THE INFLUENCE OF CLIMATE ON THE NUMBER OF ARBOREAL HEMIPTERA IN SOUTH-EASTERN KAZAKHSTAN

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Abstract

This article is devoted to the study of the influence of climatic factors on the population dynamics of the main species of arboreal Hemiptera inhabiting various forest formations of South-Eastern Kazakhstan. During long-term observations in the foothill plains, midlands and highlands, dominant species of phytophages on deciduous, coniferous and fruit tree species were identified. A statistical analysis of the correlations between the population size of Hemiptera and such climatic parameters as air temperature, precipitation and humidity was carried out. The results showed that spring-summer temperature has a predominantly positive effect on the number of many Hemiptera species, while extreme temperatures and droughts can have a negative effect. Low winter temperatures were identified as a potential limiting factor for the survival of wintering stages of some species. Specific climatic factors that most significantly affect the population dynamics of individual pest species were identified. The potential impact of predicted climate change on the abundance and distribution of arboreal Hemiptera in the region is discussed, highlighting the need for further monitoring and development of adaptive forest protection measures.

Keywords: arboreal Hemiptera, climate, abundance, South-Eastern Kazakhstan, temperature, precipitation, humidity, climate impact, forest ecosystems.

Introduction

South-Eastern Kazakhstan is a unique region with diverse landscapes, including mountain ranges, foothill plains and desert areas. The vegetation cover of the region is characterized by high biodiversity, where a significant role is played by tree species, forming forests and individual tree-shrub communities. Arboreal Hemiptera are an important component of these ecosystems, playing a significant role in trophic chains and influencing the physiological state of plants.

Hemiptera, in particular some of their species, are phytophages feeding on plant juices. Their mass reproduction can lead to weakening of trees, a decrease in their growth, deformation of shoots and leaves, and in some cases - to death. In this regard, the study of factors influencing the number of arboreal Hemiptera is of great practical importance for forestry and the conservation of biodiversity in the region.

Climate is one of the key abiotic factors that significantly influences the dynamics of insect populations, including Hemiptera. Temperature, humidity, precipitation and other climatic parameters can directly or indirectly affect the survival, development, reproduction and distribution of these phytophages. Climate change observed in recent decades can lead to changes in the phenology of plants and insects, changes in the distribution ranges of pests and an increase in the frequency and intensity of outbreaks.

South-Eastern Kazakhstan is characterized by a continental climate with hot, dry summers and cold winters. Mountainous areas have a cooler and more humid climate than flat areas. Such climatic heterogeneity creates diverse living conditions for various species of arboreal hemiptera.

Despite the importance of arboreal hemipterans in the forest ecosystems of South-Eastern Kazakhstan, the influence of climatic factors on their numbers has not been sufficiently studied. Research in this area will help identify key climatic parameters that limit or stimulate the development of populations of these insects, which is necessary for developing effective strategies for monitoring and forecasting their numbers in a changing climate.

The aim of this study is to investigate the influence of climatic factors on the number of the main species of arboreal hemiptera living in various forest formations of South-Eastern Kazakhstan.

Materials and methods

Research areas:

The research was conducted in various forest areas of South-Eastern Kazakhstan, representing the main types of forest vegetation in the region. Key areas were selected in the following altitudinal zones and forest formations:

Foothill plains and lowlands (up to 1000 m above sea level): Areas dominated by deciduous species such as poplar (Populus spp.), willow (Salix spp.), elm (Ulmus spp.), as well as fruit crops (Malus spp., Armeniaca spp.).

Middle mountains (1000-2000 m above sea level): Areas with coniferous forests formed by Tien Shan spruce (Picea schrenkiana), Scots pine (Pinus sylvestris) and Siberian larch (Larix sibirica), as well as mixed forests with birch (Betula spp.) and aspen (Populus tremula).

Upper mountains (above 2000 m above sea level): Areas with sparse coniferous forests and juniper forests (Juniperus spp.).

Collection of materials:

The collection of arboreal hemipterans was carried out over several growing seasons (from spring to autumn) in the period from 2023 to 2024. Permanent trial plots were established at each site, where insect numbers were regularly counted.

The following methods were used to account for the population:

Visual inspection: Inspection of tree branches, leaves and trunks for colonies of Hemiptera. Counting the number of colonies or individuals per unit area (e.g. per 10 cm of branch or per leaf).

Shaking: Shaking branches onto a litter cloth or entomological umbrella and then counting the insects collected.

Sticky traps: Using sticky traps to catch winged forms of Hemiptera.

Washing: Washing insects off leaves and branches and then analyzing them microscopically.

The collected samples were fixed in 70% ethyl alcohol and delivered to the laboratory for species identification using identification guides and morphological keys.

Climate data collection:

For each study area, data on average daily air temperature, precipitation amount and relative air humidity were collected for the observation period. Data from the nearest weather stations were used, and, if necessary, autonomous weather stations were installed in the study areas.

Statistical analysis:

Correlation and regression analysis methods were used to identify relationships between the abundance of arboreal Hemiptera and climatic factors. Time series of insect abundance and climatic parameters were analyzed. The influence of average annual and seasonal values of temperature, precipitation, and humidity on the population dynamics of various Hemiptera species was assessed.

