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ON THE ACCLIMATIZATION OF THE COLORADO POTATO BEETLE *LEPTINOTARSA DECEMLINEATA* (SAY, 1824) (COLEOPTERA: CHRYSOMELIDAE) IN PRIMORSKY KRAY

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Summary. The successful naturalization of the Colorado potato beetle in Primorsky Kray is limited by the monsoon climate, namely unstable fluctuating weather conditions with periodic catastrophic precipitation. The most of potato fields are located in the bottomlands of rivers or in close proximity to water bodies and a drastic increase in the runoff due to excessive simultaneous rainfall leads to the flooding of agricultural lands and the elimination of the fodder plants. The Colorado potato beetle is an oligophage and can not switch to alternative food sources during these periods. Moreover, beetles that enter diapause under these conditions die because of flooding and cold injury. Despite this fact, the pest remains a threat to the potato production in the region and can cause significant damage in case of repeated invasions during periods with more favorable conditions.

Key words: Coleoptera, pest species, invasion, monsoon climate, Russian Far East.

Н. В. Мацишина. Об акклиматизации колорадского жука *Leptinotarsa decemlineata* (Say, 1824) (Coleoptera: Chrysomelidae) в Приморском крае // Дальневосточный энтомолог. 2023. N 480. С. 23-28.

Резюме. Успешная натурализация колорадского жука в Приморском крае ограничивается муссонным климатом, а именно неустойчивыми изменчивыми погодными условиями с периодическими катастрофическими осадками. Большинство картофельных полей расположено в поймах рек или в непосредственной близости от водоемов и резкое увеличение стока из-за чрезмерных одновременных осадков приводит к затоплению сельскохозяйственных угодий и уничтожению кормовых растений. Колорадский жук является олигофагом и не может в эти периоды переходить на альтернативные источники питания. Более того, жуки, входящие в диапаузу в этих условиях, гибнут из-за затопления и переохлаждения. Несмотря на это, вредитель остается угрозой для производства картофеля в регионе и может нанести значительный ущерб при повторных инвазиях в периоды с более благоприятными условиями.

INTRODUCTION

The Colorado potato beetle *Leptinotarsa decemlineata* (Say, 1824) is one of the most widespread and dangerous pests of potato in the world. In Russia, this pest inhabits around 205 million hectares of potato fields, which comprises approximately 80% of the total land

area under potato cultivation in the country (Kadoić *et al*., 2020). The dangerousness of the Colorado potato beetle can be explained by its exceptional ecological plasticity, which allows the pest to easily adapt to changes in the environment and to preserve a high potential survivability, a high reproduction rate, and the general harmfulness of its population (Gui *et al*., 2020). The Colorado potato beetle has several types of dormancy (winter, summer, recurrent, and long-term dormancy) and high genetic diversity of the population. This facilitates the survival of the pest in extreme agro-climatic conditions, fast adaptation to new daily and seasonal fluctuations of biological factors, colonization, and active reproduction. For the first time, the invasion of the Colorado potato beetle was noted in Primorsky Kray in 2000, although it had been believed that this species could not survive the harsh winters of the region (Matsishina & Rogatnykh, 2013). By 2007, the pest inhabited already 1,147 ha in seven districts of the Primorsky Kray (Matsishina, 2011a). These factors make it necessary to study the biology and ecology of the Colorado potato beetle in the south of the Russian Far East.

MATERIAL AND METHODS

The basis of the study was the insect collecting and scientific observations conducted by the author in Primorsky Kray in 2008–2023. In total, 14 thousand imagines and 26 thousand larvae of the Colorado potato beetle were collected and studied, 870 plots were investigated, including 12 industrial crop fields. In the course of our research, 920 records were made on the number of imagines, larvae, and pupae of the Colorado potato beetle. We carried out 16 laboratory and 18 field experiments. Route surveys (200 in total) were conducted by the author in the following eight districts of Primorsky Kray: Ussuriysky, Mikhailovsky, Anuchinsky, Chuguevsky, Yakovlevsky, Spassky, Chernogovsky, and Kirovsky districts. The dynamics of the population size of the Colorado potato beetle were studied using standard methodology (Kozhanchikov, 1961). Software PAST was employed for modelling the parameters of the ecological niche (Hammer *et al*., 2001).

