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## REVIEW ARTICLES

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### SPECIES COMPOSITION AND COMPARATIVE-HISTORICAL ASPECTS OF EXPANSION OF ALIEN SPECIES OF VASCULAR PLANTS ON THE SOCHI BLACK SEA COAST (RUSSIA)

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This article provides an overview of 167 alien species of vascular plants of the far south of the Russian Federation. Considered is the distribution of alien species of ecological-altitude belts of the southern macroslope of the western Caucasus, at the interfluvium of the rivers Tuapse and Psou and their geographical origin. It shows the predominance of alien species from North America and Eastern Asia. The authors considered an increasing number of alien species and the speed of distribution of the most aggressive invaders. We identified the capability of interchangeability of invasive species during a certain time.

**Key words:** alien species, dissemination along ecological-altitude belts, geographical origin, Sochi Black Sea Coast, turnover of invaders, vascular plants

#### Introduction

The number of naturalised vascular plant species in disturbed and natural ecosystems on the Black Sea coast of Krasnodar region is constantly growing. This is connected with an increasing in the range of cultivated alien species, their ability to run in the wild and an unprecedented scale development on the Sochi Black Sea, especially in the valleys of large rivers such as the Mzymta, Shakhe, Psezuapse and in the seaside strip. The vast majority of alien species are recorded on the foothills and in river valleys. The number of alien species decreases by an increase of the altitude in mountains. This is primarily due to the cultivation of subtropical species on the Black Sea coast. These plant species are unable to naturalise in the middle and upper altitude-ecological belts of mountains which have a more severe feature of the microclimate. However, intensive work on the creation of the alpine resort «Krasnaya Polyana», does not help previously recorded species in the flora of Russia to penetrate into middle-mountain landscapes, where they were brought by the transport and foreign building material (Timukhin & Tuniyev, 2010; Tuniyev, 2012). In our present study we aimed to investigate changes in the alien flora, the invasion rate and the ability of invasive species to change over a limited period.

#### Material and Methods

Material was collected in the period 2000–2017 during the floristic survey routing method of the Black Sea territory of Sochi (southern macroslope of the Western Caucasus along the Black Sea coast between town Tuapse and the border with the Republic of Abkhazia – River Psou) (Fig. 1). The routes cover all high ecological-altitude belts of the studied territory. For isolated mountains and small mountain ranges lists of local floras have been used. Monitoring in the valleys of the large rivers of Sochi (Ashe, Psezuapse, Shakhe, Mzymta and Psou) allowed to reveal the dynamics of penetration of alien species, and, sometimes, replacement of most aggressive invaders by other ones. Particular attention has been paid to the coastal strip, as most transformed and long-exploited by man, as well as the vicinity of the settlement Krasnaya Polyana and the shepherd's camps in the highlands at places of traditional sheep ranching, which has had a long history since the first half of the 20th century. The collected plants have been transferred in the Herbarium of the Sochi National Park (SNP) and, partially, in the Herbarium of the Botanical Institute of Russian Academy of Sciences (St.-Petersburg).

#### Results

There are 167 alien plant species accounted in the Sochi Black Sea region since 2000. The vast

majority of them are restricted to the coastal strip and the valleys of lower-flow of major rivers. Upward from the dark-coniferous belt on the southern macroslope of the Main Caucasian Ridge no alien plants, with rare exceptions, were detected. Below is an annotated list of all the alien species of vascular plants of the Sochi Black Sea coast.

Classis PINOPSIDA  
Fam. Pinaceae

1. *Cedrus deodara* Loud. Origin place – Himalayas and Hindu Kush. It is widely used in landscaping, rarer in cultures. In some places, there self-seeding is observed and penetration to broad-leaved forests in the seaside belt of hills (Lazarevskoe district of Sochi).

2. *Pinus pallasiana* D. Don. Origin place – Crimea, Northwestern Caucasus. There are considerable large cultivars, which give self-seeding in Lazarevskoe district of Sochi.

3. *Pinus pinaster* Alton. Origin place – Western Mediterranean. Trees of this species have been planted from the settlement Magri to the River Psou.

As a rule, trees are being damaged in winter. And then they fall under the snow weight. But there has been noticed subsequent reproduction and successful development of undergrowth trees on some sites of study area: e.g. in the neighbourhood of the village Veseloe and near the settlement Sergey-Pole.

4. *Pinus pinea* L. Origin place – Mediterranean. In the Adler district of Sochi: vicinity of settlement Kudepsta, near the road to the village Energetik.

5. *Pseudotsuga menziesii* (Mirb.) Franco. Origin place – North America. Near the village Golovinka, forest park «Jubileyny», vicinity of settlement Krasnaya Polyana. Everywhere there is observed self-seeding, but far from the initial groups of plants there is no propagation.

Fam. Cupressaceae

6. *Biota orientalis* Endl. (*Platycladus orientalis* (L.) Franco). Origin place – Northern China. It is widely used in gardening. It is quite common on rocky sites of plant communities of xerophytes and mesoxerophytes, formed by *Carpinus orientalis* Mill. in a gorge of the River Chimit (Fig. 2a).

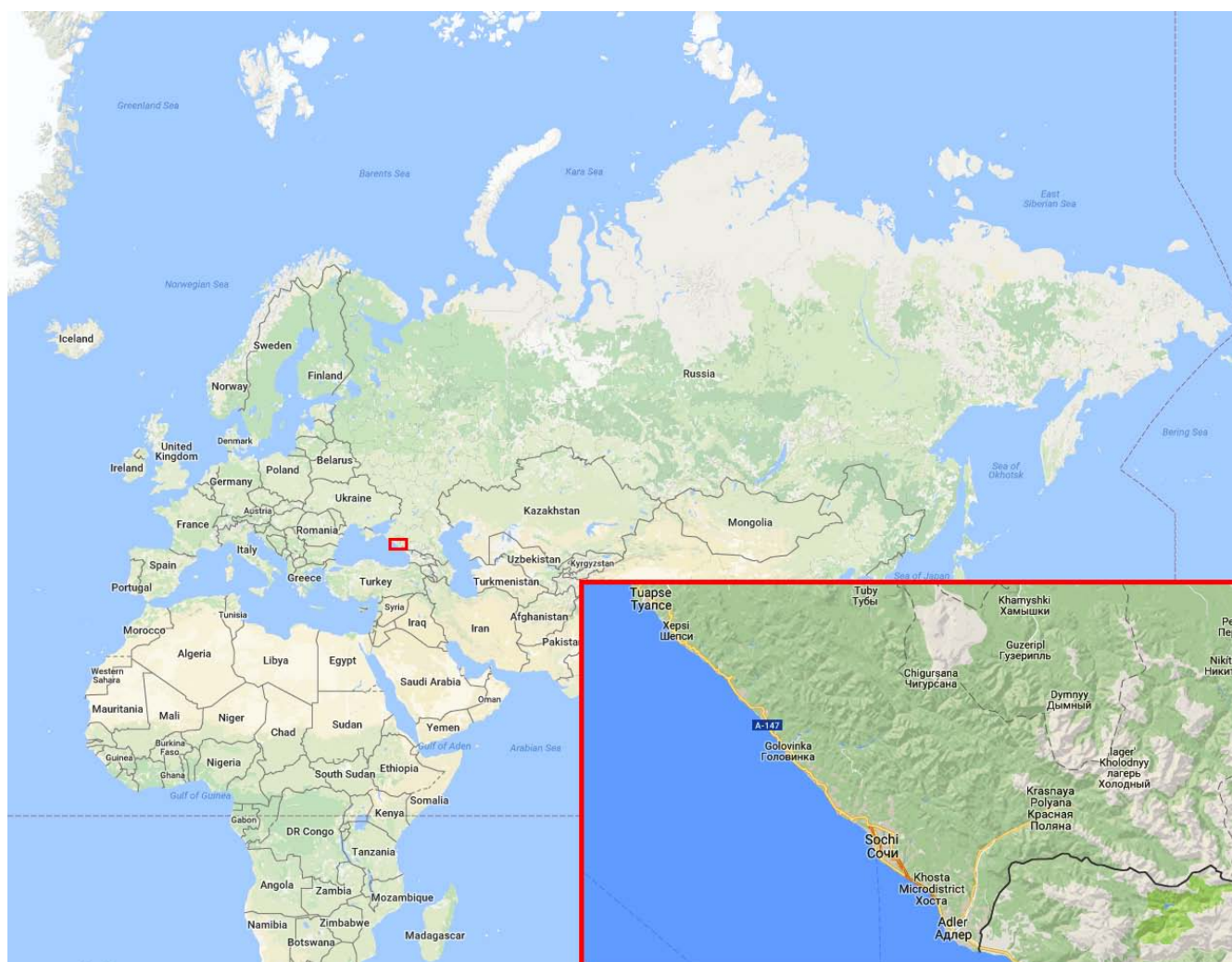
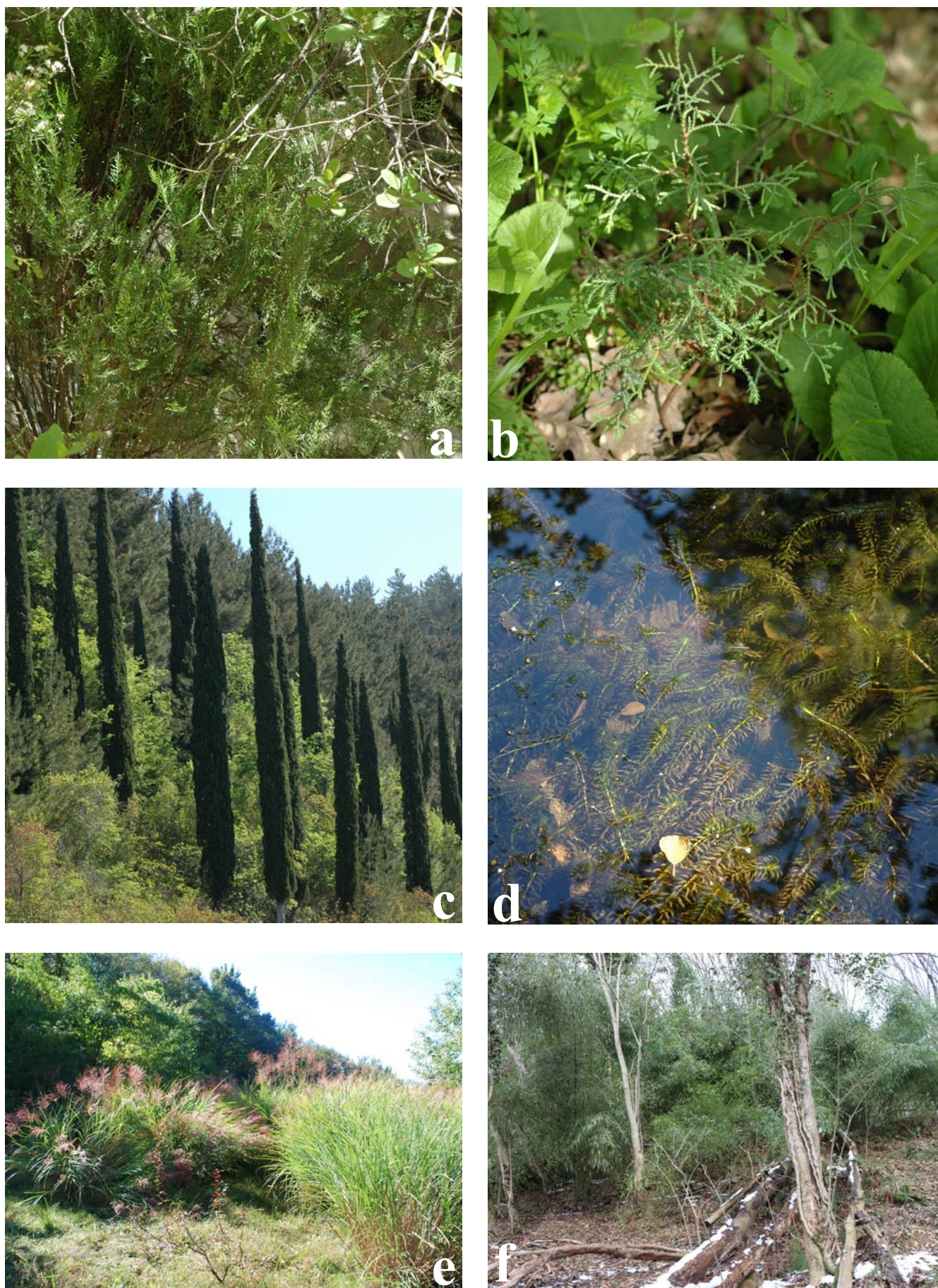


Fig. 1. Location of study area – Sochi Black Sea coast.





