

The Maritime Pine, *Pinus pinaster* Aiton (Pinaceae), a Naturalised Alien on the Bulgarian Black Sea Coast

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Abstract: The Maritime pine *Pinus pinaster* is a fast growing tree, well adapted to sandy soils. It is native to the Western Mediterranean. The wood is used for construction works and furniture. Also, it is used for production of turpentine and rosin. Therefore, it was planted widely for timber production, reforestation of degraded soils and dune stabilisation in areas of the world with a Mediterranean type of climate (East Mediterranean, South Africa, Australia, parts of North and South America). Nowadays, it is considered highly invasive in most of these areas. In Bulgaria, it was planted in areas in South Bulgaria and on the Black Sea Coast mostly during the period 1960-1985. Some plantations are on dune habitats. During the past two decades successful reproduction has been observed in some of the plantations. We report data about the naturalisation of *P. pinaster* both in Northern and Southern Black Sea Coast floristic subregions. The scale of the local spread, the high invasion success and the impact on the natural vegetation are very obvious and problematic in two particular areas: the coastal dune habitats in the area Kamchiyski Pyasatsi, which borders the Kamchia Reserve (Natura 2000 site BG0000161 Kamchia) and the inland dunes in and near the Pobiti Kamani Protected Site, close to Beloslav Town (Natura 2000 site BG0000132 Pobitite Kamani).

Key words: Alien species, Bulgarian flora, forest plantations, *Pinus*, Pinaceae

Introduction

The Maritime pine, *Pinus pinaster* Aiton (syn. *Pinus maritima* Lam.) (Pinaceae), is native to the West Mediterranean Basin, including the southern parts of the Atlantic coast of Europe. There is a natural variability and 2-5 subspecies are recognised by different authors. In its native distribution area it is found at a wide range of altitudes, on sandy substrates on coastal dune habitats or poor soils on mountain rocky slopes, preferably on siliceous bedrock but sometimes on limestone as well (GAUSSEN et al. 1993, ABAD VIÑAS et al. 2016).

It is a fast-growing tree. The wood is used for construction works and furniture. It is also used for production of turpentine and rosin. Due to these qualities, it was planted widely for timber

production, reforestation of degraded soils and dunes stabilisation in many areas of the world with a Mediterranean type of climate: East Mediterranean Basin, South Africa, Australia, parts of North and South America (ABAD VIÑAS et al. 2016). It reproduces easily by seeds, which are winged and thus, dispersed by wind. Nowadays, it is considered highly invasive in most of the areas outside its native range (RICHARDSON 2005, CABI 2017, etc.).

In Bulgaria, the species was first introduced and cultivated mainly as exotic park-tree at the end of the 19th century in several places: Hisarlaka Hill near Kyustendil Town, Evksinograd Park near Varna City, the Mitropolit Metodiy Kusev Park (Ayazmoto) near Stara Zagora Town, Sofia (King

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Boris's forest plantations), the forest nursery near Belovo Town, and the Gyunduz-Cheshme locality near Varna (DIMITROFF & STEFANOFF 1928). The first forest plantations were established in 1949-1951 in Strandzha Mountains, and till 1967, on the territory of the Burgas Regional Forest Department, 174 ha were planted in many small pure stands (KOSTADINOV et al. 1998). It was planted more widely in areas in South Bulgaria and the Black Sea Coast during the period 1960-1985. Some of the established plantations were mixed with *Pinus nigra* J. F. Arnold, *P. hallepensis* Mill. s.l. of different origin, or deciduous species as lime or maple (GRAMATIKOV 1992, KOSTOV 1994, KOSTADINOV et al. 1998). Sometimes the plantations are on dune habitats. Although there are studies and reports about the results of the introductions and productivity of the species (KOSTADINOV et al. 1998), it is not reported as a naturalised species yet and it is not included in the recent general sources for the Bulgarian flora (DELIPAVLOV & CHESMEDZHIEV 2011, ASSYOV & PETROVA 2012).

