Distribution of Hippophae Rhamnoides L. in Primorsky Krai and its Invasive Potential

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Abstract. *Hippophae rhamnoides* L. (Elaeagnaceae Juss.) is a valuable multipurpose plant with vast secondary area which covers many regions of Europe, Asia and North America. When introduced in new places, it often exhibit invasive properties. In Primorsky Krai (Russian Federation) sea buckthorn is detected in 139 settlements where it grows mainly in household plots and is used as medicinal and food plant. Easily forming numerous root suckers, sea buckthorn often create more or less dense thickets. Six places were found in Primorsky Krai where *Hippophae rhamnoides* actively reproduces vegetatively. These places are disturbed areas and sea buckthorn cultivation plots. The plant don't penetrate into natural phytocoenoses which allows regarded it as epecophyte.

Keywords: sea buckthorn, *Hippophae rhamnoides*, economic value, distribution, Russian Federation, Primorsky Krai, cultivation, vegetative propagation, epecophyte.

Introduction

Hippophae rhamnoides L. (sea buckthorn) is a dioecious woody plant of the family Elaeagnaceae Juss., which has a vast area in the temperate zone of Eurasia [1].

It's a very valuable and multipurpose plant. Its medicinal properties (antioxidant, immunomodulatory, antitumoral, gepatoprotective) are most known [2-3]. Fruits are a significant source of flavonoids, carotenoids, vitamins (especially A, E and K). Medicinal parts are also twigs and leaves. Due to the high content of antioxidants in fruits, sea buckthorn preparations are effective in the treatment of diabetes, cardiovascular diseases, osteoporosis, skin aging, brain diseases, allergies, ulcerative gastritis, cancer, as well as atrophy and erosion of the mucous tissues of the stomach and genitourinary system, and many other diseases. Vital microelements: Cr, Fe, Mn, Mo and

Co, in sea buckthorn are in an easily assimilable biogenic form. It accumulates these and other elements more intensively than other plants and does not absorb toxic ones: lead and arsenic. Not only fruits – almost all sea buckthorn organs contain valuable bioactive elements. The leaves lack caffeine, they have antimicrobial and antiviral activity and serve as raw materials for vitamin tea. The bark is a valuable raw material for the production of serotonin, a hormone that plays an important role in the body of animals and plants.

Often Hippophae rhamnoides is cultivated in Russia, Europe, United States and other countries as a food plant and source of enrichment of products with biologically active constituents – sugars, organic acids, vitamins, tannins etc. [4]. The most consumed part of the plant are berries [5]. Methods of using sea buckthorn powder in the food industry are being developed including cryochemical processing.

The species is used in cosmetics [6], animal breeding [7], as decorative in urban landscapes. It possesses high anti-erosion properties and used in the reclamation of disturbed areas [8], have nitrogen-fixing ability [9] which allows using it in soil and water conservation [10]. The anti-erosion function is realized due to its intensive sucking formation activity [11]. The root systems of sea buckthorn are superficial. Cord-like, fleshy roots with underdeveloped mechanical tissue, unlike shoots, branch weakly. They move in different directions from the stems far beyond the crown – by 10-12 m, exceeding the diameter of the latter by 1.5 (tall forms of sea buckthorn) – 2.5 (3) times (depressed individuals). The depth of root penetration into the soil is 10-30 cm. Sea buckthorn roots penetrate the upper layers of disturbed areas, holding the loose soil, and the growing offspring prevent the drift and washout of organic matter. The unevenness of the surface between the roots is smoothed out by litter and undifferentiated mass, preventing soil erosion and contributing to the emergence of other plants. In the conditions of the mountainous terrain, these properties of sea buckthorn are especially important for nature protection.