**Fig. 2.** Alien species of Sochi Black Sea coast: a – *Biota orientalis* Endl.; b – *Cupressus lusitanica* Mill. (self-sowing); c – *Cupressus sempervirens* L.; d – *Elodea canadensis* Michx.; e – *Miscanthus sinensis* Andersson; f – *Phyllostachys aurea* Rivière & C.Rivière.



7. *Cupressus lusitanica* Mill. Origin place – Mexico and Guatemala. Yew-boxwood Grove, valleys of rivers Kudepsta, Matrosskaya Schel (Kodesh), vicinity of settlement Dagomys. It is individually found only on edges; it gives self-sowing (Fig. 2b).

8. *Cupressus sempervirens* L. Origin place – Mediterranean. It is widely used in landings, and grows wild in the coastal strip, sporadically encountered Lazarevskoe district from the settlement Dagomys to the settlement Chemitokvadzhe (Fig. 2c).

#### Classis LILIOPSIDA

##### Fam. Agavaceae

9. *Yucca brevifolia* Engelm. Origin place – Central America. This cultivated plant flower twice a year, but the introduction into natural plant communities were noted very rarely: Lazarevskoe district, along the Novorossiysk highway between settlement Chemitokvadzhe and settlement Yakornaya Schel.

##### Fam. Amaryllidaceae

10. *Narcissus poeticus* L. Origin place – Mediterranean. It is widely cultivated in the city and private landscaping, often found along roads, in abandoned gardens throughout. It is capable of vegetative propagating, forming large clones.

##### Fam. Commelinaceae

11. *Commelina communis* L. Origin place – East Asia. It is recorded in Imeretinskaya lowland, Yew-boxwood Grove, along the valleys of rivers Mzymta, Kudepsta, Stariki, Shakhe, settlement Sergey-Pole. Usually on edges and hazelnut gardens, river valleys, detuned logging.

##### Fam. Cyperaceae

12. *Cyperus difformis* L. Origin place – Tropical Asia. In weedy places of Imeretinskaya lowland.

13. *Cyperus eragrostis* Lam. Origin place – South America. On wetlands in Imeretinskaya lowland, in the Valley of the lower flow of the Mzymta River, in vicinity of settlement Khosta. Tends to settle.

14. *Cyperus longus* L. The species is described from southern Europe. It grows on damp marshy ground of Imeretinskaya lowland, on the banks of ditches, on the verges, prior to the construction of the seaside cluster of Sochi Olympics 2014 it was observed on irrigated crops too.

15. *Cyperus rotundus* L. Origin place – tropical and subtropical Asia. It grows in lowland and foothill areas and prefers salty soils. It was found on Imeretinskaya lowland along ditches.

##### Fam. Hydrocharitaceae

16. *Elodea canadensis* Michx. Origin place – North America. It is found in the Imeretinskaya lowland, artificial lakes along the River Kherota (Fig. 2d).

17. *Elodea densa* (Planch.) Casp. (*Egeria densa* Planch.). Origin place – South America. In reservoirs of stagnant water in the Imeretinskaya lowland, vicinity of settlement Progress (River Matzesta basin), tract Vtoraya Rota (basin of the River Western Dagomys). It forms a large biomass, good blossom and bears fruit.

18. *Vallisneria spiralis* L. Pantropical species. It was noted in the Sochi Black Sea region for the first time in an artificial lake in the valley of the River East Dagomys.

##### Fam. Iridaceae

19. *Iris × germanica* L. Origin place – Central Europe. It is widely cultivated in the city and private landscaping. It has been recorded along the roads and near settlements between the settlement Yakornaya Schel and settlement Detljazhka, elsewhere along the coast.

##### Fam. Juncaceae

20. *Juncus tenuis* Willd. Origin place – North America. In the territory of Sochi Black Sea, it is widely found on ruderal/abandoned meadows, along forest roads, trails, in riparian habitats, and along roadside ditches.

##### Fam. Liliaceae

21. *Hemerocallis fulva* L. Origin place – East Asia. It is noted in natural forest cenosis mainly in oak-forest belt: foothill of Mountain Dzykhra, Yew-boxwood Grove, Valley of Kudepsta River, and Mountain Aibga.

##### Fam. Palmaceae

22. *Trachycarpus fortunei* H. Wendl. Origin place – Southern China. Yew-boxwood Grove and all foothill area between Sochi and River Psou. *Turdus* species are the main birds contributing to the seed dispersal of this plant. In vicinity of settlement Khosta, it forms understory level in hornbeam forest [*Carpinetum trachycarposum*].

##### Fam. Poaceae

23. *Andropogon virginicus* L. Origin place – North America. Adler and Khosta districts of Sochi, marginal plots of Imeretinskaya lowland in the valleys of the rivers Mzymta and Psou, vicinity of Yew-boxwood Grove. There has been a kind of active expansion northwest along the Black Sea coast in postforest glades and abandoned agricultural lands.

24. *Arthraxon hispidus* (Thunb.) Makino. Origin place – Japan. At riverbeds of the River Psou, Mzymta, Kudepsta.

25. *Avena sativa* L. Origin place – Mediterranean. In several years it was noted on different places of the foothill areas of Sochi region, predominantly along the roads.

26. *Briza maxima* L. Origin place – Mediterranean. It is uncommon in the territory of Sochi Black Sea area among weeds, near human settlements and on seaside slopes with Pitsunda pine groves (*Pinus pityusa* Steven).

27. *Bromus scoparius* L. Origin place – Southern Europe. Occasionally on coastal beaches of Imeretinskaya lowland.

28. *Cortaderia selloana* (Shult. et Schult. Fil.). Origin place – South America. It is widely cultivated in decorative landscaping of Sochi, possesses a high germination. It is recorded on seaside slopes between Cape Vidny (Khosta) and the foothill of Mountain Maly Akhun, climbing along the road to Mamajsky pass. It is increasing in the vicinity of Sochi.

29. *Cynodon dactylon* (L.) Pers. Origin place – Southern Europe and North Africa. On various weedy places and in roadsides in the foothills.

30. *Digitaria ciliaris* (Retz.) Koeler. Origin place – Tropical Asia. It occurs occasionally on coastal sands and pebbles of Imeretinskaya lowland.

31. *Digitaria ischaemum* (Schreb.) H.L. Muhel. Origin place – Far East. It is common on coastal sands and marshlands of Imeretinskaya lowland.

32. *Digitaria pectiniformis* (Hern.) Tzvelev. Origin place – Mediterranean. It is rare on abandoned fields of Imeretinskaya lowland.

33. *Digitaria sanguinalis* (L.) Scop. Origin place – Mediterranean. It is found in abandoned orchards, cornfields after the harvest. It is recorded in all areas of Sochi Black Sea coast.

34. *Digitaria violascens* Link. Pantropical species. Often along roads in the Imeretinskaya lowland.

35. *Eleusine indica* (L.) Gaerth. Origin place – South-East Asia. It grows in weedy places at Imeretinskaya lowland.

36. *Leersia oryzoides* (L.) Sw. Origin place – Eastern Mediterranean. On wetlands in Imeretinskaya lowland.

37. *Microstegium vimineum* (Trin) A. Camus. Origin place – South-East Asia. It is found quite often in the valleys of lower flow of rivers in disturbed forests, on edges, along roads: rivers Kherota, Kudepsta, East Dagomys, Shakhe.

38. *Miscanthus sinensis* Andersson. Origin place – Japan, China. On edges of broadleaved deciduous forests and on disturbed sites on the limestone rocks of the foothills: Yew-boxwood Grove, vicinity of settlements Kudepsta, Matzesta and Adler. It tends to increase its range (Fig. 2e).

39. *Muhlenbergia schreberi* J.F. Gmel. Origin place – East Asia. On coastal beaches of Imeretinskaya lowland.

40. *Panicum capillare* L. Origin place – North America. Rarely in weedy places in vicinity of settlement Adler.

41. *Panicum dichotomiflorum* (Albov) Tzvelev. Origin place – Central and South America. Rarely in weedy places along the coastal zone.

42. *Paspalum dilatatum* Poiret. Origin place – South America. It is found along the unpaved roads in the Imeretinskaya lowland.

43. *Paspalum paspalodes* (Michx.) Scribn. Place of origin – North America. Yew-boxwood Grove, forest edges and deciduous forests of the entire Sochi Black Sea coast. An aggressive weed.

44. *Phalaris minor* Retz. Origin place – Mediterranean. It is distributed sporadically in the foothills of all the districts of Sochi.

45. *Phyllostachys aurea* (André) Rivière & C. Rivière. Origin place – China. Near settlements and along the banks of the lower flow of rivers of Sochi Black Sea from settlement Lazarevskoe to River Psou (Fig. 2f).

46. *Phyllostachys bambusoides* Siebold et Zucc. Origin place – South-East Asia. In the Imeretinskaya lowland, right bank of River Kudepsta, Mountain Ovsianikova, Valley of River Khosta; between settlement Matzesta and village Razdolnoe. It actively settles vegetative propagating (rhizomes) on wet beams and under the canopy of wet Alder-hornbeam forests [*Alneto-Carpinetum strutiopteridosum*].

47. *Pseudosasa japonica* (Siebold & Zucc. ex Steud.) Makino ex Nakai. Place of origin – East Asia. Local groups are marked in the Yew-boxwood Grove, in the valley of the river Kudepsta and on the seaside slope of Mountain Akhun (Fig. 3a).

48. *Secale cereale* L. Origin place – Mediterranean and Asia Minor. It occurs sporadically throughout the territory of all the districts of Sochi.

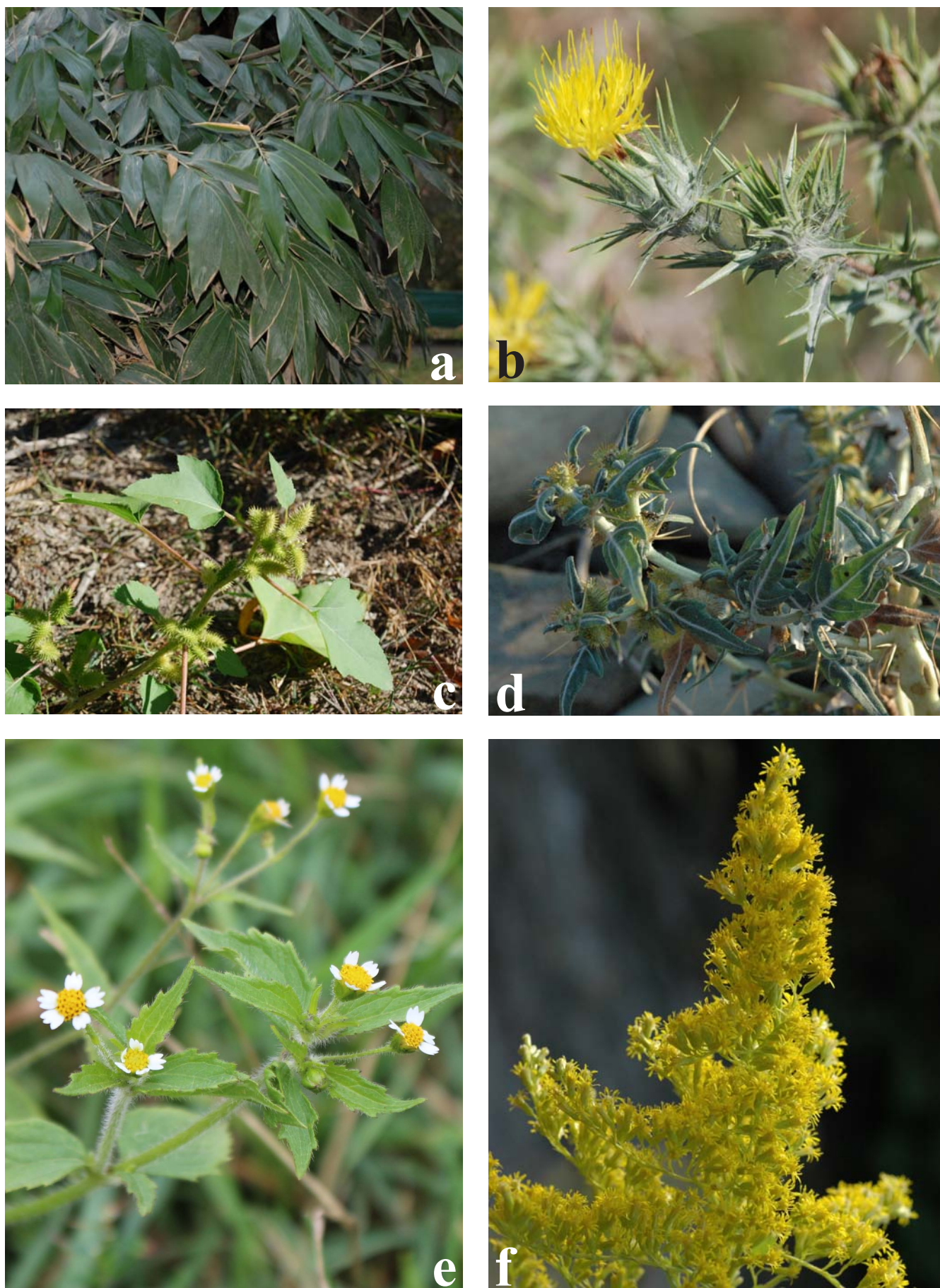
49. *Setaria italica* (L.) P. Beauv. Origin place – East Asia. On dry meadows and glades in the foothills from town Tuapse to settlement Adler.

