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BIOLOGICAL INVASION IN TERRESTRIAL ECOSYSTEMS OF SUBTROPICS OF RUSSIAN FEDERATION

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Abstract

In recent decades, as a result of active uncontrolled of ornamental woody plants import from abroad, a threat that new pests and diseases might penetrate to Russian Black Sea coast appeared, which led to the extent of an environmental problem. The given paper provides information about the new species detected on fruit, flower and ornamental crops in Sochi (Russia) in the period from 1995 to 2013, which has not been earlier recorded in the region. Among the pests Plurivorous species of *Ceratitis capitata* Wied. mostly represents danger for fruit plantations and *Frankliniella occidentalis* Perg. – for flower crops. In 2013, the massive shrinkage of boxwood was noted, which was caused by damage from caterpillars *Cydalima perspectalis* Walker. This species appeared in the region presumably in 2011 – 2012. The five following species of powdery mildews fungi were recorded for the first time in the study area: *Erysiphe azalea* (U. Braun) U. Braun & S. Takam. on leaves of *Rhododendron luteum* Sweet, *E. betae* (Vaňha) Weltzien – on leaves of *Hydrangea macrophylla* Ser.*, E. syringae,* Schwein. – on leaves of *Syringa vulgaris* L.*, E. tortilis* (Wallr.) Link – on leaves of *Cornus* sp. *Golovinomyces sparsus* (A. Braun) V. P. Heluta – on leaves of *Viburnum opulus* L. Because of the emergence of new pests and diseases there is a tendency of expansion of the range of host plants for existing species in the region.

Key words: invasion, pests, pathogens, *Cydalima perspectalis*, terrestrial ecosystems, Black Sea coast of Russia

Carrying out continuous monitoring of specific composition of harmful species in gardens, urban and natural plantings is one of the main objectives in plant protection. Early detection of a new object enables fast development and application of control measures. This is especially actual for the humid Russian subtropics, where favorable climatic conditions are conducive to the development of fruit, subtropical and ornamental woody plants, and mass distribution of pests and pathogens. Analyzing changes in terrestrial ecosystems due to various exogenous impacts, the leading ecologists allocated 4 classes of dynamical phenomena that characterize the degree of transformation in ecosystems (Kashmilov, 1974; Budako, 1984; Zavadskii, 1984; Kolchinskii, 1977), including loss of biodiversity, replacement of one dominant consument species in ecosystems by others similar in environmental and physiological characteristics; biological invasions lead to expansion of species ranges, which is one of the major threats to biodiversity, and are classified as “biological pollution of ecosystems” (Pavlushin, Vilkova and Suhoruchenko, 2013). In recent decades, as a result of active uncontrolled import of ornamental woody plants, a threat that new species may penetrate to the region appeared, which gradually results in extent of an environmental problem. The invasions are among the main factors leading to reduction of the regional species diversity. Many invasive species act as biological contaminants (Igevskii, 1995; 2002). Our task was to determine what invasive species have appeared on the Black Sea coast of Russia (Sochi area) for recent years, and to assess the degree of danger from the new pests and pathogenes for terrestrial ecosystems.

MATERIAL AND METHODS

The research was conducted in fruit, ornamental and natural plantings of Sochi from 1995 till 2013. The species diversity was determined applying the methods of route investigation with the collection of herbarium samples and further stationary observations. The quantity and development dynamics were recorded, using stationary observations on the model plots of fruit, ornamental and natural plantings throughout the growing period (every two weeks). Model plots were located equally in all administrative districts of the city of Sochi. For determining the extent and severity of the species, generally accepted techniques were used (Kosova, Polyakova, 1958; Smolyakova et al., 1999).

The population density of the box tree moth on boxwood hedges was determined as follows: measuring plate was placed on the upper surface of the hedge and the moth number was counted on the entire height of the hedge. The hedges of boxwood with an average height of 50 – 70 cm were used for carrying out the measurements.

RESULTS AND DISCUSSION

Over the past 20 years, a number of new pests species and pathogens were established, which had not been spread earlier in humid subtropics of the Russian Federation (Table 1) and are potentially dangerous for plant component of terrestrial ecosystems.

