Influence of invasive pest and natural enemies on entomofauna formation in the Sochi region

Ludmila Bugaeva*, *Evgeniya* Kashutina, *Tatyna* Ignateva

Lazarevskaya Plant Protection Research Station, Sochi, Russia

Abstract. The article describes the changes in local entomofauna in the Sochi region. Monitoring for several decades provides information about the spreading and density of invasive species established a long time ago and causing massive damage to agricultural plants during regular outbreaks. This group of species, which includes the Boisduval scale *Diaspis boisduvalii*, the Japanese planthopper *Ricania japonica*, and the fall webworm *Hyphantria cunea*, has had an enormous effect on local insects' community for the last 50 years. What is most important is that this list of alien species continues to grow. Since the late 1990s, several invaders have been discovered in the Sochi region, including including the sycamore lace bug *Corythucha ciliata*, the leafhoppers *Metcalfa pruinosa* and *Arboridia kakogawana*, the brown marmorated stink bug *Halyomorpha halys*, the tortoise wax scale *Ceroplastes japonicus* and the woolly aphid *Eriosoma lanigerum*. The invasion process causes significant changes in the relationship between newly established populations of invasive pests and their natural enemies, which are partly used as biocontrol agents. So the impact of local and introduced entomophagous species on the fauna is also discussed.

1 Introduction

During recent decades the problem of biological invasion has become one of the most important in ecosystems research. One of the top-priority tasks in the study of invasive species is the monitoring of their development, which cannot be appropriately done without estimation of the influence of natural enemies on pest density.

Invasion by new species is a burning issue for the Sochi area, mostly because of its geographical location, intensive resort development activity, huge tourist traffic and lack of quarantine control. The main goal of our research is the monitoring of new invasive pests and their natural enemies in the Sochi region.

Mapping the routes of invasion processes is an essential part of the initial stage of the research. The majority of these pathways are connected with the transportations' routes, which are passing through the Sochi region.

* Corresponding author: bugaevaln@mail.ru

2 Material and methods

Studies were conducted on the territory of the Lazarevsky district. Monitoring carried out on model plants during the monthly route surveys. The identification of collected insects was performed in the laboratory according to generally accepted established methods. For accurate counting of small insects, "Device for recording insects" (RF patent No. 138188) was used.

3 Results and Discussion

In the beginning of spring 2016, government of Krasnodar Territory has announced the emergency state for the local plant protection services due to appearance of Moroccan locust (*Dociostaurus maroccanus*) which is alien to Kuban region.

On June 21st, 2016 swamps of Moroccan locust reached suburbs of the city of Sochi. The insects were noticed in different part of the Sochi region, mostly in Lazarevsky and Dagomys districts, and to the lesser extent in Khostinskiy and Adler districts.

Spreading across Lazarevskaya village occurred in a form of distinctive flocks with highly irregular territorial distribution. Though the observed insect density ranged between 1 and 47 specimens per square meter, no substantial damage to the foliage was noted. Before June 25th the number of insects was increasing, but since June 27th the number dropped rapidly because multiple swamps of locust perished by drowning into the sea water.

Consequently, the results of the field surveys of Moroccan locust landing sites were negative as no egg lays were found. Another field survey in the followed spring season confirmed absence of the pest throughout Lazarevsky district territory. Therefore, the occurred intrusion of the locust may be referred to as temporary and transitory with no influence upon local ecosystems.

That case with locust invasion was exceptional and hopefully unique for the Sochi region. There are, however, several another invasive species, established long time ago and causing huge damage of agricultural plants during regular outbreaks. This group includes the boisduval scale *Diaspis boisduvalii*, the Japanese planthopper *Ricania japonica* and the fall webworm *Hyphantria cunea* [1-3].

For instance, the last outbreak of *H. cunea* took place in summer 2019 in the Sochi region. Unusual hot and dry weather during the summer made proliferation of three pest generations possible. Emergency state was declared over entire territory of the city and chemical pesticides were applied to mitigate the problem.

The list of alien species, discovered in the Sochi region, continues to grow. Since the late 1990s, several invaders have been discovered in the Sochi region, including the sycamore lace bug *Corythucha ciliata* (Fig. 1), the leafhoppers *Metcalfa pruinosa* (Fig. 2) and *Arboridia kakogawana*, the brown marmorated stink bug *Halyomorpha halys*, the tortoise wax scale *Ceroplastes japonicus* (Fig. 3) and the woolly aphid *Eriosoma lanigerum* [4, 5].

Fig. 1. Leafhopper *Metcalfa pruinosa*

Fig. 2. Lace bug *Corythucha ciliata* on a plane tree

Fig. 3. Tortoise wax scale *Ceroplastes japonicus* on Magnolia tree leaf.

Plane tree is the most important decorative plant for Sochi. The trees possess bountiful crown of large leaves well adopted to urban environment. Unfortunately, up to 96% of those trees are colonized by lace bug *C. ciliata* (Table 2). Nymphs and adults of this bug feed on leaf sap adversely affecting the physiological processes, causing reduction of foliage mass,

untimely leaf falling and general withering of trees. Adults survive through the winter under tree bark or in the litter. Insect emergence after hibernation occurs in the first half of May, followed by the egg laying in the second half of May. Under conditions of subtropical climate the lace bug produces three complete and one incomplete generation.

To control the lace bug, efforts comprise general agrotechnical practices such as removal of pilled-off tree bark, cleaning of wintering ground beds and effective reduction of tree crown. Local populations of natural enemies such as entomopathogenic fungi and polyphagous predatory insects (spriders, mantises, carabids and bugs) may contribute to the phytophage suppression. No specific predators or parasites harmful to lace bugs have been revealed yet.

