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DISTRIBUTION OF INVASIVE ALIEN SPECIES ALONG THE HADZHIYSKA 1 RIVER MOUTH (SOUTHERN BLACK SEA COAST, BULGARIA) 2

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ABSTRACT 5

The purpose of the publication is to study the diversity and quantitative participation of invasive alien species (IAS) at the mouth of Hadziiska river and its role in their distribution on NATURA 2000 sand dune habitats on the territory of municipality of Nessebar (Southern Black Sea Coast, Bulgaria) . The survey was conducted in the period May-July, 2022. At a distance of 1 km from the mouth along the river on both banks, 20 sample plots (SP) were set up (10 SP on each bank). The area of each SP is 50 m². The distance between SP is 100 m. A comparative distribution of species was made according to synanthropic characteristics - anthropophytes (At), apophytes (Ap) and autochthonous species (Av). In the studied area IAS, plants with nature protection status and characteristic for different dune habitat types species were registered. As a result of the study, 77 species of higher plants were found, 17 (22.1%) of which were trees and shrubs, nine IAS were registered (11.6% of the species composition), of which 3 trees and 6 herbaceous plants. Among the IAS, *Amorpha fruticosa* has the highest cover abundance, and *Phragmites australis* among the natives. The percentage distribution of synanthropic groups is as follows: anthropophytes (At) – 53.2%, autochthonous species (Av) – 39.0%, apophytes (Ap) – 7.8%. Three of the established species have a nature protection status - *Silene thymifolia*, *Cladium mariscus* and *Centaurea arenaria*. Twelve species are characteristic for different dune habitat types as follows: 2130 Fixed dunes with herbaceous vegetation ('grey dunes')- 6 species; 2190 Humid dune slacks -3 species, 2110 Embryonic shifting dunes- 3 species. The study categorically shows that Hadzhiyska river is a vector for the spread of IAS on the territory of the dunes, which threaten the biodiversity of the protected dune habitats in the investigated area.

At the present stage, the most aggressive of the IAS established in the study area, which has already partially settled on the territory of the dunes, is *Amorpha fruticosa*. The species *Asclepias syriaca*, *Ailanthus altissima*, *Robinia pseudoaccacia* and *Xanthium italicum* are also a potential threat. Common reed is a serious competitor of the IAS and at this stage prevents their direct penetration, but the increase in the cover abundance of this species poses a serious danger to the course of the river, which in some places shows signs of swamping and creates a

prerequisite for the accommodation of unwanted species and is an indirect factor for the deterioration of the river habitat and the adjacent dunes.

Keywords: Habitats; River Banks; Dunes; Invasive Alien Species, Vegetation, Communities

1. Introduction

Although sand dunes in Bulgaria are protected areas and national reserves they have been exposed to the expanded anthropogenic pressure after year 2000 (Stancheva, 2010) including the so called “fixed dunes” and closely related to them over-wet and flooded dune slacks. These are two of the priority habitat types (2130 Fixed dunes with herbaceous vegetation (‘grey dunes’) and 2190 Humid dune slacks) for conservation in the European Union (Council Directive 92/43/EEC, 1992) and according to EUNIS (2022) classification belongs to habitat types B1.4B11 Southwestern Pontic fixed dunes and B1.85 Dune-slack reed beds, sedge beds and cane beds. Currently, habitat type 2130 occupies about 5 km² of the territory of Bulgaria, mainly along the Black Sea coast and is assessed as Endangered under Criterion B1 and B2 both at the EU28 and the EU28+ levels, as the habitat has a small geographical distribution (extent of occurrence (EOO) < 20,000 km² and area of occupancy (AOO) < 20km²), and there is a continuing decline in spatial extent of the habitat (Tzonev, 2015a). The Critically endangered habitat type 2190 occurs in the Shablenska Tuzla locality, near Shkorpilovtsi village – Kamchia River, Gradina and Zlatna Ribka camping places, near Nessebar and Sunny Beach tourist complex (Tzonev, 2015b). The last of the chosen localities is situated North of the Nessebar Peninsula (South Bulgarian Black sea coast) where the small dune complex combines in itself the features of these two habitat types- 2130 and 2190. The place is also a part of the protected site „Pyasachni dyuni – Babata – Slanchev Bryag”, designated in 1984 to protect significant botanical and geological objects (Peev et al., 2012). Despite the special status of this part of the Black sea coast constant buildings of hotels and other tourist infrastructures in the Sunny Beach resort in the nearly past could be considered as main reasons for degradation of wide dune areas (Stancheva, 2010). Today, the construction process has stopped, but another treat to this habitat types is being neglected. The only river in this region that flows into the Black Sea, Hadzhiyska River, passes through it. Dunes are open and dynamic systems, making it easier for invasive alien species (IAS) to settle (LIFE20 NAT/BE/001442, 2021) and rivers are one of the most used routes for the spread of IAS and periodic information about their participation in the composition of the local vegetation is a key part of the monitoring for the protection of the river and adjacent habitats (Glogov, 2021).

