Turczaninowia 21 (4): 63–72 (2018)
DOI: 10.14258/turczaninowia.21.4.7
http://turczaninowia.asu.ru

ISSN 1560–7259 (print edition)
TURCZANINOWIA
ISSN 1560–7267 (online edition)

УДК 576.316:581.524.2(571.151)

Chromosome numbers of invasive species of the Altai Republic flora. II

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Keywords: Altai Republic, Amaranthaceae, Asteraceae, Caryophyllaceae, chromosome numbers, invasive species, Lamiaceae, Onagraceae, Poaceae.

Summary. Chromosome numbers (2*n*) in 16 invasive plant species from the families Amaranthaceae, Asteraceae, Caryophyllaceae, Lamiaceae, Onagraceae and Poaceae are reported on the material from the Altai Republic for the first time. Among them, chromosome complements were first examined in Russia for *Chaiturus marrubiastrum* (L.) Ehrh. ex Reichenb. (*2n* = 24) and *Oenothera villosa* Thunb. (*2n* = 14). Five species: *Amaranthus lividus* L. (2*n* = 34), *Elisanthe noctiflora* (L.) Rupr. (*2n* = 24), *Galeopsis speciosa* Mill. (*2n* = 16), *Oenothera biennis* L. (*2n* = 14) and *Bromus japonicus* Thunb. (*2n* = 14), were studied first from Siberia. The most part of the species studied are diploids. The general distribution and the history of floristic findings of these species in the Altai Republic are given. The data on chromosome numbers published earlier on the material from Russia are cited.

Числа хромосом инвазионных видов во флоре Республики Алтай: сообщение 2

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Ключевые слова: инвазионные виды, Республика Алтай, числа хромосом, Amaranthaceae, Asteraceae, Caryophyllaceae, Lamiaceae, Onagraceae, Poaceae.

Аннотация. Приводятся данные о числах хромосом (2*n*) для 16 инвазионных видов из семейств Amaranthaceae, Asteraceae, Caryophyllaceae, Lamiaceae, Onagraceae, Poaceae, впервые полученные на материале из Республики Алтай. Впервые для России определены числа хромосом у *Chaiturus marrubiastrum* (L.) Ehrh. ex Reichenb. (*2n* = 24) и *Oenothera villosa* Thunb. (*2n* = 14), впервые для Сибири – у *Amaranthus lividus* L. (2*n* = 34), *Elisanthe noctiflora* (L.) Rupr. (*2n* = 24), *Galeopsis speciosa* Mill. (*2n* = 16), *Oenothera biennis* L. (*2n* = 14) и *Bromus japonicus* Thunb. (*2n* = 14). Большинство изученных видов являются диплоидами. Для всех исследованных видов приводятся сведения по общему распространению, истории флористических находок на территории Республики Алтай и литературные данные по числам хромосом, полученные на материале с территории России.

The Altai Republic is currently one of the regions attracting a large number of tourists from different regions of Russia and other countries. As a result, the vegetation is exposed to significant anthropogenic impact, which contributes to invasion of a large number of alien species in the area and leads to further transformation in biological diversity of the flora. Invasive species, in their turn, may themselves undergo evolutionary changes in the new conditions. That is why, the comprehensive study and biological monitoring of alien species in the natural flora is becoming increasingly important. Given that

Поступило в редакцию 06.06.2018
Принято к публикации 18.10.2018

Submitted 06.06.2018
Accepted 18.10.2018

polyploidy is a likely factor in species invasiveness (te Beest et al., 2012, and references therein), we have undertaken a detailed karyological research of all alien species in flora of the Altai Republic. This study is a part of the project on karyological investigation of the invasive flora of South Siberia and is a continuation of previous work (Zykova et al., 2018). We provide an information on the history of floristic studies on examined species at the territory of the Altai Republic, and in some cases – in Siberia. When referring to P. N. Krylov (1909, 1931, 1949) we use the terminology of modern administrative-territorial division. For all species, the references on chromosome numbers revealed on the material from Russia have been provided as well, as relevant information in the international databases "Ehe Chromosome Counts Database" (Rice et al., 2015) and "Index to Plant Chromosome Numbers" (Goldblatt, Johnson, 1979+) is reflected incompletely.

