WATER CONTENT IN TERRICOLOUS LICHENS

ANNA MATWIEJUK

Institute of Biology, University of Białystok
Świerkowa 20B, 15-950 Białystok, Poland

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ABSTRACT

Investigations of the 24-hour absorption and evaporation in *Cetraria ericetorum*, *Cetraria islandica*, *Cladonia mitis*, *Cladonia rangiferina*, *Cladonia furcata*, *Cladonia phyllophora* were carried out. A high correlation was found between these processes and weather conditions and especially 24-hour changes in relative air humidity and changes in temperature. These processes are correlated independently of the season of the year.

KEY WORDS: terricolous lichens, microclimate, ecology, diurnal and nocturnal cycles, water absorption, evaporation.

INTRODUCTION

Lichens are poikylhydrous organisms. They are characterised by a high water absorption index. They do not have organellae for water absorption, for its distribution all over the thallus and for its accumulation over a long period of time. Similarly, they dry up very quickly. They use atmospheric water, as well as rain, dew and fog.

In the direct contact with water already after 30 sec the absorption exceeds the weight of the lichen dry mass: from 116% in *Aspicilia fruticulosa* to 566% in *Collema flaccidum* (Blum 1973). Maximum water absorption is reached in the first minutes (Blum 1973; Bystrek 1997).

The pioneers of investigations of water absorption by the lichen thalli were Zukal (1895), Sievers (1908 cited in Blum O.B. (1973)) and Bachmann (1923). In their opinion water absorption depends on the structure of the thallus. According to Goebel (1926) and Stocker (1927) water gets into capillaries and air spaces between the hyphae and photobiont cells. This process leads to the swelling of the mycobiont hyphae wall surface. According to Poelt and Baumgaertner (1964) the rate of water absorption depends on the anatomical structure of the cortex. Larson (1981) reached the same conclusions on the basis of investigations of 11 species in the air blow tunnel. Poelt and Baumgaertner (1964) suggested that rhizines took part in water absorption (e.g. *Squammarina*). However, this was not confirmed by Larson (1981) who investigated the higrscopicity of rhizines in *Peltigera*. Kolumbe (1927 cited after Blum (1973)), and Blum (1973) wrote about the importance of sorediae and izidia in water absorption. In Smith's (1960) opinion 25% of water in *Peltigera* is accumulated in the medulla, much less in the cortex and in the photobiont layer. Showman and Rudolph (1971) report the highest higrscopicity (*Umbilicaria*) in the photobiont layer. Redon and Lange (1983) were concerned with the use of dew by the lichens. According to Heatwole (1966) and Bystrek (1997) the higher moisture content in the lichens at night is closely re-

lated to the increasing relative air humidity. Jahns and Ott (1983) studied the influence of microclimate on diurnal water.

According to Larson and Kershaw (1976), Larson (1979), Legaz et al. (1985), as well as Vincente and Velasco (1986) the rate of evaporation depends on the structure of the thallus. Kershaw and Rouse (1971) and Kershaw (1975) contend that the regulation of water loss depends on the relation between the sunbeam falling on the thallus and the thalli morphology. According to Lange et al. (1970) as well as Kappen et al. (1979) evaporation is extremely quick between 9 and 10³⁰ a.m. Bystrek (1997) suggests that drying up of the lichen thalli is a physical process correlated with weather conditions, especially with the increase in temperature and with insolation.

Rydzak (1953) considered that the extinction of lichens was connected with water insufficiency and with temperature. The interdependence between the ions of calcium and the ions of potassium is in Kuziel's (1975) opinion one of the basic factors determining cell's resistance to dehydration. Armstrong (1976) as well as Pearson and Benson (1977) hold that an excessive humidity inhibits the growth of the thalli. Beckett's investigations (1995, 1996) refer to mechanisms of physiological responsibility for the tolerance of drying up and lichen water demands on cellular level.

At present the research concentrates on the correlation between the moisture content in the thalli and gas exchange and activity of photosynthesis (Lange and others 1975, 1981, 1985 and Kappen and others 1979, 1980). It was proved that the activity of photosynthesis is the highest at 40-69% of water in the thalli in relation to dry mass. Türk (1980) investigates the correlation between gas exchange activity, and temperature and humidity. Fabiszewski and others (1983) proved the influence of anthropogenic factors on metabolic processes in the lichens.

