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WATER RELATIONS OF RAMONDA SERBICA PANČ. AND R. NATHALIAE PANČ. ET PETROV. IN DIFFERENT HABITAT CONDITIONS

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Previous investigations carried out in a habitat where the two *Ramonda* species grow in sympatric conditions demonstrated the isohydric type of water balance in these „resurrection" plants. The study was carried further in present work aimed to investigate the stability of this feature. For the purpose, the water relations in both species was examined in the field in specimens from a wide variety of natural habitats. In different ecological conditions both species were shown to maintain a highly conserved isohydric pattern with a stenohydric character in their water balance.

Key words: *Ramonda serbica, Ramonda nathaliae,* desiccation –tolerant plants, water relations, ecological adaptations.

Ključne reči: *Ramonda serbica, Ramonda nathaliae,* biljke koje podnose isušivanje, vodni režim, ekološke adaptacije.

INTRODUCTION

Balkan endemorelic species *Ramonda serbica* and *R. nathaliae,* members of the tropical–subtropical family of *Gesneriaceae,* belong to an extremely small group of poikilohydrous flowering plants. Within their distribution area (Fig. 1) the biological

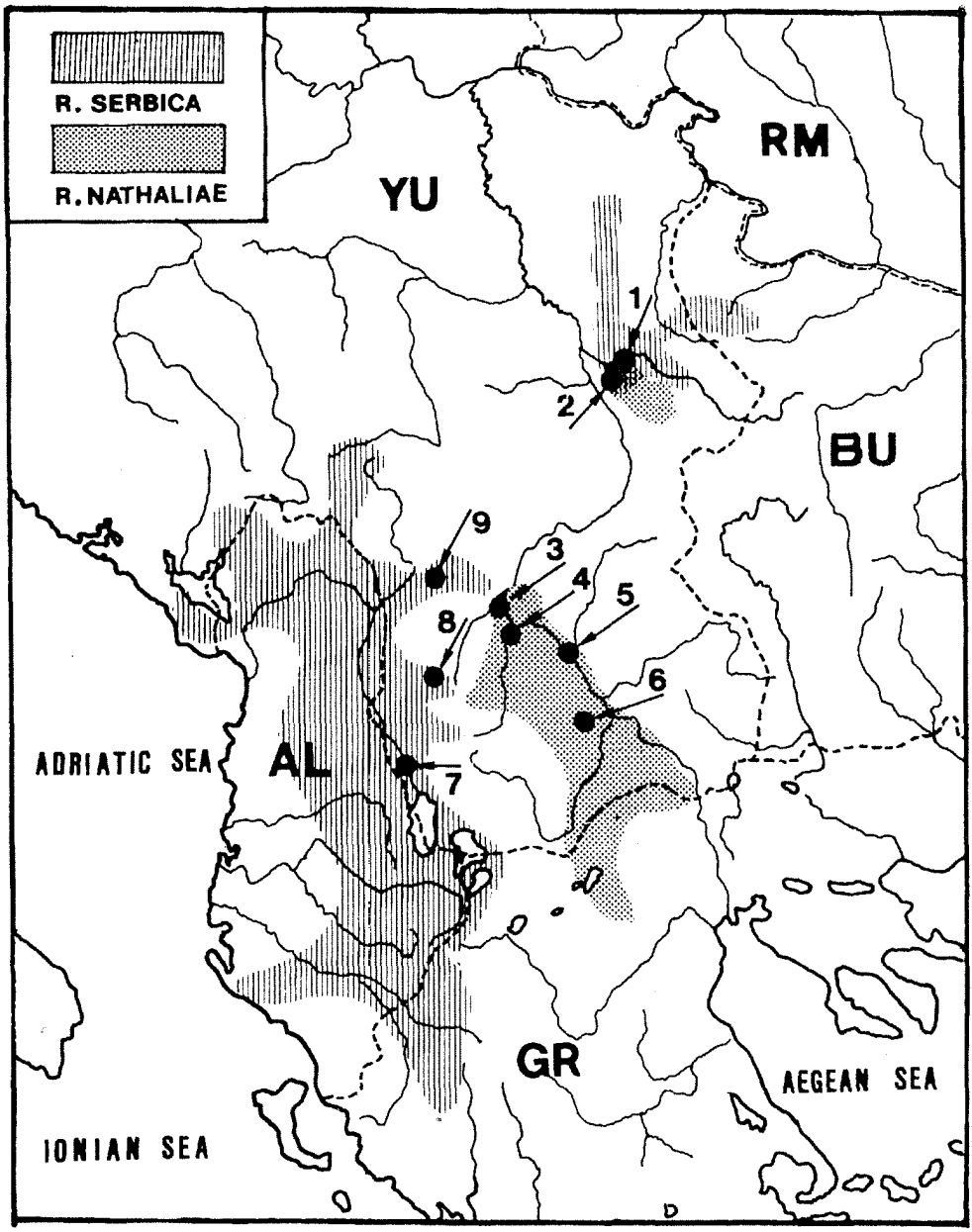

Fig. 1. – Distribution of *Ramonda serbica* and *R. nathaliae* and the localities of field investigations: 1. Oblik, 2. Radovanski kamen, 3. Raduša (serpentine), 4. Treska, 5. Pčinja (serpentine), 6. Raec, 7. Lukovo, 8. Cerovačka reka, 9. Prizrenska bistrica.

properties limit them to a very narrow ecological niche, characterized mostly by limestone substrate and absence of temperature extremes. However, they are also able to survive in the places of more xerophytic, i.e. unfavourable, conditions: on the expose rocky mountain slopes, on serpentine soil and devoid of shelter–providing surrounding vegetation. The water balance of both species in different habitats was studied in order to evaluate its ecological significance for the survival of these plants. Furthermore, the general knowledge of the parameters governing the life cycle of these „resurrection" plants is among the prerequisites for the preservation of the natural heritage of the Balkan flora which has to provide protection of these rare and slow–growing plants.