The ploidy level of samples was determined by direct count of chromosomes in metaphase on squash preparations of root meristem. All species were studied for the first time on the material collected in the Altai Republic. Seeds were germinated at 25 °C (day) and 16 °C (night) on sterile sand. The root tips were pretreated for two hours with 0.2 % colchicine water solution, fixed in 3 : 1 absolute ethanol-glacial acetic acid and stained with 1 % acetic hematoxylin. Metaphase plates were observed under 100× magnification by the Axioscope 40 (Karl Zeiss, Axio Lab) and photographed by the AxiCam MRc 5 digital camera. The herbarium specimens (vouchers) are saved in the Herbarium of the Central Siberian Botanical Garden SB RAS (NS).

For species marked with an asterisk (*), the chromosome number is determined for the first time in Russia, two asterisks (**) – for the first time in Siberia.

AMARANTHACEAE

***Amaranthus lividus** L. (*A. blitum* L.), **2*n* = 34**

"Russia, Altai Republic, Turochak district, vicinity of Turochak village, roadside, 52°15′N, 87°07′E. 5 VIII 2016. E. Zykova, Z166–2816" (NS).

Annual. This species was found in all developed agricultural areas of the world. In the Altai Republic the first findings were in Gorno-Altaysk (Ilyin, Fedotkina, 2008) and Yaylyu village (Zolotukhin, 1983). Currently, it is a common garden weed occurring on fallow lands and waste places in Gorno-Altaysk, Mayma and Turochak districts (Zykova, 2015).

The chromosome number is determined first on Siberian material. The same number was obtained for Primorye Territory (Probatova, 2014, and references therein).

***Amaranthus retroflexus** L., **2*n* = 32**

"Russia, Altai Republic, Mayma district, vicinity of Rybalka village, wasteland at a construction site, 51°55′N, 85°51′E. 2 VIII 2015. E. Zykova, Z206–3315" (NS).

Annual. The north-American species is distributed in all continents. It is a widespread invasive species in Russia including Siberia. In the Altai, *A. retroflexus* was firstly reported by Krylov (1909) from Kibisen village, the Chulyshman River valley near the Bashkaus River mouth and the Katu-Yaryk Pass. Nowadays, it is widespread in the Altai Republic (Zykova, 2015).

The same chromosome number was previously reported for Novosibirsk Region (Krasnikov, Lomonosova, 1990), Irkutsk Region (Chepinoga, 2014, and references therein; Probatova et al., 2016a), Amur Region (Probatova et al. 2006) and Primorye Territory (Probatova, 2014, and references therein) as well.

ASTERACEAE

***Bidens cernua** L., **2*n* = 24**

"Russia, Altai Republic, Choya district, vicinity of Sugul village, wet roadside, 52°03′N, 86°15′E. 25 VIII 2012. E. Zykova, Z203–5412" (NS).

Annual. This Holarctic species is common in lowlands of the Altai Territory (Krylov, 1949; Silantyeva, 2013), from there it was apparently introduced to the Altai Republic, where the first finding was in 1949 in Choya village (NS!). Currently, this species occurs in northern districts of the Altai Republic often forming wide populations (Zykova, 2015, 2017).

This chromosome number confirms earlier counts from Irkutsk Region (Chepinoga, 2014, and references therein), Khabarovsk Territory (Probatova, Sokolovskaya, 1989) and Primorye Territory (Probatova, 2014, and references therein).

***Conyza canadensis** (L.) Cronq. (*Erigeron canadensis* L.), **2*n* = 18**

"Russia, Altai Republic, Choya district, vicinity of Choya village, wasteland, 52°02′N, 86°33′E. 7 VIII 2015. E. Zykova, Z284–3715" (NS); "Russia, Altai Republic, Turochak district, vicinity of Ust-Lebed village, roadside, 52°17′N, 87°20′E. 8 VIII

2015. E. Zykova, Z283–4015" (NS); "Russia, Altai Republic, Shebalino district, vicinity of Cherga village, wasteland at the river bank 51°34′N, 85°34′E. 20 VIII 2016. E. Zykova, Z167–4316" (NS); "Russia, Altai Republic, Chemal district, vicinity of Anos village, wasteland, 51°29′N, 85°56′E. 16 VIII 2015. E. Zykova, Z285–4615" (NS) (fig. 1A).

