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REINTRODUCTION OF THE CRITICALLY ENDANGERED PLANT MARSH CLUBMOSS (*LYCOPODIELLA INUNDATA*) IN ONE OF ITS HISTORICAL OCCURRENCES

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Abstract: Reintroduction of Marsh Clubmoss (*Lycopodiella inundata*) in Chairski lakes, Central Rhodopi Mts. was attempted. The species is one of the rarest in Bulgaria and is Critically Endangered at national level. In many countries of its European range *L. inundata* is rare or threatened. Conservation of *L. inundata* is however difficult since little is known about its ecology, including potential reasons for decline and response to environmental change. The species is a weak competitor. Some of the natural populations of the Marsh Clubmoss are already extinct. Its occurrence has been confirmed at three out of seven localities. Therefore, we attempted to transplant clones at the peat islands in Chairski lakes, Central Rhodopi Mts. The experiment lasted for eight years. During the first three years of the experiment the clones developed relatively well, expansion of the vegetative shoots was observed and abundant sporophytes were produced. After 2010 the plot within *Sphagnum fallax*/*S. flexuosum* was very quickly overgrown by *Carex rostrata* and *Menyanthes trifoliata*. The bare peat area of the plot set within *Sphagnum capillifolium* was maintained easier and remained in a good state for a longer period without human interference. The overall factor important for the occurrence of this species is the presence of microhabitats with low competition. Reintroduction can only be successful if mild disturbance or continuous maintenance is provided. We suggest that the focus for the conservation of *Lycopodiella inundata* should be placed on the protection of its natural habitats instead.

INTRODUCTION

Lycopodiella inundata (L.) Holub is one of the rarest plants in Bulgaria. It is evaluated as Critically Endangered at national level (Ivanova, 2009, 2015) and included in Annex 3 of the Bulgarian Biodiversity Act.

Lycopodiella inundata is a small homosporous perennial clubmoss. The vegetative shoots are horizontal, creeping, and weakly branched. The generative shoots are upright, unbranched, with spore-bearing single cones at the apex. The distribution range of the species includes temperate and cold regions of the Northern Hemisphere – Europe (excluding the Mediterranean and most of Western Russia), the Azores, Asia and North America (Hultén and Fries, 1986). In Europe, the species occurs in 25 countries (Rothmaler and Jermy, 1993) and is Red listed in 12 of them (Byfield and Stewart, 2007). The considerable decline of its populations is due to natural or anthropogenic drying up of the wetlands and direct habitat destruction.

Lycopodiella inundata is strongly heliophylous requiring constantly moist oligotrophic environment. In Bulgaria it grows on bare (or almost so) peat and among peat mosses (*Sphagnum*) in mountainous mires of two types: oligotrophic spring fens (in Milevska Mt.) and on peat islands in distrophic lakes (in the Central Rhodopi Mts.). The habitat belongs to Natura 2000 type 7140 Transition mires and quaking bogs. It is included in Annex 1 of Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora and in Annex 1 of the Bulgarian Biodiversity Act.

Historically, *L. inundata* is known from seven localities in Bulgaria (Jordanoff, 1940; Stanev, 1975; Vodenicharov and Vassilev, 1999; Ivanova & al. 2013, and unpublished herbarium data). At present its occurrence has been confirmed in only three of them: two in the Central Rhodopi Mts. (Smolyanski and Chairski lakes) and one in Znepole floristic region (Milevska Mt.). In the remaining localities the species was not re-found, as far as it was possible to localize the sites.

The recently found locality of *L. inundata* in Milevska Mts. is in good state at present. The situation is however very different in the two other remaining locations in the Central Rhodopi Mts. The population in Chairski lakes is extremely small – only a few individuals (possibly belonging to one clone) on an area of 1-2 m^2 and no suitable unpopulated microhabitats.

The population in Smolyanski lakes is situated on the peat island in lake Lagera. It consists of numerous individuals on an area of ca. 330 m^2. In the past, the lake was transformed into a micro-dam, which has led to elevation of the water level and has had a positive impact on the development of the ecosystem and on *L. inundata* in particular. The population further benefitted from the regular visits of the island by fishermen whose trampling created suitable microsites for the establishment of the species. After 2005 the area around the lake was heavily destroyed due to intensive building of hotel complexes. In 2013 the water level was lowered to less than 1/3 of its original level by human activities. This proved catastrophic to the entire ecosystem causing severe drying out of the peat island, intensive growth of competitive larger vascular plants and decline in the population of *L. inundata* and other typical species of conservation importance.

