On stomatal behavior in the Greenland Mountain birch

HEIKKI KAUHANEN

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The study was conducted to determine response of birch stomata to evaporative demand and plant internal water status. The experiment was undertaken in Qingua-dalen at a site with microtopographical variation. Comparisons were made between trees from a dry hill and from a moist river bank, respectively.

Under natural "stress" conditions, with high air temperature and low humidity, birches in both habitats did not exhibit any significant stomatal response to evaporative demand or low xylem-water potential. Under artificial stress two different patterns appeared. Dry habitat birches closed their stomata abruptly with decreasing xylem-water potential, while stomatal closure in moist habitat trees was gradual.

Key words: Greenland, Mountain birch, Qingua-dalen, stomatal closure, xylem-water potential.

Heikki Kauhanen, The Finnish Forest Research Institute, Kolari Research-Station, SF-95900 Kolari, Finland.

Much attention has been given to the effects of water stress on stomatal behaviour. Numerous studies have shown that plant water deficit is an important factor controlling stomatal aperture. Low water potential caused by drying out of the soil or high evaporative demand sooner or later result in stomatal closure (e.g. Davies and Kozlowski 1977). There is good evidence that stomata of many species are sensitive to ambient humidity (Schulze and Kuppers 1979). Even rapid changes in atmospheric humidity may cause alterations in stomatal aperture (Fanjul and Stones 1982).

Relationships between stomatal closure and plant water potential vary among species from different habitats (Quraishi and Kramer 1970, Davies and Kozlowski 1977). Measurements on Mountain birch in northern Fennoscandia (Kauhanen, unpubl.) give some indication that this relationship may vary within a single species as well.

The climate of Greenland is characterized by such extremes as hyperoceanity and continental dryness (Böcher 1979, Ødum 1979). Thus, beside harsh temperature conditions, humidity and wind may be important environmental factors determining growth and survival of birch trees.

This paper describes stomatal behaviour in Mountain birch in Greenland. The special objective of the study is to determine response of birch stomata to evaporative demand and internal water status.

Methods

The study was carried out in Qingua-dalen, South Greenland, during the Subarctic Birch Forest Ecosystem Workshop in late July and early August of 1984. Main features of the research area are described elsewhere (Kuivinen and Lawson 1982, Ødum 1984).

Two sites were selected at the head of Qingua-dalen, a dry site on a terrace of outwash deposits and a moist site on the river bank. The sites were 200 meters apart, about one kilometer NE of the outlet of the river in lake Tasersuaq.

All measurements were made in the field during dry days. Threshold xylem-water potential values for stomatal closure were determined on one tree at each site. Decrease of xylem-water potential was induced by cutting twigs. Response of stomata was monitored on two trees per site.

Xylem-water potential was measured by pressure chamber technique (Scholander et al. 1965) and stomatal resistance by means of diffusion porometer (Turner and Parlange 1970). Five to six separate leaves and branches were sampled on each tree. Air temperature was monitored by using EireLec thermometer and K-type thermocouples.

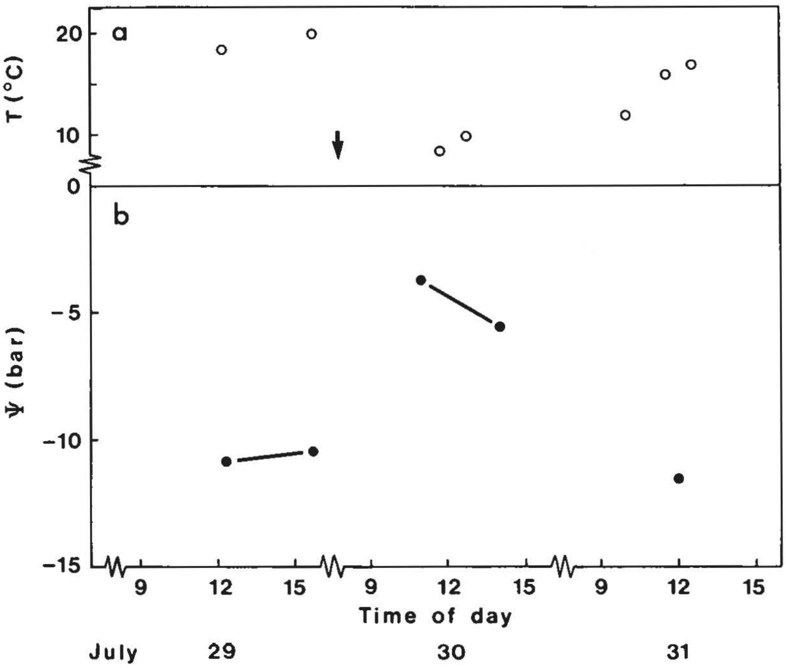

Fig. 1. Range of air temperature (a) circles and xylem-water potenial (b) for Greenlandic birch at the dry site of Qingua-dalen. Occurrence of rain is shown by the arrow.