From the above listed pest species essential harm is caused by the box tree moth (*Cydalima perspectalis*), sycamore lace bug (*Corythucha ciliata*), western flower thrips (*Frankliniella occidentalis*) and citrus leafminer (*Phyllocnistis citrella*).

In middle August 2013 as a result of the box tree moth's damage a strong desiccation of *Buxus sempervirens* was recorded all over the city of Sochi (from Adler to Lazarevskoye districts). Plants of different ages – from 5 to 70 years proved to be desiccation prone i.e. in both old plantings and newly landscaped objects. Changes in the colour of leaves and desiccation of plant parts or whole plants were very rapid. Dark green hairy caterpillars, up to 4 cm long, with large black heads were detected in *Buxus sempervirens* crowns (Figure 1). The number of these caterpillars reached 60 – 80 individuals/sq. dm

Table 1. Invasion of new species in terrestrial ecosystems of subtropics of Russian Federation

№	Name of a species	Host plant	Year of emergence in the region
	PESTS		
1.	*Ceratitis capitata* Wied. (Insecta, Diptera, Tephritidae)	*Citrus* spp., *Ziziphus jujuba*, *Ficus carica*, *Diospyrus kaki* and more than 70 other plant species	2010*
2.	*Corythucha ciliata* Say (Insecta, Hemiptera, Tingidae)	Plane tree	1999
3.	*Cydalima perspectalis* Walker (Insecta, Lepidoptera, Crambidae)	*Buxus* spp.	2011 – 2012*
4.	*Frankliniella occidentalis* Perg. (Insecta, Thysanoptera, Thripidae)	*Prunus persica*, *Rubus idaeus*, *Prunus armeniaca*, *Rosa* spp., *Dianthus* spp., vegetable cultures, etc.	1998
5.	*Obolodiplosis robiniae* Haldeman (Insecta, Diptera, Cecidomyiidae)	*Robinia pseudoacacia*	2012
6.	*Ophelimus maskelli* Ashmead (Insecta, Hymenoptera, Eulophidae)	*Eucalyptus* spp.	2013*
7.	*Parectopa robiniella* Clemens (Insecta, Lepidoptera, Gracillariidae)	*Robinia pseudoacacia*	2013
8.	*Phyllocnistis citrella* Stainton (Insecta, Lepidoptera, Gracillariidae)	*Citrus* spp., *Eucalyptus* spp., *Salix* spp., *Philadelphus* spp.	1999*
9.	*Polyphagotarsonemus latus* Banks (Acari, Trombidiformes, Tarsonemidae)	Flower, vegetable, fruit, decorative, citrus culture and more than 50 other plant species	2004
	PATHOGENS		
10.	*Erysiphe azaleae* (U. Braun) U. Braun & S. Takam. – powdery mildew (Ascomycota, Leotiomycetes, Erysiphales)	*Rhododendron* spp.	2007
11.	*E. betae* (Vaňha) Weltzien – powdery mildew (Ascomycota, Leotiomycetes, Erysiphales)	*Hydrangea macrophylla*	2009
12.	*E. syringae* Schwein. – powdery mildew (Ascomycota, Leotiomycetes, Erysiphales)	*Syringa vulgaris*	2005
13.	*E. tortilis* (Wallr.) Link – powdery mildew (Ascomycota, Leotiomycetes, Erysiphales)	*Swida* sp.	2006
14.	*Golovinomyces sparsus* (A. Braun) V. P. Heluta – powdery mildew (Ascomycota, Leotiomycetes, Erysiphales)	*Viburnum opulus*	2006
15.	*Guignardia aesculi* (Peck) V. B. Stewart, anamorphosis *Phyllosticta sphaeropsoidea* Ellis & Everh. – Guignardia leaf blotch (Ascomycota, Dothideomycetes, Botryosphaeriales)	Horse-chestnut (*Aesculus hippocastani*)	2000

* The species are found in the territory of Russia for the first time.