The aim of this article is to report the species as a naturalised alien in Bulgaria, showing some of the territories with a successful self-reproduction and high impact on the native flora and vegetation.

Materials and Methods

The data about the localities with a self-reproduction and naturalisation of *P. pinaster* have been gathered by the authors during field studies along the Bulgarian Black Sea coast since 2009. The specimens collected have been deposited in the herbarium (SOM) of the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences.

Results

Pinus pinaster Aiton, Hortus Kewensis 3: 367 (1789).

Tree, up to 40 m high, with thick reddish-brown bark. The crowns in the natural stands are wide and flat. Leaves in pairs, 10-25 × 0.2 cm, dark green, rigid and spiny. Cones 8-22 × 5-8 cm, almost sessile, ovoid-conical, shiny light brown, apophysis rhomboidal, keeled, with a small prickle. Cones ripen in the autumn, usually two years after pollination, but remain closed for 3-5 years.

Distribution in Bulgaria

Black Sea Coast (Northern): 1. Kamchiyski Pyasatsi locality, east of Novo Oryahovo Village, gray dunes, NH75, N 42.985689°, E 27.887258°; N 42.995531°, E 27.884967°; N 42.995326°, E 27.887028° &

NH76, N 43.002856°, E 27.886558°, 02.06.2012 & 20.08.2014, A. Petrova obs.; 2. Inland dunes in and near the Beloslav – West Pobiti Kamani group of Pobiti Kamani Protected Site, close to Beloslav Town, NH58, N 43.186364°, E 27.697668°, 20.07.2009, A. Petrova and V. Vladimirov obs., 08.09.2011, 25.08.2016, V. Vladimirov obs., 11.07.2014, A. Petrova obs. (Fig. 1);

Black Sea Coast (Southern): 3. Near Chernomorets Town, between Chernomorets and Sozopol Town, along the beach of the Gradina camping site, on sandy substrate among other trees and shrubs and near a plantation of *Pinus pinaster*, flat area, 3 m, NG59, N 42°24'23.7", E 27°39'40.4", 02.06.2015, coll. A. Tashev & N. Tashev (SOM); 4. In Zlatna Ribka coastal area, westwards of Sozopol Town, NG67, N 42.246719°, E 27.753744°, 15.10.2013, A. Petrova obs.; 5. North of Kiten Village, in the former International Youth Center, NG59, N 42.246179°, E 27.753623°, 15.06.2013, A. Petrova obs. (Fig. 1).

The plantations of *P. pinaster* in the Kamchiyski Pyasatsi locality, on the territory along the lower reaches of the Kamchia River, are almost 50 ha (GEORGIEV 2009). A large part of them is on the coastal dunes east of Novo Oryahovo Village. Here is one of the largest dune complexes along the Bulgarian Black Sea Coast, almost 12 km long, with a diversity of habitats. The stands of *P. pinaster* are dense, predominantly 45-50 years old, planted on flat fixed dunes. They form a stripe which is almost 3 km long (with some interruptions). The progeny is up to 15 (20) years old, mostly in fixed gray dunes east of the plantations. Self-established young trees were found near the plantations, but also at distances up to 100 m apart. There are more than 25 single individuals higher than 1.5 m (Fig. 2), some of them already produce strobils, e.g. at N 42.985689°, E 27.887258°. At the northernmost place (N 43.002856°, E 27.886558°), the younger, 4-6 years old individuals are more abundant.

This is the largest area of establishment of *P. pinaster* observed so far in Bulgaria. This area is part of Natura 2000 sites BG0000116 Kamchia (Directive 92/43/EEC) and BG0002045 Komplex Kamchia (Directive 2009/147/EC) and is adjacent to the Kamchia Natural Reserve. Previous publications reported plantations of *P. pinaster* as a reason for a loss of grassy and shrubby vegetation (GEORGIEV et al. 1997) and as a threat to the habitats 04B1 Black Sea fixed (grey) dunes (TZONEV 2015) and 05B1 Black Sea wooded dunes (TZONEV & GUSSEV 2015) in this area. TASHEV (2013) registered the species as invasive in the gray dunes habitat in BG0000116 Kamchia.



