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## 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 *Chenopodium simplex* and Australian *Dysphania carinata* and *D. pumilo*. The identification of the specimens of *Chenopodium 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* ( $\equiv$  *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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**Ключевые слова:** инвазии, маревые, распространение, Россия, сосудистые растения, чужеродные виды.

**Аннотация.** В статье приводятся три чужеродных вида, новых для флоры России: североамериканский вид *Chenopodiastrum simplex* и два австралийских – *Dysphania carinata* и *D. pumilio*. Определение образца *Chenopodiastrum simplex* с острова Мощный в Ленинградской области (Европейская Россия) подтверждено морфологическим и филогенетическим анализами. Морфологически *C. simplex* трудно отличим от *C. badachchanicum*, оба вида имеют схожие плоды и семена. Единственный образец *Dysphania carinata* из Приморского края (российский Дальний Восток) был ранее ошибочно определен как *Chenopodium pumilio* ( $\equiv$  *Dysphania pumilio*). Последний вид только недавно обнаружен в г. Беслане, Республика Северная Осетия-Алания (Северный Кавказ). Обсуждается возможная степень натурализации каждого вида.

## 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 revised 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., *Axyris 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; Germishuizen, 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]; Iamónico, 2011; USDA, NRCS, 2021; Uotila et al., 2021). The present article provides new information about the recent intercontinental introduction of three species of Chenopo-

diaceae 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 Adygeya, Karachayev-Republic, Kabardino-Balkarian, North Ossetia – Alania, Dagestan (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.  $\equiv$  *Chenopodium hybridum* var. *simplex* Torrey, 1828, in Ann. Lyceum Nat. Hist. New York 2: 239.  $\equiv$  *Chenopodium simplex* (Torrey) Raf. 1832, in Atlantic J. 1: 146.

Holotype: “[USA, Nebraska / Iowa] Engineer cantonment near Council Bluffs, [1820], Dr. James” (NY).

= *Chenopodium gigantospermum* Aellen, 1929, in Repert. Spec. Nov. Regni Veg. 26: 144. ≡ *Chenopodium hybridum* subsp. *gigantospermum* (Aellen) Hultén, 1968, Ark. Bot. a. s. 7(1): 47. ≡ *Chenopodium hybridum* var. *gigantospermum* (Aellen) Rouleau, 1944, Nat. Can. 71: 268.

Lectotype (Bassett, Crompton, 1982: 600): “Canada, British Columbia, Vernon, 9 VII 1889. J. Macoun 23329” (CAN, isolecto – US, DAO).

**Morphology.** For a detailed description see Bassett, Crompton (1982, as *Chenopodium gigantospermum*). Related to *Chenopodiastrum hybridum* (L.) S. Fuentes, Uotila et Borsch and *C. badachschanicum* (Tzvelev) S. Fuentes, Uotila et Borsch. From the first species, *C. simplex* is easily differentiated by the loose pericarp and rugose seeds (*C. hybridum* has adherent pericarp and foveolate seeds). Both *C. simplex* and *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 *C. simplex* and usually triangular in *C. badachschanicum*.

To check the relationships in *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 *C. simplex* taken from North America.

**Specimen seen.** “NW Russia, Leningrad Region, Kingisepp distr., Gulf of Finland, Moschny Island (Lavansaari), 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).

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

**General distribution.** Temperate North America (USA and Canada); as casual alien in N and W Europe.

***Dysphania carinata*** (R. Br.) Mosyakin et Clements, 2002, Ukr. Bot. Zhurn. 59(4): 382. ≡ *Chenopodium carinatum* R. Br. 1810, Prodr. Fl. Nov. Holland.: 407. ≡ *Salsola carinata* (R. Br.) Spreng. 1824, Syst. Veg., ed. 16, 1: 923. ≡ *Ambrina carinata* (R. Br.) Moq. 1840, Chenop. Monogr. Enum. 41. ≡ *Blitum carinatum* (R. Br.) C. A. Mey. ex Steudel, 1840, Nom. Bot. 2<sup>nd</sup> ed., 1: 210.

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

= *Chenopodium cristatum* var. *holopterum* Thell. 1919, Vierteljahrsschr. Naturf. Ges. Zürich 64: 724. ≡ *Chenopodium holopterum* (Thell.) Thell. et Aellen, 1928, Mitt. Naturf. Ges. Solothurn 20(8): 57. ≡ *Chenopodium carinatum* var. *holopterum* (Thell.) Aellen, 1933, Verh. Naturf. Ges. Basel 44: 312.

Holotype: “Switzerland, Derendingen bei Solothurn, 1917, Probst s. n.” (G);

= *Ambrina carinata* var. *parvifolia* Moq. 1840, Chenop. Monogr. Enum. 42. ≡ *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).

= *Chenopodium carinatum* f. *foliosum* Domin, 1921, Bibl. Bot. 89: 65.

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

**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 *Chenopodium pumilio* (Ignatov, 1988) (≡ *Dysphania pumilio*) indeed belongs to *D. carinata*.

**Specimen seen.** “Russian Far East, Primorsky Krai, Ussuriysky distr., Novo-Nikol’skoe vill. [Novonikol’sk], in the farm of «Kommunar» sovkh. 13 IX 1984. Buch et Shvydkaya, s. n.” (MHA!) (Fig. 3, 4).

**Habitat.** Not mentioned on the label, but the specimen seems to have been collected in a ruderal site.

**General distribution.** Australia; as alien in W and C Europe, South America, southern Africa.



Fig. 1. Specimen of *Chenopodium simplex* (LE).



Fig. 2. A record of *Chenopodium simplex* in Russia.

