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Harmfulness of insects of the Sievers apple tree (*Malus sieversii*) in Kazakhstan

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Abstract. *Tanabekova G, Tursynkulov A, Jashenko R, Zhaozhi L. 2024. Harmfulness of insects of the Sievers apple tree (*Malus sieversii*) in Kazakhstan. Biodiversitas 25: 3168-3178.* The purpose of this study was to assess the degree of harmfulness of insects commonly found in Sievers apple trees (*Malus sieversii* (Ledeb.) M.Roem.) and to identify entomopathogenic nematodes in soil samples from apple orchards. In this regard, the insect pests of the Sievers apple tree are divided into six main complexes according to the degree of harmfulness of insects. The food specialization and feeding relationships of insects are extremely important in plant protection. In many cases, the development of pest control measures is impossible without an accurate accounting of their host plants and various pest populations. During the research, the Iley Alatau and Zhetysu Alatau were compared in terms of the occurrence of species and the number of species damaging the Sievers apple tree. According to our data, there are more than a hundred insects on the Sievers apple tree in these areas, of which only a few species are of operational importance: *Cydia (Laspeyresia) pomonella* Linnaeus, 1758; *Archips rosana* Linnaeus, 1758; *Archips crataegana* Hübner, 1799; *Yponomeuta malinellus* Zeller, 1838; *Yponomeuta padellus* Linnaeus, 1758; *Grapholita molesta* Busck, 1916; *Aphis pomi* De Geer, 1773; *Lepidosaphes ulmi* Linnaeus, 1758; *Haplothrips reuteri* Karny, 1907; *Dasyneura mali* Kieffer, 1904; *Stigmella malella* Stainton, 1854. Their damage is episodic and is confined to the periods of mass reproduction of these species. Additionally, soil samples from apple orchards in the foothill zone were analyzed for the presence of entomopathogenic nematodes. The study revealed the presence of nematodes of the genus Steinernema, suggesting potential for developing biological control strategies against insect pests in Sievers apple orchards.

Keywords: Harmfulness, insect pests, Kazakhstan, *Malus sieversii*, Sievers apple tree

INTRODUCTION

The Sievers apple tree, *Malus sieversii* (Ledeb.) M.Roem., a relict species known since the Oligocene, plays a crucial role in the mountainous Central Asian ecosystem. As one of the ancestors of the modern cultivated apple tree, its preservation is of utmost importance (Aubakirova et al. 2014; Cornille et al. 2014; Omasheva et al. 2015). The habitat of the Sievers apple tree covers the mountainous regions of Central Asia, including Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and northwestern China. The Sievers apple tree is mainly distributed in southeast and south Kazakhstan, extending from Tarbagatai to Pamir-Alai. The main massifs of wild apple forests are in Tarbagatai (area of about 300 ha), Zhetysu Alatau (3,800 ha), Iley Alatau (1,300 ha) (Panyushkina et al. 2017; Dolgikh et al. 2023). Systematic research of wild apple trees in Zhetysu and Iley Alatau was initiated in the mid-20th century by Dzhangaliev (2010), who studied it at phytocenotic, species, and population levels in mountain systems of Kazakhstan. In Zhetysu and Iley Alatau, he singled out five types of apple communities: very dry meadowsweet-rosehip apple trees; dry herbaceous-and-shrub apple trees; fresh herbaceous-and-shrub apple trees with hawthorn and aspen; fresh multi herbaceous-and-shrub apple trees; wet grassy apple trees.

In the Zhetysu Alata, the Sievers apple tree grows on the northern slopes at an altitude of 1,200-1,500 meters above sea level (m asl.) and on the southern slopes at 1,200-1,600 m asl. (Bakhtaulova et al. 2022). In the 1960s, Zhangaliev A.D. identified 6 seed sites of wild apple trees in the Zhetysu Alatau, such as Pikhtovaya and Soldatskaya Shchels (crevices), Mushabai, Kok-Jota I, Kok-Jota II, Cherny klyuch I, Cherny klyuch II, Chernaya rechka for the purpose of obtaining seeds, selecting and preserving mother trees (Kaldybayev and Chen 2022).

In the Iley Alatau, the apple tree grows at an altitude of 900-1,500 m asl., and on the southern slopes, it rises to 1,500-1,700 m asl.. Optimal conditions for the growth of wild apple trees in the Iley Alatau are noted on the slopes of the northern exposures at altitudes of 1,300-1,600 m asl.. Zhangaliev A.D. allocated seed plots in the gorges of Mikushino, Kamennaya Shchel, and Kuznetsov's Shchel for seed production, selection, and preservation of mother trees to reproduce in nature by wide involvement of inbreeding (Ha et al. 2021; Cornille et al. 2019). In the Iley Alatau, wild apple forests are located on the territory of the Ile-Alatau State National Natural Park in the gorges of Issyk, Mikushino, Soldatsai, Talgar, Kotyrbulak, Bolshaya and Malaya Almatinka, Aksai, Kaskelen, Turgen in massifs

of various sizes, small groups and individual trees. The largest massifs of apple trees are located in the Belchabdar gorge, as well as in the Kuznetsov's Shchel selection and genetic site allocated by Zhangaliev A.D. in the 1960s, with an area of about 200 hectares, located in the Taldy-Bulak tract of the Malovodnensky forestry of the Turgen branch of the Ile-Alatau State National Natural Park. This site is the most preserved area in the Iley Alatau.

The relevance of the study is due to the need to preserve the genetic diversity of wild populations of Sievers apple trees in Zhetysu and Iley Alatau, influenced by the local faunal complex of insect pest species. Despite the fact that the area of the Sievers apple tree has decreased due to mass deforestation and plowing of territories, one of the main threats to wild populations of this species is currently posed by insect pests because, with a mass outbreak of numbers, they cause huge damage to wild apple trees (Kamusiime et al. 2023; Furmanczyk et al. 2022).

Nematodes in the Steinernematidae family have been found in natural populations of codling moth (Poinar 1991). Only the entomopathogenic nematodes (EPN) in the Steinernematidae and Heterorhabditidae families have shown potential as microbial control agents of codling moth. Research conducted over the past 50 years has demonstrated their effectiveness in controlling a wide variety of insect pests (Yagci et al. 2021; Shapiro-Ilan and Dolinski 2015; Vicente-Díez et al. 2021), including orchard pests (Noureldeen et al. 2022). Steinernematids and heterorhabditids are closely associated with symbiotic bacteria (*Xenorhabdis* spp. and *Photorhabdis* spp., respectively) that rapidly kill host insects.

