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Welwitschia mirabilis: Observations on movement of water and assimilates under föhn and fog conditions

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ABSTRACT

Evidence that *Welwitschia* is able to absorb and translocate the water which condenses on its leaves under foggy conditions has been obtained by the application and subsequent localisation of tritiated water. Scanning electron microscopy of the leaves suggests that the path of water uptake may be via the stomata. Rates of uptake under foggy and föhn wind conditions are compared. Preliminary investigation of the movement of photosynthetic assimilates indicates that these are rapidly translocated in the direction of the meristematic regions.

INTRODUCTION

Welwitschia mirabilis is, as has been described elsewhere (Bornman, Elsworthy, Butler and Botha, 1972), a plant of strikingly bizarre habit and one which may successfully survive the extremely arid conditions of the northern Namib Desert for up to two thousand years. The water relations of *Welwitschia* are thus of great interest. Although the large colony studied on the so-called Welwitschia Flats east of Swakopmund is established in sand superficially devoid of moisture and the relative atmospheric humidity of the area may drop to zero (Table I), dense advection fogs nevertheless occur over the flats. Under these conditions appreciable amounts of water condense on the leaves, whose vast surface area and specialised internal anatomy suggest that this may be the means whereby the plant's water requirements are met.

In this study, water uptake, translocation and transpiration by the leaves were investigated in the field by applying tritiated water both to intact leaf surfaces and internally to the leaf meristem. It was possible to obtain comparable data under the two extreme weather conditions experienced on successive days: namely, fog and föhn wind (Table 2). In addition, the photosynthetic activity of mature leaves and the rate of translocation of photosynthates were estimated by supplying $^{14}CO_2$ to the adaxial surface of a leaf.

MATERIALS AND METHODS

Scanning electron microscopy

Pieces of stem and leaf from both abaxial and adaxial surfaces, 25 mm^2, were freeze-dried, lightly coated with gold-palladium, and viewed in a Hitachi SSM-2 scanning electron microscope.

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2. $^{14}CO_2$ assimilation

As is shown by Figs. 9, 10 and 11, and Table 2, $^{14}CO_2$ assimilation in *Welwitschia* is a rapid phenomenon. After only 5 minutes' exposure to the source (Fig. 9), the total detectable ^{14}C activity, representing ^{14}C-labelled photosynthates, was lower in the meristematic zone than in the leaf. After 10 and 20 minutes' exposure, the activity detectable in the meristem samples was found to be considerably higher than in the corresponding leaf samples, indicating a rapid basipetal translocation of ^{14}C-photosynthates under fog conditions.

DISCUSSION

If the numerous stomata (Figs. 1—4) occurring on both leaf surfaces in *Welwitschia* are indeed the means of entry for surface water, they play a remarkable dual role, both in limiting the loss of water from the interior mesophyll, and in regulating the absorption of surface moisture when it becomes available by condensation under foggy conditions. That it is the stomata which are primarily responsible is suggested by the marked differences between uptake recorded under foggy and under föhn wind conditions. A field microscope investigation showed that, predictably, few stomata were open while the wind was blowing (Figs. 6-8). Externally-applied water appears to travel preferentially in the proximal direction towards the meristematic regions.

According to Walter (1971), the "unwettable" nature of the leaves prevents the uptake of condensed water; whereas the corky stem surface may act as a sponge. Our data indicate, however, that water applied to the leaves, without prior addition of a wetting agent, forms droplets which are readily taken up and translocated. Foliar absorption from a saturated atmosphere has been reported on another occasion in the literature (Haines, 1952).

Comparative data for CO_2 assimilation under different weather conditions are not available, since the technique of $^{14}CO_2$ application used here is appropriate only under relatively calm conditions. However, it is evident that photosynthesis proceeds at a high rate and that photosynthates are rapidly exported from the leaves in the direction of meristematic regions at the stem/leaf junction.

CONCLUSION

Since intact plants were studied under normal field conditions, the results described may safely be assumed to reflect normal physiological activities. Thus the major inference to be drawn is that atmospheric water vapour is indeed accessible to *Welwitschia* through its leaves, and hence that many of its remarkable anatomical features may be considered to have a related function. It appears that surface water may enter the leaves via the stomata which provide the only discontinuity in the relatively thick cuticle found on both adaxial and abaxial surfaces of the leaf.