50. *Setaria pumila* (Poir.) Schult. Widespread tropical weed. It is observed on the Imeretinskaya lowland, Yew-boxwood Grove, on the southern slope of the Mountain Akhun and throughout the Sochi Black Sea coast; it prefers forest edges.

51. *Sorghum halepense* (L.) Pers. Origin place – Asia Minor, North Africa. Sporadically in the foothills of all the districts of Sochi, it occurs in treeless areas, serves as a pilot plant around construction sites and other places of excavation.

52. *Sporobolus fertilis* (Steud.) Clayton. Origin place – South-East Asia. Rarely in the seaside strip of Imeretinskaya lowland.





**Fig. 3.** Alien species of Sochi Black Sea coast: a – *Pseudosasa japonica* (Siebold & Zucc. ex Steud.) Makino ex Nakai; b – *Carthamus lanatus* L.; c – *Xanthium albinum* (Widd.) H. Scholz & Sukopp.; d – *Xanthium spinosum* L.; e – *Galinsoga parviflora* Cav.; f – *Solidago canadensis* L.



## Classis MAGNOLIOPSIDA

## Fam. Aceraceae

53. *Acer negundo* L. Origin place – North America. In the lower mountainous belt consisting of de-tuned logging, or subjected to broadleaf forests with a high recreational press: Mountain Akhun, vicinity of settlement Kudepsta, vicinity of settlement Golovinka.

## Fam. Amaranthaceae

54. *Amaranthus albus* L. Origin place – North America. Throughout the foothill area in roadsides and in the lower flow valleys of major rivers of Sochi region.

55. *Amaranthus blitoides* S.Watson. Origin place – North America. On weedy places along the beaches and in the seaside strip of foothills.

56. *Amaranthus deflexus* L. Origin place – North America. On weedy places, in many settlements.

57. *Amaranthus hybridus* L. Origin place – Tropical America. In the Imeretinskaya lowland, along roads and in vegetable gardens.

58. *Amaranthus retroflexus* L. Origin place – North America. It is found quite often on weedy places: Yew-boxwood Grove, basin of River Kudepsta, Imeretinskaya lowland, lower part of River Shakhe valley.

## Fam. Anacardiaceae

59. *Rhus typhina* L. Origin place – Atlantic part of North America. It was found in hornbeam forests in settlement Dagomys. It grows along ecotones.

## Fam. Apiaceae

60. *Foeniculum vulgare* Mill. Origin place – Southern Europe. Along the shoreline of Imeretinskaya lowland and in some places along the coastline.

## Fam. Asclepiadaceae

61. *Asclepias syriaca* L. Origin place – North America. On weedy places in settlement Adler.

## Fam. Asteraceae

62. *Ambrosia artemisiifolia* L. Origin place – North America. Throughout the foothills: Imeretinskaya lowland, Yew-boxwood Grove, basin of Kudepsta River. It penetrates along the river valleys up to the villages Aibga (River Psou), Marjino (River Psezuapse), Bzogu (River Shakhe).

63. *Bidens bipinnata* L. Origin place – North America. It is quite often in humid areas of the lower flow valleys of rivers: basin of River Kudepsta, Mamajsky forest park, the Imeretinskaya lowland, River Kherota and others.

64. *Bidens frondosa* L. Origin place – North America. On the banks of ditches and reservoirs in the foothills.

65. *Carthamus lanatus* L. Place of origin – Mediterranean. It is found in postforest glades and edges of

oak forests and east hornbeam (*Carpinus orientalis* Mill.) siblijaks on the rise to the Orlinye Skaly (Eagle Rocks) in Khosta District of Sochi (Fig. 3b).

66. *Conyza albida* Willd. ex Spreng. (*Erigeron sumatrensis* Retz.). Origin place – South America. Everywhere, under the power lines, disturbed edges of oak forests and weedy places in the foothills.

67. *Conyza bonariensis* (L.) Cronquist (*Erigeron bonariensis* L.). Origin place – South America. On weedy places, along the railway.

68. *Conyza canadensis* (L.) Cronquist (*Erigeron canadensis* L.). Origin place – North America. Everywhere along the roads, postforest glades in the lower mountainous belt in the seaside zone of Imeretinskaya lowland.

69. *Conyzanthus graminifolius* (Sprengel) Tamamsch. (*Symphotrichum graminifolium* (Spreng.) G.L. Nesom). Origin place – North America. It grows in Imeretinskaya lowland, on roadsides in Central and Adler Districts of Sochi.

70. *Coreopsis tinctoria* Nutt. Origin place – North America. It is observed along roadsides in the Imeretinskaya lowland and in gorge Akhtzu.

71. *Cyclachaena xanthifolia* (Nutt.) Fresen. Place of origin – North America. It was observed in Lazarevskoe District along the postforest glades in Neozhidannaya River valley.

72. *Dichrocephala integrifolia* (L.f.) O. Kuntze. Origin place – the Tropics of the Old World. It is found up to 1500 m a.s.l. among weed vegetation throughout the forest areas of Sochi Black Sea coast, along railways, at the forest edges.

73. *Erechtites valerianifolia* (Wolf) DC. Origin place – Central America. On weedy places in the vicinity of the village Vishnevka and settlement Adler.

74. *Helianthus tuberosus* L. Origin place – North America. It is found quite often in local areas in the valleys of the rivers Psezuapse, Shakhe, Malaya Khosta, in the vicinity of settlement Adler, in the Imeretinskaya lowland.

75. *Helminthotheca echioides* (L.) Holub. Origin place – Mediterranean. It is found on Imeretinskaya lowland, along the coastal strip.

76. *Galinsoga parviflora* Cav. Origin place – South America. Yew-boxwood Grove, on open places, hazelnut gardens, everywhere up to 600 m a.s.l.. On the West of the described region it is found around herding balagans in subalpine meadows of Mountain Khakudzh (1400 m a.s.l.) (Fig. 3e).

77. *Galinsoga quadriradiata* Ruiz et Pav. (*G. ciliata* (Rafin.) Blake). Origin place – South America. It occurs in the Imeretinskaya lowland, in the basin of the River Kudepsta, in the

settlement Khosta, in the vicinity of settlement Sergey-Pole.

78. *Grindelia squarrosa* (Pursh.) Dun. Origin place – North America. Infrequent in the foothill strip of Sochi: park «Dendrary» (Arboretum), in the vicinity of settlement Adler, village Golicino (Gabrielyan et al., 2016).

79. *Phalacrolooma annuum* (L.) Dumort. (*Eriogonon annuus* (L.) Desf.). Origin place – North America. Infrequent on open places in the coastal and foothills: Imeretinskaya lowland, Yew-boxwood Grove, rivers Malaya Khosta, Kudepsta.

80. *Phalacrolooma septentrionale* (Fern. et Wieg.) Tzvelev. Origin place – North America. Along the unpaved roads of Imeretinskaya lowland.

81. *Rudbeckia hirta* L. Origin place – North America. In the lower reaches of the River Mzymta–gorge Akhtzu.

82. *Sigesbeckia orientalis* L. Origin place – North America and Far East. It is common to Imeretinskaya lowland, in the valleys of the rivers Psakho, Khosta, Kudepsta, along the railway from the River Psou to village Magri (Fig. 4a).

83. *Solidago canadensis* L. Origin place – North America. It was first discovered in the vicinity of Sochi in 2008 in the place Barkalovo (Golovinka forestry of Sochi National Park), Lazarevskoe district of Sochi [*Alnetum fontinale*] and in the vicinity of settlement Khosta. Now it is widely spread across the piedmont belt and in the valley of the River Mzymta (Fig. 3f).

84. *Xanthium albinum* (Widd.) H. Scholz & Sukopp (*Xanthium californicum* Greene). Origin place – tropical America. Along the roads in the Imeretinskaya lowland and on weedy places in the vicinity of the settlements Khosta, Kudepsta, Adler (Fig. 3c).

85. *Xanthium spinosum* L. Origin place – North America. Along railway in Imeretinskaya lowland, Yew-boxwood Grove, valleys of rivers Malaya Khosta, Kudepsta, Sochi (Fig. 3d).

86. *Xanthium strumarium* L. Origin place – North America. Along the road of Imeretinskaya lowland, river pebbles of rivers Mzymta, Kudepsta, Khosta, Shakhe, etc.

Fam. Bigoniaceae

87. *Catalpa ovata* D. Don fil. Origin place – China. Species was found in Yew-boxwood Grove, valleys of rivers Mzymta, Psou, Kudepsta, Malaya Khosta, Matzesta, Sochi, Shakhe, Bzych, Psezuapse and around Sochi Black Sea settlements. Actively spread through the valleys of large rivers (Ashe, Mzymta). In the upstream

basin of the valley of River Ashe, it reaches River Maly Nauzhi.

88. *Paulownia tomentosa* (Thunb.) Steud. Origin place – China and Japan. It occurs in small groups through the valleys of the rivers Psou Mzymta, Khosta, Kudepsta, Matzesta, Zapadny and Vostochny Dagomys, Sochi, Shakhe. It tends to increase its range, noted as a pilot plant for clearings in the foothill belt (Agursky Ridge) (Fig. 4b).

Fam. Boraginaceae

89. *Borago officinalis* L. Homeland – the African coast of the Mediterranean and Asia Minor. In Lazarevskoe District around the settlement Lazarevskoe, on the road to the village Marjino.

Fam. Brassicaceae

90. *Lobularia maritima* (L.). Origin place – Mediterranean. In the seaside strip of settlements Adler and Loo.

91. *Lunaria annua* L. Origin place – South-East Europe and Western Asia Europe. Infrequently encountered near human settlements.

Fam. Buddlejaceae

92. *Buddleja davidii* Franch. Origin place – China. The Imeretinskaya lowland, valleys of downstream of rivers Kudepsta, Kuapse, Chukhutkh, Chimit, along a bypass road on the section River Bzugu – Sochi City. It progressively settles on broad valleys of rivers Shakhe, Psezuapse, Ashe. In the basin of the River Psezuapse, it penetrates to the lower flow of River Hodzhiko; in the valley of the River Shakhe–to the mouth of River Bzych; in the basin of River Ashe it reaches the upper flow basin (River Maly Nauzhi).

Fam. Cactaceae

93. *Opuntia robusta* H.L. Wendl. Origin place – Mexico. Single specimens found on the right side of the Akhshtyr Gorge (Fig. 4c).

Fam. Caprifoliaceae

94. *Lonicera japonica* Thunb. Origin place – Japan. It occurs in the Adler District – Imeretinskaya lowland, vicinity of village Veseloe, vicinity of sanatorium «Izvestia»; in Khosta District – vicinity of settlement Khosta; in Lazarevskoe District vicinity of settlements Uch-Dere, Lazarevskoe, Maly Kichmay. Birds spread the seeds of this species (Fig. 4d).

