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Hemiptera (Heteroptera) of the Infraorder Pentatomomorpha II of the Ile-Alatau State National Natural Park

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ABSTRACT

Field research was undertaken in the Ile-Alatau State National Natural Park, Kazakhstan, between 2020 and 2021, to elucidate the diversity of the hemipteran infraorder Pentatomomorpha II. The investigation focused on two prevalent families within the infraorder: Pentatomidae and Scutelleridae. The objective was to delineate species composition, distribution patterns, and ecological attributes within these taxa. The researchers conducted field surveys within the Ile-Alatau State National Natural Park to identify and classify hemipteran insects belonging to the infraorder Pentatomomorpha II. They employed taxonomic methods and ecological observations to categorize the identified species into various groups based on their life forms, trophic specialization, food preferences, number of generations per year, and habitat preferences. A total of 34 hemipteran species were identified in the park's ecosystem, with taxonomic classification revealing a disproportionately high representation of the family Pentatomidae, which accounted for 30 species (88% of the total). In contrast, the family Scutelleridae comprised a mere 4 species (12%). These findings contribute to a more comprehensive understanding of Pentatomomorpha II diversity within this region and provide a foundation for further ecological and conservation studies.

1. INTRODUCTION

Hemipterans represent one of the most diverse insect orders in Kazakhstan, occupying a critical role within natural ecosystems. These insects are ubiquitous, inhabiting a range of environments from various desert types to subalpine and alpine meadows. Hemipterans exhibit a wide array of biological forms: although terrestrial species predominate, aquatic and surface-dwelling forms are also present. Owing to their diverse life forms, hemipterans occupy a key niche in the structure of biocenoses, playing a pivotal role in the functioning of myriad communities.

Characterized by incomplete metamorphosis, hemipterans undergo a developmental progression that includes the stages of egg, larva, and adult, with the overwintering phase occurring at different developmental stages. The majority of terrestrial hemipterans are phytophagous, feeding predominantly on the sap of plants, often targeting reproductive organs and seeds.

To date, a comprehensive, specialized study of the hemipteran infraorder Pentatomomorpha II within the Ile-Alatau State National Natural Park (SNNP) has not been conducted. This research seeks to fill this lacuna by exploring and documenting the biodiversity of this infraorder in the region. The objective is to provide a systematic account of species composition, distribution, and ecological attributes, thereby contributing to the broader understanding of their ecological roles and the health of the ecosystem.

The relevance of this study is underscored by the scarcity of prior systematic research into the Pentatomomorpha II fauna of the Ile-Alatau SNNP. This investigation is poised to enhance the existing body of knowledge regarding hemipteran interactions within their habitats and supports the development of informed conservation strategies. Moreover, the insights gleaned from this study may inform on the broader ecological implications, such as the resilience of these species to environmental perturbations and their role in the food web.

In essence, this study extends beyond mere taxonomic classification, delving into the intricate ecological relationships of hemipterans and setting the stage for subsequent research into the conservation and environmental impact within this biodiverse and unique region.

2. MATERIALS AND METHODS

The material for this study was derived from the collections and field observations conducted by the authors within the Ile-Alatau State National Natural Park (SNNP). These collections and observations followed established and standardized entomological methods [1-3], ensuring the reliability and comparability of the data.

Sampling Techniques: To capture the diversity of hemipteran species within the Ile-Alatau SNNP, various collection methods were employed. These methods were adapted to the specific ecological niches and life forms of the insects:

Mowing with Entomological Nets: This method was primarily used to collect hortobiont species, which are associated with herbaceous vegetation.

Mowing of Tree and Shrub Layers: To target dendro- and tamnobiont species, the authors conducted mowing activities in the tree and shrub layers of the park's ecosystem.

Manual Collection from Various Habitats: For epigeobionts, geo-herpetobionts, and herpetobionts, manual collection techniques were employed. This involved collecting hemipteran insects directly from the soil surface, as well as from litter and the root portions of plants.

Identification: To ensure accurate species identification, the authors employed a range of taxonomic references, including guides [4-15] and taxonomic revisions of genera. These references provided the necessary taxonomic information to distinguish and categorize the identified species.

Nomenclature: The nomenclature used for taxa in this study follows the standards established in the Catalog of Hemiptera of the Palaearctic [16], ensuring consistency and compatibility with existing taxonomic systems.

