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THE OPEN SHADE, AN INTERESTING MICROCLIMATE

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SUMMARY

When the sky is bright the shade light received at the north side of a deciduous hedge or strip of scrub contains much blue and far red radiation and little near red. The light intensity is relatively high but net radiation may be zero or slightly negative because of the strong long wave radiation loss to the „cold" bright sky. Dew persists in these situations and surface temperatures are often 6–8 °C below ambient air temperature.

Several Angiosperms, mosses, and liverworts seem to have a preference for this situation.

1. INTRODUCTION

On the north side of the patches of scrub, hedges etc., where there is shadow for most of the day, a microclimate exists which in several respects has interesting properties.

SEYBOLD (1936) was the first in botanical literature to point to the fact that the light quality in the open shade is considerably different from both of that under a leaf canopy and in the freely exposed situation. He coined the term "Blauschatten" as contrasted with "Infrarotschatten" under a canopy.

The thermal conditions in the open shade have received little attention. KELLY et al. (1957) have drawn attention to the fact that cattle at the north side of a shade not only is sheltered from the sun but that further thermal relief is given to them by radiative heat loss to the "cold" sky.

The following observations were first presented as a lecture for the section for Vegetation Research of the Royal Botanical Society of the Netherlands. Some remarks made in the discussion are also included.

2. LIGHT COMPOSITION IN THE OPEN SHADE

In *fig. 1* the spectral composition of the diffuse skylight received in the shade at the north side of an oblong patch of Hawthorn scrub (in the dunes near Oostvoorne, The Netherlands) is plotted.

For each wavelength band the relative intensity is given as compared with the intensity in full sunlight. The measurements were made in the middle of May, round noon, with a clear sky. For comparison the transmission curve of a Hawthorn (*Crataegus monogyna*) canopy is shown as well. To isolate the different wavelength bands interference filters were used as described earlier (STOUTJESDIJK 1972).

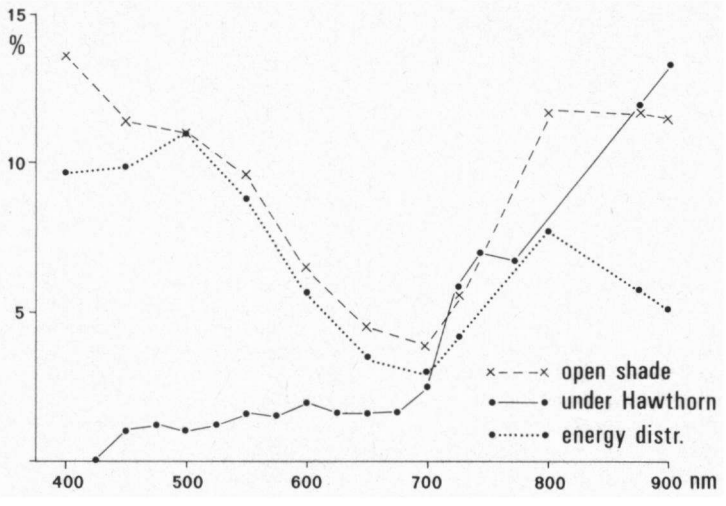

Fig. 1. Ligth composition in open shade and under Hawthorn scrub.
Intensities are given as percentages of the intensity in full sunlight in the same wave-length band.
The energy distribution in the open shade was calculated from the energy distribution of full sunlight.

As could be expected both the blue and the infrared part of the spectrum are strong. The latter is about as strong as the infrared under the canopy. The assimilable light (<700 nm) is much stronger in the open shade than under a canopy.

It is clear that the term "Blauschatten" might be better replaced by "Blau-Infrarotschatten". When the shadow is cast by a wall or cliff "Blauschatten" would be more appropriate.

3. TEMPERATURE AND RADIATION REGIME

Visually the most obvious effect of the open shade is the persistence of dew. Especially during prolonged dry periods in late summer and autumn it is striking to see how both in the open and under a woodland canopy everything is dried out but at the north side of hedges and patches of scrub dew stays all through the day and a lush moss growth is found.

In the following "open shade" is used for situations which receive no direct sunlight at least between sunrise and the time of the measurement. In the summer half year this implies there must be not only an obstacle like an east-west hedge but at least the eastern sky at low elevations must be screened as well.