The investigations described in this paper refer to: the use of atmospheric water by the lichens, the absorption and evaporation within 24 hours and in various seasons of the year as well as correlation between these processes and weather con-

ditions – 24 hours’ weather fluctuations and relative air humidity.

The research was carried out on: *Cetraria ericetorum* Opiz, *Cetraria islandica* (L.) Ach., *Cladonia mitis* (Sandst.) Hustich, *Cladonia rangiferina* (L.) Nyl., *Cladonia furcata* (Huds.) Schrad. and *Cladonia phyllophora* Hoffm.

The lichens were collected at Siemianówka, the Knyszyńska Forest and the Tyniewiczze in the Podlasie province. The experimental part of the investigations was carried out in the area of the city of Białystok.

METHODS

Before measurements were made the lichen samples had been acclimatized to the outer conditions.

The lichen samples were put on the ground in containers with soil, on the terrace beside measurement apparatus. The lichen thalli of different mass were used for the investigation so that the samples examined should not be damaged.

For measurements a self-recording thermohigrograph TZ 18D and an electronic balance Sartorius BMBH Göttinger PT 120 were used. The time of measurement did not exceed 1 min.

The experiments were carried out;
From 30 April 1998 to 1 May 1998 – from 8 p.m. to 8 p.m. next day,
From 22 July 1998 to 23 July 1998 – from 8 p.m. to 8 p.m. next day,
From 25 September 1997 to 26 September 1997 – from 8 p.m. to 8 p.m. next day,
From 11 February 1999 to 12 February 1999 – from 8 p.m. to 5 a.m. next day.

Per cent content of water in the thalli C was calculated on the basis of the following formula:

$$C=[(a-b): b] \cdot 100$$

C – content of water [%] in relation to the thallus with the lowest weight,
a – weight of the thallus [g],
b – weight of the thallus [g] with the lowest mass recorded within 24 hours’ measurements.

The results were subject to statistical analysis and there were determined: correlation coefficient r (x,y) and the level of significance (p), arithmetic means (X) and standard deviation (SD).

The index of correlation between air humidity and per cent water content in the thalli was demonstrated by the following pattern:

$$r(xy) = (\sum xy) / \sqrt{\sum (x^2) \cdot \sum (y^2)}$$

x – relative air humidity,
y – per cent water content in the thallus in relation to the thallus with the lowest weight,

SD – Standard deviation,

$$SD = \sqrt{\sum (x^2) / N-1}$$

x – successive values of per cent water content in the thallus with the lowest weight,
N – number of repetition.

TABLE 1. Results of 24-hours absorption and evaporation of water by the terricolous lichens on 30 April 1998/1 May 1998 (SPRING) in the area of the city of Białystok during high baric pressure.