Geographic Scope: While the study is based on fieldwork conducted within the Ile-Alatau SNNP, specific information about the locations within the park where collections were made and the sample sizes are not provided. This additional information would enhance the study's comprehensiveness and enable readers to better understand the scope and representativeness of the data collected.

3. RESEARCH RESULTS

The following is an annotated list of identified species. Collection points, dates, brief information on biology and ecology are given for each species.

3.1 Family turtles-Scutelleridae

These are medium-sized bugs (usually 6-10 mm), having an oval, usually strongly convex body, with a large shield covering the abdomen. They feed on vegetation, sucking juices from leaves, seeds and stems of various herbaceous vegetation, trees and shrubs; some can harm crops, such as the harmful turtle *(Eurygaster integriceps)* [12, 15]. You can meet these bugs throughout the summer in fields overgrown with shrubs, on the edges of forests.

Odontotarsus obsoletus furvus (Kiritshenko, 1926). Ileyskiy Alatau, ur. Medeu, 21.06.2020, 2♀, 3♂; 12.07.2021, 1♀, 2♂; river floodplain M.Almatinka, 31.05.2020, 4♀, 2♂; ug. Aksai, 02.06.2021, 3♀, 2♂. Hortobiont (on cereal plants); mesophile (found mainly in the high mountain biocenoses of the Tien Shan); polyphytophage; monovoltine; adults hibernate [4, 5].

Eurygaster dilaticollis (Dohrn, 1860). Foothills of the Ileyskiy Alatau, Aksai gorge, env. With. Ushkonyr, 17.06.2020, 3♀, 1♂. Hortobiont; meso-xerophile (in virgin areas of the steppe, rarely in humid places, low-mountain meadows, rises to mountains to a height of up to 1300 m above sea level); broad oligophytophage (on cereals: *Stipa, Festuca, Phleum, Briza* and other cereals [6, 7]); monovoltine; adults hibernate.

Eurygaster maura. Foothills of the Ileyskiy Alatau, ok. With. Ushkonyr, 17.07.2020, 2♀, 1♂, 02.08.2021, 3♀, 2♂. Hortobiont; mesophilic (upland meadows, edges, clearings, grain crops, in relief depressions, on the northern slopes of hills, in the forest zone - in the mountains in open xerotopic, well-heated cenoses, up to 1000 m above sea level); broad oligophytophage (on cereals, cereals, as well as Compositae [4, 6, 17]; monovoltine; adults hibernate.

Eurygaster testudinaria testudinaria (Geoffroy, 1785). Ileyskiy Alatau, ur. Medeu, 21.06.2020, 2♀, 3♂; ug. Shymbulak, 02.07.2021, 4♀, 3♂; river floodplain B. Almatinka, 08/10/2021, 2♀, 3♂. Hortobiont; hygro-mesophilic (mostly in wet biotopes, swampy and shaded places); broad oligophytophage (on sedges, grasses, adults also occurs on Asteraceae, on herbaceous plants of other families: *Polygonum, Rumex, Agrimonia, Totilis, Achillea*); monovoltine; adults hibernate [6].

3.2 Family Pentatomidae

Arma custos (Fabricius, 1794). Almaty, 14.07.2020, 1♀, 2♂; 23.06.2021, 2♀, 2♂; Almaty region, Karasai district, with. Yntymak, forest belt, 10.08.2020, 2♀, 3♂; Ileyskiy Alatau, gorge. Aksay, 21.07.2020, 1♀, 1♂; ur. Medeu, 10.07.2021, 1♀, 2♂; 14.08.2021, 3♀, 8♂. Dendro-hortobiont (on solitary trees and shrubs, along the slopes of dry hills and mountains, edges, parks, shaded wet and swampy forest areas, in floodplain forests, especially on *Salix* willow and *Alnus* alder); mesophilic (mixed mesophilic forests, in the mountains up to 900-1300 m); zoophagous (feeds on various small arthropods, more often leaf beetle larvae, actively looking for prey); monovoltine; adults hibernate [6, 8].

