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G.B. Tanabekova[1], Lu Zhaozhi[2], R.V. Jashenko[3]

[1]Al-Farabi Kazakh National University, Kazakhstan, Almaty
[2]Xinjiang Institute of Ecology and Geography, China, Urumqi
[3]Institute of Zoology CS MES RK, Kazakhstan, Almaty
Correspondent author – G. Tanabekova, e-mail: tanabekova.guli@gmail.com

BIOECOLOGICAL FEATURES OF APPLE ERMINE MOTH IN THE DZUNGAR AND TRANS-ILI ALATAU

The article describes results of the study of bioecological development features of the apple ermine moth Hyponomeuta malinellus Zell. in the Trans-Ili Alatau and Dzungar Alatau state national parks. The work's main objective is to reveal the factors influencing the pest development, determine the phenological and environmental characteristics, and identify the most vulnerable development stage of the apple ermine moth Hyponomeuta malinellus Zell., in order to apply appropriate timely measures controlling the pest. In the course of the study, the exact dates and abiotic factors were established. The results of the study activity of apple ermine moths were summarized, and a phenological calendar for the development of this pest has also been compiled. The pest developed in one generation, in the foothill zone of the Almaty region on the territory of the Trans-Ili Alatau and Dzungar Alatau state national parks in 2018–2019. The duration of the particularly dangerous period of the pest, depending on weather conditions, is from 37 to 45 days. In order to fight this pest, accurate knowledge of the phenological and environmental data is very important. During the 2018–2019 years, the pest, under conditions of the foothill zone of the Almaty region, in the area of the Trans-Ili Alatau and Dzungar Alatau state national parks, developed during one generation. The period particularly dangerous for the pest lasts 37 to 45 days, depending on weather conditions. To control the pest, scientists need to have accurate phenological and environmental data.

Key words: ermine apple moth, the Sievers apple, the Dzungar Alatau, the Trans-Ili Alatau.

Г.Б. Танабекова[1], Лю Жаожи[2], Р.В. Ященко[3]

[1]Әл-Фараби атындағы Қазақ ұлттық университеті, Қазақстан, Алматы қ.
[2]Сынцзян экология және география университеті, Қытай, Үрімші қ.
[3]ҚР БҒМ Зоология институты, Қазақстан, Алматы қ.
Корреспонденттік автор – Г.Б. Танабекова, e-mail: tanabekova.guli@gmail.com

Жоңғар және Іле Алатауындағы алма күйесінің дамуының биоэкологиялық ерекшеліктері

Мақалада Іле Алатау және Жоңғар Алатау мемлекеттік ұлттық табиғи парктерінің аумағында алма күйесінің Hyponomeuta malinellus Zell. биоэкологиялық ерекшеліктерін зерттеу нәтижелері туралы мәліметтер келтірілген. Зерттеудің негізгі мақсаты – бұл зиянкестердің дамуына әсер ететін факторларды анықтау, фенологиялық және экологиялық ерекшеліктерін зерттеу, Сиверс алма ағашының алма күйесі Hyponomeuta malinellus Zell. зиянкесіне қарсы уақтылы бақылау шараларын қолдану үшін алма күйесінің ең осал сатысын анықтау болып табылады. Ересек сатысы бойынша түрлерді анықтау және фенологиялық дамуды бақылау үшін дернәсіл сатыларын өсіру әдісі қолданылды. Дернәсіл сатыларының морфологиялық ерекшеліктерін және олардың даму мерзімдерін зерттеу үшін осы тұқымның әр дернәсіл жасы бақылауда болды. Зерттеу барысында алма күйесінің дамуына әсер ететін нақты уақыт пен абиотикалық факторлар анықталды. Алма күйесінің даму барысы қарастырылды, сонымен бірге осы зиянкестердің дамуының фенологиялық күнтізбесі дайындалды. Алматы облысының тау бөктерінде Іле Алатау мен Жоңғар Алатау мемлекеттік ұлттық табиғи саябақтарының аумағында алма күйесі 2018–2019 жж. бір буында дамыды. Ауа райына байланысты зиянкестердің аса қауіпті кезеңінің ұзақтығы 37-ден 45 күнге дейін созылды. Бұл зиянкестермен күресу үшін фенологиялық және экологиялық мәліметтерді дәл білу өте маңызды.