The purpose of the present publication is to study the variety and quantitative participation of IAS at the mouth of Hadzhiyska river and its role in their distribution on the sand dunes as possible treat for biodiversity of habitat types 2130 and 2190 on the territory of municipality of Nessebar.

2. Materials and Methods

The object of study is the species composition of the vegetation in the riverbed and on the banks of Hadzhiyska river at its mouth with the Black Sea (Figure 1). Hadzhiyska River is a river in southeastern Bulgaria, Burgas region. The river springs from the Eminska Mountain and passes through the municipalities of Ruen, Pomorie and Nessebar, and flows into the Nessebar Bay on the Black Sea. Its length is 55 km. The river has an average annual runoff of 0,64 m³/s, with a maximum in February and March and a minimum in August and September (Michev et al., 1980)



Figure 1. Location of the study area (red rectangle) on the Bulgarian rivers map; Satellite imagery of the study area

The survey was conducted in the period May-July, 2022. At a distance of 1 km from the mouth along the river on both banks, 20 sample plots (SP) were set up (10 SP on each bank). The area of each SP is 50 m² following the recommendations of Chytrý & Otýpková (2003). The distance between SP is 100 m. The selection of SP covers to the maximum extent the floristic diversity in the study area. Within the SP, floristic composition, vertical structure and cover abundance of species were studied according to the Braun-Blanquet (1964) scale. The data from the phytocoenological descriptions are summarized in a table with averaged quantitative participation of each species and their constancy (from I to V) calculated on a base of their occurrence (in %) in the SP (Pavlov, Dimitrov, 2012).

The separate phytocoenological layers (stratums) are marked with small letters next to the latin names of the plant species - a (tree layer), b (shrub layer), c (grass layer). A comparative distribution of species was made according to synanthropic characteristics - anthropophytes (At), apophytes (Ap) and autochthonous species (Av). The established invasive alien species (IAS) for the territory of Bulgaria in the studied area are according to Petrova et al. (2013). The conservation status of the species is according to the Red Data Book of the Republic of Bulgaria. Volume 1 (Peev et al., 2015) (RDB 1) and Bulgarian Biological Diversity Act (2002) (BDA). The characteristic species for the coastal and dune habitat types follows Tzonev (2015b).

3. Results

As a result of the study, 77 species of higher plants were found, 17 (22.1%) of which were trees and shrubs (Table 1). Nine IAS were registered (11.6% of the species composition), of which 3 trees and 6 herbaceous plants. Among the IAS, *Amorpha fruticosa* has the highest cover abundance, and *Phragmites australis* among the natives. The percentage distribution of synanthropic groups is as follows: anthropophytes (At) – 53.2%, autochthonous species (Av) – 39,0%, apophytes (Ap) – 7.8%. Three of the established species have a nature protection status - *Silene thymifolia* (RDB- “endangered species”), *Cladium mariscus* (RDB- “endangered species”, BDA), *Centaurea arenaria* (BDA). Twelve species are characteristic for different dune habitat types as follows: 2130 Fixed dunes with herbaceous vegetation ('grey dunes')- 6 species; 2190 Humid dune slacks -3 species, 2110 Embryonic shifting dunes- 3 species, 2120 Shifting dunes along the shoreline with *Ammophila arenaria* ('white dunes')- 2 species, 2340 Pannonic inland dunes- 1species. The species characteristic for the last two types are also characteristic for any of both habitat types 2130 and 2190.