Fig. 1. Distribution map of naturalised stands of *Pinus pinaster* in Bulgaria

In the Beloslav – West Pobiti Kamani locality, *P. pinaster* was planted about 40 years ago on inland sand dunes with limestone outcrops. A progeny of different age has been observed during the past few years. A local area with especially abundant young specimens was observed in July 2014 (Fig. 3a) and again in August 2016 (Fig. 3b). The locality near Beloslav is in area with inland dunes with specific vegetation, rich of rare plants, e.g. *Arenaria rigida* M. Bieb., *Centaurea arenaria* Willd., and *Dianthus nardiformis* Janka (PETROVA 1997, FILIPOVA-MARINOVA & PETROVA 2003). A part of the locality is in the Natura 2000 site BG0000132 Pobitite Kamani. Here, the main species in the pine plantations is *P. nigra*. Till the end of the past century, there was no self-established progeny of *P. pinaster*. The place is very dry in summer and two fires happened there during the last decades, clearing part of the area. The recruitment of *P. pinaster* is much more abundant (than that of *P. nigra*) and is developed in the area cleared by the fire. Such after-fire behaviour is typical of the species, which is a pyrophyte (RICHARDSON 2005, ABAD VIÑAS et al. 2016). The area is highly invaded by the North-American *Opuntia humifusa* (Raf.) Raf. as well (PETROVA et al. 2012), which



Fig. 2. Young trees of *Pinus pinaster* in Kamchiyski Pyasatsi locality (Photo: A. Petrova)

often dominates even under the canopy of the pine plantations.

Near Chernomorets Town, several dozens of individuals were observed, up to 15 years old and 3 m high. They grow together with *Populus nigra* L., *Prunus cerasifera* Ehrh., *Quercus frainetto* Ten., *Q. pubescens* Willd., *Q. rubra* L., *Fraxinus americana* L., *F. oxycarpa* Willd., *F. pennsylvanica* Marshall, *Platanus orientalis* L., *Rubus caesius* L., *Cornus sanguinea* L., *Paliurus spina-christi* Mill., *Osyris alba* L., *Prunus spinosa* L., *Rosa canina* L., *Vitis sylvestris* C. C. Gmel., and *Cionura erecta* (L.) Griseb. The grass layer is represented by *Brachypodium sylvaticum* (Huds.) P. Beauv., *Poa pratensis* L., *Dactylis glomerata* L., *Calamagrostis epigeios* (L.) Roth, *Carex* sp., *Sanguisorba minor* Scop., *Cichorium inthybus* L., *Eryngium campestre* L., *Daucus carota* L., *Galium* sp., and *Melilotus albus* Medik.

In Zlatna Ribka coastal area, about 15 scattered, up to 10-15 years old individuals were observed on sandy substrate, some of them already producing strobils. Here the predominantly coastal dune vegetation is rather diverse, with a lot of disturbances during the last decades. There are meadow type communities of *Imperata cylindrica* (L.) Raeusch., with spots of gray dunes, places with single trees and species as *Vitis sylvestris* C.C. Gmel. and *Periploca graeca* L. There are about 3.5 ha plantings of *P. pinaster* nearby. Two small plantations and a very dense one, about 45 years old and covering more than 1.5 ha, are situated close to the young self-sown specimens of *P. pinaster*.