Fig. 1. Caterpillar of Cydalima perspectalis Walker

Fig. 2. Powdery mildew on Hydrangea

of the area of short-haired fences. Adult caterpillars eat leaves entirely, as well as the bark of branches.

Homes of the box tree moth are China, Japan, and Korea, from where the pest came to Western Europe in 2006, and spreaded there widely. Presumably in 2011 – 2012 it came to the Black Sea coast of Russia. It is known that in European countries the box tree moth can develop in 2–3 generations (Korycinska, Eyre, 2011). The first detection of the box tree moth in Sochi refers to 2012, when it was recorded by N. V. Shiryayeva in the box tree planting material of Imeretinskaya lowland. The caterpillars of the first generation were massively observed in humid subtropics in June 2013, of the second – in early and mid-August (Karpun, Ignatova, 2013).The level of the box tree moth population in 2013 testified that the moth has been in the region for at least 2 years. In 2014, the first generation of the caterpillars was observed at the end of the first ten days of March, which is most likely due to the very warm winter. Thus, under favorable climatic conditions it is possible to expect the development of the third, and probably forth pest generations in the region.

There is concern that, together with the pathogen *Cylindrocladium buxicola* that has caused desiccation of *Buxus sempervirens* in the regional ecosystems for recent years, *Cydalima perspectalis* can kill various species of *Buxus sempervirens*.

At the turn of the century, Sycamore lace bug appeared not only in humid subtropics but also in steppe parts of Krasnodar region (Voigt, 2001). At the present time, the pest has multiplied everywhere and causes a change in the color of *Platanus* leaves from green to bronze by the beginning of August followed by premature loss of foliage.

Concerning citrus crops plantings, young growth is substantially damaged by the citrus leafminer and the broad mite. *Phyllocnistis citrella* mainly causes harm to the following crops in protected grounds: *Citrus limon, C. meyeri, C. sinensis* and *C. paradisi*. During the study period the death of shoots reached 70 – 98%. The pest damages *C. unshiu* and its cultivars to a lesser extent, as during the period of intensive development of the pest, shoots growth of this species was attenuating, although within years 2000 – 2010. *C. unshiu* shoots were damaged on 98 – 100% (Fogel and Ignatova, 2003; 2004).

The pest caterpillars penetrate into a sheet and hide in its ribs, and then, eating the leaf parenchyma, they form transparent ribbon-like mines. During pupation, the caterpillar is wrapped in a leaf edge. Damages in fruits were observed too. Up to 6 generations can develop during a year: 2 – in spring and 4 – In summer and autumn. The limiting factor of the insect mass reproduction is air temperature below +12-16 °C. At higher temperatures (greenhouse conditions) the propagation of pests and damage of plants did not stop even in winter period. This species is especially dangerous for young plants in nurseries.

The broad mite inhabits axillary shoots and ovaries of fruits and flowers. Heavily infested leaves curl and fall; flower buds withered. Throughout the year this mite develops up to 30 generations.

A dangerous pest of a closed ground western flower thrips was observed in the region in flower cultures in 1998. *Frankliniella occidentalis* was introduced to Adler farm so called “Southern cultures” together with

rose cuttings from St. Petersburg, where it came from abroad in early 1990s. (Kalishina, 2009). Earlier this species had not been recorded in Russia. Since the slightest damage can sharply reduce the value of ornamental flower cultures, the damage at any extent has economic significance.

Western flower thrips is equally dangerous for flower, ornamental and vegetable crops. Surface of the leaves infested with western flower thrips becomes discolored as strokes; deepenings appear in feeding places, followed by necrosis. Full flowers cannot be formed. In addition, it is a carrying agent of viral infections (for example, TSWV – *Tomato Spotted Wilt Virus*, which has damaged more than 360 species of cultivated plants) (Kalishina, 2009). Hidden way of living, high fertility, short development cycle and high resistance to preparations make it extremely difficult to carry out various protective measures. Consequently, *western flower thrips* is widely spread in farms of Russian subtropics of the Black Sea coast.