REFERENCES

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Table 1. Climatic conditions prevailing during isotope-translocation experiments.

Time	Temp. °C	RHat %	RH Wm %	Remarks
T+ 0; 9 a.m.	32,4	11	*	
T+ 2; 11 a.m.	40,6	10	*	
T+ 3; 12 noon	39,4	10	*	
T+ 4; 1 p.m.	47,8	10	*	TPN 1,2
T+ 7; 4 p.m.	34,4	19	*	
T+10; 7 p.m.	21,7	54	80	
T+23; 8 a.m.	17,8	80	94	TPN_3; $^{14}CO_2$
T+24; 9 a.m.	21,1	60	75	

RHat Relative humidity of atmosphere.
RHWm Relative humidity of air surrounding *Welwitschia mirabilis*.
* Data not recorded.
TPN 1,2 Transpiration experiments Nos. 1 and 2 (Föhn-wind).
TPN 3 Transpiration experiment No. 3 (Fog).
$^{14}CO_2$ ^{14}C-Photosynthesis experiments.

Table 2. Translocation of ^{14}C-photosynthates in *Welwitschia mirabilis* under fog conditions.

Exposure time (mins)	Total leaf (dpm)	Total meristem (dpm)	Mean leaf (dpm)	Mean meristem (dpm)
5,0	26 478	12 991	5 296	4 330
10,0	18 945	13 598	3 789	4 533
20,0	11 689	19 989	2 338	3 332

