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Dragonflies (Odonata) of the Syrdarya Karatau and the Arys River valley (southern Kazakhstan) with notes on seasonal latitudinal and altitudinal migrations

Стрекозы (Odonata) Сырдарьинского Каратау и долины реки Арысь (южный Казахстан) с замечаниями о сезонных широтных и высотных миграциях

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Key words: Odonata, South Kazakhstan, latitudinal migrations, altitude migrations.

***Ключевые слова*:** Odonata, Южный Казахстан, широтные миграции, высотные миграции.

Abstract. 45 dragonfly species are presented for Syrdarya Karatau Range and Arys River valley in Southern Kazakhstan, with 19 species newly registered, and *Somatochlora arctica* Zetterstedt, 1840 given on the basis of literature data. Doubtful registrations of *Calopteryx samarcandica* Bartenef, 1911 and *Somatochlora arctica* are discussed. Seasonal latitudinal migrations of the four species, *Anax ephippiger* Burmeister, 1839*, A. parthenope* (Sélys, 1839), *Pantala flavescens* (Fabricius, 1798) and *Sympetrum fonscolombii* Selys, 1840, are determined from Chokpak Pass by means of ornithological traps. Seasonal altitudinal migrations are registered for seven species, *Aeshna mixta* Latreille, 1805*, Sympetrum arenicolor* Jödicke, 1994*, S. meridionale* (Selys, 1841)*, S. striolatum pallidum* Selys, 1887*, Sympecma fusca* (Vander Linden, 1820)*, S. gobica* (Förster, 1900) and *S. paedisca* (Brauer, 1877). In mountainous biocenoses the immigrant dragonfly species flight from plains for aestivation are represented in high numbers.

Резюме. Для Сырдарьинского Каратау и долины реки Арысь (Южный Казахстан) указывается 45 видов стрекоз, из них 19 — впервые для этой территории. *Somatochlora arctica* Zetterstedt, 1840 приводится на основании литературных данных. Проанализированы указанные ранее ошибочные сведения о находках *Calopteryx samarcandica* Bartenef, 1911 и *Somatochlora arctica*. На перевале Чокпак с помощью орнитологических ловушек установлены сезонные широтные миграции четырёх видов стрекоз: *Anax ephippiger* Burmeister, 1839*, A. parthenope* (Sélys, 1839), *Pantala flavescens* (Fabricius, 1798) и *Sympetrum fonscolombii* Selys, 1840. В горах установлены сезонные высотные миграции у 7 видов стрекоз: *Aeshna mixta* Latreille, 1805*, Sympetrum arenicolor* Jödicke, 1994*, S. meridionale* (Selys, 1841)*, S. striolatum pallidum* Selys, 1887*, Sympecma fusca* (Vander Linden, 1820)*, S. gobica* (Förster, 1900) и *S. paedisca* (Brauer, 1877). В горных биоценозах наиболее массовыми являются стрекозы-иммигранты, которые прилетают сюда с равнин на период эстивации. По численности они значительно преобладают над аборигенными горными видами стрекоз.

Introduction

The dragonfly fauna of Kazakhstan is relatively well studied, as follows from the summarizing article [Chaplina et al., 2007] and further odonatological studies in various regions of this republic [Kosterin, Borisov, 2010; Kosterin, Gorbunov, 2010; Borisov, Kosterin, 2014; Kosterin, 2015; Borisov, Dumont, 2021; Boudot et al., 2021]. Nevertheless, some geographic regions, for instance, the Syrdarya Karatau Range and the Arys River valley located in the south of Kazakhstan, remain largely understudied. There are only records of several species of dragonflies [Belyshev, Shevchenko, 1958; Kukashev, 1989; Chaplina et al., 2007; Haritonov, Borisov, 2013; Borisov, 2014; Borisov, Kazenas, 2017]. At the same time, the autumn migrations of dragonflies at the Chokpak Pass have been studied in sufficient detail [Borisov, 2008, 2009, 2010, 2015].

The Syrdarya Karatau (or Karatau) Range is the northwestern spur of the Western Tien-Shan. The Syrdarya River valley is located to the southwest of it, and the Talas River valley is located to the northeast. The length of the range is about 420 km, the width of the Boroldai spurs in the south-eastern part of the range reaches 60–80 km. It is a low range with a maximum absolute height of 2176 m (Mount Bessaz), but the mountains are rather gentle and most of the massif is lower than 1500 m. Despite the general dryness of the region, almost every ravine has a small river or stream. All these watercourses are «warm», with a predominantly groundwater feeding, often drying up by the end of summer. The rivers are also fed by rains and during the spring period by melting seasonal snow. Glaciers and snow fields, which are generally characteristic of the highlands of the Tien Shan, are absent here.

The sources of the Arys River lie in the Talasskii Alatau. Its total length is 378 km. The well-defined valley of this river stretches between the Talasskii Alatau and Syrdarya Karatau ranges for more than 200 km from the Chokpak Pass in the east to the confluence of the Arys and the Syrdarya in the west.

Chokpak Pass is the narrowest point in the intermountain valley that cuts through the Western Tien Shan from the northeast to the southwest and separates the Talasskii Alatau and the Syrdarya Karatau ranges (the distance between their slopes does not exceed 7–9 km). At the same time, this is the highest point in the valley is 1200 m above sea level. Due to such orographic features («bottleneck effect»), a kind of migration corridor for birds [Gavrilov, Gistsov, 1985] and dragonflies [Borisov, 2009, 2010, 2015] exists in the intermountain valley in the upper reaches of the Arys River. It should be noted that this is a unique place for the Middle Asian Mountains, where such a large migration route of winged animals lies.

The purpose of the work is to summarize the available data on the dragonfly fauna of the Syrdarya Karatau Range and the Arys River valley, as well as on seasonal latitudinal and high-altitudinal migration characteristic of dragonflies in this region.