Results

Daytime values of xylem-water potential ranged from −3.1 to −11.8 bars depending on precipitation and temperature. July 29th was the warmest day of the visit to Qingua-dalen. A maximum temparature of 23°C was measured that day. Midday water potential value for dry habitat birches (Fig. 1) was −10.8 bars. Next day, after nightly rain, it rose above −4 bars but fell back to −11.5 bars one day later when sun was shining again.

Birches from both sites showed low stomatal resistance when measured before and after the rainy day (Table 1). Xylem-water potential values in the former case were slightly higher than those in the latter.

Determination of treshold water potential values for stomatal closure showed two different patterns (Fig. 2). Stomata of dry habitat birches began to close at a low water potential of −25 bars and the closure was abrupt, while trees from moist site closed their stomata gradually when water potential fell below −20 bars.

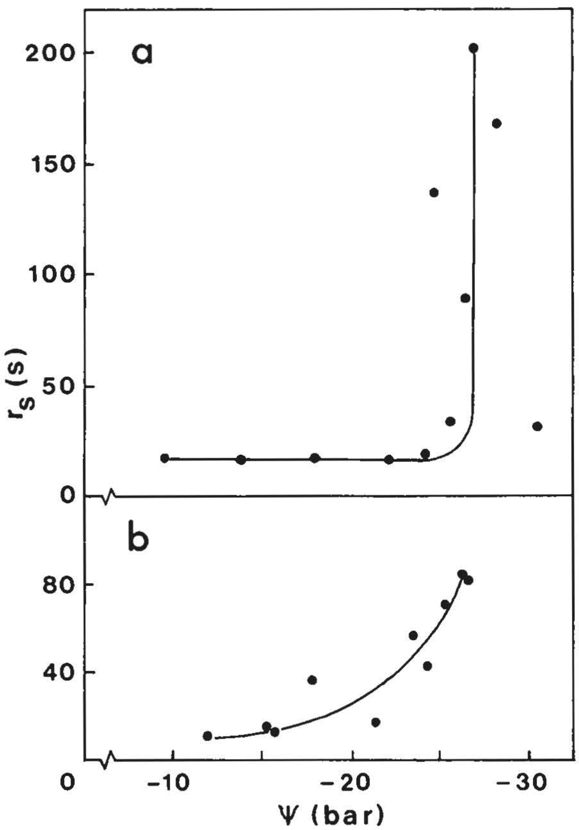

Fig. 2. Relationship between relative stomatal resistance (rs) and xylem-water potential (Ψ) in Greenlandic birch under artificial desiccation. (a) Dry site, (b) moist site. Points are individual observations.

Table 1. Relative stomatal resistance (rs) and xylem-water potential (Ψ) in Greenlandic birch at two different sites, measured in sunny weather before and after a rainy day. The rs values are given with one standard error.

	July 29		July 31	
	rs (s)	Ψ (bar)	rs (s)	Ψ (bar)
Dry site	13.41±.95	−10.8	14.18±.92	−11.5
Moist site	13.71±.50	−10.2	11.70±.90	−10.3

Discussion

Stomatal closure during the middle of the day has been reported for many species of forest trees (Kramer and Kozlowski 1979). This phenomenon has been observed in Mountain birch also in northern Sweden (Kauhanen 1986). However, Greenlandic birches did not show any sign of midday stomatal closure despite the "stress" type weather. Because data of air humidity are lacking the role of evaporative demand remains rather obscure.

Osonubi and Davies (1980) have shown in birch seedlings that a direct response of stomata to a change in vapor pressure deficit acts as a stress-avoidance mechanism. The results of this study indicate that Greenlandic birches did not have any need of stomatal adjustment; even dry habitat trees were able to keep their stomata open throughout the day. It is conceivable that, despite the high temperature, evaporative demand in Qingua-dalen was not high enough to result in stomatal adjustment.

Threshold water potential for stomatal closure varies widely between species (e.g. Federer 1977) and probably between growth stages and sites (Ritchie and Hinckley 1975). This work has shown that the form of the stomatal resistance-water potential curve may vary within a species. The curvilinear type for moist habitat trees versus the threshold curve for dry habitat trees may indicate that the former ones are more drought-avoiding than the latter ones.

Federer (1977) measured a threshold value of −15 bars for mature birch under natural conditions, whereas birch seedlings grown in greenhouse showed a value of −14 bars (Osonubi and Davies 1980). The critical value for Greenlandic birch was much lower (−25 bars, cf. Fig. 2a). It is likely that the difference is partly a procedural artifact.

There is some experimental evidence that artificial desiccation results in lower xylem-water potential values than natural desiccation (West and Gaff 1971). Therefore further measurements on Greenlandic birch are needed.

This study has indicated that internal water status of Greenlandic birches was not affected by decreasing water potential or increasing evaporative demand. A likely explanation is that, even on sunny summer days, air humidity is high enough for the stomata to remain open throughout the day. Probably the role of summer water stress in the case of Greenlandic birch is negligible.

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