Conference Paper

Fluctuating Asymmetry of Leaves of *Betula pubescens* Ehrh. for Assessment of Pollution of the Urban Environment of the Kola North

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Abstract

The results of determining the fluctuating asymmetry (FA) index of *Betula pubescens* leaves as well as the state of birches in general, as an aboriginal species in the Murmansk region to assess the pollution of urban ecosystems of the Kola North (Murmansk, Apatity, Olenegorsk, Polyarnye Zori, Kandalaksha) in the zone of influence of railway transport have been presented in the article. It has been shown that the most weakened birches grow in Kandalaksha and Olenegorsk, while in Kandalaksha area, there are more than 10% of dead trees. It has been revealed that the highest FA index which characterizes the critical state of plants and the high level of environmental pollution is observed in Olenegorsk. The increased level of FA has also been in Kandalaksha and Polyarnye Zori. The comparative analysis of the state of plants and FA index showed existence of functional interrelation only in Kandalaksha and Olenegorsk when with a significant proportion of weakened trees the indicator of FA is the highest. Due to the fact that the increase in the level of FA is influenced by stress factors caused not only by pollution, the method of assessing the quality of the environment by the fluctuating asymmetry should be used in complex with other studies.

Keywords: fluctuating asymmetry, *Betula pubescens*, urban environment, Subarctic

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1. Introduction

CityMurmansk region is an industrially developed, urbanized region beyond the Arctic Circle. The problem of improving the environment of cities is very important for the Kola Arctic [1, 2]. Properly selected assortment of plants that are resistant to adverse effects allows you to decorate the urban landscape and maintain sanitary and environmental efficiency. In urban areas, rail transport can have an additional anthropogenic load on plants, the impact of which on the environment is due to the construction and operation of railways. The main pollutants are organic substances and their combustion products, heavy metals [3, 4]. The research aimed at studying the effects of environmental pollution on the plant component of ecosystems is currently very relevant. Phytoindication

methods for the assessment of technogenic pollution are widely used. One of such methods is the determination of fluctuating asymmetry (FA) as an integral indicator of environmental quality [5]. Fluctuating asymmetry implies an independent change in the bilateral characteristics of the organism. We have revealed the phenomenon of fluctuating asymmetry associated with violation of organism development stability as a result of external factors, primarily anthropogenic [6]. FA level depends on the force of factor impact, the greater the factor of impact, the greater the deviation of an index of FA from the norm [7]. It has been also established that the FA index is not always proportional to the level of pollution; this fact is associated with the development of phenotypic adaptation in plants and with an increase in the pressure of stabilizing selection under high anthropogenic load [8, 9]. The increase of the FA integral index can be associated not so much with stress caused by general environmental pollution, but also by other factors (soil conditions, hydrothermal conditions, weather conditions, etc.) [10-12]. Plants' resistance to the action of aero toxicants is associated with their ability to withstand high concentrations of toxic gases without decreasing growth and development [13, 14].

Thus, the determination of the environmental contamination impact on the rate of fluctuating asymmetry of *Betula pubescens* leaf lamina in the zone of influence of railway transport was the purpose of our study. This species is native to the Murmansk region and is widely represented in the cities.

2. Methods and Equipment

2.1. Methods

In 2018, there were 5 test observation plots (TOP) in the territories adjacent to railway stations in 5 cities of the CityMurmansk region (Murmansk, Apatity, Olenegorsk, Polyarnye Zori, Kandalaksha). At each plot, the state of growing plants of *Betula pubescens* was assessed, which was visually determined by the sum of the main biomorphological features. There is the density of the crown, its foliage, matching the size and color of the leaves, the presence or absence of deviations in the structure of the trunk, crown and shoots. Additional signs were damages by phyto-diseases, insects and other negative natural and anthropogenic environmental factors. The assessment of the state of woody plants was carried out according to the generally accepted method [15].

The collection and herbarization of plant material *Betula pubescens* was carried out after stopping the growth of leaves in July 2018. Leaves were selected from the

lower accessible part of the crown of middle-aged trees. From each plot not less than 100 leaves were investigated. To estimate the leaf lamina, the standard set of five morphological traits [16], which characterize the stability of leaf formation in ontogenesis. All measurements were carried out manually. The calculation integral index of fluctuating asymmetry (FA) of the morphological traits of leaf lamina has been produced using normalized difference algorithm [5].

3. Results

The analysis of the results of the survey in cities showed that the highest percentage of healthy specimens of *Betula pubescens* was detected in Polyarnye Zori and Apatity, which is much less than in Olenegorsk and Kandalaksha. It is completely absent from Murmansk (Fig. 1). It should be noted that the most numbers of *Betula pubescens* grow in Olenegorsk and Kandalaksha. Of all the surveyed cities, only in Kandalaksha there was the presence of dead trees (more than 10%).

A 5-point system was developed to assess the degree of disturbance of plant development stability [5]. The range of values of the integral index of stability of development to 0.040 corresponds to the first point (conditional norm), from 0.040 to 0.044 -- the second point, from 0.045 to 0.049 -- the third point, from 0.050 to 0.054 -- the fourth point and from 0.054 and above -- the fifth point (critical state). The values of the integral asymmetry index corresponding to the first point are observed, as a rule, in a sample of plants from favorable growing conditions. The fifth point characterizes the critical state of the environment when the plants are in a very depressed state.