Material and methods

The paper is based on dragonflies collected during expedition trips in 2007–2010 and 2018. It also includes data on locations of certain dragonfly species based on photographs. Dragonflies were photographed by V.L. Kazenas during 2009–2011. Stationary researches of dragonfly migrations using ornithological traps were conducted at Chokpak Pass in the autumn seasons of 2008–2010. Dragonflies in large numbers got into traps during migrations. The design of the traps and re-

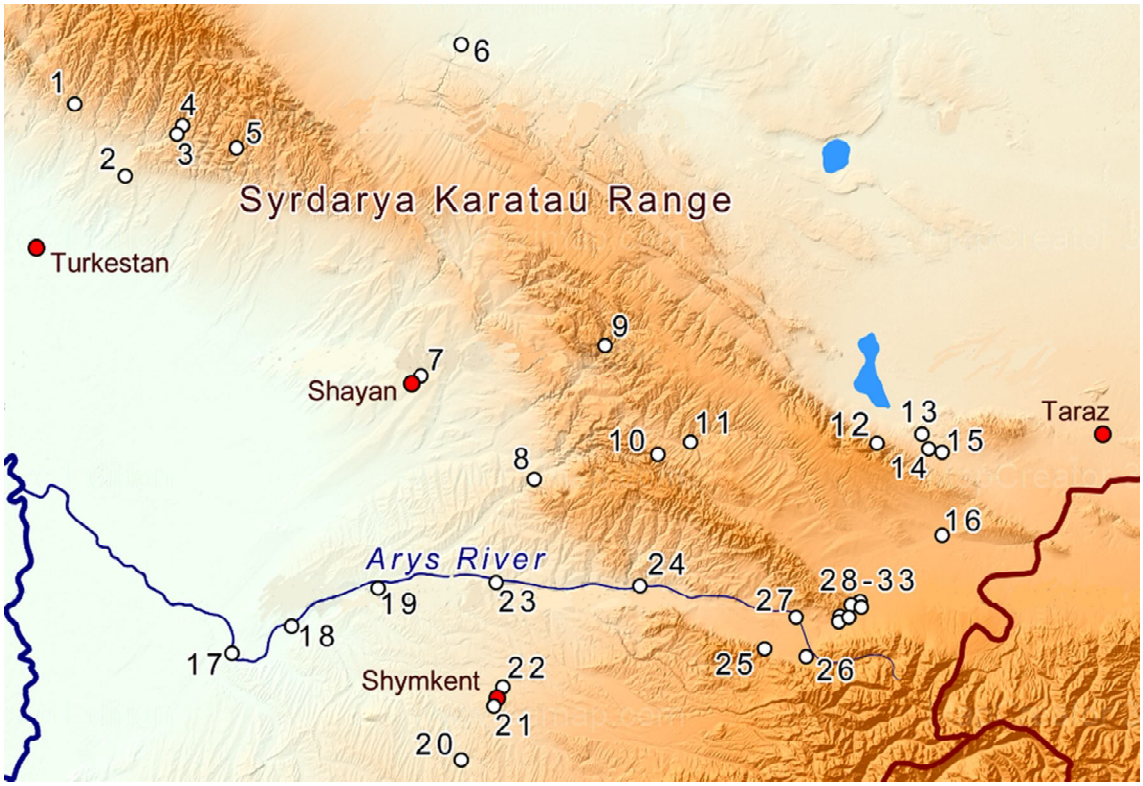

Fig. 1. Map of Syrdarya Karatau Range and valley of Arys River with designation of places of collecting and photographing dragonflies. The locality numbers correspond to those in the locality list.

Рис. 1. Карта Сырдарьинского Каратау и долины реки Арысь с обозначением мест сбора и фотографирования стрекоз. Номера локалитетов соответствуют таковым в списке местонахождений.

search methods were described earlier [Borisov, 2009, 2010].

The places of collection of dragonflies are shown on the map. Locality numbers match those in the locality list (Fig. 1). The map was made using MapCreator 3 software.

The designations of the authors when mentioned in the locality list are as follows: SNB — S.N. Borisov, ASB — A.S. Borisov, VLK — V.L. Kazenas.