Timely complex measures are crucial for protecting plants from pests. In general, the insect fauna of mountainous regions of southeast Kazakhstan has only been studied for several systematic groups, while other groups have been poorly studied or ignored altogether. Assessing biological diversity requires reliable information about insect groups. The purpose of the study was to assess the degree of harmfulness of insects on the Sievers apple tree in the Iley and Zhetysu Alatau, South-Eastern Kazakhstan.

MATERIALS AND METHODS

Site selection

The field survey was carried out in seven experimental sites of wild apple forests of the Ile and Zhetysu Alatau, where *M. sieversii* accounted for 90% of the tree species (76º47'58"-80º55'076" E, 43º07'23"-45º47'028" N; alt.: 1,025-1,714 m asl.) of Almaty and Zhetysu Provinces, Kazakhstan (Table 1, Figure 1). The study of insect pests was carried out on the territory of the Ile-Alatau and Zhongar-Alatau State National Natural Parks, which are located on the northern slope of the Iley-Alatau mountain range and the Zhetysu Alatau mountain range. Since the wild apple trees grow at altitudes of 900-1,500 m asl., the study was conducted at these heights.

Samples were taken from monitoring sites of the Ile-Alatau State National Park, such as the Aksai forestry, the Talgar forestry, the Kotyrbulak forestry, the Issyk forestry, the Kuznetsov''s shchel breeding-genetic reserve. Additionally, samples were collected from monitoring sites of Zhongar-Alatau State National Park, such as the Topolevka Forestry and Lepsi Forestry. Maps of national parks are shown in Figure 2.

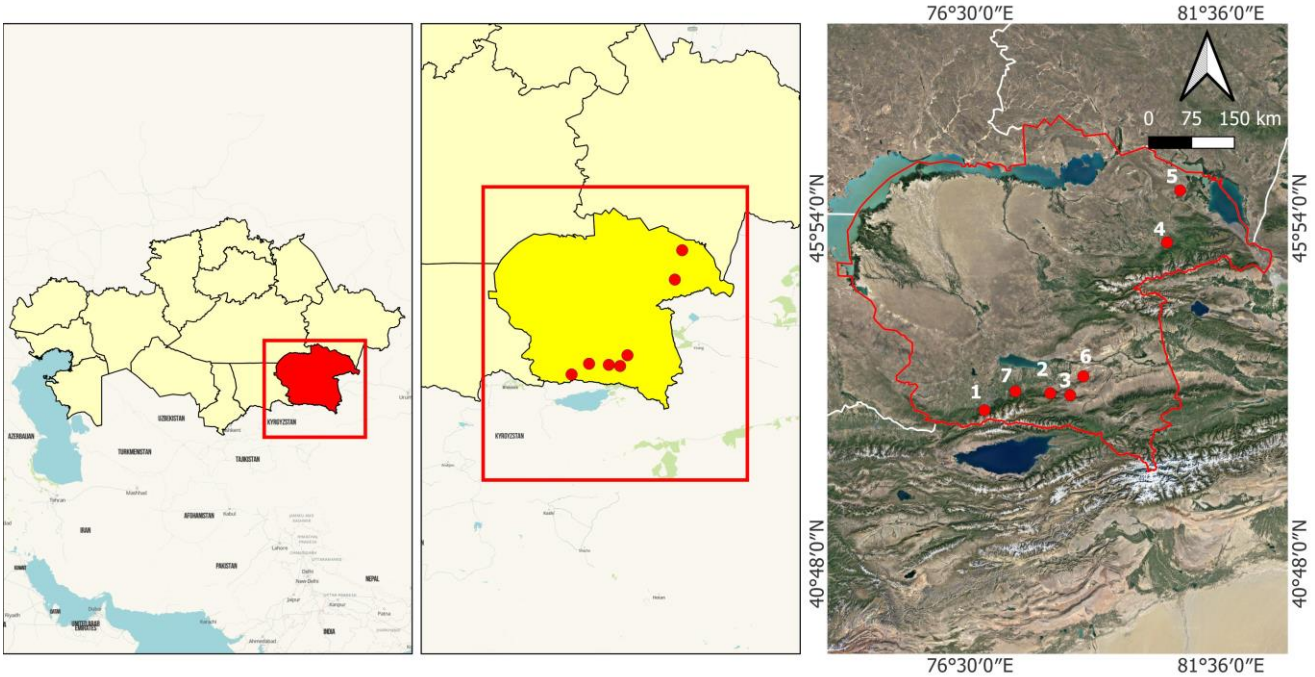

Figure 1. Schematic map of the location of monitoring sites in Kazakhstan. 1. The Aksai branch, the Aksai forestry; 2. The Talgar branch, the Talgar forestry; 3. The Turgen branch, the Issyk forestry; 4. Lepsi branch, Lepsi forestry; 5. The Sarkan branch, Topolevka forestry; 6. The Turgen branch, the Kuznetsov gorge breeding-genetic reserve; 7. The Talgar branch, the Kotyrbulak forestry

Table 1. Location of sampling areas in Kazakhstan

Location	Easting	Northing	Elevation (m asl.)
The Aksai branch, the Aksai forestry	76°47′58″	43°7′23″	1,345
The Talgar branch, the Talgar forestry	77°21′16″	43°16′5″	1,538
The Talgar branch, the Kotyrbulak forestry	77º06'57"	43º16'39"	1,025
The Turgen branch, the Issyk forestry	77°29′05″	43°15′11″	1,714
The Turgen branch, the Kuznetsov gorge breeding-genetic reserve	77°40′21″	43°22′05″	1,595
The Sarkand branch, Topolevka forestry	80º40'826"	45º39'258"	1,402
The Lepsi branch, Lepsi forestry	80º55'076"	45º47'028"	1,370