Table 1. Floristic composition of the study area

Species	Average cover abundance	Constancy	Synanthropic group	IAS	Type of NATURA 2000 dune habitat for which the species is characteristic
<i>Ailanthus altissima</i> (Mill.) Swingle (b)	+	III	At	+	
<i>Ailanthus altissima</i> (Mill.) Swingle (c)	+	II	At	+	
<i>Allium carinatum</i> L.	+	I	Av		
<i>Amaranthus hybridus</i> L.	1	II	At	+	
<i>Amorpha fruticosa</i> L. (b)	4	IV	At	+	
<i>Amorpha fruticosa</i> L. (c)	3	III	At	+	
<i>Anchusa officinalis</i> L.	+	II	At		
<i>Anthemis arvensis</i> L.	+	I	At		
<i>Aristolochia clematitis</i> L.	+	I	At		
<i>Artemisia absinthium</i> L.	+	II	Av		
<i>Artemisia campestris</i> L.	+	I	At		2130
<i>Asclepias syriaca</i> L.	+	I	At	+	
<i>Atriplex hastata</i> L.	+	I	At		
<i>Avena fatua</i> L.	1	II	At		
<i>Balota nigra</i> L.	+	II	At		
<i>Calamagrostis epigeios</i> (L.) Roth	+	I	Av		
<i>Calystegia sepium</i> (L.) R. Br.	+	III	At		
<i>Campsis radicans</i> (L.) Seeman (b)	+	I	At		
<i>Carduus acanthoides</i> L.	+	II	At		
<i>Carex ovalis</i> Good.	1	II	Av		
<i>Carthamus lanatus</i> L.	+	I	At		
<i>Centaurea arenaria</i> M. Bieb.	+	I	Av		2120, 2130,

					2340
<i>Centaurea diffusa</i> Lam.	+	II	Av		
<i>Chenopodium album</i> L.	1	I	At		
<i>Cladium mariscus</i> (L.) Pohl	2	II	Av		2190
<i>Sorghum halepense</i> (L.) Pers.	+	I	At	+	
<i>Cichorium intybus</i> L.	+	II	At		
<i>Cionura erecta</i> (L.) Griseb.	1	II	Av		2130
<i>Convolvulus arvensis</i> L.	+	II	At		
<i>Crataegus monogyna</i> Jacq. (b)	+	I	Av		
<i>Crepis foetida</i> L.	+	I	At		
<i>Cynanchum acutum</i> L.	+	III	Av		2130
<i>Datura stramonium</i> L.	+	I	At	+	
<i>Ecballium elaterium</i> (L.) A.Rich.	+	II	At		
<i>Elaeagnus angustifolia</i> L. (b)	2	II	At		
<i>Elytrigia repens</i> (L.) Nevski.	2	III	Av		
<i>Equisetum ramosissimum</i> Desf.	1	II	Av		
<i>Erigeron canadensis</i> L.	+	I	At	+	
<i>Erysimum diffusum</i> Ehrh.	+	I	At		
<i>Euphorbia seguieriana</i> Neck.	+	II	Av		
<i>Fraxinus angustifolia</i> Vahl (a)	2	II	Av		
<i>Fraxinus angustifolia</i> Vahl (b)	+	I	Av		
<i>Galega officinalis</i> L.	+	I	At		
<i>Geum urbanum</i> L.	+	II	Av		
<i>Hordeum murinum</i> L. ssp. <i>leporinum</i> (Link) Arcang.	3	II	Av		
<i>Jurinea albicaulis</i> Bunge	+	I	Av		2130
<i>Koeleria glauca</i> (Spreng.) DC.	2	II	Av		
<i>Lactuca serriola</i> L.	+	II	At		
<i>Lactuca tatarica</i> (L.) CAMEy.	+	II	At		2110
<i>Lathyrus latifolius</i> L.	+	II	Av		
<i>Lemna minor</i> L.	3	IV	Av		2190
<i>Leymus racemosus</i> (Lam) Tzvelev.	1	II	Av		2110
<i>Lolium perenne</i> L.	1	I	Av		

