Distribution of the Boojum Tree *(Idria columnaris)* on the Coast of Sonora, Mexico as Influenced by Climate

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Abstract

In a previous study a possible relationship between climate, largely relative humidity, and the restricted distribution of *Idria columnaris* Kellogg in an area near the Gulf of California coast in Sonora, Mexico was proposed. This hypothesis has been tested and, to a degree at least, confirmed here by supportive data.

Precipitation data from 4 stations for a 5-year period and relative humidity records for from 33–38 months indicate a positive correlation between high relative humidity and the occurrence of *Idria*. There was no correlation between either temperature or total annual precipitation and *Idria* occurrence. The establishment of Idria in this arid environment appears to be possible only where the limited precipitation is combined with a persistently high humidity. *Key words: Idria columnaris; Gulf of California Coast; Sonora, Mexico; seedling establishment; climate; relative humidity; precipitation.*

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Introduction

From 1967 to 1972 I, R. R. Humphrey and my wife, Roberta, were studying the ecology of the cirio or boojum *(Idria columnaris* Kellogg) in Central Baja California and Sonora, Mexico (Humphrey 1974). One objective was to determine the environmental factors that might affect the geographical distribution of this most unusual plant. Although certain tentative conclusions were reached that might explain its distribution in part, there was a need for additional data that might support some of these conclusions. As a consequence the present study was developed to investigate more fully some of the climatic factors on the coast of Sonora.

Idria is restricted to central Baja California and a small area on the coast of Sonora, Mexico (Shreve & Wiggins, 1964; Humphrey, 1974). The Baja California population represents its center of distribution; the Sonoran coastal component is apparently the result of an accidental colonization. In any case, the Sonoran habitat appears to provide a harsher environment for establishment and growth of the cirio than does most of that portion of Baja California where it occurs (Humphrey, 1974).

The Sonoran population is restricted to an area close to the coast, suggesting some relationship to a marine-influenced climate. Onshore, moisture-bearing winds blow almost daily yearlong here suggesting that the proximity of the cirio to the coast may be related to a high relative humidity. Although no humidity records were available at the time the hypothesis was proposed, we had often noticed and commented upon an apparent increase in relative humidity as we approached to within a few kilometers of the coast.

The study was not designed to examine in detail all the factors that might affect the distribution of *Idria* in the area; rather to determine a possible correlation between distribution and certain climatic elements, specifically humidity, temperature and precipitation. Consequently, physical and chemical characteristics of the soils at the four sites were not analyzed. It is of interest to note here, however, that soils are not indicated as a factor controlling distribution. Observations made prior to and during the study showed a similarity in parent material and derived soils at all of the sites. In addition, the earlier study (Humphrey, 1974) had recorded *Idria* in different parts of its range growing well on soils varying widely in parent material, texture, salt content and acidity, and on soils derived from granite, basalt, dolomitic limestone and volcanic ash.