RESULTS AND DISCUSSION

The biological invasion of plant and animal species has a global character and decreases the natural biodiversity due to fierce competition between alien and native species or the annihilation of native species by invasive predators (Sileshi *et al*., 2019). Moreover, biological invasion poses a threat to the natural development of ecosystems. The invasion of the Colorado potato beetle in Primorsky Kray at the beginning of the 21st century is one of the most important events in the agriculture of the region. The first focuses of the pest were discovered by the Department of Biological Control of the State Scientific Institution “Far Eastern Scientific Research Institute of Plant Protection” and the regional branch of the Federal State Institution “Rosselkhozcenter” in allotments in Kirovsky, Chernigovsky, Mikhailovsky, Partizansky, and Spassky districts in 2000 and later in Chuguevsky and Yakovlevsky districts. At first, the distribution of the pest was limited to a few focuses, potato fields were not colonized fully, and beetles were observed on five-six plants exclusively in the center of fields. The same pattern was described in the USA and Canada as well (MacQuarrie & Boiteau, 2003).

The quarantine was not enforced because it was believed that the pest would not be able to acclimatize in Primorsky Kray (Vlasova, 1978). Eventually, it took ten years for the Colorado potato beetle to inhabit the whole territory of the region. The pest colonized 1,056 ha of land area by 2007, 2,200 ha by 2010, 4,200 ha by 2011 (Matsishina & Rogatnykh, 2013). Twenty districts of Primorsky Kray were inhabited by the Colorado potato beetle by 2011. The population of the pest was characterized by an exponential growth until 2012 (Fig. 1).

Additionally, imagines and larvae of the Colorado potato beetle coexisted with imagines and larvae of the potato ladybird beetle in private and industrial crop fields. The increase in the population size was explained by the influence of favorable weather conditions – the hot and dry summers of 2008-2012 facilitated the improvement of the reproduction rate (Matsishina, 2011b).

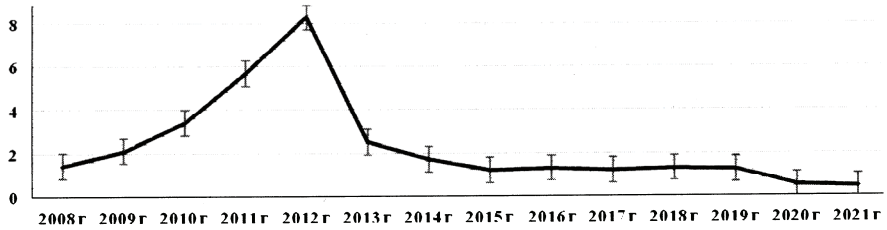

Figure 1. Dynamics of the population size of the Colorado potato beetle over the year of the research (population peaks are shown on average for Primorsky Kray).

However, our earlier hypothesis about the successful naturalization of the Colorado potato beetle in the agricultural ecosystem of the studied region should be rejected. The annual precipitation were relatively high in 2013–2019 (700–800 mm) (Lyude *et al*., 2021). During these years, the agricultural weather station of Timiryzevsky settlement recorded high daily precipitation that exceeded the daily average by ten times and sometimes even the monthly precipitation average. Monthly precipitation was unevenly distributed effecting the yield of agricultural crops. The high amount of precipitation led to flooding and caused water stress in crops significantly decreasing the food resources for phytophagous insects.

Fig. 2 shows that the population of the Colorado potato beetle had characteristics of a growing population until 2013: the pre-reproductive and reproductive groups were predominant while the post-reproductive group was not numerous.

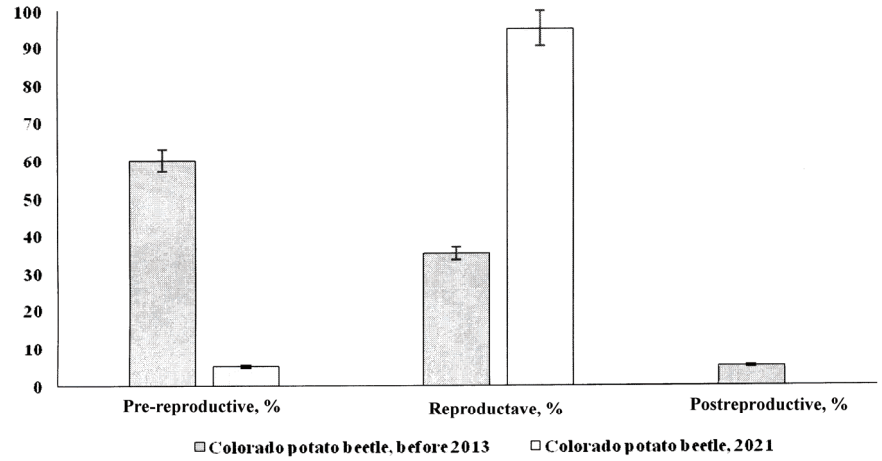

Fig. 2. Population pyramid of the Colorado potato beetle in Primorsky Kray.

