Three new alien Chenopodiaceae species in the flora of Russia

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Summary. Three new alien species of Chenopodiaceae s. str. (Amaranthaceae s. l.) are reported for the flora of Russia, the North American Chenopodiastrum simplex and Australian Dysphania carinata and D. pumilio. The identification of the specimens of Chenopodiastrum simplex from Moschny Island in the Leningrad Region (European Russia) was confirmed using both morphological and phylogenetic analyses. Morphologically, C. simplex is very similar to C. badachschanicum having the same fruit and seed characters. A single specimen of Dysphania carinata from Primorye Territory (the Russian Far East) was previously identified as Chenopodium pumilio (≡ Dysphania pumilio) incorrectly. Only recently, the latter species has been indeed found in Beslan town, Republic of North Ossetia – Alania (the North Caucasus). For each species, the possible degree of naturalization is discussed.

Три новых чужеродных вида из семейства Chenopodiaceae во флоре России

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Three new alien Chenopodiaceae species in the flora of Russia

Alexander Sukhorukov

Abstract. In this article, three new alien Chenopodiaceae species are described, each new to the flora of Russia: the American species *Chenopodiastrum simplex* and *Dysphania pumilio*. The latter was recently discovered in Beslan, Republic of North Ossetia-Alania (North Caucasus), while the former has been found in Leningrad Oblast (European Russia). The possible degree of naturalization for each species is discussed. The morphological similarity of *C. simplex* to *C. badachsinianum*, both of which have similar fruits and seeds, is noted. Morphologically, the two species are difficult to distinguish, and their identification is based on molecular studies, which will be reported in a future publication. The identification of *D. pumilio* was also confirmed by field studies in the North Caucasus (1999+) and the Far East (2019). The three species of Chenopodiaceae under consideration have not been previously reported in Russia (European Russia: Sukhorukov, 2014), but they are common in other territories of Russia.

Introduction

The Chenopodiaceae clade is recognized as a part of Amaranthaceae Juss. s. l. after extensive molecular studies (e.g., Cuénoud et al., 2002, Kadereit et al., 2003; Brockington et al., 2009). The members of this clade play an important role in steppe, desert, and coastal vegetation types or are noxious weeds in temperate regions (e.g., Korovin, 1934; Danin, 1983; Australian vegetation, 1994; Busso, Bonvissuto, 2009). In Russia, the number of Chenopodiaceae species can provisionally be estimated as 180 (133 species in European Russia: Sukhorukov, 2014), but some difficult genera like *Corispermum* L. and *Chenopodium* L. have not been properly reviewed yet in the Asiatic part.

There are many articles reporting new alien Chenopodiaceae in different provinces of Russia. Such translocations are occurring from natural vegetation types to the north suffering habitat changes. In almost all cases, the species originate in the same continent (intracontinental introduction). The Central Asian species *Atriplex laevis* C. A. Mey., *A. amaranthoides* L., *Corispermum declinatum* Stephan ex Iljin, *Salsola collina* Pall., and *Teloxys aristata* (L.) Moq. are the most frequent invaders in different parts of European Russia (Sukhorukov, 2014) being synanthropic components of the flora. These examples do not include Chenopodiaceae crossing between continents. However, the vegetation in many subtropical regions is already facing a problem with naturalization of some Chenopodiaceae, especially *Chenopodioideae* from Australia, e.g. *Atriplex inflata* F. Muell., *A. nummularia* Lindl., *A. suberecta* Verdoorn to North and South Africa and South America (Maire, 1962; Germinshuizen, Meyer, 2003; Brignone et al., 2016; APD, 2019) and *Dysphania pumilio* (R. Br.) Mosyakin et Clemants to Africa, South Europe, and the Americas (Uotila, Raus, Kalheber in Greuter, Raus, 2001 [with references therein]; Iamonico, 2011; USDA, NRCS, 2021; Uotila et al., 2021). The present article provides new information about the recent intercontinental introduction of three species of Chenopodiaceae in different parts of Russia.

Material and Methods

The first author Alexander Sukhorukov (AS) has observed many native and alien Chenopodiaceae in different parts of the world, especially in European Russia (1997+), the Nepal Himalaya (2005–2015), and African countries (2009+). The morphological evaluation of the three species under consideration has also been provided by AS. The continuous field investigations were carried out in North-West Russia (the Leningrad Region) by Elena Glazkova (1993+) who also paid special attention to alien species during field trips to the North Caucasus (2005) and the Far East (the Kuril Islands) (2019). Dmitry Shilnikov (DS) carried out the field studies in the North Caucasus (1999+) covered the Krasnodar Territory, Stavropol Territory, the Republics of Adygea, Karachayev-Circassian, Kabardino-Balkarian, North Ossetia – Alania, Daghestan (Russia) as well as Azerbaijan. Some other territories of Russia were also visited by DS. The identification of *Chenopodiastrum simplex* collected by E. Glazkova was also confirmed by the phylogenetic analysis that will be reported in another paper (Uotila et al., in prep.).

