Herb hydraulics: Inter- and intraspecific variation in three Ranunculus species

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Supplementary Information

Table S1: Species composition and corresponding ecological indicator values (humidity value; Ellenberg et al. 2012) at the dry site (*R. bulbosus*, *R. acris*), humid *R. acris* site, and humid *R. lanuginosus* site, respectively.

Site	Species	Humidity value	Remark
Dry (*R. bulbosus, R. acris*)	*Ranunculus acris*	6	wide ecol. amplitude
Dry (*R. bulbosus, R. acris*)	*Ranunculus bulbosus*	3	
Dry (*R. bulbosus, R. acris*)	*Achillea millefolium*	4	
Dry (*R. bulbosus, R. acris*)	*Bromus erectus*	3	
Dry (*R. bulbosus, R. acris*)	*Centaurea jacea*	x	indifferent
Dry (*R. bulbosus, R. acris*)	*Crepis biennis*	6	
Dry (*R. bulbosus, R. acris*)	*Dactylis glomerata*	5	
Dry (*R. bulbosus, R. acris*)	*Galium album*	x	indifferent
Dry (*R. bulbosus, R. acris*)	*Knautia arvensis*	4	
Dry (*R. bulbosus, R. acris*)	*Lotus corniculatus*	4	
Dry (*R. bulbosus, R. acris*)	*Plantago lanceolata*	x	indifferent
Dry (*R. bulbosus, R. acris*)	*Rhinanthus alectorolophus*	4	
Dry (*R. bulbosus, R. acris*)	*Rumex acetosa*	x	indifferent
Dry (*R. bulbosus, R. acris*)	*Trifolium pratense*	5	
Humid (*R. acris*)	*Ranunculus acris*	6	wide ecol. amplitude
Humid (*R. acris*)	*Chaerophyllum aureum*	5	
Humid (*R. acris*)	*Dactylis glomerata*	5	
Humid (*R. acris*)	*Geum rivale*	x	indifferent
Humid (*R. acris*)	*Lamium album*	5	
Humid (*R. acris*)	*Phleum pratense*	5	
Humid (*R. acris*)	*Plantago major*	5	
Humid (*R. acris*)	*Poa pratensis*	5	
Humid (*R. acris*)	*Polygonum bistorta*	7	
Humid (*R. acris*)	*Rumex conglomeratus*	7	
Humid (*R. acris*)	*Taraxacum officinale*	5	
Humid (*R. acris*)	*Trifolium pratense*	5	
Humid (*R. acris*)	*Urtica dioica*	6	

Table S1 (cont.)

Humid (*R. lanuginosus*)	*Ranunculus lanuginosus*	6	
Humid (*R. lanuginosus*)	*Acer pseudoplatanus*	6	
Humid (*R. lanuginosus*)	*Alliaria petiolata*	5	
Humid (*R. lanuginosus*)	*Aruncus dioicus*	6	
Humid (*R. lanuginosus*)	*Corylus avellana*	x	indifferent
Humid (*R. lanuginosus*)	*Geranium robertianum*	x	indifferent
Humid (*R. lanuginosus*)	*Geum urbanum*	5	
Humid (*R. lanuginosus*)	*Impatiens parviflora*	5	
Humid (*R. lanuginosus*)	*Lamium galeobdolon*	5	
Humid (*R. lanuginosus*)	*Sambucus nigra*	5	
Humid (*R. lanuginosus*)	*Solanum dulcamara*	8	
Humid (*R. lanuginosus*)	*Tilia platyphyllos*	5	
Humid (*R. lanuginosus*)	*Ulmus glabra*	7	
Humid (*R. lanuginosus*)	*Urtica dioica*	6	
Humid (*R. lanuginosus*)	*Veronica urticifolia*	5	

Citation: Ellenberg H, Weber EW, Wirth V, Werner W, Paulißen D (1992) Zeigerwerte von Pflanzen in Mitteleuropa. Scripta Geobotanica 18: 1-258

Table S2: Water potential at 50 and 88% of total cumulative ultrasonic emissions above -3 MPa (P_{50UE} and P_{88UE}; MPa). Thresholds computed after fitting the reparameterized Weibull function (Ogle et al., 2009) to vulnerability curves. Mean and 95% confidence intervals. Letters indicate significant differences in each row ($P < 0.05$).