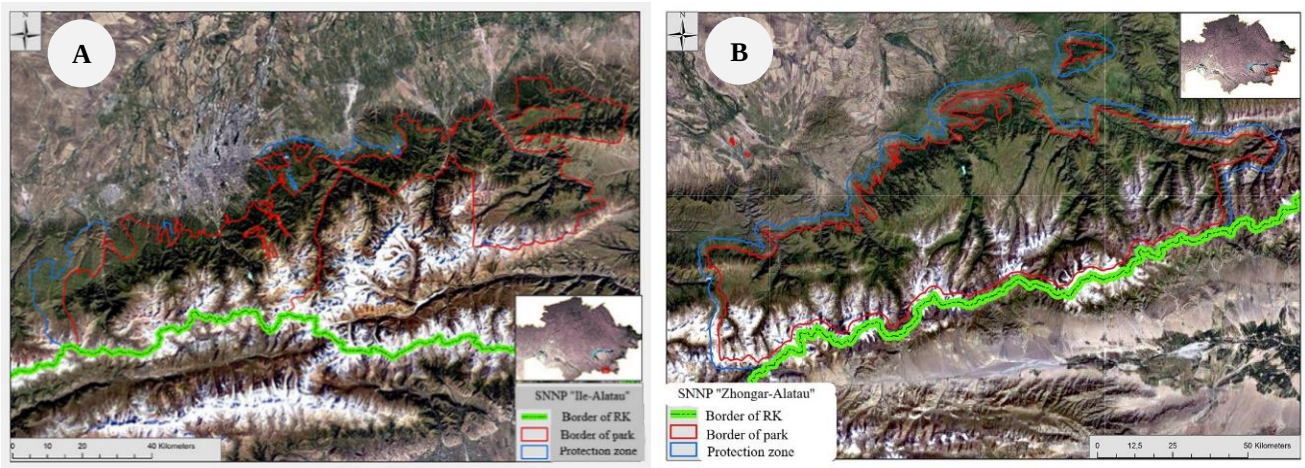

Figure 2. Maps of park location in Kazakhstan: A. Ile-Alatau State National Park; B. Zhongar-Alatau State National Park

The climate of the Zhetysu Alatau is characterized by transitional features from the humid mountainous Siberian to the drier mountainous Central Asian. The average January temperature in the foothill-low mountain tier ranges from -9 to -12°C. The average July temperature is 17-25°C. The northwestern regions are the most humidified by precipitation having 600-800 mm per year. In the southern and southeastern foothill and low-mountain areas, the annual amount does not exceed 400 mm. The following types of mountain landscapes are characteristic of this mountain system: foothill desert (500-1,300 m asl.), shrub-steppe (1,200-2,500 m asl.), forest-meadow (1,400-2,500 m asl.), and meadow-nival (2,400-3,500 m asl.).

The climate of the Iley Alatau is temperate; summers are warm, and winters are not severe. A pronounced inversion of air temperature causes the softness of winter. In the foothills, the average air temperature of the coldest month (January) is -7.4°C, and the warmest (July) is 23°C. The duration of the frost-free period is 181 days, with 560 mm of precipitation per year.

The Iley Alatau has the following mountain systems: steppe zone (750-1,200 m asl.), forest-meadow-steppe zone (1200-2,400 m asl.), high-altitude meadow and meadow-steppe zone (2,400-3,300 m asl.), high-altitude nival-rocky zone (over 3,300 m asl.) (Mukhamadiyev et al. 2017).

Sampling methods

In the course of the study, monitoring sites were surveyed using the semi-stationary counting method. Insect collecting was carried out in different ways. In each site, three circular plots with a radius of 20 m were systematically laid out. There were at least three kilometers between the sites. All wild apple trees in each plot (on average 20 trees per plot) were visually checked and classified into six damage levels of *M. sieversii*. Sampling was carried out from April to September 2022-2023.

Model trees were selected at monitoring sites to study as many insects as possible. Various methods are used for this: crown inspection, tree sorting, clearing branches with a net, counting with suction devices, and so on. All information about insects and the nature of their actions was recorded in a log. The study used accounting for damage to foliage on trees. Trees were examined against the nature of damage to leaves (skeletonization, cutouts, mines, galls), trunks, branches, flowers, fruits, etc., as well as traces of vital activity of insects (excrement, cobwebs, etc.).

A certain number of leaves from several branches at different heights were counted and collected from each model tree, and the percentage of damage by galls, mines, etc., was also calculated. The collected materials were transferred to jars, bags, and test tubes and stored in the usual way until processing and accurate determination. The processing of the material consists of studying the species composition, the biology of the development of pests, and identifying the relationship between insects and plants (Toby and Bruce 2015; Jessica and Forrest 2016; Belitz et al. 2022).

The identification of the species composition and the degree of spread of harmful organisms was carried out by route examination and mowing the crowns of trees with an entomological net at monitoring sites. Mowing was carried out on 20 trees at each site.

The results of studying the species composition of harmful insects were recorded on the following scale (i) + is rare occurrence of species (5-10% of leaves, generative and axial organs of the tree are colonized or affected); (ii) ++ is average occurrence of species (10-25% of leaves, generative and axial organs of the tree are colonized or affected); (iii) +++ is high occurrence of species (25-50% of leaves, generative and axial organs of the tree are colonized or affected).

In the period from 2022 to 2023, studies were conducted in apple orchards in the foothill zones of the Ile-Alatau and Zhetysu-Alatau National parks. Soil samples were taken randomly at the apple tree crown projection sites at each sampling site using a hand shovel after rainy days in the spring months (April, May and June). In each national park, 25 soil samples were taken, which consisted of subsamples of soil weighing 1 kg, in accordance with the number of trees in each orchard. All the subsamples were collected together, and 25 kg of the subsample mixture in plastic bags were delivered to the laboratory of the Institute of Zoology and placed in a cool room (12-15°C). A total of 50 soil samples were taken.

Isolation of entomopathogenic nematodes

Entomopathogenic nematodes were isolated from soil samples using a biological insect trap method. Larvae of *Galleria mellonella* (L.) (Lepidoptera: Pyralidae) were grown in laboratory conditions at a temperature of 25°With and relative humidity of 60%. The larvae of the last age were used as bait for catching nematodes. After careful sifting of the soil through a sieve with a 1 cm cell, 500 g of soil and 10 larvae were placed in sterile plastic containers with a diameter of 12 cm and a height of 10 cm. The containers were closed with perforated lids and incubated under controlled conditions at a temperature of 25°C and a relative humidity of 60% for 10 days. Live and dead larvae were checked every 2 days during the incubation period. Larvae with characteristic signs of nematode infection (body softness and creamy beige or red pigmentation) were transferred to separate modified traps for the isolation of invasive larvae (IJs). The IJs released after repeated rinsing with sterile water were applied to eight *G. mellonella* larvae in Petri dishes to check pathogenicity in accordance with Koch's postulates. The dead larvae were re-placed in modified traps to obtain pure IJs populations. The resulting invasive larvae were washed with sterile water and stored horizontally at a temperature of 11°C in 250 mL flasks (Gümüssoy et al. 2023).

Pest species and their identification

During the field research, insect pests were collected at various stages. Pest species have been identified using various species identifiers of various taxonomic groups of invertebrates and methodological guidelines and instructions. Currently, 117 species of insects have been identified on the Sievers apple tree in the study area; among them, the species of the Lepidoptera order (54 species), Coleoptera (30 species), and Homoptera (19 species) are dominant. In addition, Hymenoptera (6 species), Diptera (5 species), Thysanoptera (2 species), and Hemiptera (1 species) were noted among the pests of apple trees. As a result of the research, the insect species that damage wild populations of the wild apple tree in the Iley and Zhetysu Alatau have been listed (Table S1). The number of insect species associated with wild populations of the Sievers apple tree is shown in Figure 3.

