



The biological evidence of climate changes: a case study of liverwort *Lunularia cruciata* (L.) Dum. ex Lindb. in Serbia

Marko SABOVLJEVIĆ^{1*} and Jani MARKA²

¹ Institute of Botany and Garden, Faculty of Biology, University of Belgrade, Takovska 43, 11000 Belgrade, Serbia

² Department of Biology, Faculty of Natural Sciences, University of Tirana, Bul. Zog I, Tirana, Albania

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The liverwort *Lunularia cruciata* (L.) Dum. ex Lindb. (crescent cup liverwort) is an isolated member of the unique genus within the family *Lunulariaceae*. It is small thalloid plant growing on the dump soils, paths, roadsides. It is native plant of Atlantic-Mediterranean distribution. In the other area of Europe it is rather common within glasshouses and around them (SMITH 1991). It occurs commonly in Western Europe where it is native and around the Mediterranean region, as well. It is also common in California, where it grows "wild", and is known as an introduced weed in gardens and greenhouses in Australia (SCHUSTER 1992; VISNADI & VITAL 1997). In America, it grows only as a sterile form, easily recognized by the crescent-shaped cups containing asexual gemmae. In many countries it is adventive, it occurs in greenhouses and in the shaded parts of gardens. Thus, in Europe it is recorded almost everywhere but not everywhere in the wild or spontaneous. The only region of Europe it is not recorded neither in glasshouses nor in the wild are Iceland, Faroe Islands, Svalbard, Monaco, Lichtenstein, Andorra and Gibraltar (SÖDERSTRÖM *et al.* 2002, 2007). It is recently recorded in the wild also in Slovakia (JANOVICOVA & SOMOGYI 1996)

Eventhough, it was recorded in all Southeast European countries (SABOVLJEVIĆ & NATCHEVA 2006), it is not widespread species except in the Mediterranean belt. However, according to Ros *et al.* (2007) within the Mediterranean surrounding it was never recorded from Syria and Egypt, while the records from Bosnia, Macedonia, Serbia and Slovenia are made before 1962. PAVLETIĆ

(1955) cites this species for Serbia, only in the pots in the Belgrade botanical garden glasshouse. All attempts to find the species *L. cruciata* since 1993 within the Belgrade botanical garden glasshouse or around it failed. Since the species is easy recognizable by the semi lunar gemma cups, the possibility of previous misidentification is excluded.

The new and the first record of this species in the wild out of glasshouse of the Belgrade Botanical Garden "Jevremovac" is reported in this paper. The wild record was made in the Gradac river gorge near the city of Valjevo (N44°53'07.6" E02°04'44.6") on 04. November 2009 (leg. Sabovljević, M. & Marka, J.). With this record *L. cruciata* become a member of Serbian spontaneous bryophyte flora (Figs. 1 & 2).

This plant can be weedy or invasive (UVA *et al.* 1997). WATSON (1959) remarks that it is perhaps not a true native of Britain, as it is rare away from habitations. In our case, it was recorded in semi-natural environment on the soil by the road, among rocks in shadow light conditions. Besides anthropogenic habitats, *Lunularia cruciata* invades moist, shaded soils, rocks and walls (ESSL & LAMBTON 2009).

The ruderal thalloid liverwort *Lunularia cruciata*, which is certainly native to the Mediterranean region, has greatly expanded its range northward in recent decades and is considered to be an alien in much of northern Europe (ESSL & LAMBTON 2009). RIBITSCH & ESSL (2006) and ESSL & LAMBTON (2009) estimate it as invador to 12 European countries. The first bryophyte species to be recognized as

*correspondence: marko@bio.bg.ac.rs



Fig. 1. *Lunularia cruciata* in Gradac river gorge (Serbia).

introductions were *Lunularia cruciata* (1828, Karlsruhe, Germany; FRAHM 1973). BIGGS & WITTKUHN (2006) documented the presence of *L. cruciata* gemmae in the bryophyte diaspore bank in soil and litter of an urban bush land in Perth, Australia.

The population recorded in the wild of Serbia count 14 small patches, and was in sterile stage. Gemma cups were present but not very abundant. However, many bryophytes are dioecious, and since there is often only one sex in the founder population (the case of *Lunularia cruciata* in its alien European range), they can only survive via vegetative propagation (fig. 3). This feature is therefore likely to be a consequence of their colonizing history (ESSL & LAMBTON 2009).

The developmental stage of the wild plants correspond with the experiments, which showed that plants are responding to the photoperiodic stimuli of the short day and a rather fresh period of year (NACHMONY-BASCOMB & SCHWABE 1963; SCHWABE & NACHMONY-BASCOMB 1963; VALIO & SCHWABE 1969).

The influence of climate changes, ie. mean temperature changes, on cryptogams has rarely been considered even though they are proved to be more sensitive to environmental fluctuations. FRAHM & KLAUS (1997, 2001) described an extension of the ranges of 30 species, previously distributed in western and southern Europe into Central Europe, for several hundred kilometers to the east



Fig. 2. *Lunularia cruciata* with characteristic crescent gemmae cup

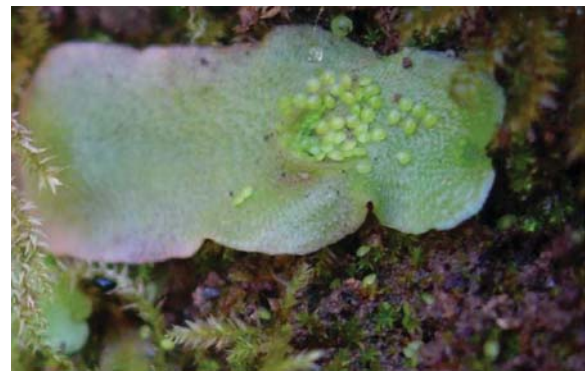


Fig. 3. Propagules of *Lunularia cruciata* spreading from crescent gemmae cups.

and north. Climate change and increasing temperatures may foster range expansions of alien bryophytes in the future (FRAHM & KLAUS 2000, 2001).

The appearance of *L. cruciata* in the wildness of Serbia is an evidence of climate changes as well, most probably the increase of winter mean temperature in the area where it was recorded. As stated by FRAHM & KLAUS (2001) the summer time with high temperature is not of the predominant value since it is combined with dry phases in which these plants are physiologically inactive and so adapted to dryness as within Mediterranean where they are coming from.

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