Jalla dumosa (Linnaeus, 1758). Foothills of Ileyskiy Alatau, gorge. Aksai, 16.07.2020, 3♀, 2♂; 16.08.2021, 2♀, 1♂. Dendro-hortobiont (on various woody and herbaceous plants); mesophilic (forest-steppe zone, in the mountains within subalpine meadows, ecologically associated with mesophytic areas of sparse forests, forest meadows); zoophagous (feeds on various small arthropods); monovoltine; adults hibernate. It is also noted in the literature [6, 17] that bugs and larvae feed on the juices of aromatic plants, such as oregano *(Oryganum),* mint *(Mentha).*

Jalla subcalcarata (Jakovlev, 1885). Ileyskiy Alatau, gorge. Aksai, 21.06.2020, 1♀, 1♂; ur. Medeu, 05.08.2020, 1♀, 2♂; river floodplain B. Almatinka, 16.07.2021, 2♀, 2♂. Hortobiont; mesophilic (along mountain systems, sparse light coniferous and mixed forests, forest and alpine meadows, adults and larvae keep under stones and on grassy vegetation); zoophagous (feeds on various small arthropods) [6]; monovoltine; adults hibernate.

Picromerus bidens (Linnaeus, 1758). Ileyskiy Alatau, ur. Medeu, 21.06.2020, 2♀, 3♂; ug. Shymbulak, 22.07.2021, 4♀, 3♂; ug. B. Almatinka, 10.07.2021, 2♀, 1♂. Dendro-hortobiont (forest zone, forest-steppe, mountain-forest belt, in places it enters the steppes, broad-leaved, mixed and coniferous forests, it rises to the mountains to the upper border of the forest); mesophile (forest meadows, clearings, tree and shrub vegetation of river valleys, birch-aspen groves, occasionally on fallows and fields); zoophagous (various small arthropods, can occasionally feed on plant sap); monovoltine; eggs hibernate [9, 18].

Zicrona caerulea (Linnaeus, 1758). Ile-Alatau SNNP, Aksai forestry, floodplain of the river. Aksai, Kaskelen. 21.06.2020, 2♀, 3♂; 10.07.2021, 2♀, 1♂. Horto-tamno-dendrobiont; mesophilic (along floodplains in the steppe, in forests, tree plantations and near them, often on grasses, in meadows on *Polygonum sp.,* etc., in mountains up to 800-2600 m, in subalpine meadows); zoophagous (feeds on various small arthropods, destroys beetle larvae - leaf beetles *Haltica spp*.); monovoltine; adults hibernate [4].

Neottiglossa leporina (Herrich-Schaeffer, 1830). Ile-Alatau

SNNP, gorge. B. Almatinka, 10.07.2020, 2♀, 1♂; Talgar forestry, ur. Maralsay, 15.07.2020, 2♀, 1♂; 28.06.2021, 3♀, 2♂; ur. Belbulak, 23.07.2021, 4♀, 2♂. Hortobiont (on various cereals); mesophilic (steppe, steppe areas, floodplains, clearings and forest edges, parks, forest belts, deposits among fields, slopes of gentle hills, less often - on crops of cereal grasses); broad oligophytophage (mainly on *Poa*, less frequently on *Agrostis, Festuca, Stipa, Koeleria*); monovoltine; adults hibernate [4, 6].

Antheminia eurynota eurynota (Horvath, 1907). Ile-Alatau SNNP, Left Talgar, 29.06.2020, 2♀, 1♂; ug. Soldatskoe, 18.08.2021, 4♀, 3♂; Ileyskiy Alatau, gorge. Aksay, 14.07.2020, 5♀, 2♂; 26.07.2021, 2♀, 3♂. Hortobiont; mesophilic (on alpine meadow and steppe vegetation); polyphytophage; monovoltine; adults hibernate [19, 20].

Carpocoris melanocerus (Mulsant & Rey, 1852). Ile-Alatau SNNP, Issyk forestry, gorge. Issyk. 04.07.2020, 3♀, 1♂; Ileyskiy Alatau, ur. Medeu, 23.06.2021, 4♀, 3♂; Koktobe, gorge. Wide gap, 04.07.2020, 3♀, 1♂; 18.08.2021, 2♀, 3♂. Hortobiont; mesophile (mountain species, forest edges and glades, subalpine meadows, rare); polyphytophage (on various herbaceous plants, more often on plants of the genus *Verbascum*); monovoltine; adults hibernate [4, 10, 21].

Carpocoris purpureipennis (De Geer, 1773). Ileyskiy Alatau, ur. Medeu, 21.06.2020, 2♀, 3♂; ug. Shymbulak, 02.08.2021, 4♀, 3♂; ug. B. Almatinka, 10.07.2020, 2♀, 1♂; Ile-Alatau SNNP, Turgen forestry, gorge. Turgen. 24.06.2020, 2♀, 1♂; 08.08.2021, 2♀, 2♂. Hortobiont; mesophilic (in the steppe and forest zones, in floodplains, in the mountains up to 700-1000 m above sea level, in mesophytic meadows, edges and forest glades, edges of forest belts, parks and other places with forbs); polyphytophage (on Compositae, Umbelliferae, Labiaceae, and Grasses) [16]; monovoltine; adults hibernate [4, 10].