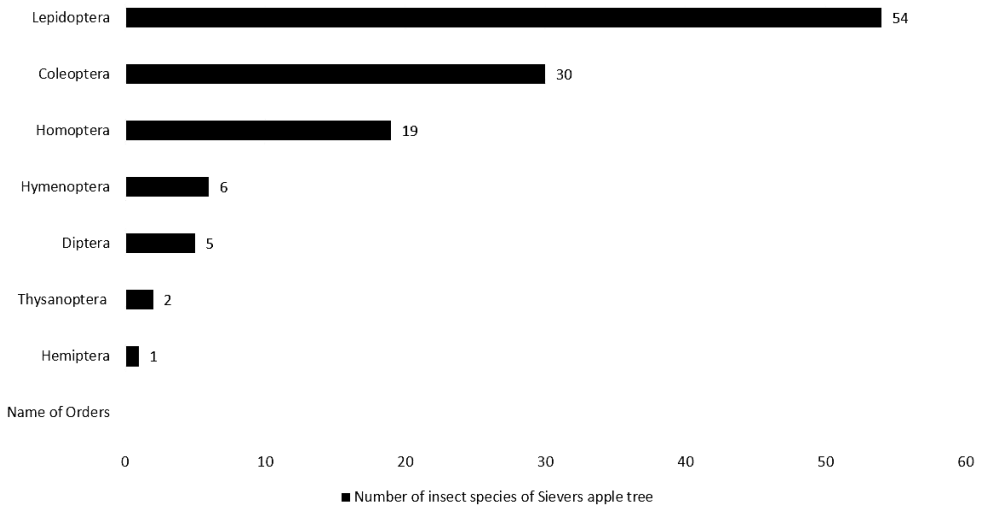

Figure 3. Insect species that are associated with wild populations of the Sievers apple tree

Table S1. Check-list of Insect species damaged wild populations of Malus sieversii (Ledeb.) M. Roem. in Iley and Zhetysu Alatau

Type Arthropoda
Class Insecta
Order Hemiptera
Suborder Aphidinea

Family Aphididae
1. *Aphis pomi* (De Geer, 1773)
2. *Dysaphis mali* (Ferrari, 1872)
3. *Dysaphis devecta* (Walker, 1849)
4. *Eriosoma lanigerum* (Hausmann, 1802)

Suborder Psyllinea

Family Psyllidae
5. *Psylla mali* (Schmidberger, 1836)
6. *Psylla pyri* (Linnaeus, 1758)

Suborder Cicadinea

Family Cicadellidae
7. *Typhlocyba rosae* (Linnaeus, 1758)

Suborder Coccinea

Family Diaspididae
8. *Epidiaspis leperii* (Signoret, 1869)
9. *Diaspidiotus prunorum* (Laing, 1931)
10. *Diaspidiotus ostreaeformis* (Curtis, 1843)
11. *Lepidosaphes ulmi* (Linnaeus, 1758)
12. *Lepidosaphes malicola* (Borchsenius, 1947)

Family Coccidae
13. *Parthenolecanium corni* (Bouché, 1844)
14. *Parthenolecanium persicae* (Fabricius, 1776)
15. *Eulecanium tiliae* (Linnaeus, 1758)
16. *Palaeolecanium bituberculatum* (Signoret, 1873)
17. *Rhodococcus turanicus* (Archangelskaya, 1937)

Family Eriococcidae
18. *Acanthococcus lagerstroemiae* (Kuwana, 1907)

Family Pseudococcidae
19. *Coccura comari* (Kunow, 1880)

Suborder Heteroptera

Family Tingidae
20. *Stephanitis pyri* (Fabricius, 1775)

Order Thysanoptera

Family Phlaeothripidae
21. *Haplothrips reuteri* (Karny, 1907)
22. *Frankliniella intonsa* (Trybom, 1895)

Order Coleoptera

Family Scarabaeidae
23. *Phyllopertha horticola* (Linnaeus, 1758)
24. *Maladera holosericae* (Scopoli, 1772)
25. *Epicometis hirta* (Poda, 1761)
26. *Oxythyrea funesta* (Poda, 1761)

Family Cerambycidae
27. *Tetrops praeusta* (Linnaeus, 1758)
28. *Cleroclytus semirufus collarius* (Jakovlev, 1885)
29. *Molorchus schmidti* (Ganglbauer, 1883)
30. *Turanium badenkoi* (Danilevsky, 2001)
31. *Trichoferus campestris* (Faldermann, 1835)
32. *Tetrops formosus bivittulatus* (Jankowski, 1934)
33. *Tetrops formosus songaricus* (Kostin, 1973)

Family Curculionidae
34. *Anthonomus pomorum* (Linnaeus, 1758)
35. *Sciaphobus squalidus* (Gyllenhal, 1834)
36. *Phyllobius pyri* (Linnaeus, 1758)
37. *Psalidium maxillosum* (Dejean, 1821)
38. *Phyllobius urticae* (De Geer, 1775)
39. *Phyllobius oblongus* (Linnaeus, 1758)

Family Rhynchitidae
40. *Rhynchites bacchus* (Linnaeus, 1758)
41. *Rhynchites giganteus* (Kryn, 1832)
42. *Neocoenorhinidius pauxillus* (Germar, 1824)

43. *Coenorrhinus aequatus* (Linnaeus, 1767)
44. *Haplorhynchites caeruleus* (De Geer, 1775)

Family Chrysomelidae

45. *Chrysomela tremulae* (Fabricius, 1787)
46. *Melasoma populi* (Linnaeus, 1758)
47. *Luperus xanthopoda* (Schrank, 1781)

Family Scolytidae

48. *Scolytus mali* (Bechstein, 1805)
49. *Scolytus rugulosus* (Müller, 1818)
50. *Xyleborus dispar* (Fabricius, 1792)

Family Buprestidae

51. *Chrysobothris affinis nevskyi* (Richter, 1944)

Family Anobiidae

52. *Cacotemnus rufipes* (Fabricius, 1792)

Order Hymenoptera

Family Pamphiliidae

53. *Neurotoma saltuum* (Linnaeus, 1758)

Family Tenthredinidae

54. *Hoplocampa testudinea* (Klug, 1816)
55. *Croesus septentrionalis* (Linnaeus, 1758)
56. *Hoplocampa brevis* (Klug, 1816)
57. *Hoplocampa minuta* (Christ, 1791)

Family Torymidae

58. *Torymus druparum* (Boheman, 1834)