Two spots with self-reproduction are observed in the coastal area between Chernomorets Village and Sozopol Town, where Natura 2000 site BG0000146 Plazh Gradina – Zlatna Ribka is declared. There are

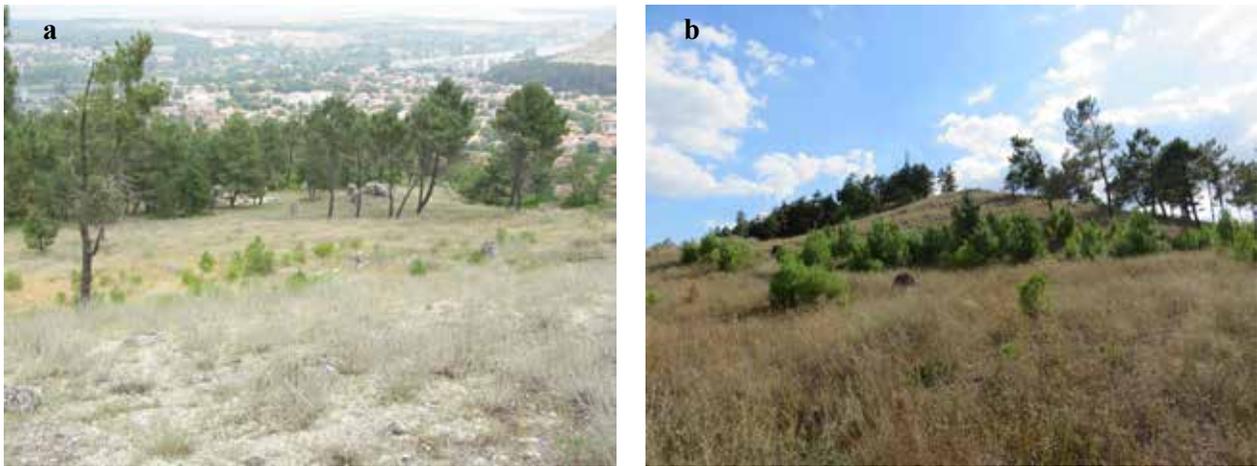


Fig. 3. A group of self-established specimens of *Pinus pinaster* in Pobiti Kamani locality above Beloslav Town: **a.** the group in 2014 (Photo: A. Petrova); **b.** the same group of young trees in 2016 (Photo: V. Vladimirov)

six pine plantations in the area with about 4 km long sand stripe, so the spread of *P. pinaster* potentially can be higher.

In the north of Kiten Village, a few young individuals were observed in a locally fenced area, close to the parent trees.

Distribution worldwide

Native to the Western Mediterranean Basin, from Portugal to Italy (ABAD VIÑAS et al. 2016). In Europe, the species has been reported as ‘casual’ for Belgium and as ‘naturalised alien’ for the United Kingdom (RAAB-STRAUBE 2014). In the South and East Europe the species is native in Italy and ‘in large-scale cultivation’ in the Mediterranean countries of the Balkan Peninsula – Albania, Croatia, Greece and Turkey-in-Europe (RAAB-STRAUBE 2014).

Discussion

The success of the intentional introduction of the species in plantations in Bulgaria has been evaluated in several works. It is worth noting that DIMITROFF & STEFANOFF (1928) reported the trials to cultivate *P. pinaster* in Bulgaria at that time as unsuccessful and the species as not promising for large-scale cultivation in the country. Moreover, GANČEV & PROKOPIEV (1959) reported that in most of the places where the species was first introduced, *P. pinaster* became extinct by the 1960s, with the only exception of Hisarlaka Hill by Kyustendil Town where a single tree survived, and in Evksinograd Park near Varna City, where 38 trees survived without any signs of establishment. Both author teams stated that the main limiting factors for cultivation of the species in Bulgaria are the low

winter temperatures, especially below minus 20°C, long summer droughts and insufficient air humidity. Based on these reports and bearing in mind our personal observations during the past decade, it can be suspected that climate change, especially the lack of prolonged periods of extremely low temperatures in the coastal areas, facilitated the establishment of *P. pinaster* in Bulgaria.

According to KOSTADINOV et al. (1998), the best results of the introduction and productivity of *P. pinaster* in Bulgaria have been obtained on sandy soils, close to the sea coast. All the observations reported here of a self-reproduction of the species are on sand dune habitats. These habitats are of high conservation concern, especially the fixed gray dunes (a priority habitat type 2130* according to the Directive 92/43/EEC). There, the native biodiversity, especially the plant diversity, is rich, with many endemic taxa (TZONEV 2015).