Annual. North-American species introduced in all continents including polar areas (Nikitin, 1983). It is one of the most aggressive actively spreading adventive species. The first findings in the Altai Republic were made in Ust-Muny village (Krylov, 1949), later it was mentioned for Ust-Kan district (Ilyin, Fedotkina, 2008). According to Zykova (2015), *C. canadensis* is common now in the northern districts of the Altai Republic.

Our chromosome count matches the number reported on the material from Buryatia Republic and Irkutsk Region (Chepinoga, 2014, and references therein), Kurgan Region (Krasnikov, Korolyuk, 1995), Krasnodar Territory (Probatova et al., 2012) and Primorye Territory (Rostovtseva, 1979; Probatova, 2014, and references therein)

Pilosella aurantiaca (L.) F. W. Schultz et Sch. Bip., ***2n* = 36**

"Russia, Altai Republic, Ust-Koksa district, eastern spurs of the Kholzun Ridge, fur-pine forest, wet meadow, 1600 m, 50°01′N, 85°11′E. 28 VIII 2013. T. An'kova, Z216–2" (NS) (fig. 1B).

Perennial herb. Native area of this species includes West and Central Europe and Middle Asia, from where it is spread as ornamental plant to Eurasia, North America and New Zealand (Kamelin, 1973; Tupitsyna, 2004). Recently *P. aurantiaca* was found in the Altai Republic (Zykova, An'kova, 2017).

The same chromosome number was known from Leningrad city (Chuksanova et al., 1968), Novosibirsk Region (Krasnikov, Tupitsyna, 2004), Sakhalin Region (Probatova et al., 2007, 2017) and Komi Republic (Lavrenko et al., 1990).

Tripleurospermum inodorum (L.) Sch. Bip. (*Matricaria perforata* Mérat), **2*n* = 36**

"Russia, Altai Republic, Mayma district, M-52 highway between Souzga and Rybalka villages, wasteland near construction site, 51°55′N, 85°51′E. 7 VI 2015. E. Zykova, Z141–0415" (NS); "Russia, Altai Republic, Mayma district, Kyzyl-Ozek village, wasteland near the bridge, 51°53′N, 86°00′E. 7 VIII 2015. E. Zykova, Z147–3515" (NS) (fig. 1C).

Annual or biennial. Eurasian species distributed in all continents is one of the most widespread adventive species in Siberia. The first findings on the territory of the Altai Republic were in Kibisen, Yaylyu and Oyrot-Tura villages, and near Karakol Mount (Krylov, 1949). At present, it is common in the northern part of the Altai Republic spreading sometimes to central regions (Zykova, 2015).

Two chromosome complements in this species were revealed on the material from Russia. 2*n* = 36 was mentioned from Novosibirsk Region (Krasnikov, Lomonosova, 1990), Irkutsk Region and Trans-Baikal Territory (Chepinoga, 2014, and references therein), Krasnoyarsk Territory (Stepanov, 1994), and Primorye Territory (Probatova, 2014, and references therein), 2*n* = 18 – from Amur Region (Probatova et al., 2008a) and Primorye Territory (Probatova, 2014, and references therein).

CARYOPHYLLACEAE

*****Elisanthe noctiflora*** (L.) Rupr. (*Silene noctiflora* L.), ***2n* = 24**

"Russia, Altai Republic, Shebalino district, vicinity of Cherga village, wasteland on the river bank, 51°34′N, 85°34′E. 20 VIII 2016. E. Zykova, Z168–4316" (NS).

Annual. European species now distributed in the most regions of South Siberia (Ebel et al., 2014). In the Altai Republic so far it was known from several villages: Elekmonar, Chemal (Krylov, 1931), Yaylyu (Zolotukhin, 1983), Ynyrga (Zuev, 1993), Paspaul (Studenikina, 2000). Now the species is common in the northern part of the Altai Republic and begins spreading southward (Zykova, 2015).