Order Diptera

Family Cecidomyiidae

59. *Dasyneura pyri* (Bouché, 1847)
60. *Dasyneura mali* (Kieffer, 1904)
61. *Thomasiniana oculiperda* (Rubsaamen, 1893)

Family Agromyzidae

62. *Phytomyza heringiana* (Hendel, 1922)

Family Tephritidae

63. *Rhagoletis pomonella* (Walsh, 1867)

Order Lepidoptera

Family Tortricidae

64. *Cydia (Laspeyresia) pomonella* (Linnaeus, 1758)
65. *Laspeyresia pyrivora* (Danilevsky, 1947)
66. *Spilonota albicana* (Motschulsky, 1866)
67. *Grapholita molesta* (Busck, 1916)
68. *Spilonota ocellana* (Denis & Schiffermuller, 1775)
69. *Archips rosana* (Linnaeus, 1758)
70. *Archips crataegana* (Hübner, 1799)
71. *Archips podana* (Scopoli, 1763)
72. *Acleris variegana* (Denis & Schiffermuller, 1775)
73. *Argyrotaenia ljungiana* (Thunberg, 1797)
74. *Eupoecilia ambiguella* (Hubner, 1796)
75. *Hedya nubiferana* (Haworth, 1811)
76. *Cacoecia xylosteana* (Linnaeus, 1758)
77. *Ptycholoma lecheana* (Linnaeus, 1758)
78. *Adoxophyes orana* (Fischer v.Roslerstamm, 1834)
79. *Ancylis selenana* (Guenee, 1845)
80. *Acleris ferrugana* (Denis & Schiffermuller, 1775)

Family Glyphipterygidae

81. *Simaethis pariana* (Clerck, 1759)

Family Yponomeutidae

82. *Yponomeuta malinellus* (Zeller, 1838)
83. *Yponomeuta padellus* (Linnaeus, 1758)

Family Gemiostomidae

84. *Leucoptera malifoliella* (Costa, 1836)
85. *Argyresthia conjugella* (Zeller, 1839)
86. *Cemiostoma scitella* (Zeller, 1839)

Family Lyonetiidae

87. *Lyonetia clerckella* (Linnaeus, 1758)

Family Momphidae

88. *Lastodacna putripennella* (Zeller, 1839)

Family Lithocolletidae

89. *Callisto denticulella* (Thunberg, 1794)

90. *Gammaornix petiolella* (Frey, 1863)
91. *Lithocolletis blancardella* (Fabricius, 1777)
92. *Lithocolletis corilifoliella* (Hübner, 1796)

Family Gelechiidae

93. *Anarsia lineatella* (Zeller, 1839)
94. *Recurvaria nanella* (Denis & Schiffermüller, 1775)
95. *Recurvaria leucatella* (Clerck, 1759)

Family Stigmeleidae

96. *Stigmella malella* (Stainton, 1854)

Family Coleophoridae

97. *Coleophora hemerobiella* (Scopoli, 1763)

Family Pyralidae

98. *Eurrhypara hortulata* (Linnaeus, 1758)

Family Geometridae

99. *Operophtera brumata* (Linnaeus, 1758)
100. *Erannis defoliaria* (Clerck, 1759)
101. *Oporinia autumnata* (Borkhausen, 1794)
102. *Lycia hirtaria* (Clerck, 1759)
103. *Chloroclystis rectangulata* (Linnaeus, 1758)
104. *Opisthograptis luteolata* (Linnaeus, 1758)

Family Noctuidae

105. *Autographa gamma* (Linnaeus, 1758)
106. *Atethmia ambusta* (Denis & Schiffermuller, 1775)
107. *Agrotis segetum* (Denis & Schiffermuller, 1775)
108. *Agrotis ipsilon* (Hufnagel, 1766)
109. *Apatele tridens* (Denis & Schiffermüller, 1775)

Family Lymantriidae

110. *Euproctis chrysorrhoea* (Linnaeus, 1758)
111. *Lymantria dispar* (Linnaeus, 1758)
112. *Orgya antiqua* (Linnaeus, 1758)

Family Cossidae

113. *Zeuzera pyrina* (Linnaeus, 1761)
114. *Cossus cossus* (Linnaeus, 1758)

Family Arctiidae

115. *Phragmatobia fuliginosa* (Linnaeus, 1758)
116. *Hyphantria cunea* (Drury, 1773)

Family Pieridae

117. *Aporia crataegi* (Linnaeus, 1758)

RESULTS AND DISCUSSION

Kazakhstan has a variety of species. Meanwhile, entomological information, even on many cultivated plants, is still extremely poor. Suffice it to say that currently, the pest fauna of the Sievers apple tree consists of 117 species of insects with large populations. The occurrence and number of species differ in the territory of the Iley and Zhetysu Alatau (Table 2). This table shows the following families have a high occurrence of species in the Iley Alatau: Aphididae, Diaspididae, Phlaeothripidae, Scolytidae, and Tortricidae. In the Zhetysu Alatau, families have a high occurrence of species: Phlaeothripidae, Cecidomyiidae, Tortricidae, Yponomeutidae, Gemiostomidae, and Stigmeleidae.

In the Iley Alatau, the average occurrence of species namely Psyllidae, Coccidae, Cerambycidae, Curculionidae, Rhynchitidae, Tenthredinidae, Cecidomyiidae, Yponomeutidae, Gemiostomidae, Lyonetiidae, Stigmeleidae, Lymantriidae, Cossidae, and Arctiidae. In the Zhetysu Alatau, the average occurrence of species are Aphididae, Psyllidae, Diaspididae, Coccidae, Curculionidae, Rhynchitidae, Scolytidae, Tenthredinidae, Lymantriidae, Cossidae, and Arctiidae. In the Iley Alatau, families have a rare occurrence of species namely Cicadellidae, Eriococcidae, Pseudococcidae, Tingidae, Chrysomelidae, Buprestidae, Pamphiliidae, Glyphipterygidae, Lyonetiidae, Momphidae, Lithocolletidae, Gelechiidae, Pyralidae, Geometridae, Noctuidae, and Pieridae. In Zhetysu Alatau, families have a rare occurrence of species namely Cicadellidae, Scarabaeidae, Cerambycidae, Chrysomelidae, Buprestidae, Anobiidae, Torymidae, Agromyzidae, Tephritidae, Lyonetiidae, Momphidae, Lithocolletidae, Gelechiidae, Coleophoridae, Pyralidae, Geometridae, Noctuidae, and Pieridae. Species found only in the Iley or Zhetysu Alatau have also been found (Table 3).