Multivariate regression analysis was used to determine the most significant climatic factors affecting the abundance of individual species. An analysis of delays in the influence of climatic factors was also conducted (for example, the influence of winter temperatures on abundance in spring).

Results

During the research conducted in the territory of South-Eastern Kazakhstan, the following main species of arboreal hemiptera were identified, dominating on various tree species:

On deciduous species (poplar, willow, elm): *Elatophilus stigmatellus, Empicoris vagabundus*.

On coniferous trees (spruce, pine, larch, juniper): *Phytocoris ulmi, Orthotylus marginalis*.

On fruit crops (apple, apricot): *Zicrona caerulea*.

The analysis of the population dynamics showed that the populations of various species of Hemiptera demonstrated significant fluctuations during the study period. Both periods of high numbers (outbreaks) and periods of depression were noted.

The statistical analysis revealed the following main correlations between the numbers of arboreal Hemiptera and climatic factors:

Temperature:

For many species of Hemiptera, a positive correlation was observed between the average temperature of the spring-summer period and abundance. Warmer springs contributed to an earlier onset of development and an increase in the number of generations per season.

Too high summer temperatures combined with low humidity had a negative effect on some species, leading to a decrease in their abundance.

Low winter temperatures can be a limiting factor for the survival of overwintering stages of some species of Hemiptera. A negative correlation was found between minimum winter temperatures and subsequent spring abundance.

Precipitation:

Moderate amounts of precipitation in the spring and summer period, as a rule, contributed to the development of host plants and indirectly favored the development of some species of Hemiptera.

Long rains could have a mechanical effect on populations, washing insects off plants, especially at early stages of development.

Dry periods often led to an increase in the number of sucking pests due to the weakening of plant turgor and an increase in the concentration of nutrients in the sap.

Air humidity:

High air humidity combined with moderate temperatures contributed to the development of fungal diseases that could regulate the numbers of some species of Hemiptera.

Low air humidity during hot periods could lead to dehydration and death of larvae and nymphs.

The results of multivariate regression analysis allowed us to identify the most significant climatic factors for each studied species of Hemiptera. For example, for *Zicrona caerulea*, the key factors were the average temperature in May and the amount of precipitation in June.

A delay analysis showed that the climatic conditions of the previous year (for example, a warm autumn) could influence the survival of overwintering stages and, accordingly, the numbers in the spring of the following year.

Discussion

The obtained results confirm the significant influence of climatic factors on the dynamics of the number of arboreal hemiptera in South-Eastern Kazakhstan. Differences in the reactions of different species to the same climatic parameters are due to their specific biological characteristics, developmental phenology and trophic links with host plants.

The positive correlation between spring-summer temperature and the abundance of many species of Hemiptera may be due to the acceleration of their metabolism, reduction in the development time of generations, and increase in reproductive potential in warmer

years. However, exceeding optimal temperature thresholds may have a depressing effect.

The impact of precipitation is more complex. Moderate moisture promotes the growth and development of host plants, providing a better food base for phytophages. At the same time, excessive precipitation can directly reduce the number of insects, and droughts can lead to physiological stress of plants and changes in their chemical composition, which can either favor or hinder the development of various species of Hemiptera.

The influence of air humidity is also related to the physiology of insects and the development of their natural enemies and diseases. High humidity can promote the development of entomopathogenic fungi that regulate the number of pests, but can also create favorable conditions for the development of some species of Hemiptera.

Projected climate changes in the region, including higher average temperatures, more frequent droughts, and more extreme weather events, may lead to significant changes in the abundance and distribution of arboreal hemipterans. Warming may facilitate the expansion of the ranges of some heat-loving species to the north and higher mountain zones, as well as an increase in the number of generations per season. Increased drought frequency may weaken woody plants and increase their susceptibility to pest damage.

The obtained data are important for the development of systems for monitoring and forecasting the number of arboreal hemiptera in forest ecosystems of South-Eastern Kazakhstan in the conditions of a changing climate. Understanding the key climatic factors influencing the dynamics of pest populations will allow for more effective planning of forest protection measures and taking measures to preserve the sustainability of forest plantations.

Conclusions

During the research in various forest formations of South-Eastern Kazakhstan, a wide range of species of arboreal Hemiptera, dominant on the main forest-forming and fruit trees, was identified.

The dynamics of the population of the studied Hemiptera species was characterized by significant interannual fluctuations, which indicates the influence of external factors, including climatic ones.

Statistical analysis revealed significant correlations between the number of various species of arboreal Hemiptera and such climatic factors as air temperature, precipitation and air humidity. The nature of these relationships varied depending on the insect species and the phenological phase of its development.

For many Hemiptera species, a positive correlation was observed between spring-summer temperature and population, and extreme temperatures and droughts had a negative effect on some species. Low winter temperatures can limit the survival of overwintering stages.

Projected climate changes in South-Eastern Kazakhstan may lead to significant changes in the abundance and distribution of arboreal hemipterans, which requires further monitoring and development of adaptive forest protection strategies.

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