95. *Lonicera ligustrina* Wall. (*Lonicera nitida* Wils.). Origin place – Western China. Occasionally on edges of box forests: Yew-boxwood Grove.

Fam. Caryophyllaceae

96. *Saponaria officinalis* L. Origin place – Western Europe. Individual and groups occur on riverbed pebbles of River Ashe near settlement Kalezh (Fig. 4e).





**Fig. 4.** Alien species of Sochi Black Sea coast: a – *Sigesbeckia orientalis* L.; b – *Paulownia tomentosa* (Thunb.) Steudel.; c – *Opuntia robusta* H.L. Wendl.; d – *Lonicera japonica* Thunb.; e – *Saponaria officinalis* L.; f – *Euphorbia humifusa* Willd.



97. *Vaccaria hispanica* (Mill.) Rauschert. Origin place – Mediterranean. On weedy places of Imeretinskaya lowland.

Fam. Celastraceae

98. *Euonymus japonicus* Thumb. Origin place – Japan. It is found only in the seaside Strip: valley of River Kudepsta, Yew-boxwood Grove, Cape Vidny.

Fam. Chenopodiaceae

99. *Atriplex hortensis* L. Origin place – Central and South Europe, and Central Asia. It is recorded for Imeretinskaya lowland.

Fam. Convolvulaceae

100. *Ipomoea purpurea* (L.) Roth. Origin place – Central America. Rarely, around rural settlements: vicinity of settlement Sergey-Pole.

Fam. Cucurbitaceae

101. *Lagenaria siceraria* (Molina) Standl. Origin place – South America. It sparsely occurs in groups in riparian forests, where sometimes it wraps around the entire tree crowns. It is found in the valleys of the rivers Tuapse and Psezuapse.

Fam. Elaeagnaceae

102. *Elaeagnus pungens* Thunb. Origin place – Japan. It is observed in the valleys of the rivers Mzymta, Kudepsta, Yew-boxwood Grove, Cape Vidny, vicinity of settlement Khosta, foothill of Mountain Akhun, between settlement Golovinka and settlement Chemitokvadzhe. It grows on the slopes under the canopy, rarely in open places. Thrushes spread the seeds mainly.

Fam. Euphorbiaceae

103. *Acalypha australis* L. Origin place – South America. It is known from the valley of the River Kudepsta, Yew-boxwood Grove, vicinity of settlements Adler, Khosta, Dagomys, near Sochi. It grows almost everywhere up to 400 m a.s.l. in the destroyed riparian forests, gardens and the outskirts of built-up areas. It has a tendency to expand territory.

104. *Euphorbia dentata* Michaux. Origin place – North America. Often in the vicinity of Sochi and settlement Adler on weedy places.

105. *Euphorbia humifusa* Willd. Origin place – North America. On pebbles and weedy places, in the foothills, in the cracks of asphalt in Sochi, cemetery in village Sergei-Pole (Fig. 4f).

106. *Euphorbia maculata* L. Origin place – North America. The Imeretinskaya lowland, valleys of rivers Kudepsta, Khosta, Mzymta, Psakho, Sochi, Zapadny Dagomys, Psezuapse, Yew-boxwood Grove. It sparsely grows as single specimens and in groups at predominantly rocky and gravelly places, in the cracks of old asphalt.

Fam. Fabaceae

107. *Acacia dealbata* Link. Origin place – Southeastern Australia and Tasmania. It is most often found in the Adler District, including Imeretinskaya lowland, vicinity of village Monastyr, settlement Kudepsta, village Veseloe. It occupies actively the edges of oak and hornbeam forests in the territory of interflows of rivers Psou and Kherota, rarely in vicinity of Sochi.

108. *Albizia julibrissin* Durazz. Origin place – Talysh (Azerbaijan). It is found at Imeretinskaya lowland, valley of river Kudepsta, brook Orekhovka (basin of River Sochi), vicinity of settlement Golovinka, Yew-boxwood Grove. It occurs sporadically. However, there are observations of its invasion into typical Colchis polydominant forests with evergreen understory. Most apparently, this shows the environmental closing of Colchis and Hyrcan relics (Fig. 5a).

109. *Amorpha fruticosa* L. Origin place – North America. The Imeretinskaya lowland, valley of River Kudepsta, Yew-boxwood Grove, lower part of River Shakhe valley, near human settlements and along the roads. It has a tendency to expand its range in the valleys of large rivers. It penetrates the basin of River Ashe upstream (Bolshoi Nauzhi River) (Fig. 5b).

110. *Cercis siliquastrum* L. Origin place – Mediterranean. Sporadically on the seaside hills from the vicinity of settlement Khosta to the settlement Uch-Dere.

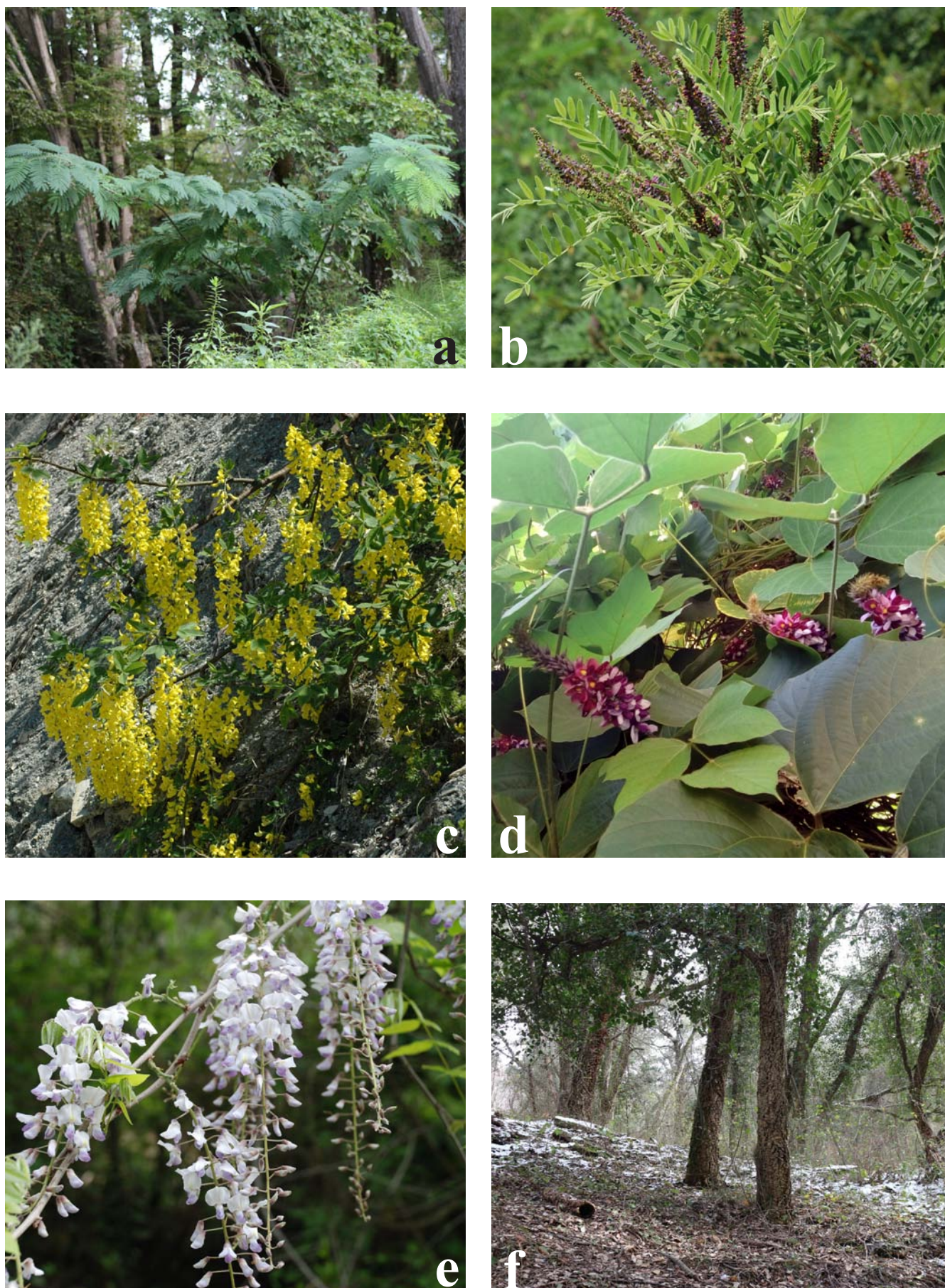
111. *Gleditsia triacanthos* L. Origin place – North America. Almost everywhere in the foothills from Imeretinskaya lowland to village Magri (valleys of rivers Kudepsta, Khosta, Dagomys, Sochi, Shakhe etc.).

112. *Laburnum anagyroides* Medikus. Origin place – Mediterranean. On the rocks in the surroundings of settlement Ashe. In the Lazarevskoe District from settlement Ashe to village Magri and further along the highway on the sea talus dry slopes in the Tuapse District. It tends to increase its range (Fig. 5c).

113. *Lupinus polyphyllus* Lindl. Origin place – the West coast of North America. It is a very active invader in the European part of Russia (Baranova & Bralgina, 2015). The invasion of this species was observed for the first time in 2017 in the beech forests of the northern slope of Aibga Ridge in the vicinity of settlement Esto-Sadok.

114. *Pueraria lobata* Ohwi. Origin place – Far East. Small but dense centres occurs on Imeretinskaya lowland, in the valley of River Kudepsta, Yew-boxwood Grove, in the mountains Maly Akhun and Bytkha, in vicinity of village Veseloe, in 2017 it penetrated into Agursky Ridge (Fig. 5d).





**Fig. 5.** Alien species of Sochi Black Sea coast: a – *Albizia julibrissin* Durazz.; b – *Amorpha fruticosa* L.; c – *Laburnum anagyroides* Medik.; d – *Pueraria lobata* Ohwi; e – *Wisteria sinensis* Sweet; f – *Quercus suber* L.



115. *Robinia pseudoacacia* L. Origin place – North America. Everywhere from the village Magri to the River Psou and from the sea to a height of 600 m a.s.l. (the Imeretinskaya lowland, Yew-boxwood Grove, valley of the River Kudepsta, Svirskoe Gorge). It generates separate stands, sometimes displacing even alder and hornbeam.

116. *Spartium junceum* L. Origin place – Mediterranean. It landed in the mass in order to fasten the slopes along the highway Adler – Novorossiysk and Tuapse – Adler railway. Places show self-sowing.

117. *Wisteria sinensis* Sweet. Origin place – China, Japan. The Imeretinskaya lowland, basin of River Kudepsta, Yew-boxwood Grove. It captures the height, but clarified stands (Fig. 5e).

Fam. Fagaceae

118. *Quercus suber* L. Origin place – Mediterranean. It is found in cultures southward from Tuapse (settlements Lazarevskoe, Loo, Sergey-Pole, Khosta, Kudepsta, Adler and City of Sochi). On the slopes of Mountain Ovsjannikova (vicinity of settlement Khosta), self-seeding is noted and insignificant penetration of this species into the forests (Fig. 5f).

Fam. Hamamelidaceae

119. *Liquidambar styraciflua* L. Origin place – South-East of North America. Widely used in gardening. It shows self-seeding and continued occurrence in the forests in the valley of River Matzesta and in the vicinity of settlement Kudepsta.

Fam. Haloragaceae

120. *Myriophyllum aquaticum* (Vell.) Verdc. Origin place – tropical America. In the artificial lake in Imeretinskaya lowland.

Fam. Hydrangeaceae

121. *Deutzia scabra* Thunb. Origin place – China, Japan. It is widely used in landscape gardening. Observed on edges oak forest [*Quercetum orientali-carpinosum*] in the valley of downstream of River Shakhe (vicinity of settlement Maly Kichmay).

122. *Hydrangea macrophylla* (Thunb. ex Murr.) Ser. Origin place – Japan. The surroundings of the settlement Kudepsta; road to village Energetic; near mouth of River Assara; hornbeam-beech forest between village Kepsha and settlement Krasnaya Polyana; brook Chegisheps (River Ashe basin). Everywhere it occurs sporadically (Fig. 6a).

