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A Palynological Study of *Riella* Spores in Hypersaline Lake Urmia, NW Iran

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Abstract

Here we present the palynological results on the abundance of the spore of liverwort *Riella* aff. cf *cossoniana* in a short sediment core from southwest of Lake Urmia. *Riella* is an aquatic plant that grows in brackish and alkaline waters, but is unable to live in high salinity waters. Being more robust than their vegetative parts, their spores can be preserved in sediments. The spores of *Riella* can be used as a palaeoecological indicator for lake level changes in saline lake environments of semi-arid regions. In our study the highest values of *Riella* spores correspond with wet periods and high lake levels, whereby climatic condition was more favorable for the expansion of forest trees, particularly oak. During dry periods, in contrast, when upland vegetation was dominated by sagebrush steppes, *Riella* curve shows continuous decline. Towards the surficial samples, *Riella* fades out, most likely as a consequence of intensive agricultural activities, drier climate and increased water salinity.

Key Words: Palynology, Lake Urmia, Water salinity, *Riella*.

Introduction

The bryophytes are found everywhere in the world except in the sea. They grow on trees, on soil, lakes, rivers even in Antartica. The bryophytes are placed taxonomically between algae and pteridophytes and there are about 24,000 species in the world. They are further divided into three phyla, Bryophyta (mosses 14,000 species), Marchantiophyta (liverworts 6000 species) and Anthocerotophyta (hornworts 300 species). The Marchantiophyta includes two subclasses, the Jungermanniidae and Marchantiidae, and six orders, 49 families, 130 genera and 6000 species. Still many new species have been recorded in the literatures (Asakava *et al.,* 2013). *Riella* Mont. (Marchantiophyta, Sphaerocarpales), is the only genus of Riellaceae, that includes some 23 taxa commonly found growing submerged in clean, shallow, fresh or brackish waters of seasonal ponds and streams, and more rarely on permanent waters, of arid or semiarid regions (Moragues *et al.,* 2012).

Riella is a genus of aquatic liverworts with a separate worldwide distribution in areas of seasonal Mediterranean-type climates. Despite the worldwide distribution of *Riella*, its populations are scattered and occur in areas of seasonal climate with temperate winters and dry summers from arid to subdesertic areas. The Mediterranean-African-SW Asian area seems to be a center of dispersal and origin of the genus. Its centre of diversity lies in the Mediterranean basin, where almost half the species in the genus occur (Puche & Moragues, 2013; Djamali *et al.*, 2008a). Liverworts are considered to be the oldest terrestrial plants and one of the first spore-producing terrestrial plants. The spores of them date back almost 500 million years (Asakava *et al.*, 2013; Djamali *et al.*, 2008a). Vegetative parts of liverworts, like many other bryophytes, are soft and rarely found in the fossil record. However, their spores, which are more robust, can be preserved in the sedimentary record. Liverwort spores have very characteristic features and can be identified with certainty to the lowest taxonomic levels. However, their palaeoenvironmental significance, especially in Quaternary palynological studies, has rarely been investigated. This is partly due to the rarity of their occurrences and partly due to their unfamiliar morphology to many palynologists. In addition their identification is also very difficult even under the microscope because they are morphologically very small and difficult to collect in large amount as pure samples. *Riella* is an aquatic genus that grows on muddy ground, which can be partly submerged and in shallow water at the margins of temporary or permanent ponds and lakes. It can tolerate somewhat brackish and alkaline (pH 7–8) waters but is unable to live in high salinity waters. *Riella cossonniana*, which has been recently reported from semi-arid southeastern Spain, prefers subsaline water (3–20 g/l) with a pH up to 8.2 (Djamali *et al.*, 2008a).

In a palynological reconstruction Djamali *et al.* (2008a) illustrated the correspondence of *Riella* spore concentration with lake level changes in Lake Urmia during Pleistocene to early Holocene. They used the spores of *Riella* as a palynological indicator of lake level changes. The pollen record indicates that *Riella* aff. *cossoniana* Trab. has played an important role in the aquatic vegetation in the plains around Lake Urmia, particularly in the late Pleistocene. The concentration of *Riella* spores was greater during the high lake stands corresponding to the middle part of the last glaciations and the upper part of the penultimate glaciations. The presence of *Riella* suggests that during these periods numerous brackish ponds and marshes developed on the present salt flats around the lake, creating suitable habitat for colonization.