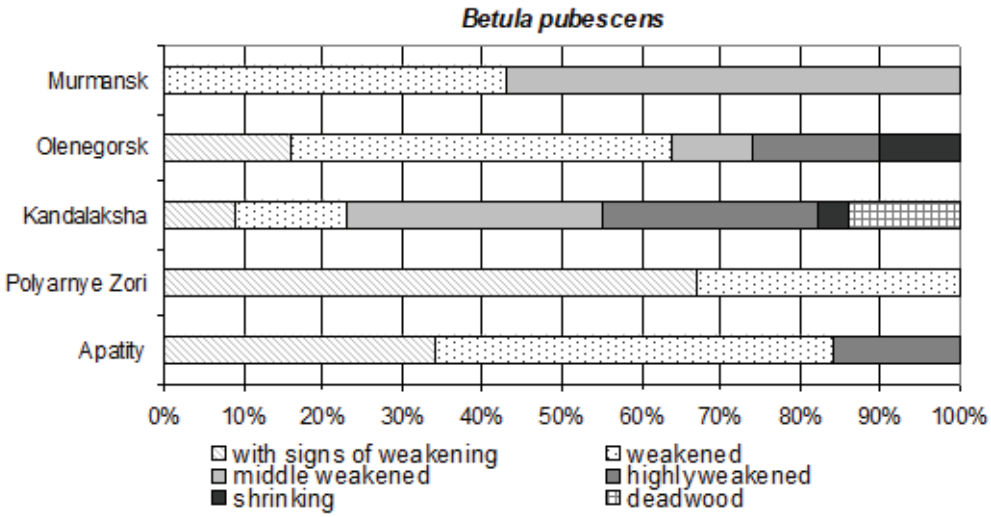

Figure 1: State of *Betula pubescens* in the surveyed cities (%).

The FA index of *Betula pubescens* leaves on the train station territory of Murmansk and Apatity corresponds to the first point, that is, indicates the norm in the development of plants. In other cities, this point is higher. In Olenegorsk there is a critical state, determined by the low stability of the development of this species (Fig. 2).

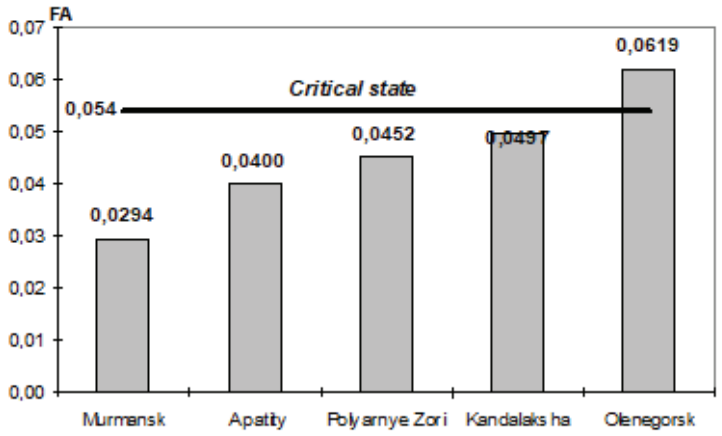

Figure 2: Integral index of fluctuating asymmetry of leaves of woody plants in the cities.

4. Discussion

The study of the variability of leaf lamina features of *Betula pubescens* showed that the third trait is the most volatile (the distance between the bases of the first and second veins of the second order, coefficient of variation is 26-35%). The most stable trait (coefficient of variation <15%) was the angle between the main vein and the second vein from the base). It should be noted that among the studied cities a higher level of variability of signs was noted in Kandalaksha. Thus, we can conclude that the first (the width of the left and right halves of leaf), second (the length of the second-order vein, the second from the base of leaf) and fifth (the angle between the main vein and the second vein from the base) parameters are the most stable. Perhaps this set of traits will be enough for a reliable assessment of the indicator of the fluctuating asymmetry.

Comparative analysis of the state of plants and the value of FA showed the presence of some functional connection in the two surveyed cities (Kandalaksha and Olenegorsk). In the station areas of these cities, with a significant proportion of weakened plants, the index of fluctuating asymmetry is highest. In other cities, the connection between these parameters is weak or completely absent. Due to the fact that the increase in the level of FA is influenced by stress factors caused not only by pollution, the methodology for assessing the quality of the environment from the fluctuating asymmetry of the leaves must be supported by additional studies.

5. Conclusion

The data obtained demonstrate that the level of instability of the development of bilateral traits in *Betula pubescens* significantly increased in the station area of Polyarnye Zori and Kandalaksha. The conditional rate of development and the initial level of stability deviations were noted in Murmansk and Apatity. In Olenegorsk, there is a critical deviation from the norm. It is rather difficult to draw unequivocal conclusions about environmental pollution and the technogenic transformation of urban ecosystems in the zone of influence of railway transport based on this bioindication method due to the combined effect of a number of factors. Environmental monitoring of associated environments (biological, soil, atmospheric) will contribute to a more accurate assessment of the state of the urban environment.

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Conflict of Interest

The authors have no conflict of interest to declare.

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