Results

Here we report three new alien species for Russia. Two of them, *Dysphania carinata* and *D. pumilio*, are from Australia, and the third species, *Chenopodiastrum simplex*, is from North America.

*Chenopodiastrum simplex* (Torrey) S. Fuentes, Uotila et Borsch, 2012, in Willdenowia 42: 12. ≡ *Chenopodium hybridum* var. *simplex* Torrey, 1828, in Ann. Lyceum Nat. Hist. New York 2: 239. ≡ *Chenopodium simplex* (Torrey) Raf. 1832, in Atlantic J. 1: 146.

Holotype: “[USA, Nebraska / Iowa] Engineer cantonment near Council Bluffs, [1820], Dr. James” (NY).
set, Crompton (1982, as Macoun 23329" (CAN, isolecto – US, DAO). “Canada, British Columbia, Vernon. 9 VII 1889. J. leau, 1944, Nat. Can. 71: 268.

\[ \text{Chenopodium gigantospermum} \]

Hultén, 1968, Ark. Bot. a. s. 7(1): 47. \equiv (Aellen) gigantospermum subsp. gigantospermum Hultén, 1968, Ark. Bot. a. s. 7(1): 47. \equiv (Aellen) gigantospermum subsp. (Tzvelev) S. Fuentes, Uotila et Borsch. From

and reveal the taxonomic status of a sample collected.

dachschanicum.

they are ovate in outline, dentate or with attenuate lobes in they are ovate in outline, dentate or with attenuate lobes in

However, the leaves demonstrate some differences: they are ovate in outline, dentate or with attenuate lobes in \text{C. simplex} and usually triangular in \text{C. badachschanicum}.

do not appear to be true representatives of the same species. Both \text{C. simplex} and \text{C. badachschanicum} possess the same carpological characters mentioned above. However, the leaves demonstrate some differences: they are ovate in outline, dentate or with attenuate lobes in \text{C. simplex} and usually triangular in \text{C. badachschanicum}.

To check the relationships in \text{Chenopodiastrum} and reveal the taxonomic status of a sample collected in the Leningrad Region, we conducted a more detailed phylogenetic analysis of the genus compared with the previous molecular trees (Fuentes-Bazan et al., 2012). The results presented in Uotila et al. (in prep.) revealed that the sample from Russia falls within one subclade with another sample of \text{C. simplex} taken from North America.

\textbf{Specimen seen.} “NW Russia, Leningrad Region, Kingisepp distr., Gulf of Finland, Moschny Island (Lavansari), NW part of the island, ca. 100 m south of Rybach’ya Bay (Suursatama), 60.02164°N, 27.81434°E. ruderal site, on sand heap, 1 exemplar. 16 VIII 2017. Elena Glazkova, EG-91” (LE 01072677!) (Fig. 1, 2).

\textbf{Habitat.} \text{Chenopodiastrum simplex} was found together with other alien species, e. g., \text{Epilobium adenocaulon} Hausskn., \text{Bunias orientalis} L., \text{Medicago lupulina} L., \text{Cirsium vulgare} (Savi) Ten., \text{Bromus hordeaceus} L., \text{Carex spicata} Huds., \text{Melilotus albus} Medik., \text{Plantago media} L., \text{Matricaria discoidea DC.}, \text{Carum carvi} L., \text{Sonchus asper} (L.) Hill, \text{Heracleum spherodium} L., subsp. \text{sibiricum} (L.) Simonk., \text{Turritis glabra} L., \text{Spergularia rubra} (L.) J. Presl et C. Presl, \text{Capsella bursa-pastoris} (L.) Medik., \text{Trifolium hybridum} L., \text{Lysimachia officinale} (L.) Scop., \text{Artemisia absinthium} L., \text{Arctium minus} (Hill) Bernh., \text{Senecio vulgaris} L., \text{Myosotis arvensis} (L.) Hill.

\textbf{General distribution.} Temperate North America (USA and Canada); as casual alien in N and W Europe.