No	Name of lichen species	Time of measurements																								X	SD	r (xy)	
		Air temperature in °C																											
		Relative air humidity in %																											
		20:00	21:00	22:00	23:00	24:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00				20:00
Data		19	17	17	16	15	14	13	13	11.5	12	13	75	75	74	65	56	55	54	53	42	42	58	59	59	59	60		
1.	<i>Cetraria ericetorum</i>	A. 4.75*	4.78	4.80	4.83	4.84	4.85	4.88	5.01	5.05	5.03	5.02	5.02	4.98	4.88	4.52	4.50	4.46	4.44	4.36	4.36	4.72	4.73	4.74	4.75	4.78			
	B.	0.39	0.42	0.44	0.47	0.48	0.49	0.52	0.55	0.59	0.57	0.56	0.56	0.52	0.42	0.16	0.14	0.10	0.08	0	0	0.36	0.37	0.38	0.39	0.42	8.60	4.226	0.943
	C.	8.94	9.63	10.09	10.78	11.01	11.24	11.93	12.61	13.53	13.07	12.84	–	11.93	9.63	3.67	3.21	2.29	1.83	0	0	8.25	8.48	8.72	8.94	9.63			
2.	<i>Cetraria islandica</i>	A. 6.62*	6.64	6.66	6.71	6.74	6.76	6.82	6.87	6.89	6.88	6.87	6.87	6.83	6.65	6.29	6.23	6.15	6.08	5.93	5.93	6.55	6.56	6.57	6.58	6.58	10.77	5.028	0.957
	B.	0.69	0.71	0.73	0.78	0.81	0.83	0.89	0.94	0.96	0.95	0.94	0.94	0.90	0.72	0.36	0.30	0.22	0.15	0	0	0.62	0.63	0.64	0.64	0.65			
	C.	11.63	11.97	12.31	13.15	13.66	13.99	15.01	15.85	16.18	16.02	15.85	–	15.17	12.14	6.07	5.06	3.71	2.53	0	0	10.45	10.62	–	10.79	10.69			
3.	<i>Cladonia mitis</i>	A. 5.14*	5.18	5.21	5.24	5.25	5.30	5.35	5.40	5.40	5.42	5.42	5.41	5.40	5.13	4.82	4.67	4.59	4.55	4.54	4.54	5.08	5.09	5.10	5.11	5.12	12.29	6.654	0.935
	B.	0.60	0.64	0.67	0.70	0.71	0.76	0.81	0.86	0.86	0.88	0.88	0.87	0.86	0.59	0.28	0.13	0.05	0.01	0	0	0.54	0.55	0.56	0.57	0.58			
	C.	13.26	14.09	14.75	15.42	15.64	16.74	17.84	18.94	–	19.38	–	–	19.16	18.94	12.99	6.16	2.86	1.10	0.22	0	11.89	12.11	12.33	12.55	12.77			
4.	<i>Cladonia rangiferina</i>	A. 2.55*	2.57	2.59	2.61	2.64	2.67	2.69	2.71	2.72	2.71	2.71	2.70	2.69	2.50	2.39	2.35	2.33	2.33	2.31	2.31	2.50	2.52	2.52	2.55	2.55	10.27	6.116	0.951
	B.	0.24	0.26	0.28	0.30	0.33	0.36	0.38	0.40	0.41	0.40	0.40	0.39	0.38	0.19	0.08	0.04	0.02	0.02	0	0	0.19	0.21	0.21	0.21	0.24			
	C.	10.39	11.25	12.12	12.98	14.28	15.28	16.45	17.32	17.75	17.32	–	16.88	16.45	8.22	3.46	1.73	0.86	–	–	–	8.22	9.09	–	10.39	–			
5.	<i>Cladonia furcata</i>	A. 11.70*	11.76	11.82	11.88	11.90	11.98	12.05	12.18	12.27	12.35	12.23	12.20	12.06	12.00	11.29	11.15	11.02	11.01	10.73	10.73	11.66	11.62	11.63	11.66	11.67	9.02	4.339	0.965
	B.	0.97	1.03	1.09	1.15	1.17	1.25	1.32	1.45	1.54	1.52	1.50	1.47	1.33	1.27	0.56	0.42	0.29	0.28	0	0	0.93	0.89	0.90	0.93	0.94			
	C.	9.04	9.59	10.16	10.72	10.90	11.65	12.30	13.51	14.35	14.16	13.98	13.69	12.39	11.83	5.22	3.91	2.70	2.61	0	0	8.66	8.29	8.38	8.66	8.76			
6.	<i>Cladonia phyllophora</i>	A. 6.00*	6.04	6.06	6.09	6.12	6.18	6.22	6.26	6.30	6.29	6.27	6.26	6.09	5.97	5.77	5.67	5.62	5.59	5.52	5.52	5.96	5.94	5.94	5.96	5.97	8.41	4.438	0.952
	B.	0.48	0.52	0.54	0.57	0.60	0.66	0.70	0.74	0.78	0.77	0.75	0.74	0.57	0.45	0.25	0.15	0.10	0.07	0	0	0.44	0.42	0.42	0.44	0.45			
	C.	8.69	9.42	9.78	10.33	10.87	11.96	12.68	13.41	14.13	13.95	13.59	13.41	10.33	8.15	4.53	2.72	1.81	1.27	0	0	7.97	7.61	–	7.97	8.15			

Legend:
A – weight of lichen thallus (g); B – difference (g) between the present weight of the thallus and the lowest weight recorded during 24-hours measurements; C – water content (%) in relation to the thallus with the lowest weight; * – initial mass of thallus in grams; Grey – shaded area – period of „anabiosis”; X – mean value of C; SD – standard deviation; r (xy) – correlation coefficient.