List of localities with Odonata records

Loc. 1. The Kyzylata Gorge, 43°36'28" N, 68°22'01" E, 548 m a.s.l., 23.VII.2010, photos, VLK. **Loc. 1a.** Ibidem, 26.VII.2010, photos, VLK. **Loc. 2.** Neighborhoods of the city of Kentau, 43°27'22" N, 68°31'19" E, 390 m a.s.l, 26.IX.2010, SNB. **Loc. 3.** Karatau Nature Reserve, the Khantagi Gorge, 43°32'51" N, 68°40'05" E, 500–600 m a.s.l., 27.IX.2010, SNB. **Loc.4.** Karatau Nature Reserve, the Khantagi Gorge, 43°33'59" N, 68°41'06" E, 616 m a.s.l., 26.VI.2011, photos, VLK. **Loc.4a.** Ibidem, 21.VII.2010, photos, VLK. **Loc. 5.** The Inkasu River, west of the Ashisay village, 43°31'11" N, 68°50'40" E, 690 m a.s.l., 24.VI.2011, photos, VLK. **Loc. 6.** Lake Kyzylkol, 43°44'35" N, 69°30'07" E, 326 m a.s.l., 13–15.IX.2008, SNB. **Loc. 7.** Artificial irrigation system in the area of the village of Chayan (modern Shayan) (about 43°02' N, 69°23' E), 27.VI.1981 [Kukashev, 1989]. **Loc.8.** The Boroldai River, environs of the Terekty village, 42°49'01" N, 69°42'58" E, 460 m a.s.l., 15–16.VII.2010, photos, VLK. **Loc. 9.** The Baizhansai Gorge, 43°06'01" N, 69°55'30" E, 700 m a.s.l., 13.VII.2009, photos, VLK. **Loc. 10.** The Boroldai River, 20 km west of the village of Koshkarata, 42°52'05" N, 70°04'39" E, 750 m a.s.l., 22.VI.2011, photos, VLK (Fig. 2). **Loc.11.** The Koshkarata River, east of the village of the same name, 42°53'34" N, 70°10'13" E, 754 m a.s.l., 21.VI.2011, photos, VLK (Fig. 2). **Loc. 12.** The nameless gorge, 8 km west of Lake Biilikul, 42°53'16" N, 70°42'52" E, 710 m a.s.l., 10–11.VII.2010, photos, VLK. **Loc. 13.** Lake Darbaza, 3 km southeast of the village of Karabastau, 42°54'17" N, 70°50'37" E, 532 m a.s.l., 9.V.2018, ASB, SNB. **Loc. 14.** The small river, 7 km southeast of the village of Karabastau, 42°52'28" N, 70°51'47" E, 586 m a.s.l., 9.V.2018, ASB, SNB. **Loc. 15.** Lake, 9 km southeast of the village of Karabastau, 42°52'05" N, 70°54'13" E, 603 m a.s.l., 9.V.2018, ASB, SNB. **Loc. 16.** The Teris-Ashchybulak Reservoir, 42°41'21" N, 70°53'56" E, 950 m a.s.l., 5.X.2009, SNB. **Loc. 17.** Environs of the village of Arys, the Arys River and floodplain lakes, 42°26'28" N, 68°59'39" E, 224 m a.s.l., 19.VIII.2008, SNB. **Loc. 18.** Environs of the village of Tortkol, the Arys River and floodplain lakes,42°29'59" N, 69°00'56" E, 240 m a.s.l., 20.VIII.2008, SNB. **Loc. 19.** Environs of the village of Temirlan, the Arys River and floodplain lakes, 42°34'58" N, 69°16'00" E, 284 m a.s.l., 20.VIII.2008, SNB. **Loc. 20.** Lake Akzhar near the village of the same name, 10 km south of Shymkent, 42°13'02" N, 69°30'29" E, 452 m a.s.l., 13.X.2007, SNB. **Loc. 21.** Chimkent City, 42°20'N, 69°36' E, 480 m a.s.l., 12.VII.1923 [Chaplina et al., 2007]. **Loc. 22.** Shymkent city, Lake Tulpar (Komsomolskoe), 42°22'26" N, 69°37'35" E, 510 m a.s.l., 15.X.2007, SNB. **Loc. 23.** The Arys River, environs of the village of Kut-Arys, 20 km north of Shymkent, 42°35'49" N, 69°36'26" E, 365 m a.s.l., 9.X.2007, SNB. **Loc. 24.** Balykty village, the Arys River and floodplain lakes, 42°35'19" N, 70°01'19" E, 515 m a.s.l., 20.VIII.2008, SNB. **Loc. 25.** A spring and a stream near the village of Eltay, 42°24'09" N, 70°22'57" E, 928 m a.s.l., 14.X.2010, SNB. **Loc. 26.** Neighborhoods of Zhabagly village, the Taldy-Bulak Gorge, 42°25'04" N, 70°28'24" E, 1200–1300 m a.s.l., 23.VIII.2008, SNB. **Loc. 26a.** Neighborhoods of the village of Zhabagly, 42°26'11" N, 70°30'13" E, 1180 m a.s.l., 1.X.2009, SNB. **Loc. 27.** Pond near the village of Ak Biyk, 42°31'06" N, 70°28'25" E, 930 m a.s.l., 12.X.2010, SNB. **Loc. 27a.** Ibidem, 29.IV.2018, ASB, SNB. **Loc. 28.** Spring and pond, 1 km east of the village of Vysokoe (modern Shakpak Baba), 42°30'25" N, 70°35'53" E, 1083 m a.s.l., 28.VIII.2008, SNB. **Loc. 28a.** Ibidem, 10.V.2018, ASB. **Loc. 29.** Ornitological traps, station in autumn, 1.5 km south-west of the Shakpak railway station, 42°31'16" N, 70°35'58" E, 1173 m a.s.l., 9–10.X.2007, SNB. **Loc. 29a.** Ibidem, stationary research 22.VIII–8.X.2008, SNB. **Loc. 29b.** Ibidem, stationary research 18.IX.–16.X.2009, SNB. **Loc. 29c.** Ibidem, stationary research 6.IX–29.X.2010, SNB. **Loc. 30.** Ornitological traps, station in spring, 2 km south of Shakpak railway station, 42°31'07" N, 70°37'38" E, 1136 m a.s.l., 3.V.2014, *P. flavescens* photo by A.E. Gavrilov [Borisov, 2015]. **Loc. 30a.** Ibidem, 10–15.V.2018, ASB, SNB. **Loc. 31.** Kalinino village surroundings, spring and stream, 42°32'40" N, 70°38'07" E, 1104 m a.s.l., 21.V.2018, ASB, SNB. **Loc. 32.** Kalinino village, pond, 42°33'03" N, 70°38'37" E, 1090 m a.s.l., 21.IX.2010, SNB. **Loc. 32a.** Ibidem, 29.IV.2018, ASB, SNB. **Loc. 32b.** Ibidem, 21.V.2018, ASB, SNB. **Loc. 33.** Amangeldy village, pond, 42°32'16" N, 70°39'49" E, 1125 m a.s.l., 17.V.2018, ASB, SNB.

List of recorded species with indication of localities

The numbers of localities are provided, including places where dragonflies were photographed (Figs 3–8). Notes on taxonomy and nomenclature are provided for certain species. An asterisk (*) denotes species that are for the first time reported for the region under study.

A total of 45 species of dragonflies were recorded in 33 localities, of which 19 species for the first time for the study area. *Somatochlora arctica* is included on the basis of literature data.

Lestidae

Lestes barbarus (Fabricius, 1798)

Material. Loc.: 5 (photo), 16, 17, 18, 19, 26.

Lestes dryas Kirby, 1890

Material. Loc.: 26.

Sympecma fusca (Vander Linden, 1820)

Material. Loc.: 26, 26a, 27, 28, 29, 29a, 29b, 29c.

