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PLANT GROWTH UNDER DESERT CONDITIONS

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During the last years I have visited desert areas in different parts of the world, and I have found that they were differing more than I had expected from published descriptions. I would, therefore, like to stress some of the differences which were observed. The deserts visited include:

(1) The fog desert along the Peruvian coast in the neighborhood of Lima. Dr. Ferreyra and Engineer Postigo were kind enough to take me around and show me some of the typical aspects of this desert including the so-called Lomas.

(2) The dust desert which was found in the Northern Sahara around Beni Ounif where Dr. Killian kindly put the facilities of the Station Biologique Saharienne at my disposal.

(3) The clear but dry deserts of Southern California and Israel. The latter were visited through the help of Drs. Boyko, Dr. Zohary and Dr. Evenari.

The following table gives some comparison between a number of typical localities.

TABLE I

Comparison between the vegetation of different deserts.

		Altitude in meters	Radiation	Rel. Humidity	Daily temp. fluctuat.	Precipitation	Vegetation
Peru,	coast	0	low	high	small	25 mm	0
	Lomas	300	low	v. high	small	125 „	good
Algeria,	Beni Ounif	800	interm.	v. low	great	125 „	desert
Israel,	Elat	0	high	v. low	v. great	25 „	desert
	Subeita	500	high	v. low	great	125 „	desert-steppe
So. Cal.	Death Valley	−50	high	v. low	v. great	35 „	desert
	29 Palms.	800	high	low	great	125 „	desert-steppe

It is evident that as far as precipitation is concerned the Loma de Lachay in Peru, Beni Ounif, the central Negev and Twentynine Palms

in Southern California have approximately the same total precipitation as measured with a rain gage. Their altitude is also approximately the same. However, there are enormous differences in vegetation. At Beni Ounif we are dealing with a typical desert as far as plant growth is concerned. On the flat desert plains less than 1 % of the surface is covered with perennial plants. To these belong *Anabasis arietoides*, *Limoniastrum Feei*, *Zilla macroptera*, *Launaea spp.* and a few other low shrubs. Along the smaller washes *Zizyphus Lotus* is the only larger shrub which grows up to 2 meters high but for the rest the area is barren. Against mountains there was slightly better vegetation but the surface coverage was still considerably under 10 %. There had been a fairly rich vegetation of annuals because of heavy Autumn rains in 1953, but all these annuals were entirely dry at the time of my visit in June 1954. Near villages plants of *Peganum Harmala* were bright green and remained uneaten by sheep because of their extreme toxicity. The only other lush green plant was *Capparis spinosa* which was found growing out of cracks in rocks with no apparent root connection with soil. Again, because of extreme bitterness, this plant was not eaten by animals.

The area around Twentynine Palms which has the same altitude as Beni Ounif and the same rainfall, is entirely different as far as vegetation is concerned. The desert floor there is covered with fairly large shrubs which grow up to 2 meters height, whereas in the washes shrubs and trees reach a height of 5 or more meters. At least 20 % of the soil surface is covered with perennial plants, mainly consisting of *Larrea divaricata*, *Franseria dumosa*, *Hymenoclea Salsola* and *Krameria canescens*. Along the washes *Dalea spinosa* and *Acacia Greggii* are abundant.

A similarly rich shrub vegetation is found in the Negev at the same altitudes and with similar rainfall. This vegetation cannot be characterized as desert-like, but is also in the nature of a desert steppe.

Still more extreme is the vegetation of the Lomas along the coast of Peru. Whereas immediately along the coast the rainfall is less than 25 mm which results in absolute desert without any plants at all, as one goes further inland into the foothills of the Andes, the rainfall increases and soon big plants of *Tillandsia* grow in the sand. Also several species of *Trichocereus* appear, amazingly enough covered with lichens and small *Tillandsia* species. Shrubs of *Nicotiana* and of *Croton Ruizianus* start to appear and finally in areas with a rainfall of 125 mm shrubs and small trees grow and there is about 50 % coverage of the surface with perennials. The trees are *Caesalpinia* and *Capparis prisca* with a few specimens of *Carica candicans*. Most amazing was the dense growth of mosses on the branches of the trees, especially on the *Caesalpinia*, and numerous epiphytes of *Peperomia crystallina* were standing upright on the branches. Among the perenials there were among others *Hyptis sidaefolia*, *Pitcairnia ferruginea*, *Piqueria peruviana*, *Trixis paradoxa*, *Loasa urens*, *Oenothera laciniata*, *Malvastrum peruvianum*, *Heliotropium lancelotum*, and *Cestrum hediundinum*.

From these short descriptions it can be seen that these three types of desert differ enormously in the kind of plant growth which occurs.