Carpocoris pudicus. Ileyskiy Alatau, gorge. Aksai, 13.07.2020, 3♀, 4♂; Ile-Alatau SNNP, Talgar forestry, gorge. Maralsay08.08.2021, 5♀, 4♂. Hortobiont; mesophile (low-mountain and subalpine meadows, 800-2400 m, edges and forest clearings, edges of forest belts, parks and other places with forbs; often in steppe regions on virgin areas and cultivated fields, in floodplain meadows); polyphytophage (on various plants: *Phlomis tuberosa, Myricaria, Caragana, Abies sibirica, Raponticum sp*.); monovoltine; adults hibernate. Imago of a new generation appears in mid-July [11].

Chlorochroa juniperina juniperina (Linneaus, 1758). Ileyskiy Alatau, ur. Medeu, 21.06.2020, 2♀, 3♂; 12.07.2021, 1♀, 2♂; ug. Aksai, 02.07.2020, 3♀, 2♂. Dendrobiont; mesophile (foothills, subalpine belt); broad oligophytophage (on larch, Scots pine, b.h. on juniper *Juniperus nana);* monovoltine; adults hibernate. New generation in early August [11].

Chlorochroa pinicola. (Ileyskiy Alatau, ur. Medeu, 17.06.2020, 2♀, 3♂; env. Almaty, Koktobe, 23.06.2021, 1♂; ug. M. Almatinka, 15.08.2021, 2♀, 1♂. Dendrobiont (on conifers: juniper, spruce, mostly on pine); mesophile (forest zone, forest-steppe, mountain-forest belt); narrow oligophytophage (species of the genus *Pinus*); monovoltine; adults hibernate [22].

Dolycoris baccarum (Linneaus, 1758). Ileyskiy Alatau, gorge. Aksai, 13.07.2020, 3♀, 4♂; ug. Shymbulak, 02.07.2021, 4♀, 3♂; ug. B. Almatinka, 10.07.2021, 2♀, 1♂; Ile-Alatau SNNP, Talgar forestry, gorge. Maralsay, 08.08.2021, 5♀, 4♂; Turgen forestry, gorge. Turgen. 14.07.2020, 2♀, 1♂. Euryhortobiont; mesophilic (common everywhere, in various mesophytic biotopes, including fields, gardens, along floodplains and river valleys); polyphytophage (on plants of many families; after wintering, adults feed on shoots and buds of many tree species, and in autumn, adults suck out the contents of their seeds and fruits, a pest of cultivated plants); monovoltine; adults hibernate. They feed on 58 plant species belonging to 24 families [22]. Harm is noted on many cultivated plants - wheat, corn, potatoes and other plants [12, 16].

Dolycoris penicillatus. Ileyskiy Alatau, gorge. Aksai, B. Almatinka, 27.06.2020, 4♀, 3♂; ur. Medeu, 16.07.2021, 3♀, 3♂; Koktobe, 08.07.2021, 4♀, 3♂; Ile-Alatau SNNP, Talgar forestry, gorge. Maralsay, 07/17/2021, 1♀, 1♂. Hortobiont; mesophilic (low-mountain and subalpine meadows, 800-2400 m, in various mesophytic biotopes); polyphytophage (on many wild herbaceous plants, a pest of agricultural plants: wheat, barley, sunflower, tomato, alfalfa, etc. [17]; monovoltine; adults overwinter. Overwinter on steppe slopes in large clusters (up to 100 or more individuals together) under stones, wormwood and mullein leaves.

Holcostethus capitatus. Foothills of Ileyskiy Alatau, gorge. Aksai, 12.07.2020, 5♀, 2♂; 08.08.2021, 2♀, 2♂. Hortobiont; mesophile (foothills and river valleys); polyphytophage (on various herbaceous plants); monovoltine; adults hibernate [4].

Holcostethus strictus vernalis. 02.07.2020, 2♀, 1♂; Almaty region, Karasai district, with. Yntymak, 10.07.2020, 2♀,1♂; Ile-Alatau SNNP, Kokbastau forestry, gorge. Soldatskoe. 17.08.2021, 1♀, 2♂. Hortobiont; mesophilic (in the forest and steppe zones; edges and forest clearings and other dry and well-heated biotopes, often on cultivated fields, in the mountains in subalpine meadows, 850-2300 m, near a stream); polyphytophage (after wintering, they are often found on berry bushes and trees (*Alnus, Acer*), but then fly off to open places; larvae develop mostly on Compositae, less often on legumes, cruciferous, umbelliferous, cereals and on plants of other families) [17]; monovoltine; adults hibernate.