Sympecma gobica Föerster, 1900

Material. Loc.: 2, 3, 9 (Fig.3), 11 (photo), 22, 23, 26, 27, 29, 29a, 29b, 29c.

Sympecma paedisca (Brauer, 1877)

Material. Loc.: 2, 3, 26, 26a, 27, 29, 29a, 29b, 29c.

Calopterygidae

Calopteryx samarcandica Bartenev, 1912

Material. Loc.: 10 (photo), 21, 31 (fig. 5).

**Calopteryx splendens* (Harris, 1782)

Material. Loc.: 9 (photo), 10 (photo), 11 (photo), 17, 32, 32b.

Platycnemididae

**Platycnemis pennipes* (Pallas, 1771)

Material. Loc.: 4 (photo), 5 (photo), 8 (Fig.4), 32b.

Coenagrionidae

**Coenagrion puella* (Linnaeus, 1758)

Material. Loc.: 32b, 33.

Fig. 2. Syrdarya Karatau Range, Koshkarata River (Loc. 11) (above) and Boroldai River (Loc. 10) (below). Photo by V.L. Kazenas.

Рис. 2. Хребет Сырдарьинский Каратау, река Кошкарата (Loc. 11) (вверху) и река Бородлай (Loc. 10) (внизу). Фото В.Л. Казенаса.

**Coenagrion pulchellum*
(Vander Linden, 1825)

Material. Loc.: 32b.

Notes. For the subspecific status of melanistic forms of *C. pulchellum* in the eastern part of the range see Borisov, Haritonov [2007], Schröter [2010], Boudot, Nelson [2015] and Malikova, Kosterin [2019].

**Enallagma cyathigerum risi*
Schmidt, 1961

Material. Loc.: 32b.

Notes. For the subspecific status of *E. c. risi* see Kosterin [2004]; Kosterin, Zaika [2010] and Kalkman, Kitanova [2015].

**Erythromma viridulum* (Charpentier, 1840)

Material. Loc.: 17, 18.

Ischnura elegans (Vander Linden, 1820)

Material. Loc.: 13, 14, 15, 17, 18, 19, 24, 27a, 32a, 32b, 33.

Notes. The current consensus is an absence of clear subspecies in *I. elegans* [Schröter et al., 2015; Kosterin, Ahmadi, 2018; Schneider et al., 2018; Malikova, Kosterin, 2019].

**Ischnura evansi* Morton, 1919

Material. Loc.:17.

Ischnura forcipata Morton, 1907

Material. Loc.: 3.

**Ischnura fountaineae* Morton, 1905

Material. Loc.: 4a (Fig. 7), 17.

**Ischnura pumilio* (Charpentier, 1825)

Material. Loc.: 3, 13, 14, 15, 17, 18, 19, 23, 24, 27a, 28a, 32a, 32b, 33.

Aeshnidae

**Aeshna affinis* Vander Linden, 1820

Material. Loc.: 26.

Aeshna mixta Latreille, 1805

Material. Loc.: 3, 20, 26a, 27, 29.

Anax ephippiger (Burmeister, 1839)

Material. Loc.: 29a, 29b, 29c.

Anax parthenope (Selys, 1839)

Material. Loc.: 6, 13, 14, 15, 29, 29a, 29b, 29c.

Notes. At present, the species is considered to be monotypic. The closely related *A. julius* Brauer, 1865 replaces *A. parthenope* in the Eastern Palearctic [Kalkman, Proess, 2015].

Gomphidae

Lindenia tetraphylla (Vander Linden, 1825)

Material. Loc.: 12 (photo).

Onychogomphus lefebvrii (Rambur, 1842)

Material. Loc.: 1 (photo), 4 (photo), 5 (photo), 8 (photo), 9 (photo), 11 (photo), 12 (photo).

**Ophiogomphus reductus* Calvert, 1898

Material. Loc.: 4 (photo), 8 (photo), 11 (photo).

Cordulegastridae

Cordulegaster coronata Morton, 1916

Material. Loc.: 12 (photo), 28a.

Notes. Formerly considered to be a member of the *insignis* group, this central Asian endemic is now regarded as a fully distinct species upon preliminary results of genetic investigations [Schröter, 2013].

Corduliidae

Somatochlora arctica (Zetterstedt, 1840)

Material. Loc.: 7.

Libellulidae

Crocothemis erythraea chaldaeorum
Morton, 1920

Material. Loc.: 17, 24.

Notes. For the subspecific status of *C. e. chaldaeorum* see Borisov, Haritonov [2008], Kosterin, Ahmadi [2018].

**Crocothemis servilia* (Drury, 1770)

Material. Loc.: 1a (Fig. 6), 2, 3, 6, 20.

Libellula depressa Linnaeus, 1758

Material. Loc.: 32b, 33.

Libellula quadrimaculata Linnaeus, 1758

Material. Loc.: 28a, 32b, 33.

**Orthetrum albistylum* (Selys, 1848)

Material. Loc.: 11 (Fig. 8), 13, 14, 15, 17, 18, 19, 24, 27a, 32b, 33.

Notes. The eastern subspecies *O. a. speciosum* (Uhler, 1858) was shown to have no reliable diagnostic differences and cannot be supported [Seehausen, Fiebig, 2016; Malikova, Kosterin, 2019].

**Orthetrum brunneum* (Fonscolombe, 1837)

Material. Loc.: 1, 3, 4, 6, 8, 11, 12, 17, 18, 19, 24, 27a, 28, 30a, 32b.

**Orthetrum cancellatum* (Linnaeus, 1758)

Material. Loc.: 13.

**Orthetrum coerulescens anceps* (Schneider, 1845)

Material. Loc.: 1, 6, 17, 24.

Notes. For the subspecific status of *O. c. anceps* see Kalkman, Ambrus [2015].

**Orthetrum sabina* (Drury, 1773)

Material. Loc.: 17.

