *Lestes disjunctus* Selys, 1862; Coenagrionidae: *Coenagrion angulatum* Walker, 1912, *C. interrogatum* (Hagen in Selys, 1876), *C. resolutum* (Hagen in Selys, 1876), *Enallagma annexum* (Hagen, 1861), *E. boreale* Selys, 1876, *Nehalennia irene* (Hagen, 1861); Aeshnidae: *Aeshna eremita* Scudder, 1866, *A. interrupta* Walker, 1908, *A. palmata* Hagen, 1856 (just reaches 62° N), *A. sitchensis* Hagen, 1861, *A. septentrionalis* Burmeister, 1839, *Anax junius* (Drury, 1770) (one record in the second last century); Corduliidae: *Cordulia shurtleffi* Scudder, 1866, *Somatochlora albicincta* (Burmeister, 1839), *S. franklini* (Selys, 1878), *S. hudsonica* (Hagen in Selys, 1871), *S. kennedyi* Walker, 1918, *S. semicircularis* (Selys, 1871); Libellulidae: *Leucorrhinia borealis* Hagen, 1890, *L. patricia* Walker, 1940, *L. proxima* Calvert, 1890, *L. hudsonica* (Selys, 1850), *Libellula quadrimaculata*, *Sym-*

petrum internum Montgomery, 1943 and *S. danae*. Extension of the area considered to include the territories of Canada north of 62° N, forming a conventional «northern North America», adds four more species: *Lestes forcipatus* Rambur, 1842, *Ophiogomphus colubrinus* Selys, 1854, *Somatochlora septentrionalis* (Hagen, 1861), *S. whitehousei* Walker, 1925, rising the total to 34 species.

The Bering Strait is obviously a strong biogeographical barrier. Its efficiency, however, cannot be evaluated at present because of taxonomical problems, namely somewhat discordant «Eurasian» and «American» taxonomies of Odonata. There are many pairs of too similar or nearly identical Eurasian/American species which may be proved or agreed to be the same species when a comprehensive and unified Holarctic taxonomical system will be worked out. Moreover, such solutions depend strongly on the species concept adopted. The outdated typological concept would assume many such pairs to be the same species. Adoption of the modern and fashionable phylogenetic concept would make most of all of them pairs of different species; at the same time many cryptic species would be recognised in each continent, that would affect the biogeographical analyses. Such Eurasian/American pairs as *E. cyathigerum*/*E. annexum* and *C. aenea*/*C. shurtleffi* are the recent examples. Members of each pair lack any reliable morphological differences, however those of the former pairs used to be considered as the same species while those of the latter pair as two different species. Both pairs were assumed to be composed of different species after respective molecular phylogenetic analyses [Jödicke et al., 2004; Stoks et al., 2005]. At the same time, in each group one more Eurasian taxon has been recognised as bona species: *E. risi* in the former [Stoks et al., 2005] and *E. amurensis* in the latter [Jödicke et al., 2004], in spite of existing evidence of broad transitional zones between *cyathigerum* and *risi* in Siberia [Kosterin, 2004; Kosterin, Zaika, 2010] and, contrary, of missing data on the contact zone between *aenea* and *amurensis*, including information where it is situated in the broad and contiguous range of the genus *Cordulia* in Eurasia [Kosterin, Zaika, 2010]. We expect that investigation of this putative contact zone will prove *aenea* and *amurensis* to be the same biological species (as *cyathigerum* and *risi* are). The use of the most reasonable biological concept of species (in the sense by Ernst Mayr) unfortunately faces difficulties with geographically isolated taxa: it is unknown if Eurasian and American species would mate freely and produce viable progenies if they contacted geographically.

There are more Eurasian/American pairs of very similar species which should be reconsidered for being different or the same species from a point of view independent from the Eurasian or American background and based on analysis of the entire relevant genera, these are: *L. sponsa*/*L. disjunctus*, *C. lunulatum*/*C. angulatum*, *A. caerulea*/*A. septentrionalis* and may be more. If to involve them into molecular phylogenetic analyses, specimens from Chukotka (or at least North Yakutia) would better be included.