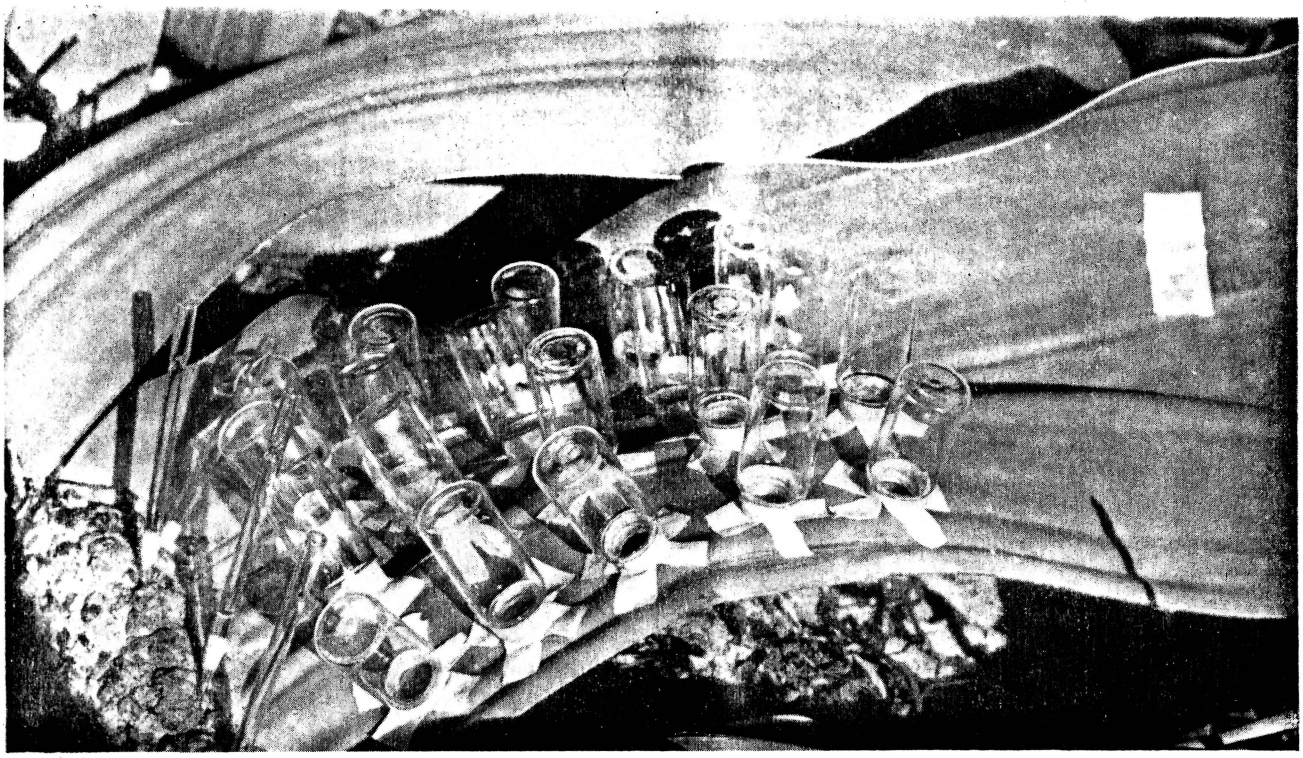


Figure 5. General layout of transpiration experiment showing liquid-scintillation vials taped to the adaxial leaf surface of an adult female *Welwitschia*. Four Pasteur pipettes are inserted in the stem adjacent to the meristematic zone.