Pantala flavescens (Fabricius, 1798)

Material. Loc.: 29c (04.X.2010), 30 (3.V.2014, photo, A.E. Gavriliv).

**Selysiothemis nigra* (Vander Linden, 1825)

Material. Loc.: 17.

Sympetrum arenicolor Jödicke, 1994

Material. Loc.: 2, 3, 22, 29, 29a, 29b, 29c.

Sympetrum flaveolum (Linnaeus, 1758)

Material. Loc.: 26.

Figs 3–8. Dragonfly species photograph from different localities: 3 — *Sympecma gobica* (Loc. 9), 4 — *Platycnemis pennipes* (Loc. 8), 5 — *Calopteryx samarcandica* (Loc. 31), 6 — *Crocothemis servilia* (Loc. 1a), 7 — *Ischnura fountaineae* (Loc. 4a), 8 — *Orthetrum albistylum* (Loc. 11). Photograph 3, 4 and 6–8 by V.L. Kazenas, and 5 by A.S. Borisov.

Рис. 3–8. Избранные фото стрекоз из различных локалитетов: 3 — *Sympecma gobica* (Loc. 9), 4 — *Platycnemis pennipes* (Loc. 8), 5 — *Calopteryx samarcandica* (Loc. 31), 6 — *Crocothemis servilia* (Loc. 1a), 7 — *Ischnura fountaineae* (Loc. 4a), 8 — *Orthetrum albistylum* (Loc. 11). Фото 3, 4 и 6–8 В.Л. Казенаса; 5 — А.С. Борисова.

Sympetrum fonscolombii (Selys, 1840)

Material. Loc.: 2, 3, 22, 27, 29, 29a, 29b, 29c, 32, 32a, 32b.

Sympetrum haritonovi Borisov, 1983

Material. Loc.: 26a.

Sympetrum meridionale (Selys, 1841)

Material. Loc.: 2, 16, 20, 28, 29a, 29b, 29c.

**Sympetrum sanguineum* (Müller, 1764)

Material. Loc.: 26.

Sympetrum striolatum pallidum (Selys, 1887)

Material. Loc.: 2, 3, 6, 20, 22, 23, 25, 26, 26a, 27, 28, 29a, 29b, 29c, 32.

Sympetrum vulgatum decoloratum (Selys, 1884)

Material. Loc.: 26, 26a, 27, 28, 29a, 29b, 29c.

Discussion

NOTES ON THE DISTRIBUTION OF CERTAIN SPECIES

***Calopteryx samarcandica* Bartenef, 1911.** According to our data, the range of this little-known species covers the mountainous and foothill regions of the Tien Shan, the western part of the Pamir-Alay (the Gissar-Alay) and the northern spurs of the Western Hindu Kush. This includes the territories of 6 states: Kazakhstan, Kyrgyzstan, Uzbekistan, Turkmenistan, Tajikistan and Afghanistan [unpublished]. The northern limit of distribution lies in Southern Kazakhstan along the Syrdarya Karatau Range. I.A. Chaplina [2004] using the specimens from collection of Zoological Institute (Saint-Petersburg) with the label «Yany-Kurgan, 21.VI.1907, leg. Pelz» erroneously indicated *C. samarcandica* for the city of Taraz in the south of Kazakhstan, considering that this is the modern name of Yany-Kurgan. Later, the same mistake was repeated by us [Borisov, Haritonov, 2007: 346, 354, map 5]. Actually, the village of Yany-Kurgan (modern Zhanakorgan) is located in the lower reaches of the Syrdarya River (43°53' N, 67°14' E), 350 km northwest of Taraz. Currently, it is the northernmost point of the range of *C. samarcandica*.

***Platycnemis pennipes* (Pallas, 1771).** In the eastern part of the range, the southern limit of the distribution of *P. pennipes* lies in the foothill strip along the northern principal slope of the Tien Shan. Here this species lives on small rivers with a predominantly ground water feeding, in irrigation canals and in semi-flowing reservoirs/ponds formed by springs (for example, Loc. 39b). The South Kazakhstani section of the *P. pennipes* range extends in a narrow strip for more than 1000 km — from the lower reaches of the Ayaguz River in the east [unpublished], to the middle part of the Syrdarya Karatau (Loc. 4) in the west. This part is considered isolated from the main range [Boudot et al., 2015]. So, in the northern part of Kazakhstan, this species was recorded no more south of 49° N [Borisov, Kosterin, 2014], in the northeastern part no more south of 48° N [Chaplina et al., 2007]. Meanwhile, we found this species in the lower reaches of the Ayaguz River, which flows in the eastern part of Kazakhstan in a latitudinal direction. This river can serve as a «connecting bridge» between the northern and southern parts of the range of *P. pennipes* in Kazakhstan.

***Ischnura evansi* Morton, 1919.** Earlier, for the territory of Kazakhstan, this species was known only from the Ustyurt Nature Reserve in Mangystau province (42°59' N, 54°22' E) [Kosterin, Gorbunov, 2010]. This locality, markedly isolated from the main range, is currently the northernmost point of the *I. evansi* range. Our find of this species in the valley of the Arys River (Loc. 17) was made somewhat to the south, but much to the east of the Ustyurt Plateau. The location closest to Arys is located 240 km to the south in Uzbekistan near the village of Dalverzin (40°24' N, 69°17' E) [unpublished]. We should also mention, the finding of *I. evansi* in North China (39°40' N, 106°30' E) [Dumont, 1996], extremely remote from the main part of the range (almost 3000 km).

***Ischnura forcipata* Morton, 1907.** The finding of *I. forcipata* in the Syrdarya Karatau (Loc. 3) is the only one for the territory of Kazakhstan and is the northernmost point of the range. The nearest location lies 250 km to the south, in the vicinity of Tashkent. In Central Asia, this species is widespread in the eastern foothill and mountainous regions of Uzbekistan and in the western half of Tajikistan, and only slightly enters southern Kazakhstan, southwestern Kyrgyzstan, and southeastern Turkmenistan, where the species is known from Kugitang Range [Borisov, 2014].