The degree of harmfulness of insects is not uniform and varies significantly. In this regard, the insect pests of the Sievers apple tree are divided into six main complexes according to the degree of harmfulness (i) species that are constantly in mass reproduction; (ii) species that periodically give outbreaks of mass reproduction; (iii) species that appear in significant numbers in some years and cause significant harm; (iv) species with small numbers and little noticeable harmfulness; (v) rare species found in isolated individuals; (vi) species that accidentally damage the Sievers apple tree. Pests that constantly in mass reproduction are capable of reducing the harvest annually or destroying it completely if appropriate measures pest control are not taken in a timely manner.

Table 2. Comparison of the Iley and Zhetysu Alatau by the occurrence of species and the number of species damaging the Sievers apple tree

Order	Iley Alatau		Zhetysu Alatau	
	No. of species	Occ. of species	No. of species	Occ. of species
Hemiptera				
Family Aphididae	4	+++	3	++
Family Psyllidae	2	++	1	++
Family Cicadellidae	1	+	1	+
Family Diaspididae	5	+++	4	++
Family Coccidae	5	++	4	++
Family Eriococcidae	1	+	0	-
Family Pseudococcidae	1	+	0	-
Suborder Heteroptera				
Family Tingidae	1	+	0	-
Thysanoptera				
Family Phlaeothripidae	2	+++	2	+++
Coleoptera				
Family Scarabaeidae	4	+	4	+
Family Cerambycidae	6	++	5	+
Family Curculionidae	6	++	6	++
Family Rhynchitidae	4	++	6	++
Family Chrysomelidae	1	+	3	+
Family Scolytidae	3	+++	5	++
Family Buprestidae	1	+	1	+
Family Anobiidae	0	-	1	+
Hymenoptera				
Family Pamphiliidae	1	+	0	-
Family Tenthredinidae	4	++	4	++
Family Torymidae	0	-	1	+
Diptera				
Family Cecidomyiidae	2	++	3	+++
Family Agromyzidae	0	-	1	+
Family Tephritidae	0	-	1	+
Lepidoptera				
Family Tortricidae	17	+++	14	+++
Family Glyphipterygidae	1	+	0	-
Family Yponomeutidae	2	++	2	+++
Family Gemiostomidae	3	++	3	+++
Family Lyonetiidae	1	++	1	+
Family Momphidae	1	+	1	+
Family Lithocolletidae	4	+	2	+
Family Gelechiidae	2	+	3	+
Family Stigmeleidae	1	++	1	+++
Family Coleophoridae	0	-	1	+
Family Pyralidae	1	+	1	+
Family Geometridae	5	+	6	+
Family Noctuidae	5	+	5	+
Family Lymantriidae	3	++	3	++
Family Cossidae	2	++	2	++
Family Arctiidae	2	++	2	++
Family Pieridae	1	+	1	+

Notes: + - rare occurrence of species; ++ - average occurrence of species; +++ - high occurrence of species. The numbers indicate the number of species themselves from the marked families

Species (13) that are constantly in mass reproduction are *Cydia (Laspeyresia) pomonella* Linnaeus, 1758; *Archips rosana* Linnaeus, 1758; *Archips crataegana* Hübner, 1799; *Yponomeuta malinellus* Zeller, 1838; *Yponomeuta padellus* Linnaeus, 1758; *Grapholita molesta* Busck, 1916; *Aphis pomi* De Geer, 1773; *Lepidosaphes ulmi* Linnaeus, 1758; *Lepidosaphes malicola* Borchsenius, 1947; *Haplothrips reuteri* Karny, 1907; *Dasyneura mali* Kieffer, 1904; *Stigmella malella* Stainton, 1854; and *Anthonomus pomorum* Linnaeus, 1758.

Table 3. Comparison of the Iley and Zhetysu Alatau as found on the Sievers apple tree.

Species diversity
Only found on Iley Alatau
Dysaphis mali (Ferrari, 1872)
Psylla pyri (Linnaeus, 1758)
Lepidosaphes malicola (Borchsenius, 1947)
Parthenolecanium persicae (Fabricius, 1776)
Acanthococcus lagerstroemiae (Kuwana, 1907)
Coccura comari (Kunow, 1880)
Stephanitis pyri (Fabricius, 1775)
Turanium badenkoi (Danilevsky, 2001)
Tetrops formosus bivittulatus (Jankowski, 1934)
Spilonota albicana (Motschulsky, 1866)
Eupoecilia ambiguella (Hubner, 1796)
Cacoecia xylosteana (Linnaeus, 1758)
Simaethis pariana (Clerck, 1759)
Lithocolletis corilifoliella (Hübner, 1796)
Callisto denticulella (Thunberg, 1794)
Only found on Zhetysu Alatau
Tetrops formosus songaricus Kostin 1973
Neocoenorhinidius pauxillus Germar 1824
Cacotemnus rufipes Fabricius 1792
Torymus druparum Boheman 1834
Dasyneura pyri Bouché 1847
Phytomyza heringiana Hendel 1922
Recurvaria leucatella Clerck 1759
Coleophora hemerobiella Scopoli 1763
Operophtera brumata Linnaeus 1758

The results show that the apple moth *C. pomonella* is still ubiquitous in Kazakhstan, causing large losses in fruit harvesting every year. The main pests among leafhoppers are *A. rosana* (Piekarska-Boniecka et al. 2019) and hawthorn leafhopper *A. crataegana*, which have a high degree of population and abundance (Tanabekova et al. 2020). The apple moth *Y. malinella* (Narmanlioğlu and Çoruh 2017) is the main pest of apple trees in the Northern Tien Shan. An example is the outbreak of mass reproduction of the apple moth in 1998-2003 in the Zhetysu Alatau and 2008-2011 in the Iley Alatau when unique Sievers apple trees were threatened with extinction. Ermine hawthorn moth *Y. padellus*, constantly reproduces in huge quantities on the territory of the Zhetysu Alatau. Oriental fruit moth *G. molesta* is an object of internal quarantine, willingly settling on apple trees and other fruit and berry crops. Several dozen species of aphids harm the Sievers apple tree, the most important being the green apple aphid *A. Romi* (Dampo et al. 2020), which reproduces in bulk on seedlings, saplings, and young trees in the southeast and south of the country.

The apple-shaped shield *of L. ulmi* in recent years has multiplied in huge numbers in the southeast of Kazakhstan. Reuter's thrips, *H. reuteri*, is a polyphage found in large quantities on apple trees and the flowers of wild and cultivated plants. Apple gallica *D. mali*, this species' range covers the entire apple-growing area. In Kazakhstan, it is spread throughout all areas of fruit growing and wild fruit forests in the southeast of the country. The apple blossom

eater *A. pomorum*, which has a mass distribution, can destroy most of the buds and reduce the yield. It damages mainly apple and pear trees. Each species has specific features regarding the duration, scale, and nature of outbreaks, as well as the intervals between them and the conditions that generate them. Thus, 13 species of pests are known on the Sievers apple tree in Kazakhstan, constantly multiplying in large quantities. Systematic control of these pests is necessary (Agnello et al. 2017). Unfortunately, most of them, such as aphids and coccidae, apple gallica, Reiter's thrips, are not controlled.