Wide distribution of Hippophae rhamnoides is connected with its ecological properties. It's a very heliophilous, hardy, drought-tolerant, salt-tolerant species which successfully adapts to different extreme conditions. Hippophae rhamnoides can grow on poor soils preferring aerated substrates. Nitrogen-fixing bacteria develop on its roots, so it often settles on substrates poor in organic matter, withstands some soil salinization, but does not tolerate waterlogging. It grows and bears fruit best of all in areas with a high level of groundwater and flowing moisture (along rivers, on the slopes of ravines) on sandy loam and light loamy soils with a slightly acidic and neutral reaction and a high calcium content.

The plant reproduces by seeds and vegetatively [12]. It easily forms numerous root suckers which may create thickets.

The economic use and ecological characteristics have resulted in the formation of an extensive secondary area of Hippophae rhamnoides. Currently, it is found in culture in many countries in Europe, East Asia [13] as well as in North America [14].

The ability of the plant to form root suckers resulted in invasive properties in various places of cultivation.

In Russia Hippophae rhamnoides is included in the Black Book of Flora of Central Russia. It exhibits potentially invasive properties in the Pskov region, Siberia.

It is important that together with Hippophae rhamnoides its phytophagous insects also penetrate.

In the Russian Far East, Hippophae rhamnoides first appeared in the middle of the 20th century. Now it is used mostly as food and medicinal plant, less often as ornamental plant in the Primorskii Krai, Amur Oblast', Khabarovsky Krai. In places of culture the plant often reproduces vegetatively forming root suckers.

In the Amur Oblast', sea buckthorn appeared in the late 1940s as a fruit plant and for protective afforestation. At present, it is found in most settlements of the region, spreading both by root suckers and by seeds carried by rodents and birds.

In the vicinity of Blagoveshchensk (Amur Oblast') it naturalizes most actively in disturbed areas, which are characterized by weakened interspecies competition, high insolation, increased soil salinity and the presence of various water basins.

In the Khabarovskii Krai, sea buckthorn has been found in culture since the second half of the 20th century. Natural spreading has been especially active since the end of the 20th century. On coastal sands, artificially washed sandy hills, it forms thickets. Occurs along railway embankments, weedy places. Thickets can reach an area of tens of square kilometers.

It shows invasive properties in the Khabarovsky Krai, Amur Oblast' (for the valley of the river Bureya it regarded as ergaziophyte, agriophyte, euneophyte).

In the Primorskii Krai, the first plantings of sea buckthorn appeared in the middle of the last century. Back in the 1950s. it was rare enough. It was brought to the Gornotezhnaya Station from Siberia and showed itself as an exceptionally winter-hardy, unpretentious and resistant to diseases and pests plant. Due to its good survival rate and the ability to give massive root shoots, sea buckthorn quickly develops new habitats and becomes one of the most widespread berry crops.

Materials and Methods

The distribution of Hippophae rhamnoides in the Primorskii Krai (Russian Far East) was studied. By the traditional route-reconnaissance method more than 200 settlements of the Primorsky Krai were surveyed in the period of 2016-2020.

Results and Discussion

In the Primorskii Krai, Hippophae rhamnoides is widely cultivated mainly as a food and medicinal plant. It represented by clone systems, single shrubs or small trees, reaching significant sizes (up to 5 m in height and 28 cm in diameter). According to the results of route studies, Hippophae rhamnoides was found in 139 settlements of the region (Fig. 1).