The western boundary of the distribution of *I. forcipata*, which lies in Turkmenistan and Iran, remains not entirely clear. For Iran, reliable locations are known in the southeast of the country in Zahedan [Dumont, Heidari, 1996; Heidari, Dumont, 2002] and in the northeast of Khorćsćn-e-Razavi province [Schneider, Ikemeyer, 2016; Schneider et al., 2018]. All other reports of *I. forcipata* in northern Iran were apparently erroneous. Earlier [Dumont, Borisov, 1995] it was revealed that specimens from the Tehran Province, which were identified by E. Schmidt [Schmidt, 1954] as *I. forcipata*, in fact belong to a closely related species *I. intermedia* Dumont, 1974. Later *I forcipata* was again reported for northern Iran (rice paddies off the southern coast of the Caspian Sea) [Ghahari et al., 2009]. We assume that this report also resulted from identification error, and the authors were dealing with *I. intermedia*. The same apparently concerns the reports of *I. forcipata* for southern Turkmenistan for Kara-Kala in the Southwestern Kopetdag [Schoorl, 2000] and for the Kou sulfur spring in the Central Kopetdag [Starostin, 1951]. Presumably, in both cases, the authors dealt with *I. intermedia,* which is widespread in the Kopetdag Mts [Borisov, 2014].

***Onychogomphus lefebvrii* (Rambur, 1842).** The range of *O. lefebvrii* extends from Southeast Turkey and the Levant in the west to Tajikistan and Kyrgyzstan in the east [Borisov, Kazenas, 2017]. The findings of this species in the Syrdarya Karatau are northernmost, at least in the eastern part of the range. The closest previously known localities are in the north of Uzbekistan in Tashkent [Borisov, Kazenas, 2017] and on the northern macro slope of the Kyrgyzskii Range in northern Kyrgyzstan [Schröter, 2010].

O. lefebvrii is rheophilic species. The larvae develop in mountain rivers and streams with a predominantly groundwater feeding with a stony, poorly silted bed. These dragonflies do not live in rivers with a snow-glacial or glacial-snow feeding type, nor have they been found in artificial watercourses, irrigation canals and aryks. The Syrdarya Karatau Range is the western low-mountainous part of the Tien Shan. 'Warm' rivers and streams are common here (Fig. 2), as there are no glaciers and snowfields, which are so typical for the Tien Shan as a whole. This circumstance contributes to the

wide distribution of *O. lefebvrii* in these low mountains. In general, in Middle Asia, these dragonflies can be classified as stenotopic and hemerophobic species with a local distribution. In Kyrgyzstan, the species is known only in two places in the Chui and Jalalabad regions [Schröter, 2010], in Uzbekistan in only two localities (in the north and in the south of this state), in Tajikistan in four localities. At the same time, this species is quite common in the Kopetdag mountains, which are very similar to the Syrdarya Karatau by their orographic features (low mountains with rivers with a groundwater feeding) [Borisov, Haritonov, 2008].

***Somatochlora arctica* Zetterstedt, 1840.** *S. arctica* has a wide range covering the northernmost two-thirds of the Palearctic. Some isolated localities are known south of its main range, notable in south-west France, Bulgaria, Romania, Central Asia and central Japan [Boudot, Karjalainen, 2015].

D.Sh. Kukashev [1989] reported this species from the south of Kazakhstan and, in general, in Middle Asia for the first time. In 1981, this author found *S. arctica* on an irrigation system near the village of Chayan (modern Shayan) in the Chimkent district. Dragonflies were identified by A.Yu. Haritonov. In her thesis, I.A. Chaplina [2004] added information that one female was found 40 km from the village of Chayan on 27 June 1981. Later, in the summarizing article about dragonflies in Kazakhstan [Chaplina et al., 2007], it was already indicated that *S. arctica* female, collected from an «artificial irrigation system near Chayan village, Chimkent district», is kept in the collections of the Zoological Institute of the Russian Academy of Sciences (Saint Petersburg), and that it was this finding which was previously published by D. Kukashev [1989]. At the same time, the article [Chaplina et al., 2007: 357] indicates the locality number corresponding to the city of Chimkent, which is located 80 km south of the village of Chayan.

All of these inconsistencies compel us so far to consider the presence of *S. arctica* in our study area only very provisionally (Loc. 7). It should also be pointed out that a technical error was made in the design of the schematic map of the distribution of *S. arctica* in our article about Middle Asian dragonflies [Borisov, Haritonov, 2008: 115, map 14]. On the map, this species was erroneously indicated in 4 points, including for South-Eastern Kazakhstan and Northern Kyrgyzstan, while the text [Borisov, Haritonov, 2008: 105] properly says only about the single finding of this dragonfly in Chayan. Further, because of this defective map, *S. arctica* was erroneously indicated for South-Eastern Kazakhstan on the map of the range in Atlas of the European dragonflies [Boudot, Karjalainen, 2015: 239].

The finding of *S. arctica* in the Syrdarya Karatau is unique. In Kazakhstan, this species was elsewhere found only high in the Altai Mts, at a small lake at the border of Russia and Kazakhstan in the Katun' and Belaya Berel' interfluve [Kosterin, 1989]. The locations nearest to the study area are almost one and a half thousand kilometers north — in the Southern Ural (54°31' N, 58°53' E) [Haritonov, Eremina, 2010] and in the south of Western Siberia [53°44' N, 77°52' E) [Borisov et al., 2010].

***Sympetrum haritonovi* Borisov, 1983.** This is a purely mountainous view. Its range covers the Asia Minor Highlands, the Iranian Highlands, the Hindu Kush, Pamir-Alai and Tien Shan. The location of *S. haritonovi* in the upper reaches of the Arys River in the Talasskii Alatau (Loc. 26a) is the northernmost point of the range and is located 2 degrees north of the known finds of this species in Turkey [Pelt, 2004].