Our chromosome count is the first on the material from Siberia. The same chromosome number was reported earlier from Sakhalin Region (Probatova et al., 2007, and references therein).

LAMIACEAE

****Chaiturus marrubiastrum*** (L.) Ehrh. ex Reichenb., ***2n* = 24**

"Russia, Altai Republic, Turochak district, vicinity of Turochak village, roadside, 52°15′N, 87°07′E. 5 VIII 2015. E. Zykova, Z198–2816" (NS) (fig. 1D).

Annual or biennial. Eurasian species introduced elswhere. In the Altai Republic it has been recently found in Turochak village (Zykova, 2015). For several years, the species is actively distributed in disturbed habitats, where it often forms thickets. *C. marrubiastrum* occasionally enters in light forests.

The chromosome number is counted first in Russia. It confirms the only data previously reported from Romania (Tarnavschi, 1948).

***Galeopsis speciosa** Mill., ***2n* = 16**

"Russia, Altai Republic, Mayma district, Podgornoe village, roadside, 52°01′N, 85°53′E. 31 VII 2016. E. Zykova, Z222–1916" (NS); "Russia, Altai Republic, Shebalino distr., vicinity of Cherga village, wasteland on the river bank, 51°34′N, 85°34′E. 20 VIII 2016. E. Zykova, Z221–4316" (NS) (fig. 1E).

Annual. Euro-Mediterranean species, spreading in Eurasia. In the Altai Republic *G. speciosa* was first found in the late XX century at the mouth of Sema River, and in Marchela and Anos river basins (Pshenichnaya, 1997). Now this species is actively spreading in Gorno-Altaysk city and Mayma district, less common in Chemal and Shebalino districts (Ilyin, Fedotkina, 2008; Zykova, Erst, 2012; Zykova, 2014b, 2015).

This is the first chromosome count in Siberian population, which agrees with the data reported for Amur Region (Sokolovskaya et al., 1986).

ONAGRACEAE

***Oenothera biennis** L., ***2n* = 14**

"Russia, Altai Republic, Turochak district, vicinity of Ust-Lebed village, roadside, 52°17′N, 87°20′E. 8 VIII 2015. E. Zykova, Z183–4015" (NS); "Russia, Altai Republic, Turochak district, vicinity of Turochak, wasteland, 52°17′N, 87°20′E. 7 VIII 2015. E. Zykova, Z184–3815" (NS) (fig. 1F).

Biennial. North American species, settled in Eurasia. In the Altai Republic it is found in Gorno-Altaysk city (Zykova, 2002), Mayma, Chemal (Shaulo et al., 2010) and Turochak (Zykova, 2017) districts. *O. biennis* occurs much less often than the following species of *Oenothera.*

The chromosome number is determined for the first time on Siberian material. The same data were obtained from Stavropol Territory (Magulayev, 1984) and Primorye Territory (Probatova et al., 2014a), as well as Sakhalin Region (Probatova et al., 2007, and references therein).

***Oenothera villosa** Thunb., ***2n* = 14**

"Russia, Altai Republic, Mayma district, Rybalka village, wasteland at a construction site, 51°55′N, 85°51′E. 18 VIII 2015. E. Zykova, Z182–5215" (NS); "Russia, Altai Republic, Chemal district, vicinity of Chemal village, the Chemal riverside, 51°25′N, 86°00′E. 29 VII 2012. E. Zykova, Z195–2912" (NS) (fig. 1G).

Biennial. North American species spreading in all continents. In the Altai Republic *O. villosa* was found first in the 1980s in Ust-Koksa and Choya districts (Ebel, 2008), later – in Gorno-Altaysk city and Mayma (Shaulo et al., 2010), Turochak (Zykova, 2015), Chemal (Zykova, 2014a) and Ulagan (Ebel, 2008; Zykova, 2017) districts. The species is quite active in the northern part of the Altai Republic, but in the central part only few locations were found.

The chromosome number is counted from Russia for the first time.

POACEAE

***Bromus japonicus** Thunb., ***2n* = 14**

"Russia, Altai Republic, Mayma district, Mayma village, on pebble of roadside, 52°02′N, 85°54′E. 18 VII 2015. E. Zykova, Z204–1715" (NS) (fig. 1H).

