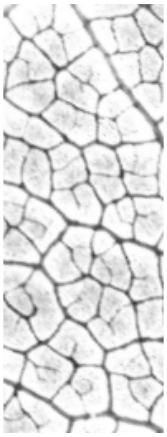

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Dispersal and development of beet webworm Loxostege sticticalis (L.) in Ukraine

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Abstract

Introduction: The beet webworm Loxostege sticticalis (L.) is a dangerous agricultural pest with high migratory and outbreak capacities. Its taxonomy at the generic level has been changed several times, the two most acknowledged genera being Loxostege and Pyrausta.
The beet webworm Loxostege sticticalis (L.), (Pyraloidea, Crambidae) is a dangerous outbreak pest, causing serious damage to the crops such as soybean, sugar beet, alfalfa and sunflower in Eurasia, including Northern China and steppe zones of European and Asian parts of Russia (Chen et al. 2008, Frolov et al. 2008). It was initially described as Pyralis sticticalis (Linnaeus 1761), later it was attributed by the different authors to the genera of Botys Latreille, 1802, Loxostege Hübner, 1825, Margaritia Stephens, 1827 and Phlyctaenodes Hampson, 1899. The combination Loxostege sticticalis is the one most widely accepted by the modern taxonomic summaries (de Jong 2011, Goater et al. 2005, Heppner 1998, Karsholt and Razowski 1996).
Material and Methods: The field data was obtained in 2017 – 2018 at the research field in different regions of Ukraine.
Adult moths of beet webworm Loxostege sticticalis (L.) were caught by net at the meadows in Luhansk, Zaporizhia, Mykolaiv, Kherson regions.
Commonly accepted methods of faunal studies in entomology and calculation of insect numbers, field and laboratory studies, modeling the population dynamics of insects were used in the research. The analysis of Department of Forecasting reports, Phytosanitary Diagnostics and Risk Analysis of Ukraine were conducted.
Results: In 2018, the first spring generation had the most favorable conditions for development - enough moisture, moderate temperatures, presence of flowering vegetation, which led to a significant increase in the number of depredators, especially in the centers of the southeastern and sometimes central areas.
The beet webworm Loxostege sticticalis (L.) developed within three generation in most areas in the spreading zones, except Kharkiv, Poltava and Vinnytsia regions, where only two generations were noted.
Conclusion: Considering the degree of the beet webworm Loxostege sticticalis (L.) threat, it is necessary to observe the dynamics of their dispersal constantly, which would allow to avoid “unexpected” destruction of agricultural crops by caterpillars.
In 2019 it is necessary to strengthen the beet webworm Loxostege sticticalis (L.) appearing, to monitor the depredator’s development and to use pesticides in time.

Keywords: sunflower, beet webworm Loxostege sticticalis (L.), insects

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INTRODUCTION

The beet webworm Loxostege sticticalis (L.) belongs to the family Pyraustidae, type of Lepidoptera (Chen et al. 2008, Heppner 1998, Prado et al. 2011, Tunca et al. 2009). The beet webworm Loxostege sticticalis (L.) is characterized by cyclic outbreaks of population boom. Many scientists have tried to analyze the causes of this depredator’s population boom. According to entomological chronicles, the first boom was dated in Ukraine in 1686 (Malysh et al. 2014).

It is a dangerous depredator that damages a wide range of crops, has high reproduction capability, adaptability and harm. They can fly over long distances and populate large areas within 2-3 days. This species is widespread in Eurasia and North America (Hampson 1899). Typical breeding sites are steppes, especially favorable ones are arid areas with rainfall 250 - 300 mm

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per year. It is common in the Central and Eastern forest steppes and steppes of Ukraine, but during the years of population boom it is numerous everywhere and may present a threat to crops (Goater et al. 2005, Govorov et al. 2012, Hebert et al. 2010, Heppner et al. 1998, Karsholt et al. 1996, Tunca et al. 2009). This is a typical polyphagous depredator, and its caterpillars can damage plants from 35 families of crops (Karsholt and Razowski (Eds.) 1996, Mayr et al. 2012, Michener et al. 1970). The favorable plants for it from agrestic weeds are like saltbush, bindweed, sagebrush to cultivated plants like beets, sunflowers, bean family. During growing periods, the beet webworm Loxostege sticticalis (L.) damages sugar beet heavily, all bean family, sunflower, corn and vegetable crops, as well as tree and shrubbery plantings in gardens, fruit and forest nurseries, grape and hop planting (Averin 2019, Frolov et al. 2008, Pepper 2003, Vareneek 2017).