Түйін сөздер: алма күйесі, Сиверс алмасы, Жоңғар Алатау, Іле Алатау.

Г.Б. Танабекова[1*], Лю Жаожи[2], Р.В. Ященко[3]
[1]Казахский национальный университет им. аль-Фараби, Казахстан, г. Алматы
[2]Синьцзянский университет экологии и географии, Китай, г. Урумчи
[3]Институт Зоологии КН МОН РК, Казахстан, г. Алматы
Корреспондентский автор – Г.Б. Танабекова, *e-mail: tanabekova.guli@gmail.com

Биоэкологические особенности развития яблонной горностаевой моли в Жонгарском и Заилийском Алатау

В статье приведены данные о результатах исследования биоэкологических особенностей развития яблонной горностаевой моли Hyponomeuta malinellus Zell. на территории Иле-Алатауского и Жонгар Алатауских государственных национальных парков. Основной целью исследования является уточнение факторов влияния на развитие данного вредителя, определение фенологических и экологических особенностей, выявление самой уязвимой стадии яблонной горностаевой моли Hyponomeuta malinellus Zell. для применения своевременной меры борьбы с данным вредителем яблони Сиверса. В целях видового определения по взрослой фазе и для проведения наблюдений за фенологическим развитием применялась методика культивирования личиничных стадий. Для изучения морфологических особенностей личиночных стадий и сроков их развития фиксировался каждый личиночный возраст этого вида.

В ходе исследования были установлены точные даты и абиотические факторы, которые влияют на развитие яблонной горностаевой моли. Обобщены результаты исследования деятельности яблонной горностаевой моли, также был составлен фенологический календарь развития данного вредителя. В условиях предгорной зоны Алматинской области на территории Иле-Алатауского и Жонгар Алатауских государственных национальных парков вредитель развивался в 2018–2019 гг. в одном поколении. Продолжительность особо опасного периода вредителя в зависимости от погодных условий составляет от 37 до 45 дней. В целях борьбы с данным вредителем точное знание фенологических и экологических данных очень важно.

Ключевые слова: яблонная горностаевая моль, яблоня Сиверса, Жонгар Алатау, Заилийский Алатау.

Introduction

The Sievers apple tree is a valuable gene pool, and the study and preservation of diversity of its forms for the present-day and future selection, reforestation, and forest cultivation is an urgent task (Yan, Han, Mei, 2016: 683-689). Special value of the species is that it is the keeper of a unique germplasm, the ancestor of many cultivars (Ainabekov, Turekhanova 2015:15-28; Harris, Robinson, Juniper, 2002:426-430; Morgan, Richards, Dowle, 2002:316). Modern genetic studies of approximately 2,500 modern apple varieties indicate that the Sievers apple tree is the progenitor of almost all varieties of domestic apple trees. Paleontological data show that this apple tree species originated in the middle of the Cretaceous period, i.e., has an age of approximately 165 million years (Forsline, Aldwinckle, Dickson, Luby & Hokanson, 2003: 1–61). The study has top actuality as over the past few decades the range of the wild population species has significantly decreased due to state economic activities, genetic and environmental pollution, as well as the emergence of dangerous pests around the area.