This population pyramid corresponds to the r-selection strategy. It is well known that organisms following the r-selection strategy multiply exponentially irrespective of the population density until all resources of the environment are exhausted. The title of this strategy highlights their primary goal – maximal growth rate of their population (r). The r-selection strategy is aimed at colonizing a vast territory in the shortest time possible (Rasnitsyn, 2015). This postulate is supported by the results of our research – the habitat range of the Colorado beetle increased at a rate of 2,000 ha per year (Matsishina & Rogatnykh , 2013). In 2013–2015, the population size of the pest decreased rapidly due to unfavorable conditions. By 2021, only localized focuses remained within the borders of agricultural lands. The pest population in the focuses was characterized by predominantly reproductive and pre-reproductive groups with a very little number of post-productive forms. Today the population of the Colorado potato beetle in Primorsky Kray is considered stable with a tendency towards a decrease in the population density and habitat range. Probably, the population of the Colorado potato beetle passed "the bottleneck" in 2013–2015 as the result of certain climatic events that were catastrophic for the pest. We suggest that a significant part of the genetic diversity of the population might have been lost during these events. This, in its turn, reduced the tendency towards the r-selection strategy and presumably decreased the adaptive potential of the population. After the cessation of the unfavorable factors, the pest did not recolonize territories outside the remained focuses.

The analysis of the obtained data showed that the successful acclimatization of the Colorado potato beetle to the ecosystem of Primorsky kray is possible only in the periods with favorable climatic conditions. Relying on the conservatism of ecological niches (Whiens & Graham, 2005), it can be concluded that alien species will follow the same ecological principles in a new environment as they did in their native territory. However, modelling the ecological niche of the Colorado potato beetle by the method of metric two-dimensional scaling using the Jaccard coefficient (Mochalov, 2010) demonstrated that the model of the Far Eastern population was not an component of the European population and differed significantly from the North American one (Fig. 3).

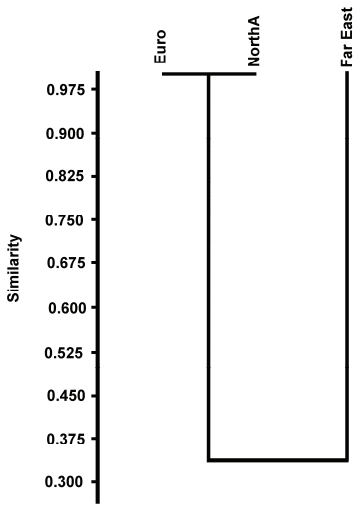

Figure 3. Modelling of the ecological niches of the Colorado potato beetle for the Far Eastern, European, and North American habitats by the method of metric two-dimensional scaling using the Jaccard coefficient.

In conclusion, the successful naturalization of the Colorado potato beetle is limited by the following factors in the monsoon climate of Primorsky Kray: unstable fluctuating weather conditions with periodic catastrophic precipitation, which might exceed the long-term average by many times. This influence is determined by the close connection between the phytophagous insect and soil as well as the geographical overlap of fodder and diapause sites. The structure of ecosystems in the region is conditioned by the fact that most of them are located in the bottomlands of rivers or in close proximity to water bodies. A drastic increase in the runoff due to excessive simultaneous rainfall leads to the flooding of agricultural lands and the elimination of the fodder plants. The Colorado potato beetle is an oligophage and can not switch to alternative food sources during these periods. Additionally, beetles that enter diapause under these conditions die because of flooding and cold injury.

The acclimatization of the Colorado potato beetle in the Primorsky Kray can not be considered successful. Despite this fact, the pest remains a threat to the potato production in the region and can cause significant damage in case of repeated invasions during periods with more favorable conditions.

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