All these observations led us to consider urgent measures for the conservation of *L. inundata* in Bulgaria and to undertake the current transplant experiment.

MATERIAL AND METHODS

The experiment was performed on the *Sphagnum* islands in two of the Chairski lakes (Central Rhodopi Mts.) – Golemia gyol and Kadirev gyol. It lasted for 8 years. Plant material was taken from the nearest population of the species at lake Lagera (Smolyan lakes). Since the ecology and biology of *L. inundata* in Bulgaria is still poorly understood, we made two transplant plots of ca. 1 m^2. The plots were cleared off vascular plants and 2-3 cm of the peat moss cover was removed (Figs. 1A, 2A). Thus, we created a microhabitat that was similar to the source population. The plot at lake Golemia gyol was made within *Sphagnum fallax*/*S. flexuosum* stand (faster growing at a wetter site). The plot at lake Kadirev gyol was made in a pure *S. capillifolium* mat (slower growing at a relatively drier site). In the middle of each plot, we inserted one ca. 25×25 cm clone of *L. inundata*. The plots were visited in 2008, 2010, 2013-2015. During each visit the size of the clone was measured and the number of fertile shoots was counted. We cleaned also the vascular plants that were growing within the plot area and the clone itself as much as possible, taking care not to disturb *L. inundata*.

A. in 2007

B. in 2015

Fig. 1. Plot at lake Golemia gyol

A. in 2007

B. in 2015

Fig. 2. Plot at lake Kadirev gyol

RESULTS AND DISCUSSION

During the first three years of the experiment the development of *L. inundata* at both sites progressed at comparable rate (Figs. 3, 4). It has to be noted that the clone size at lake Kadirev gyol increased slower than the one at lake Golemia gyol. This could partly be due to the increase in the cover of vascular plants at the latter site and the tendency of *L. inundata* to escape their competition and spread faster sideways at the expense of spore production. This is supported by the lower number of fertile shoots at lake Golemia gyol in the period 2008-2010 as compared to lake Kadirev gyol.

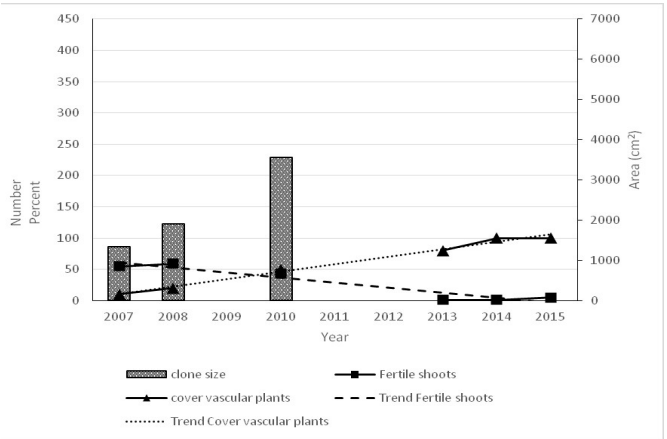

Fig. 3. Development of the transplanted clone of *Lycopodiella inundata* on the *Sphagnum* island in lake Golemia gyol.

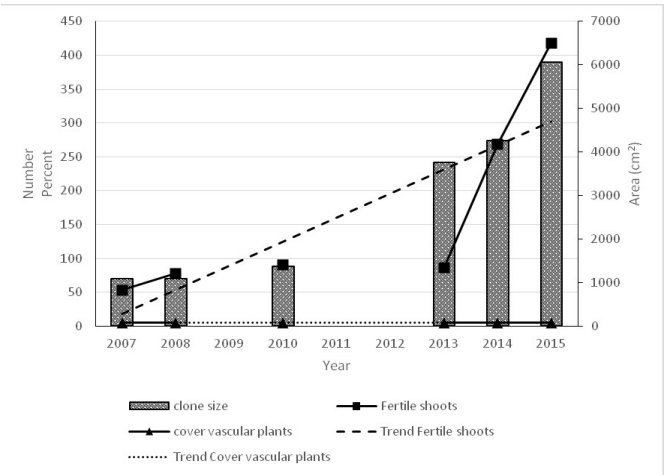

Fig. 4. Development of the transplanted clone of *Lycopodiella inundata* on the *Sphagnum* island in lake Kadirev gyol.