The fauna of Odonata of the northern Krasnoyarskiy Kray Province and Taymyr Peninsula remains almost unknown, and too scarce data exist for the northern West Siberian Plain [e.g. Belyshev, Korshunov, 1976]. The only region which still can be compared to Chukotka is «northern Europe», north of 62° N. It includes the territories of Russia west of the northern Urals (inclusive), Finland, Norway and Sweden. The list may be inferred from Bos and Wasscher [1999] and Skvortsov [2010], with notable additions by Bernard and Daraz [2010] and Bernard [2012]; it includes as many as 53 species. All but two species found in Chukotka are present in «northern Europe»; the two exceptions are *S. exuberata* and *L. intermedia*, which are replaced in Europe by close species *Somatochlora metallica* (Vander Linden, 1825) and *Leucorrhinia rubicunda* (Linnaeus, 1758). Other species found in «northern Europe» are as follows: Calopterygidae: *Calopteryx splendens* (Harris, 1782), *C. virgo* (Linnaeus, 1758); Lestidae: *Lestes dryas*, *L. sponsa*, Coenagrionidae: *Coenagrion armatum*, *C. glaciale*, *C. hastulatum*, *C. hylas*, *C. hastulatum*, *C. johannsoni*, *C. puella* (Linnaeus, 1758), *C. pulchellum* (Vander Linden, 1825), *E. cyathigerum*, *E. najas najas* (Hansemann, 1823), *Ischnura elegans* (Vander Linden, 1820), *Nehalennia speciosa* (Charpentier, 1840), *Pyrrhosoma nymphula* (Sulzer, 1776); Platycnemididae: *Platycnemis pennipes* (Pallas, 1771); Aeshnidae: *Aeshna caerulea*, *A. crenata*, *A. cyanea* (Müller, 1764), *A. grandis* (Linnaeus, 1758), *A. juncea*, *A. serrata*, *A. subarctica*, *A. viridis* Eversmann, 1836, *Anax imperator* Leach, 1815, *Brachytron pratense* (Müller, 1764), Gomphidae: *Gomphus vulgatissimus* (Linnaeus, 1758), *Onychogomphus forcipatus* (Linnaeus, 1758), *Ophiogomphus cecilia* (Fourcroy, 1785); Cordulegasteridae: *Cordulegaster boltonii* (Donovan, 1807); Corduliidae: *C. aenea*, *E. bimaculata*, *Somatochlora alpestris*, *S. arctica*, *S. flavomaculata* (Vander Linden, 1825), *S. graeseri*, *S. metallica* (Vander Linden, 1825), *S. sahlbergi*, Libellulidae: *Leucorrhinia albifrons* (Burmeister, 1839), *L. caudalis* (Charpentier, 1840), *L. (dubia) dubia* (Vander Linden, 1825), *L. (dubia) orientalis*, *L. pectoralis* (Charpentier, 1825), *L. rubicunda* (Linnaeus, 1758), *Libellula depressa* Linnaeus, 1758, *L. quadrimaculata*, *Sympetrum danae*, *S. flaveolum*, *S. sanguineum* (Müller, 1764), *S. striolatum* (Charpentier, 1840), *S. vulgatum*, *Orthetrum cancellatum* (Linnaeus, 1758).

The share of Odonata species of Chukotka which are common with «northern Yakutia», «northern Europe» and «northern North America» are 100 %, 88 % and 24.5 %, respectively. The opposite shares, of species common with Chukotka in the respective regions, are 53 %, 28 % and 12 %, but these are not so informative because these regions are larger than Chukotka.

Having chosen the parallel of 62° N, being the southern limit of Chukotka, as the southern limit of our consideration, we considered three regions of the Holarctic of comparable areas: «northern Europe», «northern Yakutia»+Chukotka, and «northern North America». They have, respectively, 53, 31 and 34 species of Odonata. The 70 % gain in species richness in Europe

has a plain explanation of its milder climate because of the Gulfstream. Only 17 species have been registered in Chukotka, the area of which is only one and half times less than that of 'northern Alaska', which has 30 species. No doubt this is because the climate of Chukotka is much more severe. Note that one more large northern region of the Holarctic, Greenland, has no Odonata at all.

At last, we may compare the fauna of Chukotka with one more region of a comparable area, Kamchatka Peninsula. Although situating much more southerly and having milder climate and a lot of boreal forests, it nevertheless suffers from being surrounded by very cold seas. Its fauna have been summarised by Dumont et al. [2005] as including 24 species (not counting occasional migrants known by solitary old specimens). The Odonata fauna of Kamchatka includes all species found in Chukotka but *C. glaciale*, that is 94 % (for the above reasons, here we assume the name *C. aenea* for *Cordulia* from Kamchatka). The share of species common with Chukotka in the fauna of Kamchatka comprises 71 %. The remaining eight species of Kamchatka are: *C. armatum*, *C. hastulatum*, *A. serrata*, *E. bimaculata*, *S. alpestris*, *L. quadrimaculata*, *S. danae* and *S. flavolum* (all found also in «northern Yakutia»). Taking into account similar situation of Chukotka and Kamchatka at the north-eastern extremity of Eurasia, their similar harsh climate and widespread ranges of the last mentioned species (with all they present in Yakutia), we expect that at least some of them may be found in Chukotka as well.