Annual. European-W Asian species, as alien elsewhere. In the Altai Republic the first localities were found in 2009 in Gorno-Altaysk city (Shaulo et al., 2010) where this species now is actively propagating, and in Mayma district as well (Zykova, 2015).

The chromosome number is determined on the material from Siberia for the first time. The same data were obtained from the Crimea (Petrova, 1972), Dagestan Republic (Sokolovskaya, Probatova, 1979) and Primorye Territory (Probatova, 2014 and references therein).

***Eragrostis amurensis** Prob., ***2n* = 40**

"Russia, Altai Republic, Chemal district, vicinity of Chemal village, the Chemal riverside near the bridge, 52°25′N, 86°00′E. 30 VII 2016. E. Zykova, Z181–1516" (NS); "Russia, Altai Republic, Turochak district, vicinity of Turochak village, wasteland, 52°15′N, 87°07′E. 6 VIII 2015. E. Zykova, Z172–3016" (NS); "Russia, Altai Republic, Shebalino district, vicinity of Cherga village, wasteland near the riverside, 51°34′N, 85°34′E. 20 VIII 2016. E. Zykova, Z180–4316" (NS).

Annual. The species distribution range covers Central and East Siberia, the Far East, Manchuria. In the Altai Republic it was discovered in late XX century in Choya (Studenikina, 1999) and Ulagan (Pyak, Ebel, 2001) districts. Now this species is quite common in the northern region and is found in central part of the Altai Republic (Shaulo et al., 2010; Seregin, 2012; Zykova, 2014a, 2015, 2017).

The same chromosome number ($2n = 40$) was determined from Irkutsk Region and Trans-Baikal Territory (Chepinoga, 2014, and references), Khabarovsk Territory (Probatova, Sokolovskaya, 1984).

***Hordeum jubatum** L., ***2n* = 28**

"Russia, Altai Republic, Ulagan district, Aktash village, the Menka riverside, pebble, 50°19′N,

