

**IMPACT OF KARABASH COPPER SMELTER EMISSIONS  
ON LEAF SIZE AND FLUCTUATING ASYMMETRY  
OF *BETULA PENDULA* (BETULACEAE) UNDERGROWTH**

© **D. V. Veselkin**,<sup>1,\*</sup> **N. B. Kuyantseva**,<sup>\*\*</sup>,<sup>\*\*\*</sup>

**O. E. Chashchina**,<sup>\*\*</sup> **E. V. Koroteeva**<sup>\*\*</sup>

\*Institute of Plant and Animal Ecology, Ekaterinburg, Russia

\*\*Ilmen State Nature Reserve, Chelyabinsk region

\*\*\*South-Ural Federal University, Chelyabinsk

<sup>1</sup>E-mail: denis\_v@ipae.uran.ru

REFERENCES

1. Zakharov V. M., Baranov A. S., Borisov B. I. et al. 2000. *Zdoroviye sredy: metodika otsenki. Otsenka sostoyaniya prirodnykh populyatsiy po stabilnosti razvitiya: metodologicheskoye rukovodstvo dlya zapovednikov* [Environmental Health: methods of evaluation. Assessment of the status of nature populations based on developmental stability: a methodological guide for the nature reserves]. Moscow. 68 p. (In Russian)
2. Zakharov V. M., Chubinishvili A. T., Dmitriev S. G., Baranov A. S. et al. 2000. *Zdoroviye sredy: praktika otsenki* [Environmental Health: practice of an estimation]. Moscow. 318 p. (In Russian)
3. Boyko A. A. 2004. Evaluation of developmental stability in silver birch leaves under the impact of aerotechnogenic pollution. — *Vestnik MGUL. Lesnoy vestnik*. 5(36): 121—123. (In Russian)
4. Gelashvili D. B., Lobanova I. V., Erofeeva E. A., Naumova M. M. 2007. Influence of forest pathology status of silver birch on the value of leaf fluctuating asymmetry. — *Povolzhskiy ekologicheskiy zhurnal*. 2: 106—115. (In Russian)
5. Bulatova E. S., Babina S. G., Onishchenko S. S., Ilyashenko V. B., Sonnikova A. E. 2009. Evaluation of state of silver birch (*Betula pendula*) population in protected southern Siberia nature areas. — *Isvestiya Samarskogo nauchnogo tsentra RAN*. 11(1—3): 363—368. (In Russian)
6. Ivanov V. P., Marchenko S. I., Akimenkov N. V. 2009. Using the leaf blade area asymmetry in *Betula pendula* as an indicator of the ecological state of the environment. — *Vestnik Povolzhskogo gos. tekhnol. un-ta. Ser.: Les. Ekologiya. Prirodopolzovanie*. 3: 68—74. (In Russian)
7. Amosova I. B., Feklistov P. A. 2010. Fluctuating asymmetry of the leaf blade of *Betula pendula* in different age individuals in suburban forests in Arkhangelsk. — *Isvestiya vuzov. Lesnoy zhurnal*. 2: 60—66. (In Russian)
8. Mandra Yu. A., Eremenko P. S. 2010. Bioindicating environmental assessment of Kislovodsk based on an analysis of fluctuating asymmetry. — *Isvestiya Samarskogo nauchnogo tsentra RAN*. 12(1—8): 1990—1994. (In Russian)
9. Shabalina O. M., Demyanenko T. N. 2011. Estimation of influence of pollution and soil factors on the indexes leaf fluctuating asymmetry of silver birch (*Betula pendula* Roth) in Krasnoyarsk. — *Vestnik KrasGAU*. 2: 135—140. (In Russian)
10. Erofeeva E. A., Naumova M. M. 2012. Seasonal dynamics of morphophysiological indicators of *Betula pendula* (Betulaceae) leaf under the influence of road transport pollution. — *Rastitelnye resursy*. 48(1): 59—70. (In Russian)