Measurements of surface temperatures in the open shade were made with a radiation thermometer as described by STOUTJESDIJK (1974). *Fig. 2* shows measurements of surface temperatures, air temperatures and effective radiation temperatures of the sky. Some temperatures of sunlit areas nearby are included

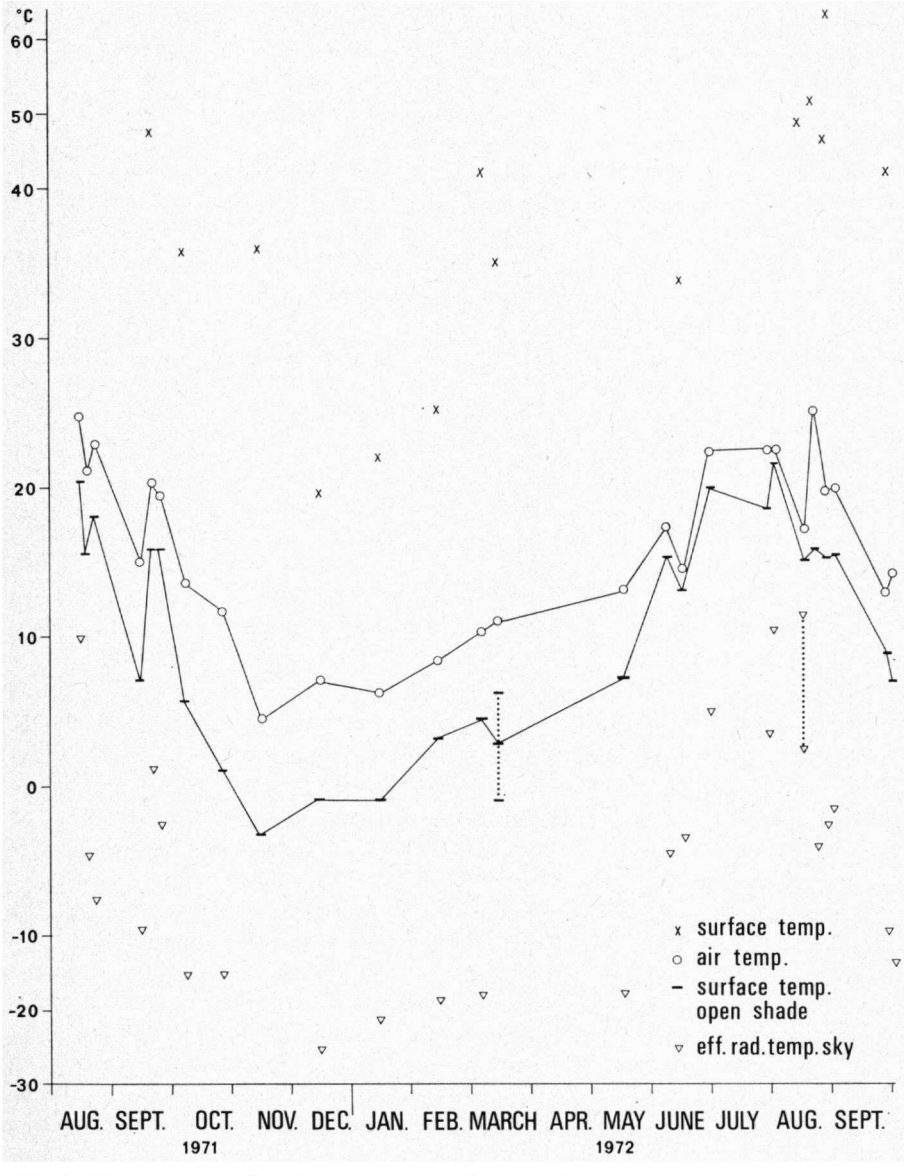

Fig. 2. Measurements of surface temperatures in open shade etc.
The lines connecting the points are intended as a visual aid only.

to show the great range of temperatures that can be found in a small area. All measurements were taken round noon, with a clear sky and little wind, dew was always present on the shaded surface.

As the figure shows, open shade surface temperatures are often 6–8 °C and sometimes over 10 °C below ambient air temperature. These are unexpectedly

low temperatures, While it is easy to find microclimates with temperatures higher than those of ambient air, temperatures which are considerably lower are rarely found by day.

A consideration of the heat budget of the surface partially explains the situation, as the following example will show.