Fig. 1. Diagram to Table 1 (Spring)

Fig. 1'. Diagram to Fig. 1

RESULTS

Spring exposure (Table 1, Fig. 1 and 1'). High-pressure area, cloudless sky, air temperature in place of exposure of the samples 19°C, relative air humidity 60%. Hydration of the thalli: 9% (*Cetraria ericetorum*), 13% (*Cladonia mitis*).

The exposed thalli completed water and then absorption ended between 4 and 5 a.m. Over the night the temperature was falling successively while relative humidity was increasing (Table 1, Fig. 1 and 1'). The evaporation lasted until 2 p.m.; at first it was slow, but between 8 and 11 it was intensive. It was correlated with increase of temperature and decrease of relative humidity. At 2 p.m. the thalli were dry and this state remained until 4 p.m. The afternoon absorption started with an intensive accumulation of atmospheric water. This process was correlated with the decrease of temperature and increase of relative humidity (Table 1, Fig. 1'). Measurements were interrupted at 8 p.m., the thalli hydration being the same as at 8 p.m. the previous day.

The correlation between relative air humidity and per cent water content in the thalli expressed in values of correlation coefficients is very high ($\pm 0.95 \leq r(x,y) < 1$). The determined correlation coefficients are significant at $p < 0.05$ and $N = 25$ (Table 1). Mean 24-hour water content in the thalli (Table 1) ranged from 8.6% (*Cetraria ericetorum*) to 12.29% (*Cladonia mitis*).

Summer exposure (Table 2, Fig. 2 and 2'). High-pressure area, low cloud cover in the evening, high at night and in the morning, relative air humidity 61% (Fig. 2'). The thalli hydration from 4.5% (*Cladonia rangiferina*) to 5.6% (*Cetraria islandica*).

The absorption was low, up to 0.3% per hour on the average. It ended at 10 a.m. At this time changes in weather conditions were small. The temperature slightly lowered. Relative humidity was high (a decrease by 4%). The evaporation started together with the rise of the temperature and the drop of relative humidity. The thalli were dehydrating until 2 p.m., until the thalli dried up. This state kept up for 2 hours. The afternoon absorption started together with the lowering of temperature, and an increase in relative humidity (Table 2, Fig. 2'). Measurements were stopped at 8 p.m., the hydration of the thalli being the same as at 8 p.m. the previous day.

The correlation between relative air humidity and per cent water content in the thalli expressed by means of correlation coefficient value, is high (almost complete correlation $0.92-0.95 \leq r(x,y) < 1$). The determined correlation coefficients are significant, at $p < 0.05$ and $N = 25$ (Table 2). Mean 24-hour water content in the thalli (Table 2) ranged from 4.73% (*Cladonia rangiferina*) to 6.17% (*Cetraria islandica*).

Autumn exposure (Table 3, Fig. 3 and 3'). Depression, high cloud cover, the temperature at the samples level 11°C, relative humidity 78%. Water hydration 11.54% (*Cladonia phyllophora*), 17.05% (*Cetraria islandica*).

The absorption proceeded successively and ended between 5 and 6 a.m. The amount of water in the thalli was increased to over 20% (17.58-22.20). Relative humidity was increasing successively and at 6 a.m. it reached 91%. Over the night the temperature kept up on the same level (11-12°C). The evaporation, at first slow, ended at 1 p.m. with drying up of the thalli. The afternoon absorption started at about 2 p.m. It was followed by a successive temperature fall and an increase in relative humidity. Measurements were interrupted at 8 p.m., the hydration being the same as at 8 p.m. the previous day.

The correlation between relative air humidity and per cent water content in the thalli expressed by means of the correlation

TABLE 2. Results of 24-hours absorption and evaporation of water by the terricolous lichens on 22 July 1998/23 July 1998 (SUMMER) in the area of the city of Białystok during baric high pressure.