Individual spores of *Riella* have also occasionally been observed in the Holocene sediments of the hypersaline Lake Maharlou in SW Iran. Today, the closest stands of *Riella* spp. belong to *R. helicophylla* in Turkey and *R. cossoniana* in Palestine. Finding the *Riella* aff. *cossoniana* spores indicates that the species most probably still occurs in Iran (Djamali *et al.*, 2008a).

The main objective of this study is to illustrate the late Holocene relationship between *Riella* spore concentration and lake level changes and upland vegetation composition at the southwest shore of Lake Urmia.

Materials and methods

Study area

Lake Urmia is a hypersaline lake in northwestern Iran near the border of Iran and Turkey. The lake is *ca*. 5,200 km^2, 140 km long and 55 km wide (Fig.1). The climatic regime of the Lake Urmia region is Mediterranean pluviseasonal–continental in the Global Bioclimatic Classification System. Mean annual temperature and precipitation in the city of Urmia, 10 km west of the lake, are 11.2°C and 341 mm, respectively. Mean maximum and minimum temperatures occur in July (23.9°C) and January (−2.5°C), respectively (Djamali *et al.*, 2008b). Lake Urmia region is located within the *Artemisia fragrans* steppe zone which is the regional vegetation type of the East Anatolian plateau, Armenia and NW Iran (van ziest & Bottema, 1977). The scrub vegetation occurring in the valleys and mountains bordering the western edges of the lake consists mostly of shrubs and small trees of the Rosaceae

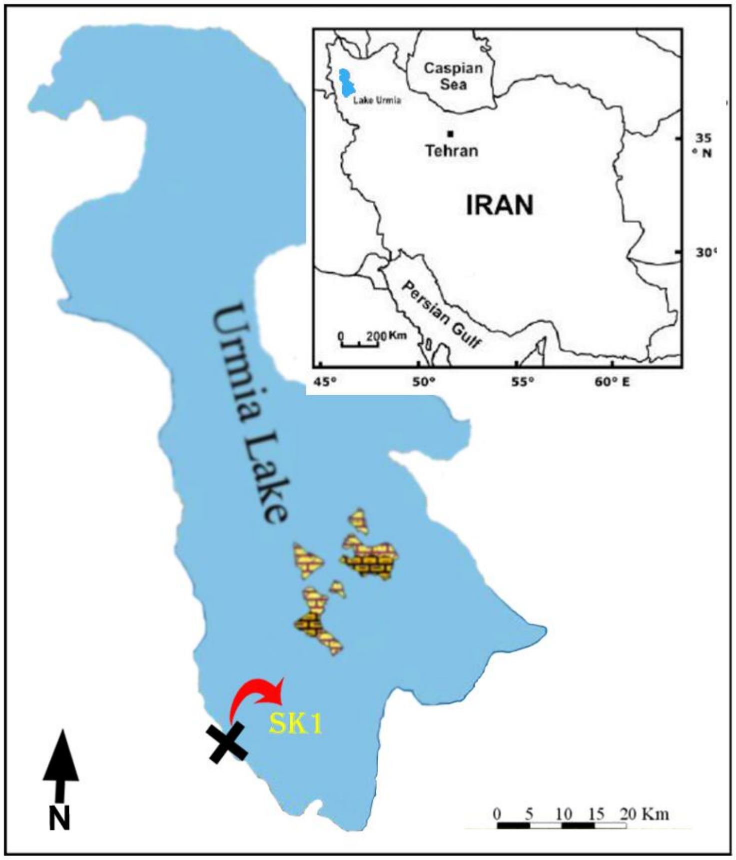

Fig 1: Geographical position of Lake Urmia, NW Iran and the location of the studied core (SK1).

family. In some places (e.g. on lake islands), isolated stands of *Pistacia*, *Rhamnus* and *Juniperus* scrubs can also be found. Modern vegetation of around the Lake Urmia region is heterogeneous. Salt marshes and saline flats are covered by halophilous vegetation dominated by Chenopodiaceae species with halophytic grasses (Djamali *et al.*, 2008b).

Coring and palynological method

A 100 cm core was collected using a Russian type chamber corer from the SW corner of Lake Urmia in March 2012. For the palynological studies 4 cm^3 pollen samples were taken at 4 cm intervals. Sample preparation followed standard techniques (cf. Fægri and Iversen, 1989).