In 2012, in the garden "Tree of Friendship", we observed massive fruit damage (to 92%) in *Ziziphus jujuba* caused by the Mediterranean fruit fly. Later, the damages were fixed on the neighbor citrus plantations, where the damage level did not exceed 18%. Thanks to timely protective measures, the nidus was eliminated.

As for the black locust gall midge, locust Digitate Leafminer and *Eucalyptus* gall wasp, the populations of these species in the ecosystems of the region is low. The first two species have been observed in Krasnodar region by the specialists of the Federal State Budget Institution "Roslesozashchita" since 2010 (Gninenko, 2010; Gninenko et al., 2011; Shturov et al., 2013), while *Ophelimus maskelli* Ashmead has been recorded in Russia for the first time. Nevertheless, it is necessary to closely monitor the populations of these pests as these species have become widespread for recent years in Europe, North Africa and the Middle East; they are related to invasive species there, causing significant damage to host plants and resulting in total or partial defoliation (Protasov et al., 2007; Durand et al., 2011; Kaptun et al., 2013).

From the new pathogens identified in the region over the past 15 years, the most notable are causative agents of powdery mildew. For the first time we observed 5 species (Table 1) for the study area: *Erysiphe azaleae* on leaves *of Rhododendron luteum* Sweet*, E. betae* on leaves *of Hydrangea macrophylla* Ser.*, E. syringae* on leaves of *Syringa vulgaris* L.*, E. tortilis* on leaves of *Cornus* sp., *Golovinomyces sparsus* on leaves of *Viburnum opulus* L. (Karpun, 2012). These species are likely to have been delivered to the region with the planting material of ornamental plants. All these species are characterized by annual incidence, increased development intensity of the caused disease and the frequency of occurrence in natural and artificial ecosystems.

In our opinion, invasion of *Erysiphe betae (Vaňha) Weltzien,* syn. *Erysiphe polygoni* DC appears most clearly. The disease had not been observed in the region before 2009, but at the moment it is a fairly common disease of *Hydrangea,* which is annually registered while becoming more and more common and penetrating new cultivars of this culture (Figure 2). To date, the disease is marked by us in 5 cultivars of *Hydrangea macrophylla*, including the most common – "Joseph Banks" and "Madame Faustin Travouillon" (previously wrongly identified as "Hortensia"). The degree of damage from powdery mildew is about the same.

Brown leaf spot of *Aesculus hippocastanum* has been developing in humid subtropics of Russia during the last 5 years at epiphytoty level. The intensity of disease development reaches 100 per cent of leaves with lesions greater than 50% of the leaf blade. The disease leads to premature defoliation. For a long time it was considered that the disease was caused by abiotic factors, which was associated with abjection difficulties. It should be noted that epiphytoty of this disease is currently observed throughout the whole European part of Russia.

It was established that a late-blossoming form of *Aesculus hippocastanum* is infected by the disease 10 – 14 days later, and it is to a lesser extent. Thus, during the first ten days period of September (the maximum degree of disease development), an affected area of the leaf blade was determined: early form – 77%, late form – 58%.

It should be noted that apart from the above mentioned species, there were also allocated other dendrotropheus species of fungi in the region for the first time, but they are not widespread or harmful.

Thus, 13 new pest species and plant pathogens have been recorded in the humid subtropics of Russia for the last 20 years.

Based on the biology of species, all of them can give outbreak in the region and bring significant economic damage to agrocenosis and urbocenosis. The greatest harm is caused by the following pests in the region: *Phyllocnistis citrella*, *Cydalima perspectalis*, *Frankliniella occidentalis*, *Corythucha ciliata*; their outbreaks were recorded in different years of studies. The biggest danger is represented by *Guignardia aesculi* - brown leaf spot pathogen of *Aesculus hippocastanum*. Other species should be classified as potentially dangerous.

The only species which distribution center could be located is *Ceratitis capitata*.

The emergence of new species with planting material, cutting of flowers and fruits requires to organize strict control over their dispersal, population size and development terms in the region, which is necessary to develop measures for protection of fruit trees and ornamental plants.

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