No	Name of lichen species	Time of measurements																							X	SD	r(x,y)			
		Air temperature in °C												Relative air humidity in %																
		20:00	21:00	22:00	23:00	24:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00				
		29	28	27	26	25	24	24	23	22	21	21	21	21	21	22	29	34	37	40	44	40	39	40	35	30				
1.	<i>Cetraria ericetorum</i>	61	62	61	61	62	63	63	63	65	64	64	63	64	65	62	55	53	51	46	52	56	50	54	58					
	A.	4.35*	4.31	4.32	4.35	4.38	4.39	4.40	4.44	4.46	4.47	4.45	4.44	4.45	4.57	4.52	4.28	4.21	4.12	4.12	4.17	4.22	4.13	4.18	4.29					
	B.	0.23	0.19	0.20	0.23	0.26	0.27	0.28	0.32	0.34	0.35	0.35	0.32	0.35	0.41	0.45	0.40	0.16	0.09	0	0	0.05	0.10	0.01	0.06	0.17	5.42	3.162	0.926	
2.	<i>Cetraria islandica</i>	5.58	4.61	4.85	5.58	6.31	6.55	6.79	7.76	8.49	8.49	7.76	8.49	9.95	10.92	9.71	3.88	2.18	0	0	1.21	2.43	0.24	1.45	4.13					
	A.	6.31*	6.38	6.38	6.40	6.45	6.48	6.49	6.52	6.58	6.60	6.62	6.55	6.57	6.62	6.66	6.51	6.18	6.13	5.98	5.98	6.00	6.10	6.04	6.10	6.20				
	B.	0.33	0.40	0.40	0.42	0.47	0.50	0.51	0.54	0.60	0.62	0.64	0.57	0.59	0.64	0.58	0.53	0.20	0.15	0	0	0.02	0.12	0.06	0.12	0.22	6.17	3.765	0.953	
3.	<i>Cladonia mitis</i>	5.52	6.08	6.08	7.02	7.86	8.36	8.53	9.03	10.36	10.70	9.53	9.86	10.70	9.69	8.86	3.34	2.51	0	0	0.33	2.01	1.00	2.01	3.67					
	A.	3.09*	3.08	3.09	3.11	3.12	3.13	3.14	3.16	3.18	3.19	3.18	3.18	3.15	3.21	3.22	3.16	3.01	2.95	2.95	2.95	2.96	3.03	2.98	3.00	3.05				
	B.	0.14	0.13	0.14	0.16	0.17	0.18	0.19	0.21	0.23	0.24	0.23	0.23	0.20	0.26	0.27	0.21	0.06	0	0	0	0.01	0.06	0.03	0.05	0.10	4.74	3.053	0.945	
4.	<i>Cladonia rangiferina</i>	4.74	4.41	4.74	5.42	5.76	6.10	6.44	7.12	7.79	8.13	7.79	8.81	9.15	9.15	7.12	2.03	0	0	0	0.34	2.03	1.01	1.69	3.38					
	A.	2.34*	2.34	2.35	2.35	2.36	2.38	2.38	2.39	2.40	2.41	2.40	2.39	2.39	2.45	2.43	2.43	2.31	2.27	2.24	2.24	2.25	2.29	2.26	2.29	2.31				
	B.	0.10	0.10	0.11	0.11	0.12	0.14	0.14	0.15	0.16	0.17	0.16	0.15	0.15	0.21	0.19	0.19	0.07	0.03	0	0	0.01	0.05	0.02	0.05	0.07	4.73	2.836	0.935	
5.	<i>Cladonia furcata</i>	4.46	—	4.91	—	5.35	6.25	6.69	7.14	7.58	7.14	6.69	—	—	9.37	8.48	8.48	3.12	1.34	0	0	0.45	2.23	0.89	2.23	3.12				
	A.	11.51*	11.52	11.53	11.62	11.65	11.68	11.70	11.78	11.85	11.90	11.87	11.84	11.80	11.94	11.96	11.81	11.15	11.07	10.96	10.96	11.07	11.15	11.00	11.25	11.45				
	B.	0.55	0.56	0.57	0.66	0.69	0.72	0.74	0.82	0.89	0.94	0.91	0.88	0.84	0.98	1.00	0.85	0.19	0.11	0	0	0.11	0.19	0.04	0.29	0.49	5.11	3.126	0.957	
6.	<i>Cladonia phyllophora</i>	5.02	5.11	5.20	6.02	6.29	6.57	6.75	7.48	8.12	8.57	8.30	7.66	8.94	9.12	7.75	1.73	1.00	0	0	1.00	1.73	0.36	2.64	4.47					
	A.	5.62*	5.62	5.63	5.65	5.68	5.70	5.71	5.74	5.77	5.80	5.78	5.77	5.75	5.85	5.85	5.85	5.61	5.47	5.41	5.36	5.36	5.42	5.38	5.50	5.58				
	B.	0.26	0.26	0.27	0.29	0.32	0.34	0.35	0.38	0.41	0.44	0.42	0.41	0.39	0.49	0.49	0.49	0.25	0.09	0.05	0	0	0.06	0.02	0.14	0.22	5.10	3.021	0.926	
		4.85	—	5.04	5.41	5.97	6.34	6.53	7.08	7.65	8.21	7.83	7.65	7.27	9.14	—	9.14	4.66	1.68	0.93	0	0	1.12	0.37	2.61	4.10				