Acknowledgements

The authors are grateful to A.V. Barkalov, V.K. Zinchenko and P.Y. Gorbunov for offering Odonata specimens collected in Chukotka for investigation and to E.I. Malikova for the help concerning the list of species collected at Markovo by M. Danilevskaya. The work of O. Kosterin was supported by Russian State Project VI.53.1.3, the work by S.N. Borisov — by the grant 12-04-00824a of Russian Fund of Fundamental Research.

References

- Belyshev B.F. 1973. The Dragonflies of Siberia (Odonata). Volume I. Novosibirsk: Nauka, Siberian Division. 620 p. [In Russian, English title].
- Belyshev B.F., Korshunov Y.P. 1976. [New materials for comprehension of the dragonfly fauna (Insecta, Odonata) of transpolar Siberia.] // Zolotareno, G.S. (ed.) Fauna gel'mintov i chlenistonogikh Sibiri. Fauna Sibiri. Trudy Biologicheskogo Instituta 18. Novosibirsk: Nauka, Siberian Division. P.151–156. [In Russian].
- Belyshev B.F., Bessolitsina E.P., Kostina N.S., Polyakova P.E. 1978. [New data on odonate fauna (Insecta, Odonata) of North-East Asia] // Chlenistonogie Sibiri. Novosibirsk: Nauka, Siberian Division. P.39–46 [In Russian].
- Bernard R., Daraz B. 2010. Relict occurrence of East Palaearctic dragonflies in northern European Russia, with first records of *Coenagrion glaciale* in Europe (Odonata: Coenagrionidae) // International Journal of Odonatology. Vol.13. P.39–62.
- Bernard R. 2012. East Palaearctic *Somatochlora graeseri* Selys occurs as a postglacial relict in Europe west of the Urals (Anisoptera: Corduliidae) // Odonatologica. Vol.41. P.309–348.
- Bos F., Wasscher M. 1997. Veldgis Libellen. Utrecht' Stichting Untgeverij KNNV. 256 p.
- Dumont H., Haritonov A.Y., Kosterin O.E., Malikova E.I., Popova O.G. 2005. A review of the Odonata of Kamchatka peninsula, Russia // Odonatologica. Vol.34. P.131–153.
- Haritonov A.Yu., Malikova E.I. 1998. Odonata of the Russian Far East: a summary // Odonatologica. Vol.27. P. 375–381.
- Hudson J., Armstrong R.H. 2005. Dragonflies of Alaska. Anchorage: published by the authors. 48 p.
- Jödicke R., Langhoff P., Misof B. 2004. The species group taxa in the Holarctic genus *Cordulia*: a study in nomenclature and genetic differentiation (Odonata: Corduliidae) // International Journal of Odonatology. Vol.7. P.37–52.
- Kosterin O.E. 2004. Odonata of the Daurkiy State Nature Reserve area, Transbaikalia, Russia // Odonatologica. Vol.33. P.41–71.
- Kosterin O.E., Sivtseva L.V. 2009. Odonata of Yakutia (Russia) with description of *Calopteryx splendens njuja* ssp. nov. (Zygoptera: Calopterygidae) // Odonatologica. Vol. 38. P.93–202.
- Kosterin, O.E., Zaika V.V.. 2012. Odonata of Tuva, Russia // International Journal of Odonatology. Vol.13. P. 277–328
- Malikova E.I. 1995. [Dragonflies (Odonata, Insecta) of the Far East of Russia]. Dissertation, Institut sistematiki i ekologii zhivotnykh, Novosibirsk. 233 p. [In Russian].
- Pauslon D. 2009. Dragonflies and Damselflies of the West. Princeton: Princeton University Press. 535 p.
- Skvortsov V.E. 2010. The Dragonflies of Eastern Europe and Caucasus: an Illustrated Guide. Moscow: KMK Scientific Press Ltd. 623 p. [Bilingua: Russian and English].
- Stoks R., Nystrom J.L., May M.L., McPeck M.A. 2005. Parallel evolution of ecological and reproductive traits to produce cryptic dragonfly species across the Holarctic // Evolution. Vol.59. P.1976–1988.
- Suslov S.P. 1954. [Physical geography of the USSR. Asian Part.]. Moscow: Gosudarstvennoe Tekhnicheskii-Pedagogicheskoe Izdatel'stvo Ministerstva Obrazovaniya RSFSR. 711 p. [In Russian].