\textbf{Dysphania carinata} (R. Br.) Mosyakin et Clemants, 2002, Ukr. Bot. Zhurn. 59(4): 382. \equiv \text{Chenopodium carinatum} R. Br. 1810, Prodr. Fl. Nov. Holland.: 407. \equiv \text{Salsola carinata} (R. Br.) Spreng. 1824, Syst. Veg., ed. 16, 1: 923. \equiv \text{Ambrina carinata} (R. Br.) Moq. 1840, Chenop. Monogr. Enum. 41. \equiv \text{Blitum carinatum} (R. Br.) C. A. Mey. ex Steudel, 1840, Nom. Bot. 2nd ed., 1: 210.

Holotype: “[Australia] New South Wales, Hawkesbury River, R. Brown s. n.” (BM!).

\equiv \text{Chenopodium crassifolium Moq. 1840, Chenop. Monogr. Enum. 42.} \equiv \text{Blitum glandulosum var. parvifolium} (Moq.) Moq. 1849, in DC., Prodr. 13(2): 82.

Lectotype (Wilson, 1984: 150): “[Australia] New South Wales, Port Jackson, D’Urville” (P).

\equiv \text{Chenopodium carinatum f. foliosum} Domin, 1921, Bibl. Bot. 89: 65.

Type: “[Australia] Queensland, Brisbane River, 1863, A. Dietrich 968” (PR?; iso – NSW, SING0057801).

\textbf{Morphology.} The description of this Australian species is available, e. g., in Wilson (1984). It has white, keeled and usually hairy perianth segments. As an alien species, it has been found in West and Central Europe (Aellen, 1961), but it seems to be rather scattered in Europe. A record of \text{Chenopodium pumilio} (Ignatov, 1988) (≡ \text{Dysphania pumilio}) indeed belongs to \text{D. carinata}.

\textbf{Specimen seen.} “Russian Far East, Primorsky Krai, Ussuriysky distr., Novo-Nikol’skoe vill. [Novonikol’sk], in the farm of «Kommunar» sovkhoz. 13 IX 1984. Buch et Shvydkaya, s. n.” (MHA!)

\textbf{Habitat.} Not mentioned on the label, but the specimen seems to have been collected in a ruderal site.

\textbf{General distribution.} Australia; as alien in W and C Europe, South America, southern Africa.
Fig. 1. Specimen of *Chenopodiastrum simplex* (LE).
Dysphania pumilio (R. Br.) Mosyakin et Cle-mants, 2002, Ukr. Bot. Zhurn. 59(4): 382. ≡ Chenopodium pumilio R. Br. 1810, Prodr. Fl. Nov. Holl. 1: 407. ≡ Blitum pumilio (R. Br.) Moq. 1849, in DC., Prodr. 13(2): 82. ≡ Ambrina pumilio (R. Br.) Moq. 1840, Chenop. Monogr. Enum.: 42. ≡ Teloxys pumilio (R. Br.) W. A. Weber, 1985, Phytologia 58(7): 478.

Holotype: “Australia, Kangaroo Island, R. Brown” (BM! iso – K!).

≡ Blitum glandulosum Moq. 1849, in DC., Prodr. 13(2): 82. ≡ Chenopodium glandulosum (Moq.) F. Muell. 1869, Fragm. 7: 11. ≡ Chenopodium pumilio f. glandulosum (Moq.) Aellen, 1933, Verh. Naturf. Ges. Basel 44: 315.

Lectotype (designated here): “Blitum glandulosum Moq. Chenopodium. Nova Hollandia [Australia]. Ex herb. Desfont.” (P00606458!).

Morphology. The description of this species is available, e. g., in Wilson (1984) and Sukhorukov (2014). Compared to Dysphania from Africa and Asia (see detailed investigations of Uotila, 2013; Sukhorukov, 2014; Sukhorukov, Kushunina, 2014; Sukhorukov et al., 2019; Uotila et al., 2021), this species has white (not green) incurved perianth segments and other reproductive characters. Compared with D. carinata, D. pumilio has slightly keeled (nor carinate or cristate), glabrous or slightly hairy perianth segments.

Specimen seen. “North Caucasus, North Ossetia – Alania Rep., Beslan town, Gor’ky St., N43°11.822, E44°33.348, 24 VII 2013. D. S. Shilnikov, s. n.” (LE 01072678!) (Fig. 5, 6).

Habitat. A small population (10 m²) was found near a private house in a disturbed habitat, together with Polygonum arenastrum Boreau, Poa pratensis L., Plantago major L., and Taraxacum officinale F. H. Wigg.