Fam. Lauraceae

123. *Laurus nobilis* L. Origin place – Mediterranean. By single specimens and groups on the left bank part of Yew-boxwood Grove (Tsvigun & Timukhin, 2004); in the Imeretinskaya lowland, along the River Kudepsta and in Laza-

revskoe District: valley of River Hodzhipse (settlement Yakornaya Schel), settlement Detljazhka. In addition, by single specimens and often by groups of undergrowth on seaside slopes of hills between settlement Adler and settlement Lazarevskoe (Fig. 6b).

Fam. Juglandaceae

124. *Carya pecan* Engl. & Graebn. (*Carya illinoensis* (Wangenh.) K.Koch). Origin place – Central States of the United States of America. It is widely used in landscaping and forest cultures in the Adler District of Sochi. Here it shows self-sowing and introduction in the deciduous forests of the valley of River Mzymta between gorges Akhshtyr and Akhtzu (Fig. 6c).

125. *Juglans nigra* L. Origin place – North America. In the landings, rarely shows self-sowing: vicinity of settlement Kudepsta.

126. *Juglans regia* L. Origin place – Frontal and Middle Asia. On the whole territory of Sochi Black Sea area, mainly in the valleys of the rivers and streams up to 700 m a.s.l. It is an ancient coloniser widely cultivated by Adygei aboriginal people of Sochi Black Sea coast. Together with wild fruit trees, it forms so-called «Circassian gardens» (Fig. 6d).

Fam. Lamiaceae

127. *Elsholtzia ciliata* (Thunb.) Hylander. Origin place – Japan. On weedy places of lower flow of River Mzymta.

128. *Perilla nankinensis* (Lour.) Decne (*Plectranthus scutellarioides* (L.) R.Br.). Origin place – East Asia. It grows in groups in river valleys and near the borders of ruderal places of Yew-boxwood Grove; in the valley of River Shakhe near settlement Solokh-Aul; at confluence of rivers Shakhe and Bzych.

Fam. Malvaceae

129. *Abutilon theophrasti* Medikus. Origin place – Mediterranean. Quite often it grows in groups of dry, weedy places in the foothills: Imeretinskaya lowland, along the right bank of River Kudepsta, lower flow of River Shakhe, village Chereshnja, settlement Sergey-Pole, village Ermolovka.

130. *Hibiscus syriacus* L. Origin place – Asia. Individually and in groups in the vicinity of settlement Kudepsta, in the vicinity of Yew-boxwood Grove (Fig. 6e).

Fam. Moraceae

131. *Maclura pomifera* (Rafin.) Schneid. Origin place – North America. It is found in the foothills between rivers Psou and Mzymta and on the slopes of the mountain Akhun.





**Fig. 6.** Alien species of Sochi Black Sea coast: a – *Hydrangea macrophylla* (Thunb. ex Murr.) Ser.; b – *Laurus nobilis* L. (self-sowing); c – *Carya pecan* Engl. & Graebn.; d – *Juglans regia* L. (Ancient coloniser); e – *Hibiscus syriacus* L.; f – *Morus alba* L. (Ancient coloniser).



132. *Morus alba* L. Origin place – East Asia. Ancient coloniser, which was cultivated by local people. It is recorded in Imeretinskaya lowland, Yew-boxwood Grove, in the vicinity of settlement Chemitokvadzhe. It episodically spreads off throughout the Sochi Black Sea coast, mainly in river valleys up to 400 m a.s.l. The species actively takes the square, previously covered by box forests (Fig. 6f).

133. *Morus nigra* L. Origin place – West Asia. In the Imeretinskaya lowland, rarely found in the basin of the rivers Mzymta, Kudepsta, in Lazarevskoe District – in the vicinity of settlements Nizhnyaya Khobza and Verkhnyaya Beranda.

Fam. Oleaceae

134. *Ligustrum japonicum* Thunb. Origin place – Japan. The Imeretinskaya lowland, Yew-boxwood Grove, vicinity of settlement Kudepsta. In Lazarevskoe District in the vicinity of settlements Shujuk, Glubokaya Schel, Uch-Dere. It is actively spread by birds (Fig. 7a).

Fam. Onagraceae

135. *Oenothera biennis* L. Origin place – North America. Rare, in River Mzymta valley.

136. *Oenothera oakesiana* (A.Gray) Robbins ex S.Walt. & Couit. Origin place – North America. It was found for the first time on the right bank of the River Laura in 2002 (Timukhin, 2008), already in 2008 – in the lower reaches of the River Mzymta (Akhshtyrskoe Gorge) and along a dirt road at hornbeam-beech forest on Psekhako Ridge (Fig. 7b).

Fam. Oxalidaceae

137. *Oxalis corniculata* L. (*Xanthoxalis corniculata* (L.) Small). Origin place – Southern Europe, North Africa, Southwest Asia. It occurs frequently throughout the Sochi Black Sea coast and it prefers the edge biotopes in the foothills. It shows settling.

Fam. Papaveraceae

138. *Eschscholzia californica* Cham. (*Papaver californicum* Gray.) Origin place – North America. It was found for the first time in 2016 on the conglomerate slopes and talus in the vicinity of the village Veseloe (Fig. 7c).

Fam. Phytolaccaceae

139. *Phytolacca americana* L. Origin place – North America. In the Imeretinskaya lowland, on the slopes of low ridges and valleys of all the rivers of the Sochi Region. It has a tendency to spread rapidly deep into the mountainous territory, including the territory of the Caucasian reserve (ridge Bzych) (Fig. 7d).

Fam. Platanaceae

140. *Platanus acerifolia* Willd. Hybrid between *Platanus orientalis* L. (origin place – South-

west Asia) and *P. occidentalis* L. (origin place – North America). Occasionally in the valleys of Sochi Black Sea coast. It gives abundant shoots and seedlings on the pebbles of the lower stream of rivers Sochi and Mzymta.

Fam. Primulaceae

141. *Anagallis arvensis* L. Origin place – Europe. It occurs everywhere on weedy places from the seaside strip to the settlement Kalezh, village Aibga, etc. (Fig. 7e).

Fam. Rosaceae

142. *Cydonia oblonga* Miller. Origin place – Southwest Asia. Occasionally in Sub-Mediterranean sibliaks in Western part of described region: in the vicinity of the village Vishnevka, settlement Soloniki and settlement Tzuskhvdzh (Fig. 7f).

143. *Duchesnea indica* (Andr.) Focke. Origin place – South-East Asia. Actually, in all the valleys and gorges, glades and edges along the roads throughout the foothills of Sochi Black Sea coast. It is actively embedded to bright hornbeam and oak forests, as well as to box forests (Fig. 8a).

144. *Eriobotrya japonica* (Thunb.) Lindl. Origin place – Japan. Rarely found in broad-leaved forests around human settlements. Noted in Yew-boxwood Grove [*Fraxinetum buxosum*] (Tsvigun & Timukhin, 2004).

145. *Malus sylvestris* Mill. Origin place – Europe. Yew-boxwood Grove, sporadically in broad-leaved forests and in the meadows from the foothills up to the middle mountain belts.

146. *Persica vulgaris* Mill. Origin place – China. It was noted sporadically on the bleached areas of Yew-boxwood Grove, in the valleys of rivers Kudepsta, Shakhe.

147. *Prunus cerasus* L. Origin place – Europe. Occasionally throughout the Sochi Black Sea coast.

148. *Prunus tomentosa* Thunb. Origin place – Japan, China. It occurs sporadically in River Shakhe valley.

149. *Pyrus communis* L. Birthplace – Europe. Lazarevskoe District: in the vicinity of the villages Magri and Shkhafit.

150. *Rosa multiflora* Thunb. Origin place – East Asia. In coastal and foothill strip, the valleys of the rivers Shakhe, Chukhutkh, Kudepsta, etc.

Fam. Rutaceae

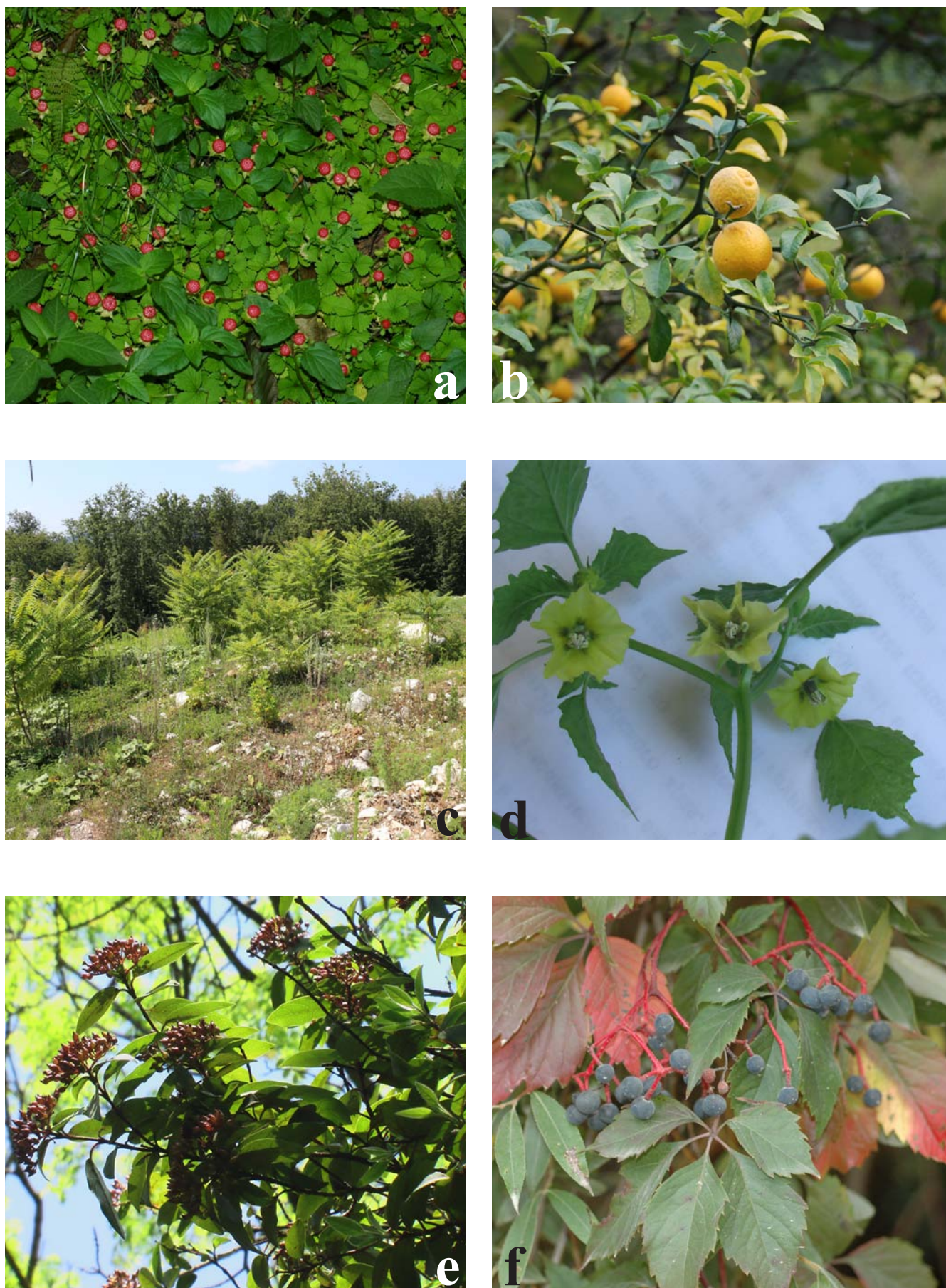
151. *Phellodendron amurense* Rupr. Origin place – Far East, Northeastern China, Korea. Groups and single specimens found in the valley of the River Kudepsta and at former Loo Forestry (rivers Buu, Shakhe), in vicinity of settlement Krasnaya Polyana.





**Fig. 7.** Alien species of Sochi Black Sea coast: a – *Ligustrum japonicum* Thunb.; b – *Oenothera oakesiana* (A.Gray) Robbins ex S.Walt. & Coult.; c – *Eschscholzia californica* Cham.; d – *Phytolacca americana* L.; e – *Anagallis arvensis* L.; f – *Cydonia oblonga* Miller.





**Fig. 8.** Alien species of Sochi Black Sea coast: a – *Duchesnea indica* (Andr.) Focke.; b – *Poncirus trifoliata* (L.) Pafin.; c – *Ailanthus altissima* (Mill.) Swingle; d – *Physalis philadelphica* Lam.; e – *Viburnum tinus* L.; f – *Parthenocissus quinquefolia* (L.) Planch.