Legend:
A – weight of lichen thallus (g); B – difference (g) between the present weight of the thallus and the lowest weight recorded during 24-hours measurements; C – water content (%) in relation to the thallus with the lowest weight; * – initial mass of thallus in grams; Grey – shaded area – period of „anabiosis”; X – mean value of C; SD – standard deviation; r (xy) – correlation coefficient.

Fig. 2. Diagram to Table 2 (Summer)

Fig. 2'. Diagram to Fig. 2

tion coefficient value, is high (almost complete correlation $\pm 0.96 \leq r(x,y) < 1$). The determined indices of correlation are significant, at $p < 0.05$ and $N = 25$ (Table 3). Mean 24-hour water content in the thalli (Table 3) was from 12.14% (*Cladonia phyllophora*) to 16.72% (*Cetraria islandica*).

Winter exposure. Low cloud cover, the air temperature - 3°C, relative humidity 67%. After 6-hour acclimatization the hydration of the thalli of *Cladonia phyllophora* was 7.22%, *Cladonia rangiferina* 11.92%, *Cetraria ericetorum* 12.34%, *Cetraria islandica* 12.34%, *Cladonia mitis* 13.22%, *Cladonia furcata* 14.84%.

The evening and night absorption was minimum and it lasted until 5 a.m. and the amount of water in the thalli increased from 1.5-4%. After freezing of water the experiment was stopped early in the morning.

DISCUSSION

In our climatic conditions the maximum saturation with water occurs rarely and only during rainfall or a considerable dewfall. With varying climatic conditions the lichens are endangered water scarcity and they dry up completely during sunshine. The basic source of water for lichens is atmospheric water (Bystrek 1997) and the 24-hour changes in water content in the thalli create optimum conditions for the regular course of metabolic process. Kappen and others (1979) recorded that when the thallus was desiccated, the physiological activity of lichens was lowered, which led to an inhibition of life processes. This state was called "anabiosis" by Bystrek (1997).

The evaporation in all the samples was correlated with weather conditions and ended with drying up of the thalli. In the afternoon and early afternoon, during sunny weather and at high temperature, and the lowest within 24 hours relative air humidity the thalli were air-dry and they remained in such a state for 1-2 hours. They activated with increase of air humidity.

From the experiments carried out in various months it results that irrespective of the season of the year the absorption started in the early afternoon and ran successively, 0.5-1% per hour on the average. Within 24 hours it did not exceed 23% in relation to the dry mass of the thalli. It was correlated with weather conditions (recorded during the investigations: temperature, relative air humidity, pressure configurations); increase in relative air humidity simultaneous lowering of temperature (Tables 1-3, Fig. 1'-3'). In the samples examined on the turn of April when the pressure was high, the absorption ended at 4-5 a.m. and the amount of water fluctuated from 13.53% to 19.38% (Table 1, Fig. 1'). In the samples exposed in July the values of absorption were lower, from 9.12% to 10.92% (Table 2, Fig. 2'). In September, during depression and total cloud cover in the evening and at night (Table 3, Fig. 3'), and at high relative humidity keeping up to 6 a.m. on $\pm$ the same level, the absorption in the samples exposed lasted to 6 a.m. and was 23%.

In urban conditions (artificial for the lichens growing in forests) the amount of water absorbed from the atmosphere does not exceed 23%. The per cent of saturation is usually lower in towns. The most active absorption occurred (independently of the season of the year) in the afternoon when relative humidity was increased. The results of investigations carried out in towns are comparable with results obtained in the field (Bystrek 1997). This refers both to the amount of absorbed water and the correlation between the evaporation and the absorption, and 24-hour changes in relative humidity. Heatwole (1966) found in several species of *Cladonia* a large

TABLE 3. Results of 24-hours absorption and evaporation of water by the terricolous lichens on 25 September 1997/26 September 1997 (AUTUMN) in the area of the city of Białystok during depression.