Mimula alatavica (Kiritshenko, 1931). Ileyskiy Alatau, gorge. Alma-Arasan, 27.07.2020, 3♀, 2♂; ur. Medeu, 13.07.2021, 2♀, 3♂. Hortobiont; mesophile (high in the mountains); polyphytophage; monovoltine; adults hibernate [23].

Palomena prasina (Linnaeus, 1761). Almaty region, Karasai district, env. With. Kamenka, apple orchard, 28-30.06.2020, 9♀, 6♂; Ile-Alatau SNNP, Talgar forestry, gorge. Maralsay, 08.08.2021, 5♀, 4♂; Turgen forestry, gorge. Turgen. 14.07.2021, 2♀, 3♂. Tamnobiont dendro (on trees, imagoes, after leaving wintering, fly off to open places, including cultivated fields, later they return to forests, but mainly stay on the edges; larvae develop on herbaceous plants and shrubs); mesophile (apple and mixed forest); polyphytophage (more often on shrubs and trees: *Ribes, Rubus, Rosa, Quercus, Crataegus, Prunus, Sorbus, Acer, Fraxinus, Tilia, Betula, Alnus,* etc.); monovoltine; adults hibernate. New generation in early August [11].

Pentatoma rufipes (Linneaus, 1758). Ileyskiy Alatau, gorge. Aksai, B. Almatinka, 11.07.2020, 2♀, 3♂; ur. Medeu, 26.07.2021, 2♀, 3♂; Koktobe, 07/08/2021, 2♀, 3♂; Ile-Alatau SNNP, Talgar forestry, gorge. Maralsay, 17.08.2021, 1♀, 2♂. Dendro-tambiont; typically forest (mostly in deciduous forests, rises to the mountains to a height of up to 1700 m above sea level); mesophile; polyphytophage (on various trees and shrubs: *Quercus, Fagus, Tilia, Betula, Acer, Alnus, Corylus, Cornus* and others; sucks out vegetative and generative parts [6]; monovoltine; larvae hibernate (Table 1).

Table 1. Taxonomic composition of hemipterans of the infraorder Pentatomomorpha II of the Ile-Alatau SNNP

