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# THE INTERCEPTION AND CONDENSATION OF ATMOSPHERIC MOISTURE BY FOREST CANOPIES

by

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## Introduction

Many qualitative experiments to determine the reality of occult precipitation on forest vegetation have been conducfed during the last eighty years. It is now generally accepted that on foggy and misty days, or in zones where advective sea-fog is prevalent, moisture may condense on foliage and water in the form of drip and run-off be recorded, although no rainfall has occurred in open ground. Wicht (1951) has stated "... No satisfactory technique for estimating the volume of water thus deposited on land surfaces has yet been developed. It is, however, considerable and will introduce a significant error in the volumentric determination of rainfall in certain areas. It would seem worthwhile to investigate further and in greater detail this condensation of atmospheric moisture on vegetation wherever it occurs ..."

## Statement of the Problem

Every floristic region has some key problem which preoccupies foresters, ecologists and botanists. In East Africa it is the origin and distribution of her indigenous montane vegetation; why the floras of isolated peaks and mountain ranges should be so similar and why the regenerative potential of certain high forest species in these habitats should shew such marked distinction. This is particularly true of the two coniferous genera Podocarpus and Juniperus whose distribution appears to be closely correlated with the incidence of fog and mist. The present paper attempts to analyse existing concepts concerning these phenomena and condenses the corpus of opinion as expressed today. The programme of research established at Muguga is outlined and the apparatus briefly described. No attempt is made to consider the possibility that intercepted atmospheric

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Review of the Problem

From Biblical times (Exodus, Ch. XVI, v. 13) to the present day (Parsons 1960), the great majority of papers reviewing the problem of occult precipitation and fog drip have been largely observational and qualitative. Those which have included measurements are generally of very local interest, based as they are on limited experimentation and apparatus. There has been a regrettable tendency to publish startling figures which have been accepted into the canon as being of wide application and validity. In actual fact we know little more today about the actual volume of water deposited on land surfaces from occult sources than did Glas (1764), when he observed the drip phenomenon under a spreading tree in the Canary Islands. We do, however, know quite a lot about the meteorological phenomena initiating fog and mist belts.

Observations on the occurrence of mist or fog in relation to vegetation belts or zones have been recorded from many parts of the world, but with notable exceptions, most measurements have been based upon a single or at most two pairs of rain gauges, one of which is usually equipped with a fog catching device consisting of either wire gauze, wires, or twigs and branches. Not invariably the apparatus has been sited in the most advantageous situations, either under or adjacent to a suitable forest canopy. In many cases scant effort has been made to distinguish between the catch from rain, drizzle or other recordable precipitation, and that derived solely from an occult source. There has been little correlation between the amount of drip and the frequency of fog and mist, the variation in topography, season, and the type of canopy intercepting the moisture. This latter according to Went (1955) may be critical, the coniferous type of leaf being a very much more effective interceptor than that of broad-leaved trees. As comparative experiments some of them were perhaps adequate but rarely have they produced any quantitative measure in relation to land surface area.

Reviewing the salient features of the phenomena connected with occult precipitation the following facts and possibilities emerge:-

1. The interception of fog and mist by forest vegetation is undeniable.

2. The amount of precipitation reaching the ground from such sources is unknown and therefore its significance in influencing the distribution and regeneration of the plants involved is still a matter for investigation. It may, however, be considerable under optimum conditions. These may be dependent upon:-

   (a) The type and nature of the intercepting surface.
   (b) The nature and topography of the land surface.
   (c) The speed and direction of air flow.
   (d) The seasonal variation in climate.
   (e) The temperature of the air.

3. It is suggested that interception by coniferous forest is much greater than any other and is inversely related to both intensity and duration of the mist belt. It has yet to be proved that the type of leaf surface is more important than the sum total of surface area of plants present.

4. It is generally believed that the maximum contribution of cloud and fog moisture to the ground through vegetation capture is to be found in the high altitude tropics, largely because of the greater water content of the air.

6. It is likely, but not yet completely proved, that a forest cover is more effective than a herbaceous cover in capturing moisture. Contrary to widely held opinion, forests may enhance turbulence which in turn promotes condensation by diverting the fog flowing over the top of the canopy into the interior of the forest. The amount and degree of turbulence also depends upon the density and area of the

6. It has yet to be proved that the phenomena described are limited to the margins of forest belts; although it is probable that the larger the front presented to the prevailing wind, the less the capture of the fog particles as it moves to the leeward edge.

7. It is not known what the limits of capture by vegetation are, but presumably a large proportion of available moisture in fog and mist passes over or through the canopy.

8. It is agreed that under certain atmospheric conditions irrespective of the possible benefits to be derived from their precipitation, fog and mist may depress evapo-transpiration processes and thus favour the water balance. A reduction in solar radiation will retard assimilation processes in the plant, particularly during the period of greatest seasonal activity, i.e. in summer.