Species	P_{50UE}	P_{88UE}
R. bulbosus (dry)	-1.05 (-1.31, -0.87)[a]	-2.47 (-3.35, -1.48)[a]
R. lanuginosus (humid)	-0.83 (-1.00, -0.68)[a]	-1.26 (-1.67, -0.80)[ab]
R. acris (dry)	-0.96 (-1.19, -0.78)[a]	-3.30 (<-3.50, -2.75)[a]
R. acris (humid)	-0.43 (-0.62, -0.33)[b]	-0.80 (-1.35, -0.45)[b]

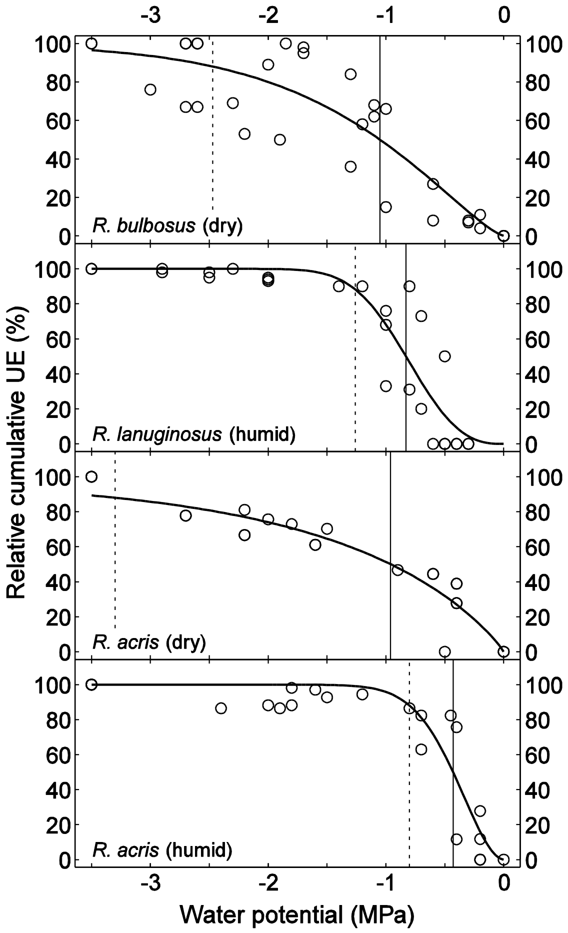

Figure S1: Relative cumulative ultrasonic emissions (UE; % of total number of recorded UE above -3 MPa) vs. water potential in *Ranunculus bulbosus*, *R. lanuginosus*, and dry and humid *R. acris* populations. Vertical lines indicate fitted hydraulic parameters P_{50UE} (solid) and P_{88UE} (dashed). Curves were extrapolated using the same equation and parameters used for vulnerability curves (Eq. (2)).

