DISTRIBUTION OF INVASIVE SPECIES ACTINOCYCLUS NORMANII (HEMIDISCACEAE, BACILLARIOPHYTA) IN SERBIA

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Abstract: In Serbia Actinocyclus normanii was registered in several rivers and canals. In 1997, it was found as planktonic species in the Tisza River and in benthic samples (in mud) in the Veliki Bački Canal. In 2002, it was found as planktonic species in the Danube–Tisza–Danube Canal (Kajtaso-vo) and the Ponjavica River (Brestovac and Omoljica). Four years later, in 2006, the species was found in plankton, benthos and epiphytic samples in the Ponjavica River (Omoljica). A. normanii is a cosmopolite, alkalibiontic and halophytic species. It occurs in waters with moderate to high conductivity and it is indicator of eutrophied, polluted waters. Its spread could be explained by eutrophication of surface waters.

Key words: Actinocyclus normanii, distribution, invasive species, Serbia

INTRODUCTION

An invasive species is a non-native species to a new area, whose introduction has a tendency to spread and cause extinction of native species and is believed to cause economic or environmental harm or harm to human, animal, or plant health. Invasive species may impact native flora and fauna causing severe disturbance in food webs. Invasions by marine macroscopic algae (Williams and Smith 2007) and vascular plants (Hejda et al. 2009) are well known. However, invasions by freshwater taxa are poorly understood (Korneva 2007, Kaštovs-ký et al. 2010).

According to literature data some of known freshwater invasive algae are: Cylindrospermopsis raciborskii (e.g. Szalai 1942, Padisák 1997, Briand et al. 2004, Kaštovs-ký et al. 2010), Didymosphenia geminata (e.g. Subakov-Simić and Cvijan 2004, Blanco and Ector 2009, Gillis and Chalifour 2010, Kilroy and Unwin 2011), Thalassiosira baltica (Edlund et al. 2000),

According to some authors, two forms of A. normanii are distinguished: f. normanii and f. subsalsus (e.g. Krammer and Lange-Bertalot 2004, Kaštovský et al. 2010, Medvedeva and Nikulina 2014, Guiry and Guiry 2016). The distinction of these forms is based on differences of valve diameter and water type preferences (sea or fresh water) (Hustedt 1957). Contrary, according to Kiss et al. (1990), f. subsalsus has no taxonomical value and they propose to use only the name A. normanii. According to them, as well as other authors (e.g. Belcher and Swale 1979), the supposed difference in cell size of sea populations and fresh water populations is not sufficient for separation and does not merit taxonomic value.

Actinocyclus normanii (W. Gregory ex Greville) Hustedt was considered to be a marine and brackish species (Kípp et al. 2012). During the last decades it has been recorded all over the world in eutrophic rivers and lakes (Kípp et al. 2012). Its occurrence rate increase and it might be considered as an invasive species (Korneva 2007, Kípp et al. 2012).

Actinocyclus normanii f. subsalsus (Juhlin-Dannfelt) Hustedt could originally be a native marine or brackish water species (Baltic Sea, Caspian Sea) (Liukkonen et al. 1997). It is known to spread from brackish into common freshwaters, throughout the world, and was considered as invasive or potentially invasive species (Kaštovský et al. 2010, Kípp et al. 2012). According to Kípp et al. (2012) good adaptation to fluctuating light levels and avoiding or tolerating silica limitations (species is heavily silicified) allow A. normanii f. subsalsus to spread. Kaštovský et al. (2010) pointed out that the expansion of this species is probably explained by eutrophication of surface waters.

The aim of this study was to collect information on the distribution and ecology of A. normanii f. subsalsus and A. normanii f. normanii in Serbia. Also, we want to obtain a wider data basis for better characterisation its ecological preferences. These new information are important for further prediction of diatoms as bioindicators, and river monitoring programs.
MATERIAL AND METHODS

The material was collected from 5 localities which are located in the northern part of Serbia, in the Pannonian Plain: Tisza River, Veliki Bački Canal, Danube–Tisza–Danube Canal (Kajtasovo), Ponjavica River (Brestovac) and Omoljica). Samples from Tisza River, Veliki Bački Canal were collected in 1997, from Danube–Tisza–Danube Canal (Kajtasovo), Ponjavica River (Brestovac and Omoljica) in 2002 and again from Ponjavica River (Omoljica) in 2006. Diatom species were collected from three different communities: phytoplankton, phytobenthos and epilithic. A. normanii f. subsalsus was found in phytoplankton and phytobenthos samples at all localities. Chemical analysis of water was examined at the Institute of Public Health of Serbia “Dr Milan Jovanović Batut” and Serbian Hydrometeorological Institute.