A fairly common phenomenon in the plant invasion is the so cold ‘lag phase’ after the introduction of the species in a new area (KOWARIK 1995, MARSICO et al. 2010). Our observations show that this lag phase is over in the case of *P. pinaster* in Bulgaria. The registered scale of the local spread, the high invasion success and the impact on the natural vegetation is very obvious and problematic in two particular areas: the coastal dune habitats in the area Kamchiyski Pyasatsi, south of the Kamchia River estuary, and the inland dunes in and near the Beloslav – West Pobiti Kamani group of Pobiti Kamani Protected Site.

Bearing in mind the biological and ecological adaptations and invasive potential of the species (RICHARDSON 2005, CABI 2017), there is an urgent need for a comprehensive study of all stands of *P. pinaster* in the coastal areas, with a special attention

to the Natura 2000 sites. The study has to cover the extent of the plantations and ornamental plantings, their age and growth conditions, the reproductive status, presence and extent of self-reproduction. There is a need for control of the species invasion. The following measures are recommended: gradual cut of the forest plantations on and near sand dunes, eradication of the self-established young

individuals nearby, and restoration of the habitat after clearing of the forest plantations.

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References

- ABAD VIÑAS R., CAUDULLO G., OLIVEIRA S. & DE RIGO D. 2016. *Pinus pinaster* in Europe: distribution, habitat, usage and threats. In: SAN-MIGUEL-AYANZ J., DE RIGO D., CAUDULLO G., HOUSTON DURRANT T. & MAURI A. (Eds.): European Atlas of Forest Tree Species. Luxembourg: Publication Office of the European Union, pp. e012d59+.
- ASSYOV B. & PETROVA A. (Eds.) 2012. Conspectus of the Bulgarian vascular flora. Distribution maps and floristic elements. Edition 4. Sofia: Bulgarian Biodiversity Foundation, 490 p.
- CABI 2017. *Pinus pinaster* [original text by N. Pasiecznik]. In: Invasive species compendium. Wallingford, UK: CAB International. www.cabi.org/isc (accessed 18.02.2017)
- DELIPAVLOV D. & CHESHMEDZHIEV I. (Eds.) 2011. Handbook for Plants in Bulgaria. Plovdiv: Academic Press of the Agrarian University, 591 p. (in Bulgarian)
- DIMITROFF T. & STEFANOFF B. 1928. Les essences forestières exotiques et leur culture en Bulgarie. Sofia: Darzhavna Pechatnitsa [State Printing House], 192 p. (in Bulgarian)
- DIRECTIVE 92/43/EEC. 1992. Council Directive 92/43/EEC of 21 May 1992 on the conservation of the natural habitats and of wild fauna and flora. Official Journal of the European Union L 206: 7-50.
- DIRECTIVE 2009/147/EC. 2009. Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds. Official Journal of the European Union L20: 7-25.
- FILIPOVA-MARINOVA M. & PETROVA A. 2003. Botanical characteristic of the protected area Landmark Pobiti Kamani. Bulletin du Musee National de Varna 34-35 (49-50): 339-368. (in Bulgarian)
- GANČEV A. & PROKOPIEV E. 1959. Fremdländische Bäume und Sträucher in Bulgarien. Sofia: BAS Publishing and Printing House, 148 p. (in Bulgarian)
- GAUSSEN H., HEYWOOD V. H. & CHATER A. O. 1993. *Pinus* L. In: TUTIN T. G., BURGESS N. A., CHATER A. O., EDMONDSON J. R., HEYWOOD V. H., MOORE D. M., VALENTINE D. H., WALTERS S. M. & WEBB D. A. (Eds.): Flora Europaea, Edition 2. Cambridge: Cambridge University Press, Vol. 1, pp. 40-44.