MATERIAL AND METHODS

Ramonda serbica was found to grow only on limestone, and the data were collected on several localities throughout its distribution area: Lukovo, Cerovačka reka (Macedonia), Radovanski kamen, Oblik and Prizrenska Bistrica (Serbia).

Ramonda nathaliae grows mostly on limestone but is also a facultative serpentinophyte. The data were collected in field investigations on the specimens at: Raec, Treska (Macedonia), Radovanski kamen and Oblik (Serbia), for limestone; Pčinja and Raduša (Macedonia), for serpentine. The measurements were sampled out several times in the course of a year. The plants were found to be in the state of anabiosis from the end–July to mid–September.

Water balance was assessed through the measurements of transpiration (S t o c k e r, 1929, 1956), of the water content in leaves (oven–drying to „constant" weight), and of the osmotic pressure of the cell sap (cryoscopic method after W a l t e r, 1931,1970).

RESULTS AND DISCUSSION

Within their ecological niche, where the habitat conditions are most favourable, both species are found to have an isohydric type of water balance with a small range of daily and seasonal amplitutes (Fig. 2 and 3). The transpiration intensity is small; in *R. serbica:* 1,04–8,58 mig.g.min, in *R. nathaliae:* 1,15–9,26 mg·g·min. The transpiration curve has a rather steady course in *R. serbica,* while it appears as a sequence of pulses in *R. nathaliae.* The most intensive transpiration rate is found in *R. nathaliae* growing on serpentine (Fig. 3).

The water content in leaves is relatively high; in *R. serbica:* 69,94–78,34%, in *R. nathaliae:* 68,54–76,08%. It appears to be relatively stable, hardly changing at all in either diurnal or seasonal dynamics. Moreover, it remains unaffected by different soil substrates of *R. nathaliae* habitats.