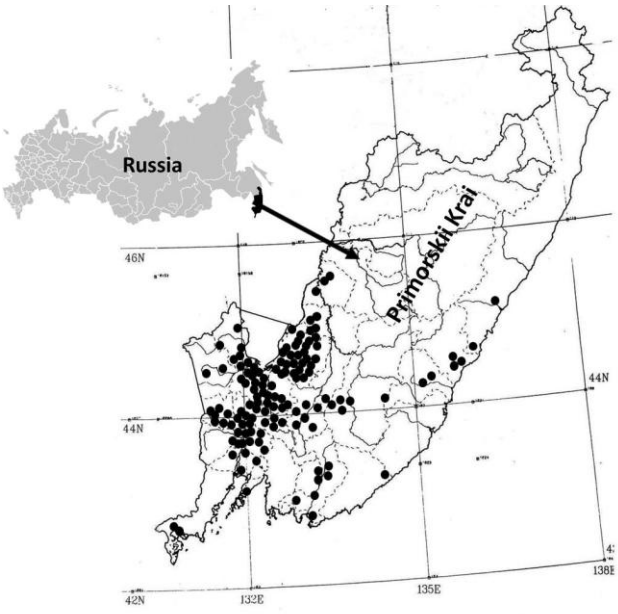

Fig. 1. Distribution of sea buckthorn in settlements in Primorsky Krai.

It is found mainly in household plots, near residential buildings next to highways.

In places of planting, it often creates root suckers. This happens most intensively in the territories of abandoned or destroyed residential buildings or industrial facilities.

We found a number of places in the Primorsky Krai, where Hippophae rhamnoides more or less actively reproduces vegetatively.

3.1 Ussuriysk City District

Ussuriysk city (43°48′ N, 131°57′ E). One of the places is the territory of an unfinished combined heat and power plant in the valley of the river Komarovka. Here, before the construction of the power plant begun, there were a dacha settlement and a biological station of the Ussuriysk State Pedagogical Institute. Hippophae rhamnoides were also cultivated on personal plots. This territory was freed from buildings, and the fertile layer was taken out, only small fragments of the original plantings remained.

At the end of the 20th century, colonization of this territory and the adjacent slope by Hippophae rhamnoides fell began. Probably, first diasporas were introduced here by birds, and then vegetative dispersal took place for 10-15 years. In the early 2000s the plant formed a number of clone systems of different sizes. In 2006, the maximum age of maternal individuals was 15 years. Probably, the invasion of sea buckthorn began at the end of the last century. This is quite logical, given that this time coincides with the restoration of summer cottage gardening and the completion of the acclimatization of sea buckthorn in cultural plantings in the region. The variety of colors and shapes of sea buckthorn fruits in the thickets indicates that they are formed

by clones of different varieties, which once again emphasizes the fact of introduction in the region.

In 2020, there were 10 clone systems here, each of them includes 5 to 20-30 suckers. The largest one consists of 30 shrub-like root suckers (tree-like forms are absent) up to 2-3 m in height and with a trunk diameter of 1.2 to 2.5 cm. There are many dried up plants.

In twenty years, Hippophae rhamnoides from the valley climbed the slope of the adjacent hill. At present, it has survived only on bare, eroded, heavily indented sections of the slope of the hill, where the fire did not reach. In the areas below, at the base of the hill, there were also quite extensive thickets of sea buckthorn, but because of the fires, now there are only dried burnt individuals and single living ones. It should be noted that fires are a possible reason for the low preservation of sea buckthorn when using it to fix disturbed lands on the dumps of the Luchegorsk coal mine.

The largest of the surviving thickets has an area of 50x15 m and has about 150 suckers up to 1.5 (2) m in height and up to 3.5 cm in diameter (fig. 2). Above, Mongolian oak (Quercus mongolica Fisch. ex Ledeb.) forest begins, into which Hippophae rhamnoides does not enter. Below there are shrub-herbaceous thickets formed by Lespedeza bicolor Turcz., wormwood species (Artemisia L.) and various grasses (Poaceae Barnh.).

In Ussuriysk we also found small clone system of Hippophae rhamnoides on the railway gravel embankment in the southeastern part of the city. It consists of 13 suckers 0.3-1 m high and with stems up to 2 cm in diameter.

Fig. 2. Hippophae *rhamnoides* in Ussuriysk city vicinity.

3.2 Kavalerovsky District

Vicinity of the village Vysokogorsk (44°24'15" N, 135°24'06" E). Hippophae rhamnoides formed here a thicket of 20 suckers from 0.7 to 2.5 m in height on an area of 6x12 m, with a stem diameter of 1.5-2.5 cm.