Diatom samples were treated following standard methods to obtain permanent slides (Krammer and Lange-Bertalot 1986). After this process the material was air dried on cover glasses and mounted in Naphrax® mounting medium. Permanent slides, prepared material and aliquots of the samples were deposited in the diatom collection of the University of Belgrade, Faculty of Biology. Light microscope micrographs were obtained by Zeiss Axio Imager M.1 microscope with DIC optics and Axio Vision 4.8 software. Terminology of valve morphology and identification is based according Krammer and Lange-Bertalot (2004). The abundance was estimated by counting 400 valves of each taxa present on the slide and by counting the percentage of valves.

RESULTS AND DISCUSSION

Here we present the descriptions and distribution of the invasive A. normanii f. subsalsus found in the Serbian part of the Pannonian Plain.

*Actinocyclus normanii* (W. Gregory ex Greville) Hustedt 1957 f. subsalsus (Juhlin-Dannfelt) Hustedt 1957 (Hemidiscaceae, Coscinodiscales)

(Fig. 1A–G)

Morphological characteristics

Valves are circular; one valve is concave and other more convex in the middle. The diameter ranges from 15.85–29.26 μm. Valves are with patterns of radiating parallel rows of areolae which are organized into sectors. The numbers of areolae are 11–12 in 10 μm and maintain constant throughout the valve. Characteristic
The morphological feature of the valve is the ring of rimoportulae (Fig. 1 A–C), located on the internal side of the valve. The species can occur as single cells or as colonies. According to Krammer and Lange-Bertalot (2004) the valve diameter is 16–58 μm. Kipp et al. (2012) present populations with valve diameter 16–47.5 μm.

**Distribution**

New data on distribution in Serbia (with UTM grid codes in brackets): Tisza River (DR25), Veliki Bački Canal (CR38); Danube–Tisza–Danube Canal (Kajtasovo, EQ17), Ponjavica River (Brestovac, DQ85) and Ponjavica River (Omoljica, DQ75) (Fig. 2).

*Actinocyclus normanii* (f. subsalsus) was found in phytoplankton and phyto-benthos communities in relative abundances from 0.20–16.25 % (Table 1).


![Fig. 1A–G. LM micrographs of the *Actinocyclus normanii* (f. subsalsus).](image-url)
Fig. 2. UTM map of Serbia with new data on distribution of Actinocyclus normanii (f. subsalsus).
Atlantic Islands: Canary Islands (Afonso-Carrillo 2014), Faroe Islands (Witon and Witkowski 2006).

North America: Great Lakes (Stoermer et al. 1999, Kipp et al. 2012), NW USA (Bahls 2009), United States of America (Marshall 2005, Kociolek 2005, Eberle 2008). (Fig. 3).

South America: Argentina (Rodriguez et al. 2006, Gómez et al. 2009), Brazil (Eskinazi-Leça et al. 2010), Colombia (Lozano-Duque et al. 2011, Montoya-Moreno et al. 2013). (Fig. 3).

Asia: Russia (Far East) (Medvedeva and Nikulina 2014), China (Liu 2008), Israel (Barinova et al. 2008), Korea (Joh 2010), Japan (Tanaka 2014). (Fig. 3).

Australia and New Zealand: Australia (Bostock and Holland 2010, McCarthy 2013), New Zealand (Harper et al. 2012).

Ecology

Actinocyclus normanii (f. subsalsus) from our samples occurs in waters with moderate to high conductivity (348–918 μS/cm), pH ranges from 8.0–8.83, at a water temperature between 8.0–25.7 °C with a maximum abundance at 16.2 °C (Table 1).
According to the literature data *Actinocyclus normanii* (f. *subsalsus*) is a cosmopolite, planktonic, phytobenthic, alkalibiontic and halophytic species, which occurs in waters with moderate to high conductivity and it is indicator of eutrophied, polluted waters (Korneva 2003, Krammer and Lange-Bertalot 2004, Kaštovský et al. 2010, Kiss et al. 2012, Kipp et al. 2012). Populations in the Great Lakes had shown a maximum abundance at a water temperature around 20 °C (Kipp et al. 2012).

**CONCLUSIONS**

The presence of many diatom taxa could give evidence of a wide scale of the environmental possibilities for their development within the studied area. Identification of invasive algae species in water bodies is possible through the long-term floristical studies and continuous biomonitoring of surface waters. Therefore, we continue to monitoring the occurrence of invasive taxa in the waters of Serbia.

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