	Odontotarsus obsoletus furvus (Kiritshenko, 1926)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
Scutelleridae	*Eurygaster dilaticollis* (Dohrn, 1860)	chortobiont, meso-xerophile, wide oligophytophage, monovoltine, adults hibernate	4
	Eurygaster maura (Linnaeus, 1758)	chortobiont, mesophile, wide oligophytophage, monovoltine, adults hibernate	
	Eurygaster testudinaria testudinaria (Geoffroy, 1785)	chortobiont, hygro-mesophile, wide oligophytophage, monovoltine, adults hibernate	
	Arma custos (Fabricius, 1794)	dendro-hortobiont, mesophile, zoophage, monovoltine, adults hibernate	
	Jalla dumosa (Linnaeus, 1758)	dendro-hortobiont, mesophile, zoophage, monovoltine, adults hibernate	
	Jalla subcalcarata Jakovlev, 1885	chortobiont, mesophile, zoophage, monovoltine, adults hibernate	
	Picromerus bidens (Linnaeus, 1758)	dendro-hortobiont, mesophile, zoophage, monovoltine, eggs hibernate	
	Zicrona caerulea (Linnaeus, 1758)	chorto-tamno-dendrobiont, mesophile, zoophage, monovoltine, adults hibernate	
	Neottiglossa leporina (Herrich-Schaeffer, 1830)	chortobiont, mesophile, wide oligophytophage, monovoltine, adults hibernate	
	Antheminia eurynota eurynota (Horvath, 1907)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Carpocoris melanocerus (Mulsant & Rey, 1852)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
Pentatomidae	*Carpocoris purpureipennis* (De Geer, 1773)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	30
	Carpocoris pudicus (Poda, 1761)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Chlorochroa juniperina juniperina (Linneaus, 1758)	dendrobiont, mesophile, wide oligophytophage, monovoltine, adults hibernate	
	Chlorochroa pinicola (Mulsant & Rey, 1852)	dendrobiont, mesophile, narrow oligophytophage, monovoltine, adults hibernate	
	Dolycoris baccarum (Linneaus, 1758)	eurychortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Dolycoris penicillatus (Horvath, 1904)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Holcostethus capitatus (Jakovlev, 1889)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Holcostethus strictus vernalis (Wolff, 1804)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Mimula alatavica (Kiritshenko, 1931)	chortobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Palomena prasina (Linnaeus, 1761)	dendro-tamnobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Pentatoma rufipes (Linneaus, 1758)	dendro-tamnobiont, mesophile, polyphytophage, monovoltine, larvae hibernate	
	Piezodorus lituratus (Fabricius, 1794)	chorto-tamno-dendrobiont, mesophile, broad oligophytophage, monovoltine, adults hibernate	
	Sciocoris microphthalmus (Flor, 1860)	herpetobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Sciocoris umbrinus (Wolff, 1804)	herpetobiont, mesophile, polyphytophage, monovoltine, adults hibernate	
	Capnoda nigroaenea Jakovlev, 1887	chortobiont, mesophile, wide oligophytophage, monovoltine, adults hibernate	
	Eurydema oleracea (Linnaeus, 1758)	hortobiont, mesophile, wide oligophytophage, bivoltine, adults hibernate	
	Eurydema ornata (Linnaeus, 1758)	hortobiont, mesophile, wide oligophytophage, bivoltine, adults hibernate	
	Eurydema dominulus (Scopoli, 1763)	hortobiont, mesophile, wide oligophytophage, bivoltine, adults hibernate	
	Graphosoma consimile Horvath, 1903	hortobiont, mesophile, wide oligophytophage, bivoltine, adults hibernate	
	Graphosoma lineatum (Linnaeus, 1758)	hortobiont, mesophile, wide oligophytophage, bivoltine, adults hibernate	
	Oplistochilus pallidus (Jakovlev, 1887)	chortobiont, mesophile, narrow oligophytophage, monovoltine, adults hibernate	
	Sternodontus ampliatus (Jakovlev, 1887)	chortobiont, mesophile, monophytophage, monovoltine, adults hibernate	
2			34

Piezodorus lituratus (Fabricius, 1794). Ile-Alatau SNNP, Talgar forestry, gorge. Maralsay, 08.07.2020, 3♀, 4♂; Turgen forestry, gorge. Turgen. 14.08.2021, 2♀, 1♂. Horto-tamno-dendrobiont; mesophile (steppe, tall grass meadows, floodplain forest, edges, clearings, rises to the mountains to a height of up to 1500 m above sea level); broad oligophytophage (on various legumes Leguminosae: *Vicia, Caragana,* etc.; young adults are often found on many types of trees and shrubs [4, 6]; monovoltine; adults hibernate.

Sciocoris microphthalmus (Flor, 1860). Ileyskiy Alatau, gorge. Aksay, 23.06.2020, 2♀, 3♂; ur. Medeu, 16.07.2021, 2♀, 2♂. Herpetobiont (in the basal part of legumes, cereals, wormwood, etc.); mesophilic (steppe, forest-steppe, mountain-steppe belt, mesophytic and slightly arid areas located on sandy soils, on meadow-steppe and fescue-feather grass associations, in subalpine and low-mountain meadows, 1400-2500 m, glades and forest edges); polyphytophage (under *Ranunculus, Trollius, Thymus, Echium, Bromus, Scabiosa* and other plants [6]; monovoltine; adults hibernate.

Sciocoris umbrinus (Wolff, 1804). Ile-Alatau SNNP, Talgar forestry, gorge. Maralsay, 18.08.2020, 3♀, 2♂; Issyk forestry, gorge. Issyk. 24.06.2021, 2♀, 3♂. Herpetobiont; mesophilic (forest-steppe, in mesophytic habitats, prefers sandy and sandy soils overgrown with forbs, in the mountains up to 1200 m above sea level); polyphytophage (under various plants); monovoltine; adults hibernate [4, 6, 24].

Capnoda nigroaenea (Jakovlev, 1887). Ileyskiy Alatau, gorge. Aksai, 07.08.2020, 1♀, 2♂; ur. Medeu, 06/24/2020, 2♀, 3♂; 08/12/2021, 1♀, 2♂. Hortobiont; mesophilic (in alpine meadows: subalpine and alpine); broad oligophytophage (on buttercup Ranunculaceae); monovoltine; adults hibernate [6].