No	Name of lichen species	Time of measurements																							X	SD	r(N)		
		Air temperature in °C																											
		Relative air humidity in %																											
		20:00	21:00	22:00	23:00	24:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00			
78	80	82	84	85	85	87	88	90	90	91	90	89	88	85	69	57	37	55	60	65	66	68	72	76					
1.	<i>Cetraria ericetorum</i>	A. 4.48*	4.51	4.55	4.58	4.58	4.60	4.62	4.64	4.66	4.67	4.64	4.62	4.60	4.59	4.36	4.12	3.88	4.04	4.14	4.22	4.28	4.44	4.46	4.50	14.86	5.683	0.910	
	B.	0.60	0.63	0.67	0.70	0.70	0.72	0.74	0.76	0.78	0.78	0.79	0.76	0.74	0.72	0.71	0.48	0.24	0	0.16	0.26	0.34	0.40	0.56	0.58				0.60
	C.	15.46	16.24	17.26	18.04	18.55	19.07	19.58	20.10	20.36	20.36	20.36	19.58	19.07	18.55	18.29	12.37	6.18	0	4.12	6.70	8.76	10.31	14.43	14.95				15.46
2.	<i>Cetraria islandica</i>	A. 9.13*	9.22	9.35	9.41	9.48	9.48	9.48	9.49	9.55	9.58	9.52	9.50	9.50	9.48	9.04	8.45	7.80	8.23	8.32	8.44	8.62	8.86	9.03	9.10	16.72	6.561	0.980	
	B.	1.33	1.42	1.55	1.61	1.68	1.68	1.69	1.69	1.75	1.78	1.72	1.70	1.70	1.68	1.24	0.65	0	0.43	0.52	0.64	0.82	1.06	1.20	1.30				
	C.	17.05	18.21	19.87	20.64	21.54	21.66	22.43	22.82	22.82	22.82	22.05	21.79	21.79	22.82	15.89	8.33	0	5.51	6.66	8.20	10.51	13.59	15.38	16.66				
3.	<i>Cladonia mitis</i>	A. 9.27*	9.38	9.52	9.56	9.61	9.65	9.71	9.78	9.84	9.85	9.88	9.84	9.77	9.76	9.32	8.60	8.10	8.33	8.51	8.70	8.82	9.03	9.16	9.25	15.00	6.656	0.974	
	B.	1.17	1.28	1.42	1.46	1.51	1.55	1.61	1.68	1.74	1.75	1.78	1.74	1.67	1.66	1.65	1.22	0.50	0	0.13	0.41	0.60	0.72	0.93	1.06				1.15
	C.	14.44	15.80	17.53	18.02	18.64	19.13	19.87	20.74	21.48	21.60	21.97	21.48	20.62	20.49	20.37	15.06	6.17	0	1.60	5.06	7.41	8.88	11.48	13.08				14.19
4.	<i>Cladonia rangiferina</i>	A. 6.49*	6.56	6.65	6.68	6.75	6.77	6.80	6.82	6.84	6.86	6.88	6.88	6.83	6.83	6.81	6.53	6.00	5.63	5.81	5.91	6.08	6.16	6.34	6.40	6.49	15.59	6.785	0.976
	B.	0.86	0.93	1.02	1.05	1.12	1.14	1.17	1.19	1.21	1.23	1.25	1.25	1.20	1.20	1.18	0.90	0.27	0	0.18	0.28	0.45	0.53	0.71	0.77	0.86			
	C.	15.27	16.52	18.12	18.65	19.89	20.25	20.78	21.13	21.49	21.84	22.20	22.20	21.31	20.95	15.98	4.79	0	3.19	4.97	7.99	9.41	12.61	13.67	15.27				
5.	<i>Cladonia furcata</i>	A. 13.91*	14.04	14.17	14.30	14.35	14.44	14.52	14.54	14.58	14.62	14.67	14.62	14.56	14.55	14.54	14.00	12.97	12.21	12.74	12.82	12.96	13.21	13.55	13.73	13.88	14.16	5.937	0.975
	B.	1.70	1.83	1.96	2.09	2.14	2.23	2.31	2.33	2.37	2.41	2.46	2.41	2.35	2.34	2.33	1.79	0.76	0	0.53	0.61	0.75	1.00	1.34	1.52	1.67			
	C.	13.92	14.98	16.05	17.11	17.52	18.26	18.92	19.08	19.41	19.73	20.14	19.74	19.24	19.16	19.08	14.66	6.22	0	4.34	4.99	6.14	8.19	10.97	12.45	13.67			
6.	<i>Cladonia phyllophora</i>	A. 4.06*	4.11	4.15	4.18	4.19	4.20	4.22	4.23	4.25	4.26	4.28	4.25	4.20	4.19	4.17	4.03	3.74	3.64	3.70	3.82	3.91	3.98	4.06	4.10	4.13	12.14	5.065	0.966
	B.	0.42	0.47	0.51	0.54	0.55	0.56	0.58	0.59	0.61	0.62	0.64	0.61	0.56	0.55	0.39	0.10	0	0.06	0.18	0.27	0.34	0.42	0.46	0.49				
	C.	11.54	12.91	14.01	14.83	15.11	15.38	15.93	16.21	16.76	17.03	17.58	16.76	15.38	15.11	14.56	10.71	2.74	0	1.64	4.94	7.41	9.34	11.54	12.64	13.46			