General distribution. Australia; as alien and naturalized in N and S America, N, S and E Africa, South Europe, East Asia.

Discussion

The introduction with subsequent naturalization of alien species and possible transformation of natural and secondary habitats is one of the biggest problems in the biological sciences (Didham et al., 2005; Traveset, Richardson, 2006; Pyšek et al., 2017; Russell et al., 2017). In the Chenopodiaceae clade (Amaranthaceae s. l.), some species, especially from Chenopodioidae, are widespread weeds in temperate regions of Eurasia, as well as being alien
Fig. 3. Specimen of *Dysphania carinata* (MHA).
and naturalized in other continents. *Chenopodium album* L., *C. vulgaris* L., *C. opulifolium* Schrad. ex W. D. J. Koch et Ziz, *Oxybasis glauca* (L.) S. Fuentes, Uotila et Borsch (previously known as *Chenopodium glaucum* L.), *Atriplex prostrata* Boucher ex DC. originated from different regions of Eurasia and have been reported as alien in Australia (Wilson, 1984). A large number of Eurasian Chenopodiaceae with further naturalization were discovered in temperate South and North America (e.g., Aellen, 1929; Zappettini, 1953; Clemants, Mosyakin, 2003; Brignon et al., 2016; Jocou et al., 2020; Brignon, Denham, 2021). Similarly, many Australian and American Chenopodiaceae, especially different *Chenopodium* taxa (recently considered within the genera *Chenopodium s. str.*, *Blitum*, *Lipandra* and *Oxybasis*: Fuentes-Bazan et al., 2012), were discovered in Europe especially in the first half of the 20th century, mostly brought with wool and other goods (Aellen, 1929; Uotila, 2001). Here we pay special attention to the distribution of *Chenopodiastrum simplex*, *Dysphania carinata* and *D. pumilio* outside their natural range, with further categorization of their possible alien status.

*Chenopodiastrum simplex* is native to North America and seems to be a rare casual alien species in Europe known in Fennoscandia mostly from the first half of the 20th century (Uotila, 2001). However, examination of herbarium collections in Vienna (W) by the first author (AS) showed the presence of plants with the same leaf and fruit/seed characters in Austria. According to GBIF (2019+), the species is also known from Germany, the Netherlands and Spain, but the corresponding records have not been checked by us. To date, the recent distribution of *C. simplex* in Europe requires further study. The report of *C. simplex* in Siberia (Lomonosova, 1992, as *Chenopodium hybridum* subsp. *gigantospermum*) is erroneous and a corresponding specimen belongs to *C. badachschanicum* (Tzvelev) S. Fuentes, Uotila et Borsch, a species widely distributed in Central Asia, South Siberia, the Himalaya and Tibet (Uotila et al., in prep.). Both species are morphologically similar, and the exact identification may be verified by phylogenetic analysis.

Fig. 4. A record of *Dysphania carinata* in Russia.
Fig. 5. Specimen of *Dysphania pumilio* (LE).
Chenopodiastrum simplex seems to be a recent immigrant to the remote Moschny Island, since it was not found during previous expeditions to the islands of the Eastern Gulf of Finland (Glazkova, 2001). Although only one exemplar of C. simplex was found in August 2017, and it was not possible to visit this island later, the population may not be extinct owing to ability of many annual Chenopodioideae including Chenopodiastrum to form a viable soil seed bank for at least several years in conjunction with the carpological characteristics (different thickness of the seed-coat testa resulting in the heterospermous seeds) and physiological dormancy (Sukhorukov, Zhang, 2013; Sukhorukov, 2014, with references therein). The introduction of C. simplex may be connected with crop import. Similarly, C. simplex was brought into Fennoscandia as a rare casual species with North American grain and soybeans (Uotila, 2001). The current status of C. simplex in Russia can be described as ‘casual alien’, as for some other rare exotic Chenopodiaceae in the Leningrad Region, e. g. Beta maritima L. and Atriplex oblongifolia Waldst. et Kit. found on the islands of the Gulf of Finland earlier (Glazkova, 2006; Sukhorukov, Uotila, 2007).