In different zones of Ukraine, one to three generations of the beet webworm Loxostege sticticalis (L.) develop in Polesia (Polissia), the forest steppe and in the north of the steppe; there are two generations in the south of the steppe and three - in Crimea. The flight of the beet webworm Loxostege sticticalis (L.) is observed from May to October: the departure of the wintering generation starts at the end of April to May, the first - in June to July, the second - in July to September (Beletsky 1993, Masliiov et al. 2018, Pepper 2003).

One of the characteristic features of the species is periodic outbreaks of the population boom (once every 10-12 years). The previous outbreaks occurred in 1912, 1927, 1929, 1972 -1979 and 1986-1989, with the peaks of booms in 1929, 1975, 1988. The weather conditions of the last year were favorable for the development of the meadow moth in many regions of Ukraine and the neighboring countries where it caused serious damage to agricultural crops (Beletsky 2018, Korneychuk 2018, Malysh et al. 2014).

The outbreak began in the east of the territory in 2011 and acquired a gradual expansion on the covered area, the peak of reproduction was observed in 2015-2016, in the following years including the 2017-2018 when there was a decrease in number of the meadow moth.

The Purpose of the Research

Improvement of monitoring and forecasting methods of appearing of the beet webworm Loxostege sticticalis (L.), investigation of harmfulness and the current state of the beet webworm Loxostege sticticalis (L.) population in Ukraine.

MATERIALS AND METHODS

The field data was obtained in 2017-2018 at the research field in the different region of Ukraine (Zaporizhia, Luhansk, Donetsk, Kherson, Kyiv, Kharkiv, Dnipropetrovsk, Cherkasy regions).

Fig. 1. Conducting spring control research of sunflower seeds in Zaporizhzhia region

Fig. 2. Conducting spring control research of sunflower seeds in Luhansk region

Commonly accepted methods of faunal studies in entomology and calculation of insect numbers, field and laboratory studies, modeling the population dynamics of insects were used. The analysis of Department of Forecasting reports, Phytosanitary Diagnostics and Risk Analysis of Ukraine were conducted.

Direct observations and records of the depredator development began to be carried out in the spring, after the changing of the average daily temperature of air to + 5° C, in the wild (when there was enough number of them). For this purpose, there were about 15 caterpillar cocoons collected with the depredator on the agricultural lands, forest belts, roadsides. Then the cocoons were open carefully and the conditions of the individuals were recorded (like live caterpillars, caterpillars lost from illness or other causes, caseworms, larvae or puparium of the depredator, etc.). Such records were repeated once every ten days until middle of April, and then once every five days before the flight period of the beet webworm Loxostege sticticalis (L.), (**Figs. 1** and **2**).

With the appearing of the first caseworms there were spring control surveys conducted on the population of the phytophagans on the agricultural lands to determine the condition of the depredators after overwintering. For this reason, soil excavation was carried out in fields or

Table 1. Scale for estimating the flight strength of the meadow moth

The flight strength degree of the meadow moth	Score
One flight – to 1 meadow moth within 50 steps	1
Weak flight – 1 to 5 meadow moths within 50 steps	3
Middle flight - 6 to 50 meadow moths within 50 steps	5
Strong flight - 51 to 250 meadow moths within 50 steps or 1to 5 meadow moths within 1 step	7
Massive flight – more than 250 meadow moths within 50 steps or more than 5 meadow moths within 1 step	9

Table 2. The scale of determining the degree of damage to plants

Signs of damage to plants	Score
The plants not damaged by depredators	0
The leaf surface damaged to 5%	1
The leaf surface damaged from 6% to 25%	3
The leaf surface damaged from 26% to 50%	5
The leaf surface damaged from 51% to 75%	7
The leaf surface damaged from 76% to 100% or plants died	9

areas with the highest population of cocoons of the meadow moths that were found the previous autumn. On each field up to 100 hectares in two diagonals there were carefully selected 12 quadrats of 50x50 cm in size, on which the layer of soil was carefully removed to 10 cm and paddled by hands. Collected during the day the cocoons were opened in the laboratory and the total number was calculated, including live caterpillars or caseworms, caterpillars or caseworms died from diseases or entomophages and for other reasons. The results of the research were recorded in the logbook, then compared to those data registered in the logbook in these fields during the autumn period and the percentage of decrease of number and survival of the depredator was determined (Truskavetska 2018).