<i>Lycopus europaeus</i> L.	+	I	Av		
<i>Malva neglecta</i> Wallr.	+	III	At		
<i>Medicago minima</i> (L.) Bartal.	+	I	At		
<i>Morus alba</i> L. (b)	+	I	At		
<i>Pastinaca sativa</i> L.	1	I	Av		
<i>Periploca graeca</i> L. (b)	+	II	Av		
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.	5	V	At		2190
<i>Platanus acerifolia</i> (Aiton) Willd. (a)	2	I	Ap		
<i>Populus</i> × <i>canescens</i> (Aiton) Sm. (b)	+	I	Av		
<i>Populus</i> × <i>canescens</i> (Aiton) Sm. (c)	+	I	Av		
<i>Populus alba</i> L. (a)	2	II	Av		
<i>Populus alba</i> L. (b)	1	I	Av		
<i>Populus alba</i> L. (c)	+	I	Av		
<i>Populus tremula</i> (b)	+	I	Av		
<i>Populus tremula</i> (c)	+	I	Av		
<i>Potentilla reptans</i> L.	+	II	At		
<i>Prunus cerasifera</i> Ehrh.	+	II	Ap		
<i>Robinia pseudoacacia</i> L.	1	II	At	+	
<i>Rosa agrestis</i> Savi (b)	+	I	Ap		
<i>Rubus discolor</i> Weihe & Nees (b)	1	III	Ap		
<i>Rumex crispus</i> L.	+	II	At		
<i>Salix babylonica</i> L. (a)	2	II	Ap		
<i>Scolymus hispanicus</i> L.	+	I	At		
<i>Silene thymifolia</i> Sm.	+	I	Av		2120, 2130
<i>Stellaria media</i> (L.) Vill.	2	III	At		
<i>Taraxacum officinale</i> (L.) Weber ex FHWigg.	+	II	At		
<i>Verbascum blattaria</i> L.	+	I	At		
<i>Vicia villosa</i> Roth.	+	I	Av		

<i>Vitis sylvestris</i> C.C.Gmel. (b)	2	I	Ap		
<i>Vitis sylvestris</i> C.C.Gmel. (c)	+	I	Ap		
<i>Xanthium italicum</i> Moretti	1	II	At	+	2110
<i>Mahonia aquifolium</i> (Pursh) Nutt. (c)	+	I	At		

140

About 70% of the surface of the river bed in the studied area is covered by monodominant communities of common reed (*Phragmites australis* (Cav.) Trin. ex Steud.) with stem height up to 6.5 m. Along the banks, the height of the common reed' individuals reaches 4.5 m. (Figure 2).

141

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Figure 2. Sections of Hadzhiyska River (Photo: P. Glogov)

147

In the last 100 m from the mouth of Hajijjska river, the vegetation sharply decreases and is limited to a single presence of psamophytes typical of the dunes, as well as a few individuals of the IAS *Amorpha fruticosa*, which are located at a distance of 3-5 meters from the river course (Figure 3)

148

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Figure 3. Individuals of *Amorpha fruticosa* on the dunes in the immediate vicinity of Hadzhiyska river(Photo: P. Glogov)

The vertical structure of plant communities along the river banks is well expressed. Cover abundance of the tree layer varies from 0 to 65%. Among the trees with a higher participation are the species *Populus alba* and *Fraxinus angustifolia*, *Eleagnus angustifolia*, *Platanus acerifolia* and the IAS *Ailanthus altissima* and *Robinia pseudoaccacia* are more limited. The cover abundance of the shrub layer varies from 5 to 60%, and it is dominated by *Amorpha fruticosa* and *Rubus discolor*. The grass layer has 80 to 100% cover abundance and is dominated by *Phragmites australis* in most SP. A higher participation and uniform distribution of the trees and shrubs in the composition of the vegetation cover is observed along the southern bank of the river.