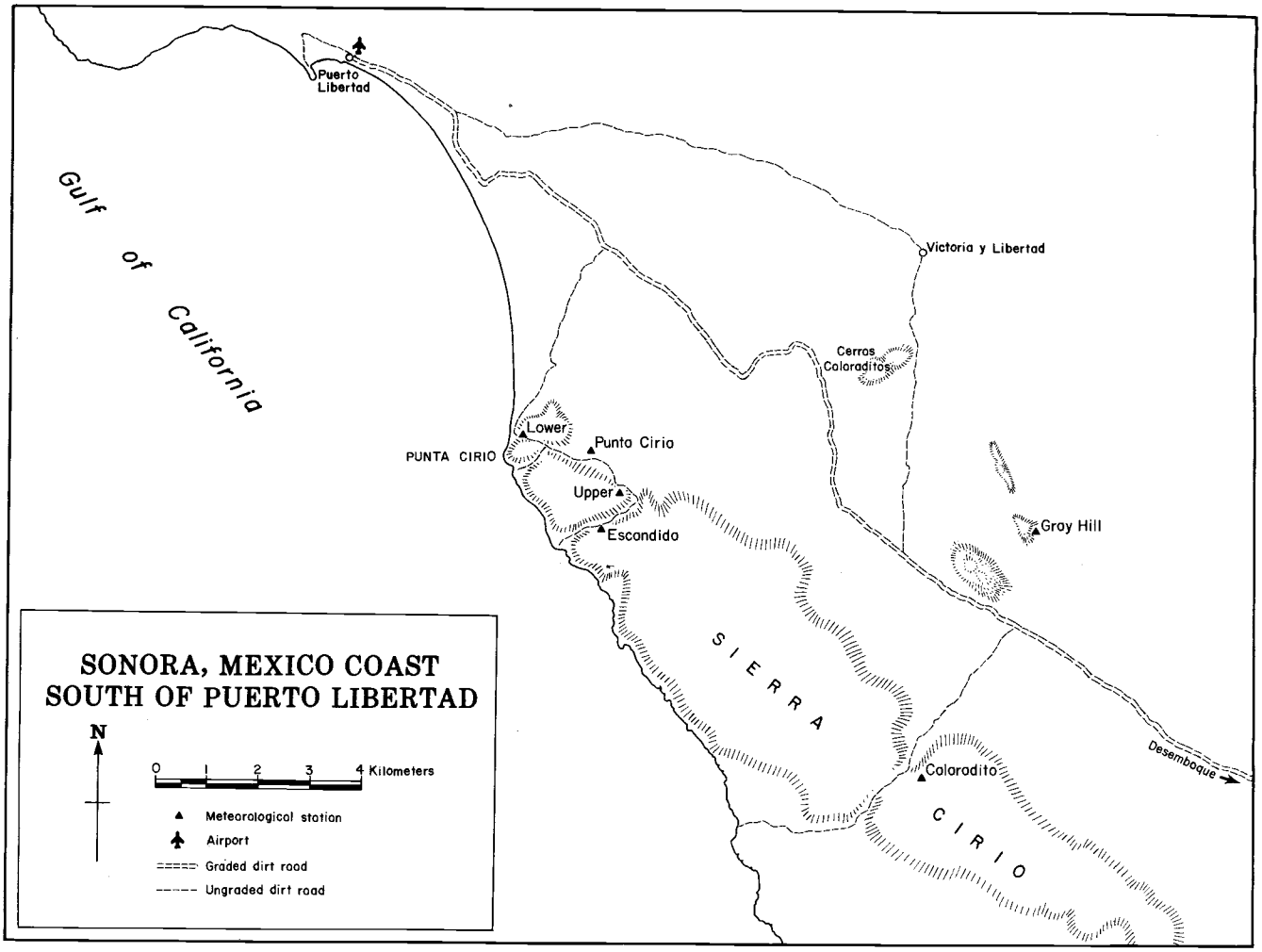

Figure 1. *Map showing Sonoran Coast immediately south of Puerto Libertad and location of meteorologic stations.*

The Study Area

Location. The study area is located near the north end of the Sierra Cirio, a low coastal range that borders the Gulf of California for about 48 kilometers (Fig. 1). The north end of this range terminates abruptly in the waters of the Gulf at Punta Cirio (Fig. 2), about 7.8 kilometers south of Puerto Libertád, which, in turn, is 250 killometers southwest of Nogales, Arizona. In this area *Idria* grows in washes as well as on slopes (Figs. 3, 4).

Soil Derivation.—Throughout most of the Sierra Cirio the soils are coarse-sandy and rocky or gravelly loams derived largely from porphyritic granites. These are interspersed occasionally with reddish outcrops of rhyolite and, in the southern end, by extensive dark-colored lava flows known locally as malpais. All the field stations were in the north end of the sierra, where the soils are granite-derived.

Climate. Temperature, precipitation, and evaporation data have been recorded at Puerto Libertád by the Mexican government since 1961. Prior to this, precipitation was recorded by the Carnegie Desert Laboratory from two gauges for the period 1925–1935, one located near Puerto Libertád, the other at Punta Cirio (Mallery, 1936a, 1936b).

Supplemental precipitation data have been obtained more recently from two additional gauges (designated "Upper" and "Lower") located near Punta Cirio and well within the cirio distribution area.

The combined records show a mean-annual rainfall at Punta Cirio of 106 mm, most of which falls in two seasons, summer and winter. Temperatures and evaporation rates are highest in July, August and September and lowest in December and January (Humphrey, 1975; Secretaria de Recursos Hidraulicos, 1961–1971).

Study Methods

Stations and equipment. In the current investigation, data for temperature, relative humidity and precipitation were obtained from four stations. Two of these were located in a habitat where *Idria* was growing; two were nearby where there was no *Idria*.

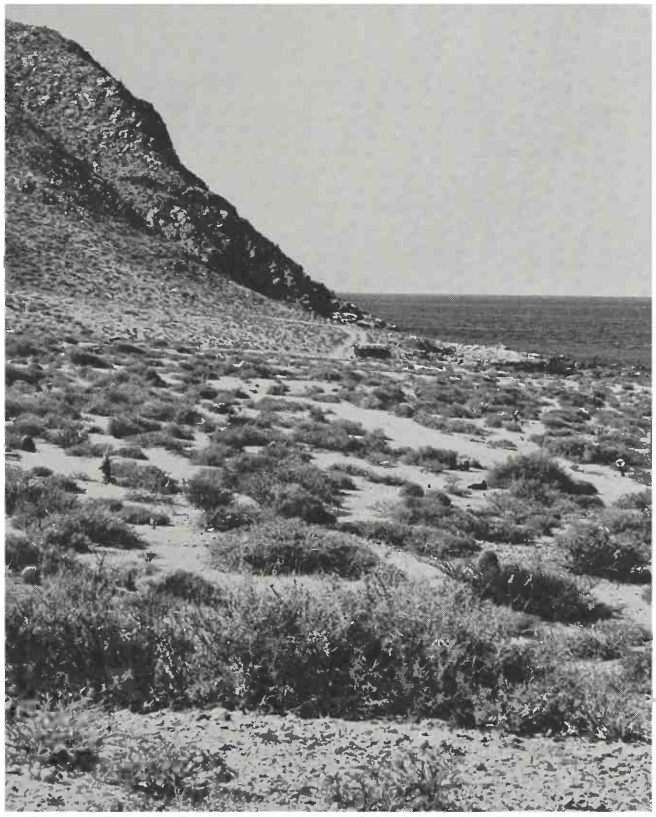

Figure 2. *Punta Cirio and the adjacent bajada and gulf. Idria grows on the hillside.*