Seasonal latitudinal migrations of dragonflies through the Chokpak Pass

Seasonal latitudinal migrations in Middle Asia and Kazakhstan are indicated for 4 species of dragonflies. For 3 species (*Anax ephippiger, Pantala flavescens* and *Sympetrum fonscolombii*), it is supposed that they arrive in temperate latitudes from the southern parts of the range for breeding in spring, and in autumn their descendants (individuals of summer generation) migrate back to the south. Hibernation of these dragonflies in the northern parts of the range is impossible due to temperature preferences. Migration strategy of another dragonfly species, *Anax parthenope*, is different. Regular migrations and, at the same time, development and hibernation of larvae throughout the range suggest the existence in the population of two different life cycle cohorts, «migratory» and «aborigine» [Borisov, 2015].

During the autumn migrations, dragonflies regularly got into ornithological traps which were placed on Chokpak Pass to catch and ring migratory birds (Fig. 9). These traps were used to record migratory dragonflies in the autumn periods of 2008–2010 (Loc. 29a, 29b, 29c).

Two features of autumn migrations of dragonflies, related to weather conditions and wind direction, should be mentioned. Intensity of migrations rose sharply with cold snap, that is, with the arrival of cold air fronts. This was found out when comparing the course of average daily air temperatures with the number of dragonflies caught in the traps [Borisov, 2010].

We observed these dragonflies flying only close to the earth surface. However, they always flew against the wind. If the wind subsided, or became favorable for migrants, then visible flights near the surface ceased. It is assumed that the main movements of «latitudinal migrants» occur with a tailwind at high altitudes and are inaccessible for visual observation [Borisov, 2010, 2015].

If the wind becomes headwind, the dragonflies are forced to descend and continue their flight against the wind near the earth surface within the so-called «flight boundary layer» (that is the layer of air, extending a variable distance up from the ground, where the ambient wind speed is lower than the insect's self-propelled

Fig. 9. Ornitological traps at Chokpak Pass (autumn station). Photo: S.N. Borisov.
Рис. 9. Орнитологические ловушки на перевале Чокпак (осенний стационар). Фото: С.Н. Борисов.

flight speed) [Srygley, Dudley 2008; Chapman et al. 2015].

In this case, an analogy can be traced with the flights of birds, which fly at a high altitude with a tailwind and at the surface of the earth in a headwind and fall into traps in large numbers [Gavrilov, Gistsov, 1985].

***Anax ephippiger* (Burmeister, 1839).** In small numbers (only about fifty individuals in three seasons), dragonflies of this species fell into ornithological traps during autumn migrations from August 28 to October 13. It should be mentioned that the presence of *A. ephippiger* in the study region and, in general, in the Western Tien-Shan, was possible to register only thanks to using traps. In Kazakhstan, except Chokpak, this species is known from single findings in only two places on the Ustyurt plateau [Kosterin, Gorbunov, 2010; Borisov, 2011a], in Ust-Kamenogorsk [Chaplina et al., 2007] and on the Lake Maly Sorbulak (30 km north of Almaty) [unpublished]. Autumn migrations of *A. ephippiger* through Chokpak pass demonstrate the successful development of summer generation of these dragonflies in Kazakhstan and a wider distribution here than is known to date.

***Anax parthenope* (Selys, 1839).** Autumn migrations of *A. parthenope* were recorded from 28 August to 28 October. On some days (for example, 4.X.2010) more than 100 individuals fell into the trap [Borisov, 2012a].

The fact that *A. parthenope* is characterized by regular autumn migrations to the south is beyond doubt. But it remains unknown when these dragonflies arrive in Kazakhstan in spring. The origin of dragonflies (these are aboriginal individuals or immigrants from the south), which we noicted in the foothills of the Karatau on May 9 (Loc. 13, 14, 15), also remains unknown. We can only say that all individuals during this period were mature and active reproductive actions were taking place. For comparison, in the Altyn Emel Natural Park (South-East Kazakhstan) in April 28, 2012, we observed a mass emergence of *A. parthenope*. In this case, no doubt, the dragonflies were «local», that is, their larvae overwintered here [unpublished].

***Pantala flavescens* (Fabricius, 1798).** This is one of the most well-known migratory species among dragonflies. In the south of Kazakhstan, it is located at the northern limits of distribution [Borisov, 2012b]. In the autumn, only one individual fell into trap (Loc. 29c, 4.X.2010). On 3 May 2014, in the trap placed in «spring» station, four individuals were photographed by A.E. Gavrilov [Borisov, 2015].

Spring immigration and development of the summer generation of these dragonflies were observed in the lower reaches of the Syrdarya River (about 400 km northwest of the Chokpak Pass). The presence of immigrant dragonflies was also registered in southeastern Kazakhstan (northeast of the Chokpak Pass) [Borisov, 2012b].

The study of migrations of *P. flavescens* using stable isotope analysis (SIA) made it possible to reveal that these dragonflies migrate in spring from East Africa and/or the Arabian Peninsula to Central Asia (including Southern Kazakhstan) for breeding. Their descendants, developed during summer, migrate back to the south. Also, it is supposed that some of individuals migrate to Africa in a large circle through the southern part of Hindustan, overcoming the Indian Ocean. The total length of the migration circle may exceed 14000 km

[Borisov et al., 2020a].

***Sympetrum fonscolombii* Selys, 1840.** In April 29, near Chokpak Pass, the first individuals which arrived in the spring from the south and reproductive behavior were observed (Loc. 32a); on May 21 (Loc. 32b), this species was very abundant there. Apparently, the inflow of dragonflies from the south to the Karatau lasts throughout the summer up to September. Thus, on September 26, old individuals with worn out wings, which were passive and easy to catch, were found in the vicinity of Kentau (Loc. 2) away from reservoirs. Probably these were immigrants from the south, which had used up their reproductive potential and were in the stage of dieback. Curiously, at the same time the emergence of individuals of the summer generations *S. fonscolombii* took place in the same region.