Eurydema oleracea (Linnaeus, 1758). Ileyskiy Alatau, gorge. Aksai, B. Almatinka, 11.07.2020, 4♀, 5♂; ur. Medeu, 16.07.2021, 3♀, 3♂; Koktobe, 08.07.2021, 4♀, 3♂; Ile-Alatau SNNP, Turgen forestry, gorge. Turgen, 17.08.2021, 3♀, 4♂. Hortobiont; mesophile (steppe, floodplain, wasteland, forests, subalpine meadows, 800-2400 m, edges, clearings, meadows, relief depressions in the steppe and other more or less humid biotopes); broad oligophytophage (on various cruciferous plants); bivoltine; adults hibernate [4, 13].

Eurydema ornata (Linnaeus, 1758). Ile-Alatau SNNP, Turgen forestry, gorge. Turgen, 17.06.2020, 3♀, 4♂; Talgar

forestry, gorge. Maralsay, 08.08.2021, 3♀, 2♂; Issyk forestry, gorge. Issyk. 07/24/2020, 2♀, 3♂; Ileyskiy Alatau, gorge. Aksai, B. Almatinka, 11.07.2021, 4♀, 5♂; ur. Medeu, 16.07.2020, 3♀, 3♂; Koktobe, 28.06.2021, 4♀, 3♂. Hortobiont; mesophilic (steppe, semi-desert, foothills, up to 900 m, edges, clearings, meadows and other more or less humid biotopes); broad oligophytophage (on various wild and cultivated cruciferous plants [16]; bivoltine; adults hibernate [4, 13].

Eurydema dominulus (Scopoli, 1763). Ileyskiy Alatau, gorge. Aksai, 23.06.2020, 1♀, 2♂; Koktobe, 08.07.2021, 2♀, 3♂. Hortobiont; mesophilic (in the meadows, in the mountains); broad oligophytophage (on cruciferous crops, harms cruciferous crops [4, 13]; bivoltine; adults hibernate.

Graphosoma consimile (Horvath, 1903). Ileyskiy Alatau, gorge. Aksai, B. Almatinka, 11.07.2020, 4♀, 5♂; ur. Medeu, 16.07.2021, 3♀, 3♂; Koktobe08.07.2020, 4♀, 3♂; Ile-Alatau SNNP, Issyk forestry, gorge. Issyk. 24.06.2021, 2♀, 3♂; Turgen forestry, gorge. Turgen, 17.07.2021, 3♀, 2♂. Hortobiont; mesophile (found both on the plains and in the mountains, up to a height of 3000-3500 m); broad oligophytophage (trophically associated with umbrella Umbelliferae, especially fruit-bearing *Prangos pabularia, Ferula ferdanensis*; monovoltine; adults overwinter [4, 14].

Graphosoma lineatum (Linnaeus, 1758). Ileyskiy Alatau, ur. Medeu, 03.08.2020, 2♀, 2♂; Big Almaty Lake, 29.07.2021, 5♀, 3♂; river valley B. Almatinka, 20.07.2021, 2♀, 4♂; river floodplain M. Almatinka, 21.07.2020, 3♀, 3♂. Hortobiont; mesophilic (everywhere, found in flat and mountainous areas, tends to floodplain meadows and other moderately moist biotopes, in the mountains 900-2400 m); broad oligophytophage (on various Umbelliferae; adults and larvae mostly on generative organs [4]); monovoltine; adults hibernate.

Oplistochilus pallidus (Jakovlev, 1887). Ileyskiy Alatau, ur. Medeu, 03.08.2020, 2♀, 2♂; Big Almaty Lake, 20.07.2021, 1♀, 2♂; river valley B. Almatinki, 20.07.2021, 2♀, 2♂; ug. Aksai, 29.06.2021, 1♀, 1♂. Hortobiont; mesophilic (widely distributed in the foothills and alpine steppes 2000-2500 m); narrow oligophytophage (fam. Umbrella, trophically associated with prangos *Prangos pabularia* [25]; monovoltine; adults hibernate.

Sternodontus ampliatus (Jakovlev, 1887). Ile-Alatau SNNP, Talgar forestry, gorge. Maralsay, 14.07.2021, 2♀, 1♂. Hortobiont; mesophile (in the mountains); monophytophage (family Umbrella, trophically related to the gill Seseli fedtschenkoanum [4]; monovoltine; adults hibernate. Kazakhstan (noted for the first time) [26].