Species (15) that periodically appear in mass reproduction on the Sievers apple tree are *Cemiostoma scitella* Zeller, 1839*; Lyonetia clerckella* Linnaeus, 1758*; Psylla mali* Schmidberger, 1836*; Eurrhypara hortulata* Linnaeus, 1758*; Parthenolecanium corni* Bouché, 1844*; Epicometis hirta* Poda, 1761*; Scolytus mali* Bechstein, 1805*; Scolytus rugulosus* Müller, 1818*; Spilonota ocellana* Denis and Schiffermuller, 1775*; Adoxophyes orana* Fischer v.Roslerstamm, 1834*; Leucoptera malifoliella* Costa, 1836*; Hyphantria cunea* Drury, 1773*; Euproctis chrysorrhoea* Linnaeus, 1758*; Operophtera brumata* Linnaeus, 1758*; Simaethis pariana* Clerck, 1759.

These species periodically appear in mass quantities. In the years of mass reproduction, partly due to the suddenness of their emergence, they are capable of causing very great damage. There are about 15 species of such pests. The areas covered by outbreaks of mass reproduction, which took place almost everywhere, can be either exceptionally large or small areas like the *P. corni* and *R. turanicus*. The American white butterfly, *H. cunea*, was massively distributed in Zhambyl and Almaty regions in 2004. In the southeast of Kazakhstan, in some years, the caterpillars of the winter moth, *O. brumata*, completely devour the leaves, and the trees remain bare, as if after a fire (Mannai et al. 2017). The trees are depleted and shrink when damaged again. Copperhead or apple leaf block *P. mali* in Kazakhstan harms mainly the gardens in West Kazakhstan and Almaty regions. During the years of mass reproduction by the *E. pruni*, premature yellowing and leaf fall are observed.

Species (47) appeared in large numbers in some years and caused significant harm to the Sievers apple tree in Kazakhstan namely *Lymantria dispar* Linnaeus, 1758*; Aporia crataegi* Linnaeus, 1758*; Eriosoma lanigerum* Hausmann, 1802*; Rhynchites bacchus* Linnaeus, 1758*; Dysaphis mali* Ferrari, 1872*; Coleophora hemerobiella* Scopoli, 1763*; Dysaphis devecta* Walker, 1849*; Typhlocyba rosae* Linnaeus, 1758*; Epidiaspis leperii* Signoret, 1869*; Eulecanium tiliae Linnaeus, 1758; Palaeolecanium bituberculatum* Signoret, 1873*; Stephanitis pyri* Fabricius, 1775*; Luperus xanthopoda* Schrank, 1781*; Xyleborus dispar* Fabricius, 1792*; Hoplocampa testudinea* Klug, 1816*; Hoplocampa minuta* Christ, 1791*; Croesus septentrionalis* Linnaeus, 1758*; Thomasiniana oculiperda* Rubsaamen, 1893*; Laspeyresia pyrivora* Danilevsky, 1947*; Acleris variegana* Denis and Schiffermuller, 1775*; Argyrotaenia ljungiana* Thunberg, 1797*; Hedya nubiferana* Haworth, 1811*; Ptycholoma lecheana* Linnaeus, 1758*; Ancylis selenana* Guenee, 1845*; Acleris ferrugana* Denis and Schiffermuller, 1775*; Frankliniella intonsa* Trybom, 1895*; Maladera holosericae* Scopoli, 1772*; Oxythyrea funesta* (Poda, 1761*; Psalidium maxillosum* (Dejean, 1821*; Phyllobius urticae* (De Geer, 1775*; Lycia hirtaria* Clerck, 1759*; Chloroclystis rectangulata* Linnaeus, 1758*; Opisthograptis luteolata* Linnaeus, 1758*; Autographa gamma* Linnaeus, 1758*; Zeuzera pyrina* Linnaeus, 1761*; Phragmatobia fuliginosa* Linnaeus, 1758*; Argyresthia conjugella* Zeller, 1839*; Anarsia lineatella* Zeller, 1839*; Recurvaria nanella* Denis and Schiffermüller, 1775*; Recurvaria leucatella* Clerck, 1759*; Erannis defoliaria* Clerck, 1759*; Oporinia autumnata* Borkhausen, 1794*; Atethmia ambusta* Denis and Schiffermuller, 1775*; Agrotis segetum* Denis and Schiffermuller, 1775*; Cossus cossus* Linnaeus, 1758*; Cleroclytus semirufus collarius* Jakovlev, 1885*; Rhodococcus turanicus* Archangelskaya, 1937

The third group includes many species that appear in significant numbers in some years and cause noticeable damage. In some cases, these damages are observed only on individual sites of Sievers apple trees, while in others, more extensive spaces are covered. Some of these species, under particularly favorable conditions of development, are capable of turning into mass pests (Myers and Sarfraz 2017).

Species (18) with small numbers and little noticeable harmfulness namely *Chrysomela tremulae* Fabricius, 1787*; Lithocolletis corilifoliella* Hübner, 1796*; Callisto denticulella* Thunberg, 1794*; Gammaornix petiolella* Frey, 1863*; Lithocolletis blancardella* Fabricius, 1777*; Apatele tridens* Denis and Schiffermüller, 1775*; Turanium badenkoi* Danilevsky, 2001*; Diaspidiotus prunorum* Laing, 1931*; Phyllopertha horticola* Linnaeus, 1758*; Phyllobius pyri* Linnaeus, 1758*; Phyllobius oblongus* Linnaeus, 1758*; Phytomyza heringiana* Hendel, 1922*; Cacoecia xylosteana* Linnaeus, 1758*; Molorchus schmidti* Ganglbauer, 1883*; Tetrops formosus bivittulatus* Jankowski, 1934*; Tetrops formosus songaricus* Kostin, 1973*; Sciaphobus squalidus* Gyllenhal, 1834*; Haplorhynchites caeruleus* De Geer, 1775.