The number of the beet webworm Loxostege sticticalis (L.) population in crops and other agricultural lands is better to conduct by counting the flying individuals during the going through the fields. To do this, on each accounting field, at least once every three days in five places along the diagonal, at equal intervals (50, 100 steps), there were ten steps made and all meadow moths flying from under the feet were counted. The average number of them in the field was taken within the distance of ten steps. In a first place for the survey, the fields of row crops (beets, corn, vegetables, etc.) were taken as well as crops of perennial legumes and areas with blooming agrestic weeds (Omelyuta et al. 1980, Page 1996, Tribel 1976). The strength of the flight of the meadow moths determined the degree of threat and expediency of the protection measures (**Table 1**).

During the outbreak of the beet webworm Loxostege sticticalis (L.), its development was monitored daily. The calculating of laid eggs and caterpillars was carried out once every 2 - 3 days. After monitoring is should be admitted that the most often, meadow moths lay eggs on forewing saltbush. To detect the laid eggs, we passed through the diagonal fields and excavated in 20 places five plants of saltbushes, necessary for examining them on the presence of eggs. If on both sides of the leaves white or browned shiny drops or chains of eggs were found, then with the help of 4 - 8 – 10-time magnifying glass the number of eggs per plant was counted. Then at least on 8 plots of 50 x 50 cm all crops, agrestic weeds, plant remains and soil surface were viewed by to count the number of eggs. After that calculations per 1 m² or on the plant on average are made. The most part of the eggs could be found on stems, dry plant remains, handful of soil, and therefore they need to be reviewed very carefully (Peairs et al. 1956, Tribel 1976).

The presence of caterpillars was determined on 100 plants (5 plants in 20 samples), especially in the centers where laid eggs were found. When detecting caterpillars, their amount per plant was determined on 1 m². The caterpillars, which have been bred on leaves of beets, sunflowers, white beans and other plants with large leaves, could be detected by the presence of small “windows” of irregular shape. On such leaves or plants, it is necessary to look for caterpillars. On small-flowered crops (like carrots, flax, lucerne) caterpillars can be detected by mowing the entomological butterfly net, or it is necessary to drag off a few plants carefully and shake them a little over a sheet of paper. In this case, disturbed caterpillars go down on the web (Tribel 1976, Vareneek 2017).

Damage of plants is carried out by eye estimation.

Their number is counted on 1 m² or per plant (**Table 2**).

Observations on the development of the second and subsequent generations are carried out in a similar way.

RESULTS

In 2018, the first spring generation had the most favorable conditions for development - enough moisture, moderate temperatures, presence of flowering vegetation, which led to a significant increase in the number of depredators, especially in the centers of the southeastern and sometimes central areas.

In most areas in the spreading zones, the beet webworm Loxostege sticticalis (L.), developed within three generations, except for Kharkiv, Poltava and Vinnytsia regions, where only two generations were noted.

Fig. 3. The summer inspections were carried out in Luhansk region

Fig. 4. Carry out a survey of sunflower crops in the Lugansk region to detect the beet webworm Loxostege sticticalis (L.)

The beet webworm Loxostege sticticalis (L.) flight began in mid-May last year. At the edges of the field of sunflower, winter wheat, corn, on noncroplands, in perennial grasses in Kyiv, Kharkiv, Dnipropetrovsk, Cherkasy regions where the average number of depredators of bulla was from 2 to 25 ex. / 10 steps, sometimes in the centers of Zaporizhia, Luhansk, Donetsk regions its number ranged from 10 to 150 ex. / 10 steps (**Figs. 3** and **4**). The flight strength of the meadow moths of the 1st generation (from 2 to 50 ex. / 10 steps) was observed within all areas of the steppe zone and somewhat smaller (from 1 to 12 ex. / 10 steps) in Kyiv, Cherkasy and Sumy regions.

Mass rebirth of caterpillars began in early June. The caterpillars damaged beets, sunflower, corn, leguminous crops, perennial grasses. The average number of depredators was 3.0-8.0 ex./m², in Zaporizhia, Luhansk, Donetsk, Kharkiv, Sumy regions locally on lucerne, sunflower, soybeans, corn, sugar beet amounted to 8.0-14.0. ex./m². That means 5-18% of plants were damaged.