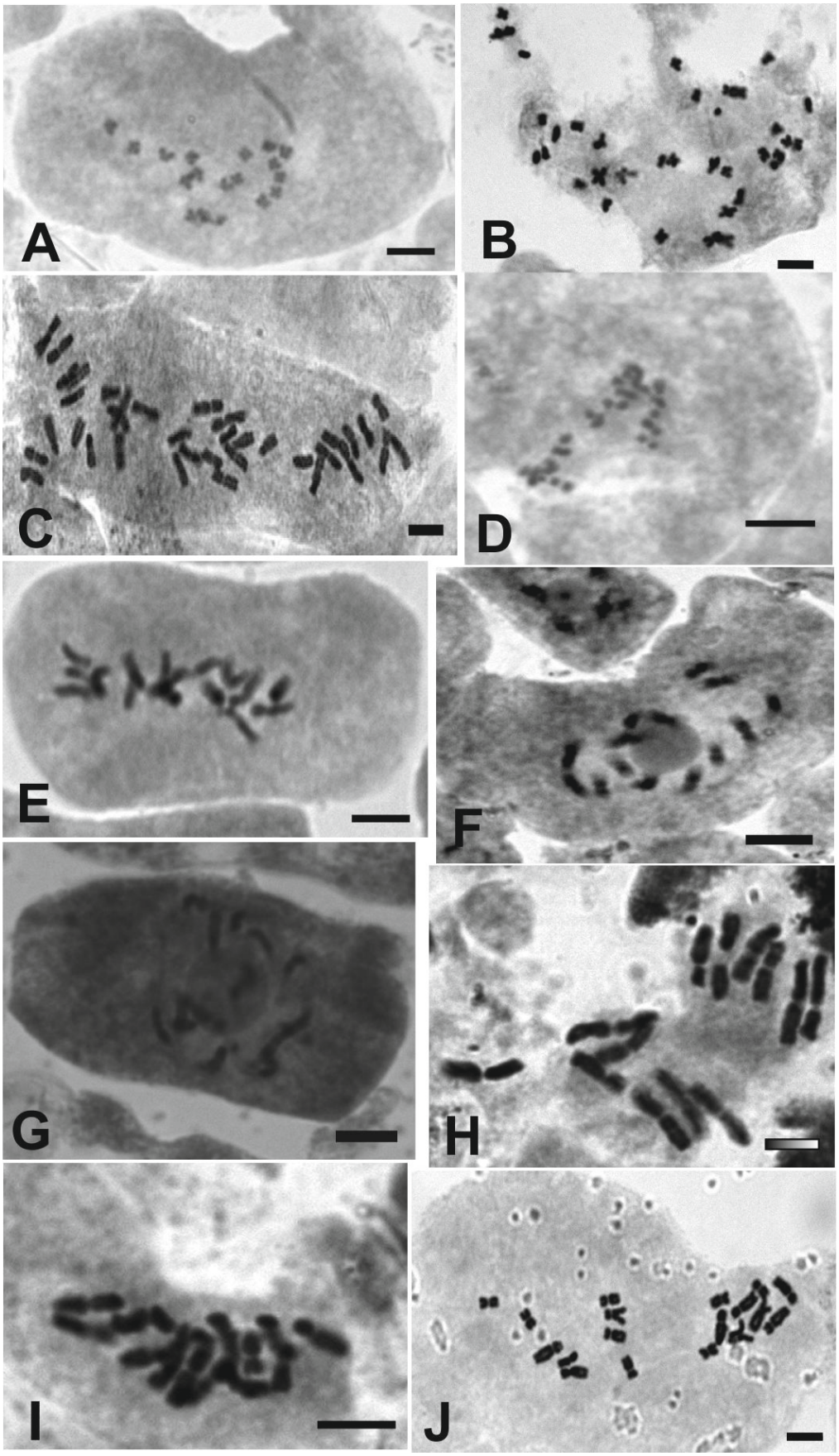

Fig. 1. Mitotic metaphase: **A** – *Conyza canadensis*, 2*n* = 18; **B** – *Pilosella aurantiaca*, 2*n* = 36; **C** –*Tripleurospermum inodorum*, 2*n* = 36; **D** – *Chaiturus marrubiastrum*, 2*n* = 24; **E** – *Galeopsis speciosa*, 2*n* = 16; **F** – *Oenothera biennis*, 2*n* = 14; **G** – *Oenothera villosa*, 2*n* = 14; **H** – *Bromus japonicus*, 2*n* = 14; **I** – *Lolium multiflorum*, 2*n* = 14; **J** – *Panicum ruderale*, 2*n* = 18. Scale = 5 µm.

87°37′E. 10 VIII 2012. E. Zykova, Z75–4212" (NS); "Russia, Altai Republic, Ulagan district, Aktash village, streets, 50°19′N, 87°37′E. 26 VII 2013. E. Zykova, Z7–6813" (NS); "Russia, Altai Republic, Ulagan district, Aktash village, streets, 50°19′N, 87°37′E. 25 VII 2015. E. Zykova, Z92–2315" (NS); "Russia, Altai Republic, Ulagan district, Ulagan village, flowerbed in the hospital's yard, 50°37′N, 87°57′E. 16 VIII 2014. E. Zykova, Z8–5014" (NS); "Russia, Altai Republic, Ulagan district, Balyktuyul village, nearly Pazyryksk mounds, roadside 50°45′N, 88°02′E. 16 VIII 2014. E. Zykova, Z6–5114" (NS); "Russia, Altai Republic, Kosh-Agach district, M-52 highway from Chegan-Uzun to Aktash villages, roadside. 25 VII 2015. E. Zykova, Z93–2515" (NS); "Russia, Altai Territory, Altai district, camping «Turquoise Katun», close to Taldin caves, paths, 51°46′N, 85°43′E. 31 VII 2014. E. Zykova, Z14–2714" (NS).

Annual or perennial herb. As an alien, this species is distributed in all continents. In the Altai Republic *H. jubatum* was first discovered in Onguday (Pyak et al., 2000) and Ulagan (Pyak, Ebel, 2001) districts. Currently, it continues to propagate along the Chuya Tract (Ebel, 2008; Shaulo et al., 2010; Zykova, 2017). Besides, it is registered in Chemal district (Ilyin, Fedotkina, 2008; Zykova, 2015), Gorno-Altaysk city (Zykova, 2014b), Mayma and Ust-Koksa (Zykova, 2015) districts.