The difference does not lie in the amount of rainfall because this was the same in the four localities discussed. There are, however, big differences in the relative humidity. At the Loma de Lachay the relative humidity is 100 % all through the night and even while the sun is shining it does not drop to below 90 %. At 17:30 the humidity was again 98 % while the sun was shining. This humidity is the same as found in a tropical rain forest and the epiphytic growth proves that the humidity remains high throughout the year. Therefore the dense vegetation on the Lomas along the coast of Peru is largely due to water available to the plants in the form of fog or dew. The degree to which fog is of importance can be seen immediately along the coast. Along the seaward side of the road where the road edge protrudes somewhat from the rest of the slope and where consequently more fog can be caught some plant growth occurs, namely *Suaeda foliosa*, *Cynodon dactylon* and *Chenopodium murale*. Similar fog conditions seem to occur along the western coast of South Africa where also fog is held back by coastal mountains and where plant growth occurs greatly in excess of the amount of precipitation available.

The humidity in the other deserts is low at practically all times and there is no trace of any epiphytic vegetation. Therefore, the difference between the Sahara, on the one hand, and the Southern California and Israel deserts on the other hand should be accounted for in some other manner. During my stay at Beni Ounif in Southern Algeria, on the Northern edge of the Sahara, the sky was continuously dusty because of frequent gusts of wind which often reached a velocity to move also sand grains and become sand storms. This wind also causes a curious surface pitting of stones which I had not observed in other deserts. These winds come very suddenly and stop equally suddenly. This is largely a question of very local heating, for the barometer does not change abruptly during these wind storms, and during night and early morning the air is very quiet. The enormous expanses of flat terrain without intervening high mountain ranges such as found in the Southern California deserts, must help in building up strong winds. In deserts it is easy to recognize areas with frequent and strong winds; such areas are characterized by sand dunes which are found in only few places in Southern California or in the Negev, whereas they are very frequent in the Sahara. In deserts where the flat areas are frequently intercepted by mountains, only very limited lateral air movements develop, which are indicated by so-called 'dust devils' or whirlwinds.

The dustiness of the air in the Sahara is best characterized by the high luminosity of the whole sky which looks gray rather than blue, and the grayish haze which hides the more distant objects also is the cause of the lack of dew which was observed by many desert travelers such as Fitting. Instead of considering this lack of dew a characteristic of the Sahara he claimed that there was no dew in deserts. However, Volkens and Duvdevani have clearly shown the frequent occurrence of dew in Israel and other desert areas, and it also can be observed not infrequently in the Southern Californian deserts. In these places

mountains, even at great distances usually look very clear because of a lack of dust and haze.

With a rainfall of only 25 mm permanent plant growth is impossible except where water collects immediately after infrequent rains. In the Death Valley area shrubs of *Larrea divaricata*, *Peucephyllum Schottii* and *Atriplex Hymenelytra* are very widely spaced and are able to grow with less than 50 mm of rainfall. After a long drought period, however, these plants are hardly active any more and sometimes seem dead. With less than 50 mm of precipitation the vegetation in Peru is also very scanty and consists exclusively of *Tillandsia* and *Trichocereus*. Near Elat in Israel only one plant was found growing on top of a ridge with no apparent source of water except from rain. This plant was *Capparis spinosa* which was completely green and apparently in excellent condition after a year without any precipitation. This plant is also found in areas with much higher precipitation such as in Jerusalem with 500 mm and the Ruisseau des Singes in the Atlas de Blida in Algeria with perhaps even more rain. There they occur on walls or on rocky slopes. This plant has definitely the widest range of drought tolerance of any plant I have observed. Since it also grows in rocks in Beni Ounif it is very unlikely that *Capparis* is able to utilize dew.

As far as vegetation and physical characteristics are concerned we should distinguish three types of desert:

(1) The regular desert with low humidity and high radiation because of the clear sky which results in a fair degree of vegetation in spite of the very low rainfall. It is very likely that in these deserts such as found in Southern California and in Israel, dew must be an important source of water and supplements the deficient rainfall.

(2) The fog desert with low radiation and high humidity and very low precipitation. Here the vegetation is very definitely more extensive than in the ordinary deserts mentioned under (1), and it is equally obvious that plants derive a lot of water from fog and dew. The reasons for the low radiation are not obvious but lie in a curious general haziness which results in brilliantly red sunsets.

(3) Dust deserts where there is a very high degree of diffused radiation, very low humidity and frequent high wind velocities. Here the vegetation is poor compared with other types of desert which is attributable to the capability of the plants to derive moisture from dew.

Another factor of great importance in the degree of vegetation of a desert area lies in the distribution of rain over a year. In all the areas discussed thus far, the rain occurs predominantly or exclusively during the winter months. In areas with summer rain, such as New Mexico with 250 mm of precipitation, the vegetation may be as poor as in winter rain deserts. Apparently the water available after a summer rain is too soon exhausted by the vegetation and rain at lower temperatures is far more effective.

(4) This leads us to a fourth type of desert which we can call the summer rain desert.