152. *Poncirus trifoliata* (L.) Raf. Origin place – Northern China. It occurs in Yew-boxwood Grove (Timukhin & Akatova, 2002), by the entire coastal territory of Sochi Black Sea meets infrequently, sometimes forms thickets on open ground in the foothills (Fig. 8b).

Fam. Salicaceae

153. *Salix babylonica* L. Origin place – the Near East. Found on the territory of Sochi Black Sea coast near human settlements mainly on ruderal places and along rivers.

Fam. Simaroubaceae

154. *Ailanthus altissima* (Mill.) Swingle. Origin place – China. The Imeretinskaya lowland, Yew-boxwood Grove as well as lighted places along the rivers Matzesta, Vostochnaya Khosta, Kudepsta, Sochi, Shakhe, Psezuapse, Svirscoe Gorge, Ashe, etc. It penetrates intensively to logging destroyed forest at riverbed and slopes along the roads into the mountains, up to 600 m a.s.l. It reaches the upstream valley of the River Ashe basin (Fig. 8c).

Fam. Solanaceae

155. *Datura innoxia* Miller. Origin place – Central and South America. It occurs often on wasteland, along the fences near the settlements.

156. *Datura stramonium* L. Origin place – America. It is common in the Imeretinskaya lowland, especially along roads; in the vicinity of settlement Sergey-Pole.

157. *Hyoscyamus niger* L. Origin place – Southern Europe. Rare along roads on forest borders from sea level up to 800 m. It was noted from Imeretinskaya lowland upward to village Aibga and in Lazarevskoe District – foothill of Mountain Khakukay (basin of River Ashe), place Barkalovo (basin of River Shakhe).

158. *Physalis philadelphica* Lam. Origin place – North America. On the territory of Sochi Black Sea coast, it is rarely found in the foothill belt on edges of deciduous forests and box-forests at interflow of rivers Psou – Khosta; on weedy places in the seaside strip of Imeretinskaya lowland (Fig. 8d).

159. *Solanum cornutum* Lam. Origin place – North America. Rare on coastal sands of Imeretinskaya lowland.

160. *Solanum nigrum* L. Origin place – Peruvian Andes. Very common species. It is founds throughout the Sochi Black Sea coast up to 1500 m a.s.l.

Fam. Theaceae

161. *Thea sinensis* L. Origin place – China. It is widely used on the Black Sea coast in agricultural plantations. We noted introduction of self-seeding tea under canopy of hornbeam and foot-

hill' hornbeam-beech forests [*Carpineto-Fagetum varia-herbosum*] in the valley of River Mzymta; on Mountain Chornaya (a watershed of rivers Vostochny Dagomys and Sochi).

Fam. Verbenaceae

162. *Verbena hastata* L. Origin place – North America. It was observed in the Imeretinskaya lowland and on edges of deciduous forests, glades, on weedy places of foothills between rivers Kudepsta and Psou.

163. *Verbena venosa* Gill. & Hook. Origin place – South America. Species occurs occasionally on the Imeretinskaya lowland beach.

Fam. Viburnaceae

164. *Viburnum tinus* L. Origin place – Mediterranean. Forest edge in the valley of the river Kudepsta, more common on steep slopes in coastal Lazarevskoe District between settlement Golovinka and settlement Lazarevskoe (Fig. 8e).

Fam. Vitaceae

165. *Parthenocissus quinquefolia* (L.) Planch. Origin place – North America. It was found in Yew-boxwood Grove, single specimens in the *Taxus baccata* L. forests [*Taxetum laurocerosum*] and in riparian forests near rivers Kudepsta, Khosta, in the midstream valley of River Psezuapse. It occurs considerably northward – in the valley of the lower flow of the River Pshada (Gelendzhik Resort) (Fig. 8f).

166. *Vitis labrusca* L. Origin place – North America. Sporadically throughout the Sochi Black Sea coast, close to the settlements.

167. *Vitis vinifera* L. Origin place – Mediterranean. Occasionally around settlements Makopse, Sergey-Pole, Adler.

## Discussion

We identified 167 alien species making up 8% of the total flora of the Sochi Black Sea – 2065 species (Zernov, 2013). Bearing in mind that only in the Park «Dendrary» in 2016 grew 1815 species (Soltani et al., 2016), mainly introduced trees and shrubs from all over the world, the alien species list could be greatly expanded. However, if we will take into account the total number of introduced plants cultivated in the range from Tuapse to the border with Abkhazia, this number would be increased from 167 to 2000 alien plants. But, fortunately, most of these cultivated plants do not occur in the wild in our area. And these cannot be considered as invasive plant species.

Therefore, we do not include Zernov's (2006) results of alien species for Sochi Black Sea: *Lolium multiflorum* Lam., *Echinochloa crus-galli* (L.)

P. Beauv., *Paspalum thunbergii* Kunth ex Steudel, *Microstegium nudum* (Trin.) A. Camus s.l., *Chamaerops humilis* L., *Crinum* × *powellii* Hort. ex Baker, *Ophiopogon japonicus* (L. fil.) Ker-Gawl., *Quercus ilex* L., *Amaranthus caudatus* L., *A. blitum* L., *A. paniculatus* L., *A. graecizans* L., *A. hypochondriacus* L., *A. powellii* S. Watson, *A. viridis* L., *Mirabilis jalapa* L., *Opuntia camanchica* Engelm. & Bigel., *Mollugo cerviana* (L.) Ser., *Berberis levis* Franch., *Fumaria capreolata* L., *Cleome hassleriana* Chod., *Armoracia rusticana* P. Gaertner, B. Meyer & Schreber, *Diplotaxis muralis* (L.) DC., *Brassica nigra* (L.) W.D.J. Koch, *Raphanus raphanistrum* L., *Lepidium densiflorum* Schrader, *L. virginicum* L., *Iberis amara* L., *Ribes nigrum* L., *Spiraea chamaedrifolia* L., *Fragaria* × *ananassa* Duch., *Prunus armeniaca* L., *Euphorbia marginata* Pursh, *E. nutans* Lagasca, *E. canescens* L., *E. peplus* L., *Acer buergerianum* Miq., *Aesculus hippocastanum* L., *Impatiens balsamina* L., *I. walleriana* Hooker fil., *Hibiscus trionum* L., *Epilobium ciliatum* Rafin. s.l., *Coriandrum sativum* L., *Cyclosporum leptophyllum* (Pers.) Sprague ex Britt., *Froriepia subpinnata* (Ledeb.) Baill., *Hydrocotyle ramiflora* Maxim., *Anethum graveolens* L., *Ipomoea purpurea* (L.) Roth, *Moluccella laevis* L., *Mentha* × *piperita* L., *Ocimum basilicum* L., *Solanum tuberosum* L., *S. dulcamara* L. s.l., *S. villosum* Miller, *Lycopersicon esculentum* Miller, *Linnaria incarnata* (Vent.) Sprengel, *Cucumis sativus* L., *C. melo* L., *Trichosanthes kirilowii* Maxim., *Luffa cylindrica* (L.) M. Roem., *Citrullus lanatus* (Thunb.) Matsum. & Nakai, *Bryonia aspera* Steven ex Ledeb., *Cucurbita pepo* L., *Echinocystis lobata* (Michx.) Torrey & Gray, *Lobelia erinus* L., *Aster laevis* L., *Aster novi-belgii* L., *Ambrosia psilostachya* DC., *Helianthus annuus* L., *Bidens aurea* Sherff, *Cosmos bipinnatus* Cav., *Matricaria suaveolens* (Pursh) Buchenau, *Chrysanthemum morifolium* Ramat., *Calendula officinalis* L., *Zea mays* L. Most of these species have not been seen in the wild, but the vast majority we did not include in our list being decorative, not identified in the wild (*Chamaerops humilis* L., *Crinum* × *powellii* Hort. ex Baker, *Chrysanthemum morifolium* Ramat. and others), or they are regarded as vegetable and garden crops, which for obvious reasons can be found in different years near villages. So, every year single specimens of *Zea mays*, *Helianthus annuus*, *Cucumis sativus*, *Coriandrum sativum* can be observed in various regions of Sochi. But there is neither any considerable area expansion, nor the formation of sustainable populations of these spe-

cies despite of the long history of their cultivation in the region. Among other cultivated plants, Zernov (2013) has noted some native species (*Celtis australis* L., *Erianthus ravennae* (L.) P. Beauv., etc.), which have not been included in the list of alien plants of the Sochi Black Sea coast.

Soltani (2003) in her doctoral thesis presents 140 species of naturalised invaders, but most of the observations she has conducted on the territory of the Park «Dendrary» and production of self-seeding under uterine trees is not a reason for adding these plants to the list of alien species. Despite a fair indication by Soltani to the existence of varying degrees of naturalisation and the correct interpretation of the term «naturalisation» (adaptation to environmental conditions, reproduction and distribution of organisms in nature without human help), it is difficult to agree with her conclusion on the naturalisation of 140 species, which do not go beyond the bounds of the «Dendrary» Park. For this reason, we have not included into our list such species mentioned by Soltani (2003) as: *Phyllostachis viridiglaucescens* (Carrière) Rivière & C. Rivière, *Berberis julianae* C.K. Schneid., *B. soulieana* C.K. Schneid., *Campsis radicans* (L.) Seem., *Elaeagnus umbellata* Thunb., *Fraxinus pennsylvanica* Marshall, *Pittosporum tobira* (Thunb.) W.T. Alton, *Fatsia japonica* (Thunb.) Desne. & Planchon, *Ginkgo biloba* L., *Chamaerops humilis* L. and many others. Moreover, among the introduced species the author also indicated, in our understanding, some native species (e.g. *Teline monspessulana* (L.) Koch and *Ficus carica* L.).

However, for the first time we have indicated a number of new alien species (*Pinus pinaster* Aiton, *Cupressus lusitanica* Mill., *Rhus typhina* L., *Vallisneria spiralis* L., *Grindelia squarrosa* (Pursh) Dunal, *Solidago canadensis* L., *Lupinus polyphyllus* Lindl., *Deutzia scabra* Thunb., *Oenothera oakesiana* (Gray) J.W. Robbins ex S. Walt. & Coult., *Eschscholzia californica* Cham., *Phellodendron amurense* Rupr., *Solanum cornutum* Lam., *Verbena venosa* Gill. & Hook.). Their total number has increased from 136 in 2010 (Timukhin & Tuniyev, 2010) to 167 in 2017.

In this regard, it is interesting to recall the gradual increase of alien species' number in the Yew-boxwood Grove of the Caucasian Reserve, where in 1938 there were only seven alien species (Alper, 1960), in 1988, their number had grown to 11 species (Golgofskaya, 1988), 1994 – 13 species (Lebedeva, 1994), in 1999 – 18 species (Semagina, 1999), and in 2004 there were 37 alien species (Tsvigun & Timukhin, 2004).



Thus, in half a century, the number of alien species of Yew-boxwood Grove has increased by more than five times. Now in connection with the death of box forests after invasion of *Cydalima perspectalis* Walker a sharp increase in alien species on the territory of the Yew-boxwood Grove is expected, in connection with the termination of pressure of native species diaspores, in this case, *Buxus colchica* Pojark.

Rejmanek (1989) showed, if there are no diaspores of native species succession does not work and an alien process starts actively.

It is obvious that our species list will constantly change by perhaps finding another considerable number of alien species along the railway, on weedy places around large buildings and highways, in the seaside strip and valleys of large rivers.

The list with alien plants counts 8 coniferous plants, 15 evergreen-leaved and 35 deciduous trees and shrubs (including lianas), 1 palm species, 1 cacti species, 3 bamboos species and 104 herbaceous plants (Fig. 9).

Over the past 10 years in Sochi Black Sea, the number of alien species has increased among coniferous species – 2, deciduous woody and shrub by breeds – 2 species, herbaceous – 23 species.

According to origin regions, the plants from both South and North America in sum predominate with 70 species. If we will separate this group, we will see the following picture. Asian (mainly from East Asia) alien plants predominate with 54 species, followed by North America (48), Mediterranean, including southern Europe (31), South America (16), Europe (7), Central America (6), Pantropical area (3), Australia (1), and there is one species of hybrid origin (Fig. 10). This is consistent with earlier conclusions for local alien floras (Timukhin & Akatova, 2002; Tsvigun & Timukhin, 2004).