4. Discussion

The analysis of species composition and the specific conditions of the terrain show that in the territory around the mouth of the Hadzhiyska river, in addition to the two studied habitat types (2130 and 2190), one more important habitat type- 2110 is established. A sparsely vegetated strip on the border between the beach and the sea, where the first stages of dune formation are observed. In this type of habitat which dynamic processes take place and the IAS can also negatively affect its development.

Data on species cover abundance and constancy at this stage show a real risk of increased spread of IAS *Amorpha fruticosa*, but other IAS such as *Asclepias syriaca*, *Ailanthus altissima*

and *Robinia pseudoaccacia* and *Xanthium italicum* (although the latter is considered diagnostic of one of the dune habitats) even were registered in the SP in close proximity to the dunes, making them a potential threat to the investigated habitats and to the localities of species with conservation and diagnostic value found in the studied section of the river.

This treat is increased by the predominant participation of anthropophytes in the floristic composition, among which there are no less aggressive species. The reason for the higher presence of shrubs and trees on the southern bank of the river is that it borders a 0.5 km² area with preserved autochthonous vegetation, in which the tree layer is represented by *Fraxinus angustifolia* (60% cover abundance), *Populus nigra* (5%), *P. deltoideus* (1-2%), and of the shrubs *Rubus discolor* predominates.

It is important to note that *Amorpha fruticosa* was not found in this adjacent forest community, probably due to the good structure and the presence of strong competitors among native trees and shrubs, which is further evidence that this IAS has penetrated the dunes via the flow of Hadzhiyska river. Some of the IAS were found only near the buildings of the Fregatata complex and did not attack the dunes at this stage, but there is a potential danger, especially from *Xanthium italicum*. Judging by other territories of the Nessebar and Sunny beach, where the species *Robinia pseudoaccacia* and *Ailanthus altissima* occupy significant parts of the dunes thanks to the human factor (past afforestation, unintentional transfer, etc.) it is important to note them also as a potential threat to the study area.

Common Reed is a powerful competitor to IAS and is itself considered an invasive species in many countries. In the specific case, on the one hand, with its thick stems, it prevents the spread of foreign species to a large extent, but on the other hand, its excessive amount causes swamping and deteriorates the qualities of the habitat, reducing its biodiversity. In the present study, common reed communities were found to cover more than 2/3 of the river bed and front line banks (5 to 10 m away from the river).

For this reason, the flow has stopped in some of the river sections, there are signs of swamping, eutrophication and waste accumulation. The access of oxygen below the surface is hampered by the large quantitative participation of *Lemna minor*. Small part of the investigated area is managed by the Ministry of environment and waters (Regional Inspectorate Burgas) according to the law and the rules for protected area. The rest of the land is under the authority of Nessebar municipality (Peev et al., 2012), which needs to take more effective measures to improve the habitat related to cleaning the river bed of Hajiyska river, control of

the flow of tourists passing through these territories, sanctions for illegal dumping of waste in the river, etc.

5. Conclusions

The study categorically shows that Hadzhiyska river is a vector for the spread of IAS on the territory of the dunes, which threaten the biodiversity of the protected dune habitats in the investigated area.

At the present stage, the most aggressive of the IAS established in the study area, which has already partially settled on the territory of the dunes, is *Amorpha fruticosa*. The species *Asclepias syriaca*, *Ailanthus altissima*, *Robinia pseudoaccacia* and *Xanthium italicum* are also a potential threat.

Common reed is a serious competitor of the IAS and at this stage prevents their direct penetration, but the increase in the cover abundance of this species poses a serious danger to the course of the river, which in some places shows signs of swamping and creates a prerequisite for the accommodation of unwanted species and is an indirect factor for the deterioration of the river habitat and the adjacent dunes.

Measures are needed for periodic cleaning of the river bed and the banks of Hadzhiyska River, both from local aggressive species such as the common reed, and from IAS and effective prohibitions regulating the negative results of the anthropogenic load on this area and its adjacent territories with a special conservation status.

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