All the counting, measurement and identification were taken under Olympus-CX31 light microscope with 400× magnification. Common pollen and spores were identified and named after Moore *et al.* (1991), Beug (2004) and with aid of the reference slides in the faculty of Natural Resources, Urmia University. The spores of *Riella* were identified after Djamila *et al*. (2008a).

Pollen and spore percentages were calculated on a pollen sum of the total land plants excluding aquatics, spores and Chenopodiaceae. Pollen percentages were calculated with TILIA 1.7.16 software (Grimm, 2011). A simplified diagram consisting of selected taxa is presented in Fig. 2.

Results and discussion

All the spores examined are alete, bifacial with a circular amb which can be triangular with highly convex sides and very rounded angles. Spore diameter can range from 55 to 84 µm and averages to 72.4 μm. Exine is 2.7 μm thick; therefore sexine and nexine are not well distinguishable. Distal surface is covered by an average of 5.2 μm long sculpture elements or processes, which are connected together at their broadened bases to form a reticulum-like pattern. These processes are spiny, spiny-truncated or baculate. Sculpture elements are less developed or absent on the proximal surface of the spores. Apices of many truncated spines and baculae have a depression towards the inside of the spore. They can also be slightly broadened apically and occasionally form hook-like ends (Fig. 3). The spore size and the shape of sculpturing elements, including the truncated and apically broadened spines and baculae, in our specimens, are well-matched to *R. cossoniana*, a species recorded from the Mediterranean region and Central and SW Asia (Djamali *et al.*, 2008a).