3.3 Dalnegorsk City District

Dalnegorsk city district is characterized by wide distribution of Hippophae rhamnoides, both in seliteb areas and vicinity of settlements. In Dalnegorsk city (44°34′ N, 135°37′ E), Rudnaya Pristan' settlement, Monomakhovo settlement etc. it is found in summer cottages, on the hill slopes near the highway, in the valley of the river Rudnaya and seashore dunes. Along the highway from Rudnaya Pristan' to Dalnegorsk we found about 18 clone systems, in which Hippophae rhamnoides often forms a continuous canopy (fig. 3).

- In Rudnaya Pristan' (44°21′ N, 135°48′ E), the largest clone system consists of 30 specimens from 0.5 to 1.8 cm in height, with trunk diameter 0.8-1.5 cm.
- In Monomakhovo (44°23′53″ N, 135°46′05″ E), a clone system with an area of 10x22 m was found, consisting of 35 fruit-bearing suckers, with a trunk diameter of 5-15 cm. One thicket was found on the bank of the river Rudnaya (probably in the place of a previously standing building). It consists of 13 suckers up to 5.5 m in height and with a trunk diameter of up to 10 cm.

Fig. 3. Hippophae *rhamnoides* near Rudnaya Pristan' settlement.

3.4 Nakhodka City District

Nakhodka city (42°49′ N, 132°53′ E). Hippophae rhamnoides is often found here in the landscaping of seliteb areas. Wild individuals were noted on Severny Prospekt]. In 2020, the authors on Severny Avenue (fig. 4) on a soil and gravel embankment along the road recorded 5 clone systems of sea buckthorn, numbering from 5 to 23 individuals. The largest clone system had an area of 3x15 m with 23 individuals 0.5-6 m high and a trunk diameter at the base of up to 15 cm; in addition, there were numerous (about 40) suckers from 0.25 m in height. The largest ones were fruiting.

Fig. 4. Hippophae *rhamnoides* in Nakhodka city.

3.5 Chernigowsky District

In Orekhovo settlement (45°32′49″ N, 134°22′00″ E) Hippophae rhamnoides abundantly grew at the site of the destroyed building on an area of about 100 m2 (fig. 5). The total number of aboveground stems was 205 specimens 0.3-3 m high, which also sprouted between the remaining foundation slabs.

Fig. 5. Hippophae *rhamnoides* in Orekhovo settlement.

According to our observations, in the Primorsky Krai, Hippophae rhamnoides does not penetrate into natural phytocenoses, settling in disturbed areas. With the appearance of aboriginal trees in the areas and further formation of a closed tree layer above the thickets of Hippophae rhamnoides, it dies from shading. This behavior is typical

for sea buckthorn growing on sand dunes in Northern Ireland where Hippophae rhamnoides is well-known dune invader [15].

According to results obtained we regarded sea buckthorn as epecophyte.

Conclusions

At present Hippophae rhamnoides in the Primorsky Krai is found in cultivation in most settlements and used as food and medicinal plant. In the absence of planting care, it can run wild and more or less intensively reproduce vegetatively and by seed, in some cases forming dense thickets. The following factors contribute to the appearance of sea buckthorn in disturbed territories: destruction of the soil and vegetation cover, which ensured the absence of competitors; availability of seed sources; the presence of birds – distributers of sea buckthorn fruits.

Today, the introduction of Hippophae rhamnoides into natural phytocenoses is not observed, which allows regarded the species as epecophyte according to the degree of naturalization. However, such factors as ability of the plant for vegetative dispersal and anthropogenic transformation of the vegetation cover of the region can promote penetration of Hippophae rhamnoides into natural communities. So, control over the dispersal of this species is necessary. Considering the high anti-erosion value of Hippophae rhamnoides due to active vegetative mobility, and high adaptation to droughts and frost, it should be recommended for the reclamation of completely disturbed landscapes in the Primorsky Krai.

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