The range of the Sievers apple tree in Kazakhstan covers the mountainous regions of the east, southeast and south of Kazakhstan, extending from Tarbagatai to the Western Tien Shan. The main wild apple forests are located in Tarbagatai (the area of about 300 hectares), the Dzungar Alatau (3800 ha), the Trans-Ili Alatau (1300 ha) and the Western Tien Shan (Dzhangaliev, Salova, Turekhanova, 2007: 32-35). In the Western Tien Shan, the apple tree is found in small groves scattered across the gorges; there is only one large massif (50 ha) titled the "Kara Alma" grove, in the Aksu river canyon of the Aksu-Zhabagly reserve. Among species of the genus *Malus* Mill., the Central Asian wildly growing Sievers apple tree possesses the large intraspecific diversity (Ponomarenko, Nazirov, 1990: 8-13), a wide range of variability in biological features, winter hardiness, drought and heat resistance, and immunity to pests and diseases.

In the middle of the XX century, wild apple trees in the Dzungar and Trans-Ili Alatau were in the focus of studies by the researcher A.D. Dzhangaliev, who considered the Sievers apple tree within the mountain system of Kazakhstan at the phytocenotic, species and population levels. The scientist established the fact of high polymorphism and genetic duplication of the local forests (Dzhangaliev, Salova, Turekhanova, 2003: 305-370, Cornille, Giraud, Smulders, Roldan-Ruiz, Gladieux, 2014: 57-65).

Justification of the choice of articles and goals and objectives

According to experts, the situation is already close to critical, as the unique intraspecific diversity of Kazakhstan populations of wild apple trees to date was intensely reduced, impoverishing the value of its gene pool. It is a hard task to restore these assets naturally, because many local populations of apple tree are practically deprived of the possibility to regenerate naturally. In addition, the direct proximity of cultivated apple orchards to wild populations of fruit forests represents a threat. The buffer protection zone framing the natural populations is often not maintained. In addition to alien plant species, insect pests and diseases of wild apple trees and other wild fruit plants endanger the wild fruit forests (Igembaev, Stepanova, 2016: 116-118).

The early seasonal defoliation of trees is especially hard for a fruit tree organism, since it impacts the radial growth of trees, causing its significant decrease over the course of several years after the outbreak of pests (Mukhamadiev, Mazarzhanova, Ashikbaev, 2013: 54-62). Such harm to conditions of tree growth breeds pathogenic fungi, bacteria and insect pests on the trees, which, in their turn, facilitate further drying of the trees.

One of the main conditions for protecting plants from pests is timely application of various complex measures based on the phenological data (Dobrovolsky, **1961: 67-83**). The precaution and prediction of the time of appearance and development of harmful insects is the chief, complex task, which, arming with the modern methods, should adjust to accurate timing of insect pest development in order to prevent it. It is important to note that the Yponomeutidae family of the Lepidoptera order occupies a special place among other insect pests (Turekhanova, Tanabekova, 2018: 90-97).

It is worth noting the need to study the phenology of the ermine apple moth *Hyponomeuta malinellus* Zell., since this representative family of ermine moths causes significant harm to fruit crops.

In the nature, there are a huge number of various harmful insects which destroy fruits and leaves of fruit croppers. One of the main and permanent pests of Kazakhstan is the apple ermine moths which disperses and reproduces in the mountain apple forests. Notably, in 1958 there was an outbreak of mass breeding of the moths in West Kazakhstan.

In 2016, there was a noticeable increase in number and scale of damage to apple trees from this monophage, the apple moth (*Hyponomeuta malinella* Zell.), as well as from the bird cherry from the bird cherry moth *(Hyponomeuta evonymella* L.). Visual examination of apple tree plantations allows noting the tachina flies, which indicate an increase in number of apple and bird cherry moths.

The ermine apple moth (arachnid moth) lives in the southern and central parts of Western Europe (Cossentine, Kuhlmann, 2002: 275-278). In the CIS, it occupies only the European part but also was introduced to Central Asia, Kazakhstan, and Transcaucasia.

The front pair of wings is white with three irregular rows of black dots; wingspan is 16-22 mm. The egg is elongated oval, oblate, yellowish. Caterpillars are yellow, 13-16 mm long at the age IV. The pupa of the **apple ermine moth (arachnid moth**) is orange-yellow, then turning greenish-yellow with a dark brown head. Cocoons are dense, white. Adult moth leads nocturnal life. During the season, the butterfly is capable of laying up to 150 eggs, which are placed on branches of fodder plants in groups (15-60 pcs.) near the buds, covering them with a reddish shield of hardening mucus, which later turns brown. Egg development lasts 8-15 days.