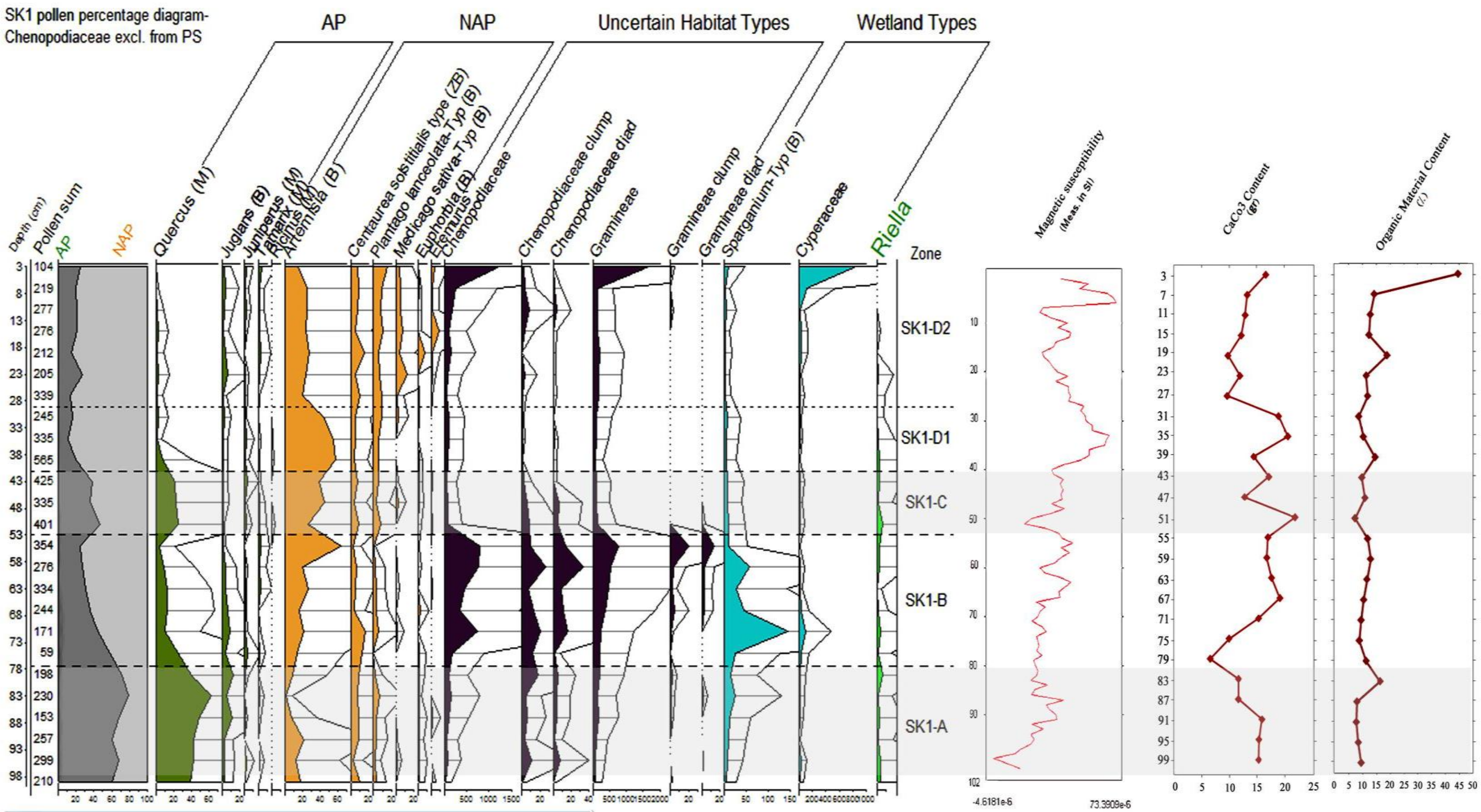

Fig 2: Simplified pollen percentage diagram correlated with magnetic susceptibility, carbonate and organic matter curves for SK1 sediment core from Lake Urmia, NW Iran.

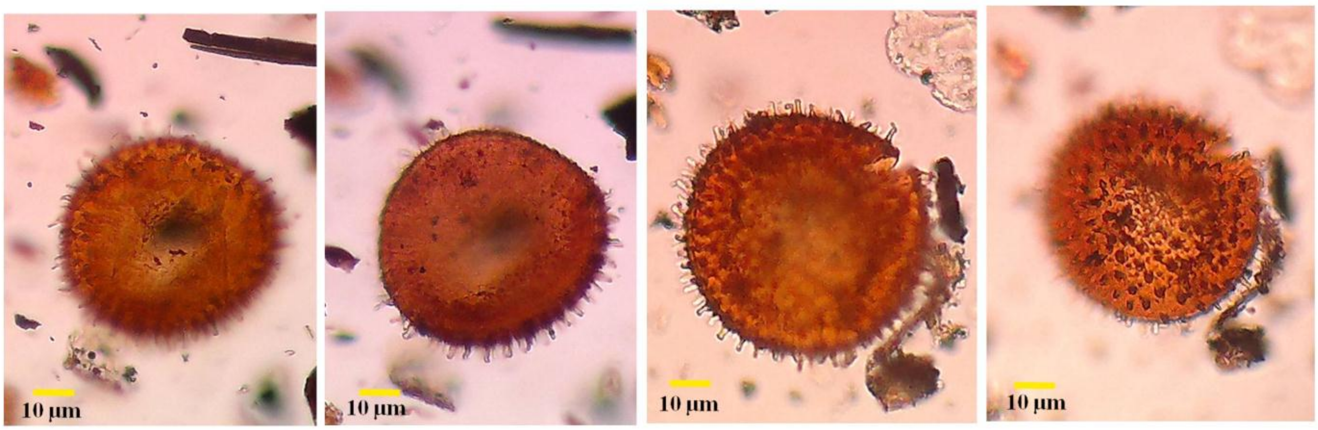

Fig 3: Light microscopic photographs of *Riella* aff. cf *cossoniana* spores. ×1000 magnification.

Riella spores were present at most levels of the core (Fig. 2) with overall good preservation state. The relative abundance of *Riella* spores was higher in SK1-A and SK1-C compared to other zones. These relatively high values fairly correspond with high arboreal pollen (AP) ,which could be attributed to forest expansion in the area and, by inference, to wet periods. These postulated climatic optimum might have been followed by dry periods, as low AP and high values of Artemisia indicate. The correlative decline of *Riella* spore over dry periods indicates that its producing plant cannot tolerate high water salinity, a postulation which has already been claimed by Djamali *et al*. (2008a). In Djamali *et al.* (2008a) *Riella* spore curve co-varies with percentage curves of other aquatic plants particularly Sparganium/Typha angustifolia-type and Cyperaceae. In SK1 pollen diagram, *Riella* curve adversely change against Sparganium, Cyperaceae and Chenopodiaceae. It seems that the lowering of lake level during dry spells have negatively affected *Riella* populations while it has triggered the exposure of saline mud flats suitable for recolonisation by chenopods and other halophytes and halotolerant vegetation such as *Sparganium* and members of Cyperaceae. The high values of organic matter, particularly in the uppermost samples, may to some extent support this hypothesis.