Fig. 5. The caterpillars of II generation of a meadow moths on sunflower crops in the Mykolaiv region

Fig. 6. Damage of sunflower crops by caterpillars of the meadow moths of the second generation in the Zaporizhia region

Beet webworm Loxostege sticticalis (L.) flight of the 2nd generation began in the middle of June. Second generation of caterpillars was populated in the central and western regions and therefore from 4 to 22% of plants within 2-10% of areas of sunflower, corn was damaged. But the most locally were planted up to 46% of areas of perennial grasses in Cherkasy region with the number of 0.3-6.0 ex./m². In the southern and eastern regions 8-28% of plants were planted on the territory of 17-45% of sunflower areas, corn, in the amount from 2 to 12 ex./m², maximum - up to 30-65% of plants, that means up to 20 ex/m² that is on the threshold level in Zaporizhia and Mykolaiv regions (**Figs. 5-7**).

The flight intensity of the beet webworm Loxostege sticticalis (L.) of the second generation (from 2 to 45 ex./10 steps) remained high in Luhansk, Odesa and Kherson regions.

Fig. 7. The caterpillars of II generation of a meadow moths on sunflower crops in the Luhask region

Fig. 8. The reproduction capability of the wintering generation of meadow moths

Fig. 9. Detection of the sunflower leaves skeletization by the catterpillars of the meadow moths in Luhansk region

The reproduction capability of the wintering generation of meadow moths was high (100-180 eggs / female), except for the Cherkasy and Zaporizhia regions, whereas the reproduction capability of the second generation was lower in the steppe areas (10-50 eggs / female, except Luhansk (76), Mykolaiv (152) regions (**Fig. 8**).

Fig. 10. Inspection of sunflower crops on the population of the beet webworm Loxostege sticticalis (L.) in Mykolaiv region

Fig. 11. Investigation of experimental areas of the Institute of Oilseed Crops in Zaporizhia region

The centers with a high number of caterpillars of the meadow moths were found in the central, steppe and eastern regions of the forest steppe zone on sunflower, corn, vegetable and cucurbit crops (**Fig. 9**).

The centers with a phytophagus of II generations high number were stored in Luhansk, Donetsk, Zaporizhia, Mykolaiv, Kherson regions, and of III generation – in Kherson and Mykolaiv regions.

The third generation of phytophagus development occurred in the central regions from the end of August to the end of September. The flight strength of the beet webworm Loxostege sticticalis (L.) was different, in the eastern regions - 3 to 40 ex/ 10 steps, in the central ones - slightly weaker. The number of caterpillars was smaller than the previous generation (2 to 6 ex / m², maximum 32 ex. / m²) on the particular areas of Zaporizhia and Mykolaiv regions (**Figs. 10-12**).

The autumn inspection of various stations of the depredator wintering stock (about nymphs in cocoons) was found with an average of 1.4 ex./m², which exceeds last year's figures (**Fig. 13**).

Fig. 12. Investigation of experimental areas of the Institute of Oilseed Crops in Zaporizhia region

Fig. 13. The autumn inspections were carried out in Poltava region

DISCUSSION

Since the beginning of 2000 the sunflower growing areas in Ukraine have increased twofold in fact and they exaggerated a scientifically substantiated and recommended index – 8 % in the structure of the crops interchange system without hard crop rotation which has become the main reason for a strong increase of the number of the beet webworm Loxostege sticticalis (L.) and appearance of a new-old pest, aggressiveness of which have increased to the utmost under such conditions.

Thus, it can be concluded that within recent years, as a result of the ecological and economic factors (decreasing the land cultivation, deterioration of agricultural technology and global warming) constant locations of meadow moths were formed in the southern regions. The condition of the population indicates an average degree of threat. However, the danger of possible population boom of depredator wintering generation still remains in Zaporizhia, Luhansk, Donetsk and Kherson regions, somehow lower - in the northern and central regions.

CONCLUSION

1. Considering the degree of beet webworm Loxostege sticticalis (L.) threat, it is necessary to observe the dynamics of their dispersal constantly, which would allow to avoid “unexpected” destruction of agricultural crops by caterpillars.
2. In 2019 it is necessary to strengthen the beet webworm Loxostege sticticalis (L.) appearing, to monitor the depredator’s development and to use pesticides in time.
3. It is necessary to conduct the complex of preventive, agronomic, organizational - managemental and chemical inspections, including scientifically based - swapping sunflower crops with another crops in crop rotation.

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