In general, the emergence of the summer generation of *S. fonscolombii* in the study region has been already observed since September 21 (Loc. 32), while the latest date of the emergence was October 12 (Loc. 27). Of course, emergence of the summer generation had started much earlier, apparently already in July. For example, in Tajikistan located to the south, the first exuvia and individuals of the summer generation of *S. fonscolombii* were found on June 29 [Borisov, 2011b]. In the lower reaches of the Syrdarya River and in the southeast of Kazakhstan, the emergence of the summer generation was observed by us in mid-August [unpublished].

At Chokpak Pass, the first *S. fonscolombii* got into traps since 28 August, but mass migrations occured in October. The maximum number of dragonflies trapped in a day exceeded 3000 individuals (11.X.2009). Intensive migrations continued until the end of October (October 28, 2010) [Borisov, 2011b]. Apparently, *S. fonscolombii* can migrate even later in a good weather conditions.

When studying the seasonal migrations of *S. fonscolombii* in Central Asia, we used the method of stable isotope analysis (SIA). Individuals from different regions of Kazakhstan and directly from Chokpak Pass, caught during autumn migrations, were used for analysis. It was found that these dragonflies arrive in Kazakhstan in spring from South–West Asia (from regions located to the south, approximately 36° N). The descendants of immigrants, which migrate in mass quantities through Chokpak Pass in autumn, can be «native» from Kazakhstan and the northernmost parts of the range of *S. fonscolombii* the Southern Ural and the south of Western Siberia. Also, the length of migrations of dragonflies of one generation (that is, one way) can exceed 4000 km [Borisov et al., 2020b].

Seasonal altitudinal migrations of dragonflies in the Western Tien Shan

In Middle Asia, seasonal altitudinal migrations and aestivation in the mountains are known for 7 species of dragonflies: *Sympecma fusca, S. gobica, S. paedisca, Aeshna mixta, Sympetrum arenicolor, S. meridionale* and *S. s. pallidum* [Borisov, 2005, 2006; Schröter, 2010]. In the summer-autumn period, all these species were common in the vicinity of Chokpak Pass and on the adjacent mountain slopes at absolute heights of 900–1500 m.

The adaptive strategies in species with high-altitude migrations are similar. By the type of life cycle they are all univoltine. Individuals from lowland and foothill populations, after emergence at the beginning of summer, fly to the mountains where they have an aestivation period, and in late autumn they return to the plains for reproduction (or wintering in imago in the species of the genus *Sympecma*). Ph. Corbet [1999] named this phenomenon as «seasonal refuge flights». Their life cycle includes diapauses, staying in puberty/inhibition of maturation of dragonflies. Various authors refer to this phenomenon as imaginal [Jödicke, 1997], reproductive [Uéda, 1989], or pre-reproductive diapauses [Samraoui et al., 1998; Corbet 1999; Borisov, 2006], or simply «dormancy» [Kimura, 2021].

In the vicinity of Chokpak Pass, dragonflies, which had arrived from the plains concentrated in forest plantations and woodlands and were absent from open steppe areas. Their activity decreased markedly or stopped completely at too high temperatures. On hot sunny days, they avoided direct sun exposure by sticking to shaded areas. Apparently for that reason the dragonflies prefer there only areas with woody or shrubby vegetation.

According to visual counts on the routes in August–October, the number of immigrants varied in wide limits, which indicates their permanent movements, but no visible directional flights were observed. It was possible to establish this only on the basis of data on catching dragonflies with traps. Large-sized dragonflies *Aeshna mixta* and species of the genus *Sympetrum* regularly get into traps, while small dragonflies (three *Sympecma* species) practically did not linger in the traps. Dragonflies with altitudinal and latitudinal migrations got into ornithological traps quite synchronously. This indicates that 'altitude migrants' also fly against the wind in open areas and that their migrations are also provoked by a cold snap, the arrival of cold air fronts.

The duration of the aestivation of dragonflies in the mountains largely depends on weather conditions. Some individuals stay there until the arrival of cold weather. For example, the last individuals of *S. s. pallidum* were recorded in traps at Chokpak Pass on 28 October. Observations at Chokpak Pass were not carried out in summer, and it remains unknown when immigrants from the plains arrive there. In the last decade of May, they were not there yet. At the same time, in the Northern Tien Shan (near Almaty), at absolute heights of 1000–1600 m, the first individuals of *Aeshna mixta*, *Sympetrum meridionale* and *S. s. pallidum*, which arrived here from the plain, were recorded since June 20 [un-

published], and all the three species of the genus *Sympecma* since June 23 [Borisov, 2005]. At the very beginning of July, all these species were already common in the mountains.

Seasonal high-altitudinal migrations of dragonflies can be considered an ethological-climatic adaptation [Gorodkov, 1985], which allows avoiding extremely high temperatures and dryness in the Middle Asian plains in summer [Borisov, 2006; Kimura 2021]. Observing the peculiarities of the stay of immigrant dragonflies in the mountains, we found out that they were most numerous on the periphery of the mountain systems, especially along the gorges that begin directly at the foothill plains. Often there are either no native mountain dragonflies there at all or they are very few in number. It turns out that in summer and autumn in the mountains, dragonflies-immigrants, which flew here from the plains, significantly prevail in number.

Explanation for this phenomenon lies in the peculiarities of the habitats of dragonfly larvae in the mountains and on the plains. On the foothill plains of the Tien Shan, as well as in Middle Asia as a whole, there is a wide network of artificial reservoirs of the irrigation system. They are very favorable for development of dragonfly larvae. At the same time in the mountains, reservoirs suitable for the development of dragonfly larvae are relatively rare, the higher the fewer of them. In the mountains, the larvae of most species of dragonflies develop in shallow, well-warmed, non-flowing reservoirs. They, with rare exception, do not live in cold mountain lakes and rivers.

Thus, it turns out that often in the mountains, initially plain species, which arrive here only for a while, can be most abundant. In summer they can reach high numbers and noticeably prevail over native species of dragonflies in mountain biocenoses.

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