Scientific research methodology

The studies were carried out employing laboratory analysis methods, route and stationary inspections of the Sievers apple plantings located in the Ile-Alatau and Dzungar Alatau state national parks.

In the Dzungar Alatau, the optimal zone for growing the Sievers apple is at an altitude of 1,200-1,500 m asl on northern slopes and at 1,200-1,600 m on southern slopes. In the Trans-Ili Alatau, apple tree lives at 900-1,500 m asl and 1,500-1,700 m on the southern slopes. The optimal conditions for growing wild apples in the Trans-Ili Alatau were observed on northern slopes of the mountains at an altitude of 1,300-1,600 m.

The objects of research were leaves populated by pests at different stages of development: larvae of different ages, pupae and imago. The studies were conducted under laboratory and field conditions during the 2018-2019 years.

To establish the species of pests were used: identifiers of agricultural pests, harmful and beneficial insects; guidelines and guidance (Guidelines for phytosanitary and toxicological monitoring of fruit species and small fruits, 1999: 83).

During field observations and collecting, the butterflies and larvae were placed in 0.5 l glass jars or glass tubes, larvae were taken with leaves of the Sievers apple tree where they were found. Leaves of the Sievers apple tree infected with the larvae were also placed in separate glass tubes. These holding

cages were marked with serial numbers; data about the place and time of collection, about the plant, the nature of its damage and other were registered in a log. Subsequently, the larvae were re-placed into separate tubes for shedding and keeping.

Under laboratory conditions, tubes containing twisted leaves were covered with gauze and labeled. The keeping and feeding of larvae in test tubes were carried out under strict control and humidification, necessary for normal development of larvae. To this end, the glass wares with larvae were placed under direct sun rays for short time only to avoid fogging up. The excess in humidity and heat negatively impacts the larvae development.

To identify the species, the biological samples were examined with a binocular and photographed.

Results and discussion

An indispensable condition for successful protection of apple trees against the apple ermine moths *Hyponomeuta malinellus Zell.* is the onset during the most vulnerable development stages opening an optimal time for the treatment. This requires knowing exact dates of the following stages in the pest development:

– start of the mass imago flight;

– start of the mass egg laying;

start of the mass larvae hatching (Fig. 1).

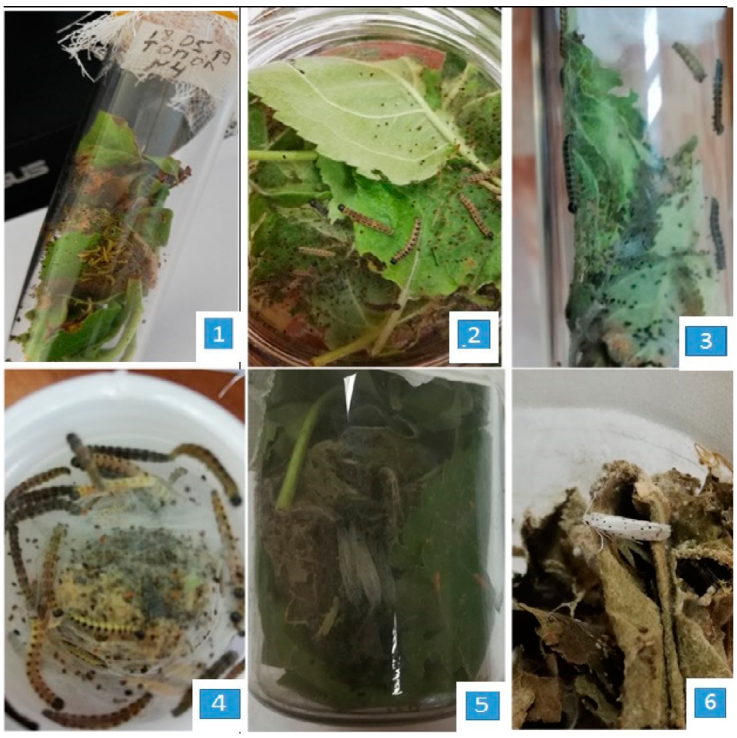

Figure 1 – Development stages of the apple ermine moth:
1, 2, 3, 4 – larvae; 5 – pupation; 6 – imago