The native distribution area of Dysphania carinata covers the easternmost part of Australia including Queensland, New South Wales and Victoria (Wilson, 1984). As an alien plant, it clearly prefers areas with arid climate, e. g., Namibia, where it mostly occupies dried-up river beds and can be considered as naturalized species (AS, pers. obs. in 2017–2018). In South Africa, it has been found in many regions (Germishuizen, Meyer, 2003). The records in other semi-arid and arid regions of Africa are still scattered (Brenan, 1954, 1988; APD, 2019; AS, pers. obs. and a specimen [MW] collected in Tanzania in 2020). Dysphania carinata seems to be introduced in Europe in the late 19th century with Australian wool (Aellen, 1929, as Chenopodium carinatum) and it is also reported in some parts of West, Central and North Europe (Uotila, 2011) and West Asia (Al-Turki, Ghafoor, 1996, as Chenopodium carinatum). However, this name is frequently misapplied to the closely related D. pumilio in many floras and checklists of Europe, another alien on the continent (Chytry, 1993). For this reason, the naturalization status of D. carinata has not been properly assessed, the records have not been mapped.
(Jalas, Suominen, 1980), and the species considered to be a casual alien (Uotila, 2011; Sukhorukov, 2014). In East Asia, it is reported from Japan (GBIF, 2019+), but at least some records refer to *D. pumilio* (Flora-Kanagawa Association, 2018; A. Sukhorukov, re-identifications in different herbaria). The reverse misidentification occurred in Ignatov (1988), when a specimen of *D. carinata* from the Primorye Territory of Russia was erroneously identified as *D. pumilio*. Thus, we exclude *D. pumilio* from the flora of the Russian Far East. Based on the scattered records of *D. carinata* in Eurasia, its naturalization in the Russian Far East seems to be impossible due to unsuitable climatic conditions (e.g., high precipitation, low winter temperatures).

*Chenopodium pumilio* occurs as a native species mostly in southern Australia (Wilson, 1984) with further spreading as an alien into many subtropical regions of southern, central and eastern Africa (Brennan, 1954; Germishuizen, Meyer, 2003; Sukhorukov et al., 2016), Japan (Flora-Kanagawa Association, 2018), North and South America (Gleason, 1952 as *Chenopodium pumilio*; Clements, Mosyakin, 2003; Funez et al. 2017; Brignone, 2020). At present, it is considered to be an invasive plant in North America (CABI, 2021). Knowledge of the occurrence and status of *D. pumilio* in Europe has changed dramatically. In the beginning of the 20th century this species had not yet been noticed (Aellen, 1929) owing to confusion with *D. carinata* (re-identifications of the late P. Aellen and A. Sukhorukov in 2019, G!), but several decades later, it was being reported as an alien species in West and Central Europe (Aellen, 1961; Jalas, Suominen, 1980). The first collections from Central Europe are dated in 1870s (Aellen, 1961). Lhotská, Hejný (1979) reported the presence in Central, South and Eastern Europe (Gleason, 1952 as *Chenopodium pumilio*; Clements, Mosyakin, 2003; Funez et al. 2017; Brignone, 2020). At present, it is considered to be an invasive plant in North America (CABI, 2021). Knowledge of the occurrence and status of *D. pumilio* in Europe has changed dramatically. In the beginning of the 20th century this species had not yet been noticed (Aellen, 1929) owing to confusion with *D. carinata* (re-identifications of the late P. Aellen and A. Sukhorukov in 2019, G!), but several decades later, it was being reported as an alien species in West and Central Europe (Aellen, 1961; Jalas, Suominen, 1980). The first collections from Central Europe are dated in 1870s (Aellen, 1961). Lhotská, Hejný (1979) reported the presence of a viable seed bank based on observations in the Czech Republic as well as different dispersal characteristics facilitating the naturalization of *D. pumilio* in Central Europe. To date, the alien status of *D. pumilio* has been changed to ‘naturalized alien’ in Central, South and East Europe (Ukraine) (Uotila, 2011). The recent detailed investigations confirm its naturalized and invasive status in at least some countries of South Europe, namely in Spain (Castroviejo, 1990; Uotila, 2011), Italy (Iamonico, 2011), and Serbia (Bogosavljević, Zlatković, 2017) being found in various disturbed habitats. According to observations by the first author (AS), *D. pumilio* is common in Barcelona (Spain) and Lisbon (Portugal) growing in asphalt cracks and sandy areas. First records of the species as a casual alien are known from Bulgaria (Grozeva, 2007) and Belarus (Dzhus, 2011). Based on the literature data and our own observations, *D. pumilio* is able to naturalize in the countries with subtropical and warm temperate climate, and therefore further records of the species in Russia are expected in the North Caucasus and in the arid regions of European Russia.

**Conclusion**

The three species reported here have different alien status in the secondary distribution areas, and we assume their different naturalization status in Russia. *Dysphania pumilio* could potentially become a successful invader in ruderal sites in the southern part of European Russia and the North Caucasus.

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