The osmotic pressure is rather low; in *R. serbica:* 5,8–11,4 bar, in *R. nathaliae:* 6,7–18,0 bar. The highest values as well as the greatest diurnal amplitudes were again found in *R. nathaliae* growing on serpentine (Fig. 4).

The general aspect of the water regime and the nature of its dynamics lacking seasonal changes, as perceived through these measurements, bring into light one characteristic feature distinugishing these resurrection species from other flowering plants. It looks like these plants do not „recognize" calender seasons in the otherwise habitual way of other plants, where the signs of senescence appear towards the end of the

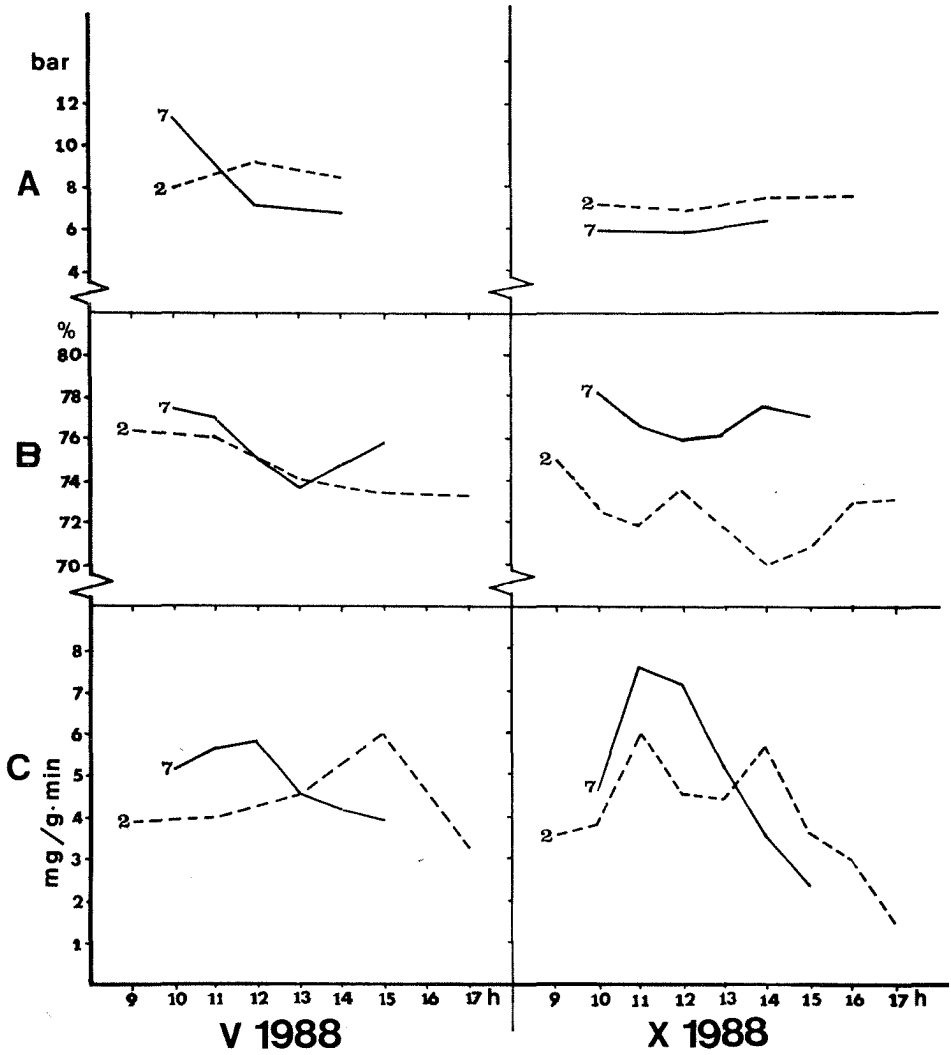

Fig. 2. – *R. serbica* – the pattern of diurnal changes of: (A) osmotic pressure, in bar, (B) water content in leaves, in % and (C) transpiration rate, in mg.g.min, on the localities of Radovanski kamen (2) and Lukovo (7).

vegetation period in autumn, and are reflected in the seasonal changes of water balance. Rather, they abide to a specific pattern of cyclic changes governed primarily by the environmental conditions (drought, in particular), which could force them to enter the state of anabiosis, marking thus the „seasonal" end of their own vegetation period. That is why, that growing in submediterranean climate, these plants could be seen in full

metabolic activity, reflected in the appropriate water balance, whenever the conditions are favourable, irrespective of the calender season.