The 1957–1962 studies established that larvae of the apple ermine moth intrude into unfurling buds and appearing leaves in the second decade of April, live inside leaves, then pass on to leaves and keep in groups in a web nidus. Their pupation occurs in the second decade of June. The mass flight of imago of the ermine apple moth begins in the late June. Larvae hatch in mid-August (Yukhnevich, Matesova, Mityaev,1958: 9-38). Currently, these indicators have largely changed. Hence, it is necessary to take into account the climatic conditions of the Trans-Ili Alatau and to re-specify the features of the apple ermine moth's individual development. A significant part of the larvae of the apple ermine moth during the periods of autumn, winter, spring dies from the effects of adverse abiotic and biotic factors. At that, their survival depends on the physiological state while preparing to the cocooning, as well as on the choice of wintering sites (Gençer, 2003: 43-46).

The overwintered larvae of the first age appear on May 4th–5th at the average daily temperature above +13 °C. Larvae start living in the open on

10th-12th day, after the first shedding. Larvae completely eat out the laminae to the base of the veins. They make web niduses by waving together a pair leaves. During the period of active development, the larval stage lasts 37-45 days, and with the wintering time, it amounts to 300-320 days.

When breeding en mass, the larvae of apple moth damage fruit trees tremendously, so that strongly infected trees may not bear fruit for several years. In addition, the affected trees weaken, get vulnerable, have low tolerance to under-zero temperatures and can perish in frosty winters.

The pupation period coincides with the time of dropping the excess ovary, in the second decade of June. Pupa develops 8 to 15 days (occasionally up to 20). Pupation proceeds in dense, white, opaque cocoons connected in compact packets that can contain up to several hundreds of cocoons. Butterflies live 20-30 days and are active from the end of June until August, at this time they do not require additional nutrition (Jonaitis, 2001: 319-325). Their active flight is observed in twilight hours, and during the daytime they hide on the underside of laminae. Mating occurs 2 weeks after leaving the pupae, and after another 5-6 days, butterflies begin laying eggs (table 1). The female apple moth lives on average about a month, the male about twenty days. Larvae hatch in 8-15 days and winterise under moisture-proof shields (Lee, Pemberton, 2005. 247-258).

Table 1 – The phenogram of the apple ermine moth Hyponomeuta malinellus Zell., 2019.

April			May			June			July			August			Wintering
I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	
-	Ω	Ω	Ω	Ω	Ω	Ω	Ω	□	□+	□+	+0	+0	+0	+0	-

□ – pupae;
+ – imago;
0 – egg laying;
Ω – larva;
- – diapause (wintering stage);
▲– especially vulnerable period.

Table 1 shows the most vulnerable stage in the pest development and the most convenient time for combating this pest – it is the stage of larvae which appear in the area starting from the first decade of May to the second decade of June. According to our observations, the mass flight of imago is often observed after precipitations. Adults insects lead an active nightlife, flying out at dusk (at air temperatures above +15°C), and during the daytime they hide in tree leaves, attaching to the leaf underside). Table 2 shows the data of laboratory phenological observations over the apple ermine moths in the Trans-Ili and Dzungar Alatau during 2018-2019.