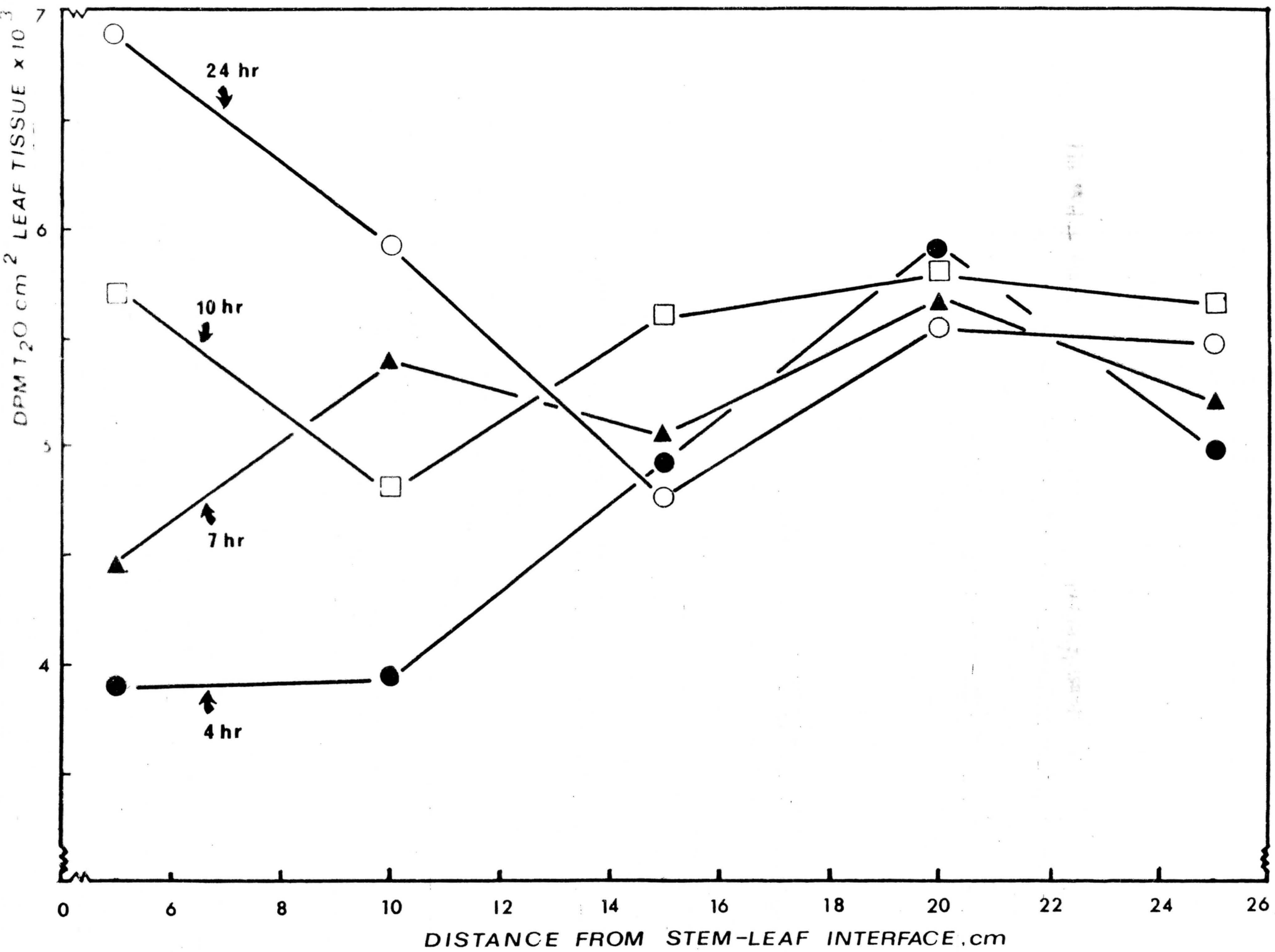
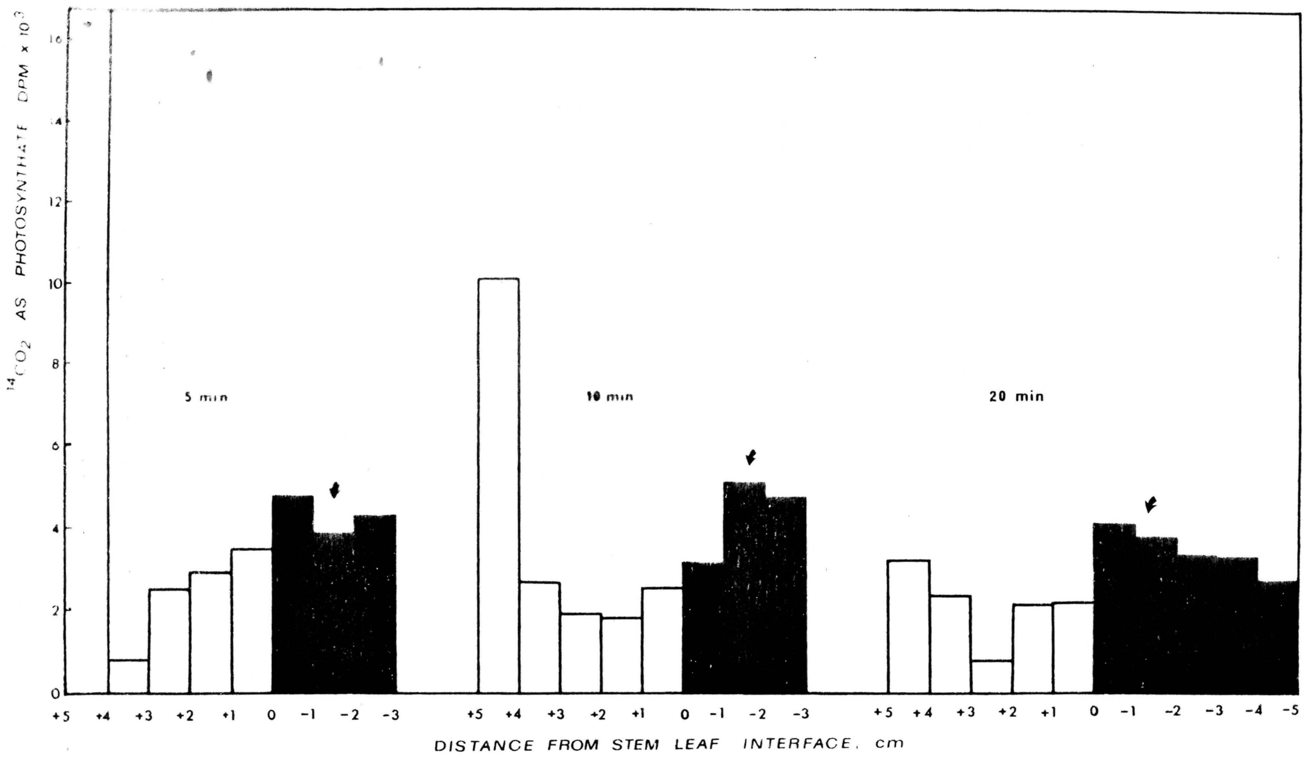


Figure 6. Results of tritiated water transpiration experiment conducted on the plant illustrated in Figure 5 under föhn wind conditions. For explanation see text.



Figures 9—11. Basipetal translocation of ^{14}C-photosynthates in a female *Welwitschia*. The abaxial surface was exposed for 5,0 (Fig. 9), 10,0 (Fig. 10) and 20,0 (Fig. 11) minutes. Arrows mark the approximate centres of the leaf meristem.