***Dysphania pumilio*** (R. Br.) Mosyakin et Clements, 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 (not 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 m<sup>2</sup>) 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 *Chenopodioideae*, are widespread weeds in temperate regions of Eurasia, as well as being alien



*Dysphania carinata* (R.Br.) Mosyakin & Clemants  
2021 det. A.P. Sukhorukov

ДВНЦ АН СССР  
БИОЛОГО-ПОЧВЕННЫЙ ИНСТИТУТ  
*Сенеродиум*  
Место сбора: \_\_\_\_\_  
Приморский край, Уссурийский р-н,  
пос. Ново-Никольское,  
ферма совх. "Коммунар"  
13 сентября 1986 г. Собр. Буч, Швыдкая  
Опр. Буч, Швыдкая 1875

Fig. 3. Specimen of *Dysphania carinata* (MHA).

and naturalized in other continents. *Chenopodium album* L., *C. vulvaria* 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; Brignone et al., 2016; Jocou et al., 2020; Brignone, 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 20<sup>th</sup> 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 20<sup>th</sup> 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.

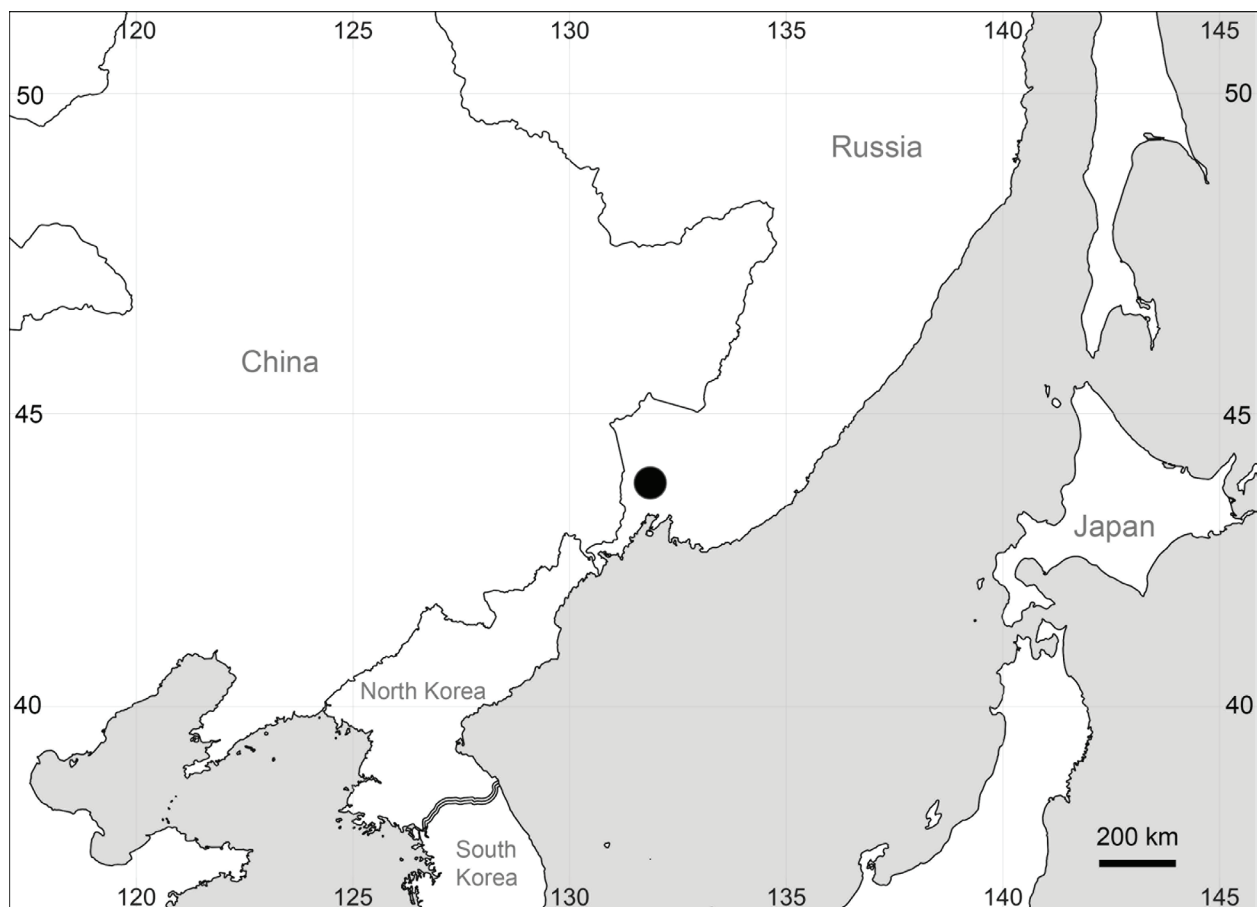


Fig. 4. A record of *Dysphania carinata* in Russia.

Fig. 5. Specimen of *Dysphania pumilio* (LE).



*Chenopodium 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 *Chenopodiaceae* including *Chenopodium* 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).



Fig. 6. A record of *Dysphania pumilio* in Russia.

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 19<sup>th</sup> 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).

*Dysphania 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 (Brenan, 1954; Germishuizen, Meyer, 2003; Sukhorukov et al., 2016), Japan (Flora-Kanagawa Association, 2018), North and South America (Gleason, 1952 as *Chenopodium pumilio*; Clemants, 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 20<sup>th</sup> 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 (Iamónico, 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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обратившему внимание на необычный образец *Chenopodiastrum* с острова Мощный. Мы также благодарим М. В. Легченко (LE) за сканирование образца *Chenopodiastrum simplex* и Н. Ю. Степанову (МНА) за сканирование образца *Dysphania carinata*.

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