Table 2 – Phenology of the apple ermine moth *Hyponomeuta malinellus* Zell., 2019

Phenological phases	Date	Daytime temperature, T°C	Relative humidity, %
start of the 1st age larvae hatching from overwintered eggs	14-15.04.	13	45
the 1st age larvae mass hatching and the start of active nutrition	10-12.05.	23	39
start of pupation	21-22.06.	29	32
mass pupation	01-02.07.	31	23
start of the imago flight	05-06.07.	30	30
mass imago flight	11-12.07.	32	33
start of the egg laying	21-22.07.	33	21
mass egg laying	01-10.08.	34-35	21
larvae hatching	20-30.08.	33-34	18
start of the diapause	01-02.09.	29	26

Duration of the development stages for the apple ermine moth in the Trans- Ile and Dzungar Alatau, according to 2018-2019 observations is as follows: the full life cycle lasts 1 year (one generation), including 8-15 days of the egg stage, 37-45 days of larvae (including the 300-320 days of wintering), 8-15 days of pupa, and 30 days of imago (Figure 2).

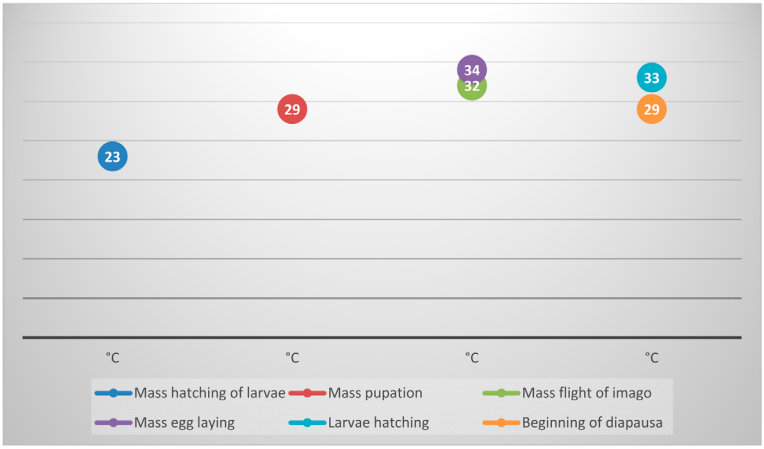

Figure 2 – Influence of temperature (°C) on development of the apple ermine moth *Hyponomeuta malinellus* Zell., 2019

Conclusion

This type of pest affects all species of apple trees, and in some cases breeds on pear trees. The greatest harm is done in the forest-steppe and steppe regions. The leaves damaged by larvae have brown tops. During mass breeding, leaves can be eaten up till complete exposure of the trees, while the apple trees drop almost the entire ovary, and the remaining fruits stay small. In some cases, the yield may be completely lost. Affected trees become more exposed to adverse environmental factors, which lead to fall in overall resistance, depletion of trees and reduced fruition in subsequent years. An effective fight of the apple moth rests on the knowledge of its biological characteristics.

As a result of the studies, carried out during 2018-2019, authors revealed that with the end of winter the larvae of the first growth begin emerging in the midlands at an average day temperature of +13 °C. In about 37-45 days, they go to the pupation stage at an average day temperature of +29°C. This stage of development lasts about 8-15 days. Mass pupation occurs in the first ten days of July at an average daily temperature of +31°C. The first imago appear in the first ten days of July at a temperature of +30°C. Mass flight of imago is observed a week later, at an average day temperature of +32°C. Adult life spans of female apple ermine moth is about a month, of male about 20 days. The research revealed that mass egg laying occurs in the late July. The apple ermine moth winters as larva of the first growth.

The apple ermine moth *Hyponomeuta malinellus* Zell. is a monophage, and as such is particularly dangerous species for apple trees, its main range. The resistance of the Sievers apple tree to diseases and pests is well known, nevertheless, the Sievers apple tree population in the Dzungar Alatau is damaged by 58%, in the Trans-Ili Alatau by 36%, the Dzungar Alatau being under larger damage by the apple ermine moth.

Acurate knowledge of the phenological and environmental data is crucial for combatting this pest. Upon the establishment of appropriate phenological data, measures of the mechanical, biological or chemical control can be applied.

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