4. CONCLUSION

As a result of field research conducted in 2020-2021. 34 species belonging to 2 families of hemipteran infraorder Pentatomomorpha II were identified on the territory of the Ile-Alatau State National Natural Park. Among them, 30 species (88%) of the family Pentatomidae prevailing in terms of species composition, and only 4 species (12%) of the family Scutelleridae are known. *Sternodontus ampliatus* Jakovlev, 1887 from the family Pentatomidae was recorded for the first time on the territory of Kazakhstan.

According to life forms, the bugs of the Ile-Alatau SNNP are distributed into 7 groups: hortobionts (22 species), eurychortobionts (1 species), dendrobionts (2 species), dendro-hortobionts (3 species), dendro-tamnobionts (2 species), chorto-tamno - dendrobionts (2 species), herpetobionts (2 species).

According to trophic specialization, they are divided into phytophages (29 species, including polyphytophages - 15 species, broad oligophytophages - 11 species, narrow oligophytophages - 2 species, monophytophages - 1 species) and zoophages (5 species). According to the type of food, both taking into account the abundance and the number of species in the complex of Hemiptera, phytophages clearly predominate.

Hemiptera of the Ile-Alatau SNNP are divided into 2 groups according to the number of generations per year: monovoltine (one generation per year) - 31 species, bivoltine (two colonies per year) - 3 species.

In the study area, there are 32 species with mesophilic ecology, 1 species is meso-xerophilic, and 1 species is hygromesophilic.

Among the hemipterans of the Ile-Alatau SNNP, 32 species (94%) hibernate in the adult stage, 1 species (3%) in the larval stage, and 1 species (3%) in the egg stage.

While this study has provided valuable insights into the diversity and ecological characteristics of hemipteran insects within the Ile-Alatau State National Natural Park, several avenues for future research and inquiry have emerged from its findings. These potential research directions include:

Ecosystem Interactions: Further investigations could explore the intricate ecological relationships between these hemipteran species and their surrounding ecosystems. This might involve studying the impact of these insects on local flora and fauna, including potential herbivore-plant interactions and the influence of these insects on vegetation dynamics.

Influence of Climate Change: Given the region's ecological sensitivity, future research may delve into how climate change impacts the distribution and behavior of these insects. Monitoring shifts in species composition and phenology in response to climate variability can provide critical insights into ecosystem dynamics.

Biodiversity Conservation: Understanding the specific habitat requirements and seasonal behavior of these insects can inform biodiversity conservation efforts within the Ile-Alatau SNNP. Future studies might aim to identify key habitats and environmental conditions necessary for the survival of vulnerable or rare species.

Genetic and Taxonomic Studies: Genetic and taxonomic research could provide a deeper understanding of the evolutionary relationships among these hemipteran species. This may help clarify their taxonomic classifications and phylogenetic histories.

Insect Overwintering Strategies: Investigating the overwintering strategies of these insects, especially those that hibernate in different stages, could shed light on their adaptations to harsh environmental conditions. It may also reveal their vulnerability to habitat disturbances and climate-related changes.

Biological Control: Research on the zoophagous species, which actively prey on small arthropods, can explore their potential role in biological pest control. Understanding their feeding preferences and behavior can be valuable in integrated pest management strategies.

Community Ecology: Studying the broader community ecology of these insects and their interactions with other species, including predators and parasites, can provide a

holistic view of their place in the ecosystem.

Comparative Studies: Comparative studies with other regions or ecosystems can help identify unique ecological patterns and adaptations specific to the Ile-Alatau SNNP. Such studies can enhance our understanding of regional biodiversity.

Overall, this study represents a foundational exploration of hemipteran insect diversity within the Ile-Alatau State National Natural Park. Future research can build upon these findings to address these and other critical questions, furthering our knowledge of the intricate ecological web in which these insects are entwined and supporting efforts for biodiversity conservation and ecosystem management.

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NOMENCLATURE

B	dimensionless heat source length
CP	specific heat, J. kg^{-1}. K^{-1}
g	gravitational acceleration, $m.s^{-2}$
k	thermal conductivity, $W.m^{-1}$. K^{-1}
Nu	local Nusselt number along the heat source

Greek symbols

α	thermal diffusivity, m^2. s^{-1}
β	thermal expansion coefficient, K^{-1}
ϕ	solid volume fraction

Θ	dimensionless temperature
μ	dynamic viscosity, kg. m^{-1}. s^{-1}

Subscripts

p	nanoparticle
f	fluid (pure water)
nf	nanofluid