9. As far as translocation of fog moisture from atmosphere to plant is concerned, much more evidence is required. It seems certain that epiphytic vegetation can directly absorb such moisture but it is not yet known if this is subsequently taken up by vascular plants. Under the saturated conditions often associated with fog and mist in mountainous areas, it is doubtful whether there is any direct absorption and translocation of water by woody plants. In zones of advective sea-fog, however, or in drier mountain areas, the phenomenon must be given serious consideration.

10. The apparatus for measuring intercepted atmospheric moisture is adequate provided that stratified random sampling is carried out over a known dimension of space, and in a sufficient number and type of localities.

The description which follows is of an experiment which was designed to attempt to solve some of the complexities of the problem without essentially departing from the idea of a fog-catching device of the type already mentioned; which seems within its limits, perfectly adequate for the production of data from which more valid conclusions can be drawn.

Interception experiments in East Africa

Kenya is ideally situated for research on the problems of fog and mist interception. Nicholson (1936), Hursh and Pereira (1953) and Pereira (1954) stress the importance of the fog drip phenomenon in the water economy of East Africa. The

Southern Monsoon produces not only abundant dew but also a heavy mist and fog. Saturated orographic clouds may occur throughout the year in certain localities, particularly those with elevations above 6,000 ft. Muguga and its environs are in the centre of a markedly foggy zone. Studying previous research in this field has prompted the thought that a more intensive network of fog catching equipment laid out in both forested land and open ground, will enable a direct comparison to be made on an area basis, of the volume of water deposited from atmospheric moisture of the 'occult' type, and from direct precipitation of rain, drizzle, etc.

<u>Research Programme</u>

The initial trials consist of two sets of inter-related experiments.

1. A series of nine fog-catching gauges laid out in open ground at 7,000 ft. with two check gauges in close proximity. The nine interceptors each consist of a 4" diameter receptable upon which is mounted an 8" x 4" tubular mesh or wire gauze. This is surmounted at an interval of 4" by a circular cowl of sheet metal with a diameter of 12" to eliminate as far as possible the entry into the receptacle of direct precipiatation. The whole apparatus is mounted on a soft-metal rod 3/8" in diameter which raises it approximately eight feet from the ground. The check gauges consist of a standard pattern 5" raingauge, and a gauge of the "Muguga" type but without the cowl and fog-catching gauze. All gauges are read at 7 a.m. and a conversion factor is applied to correlate the catch from the 4" gauges with the catch from the 5" standard meteorological gauge. The fog-catchers are spaced at approximately thirty feet intervals both along and cross the contour. The slope on this particular site is about 1:6.

Measurements were first taken at the beginning of November 1961 during a period of very intense mist prevalence and it soon became apparent that the fog-catching apparatus functioned satisfactorily; catches of up to 3 times the amount collected in the standard raingauge being recorded. These trials have now been discontinued.

2. A twenty acre plantation of Podocarpus gracilior some thirty five years old, in the Muguga Forest Reserve was considered to be an ideal site for the second series of experiments. The leading edge of this plantation faces the direction of the prevailing wind and fronts onto cultivated ground in the Kikuyu Native Land Unit. The site is approximately three miles from the area described in (1) above; at an altitude of 6,800 ft. (approximately).

Fog-catching gauges of the type described were mounted in the canopy of randomly-selected trees. The number of gauges in the forest canopy depended upon the size of the plantation and a valid statistical design. Similar gauges were sited in the open ground on the windward side of the plantation, and to the lee of the plantation. Check gauges, of the types described in (1) above, were erected in the open ground. The catch from the fog-gauges mounted in the tree canopy was directed through polythene tubing to a collecting vessel at the foot of each tree. Stratified random sampling was adopted from the leading edge of the plantation distributed in space and at the same positions in the canopy.

In addition, a series of three stem-flow gauges and three canopy drip gauges were established on and under randomly selected trees. These will be augmented in due course by a series of trough gauges distributed throughout the plantation according to stratum.

Thus, it is hoped by this extensive network that all measurable components of the moisture cycle will be collected, in a manner allowing for their individual analysis, irrespective of whether fog, drizzle or rain occur at one and the same time. Furthermore, the actual volume of water reaching the forest floor will be known on an area basis. Allowance for the direct absorption of atmospheric moisture by the plants has not been made; neither is it practicable at the present time.

## REFERENCES


C. L. Wicht (1961). Proc. CCTA Hydr. Conf., Nairobi.

J. J. Parsons (1960) Weather, Feb. 1960, Vol. 15, No. 2.

G. Glas (1764) As communicated by R.F. Wood, Weather Nov. 1960, Vol. 15, No. 11.

F.W. Went (1955) U.S. Dept. Agric. Year Book 1955, 'Water'.

J.W. Nicholson (1936) E.A. Afr. agric. J. Vols 2, (1) p.48-53 No.2 163-170, No.3, 236-240.

C.R. Hursh and H.C. Pereira (1953) E.A. Afr. agric. J. 18,(4)

H.C. Pereira (1954) E.A. Afr. agric. J, Vol. 19, (4)

B.W. Thompson (1953) Bull. Ent. Res. 44, (4)