There are species with a small number and little noticeable harmfulness on species. The species of the fourth group are usually found in small quantities, and their harmfulness does not reach the size. Rare species (12) found in isolated individuals on the Sievers apple tree namely *Rhagoletis pomonella* Walsh, 1867*; Tetrops praeusta* Linnaeus, 1758*; Neocoenorhinidius pauxillus* Germar, 1824*; Coenorrhinus aequatus* Linnaeus, 1767*; Melasoma populi* Linnaeus, 1758*; Hoplocampa brevis* Klug, 1816*; Torymus druparum* Boheman, 1834*; Agrotis ipsilon* Hufnagel, 1766*; Orgya antiqua* Linnaeus, 1758*; Dasyneura pyri* Bouché, 1847*; Diaspidiotus ostreaeformis* Curtis, 1843*; Trichoferus campestris* Faldermann, 1835.

There are rare species among the pests of the Sievers apple tree, which occupy a significant place. They are usually found in isolated individual trees and completely unrelated to pests. There are about 12 such species; in quantitative terms, they are second only to accidental pests. Similarly, the insect pests of the Sievers apple tree were divided into accidentally damaging species namely *Psylla*

pyri Linnaeus, 1758*; Rhynchites giganteus* Kryn, 1832*; Neurotoma saltuum* Linnaeus, 1758*; Spilonota albicana* Motschulsky, 1866*; Archips podana* Scopoli, 1763*; Eupoecilia ambiguella* Hubner, 1796*; Parthenolecanium persicae* Fabricius, 1776; *Acanthococcus lagerstroemiae* Kuwana, 1907*; Coccura comari* Kunow, 1880*; Chrysobothris affinis nevskyi* Richter, 1944*; Cacotemnus rufipes* Fabricius, 1792*; Lastodacna putripennella* Zeller, 1839.

Finally, at least 12 species of insects and mites are registered on the Sievers apple tree. They belong to the category of accidental; their damage is insignificant, temporary, and characteristic of the vast majority of omnivorous insects. There are also imported pests from other regions. They get in for different reasons and in different ways. In the absence of regular nutrition, they are forced to eat fruit and berry plants (Mall et al. 2018).

Thus, from the point of view of harmfulness assessment, all insects living on the Sievers apple tree are divided into pests of varying degrees (Figure 4). The latter significantly prevail in terms of the number of species but are much inferior to the former in terms of the abundance of individuals. Insects' food specialization and feeding relationships are extremely important in plant protection. In many cases, developing pest control measures is impossible without careful consideration of their host plants and different pest populations.

The fertility and abundance of species largely depend on insects' feeding habits and the usefulness of food. In this regard, trees suffer uneven damage. Among the complex of specific pests, two aspects of the species are distinguished. Representatives of the first aspect, which is more numerous, feed on all or most types of fruit and berry plants. These include the following species: *H. cunea*, *Y. padellus*, *G. molesta*, *A. rosana*, *A. crataegana*, *H. reuteri*, *C. scitella*, *P. corni*, *R. turanicus*, *E. hirta*, *S. rugulosus*, *S. ocellana*, *A. orana*, *L. malifoliella*, *H. cunea*, *E. chrysorrhoea*, *O. brumata*, *S. pariana*, *C. hemerobiella*, *E. hortulata* and so on. The species of the second aspect are characterized by monophagy. The following species are known on the Sievers apple tree: *C. pomonella*, *A. pomi*, *D. mali*, *S. malella*, *S. mali*, *D. mali*, *E. lanigerum*, *P. heringiana*, *B. putripennella*, and *R. nanella*.

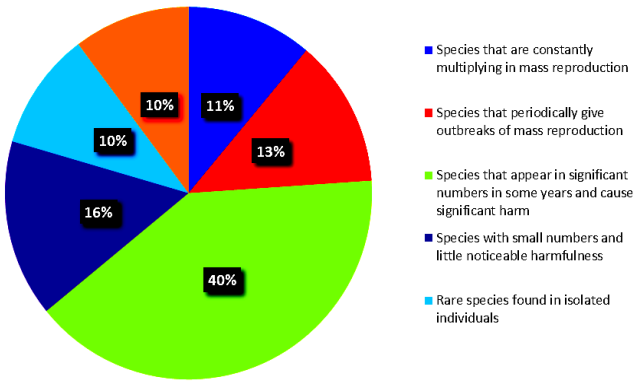

Figure 4. Six main harmful complexes of the Sievers apple tree in Kazakhstan

The highest percentage of olygophages is observed in gall-forming plants, miners, woodworms, and bark beetles, i.e., species leading a hidden lifestyle on plants. In this regard, the number of monophagous, for example, on the rosehip, is significantly higher than on the apple tree. However, it is incomparably richer in pest fauna than the rosehip. However, several species of gall flies, mining flies, and mining moths develop on the apple tree, which produces a higher percentage of monophagous. Several omnivorous pest species periodically give outbreaks of mass reproduction, but the majority of species feed on apple leaves (Jashenko et al. 2023). Without their usual food plants, they are forced to eat fruit and berry crops. Many insects' forage specialization manifests itself not only in certain plants but also in their individual parts. Some adapt to eat and harm several plant organs (the majority), while others specialize in any one. They also feed on other parts of plants, but in the adult stage, they prefer flowers.

It lives on branches and trunks (*S. mali*, *S. Rugulosus*), types of shields (*L. ulmi*, *E. leperii*) and types of false shields (*P. corni*, *R. turanicus*), a number of species of goldfinches, barbels, and bark beetles (*H. caeruleus*, *L. dispar*). Among this insect complex, in turn, there is a differentiation in the way of nutrition and the nature of damage to plants. Aphids and coccidae suck the bark juices, often causing depletion and death of forage plants. Bark beetles, elephants, and glassworms specialize in feeding bark tissues partially with sapwood. Goldfinches, barbels, and woodworms are specific inhabitants of the wood of plants. Thus, the forage attachment of pests is manifested not only in various taxonomic groups of plants but also in their individual organs.

Totally, 50 soil samples were selected: 25 from the Ile-Alatau National Park and 25 from the Zhetysu-Alatau National Park. As a result of the studies, entomopathogenic nematodes were found in 11 samples, which is 22% of the total. Based on the morphological analysis, all positive samples were assigned to the genus Steinernema sp. This result indicates the moderate presence of entomopathogenic nematodes in the soils of these national parks, which highlights their potential role in the natural regulation of insect pest populations in these ecosystems.

In conclusion, it should be noted that the fauna of harmful insects in the apple tree is mixed and very complex. This is due to the vastness of the surveyed territory, the presence in the list of species, representatives of the most diverse groups of the insect class, the diversity of apple trees, and the significant species richness of non-specific and accidental pests. Pests that are constantly moving in mass quantities cause the greatest economic impact. The diversity of apple trees further complicates the situation, necessitating a comprehensive approach to pest control. Suppose appropriate measures are not taken in a timely manner. In that case, we risk the irreversible deterioration of the health of infested Sievers apple forests, this ancient Tian Shan econiche, across huge areas.

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