The curve of magnetic susceptibility (MS) may be taken as additional proxy for lake level and vegetational changes in the surrounding landscape (Fig. 2). During high-stands (under wet climate and developed forest cover) the curve shows low values, while during low-stands (under dry periods and sparsely-covered steppe to semi-desert vegetation such as *Artemisia*) it shows high values. Poor vegetation cover (*Artemisia* steppe) is associated with increased erosion rate. In our study, the curve of calcium carbonate ($CaCO_3$) does not show any clear relationship with lake level changes. In Bottema (1986), low values of $CaCO_3$ during wet periods (high stands) was assigned to its dilution in lake water.

As can be observed in SK1 pollen diagram, *Riella* spores vanish from 19 cm level upwards. Djamali *et al.* (2008a) encountered *Riella* spores even at the topmost 1 cm of their core from Lake Urmia. This may indicate that the plant still exist Iran., Though no species of *Riella* has so far been recorded from

Iran (Akhani and Kürschner, 2004 after Djamali *et al.*, 2008a), it can safely be assumed that the plant could be found in extensive fresh and brackish water resources around the lake during spring time. However, intensive agricultural and land use activities must have dramatically limited suitable habitats for this plant.

Conclusion

Palynological evidence from hypersaline Lake Urmia in NW Iran indicates that *Riella* aff. cf. *cossoniana*, a presently unknown liverwort from Iran, may still be extant in Lake Urmia basin and some other saline and brakish lakes in Iran. This study indicates that human-induced low water level and high water salinity are primary factors for the destruction of *Riella* habitats in Iran.

References

Asakawa, Y., Ludwiczuk, A. & Nagashima, F., 2013. Phytochemical and biological studies of bryophytes, *Phytochemistry*, 91: 52–80.

Beug, H.J., 2004. *Leitfaden der Pollenbestimmung für Mitteleuropa und Angrenzende Gebiete.* Verlag Dr. Friedrich Pfeil, 542 p.

Bottema, S., 1986. A late Quaternary pollen diagram from Lake Urmia (northwestern Iran), *Review of Palaeobotany and Palynology.*, 47: 241-61.

Djamali, M. Kürschner, H. Akhani, H. de Beaulieu, J.L. Amini, A. Andrieu-Ponel, V. Ponel, P. & Stevens, L., 2008a. Palaeoecological significance of the spores of the liverwort Riella (Riellaceae) in a late Pleistocene long pollen record from the hypersaline Lake Urmia, NW Iran, *Review of Palaeobotany and Palynology* 152: 66-73.

Djamali, M. de Beaulieu, J.L. Shah-Hosseini, M. Andrieu-Ponel, V. Amini, A. Akhani, H. Leroy, S.A.G. Stevens, L. Alizadeh, H. Ponel, P. & Brewer, S., 2008b. A late Pleistocene long pollen record from Lake Urmia, NW Iran, *Quaternary Research* 69: 413-420.

Fægri, K. & Iversen, J., 1989. *Textbook of pollen analysis* (revised by Fægri, K., Kaland, P.E. and Krzywinski, K.). John Wiley and Sons, 328 P.

Grimm, E.C., 2011, *Tilia*. Ver. 1.7.16 Illinois State Museum.

Moore, P.D., Webb, J.A. & Collinson, M.E., 1991. *Pollen Analysis*. Second Edition. Blackwell Science Publishers, 216 P.

Moragues, J., Puche, F. & Sabovljevic, M., 2012. Riella heliospora (Riellaceae) a New Monoicous Species of Riella Subgenus Trabutiella from California, *Systematic Botany*, 37(2): 307–319.

Puche, F. & Moragues, J., 2013. Riella bialata Trab. (Riellaceae, Marchantiophyta): a new addition to the European liverwort flora, *Cryptogamie, Bryologie*, 34 (3): 341-352.

van Zeist, W. & Bottema, S., 1977. Palynological investigations in Western Iran, *Palaeohistoria* 19: 19-85.