Legend:

A – weight of lichen thallus (g); B – difference (g) between the present weight of the thallus and the lowest weight recorded during 24-hours measurements; C – water content (%) in relation to the thallus with the lowest weight; * – initial mass of thallus in grams; X – mean value of C; SD – standard deviation; r(xy) – correlation coefficient.

Fig. 3. Diagram to Table 3 (Autumn)

Fig. 3'. Diagram to Fig. 3

content of water reaching 35-50% early in the morning. The higher per cent of absorbed water in the samples can be explained by different habitat conditions (forest) and very high relative humidity (80-90%). Rydzak (1953) thought that the existence of lichenless desert can be accounted for by the following factors: unfavourable humidity and desiccating activity of warm air currents in towns. What seems to confirm the Rydzak's hypothesis is the lichens' not making use of higroscopic capabilities and low cumulation of water not exceeding 23%. The convergence of the obtained results with those based on forest investigations from the environs of Bilgoraj (Bystrek 1997) does not allow to univocally support the drought hypothesis as regards terricolous lichens.

CONCLUSIONS

The examined lichens absorbed and desorbed water under the influence of varying within 24 hours weather conditions independently of the season of the year. In each experiment the correlation coefficient between moisture content in the thalli and 24-hour changes in relative air humidity was high. The absorption and evaporation were distinctly correlated with 24 hour changes in relative air humidity and 24-hour fluctuations in air temperature.

During dry weather the saturation was not complete and the higroscopic capabilities of the examined species were not used fully. The desorption of water lasts several hours and in favourable conditions it leads to the desiccation of the thalli, to the state of anabiosis.

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POJEMNOŚĆ WODNA POROSTÓW NAZIEMNYCH

STRESZCZENIE

Praca przedstawia wyniki badań nad dobowym obiegiem wody w plechach kilku gatunków porostów naziemnych w różnych porach roku i w różnych warunkach pogodowych. Badania prowadzono na terenie miasta Białegostoku. Stwierdzono, że absorpcja i ewaporacja wody u porostów wykazuje dobową periodyczność zależną od cyklicznych zmian dobowych: temperatury i wilgotności względnej powietrza, powtarzającą się we wszystkich porach roku. Z uzyskanych danych wynika, że zależność od warunków pogodowych jest większa od zmian dyktowanych porą roku. Plechy krzaczkowatych porostów naziemnych wykazały zbliżone właściwości higroskopijne w tych samych warunkach pogodowych.

Na terenie Białegostoku dobowe zaopatrzenie w wodę atmosferyczną przez plechy było małe i wiosną, w warunkach nasłonecznienia wynosiło 6-16% suchej masy, latem również w czasie wyżu barycznego 4-8% suchej masy. Jesienią, w czasie pochmurnej pogody, niżu barycznego, dużej wilgotności względnej powietrza pobieranie wody było znacznie wyższe, wahało się w granicach 10-20% suchej masy.

SŁOWA KLUCZOWE: porosty naziemne, mikroklimat, ekologia, dzienny i nocny cykl, absorpcja wody, ewaporacja.