- GEORGIEV D., DERELIEV S., YANKOV P. & PROFIROV L. 1997. Kamchia Complex. In: KOSTADINOVA I. (Ed.): Important Bird Areas in Bulgaria. BSPB Conservation Series. Sofia: BSPB, pp. 136-138. (in Bulgarian)
- GEORGIEV G. 2009. Afforestation in the flood-plain forest around river "Kamchia" retrospection and alternatives for increasing the stability of the ecosystems. Management and Sustainable Development 1 (22): 82-87.
- GRAMATIKOV D. 1992. Identification Book of Trees and Shrubs in Bulgaria. Plovdiv: IntelSis, 268 p. (in Bulgarian)
- KOSTOV I. 1994. The forestry in Burgas region. Burgas: Delfin Press, 288 p. (in Bulgarian)
- KOSTADINOV K., BROSHILOV K. & BROSHILOVA M. 1998. *Pinus pinaster* Ait. growth and productivity in the Southeastern Bulgaria. In: STOYKOV H., ALEXANDROV A., ROSNEV B., RAEV I., MARKOFF I. & NAYDENOVA T. (Eds.): Proceedings. Scientific Papers. Jubilee Scientific Conference with International Participation "70th Anniversary of the Forest Research Institute", 6-7 October 1998, Sofia. Sofia: Bulgarian Academy of Sciences, Forest Research Institute, Vol. 1, pp. 308-314.
- KOWARIK I. 1995. Time lags in biological invasions with regard to the success and failure of alien species. In: PYŠEK P., PRACH K., REJMANEK M. & WADE M. (Eds.): Plant invasions – general aspects and special problems. Amsterdam: SPB Academic, pp. 15-38.
- MARSICO T., BURT J., ESPELAND E., GILCHRIST G., JAMIESON M., LINDSTRÖM L., RODERICK G., SWOPE S., SZÜCS M. & TSUTSUI N. 2010. Underutilized resources for studying the evolution of invasive species during their introduction, establishment, and lag phases. Evolutionary Application 3 (2): 203-219.
- PETROVA A. 1997. Rare plants in the protected areas Pobiti kamani in north-eastern Bulgaria. Bocconea 5 (2): 461-464.
- PETROVA A., VLADIMIROV V. & GEORGIEV V. 2012. Invasive alien species of vascular plants in Bulgaria. Sofia: Institute of Biodiversity and Ecosystem Research, 319 p. (in Bulgarian)
- RAAB-STRAUBE E. VON 2014. Gymnospermae. In: Euro+Med Plantbase – the information resource for Euro+Mediterranean plant diversity. <http://ww2.bgbm.org/EuroPlusMed/query.asp> (accessed 10.03.2017)
- RICHARDSON D. 2005. *Pinus pinaster*. In: Global Invasive Species Database. <http://issg.org/database/species/ecology.asp?si=43&fr=1&sts=&lang=EN> (accessed 18.02.2017)
- TASHEV A. 2013. Distribution and evaluation of the conservation status of the habitat 2130* Fixed coastal dunes with herbaceous vegetation (grey dunes) in BG0000116 Kamchia. <http://natura2000.moew.government.bg/Home/ProtectedSite?code=BG0000116&siteType=HabitatDirective> (accessed 12.03. 2017)
- TZONEV R. 2015. 04B1 Black Sea stabilized (gray) dunes. In: BISERKOV V., GUSSEV C., POPOV V., HIBAUM G., RUSSAKOVA V., PANDURSKI I., UZUNOV Y., DIMITROV M., TZONEV R. & TSONEVA S. (Eds.): Red Data Book of the Republic of Bulgaria, Vol. 3. Natural habitats. Sofia: BAS & MoEW, pp. 69-71. (in Bulgarian)

TZONEV R. & GUSSEV C. 2015. 05B1 Black Sea wooded dunes. In: BISERKOV V., GUSSEV C., POPOV V., HIBAUM G., RUSSAKOVA V., PANDURSKI I., UZUNOV Y., DIMITROV M., TZONEV R.

& TSONEVA S. (Eds.): Red Data Book of the Republic of Bulgaria, Vol. 3. Natural habitats. Sofia: BAS & MoEW, pp. 72-73. (in Bulgarian)