Table 1. Colonization of plane trees by lace bug *Corythucha ciliata*

Test tree	Observation date				Wintering stock (insects/dm^2)
	29.06.2018		21.08.2018		
	Adult	Nymph	Adult	Nymph	
1	4	31	1	2	160
2	0	38	6	28	78
3	0	19	4	2	120
4	0	35	16	13	191
5	0	27	17	41	80
6	6	32	19	13	57
7	11	36	7	25	170
8	9	24	9	37	202
9	11	46	2	1	180
10	1	30	4	3	62
Mean	4,2	31,8	8,5	16,5	130
Standard error of the mean (SEM)	1,5	2,4	2,1	4,8	18,0

Substantial harm to local fauna is brought by leafhopper *M. pruinosa*, which was initially revealed on the territory of Lazarevskaya Plant Protection Research Station back in 2009. The list of plants affected by leafhopper includes valuable fruit trees, vegetables, decorative perennial and annual plants, woods, bushes and grasses. At present nevertheless, a reduction of leafhopper total population there is observed increase in variety of plants harmed by the bug. Traces of damage are noticeable on magnolia, plane, fig trees and oleander. Pockets of dense leafhopper infestation are noticed on yucca.

In the second half of 2015, an outbreak of a species new to the region has occurred – the brown marmorated stink bug *Halyomorpha halys,* a widespread and dangerous pest of subtropical agriculture [6]. Surveys of Lazarevsky district conducted in the winter of 2018 revealed uneven distribution of hibernating population, typical of the stink bug.

On the territory of Lazarevskaya village and resort facilities scattered along the coastline, there were infrequent occurrences of *H. halys*. At a distance away from the coastline, there were inland wintering sites with a population density of 10 to 15 specimens per square meter. In rural areas, within local rivers' valleys at the bugs wintering sites, the insects were clustered in hundreds (up to 300 in one spot). Such a distribution of the *H. halys* population is formed not solely by the local climate conditions but also is also influenced by the proximity of fruit and hazelnut plantations.

Parasitoids of the genus *Telenomus* (the family Scelionidae) could potentially limit the abundance of *H. halys*. Still, by now, no natural enemies able to control this harmful pest have been found yet.

Invasive and introduced *Harmonia axyridis* belongs to a group of entomophages important for regulation of phytophagous pests and comprises 60% of total coccinellid fauna in the region of Sochi.

Successful introduction of *Aphelinus mali* against the woolly aphid speaks in favour of continuation of this work. For example, as much as 69% and 81% of aphid population become infected in July and September 2018, respectively.

Table 2. Parasitism rate of *Aphelinus mali* in the blood aphid population

Observation date	Number of aphids in hot spots		Parasitism rate, %*
	Total number	Number of parasitized aphids	
06.07.2018	70	20	28,50
	12	7	58,30
	25	23	92,00
	11	8	72,70
	15	12	80,00
	45	43	95,50
	24	13	54,10
	13	12	92,30
	16	9	56,20
	49	31	63,30
Mean	28,0	17,8	69,29
27.09.2018	50	45	90,00
	25	22	88,00
	15	13	86,70
	7	4	57,10
	12	9	75,00
	16	13	81,30
	11	9	81,80
	37	30	81,00
	9	8	88,80
	41	33	80,60
Mean	22,3	18,6	81,03

*The parasitism rate was calculated as the ratio of the number of parasitized aphids to the total number of aphid in the spots.

Several decades of monitoring confirmed that parasitoid *Aphelinus* is able to control the woolly aphid population in its foci on apple trees, as by the beginning of fall season, Parasitism rate reaches 84%.

Data collected over years demonstrate not only steady area expansion of tortoise wax scale and increase the feeding plants range, but also an increase of effectiveness of its specialized parasite *Microteris clauseni*. The parasite *M. clauseni*, which normally suppresses harmful activity of the scale on persimmon, citrus and mulberry trees, was supposed to be unable to infect the host bug on the bay tree *Laurus nobilis*. Interestingly, in 2005 a single specimen of tortoise wax scale, infected by a parasitoid, further identified as *M. clauseni*, was found on the bay tree.

One more quarantine species - the obscure mealybug *Pseudococcus viburni* (formerly *Pseudococcus affinis*) - was found in Lazarevsky district for the first time. In the mealybug colonies on cycad plants, the predator beetle *Cryptolaemus montrouzieri* was observed.

The oak lace bug *Corythucha arcuata* [7], which was observed in Krasnodar region for the first time in 2015, continues to colonize new territories along the Black Sea coastline.

The bug settling on oak trees was observed along federal motorway Novorossiysk – Sochi and in the local river valleys. As a result, oak trees sustained a considerable damage due to chlorosis and foliage loss.

Indian wax scale *Ceroplastes ceriferus* was brought to Europe from Taiwan with planting stock of ficus and podocarpus in 1999-2000, first to Netherlands, then to Italy. On the territory of Russia it was first observed in 2015 on deciduous plants cultivated in Olympic village of Imeritinskaya lowland. was discovered on territory of Lazarevskaya village in 2017 *C. ceriferus* was recorded on a pear tree imported from Italy. Despite all efforts of the pest eradication in 2018, its spreading and establishing at new sites and on various host plants, such as magnolia, ivy and raspberry, continue.

Damaged trees species found on territory of Lazarevsky district require constant monitoring of phytosanitary condition to minimize the harm. They include oak trees (damaged by the gall wasp *Cynips quercusfolii*), willow trees (damaged by poplar lace bug *Monosteria unicostata*) and palm trees (damaged by South American palm borer *Paysandisia archon*).

The constant monitoring of agroecosystems is vital for discovery of invasion pathways, estimation of alien species spreading, observation of fresh-established population and introduced natural enemies to control the invaders.

4 References

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