It is interesting to note the correlation of alien species by geographic origin with an assortment of Sochi tree collection Park «Dendrary» (Arboretum), the core of which is the East Asian plants – 48%, the percentage of plants of North America – 12%, Mediterranean – 7%, Australia and New Zealand – 5%, South America – 3%. The remaining 22% of the collection consists of species from Europe and other regions of the world (Soltani et al., 2016).

Thus, over the last decade on the Sochi Black Sea coast the number of Asian alien species has risen by 17, North American – 14, Mediterranean – 5, Central American and South American – 5.

Against the backdrop of a large number of species known from a limited number of localities (sometimes only one), there are several species progressively expanding their habitat. In this case, some of them capture exclusively non-forest landscapes (postforest glades, edging, weed places, etc.), others actively penetrate into forest ecosystems. Dissemination pattern of the alien species along the altitude-ecological mountain belts and habitats within each belt is provided below.

In lowland and riparian forests of the Sochi Black Sea region and in their derivatives up to 600 m a.s.l., the most frequent are such alien species as: *Robinia pseudoacacia*, *Trachycarpus fortunei*, *Phyllostachys aurea*, *Ambrosia artemisiifolia*, *Bidens bipinnata*, *Phalacrologoma annuum*, *Xanthium spinosum*, *X. strumarium*, *Galinsoga parviflora*, *Sigesbeckia orientalis*, *Catalpa ovata*, *Buddleja davidii*, *Elaeagnus pungens*, *Acalypha australis*, *Juglans regia*, *Morus alba*, *Oxalis corniculata*, *Phytolacca americana*, *Paspalum paspalodes*, *Duchesnia indica*, *Paulownia tomentosa*, *Ailanthus altissima*, *Solanum nigrum*.

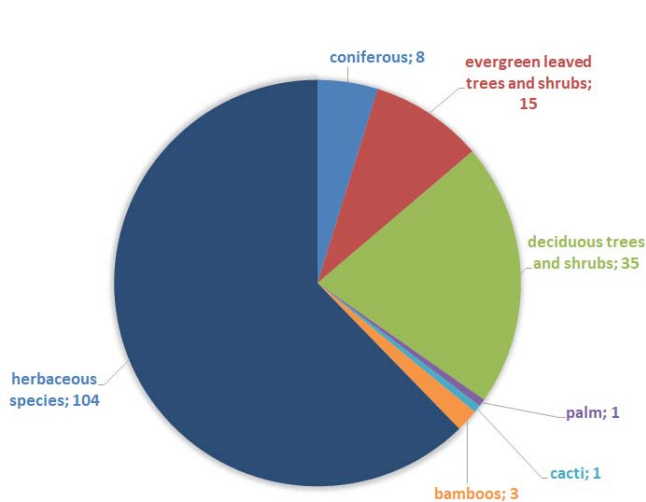


Fig. 9. Composition of alien species by different plant life forms.

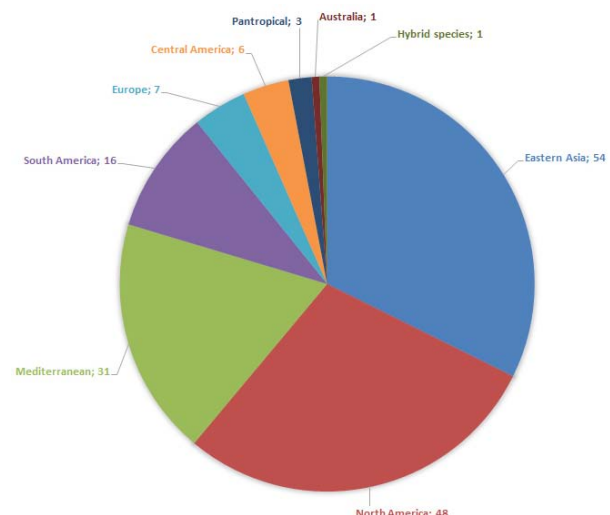


Fig. 10. Representatives of alien species by area of origin.

*Buddleja davidii*, *Pueraria lobata*, *Viburnum tinus*, *Euphorbia maculata*, *Catalpa ovata*, *Paulownia tomentosa*, *Ailanthus altissima*, *Acalypha australis* are the most frequently observed species along flood-free and well-illuminated river pebbles and rocky-scrub areas along the highways up to 100 m a.s.l.

Post-forest glades, light coniferous and broad-leaved forests of lower mountain belts cover the narrow seaside area of Sochi Black Sea coast in the southeast; and this area expands to the northwest. The described cenosis includes mostly the derivative of subtropical Pitsunda pine groves (according to the classification of Kamelin (2017) – Mediterranean Pinetum), submediterranean oak forests, secondary hornbeam forests and postforest glades up to 200 m a.s.l.. The composition of the alien flora in local plant communities is considered to be very varying, but the predominant species are *Andropogon virginicus*, *Wisteria sinensis*, *Cupressus lusitanica*, *Laurus nobilis*, *Viburnum tinus*, *Elaeagnus pungens*, *Robinia pseudoacacia*, *Trachycarpus fortunei*, *Phytolacca americana*, *Acacia dealbata*, *Phyllostachys aurea*, *Ambrosia artemisiifolia*, *Phalacrolooma annuum*, *Galinsoga parviflora*, *Galinsoga quadriradiata*, *Xanthium spinosum*, *Abutilon theophrasti*, *Paspalum paspalodes*, *Miscanthus sinensis*, *Duchesnea indica*, *Physalis philadelphica*.

Indigenous temperate oak forests and beech forests occupy slopes of relevant exposures in the range of heights from 200 up to 1700 (1850) m a.s.l. The beech forest fragments in the foothill belt (on the slopes of the northern and northwestern exposures) are covered by the same species as the lowland and the riparian forest. Within distributional belts of undisturbed beech forests (800–1800 m a.s.l.) and the temperate oak forests (200–800 m a.s.l.), they are characterised by high resistance to alien species and in these coenosis a deep penetration is only observed for *Phytolacca americana*, whereas by cutoff spaces and folded trees places – additionally for *Phalacrolooma annuum*.

Alien species are not found in the dark-coniferous belt, but along the roads and firebreaks native weed species of lower belts, such as *Scleranthus annuus* L., are observed.

Subalpine meadows, beech woodland and so-called «park maple groves» occupy the top rung of forest vegetation. In the Sochi Black Sea region these coenoses vary in different sectors of the southern macroslope of the Main Caucasian Ridge, because the boundary specified in the West coenosis lies significantly lower than in the East. Thus,

in most western meadows of the Main Caucasian Ridge tops (Mountain Lysaya, Kashina, Nauzhi, Grachev Venec, Khakudzh, Bekeshey) these coenoses lie within the range of heights of 1300–1600 m a.s.l. To the East, on the tops Khuko, Amuko, Autl', the upper limit of forests and subalpine meadow coenosis is observed from 1700 to 1900 m a.s.l. Finally, in the eastern sector of the Main Caucasian Ridge (from mountains Achishkho, Chugush and further East to the border with Abkhazia) and within Southern Forward Ridge (mountains Aibga, Cherny peak, Al'bova peak, Mountain Agepsta) is a typical high-altitude subalpine belt location of vegetation from 1800 to 2200 (2400 m) a.s.l.

In the western sector prior to 2006, there was noted only penetration of *Erigeron canadensis* (Timukhin & Tuniyev, 2010; Tuniyev, 2012), in 2017, there is noted the occupancy of *Galinsoga parviflora* too. In the eastern sector currently alien species are only observed along the road and there is accommodation of native species of the lower belts, such as *Tussilago farfara* L., *Sagina procumbens* L., etc.

Another feature in the spread of alien species associated with the transitional nature of the soil and climatic conditions within the Sochi Black Sea area from the Northwest to the Southeast. So, the Sub-Mediterranean climate of corresponding landscapes in the West of the region is characterised by species such as *Biota orientalis*, *Laburnum anagyroides*, *Viburnum tinus*, *Cydonia oblonga*, etc. Conversely, only in the extreme South-East (interflow of rivers Sochi – Psoy), there is naturalisation of species such as *Euonymus japonica*, *Acalypha australis*, *Acacia dealbata*, etc.

Together with species, which have shown an active invasion over a sufficiently long period (*Catalpa ovata*, *Paulownia tomentosa*, *Trachycarpus fortunei*, *Paspalum paspalodes*, etc.), there are a number of neo-alien species actively intervening in the natural ecosystems of the Sochi Black Sea coast in more recent years (*Oenothera oakesiana*, *Acalypha australis*, *Euphorbia maculata*, *Euphorbia dentata*, *Buddleja davidii*, *Cupressus lusitanica*, *Miscanthus sinensis*, *Andropogon virginicus*, etc.).

So, *Buddleja davidii* was first noted as naturalised in natural ecosystems of the River Kuapse by A.S. Zernov in 2002. Four years later, the species was also found in the valleys of the Mzymta and the Shakhe rivers, and for the latter, there were noted only two specimens at that time (Portenier & Solodko, 2006). In 2009–2010, we noted *Buddleja davidii* for over 1 km in the valley of the River Shakhe in about hundreds of flowering and fruiting specimens.

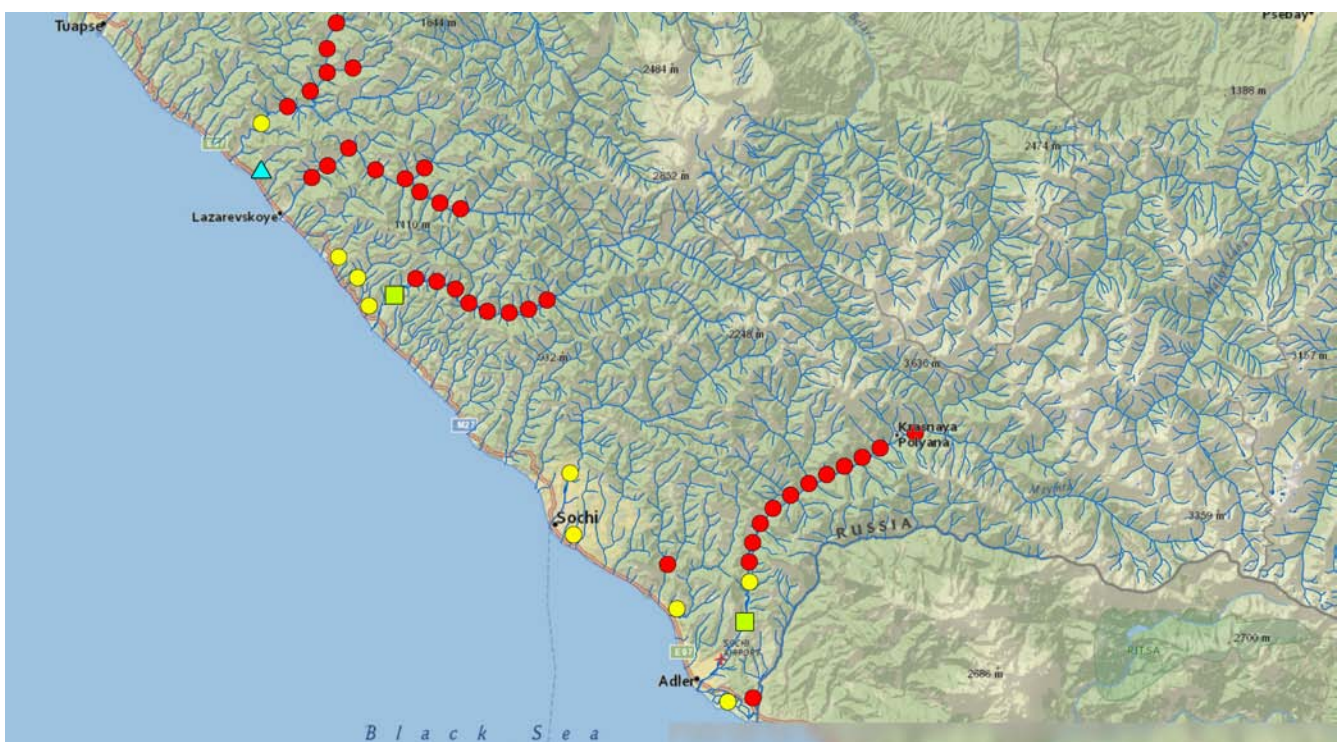


From the valley of the River Shakhe, this species entered the adjacent gorge – Matrosskaya Schel and actively colonised the downstream valleys of the rivers Ashe, Sochi, Kudepsta (Timukhin & Tuniyev, 2010). As stated above, currently *Buddleja davidii* appeared and captured all the gorge of the River Ps-ezuapse up to downstream of the River Hodzhiko, inclusive. In the valley of the River Shakhe, this species spread of to the mouth of the River Bzych, and in the basin of the River Ashe it reached the upper stream area (River Maly Nauzhi) (Fig. 11).