During 2011-2012 no maintenance of the clones was performed. At lake Golemia gyol this led to very intensive overgrowing of the plot by vascular plants and severe decrease in clone size and fertility. In 2014-2015 the cover was 100% and the shoots of *L. inundata* were barely seen with only a few fertile shoots (Fig. 1B). This is in sharp contrast to the situation in lake Kadirev gyol, where the transplanted clone and the cleaned-up area around persisted in a good state even without maintenance for three years. Furthermore, both clone size and spore production increased considerably (Figs. 2B, 4). The number of fertile shoots increased especially after the clearance of the area in 2013.

No spore recruitment was observed within the plots or anywhere in the surroundings within the duration of the experiment.

Lycopodiella inundata is a relatively slow growing pioneer species of open habitats. An important condition for its establishment and growth is moderate disturbance of the vegetation cover. As a weak competitor it requires short and open vegetation that remains in this state for a relatively long time. The overgrowing of open peat by faster growing larger species such as *Molinia coerulea*, *Potentilla palustris*, *Carex rostrata*, etc. leads to suppression of *L. inundata*.

Water availability and quality has an important role for the occurrence of *L. inundata*. Too high water level leads to fast development of more hygrophilous species, such as *Sphagnum flexuosum* and *Menyanthes trifoliata*. Too low water table even for part of the vegetative season leads to increased competition by grasses and sedges and gradual disappearance of *L. inundata*. The process of drying and increased competition is especially well seen at lake Lagera (Smolyan lakes) after 2013.

The low competitive ability of *L. inundata* is well exemplified by the transplant at lake Golemia gyol. At this site, strong competitors like *Menyanthes trifoliata*, *Molinia caerulea*, and *Carex rostrata* quickly overgrew the transplanted clone within three years of lack of maintenance. The water availability is relatively stable and water table is sufficiently high at lake Golemia gyol. It seems that other factors govern vegetation dynamics. One possibility is eutrophication that is caused by the nearby tourist hut. The hut has became actively used for the past 15 years, which has coincided with the intensive development of macrophytes and accelerated siltation of the lake.

CONCLUSION

The major factor for the occurrence of *L. inundata* is the presence of microhabitats with low competition. On the other hand we still know very little about the biology and ecology of the species in Bulgaria. Our transplant experiment demonstrated that reintroduction approach can only be effective if continuous maintenance is provided. The efforts for the conservation of the

species should be directed towards the protection of its natural habitats and ensuring a suitable management regime that will provide moderate disturbance of the vegetation layer.

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REFERENCES

1. Byfield, A., Stewart, N. 2007. *Lycopodiella inundata* (L.) Holub. http://www.plantlife.org.uk/uploads/documents/Lycopodiella_inundata_dossier.pdf
2. Hultén, E., Fries, M. 1986. Atlas of north European vascular plants north of the Tropic of Cancer. Koeltz Scientific Books, Konigstein.
3. Ivanova, D. 2009. *Lycopodiella inundata* (L.) Holub. In: Petrova, A. and Vladimirov, V. (Eds.). Red List of Bulgarian vascular plants. *Phytologia Balcanica*, 15(1): 63-94.
4. Ivanova, D. 2015. *Lycopodiella inundata* (L.) Holub. In: Peev, D. et al. (Eds.). Red Data Book of the Republic of Bulgaria. Vol. 1. Plants and Fungi. BAS & MoEW, Sofia, p. 148.
5. Ivanova, D., Natcheva, R., Stoyanov, S. 2013. Reports 77-78. In: Vladimirov, V. et al. (comps). New floristic records in the Balkans: 22. *Phytologia Balcanica*, 19(2): 278-279.
6. Jordanoff, D. 1940. Materialen zur Kenntnis der Flora von Bulgarien – 1938–1939. *God. Sofiisk. Univ. Fiz. Mat. Fak*., 36(3): 251-262. (In Bulgarian).
7. Rothmaler, W., Jermy, A.C. 1993. *Lycopodiella* J. Holub. In: Tutin, T. G. & al. (eds), Flora Europaea. Ed. 2, vol. 1. Cambridge Univ. Press. Cambridge, pp. 4-5.
8. Stanev, S. 1975. Materials on Bulgarian flora with critical notes. In: Velchev, V., Kuzmanov, B. and Palamarev, E. (Eds.). In Honour of Academician Daki Jordanov. Publishing House Bulg. Acad. Sci., Sofia, pp. 253-263. (in Bulgarian)
9. Vodenicharov, D., Vassilev, D. 1999. *Lycopodiella inundata* (L.) Holub and *Hammarbia paludosa* (L.) Kuntze in Bulgaria. In: Jubilee Scientific Conference. "25 years Shumen University", 30.10.-1.11.1996. Publishing House Shumen University, Shumen, pp. 100-102. (in Bulgarian).