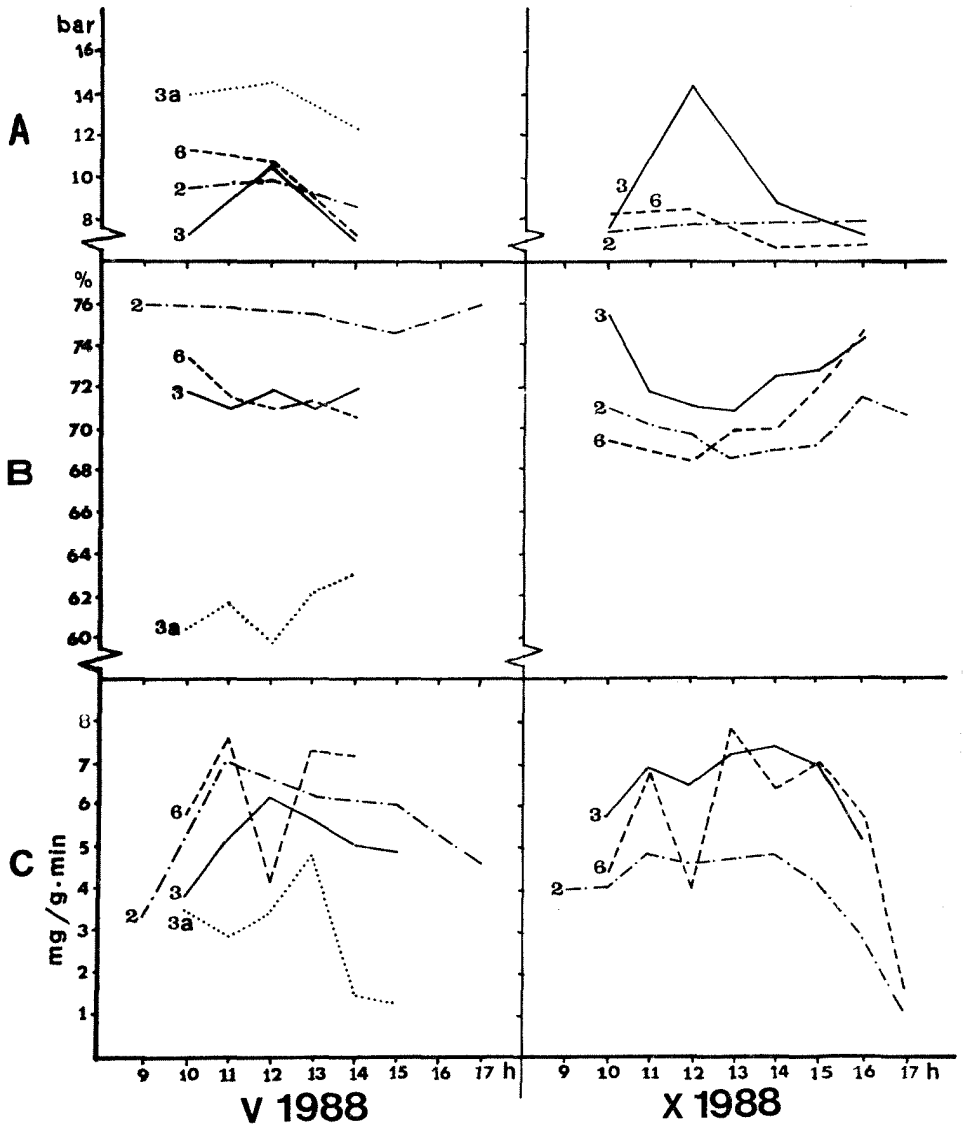

Fig. 3. – *R. nathaliae* – the pattern of diurnal changes of:(A) osmotic pressure, in bar, (B) water content in leaves, in %, and (C) transpiration rate, in mg. g. min, on the localities of Radovanski kamen (2), Raduša, serpentine (3), and Raec (6). Plants entering in the state of anabiosis were analysed on the locality of Raduša (3a).

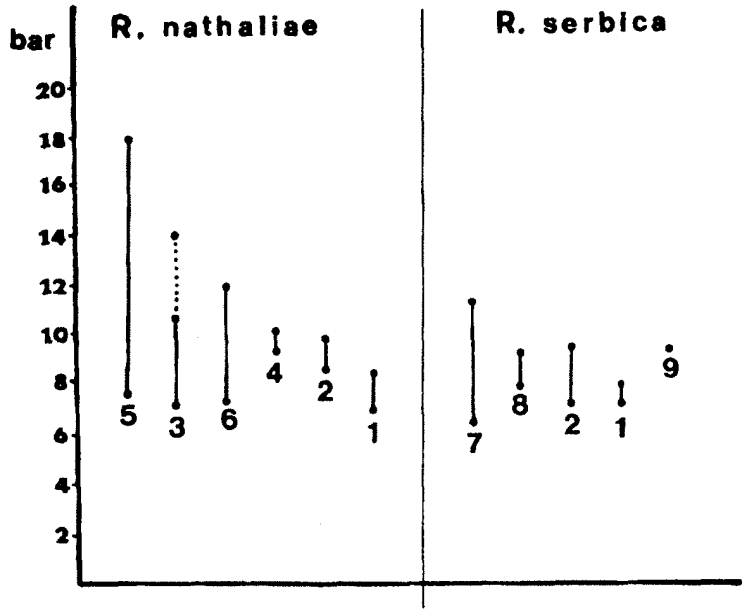

Fig. 4. – Ranges for the osmotic values in leaves of *R. serbica* and *R. nathaliae* from different localiteis.

In contrast the biological signs of their own ending vegetation season can be recognized in the changes of water balance as measured in the period preceding the anabiosis (Fig. 3, 3A), and corresponding to what can usually be seen in other flowering plants in autumn. There is a considerable fall in water content in leaves while the transpiration remains of low intensity and the osmotic pressure increases.

In this same sense, *R. nathaliae* growing on Radovanski kamen (Fig. 3) shows certain seasonal changes in autumn, reminiscent of what could be expected in most flowering plants. The reason might be in that the habitat is at the northern outskirts of the plants distribution area, and differing somewhat in climate by being colder and more humid. Here, the interrupting anabiosis period is shorter and the plants might possibly be more subject to the usual seasonal course of physiological changes in water balance.

The response of both species to less favourable conditions was found to show very little expression in their water balance which remained highly conserved within only a slightly broader range; both species maintained an isohydric pattern and a stenohydric character.

There are, however, certain differences between the two *Ramonda* species. The stenohydric character is more strictly preserved in *R. serbica*. It is also reflected in a more mesomorphic structure of its leaves (Fig. 5A). This species inhabits preferably sheltered places (S t e v a n o v i ć, B., 1986), less subject to important oscillations in environmental conditions.