The same chromosome number was determined from Irkutsk Region (Chepinoga, 2014, and references therein), Magadan Region (Probatova, Sokolovskaya, 1982), Amur Region (Probatova et al., 2008a), Yakutia Republic (Zhukova et al., 1977; Probatova, Seledets, 2008), Chukotka (Zhukova, 1967; Zhukova, Petrovskiy, 1976; Petrovskiy, Zhukova, 1983), Primorye Territory (Probatova, 2014, and references therein), Buryatia Republic and Kamchatka Territory (Probatova et al., 2016b).

Lolium multiflorum Lam., ***2n* = 14**

"Russia, Altai Republic, Mayma district, the M-52 highway between Dubrovka and Karlushka villages, roadside, which in 2011 was poured and seeded with grass, 51°55′N, 85°51′E. 18 VIII 2013. E. Zykova, Z193–8213" (NS) (fig. 1I).

Annual or biennial. Euro-Mediterranean species, introduced elsewhere. In the Altai Republic it was imported together with seeds for coating roadside slopes along Chuya Tract in 2011 (Zykova, 2014b). It occurs along the motorway and adjacent meadows; registered only in Mayma district of the Altai Republic (Zykova, 2015).

Diploid. Earlier, the same chromosome number has been counted from Irkutsk Region (Chepinoga, 2014, and references therein), Sakhalin Region (Probatova et al., 2007, and references therein) and Amur Region (Probatova et al., 2014b).

Panicum ruderale (Kitag.) D. M. Chang (*P. miliaceum* L. auct.), ***2n* = 18**

"Russia, Altai Republic, Shebalino district, vicinity of Myyuta village, roadside, 51°26′N, 85°39′E. 20 VIII 2016. E. Zykova, Z226–4216" (NS) (fig. 1J).

Annual. This weedy species is distributed in Eastern Europe, the Caucasus, Siberia, and settles in temperate zones of both hemispheres. In the Altai Republic it was found in the late XX century in Gorno-Altaysk city (Studenikina, 1999), Chemal (Nikiforova, 1990), Onguday (Pyak et al., 2000) and Ulagan (Pyak, Ebel, 2001) districts. Now it is quite common in the northern regions of the Altai Republic (Shaulo et al., 2010; Zykova, 2014a, 2015, 2017).

$2n = 18$ is a rare cytotype identified earlier from Slovakia (Murin, 1992) and Irkutsk Region (Chepinoga, 2014, and references therein). $2n = 36$ was obtained on the material from Irkutsk Region, Buryatia Republic and Trans-Baikal Territory (Chepinoga, 2014, and references therein), Altai Territory (Gnutikov et al. 2017) and Primorye Territory (Probatova et al., 2014, and references therein).

Conclusion

By now, chromosome numbers of 29 invasive species distributed in the Altai Republic were examined. Among them, the data for 16 species are represented in this study. For the first time *Chaiturus marrubiastrum* and *Oenothera villosa* have been studied on the material from Russia. The chromosome numbers of studied species are constant through their distribution range and diploid species prevail between. The exceptions are *Tripleurospermum inodorum* and *Panicum ruderale*, for which two chromosome complements are given in the literature. In recent years five polyploid species (*Amaranthus lividus, A. retroflexus, Eragrostis amurensis*, *Hordeum jubatum* and *Tripleurospermum inodorum*) have been introduced most actively in the Altai Republic, as well as lately discovered *Pilosella aurantiaca*, that is spreading in Turochak district very quickly now. A rarer diploid cytotype ($2n = 18$) was found in *Panicum ruderale* which was revealed by previous authors as tetraploid ($2n = 36$) in the vast majority of studied populations.

Acknowlegements

The study was carried out in the framework of the Scientific Program № AAAA-A17-117012610055-3 of the Central Siberian Botanical Garden SB RAS and partially supported by the Russian Foundation for Basic Research (project No 16-04-01246 to E. Zykova).

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