11. Sobchak R. O., Afanaseva T. G., Kopylov M. A. 2013. Estimation of the environmental status of recreation zones by the method of leaves fluctuating asymmetry of *Betula pendula* Roth. — Vestnik Tomskogo gosudarstvennogo universiteta. 368: 195—199. (In Russian)
12. Kozlov M. V., Zvereva E. L., Zverev V. E. 2009. Impacts of point polluters on terrestrial biota. Dordrecht; Heidelberg; London; New York. 466 p.
13. Koroteeva E. V., Veselkin D. V., Kuyantseva N. B., Mumber A. G., Chashchina O. E. 2015. Accumulation of heavy metals in the different *Betula pendula* Roth organs near the Karabash Copper Smelter. — Agrokimiya. 3: 94—102. (In Russian)
14. Kulagin Yu. Z. 1974. Drevesnyye rasteniya i promyshlennaya sreda [Woody plants and industrial environment]. Moscow. 156 p. (In Russian)
15. Frolov A. K. 1998. Okruzhayushchaya sreda krupnogo goroda i zhizn rasteniy v neom [The environment of a big city and plant life there]. St. Petersburg. 328 p. (In Russian)
16. Neverova O. A., Kolmogorova E. Yu. 2002. Xerophytization of woody plants leaves as an indicator of air pollution (on the Kemerovo example). — Ivestiya vuzov. Lesnoy zhurnal. 3: 29—33. (In Russian)
17. Vasilevskaya N. V., Lukina Yu. M. 2011. Influence of technogenic pollution on growth dynamics and leaf mesostructure of *Betula czerepanovii* Orlova (Murmansk region). Uchenye zapiski PetrGU. Seriya: Estestvennye i tekhnicheskie nauki. 8: 14—18. (In Russian)
18. Seydafariyov R. A. 2008. Ekologo-biologicheskiye osobennosti lipy melkolistnoy (*Tilia cordata* Mill.) v usloviyakh tekhnogennoy zagryazneniya: Avtoref. dis. ... kand. biol. nauk [Ecological and biological features of small-leaved linden (*Tilia cordata* Mill.) under the influence of technogenic pollution: Abstr. ... Diss. Kand. (Biology) Sci.]. Ufa. 24 p. (In Russian)
19. Zverev V. E. 2012. Vliyaniye promyshlennogo zagryazneniya na ekologiyu berezy Cherepanova (*Betula pubescens* ssp. *czerepanovii* (Orlova) Hämet-Ahti) na Kolskom poluostrove: Avtoref. dis. ... kand. biol. nauk [Impact of industrial pollution on the Cherepanov birch (*Betula pubescens* ssp. *czerepanovii* (Orlova) Hämet-Ahti) ecology on the Kola Peninsula: Abstr. ... Diss. Kand. (Biology) Sci.]. Ekaterinburg. 19 p. (In Russian)
20. Koroteeva E. V., Kuyantseva N. B., Veselkin D. V., Chashchina O. E. 2015. The Size, but not the fluctuating asymmetry of the leaf of silver birch changes under the gradient influence of emissions of the Karabash Copper Smelter Plant. — Doklady Akademii Nauk. 460(3): 364—367. (In Russian)
21. Migalina S. V., Ivanova L. A., Makhnev A. K. 2010. Change in the leaf morphology of *Betula pendula* Roth and *B. pubescens* Ehrh. along the Urals and Western Siberia zonal-climatic transect. — Ekologiya. 4: 257—265. (In Russian)
22. Kryazheva N. G., Chistyakova E. K., Zakharov V. M. 1996. Analysis of developmental stability of silver birch under the impact of chemical pollution. — Ekologiya. 6: 441—444. (In Russian)
23. Kozlov M. V., Wilsey B. J., Koricheva J., Haukioja E. 1996. Fluctuating asymmetry of birch leaves increases under pollution impact. — J. Appl. Ecol. 33(6): 1489—1495.
24. Vasilev A. G., Vasileva I. A., Marin Yu. F. 2008. Phenogenetic monitoring of the weeping birch (*Betula pendula* Roth) in the Middle Urals: testing a new method for assessing developmental instability in higher plants. — Russ. J. Ecol. 39(7): 483—489.
25. Valkama J., Kozlov M. V. 2001. Impact of climatic factors on the developmental stability of mountain birch growing in a contaminated area. — J. Appl. Ecol. 38(3): 665—673.
26. Balandaykin M. E. 2012. Connection of *Inonotus obliquus* (Pers.) Pil. infection on the birch with the value of the integral index of fluctuating asymmetry of assimilation apparatus. — Voprosy sovremennoy nauki i praktiki. Universitet im. V. I. Vernadskogo. 3: 15—22. (In Russian)
27. Black-Samuelsson S., Andersson S. 2003. The effect of nutrient stress on developmental instability in leaves of *Acer platanoides* (Aceraceae) and *Betula pendula* (Betulaceae). — Am. J. Bot. 90(8): 1107—1112.
28. Martel J., Lempa K., Haukioja E. 1999. Effects of stress and rapid growth on fluctuating asymmetry and insect damage in birch leaves. — Oikos. 86(2): 208—216.