An even more rapid expansion of a neo-alien species, *Oenothera oakesiana*, we observed in the River Mzymta valley. We first found this species, originally from the United States, in 2002, near the cordon Laura of the Caucasian Reserve. At that time the construction of a guest house for this reserve has began, receiving official guests at the former site of the village of Rudnik, opposite the cordon Laura. In 2008, species occupied the entire downstream valley of the River Achipse (tributary of the River Mzymta) and along the road knife-like entered the lower belts of ridge Psekhako. In 2008, we discovered the second species' enclave in the down flow area of the River Mzymta near Akhshtyr Gorge, to where, apparently, the seeds had been transported by water from the first locality. By 2010, *Oenothera oakesiana* occupied almost all lower and middle parts of the River Mzymta (Fig. 12).

Then started an interesting process associated with the penetration of *Solidago canadensis* on the Sochi Black Sea coast, a species also originated from North America. This species has a massive spread in the foothill zone of the Republic of Abkhazia. *Solidago canadensis* has been introduced in Abkhazia in the 1930s for cultivation in nurseries as a potential source of natural rubber (<http://sputnik-abkhazia.ru>). After the cessation of experiments in Ochamchyra and Gulrypsh Districts, the species widely spread in the East and later in the western part of Abkhazia.

*Solidago canadensis* has been detected for the first time in the vicinity of Sochi in 2008 in a riparian alder forest [*Alnetum fontinale*] (place Barkalovo, basin of River Shakhe, Golovinsky Forestry of Sochi National Park) and in the vicinity of the settlement Khosta. In 2010, the species was found in the valley of the down-flow of the River Mzymta, and in 2016, it took the entire middle-flow valley with displacing of *Oenothera oakesiana* from near river biotopes. *Solidago canadensis* is now widely spread across the piedmont belt in the River Mzymta valley. And it ousted *Oenothera oakesiana* to the wastelands under power lines and spoil heaps. Thus, after fifteen years *Oenothera oakesiana* has been replaced by the expansively distributed *Solidago canadensis* in the valley of the River Mzymta.



**Fig. 11.** Dynamics of *Buddleja davidii* resettlement on Sochi Black Sea coast: triangle – first finds in 2002 (Zernov, 2002), square – finds in 2006 (Portenier & Solodko, 2006), yellow circles – finds of 2009–2010 (Timukhin & Tuniyev, 2010), red circles – finds of last decade 2011–2017 (our data).



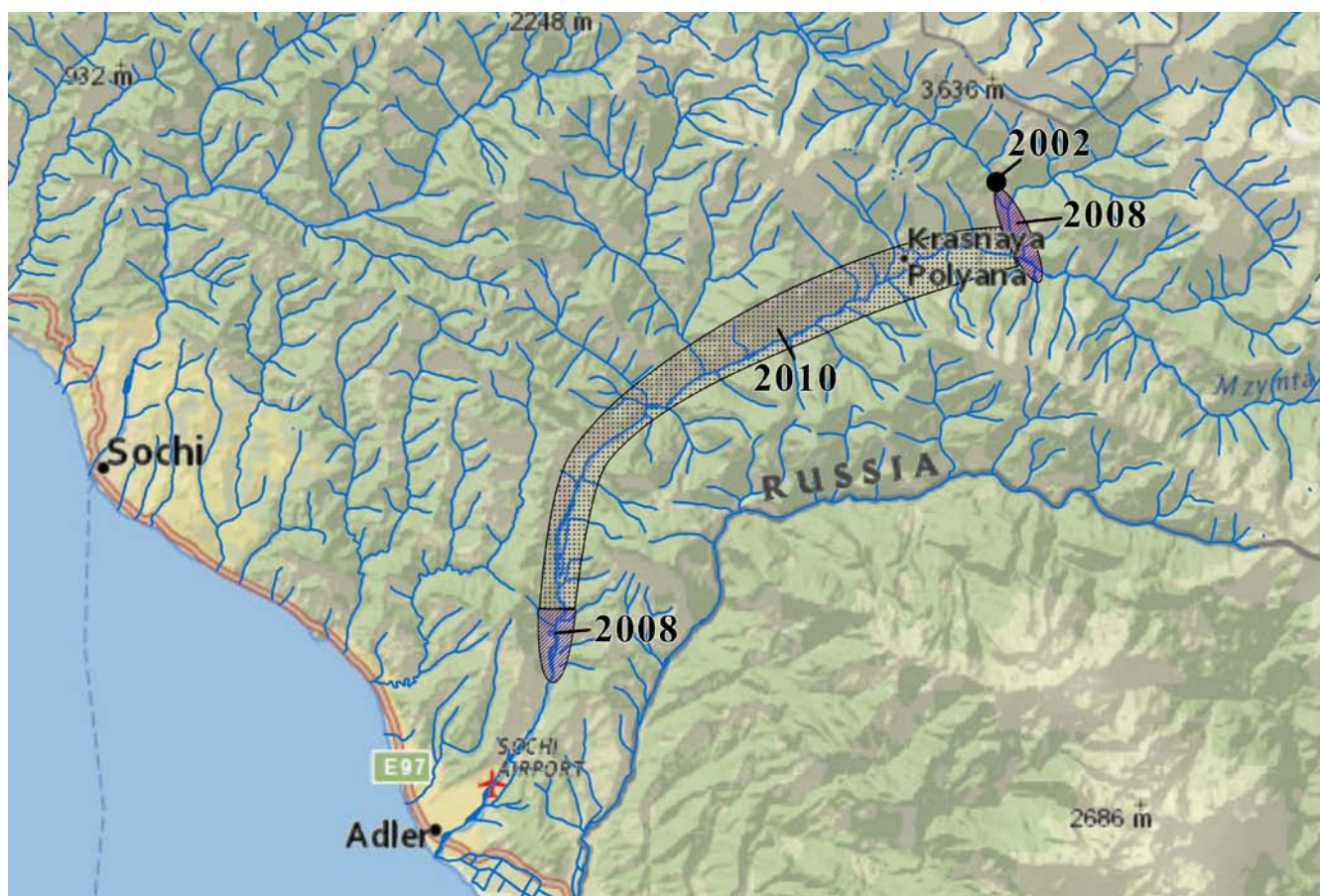


Fig. 12. Expansion of *Oenothera oakesiana* in the valley of River Mzymta: 2002 – initial locality, 2008 – primary dispersion, 2010 – colonisation of the entire valley.

There are many theoretical approaches to the evaluation of the resettlement of plants, which listed exhaustively in the work of the Khoroon (2014).

According to the analysis of Pyšek & Hulme (2005), spatial-temporal dynamics of biological invasions has three phases: a period of slow initial resettlement (the so-called *lag-phase*), where the species has a few isolated locations. After this phase should be a phase of rapid expansion (*exponential-phase*), and the third phase, which is not always observed, is a short phase of the reduction range. The duration of the lag-phase Pyšek & Hulme (2005) explained by the two following hypotheses. According to the *Genetic hypothesis*, the duration of the lag-phase depends on the speed of evolution of genotypes that promotes the growth of capacity to settle and the lag-phase is proportional to the speed of change of generations of each species. According to the *Demographic hypothesis*, the alien extends its area slowly near its borders at short distances, due to the local availability of suitable ecotopes. In our case, with the invasion of *Oenothera oakesiana* in the River Mzymta valley and the subsequent process of its replacement by *Solidago canadensis*, an interesting comparison

could be made with material of Pyšek & Hulme (2005) on the example of three riparian alien species in England and Wales. Observations were conducted for three species with a different life cycle: annual – *Impatiens glandulifera* Royle, perennial monocarpic – *Heracleum mantegazzianum* Som. & Lev. and clonal perennial – *Fallopia japonica* (Houtt.) Ronse Decr. For all three species similarities in the duration of lag-phase (40 years) were detected, indicating that there is no influence of differences in the biology of the species to the population's exponentially growth. Because the introduction time of *Oenothera oakesiana* and *Solidago canadensis* on the Sochi Black Sea coast was clearly established, we can argue that these plants are characterised by a very short lag-phase. So, it was at least 5 times shorter than shown by Pyšek & Hulme (2005) for invaders in England and Wales. The shorter lag-phases and the increasing number of alien species in the Sochi Black Sea region during the last decade (2006–2017) can be considered as disturbing facts which require further research and forecasting.

Another factor increasing the number of alien species is the uncontrolled landscaping of various



objects of recreation in specially protected territories. There are the strict requirements of the Sochi National Park to use exclusively (!) native plant species during landscaping of recreational objects in the Sochi National Park. It concerns the plants which are specific for a particular altitude-ecological belt. Despite of that, violations of these requirements are continuously observed. And alien species are introduced, despite of the fact that they can potentially become invasive species. A bright example is the penetration of *Lupinus polyphyllus* into primary beech forests on Aibga Ridge from occupation-plots landscaping objects of «Rosa-Khutor».

### Conclusions

On the Sochi Black Sea coast have been found 167 alien species, representing 8% of the total flora of this region.

The number of alien species over the last 10 years has increased from 136 to 167, including two coniferous species, two deciduous tree and bush species, and 23 herbaceous species.

A number of alien species are listed for the Sochi Black Sea region for the first time: *Pinus pinaster*, *Cupressus lusitanica*, *Vallisneria spiralis*, *Rhus typhina*, *Grindelia squarrosa*, *Solidago canadensis*, *Lupinus polyphyllus*, *Deutzia scabra*, *Oenothera oakesiana*, *Eschscholzia californica*, *Phellodendron amurense*, *Solanum cornutum*, *Verbena venosa*.

The list of alien plants shows – 8 coniferous, 15 evergreen leaved and 35 deciduous tree and shrub species (including tree-like lianas), 1 – palm, 1 – cacti, 3 – bamboos and 104 herbaceous species.

According to the area of origin the alien flora is dominated by Asian taxa, predominantly Eastern (54 species), North America (48), Mediterranean, including southern Europe (31), South America (16), European species (7), species of Central America (6), Pantropical (3), Australia (1), and one taxon of hybrid origin (1).

During the last decade on the Sochi Black Sea coast, the number of Asian alien species has risen by 17, North American – 14, Mediterranean – 5, Central American and South American – 5.

From 2002, in the valley of the River Mzymta there is noted penetration of *Oenothera oakesiana*, its expansive distribution and its replacement by *Solidago canadensis*.

For both *Oenothera oakesiana* and *Solidago canadensis* has been noticed an extremely short lag-phase, at least 5 times shorter than specified

for invaders in similar conditions characterised by river pebbles in England and Wales.

Reduction of the lag-phase of some alien plants and the increase in their number on the Sochi Black Sea coast region during the last decade (2006–2017) is a disturbing fact that requires further research and forecasting.

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## ВИДОВОЙ СОСТАВ И СРАВНИТЕЛЬНО-ИСТОРИЧЕСКИЙ АСПЕКТ ЭКСПАНСИИ ЧУЖЕЗЕМНЫХ ВИДОВ СОСУДИСТЫХ РАСТЕНИЙ В СОЧИНСКОМ ПРИЧЕРНОМОРЬЕ (РОССИЯ)

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Приведен обзор 167 чужеземных видов сосудистых растений крайнего юга Российской Федерации. Рассмотрено распределение инвазионных видов по высотно-экологическим поясам южного макросклона Западного Кавказа в междуречье Туапсе – Псоу и географическому происхождению. Показано преобладание среди чужеземных видов выходцев из Северной Америки и Восточной Азии. Рассмотрена динамика увеличения количества чужеземных видов и скорость распространения наиболее агрессивных инвайдеров. Выявлена возможность сменяемости инвазионных видов во времени.

**Ключевые слова:** географическое происхождение, распределение по высотно-экологическим поясам, сменяемость инвайдеров, сосудистые растения, Сочинское Причерноморье, чужеземные виды