R. nathaliae shows greater ecological tolerance both for harsher climate and for less favourable soil. It was found to grow on serpentine rocks and the highest values of

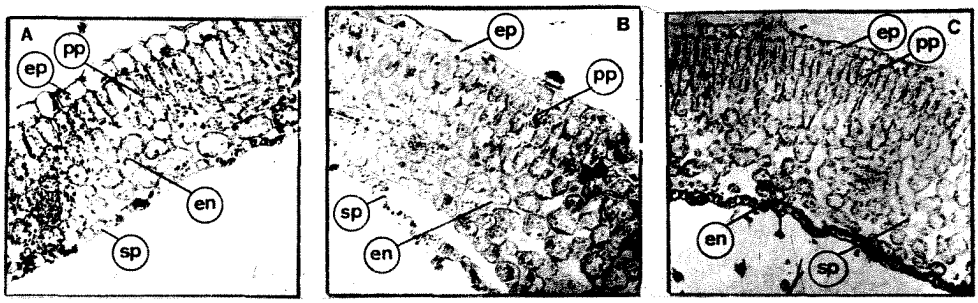

Fig. 5. – Cross–section of *R. serbica* (A), and *R. nathaliae*, limestone (B), serpentine (C): ep – upper epidermis, pp – palisade parenchyma, sp – spongy parenchyma, en – lower epidermis. The size and the shape of mesophyll cells and the ratio between the palisade and the spongy parenchyma in *R. nathaliae* leaves indicate a more xeromorphic structure particularly evident in specimens from serpentine habitats.

the plant's osmotic potential were recorded in these habitats – up to 18 bar in well hydrated leaves (Fig. 4). This species appears more capable of xeromorphic adaptation (Fig. 5B), again particularly evident in specimens from serpentine substrate (Fig. 5C).

Regardless of the fine differences both plants were observed to promptly enter the state of anabiosis as soon as the unfavourable conditons overcome their limited adaptive capacity, and remain in it as long necessary to avoid the drought stress.

It would appear that these plants resort to anabiosis as to their sole reliable strategy to survive even in habitat conditions which do elicit some morpho–physiological adaptations, but tax them to heavily.

CONCLUSIONS

Balkan endemorelic resurrection plants *Ramonda serbica* and *R. nathaliae* have isohydric type of water balance when well hydrated, as demonstrated in different habitats of their respective distribution areas. This pattern of water balance remains highly conserved even in less favourable conditions, which elicit only a slightly broader range in water regime parameters. *R. serbica* is more strict in conserving the pattern, while *R. nathaliae* shows somewhat more ecological plasticity. This is reflected in the latter species' presence on the localities subject to harsher environmental conditions. The survival strategy of both species resides in their capacity to enter the state of anabiosis whenever menaced by drought stress.

The studies in water balance indicate that both species could be regarded as insufficiently competitive in present environmental conditions; their further survival would benefit from a Landscape Preservation Program.

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Rezime

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VODNI REŽIM RAMONDA SERBICA PANČ. I R. NATHALIAE PANČ. ET PETROV. NA RAZLIČITIM STANIŠTIMA

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Balkanske endemoreliktne, poikilohidrične vrste *Ramonda serbica* i *R. nathaliae* odlikuju se izohidričnim vodnim režimom, na svim ispitivanim staništima u okviru njihovih areala. Biljke zadržavaju ovakav tip vodnog režima i u nepovoljnijim uslovima staništa, na kojima se jedino uočava nešto šira amplituda promena ispitivanih parametara (transpiracije, količine vode u listovima i osmotskih vrednosti). *R. serbica* je konzervativnija u očuvanju ovakvih vodnih odnosa, dok *R. nathaliae* pokazuje nešto veću ekološku plastičnost. Ovo se ogleda u prisustvu *R. nathaliae* na staništima sa nepovoljnijim klimatskim ili edafskim uslovima (staništa na serpentinu). Opstanak obe vrste prevashodno zavisi od njihove adaptivne sposobnosti da pređu u stanje anabioze čim se nađu ugrožene mogućim vodnim deficitom na staništu.

Istraživanja vodnog režima sprovedena na staništima pokazala su da se obe vrste mogu smatrati nedovoljno kompetitivnim u sadašnjim uslovima spoljašnje sredine; Program zaštite sredine doprineo bi očuvanju njihovih staništa, što je preduslov opstanka ovih vrsta.