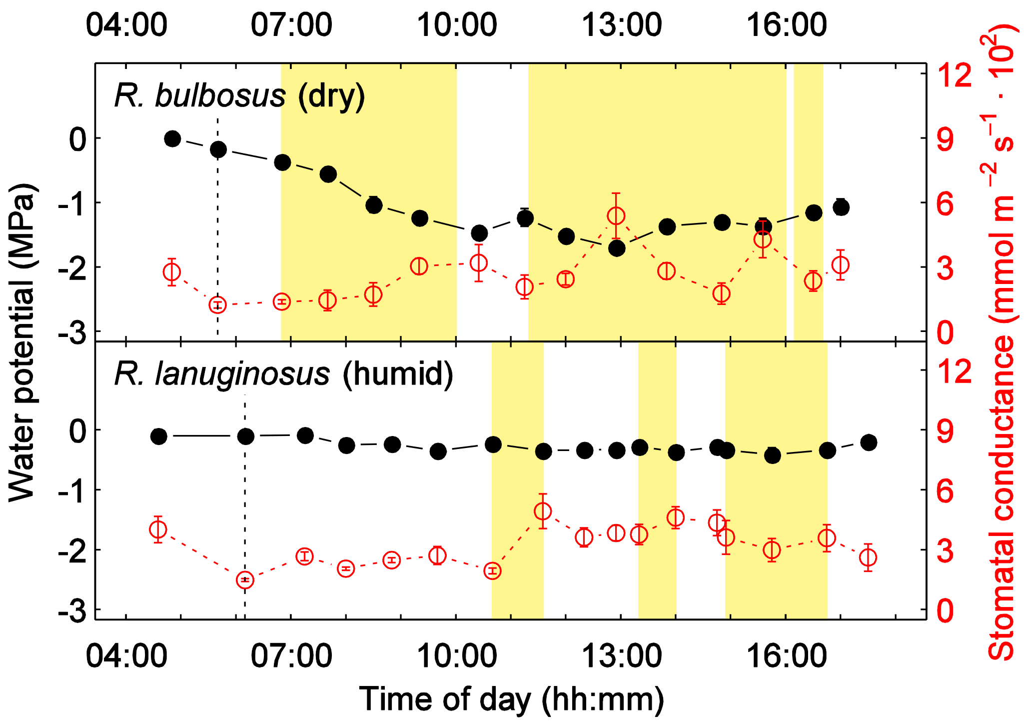

Figure S2: Diurnal variation of water potential (MPa; closed circles, solid black lines) and stomatal conductance (mmol m^{-2} s^{-1}; open circles, dashed red lines) in *R. bulbosus* and *R. lanuginosus*. Vertical line (dashed) indicates meteorological dawn, yellow boxes indicate direct sunlight. Mean ± SE.

Method for Ultrasonic Emission analysis:

Ultrasonic emissions (UE) were recorded during bench-top dehydration of four whole plants per species, whereby a 150 kHz pre-amplified resonance sensor (PK15I, Physical Acoustics Corporation, Germany) was placed on the leaf petiole approx. 3 cm from the lamina. AEWin^{TM} for USB (Ver. E3.35, Physical Acoustics Corporation, Germany) was used to record all signals of ≥ 35 db amplitude with a peak definition time, hit definition time and hit lockout time of 200, 400 and 2 µs, respectively. Silicone grease between the petiole and sensor, and a small weight (100 g) on top of the sensor, improved acoustic coupling. Recordings continued until UE from sample plants ceased.

Due to the low number of leaves per plant, additional plants of similar size were dehydrated in parallel under the same conditions [bench-top dehydration at room temperature and ambient relative humidity (ca. 50 % RH)] and used for regular Ψ_{leaf} determination, whereby Ψ_{leaf} was measured on one leaf each of two to three directly neighbouring plants and averaged at each measurement time. Control measurements showed very good agreement in Ψ_{leaf} across and within measured plants.

Plots of cumulative UE showed a distinct plateau near -2 to -3 MPa. Additional signals at later stages of dehydration were expected to be unrelated to hydraulic effects, as Ψ_{leaf} was often already outside the measurable range and plants were visibly past the point of recovery. Only signals observed until this initial plateau were used for further analysis. Plots of relative cumulative UE (% of total number of UE per plant) vs. Ψ_{leaf} from three to four plants were fitted to the Weibull function analogue to leaf hydraulic vulnerability analyses (Eq. (2), where k = 100 - relative number of cumulative UE). P_{50UE} and P_{88UE} were defined as the Ψ_{leaf} at 50 and 88% of cumulative ultrasonic emissions, respectively.