Measurements on 16 Sept. 1971, 11.30 hr, bright sky, global short-wave radiation: 0.83 cal/cm² min. Air temperature: 15.0°C, wet bulb: 10.3°C. In the shadow of Hawthorn scrub heavy dew is still present, surface temperature: 9.1°C, effective radiation temperature of the sky: −10°C. Diffuse solar radiation: 0.100 cal/cm² min, radiation budget as measured with a net radiation meter: −0.030 cal/cm² min.

The radiation budget is given below, with energy fluxes in cal/cm² min.

Incoming		Outcoming	
Diffuse solar radiation	0.100	Reflected solar radiation	0.010
Long-wave radiation from the sky	0.395	Long-wave radiation from surface	0.523
	0.495		0.533

The net radiation is 0.495 − 0.533 = −0.038 cal/cm² min. The agreement with the direct measurement of net radiation is good considering that the long-wave radiation from the sky was computed from one measurement of the sky temperature at 45° elevation, direction north. This must be due to the fact that heat radiation from the sky at lower elevations is of relatively little importance for the total radiation exchange.

Anyway both direct measurements and computation have shown that the radiation budget can be zero and even weakly negative all through the day even in August and September owing to the overriding effect of heat loss from the surface to the "cold" sky. Yet it is impossible that the weakly negative net radiation is alone responsible for the low temperatures maintained. In a bright night with a much stronger negative radiation budget surface temperatures do not fall more than 6–10°C below ambient air temperature either. An important difference is that by day evaporation of dew cools the surface, while by night heat is set free by condensation. For the moment it seems best to explain the low temperatures by evaporation from a wet surface with a zero or slightly negative radiation budget.

The effect is present all the year round. It is weakest in June and July as could be expected because of the narrow fringe of shadow cast then. In spring it is not so often observed as in late summer or autumn partly because the shadowcasting shrubs are leafless in spring, partly because of less suitable weather conditions such as weak dew formation.

4. DISCUSSION

The temperature effects in the open shade are quite strong. While it is easy to find microclimates with temperatures higher than ambient air, temperatures which are considerably lower are rarely found by day. The lower temperatures, together with the rather high short-wave radiation level and the presence of liquid water when it is elsewhere absent, make for a unique microclimate in the open shade when conditions are suitable.

Firstly there is the structure of terrain and vegetation. East-west ridges, hedges, patches of scrub, woodland edges, patches of low vegetation surrounded by higher growth all favour the optimal development of the open shade effect. In the dunes of Voorne where the present observations were made these requisites are well developed.

Secondly weather conditions are of course important for the strength and frequency of the effect and hence its biological importance. The more frequent periods of dry, still weather occur with strong dew formation, the more important the effect will be for the formation of cool humid microhabitats. A small decrease of diffuse solar radiation or of net long-wave radiation can both cause a relatively strong shift of the radiation budget to the negative side and thus make the effect much stronger.

In the Central European mountains the net long-wave radiation probably changes little with height as the lower sky radiation is compensated by a lower temperature level (LAUSCHER 1937). The diffuse short-wave radiation decreases considerably with elevation, however (TURNER & TRANQUILLINI 1961).

We now come to the question whether the vegetation on the open shade sites reflects the habitat conditions.

In the dunes near Oostvoorne *Mnium undulatum* and *M. cuspidatum* have a great preference for open shade.

STAPELVELD (1956) stated that *Cornus suecica* is found on the northern fringe of patches of scrub.

Dr. F. Tjallingii drew my attention to the fact that in dry periods in autumn, fruit bodies of fungi are only found in park landscapes and he thought it quite possible that open shade conditions play a role here.

In accordance with the expected strong development of the open shade effect in the Central European mountains Prof. J. Barkman reported the preference of the lichen community *Letharietum vulpinae* for these sites in the Alps.

Dr. J. W. Woldendorp informed me that open shade preference is shown by: *Valeriana montana, Arabis alpina, Campanula pulla, Saussurea pygmaea, Viola pinnata.*

MULLER (1972) observed the vegetation forming properties of some liverworts on north facing slopes in inland dunes grown with Scots pine and heather.

In recent years much attention has been given to vegetation edges and transition zones (VAN LEEUWEN 1966). It is clear that the shadow fringe at the north of an obstacle is not a mere transition zone in the ordinary sense of the word but has unique properties as for temperature, humidity, and radiation conditions.

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