Each station was equipped with a 31-day, battery-operated hygrothermograph, a max-min thermometer and Tru-chek rain gauge. The hygrothermographs and thermometers were housed in a 40×25×35-cm instrument shelter (Fig. 5). The rain gauges were located no more than 40 m from each shelter, projecting above the top of a small columnar cactus that had been pruned to support the gauge (Fig. 6). Evaporation from the gauges was prevented by pouring a small amount of light-weight motor oil in each and replacing it after each reading.

Each instrument shelter was secreted in a remote location where there was a little likelihood of discovery and possible vandalism or theft. In order to provide protection from the sun, as well as from physical disturbance, the shelters were placed in the entrances of rocky recesses with just enough overhang to shield them from the sun's rays. All, however, were so located as to permit free air circulation (Fig. 7).

The four stations were designated Punta Cirio, Escondido, Gray Hill and Coloradito. The first two of these lay 1.5 and .8 km respectively, from the coast and within the cirio community; the other two were 7.4 and 2.9 km respectively, from the coast and outside the cirio area. (Altitude above mean sea level: Punta Cirio—76m; Escondido—85m; Gray Hill—198m; Coloradito—303m) (Fig. 1)

Figure 3. *Plants of Idria in full leaf in a wash at Punta Cirio. Some of the Gulf shows in the center, to the left of the light-colored hill.*

Figure 4. *An Idria colony on the north slope of the hills at Punta Cirio. A Red-Tailed Hawk's nest is visible in the much-branched Idria at center on the skyline.*

Thermograph temperature readings were checked monthly by the max-min thermometers and the dry bulb on a psychrometer; relative humidity readings by the psychrometer. In those instances when instrument calibration was indicated, this was done at the time a new sheet was placed on the drum.

Duration of Record. The Punta Cirio and Coloradito instruments were set up and in operation on Oct. 8, 1972; the Gray Hill and Escondido instruments on Mar. 10, 1973. The hygrothermograph records were terminated on Nov. 11, 1975; recording of precipitation data continued through 1978. Thus, essentially continuous temperature and relative humidity records were obtained at Punta Cirio and Coloradito for 38 months, at Gray Hill and Escondido for 33 months. However, in order to have comparable, unbroken records over an identical time

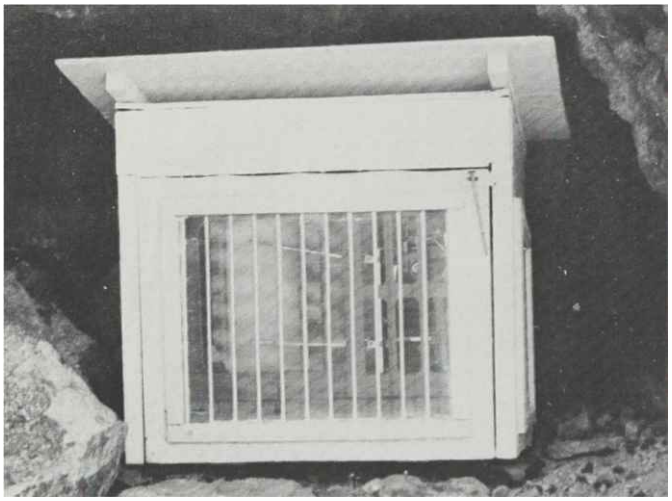

Figure 5. *Hygrothermograph in place at Punta Cirio site.*

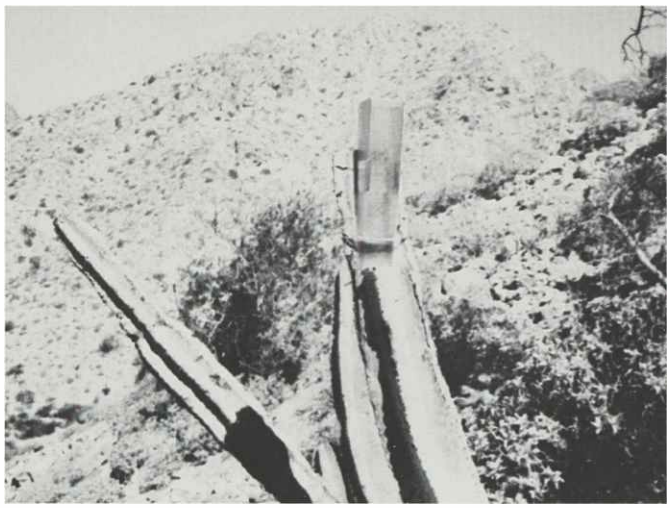

Figure 6. *Rain gauge on Cereus schottii at Escondido site.*

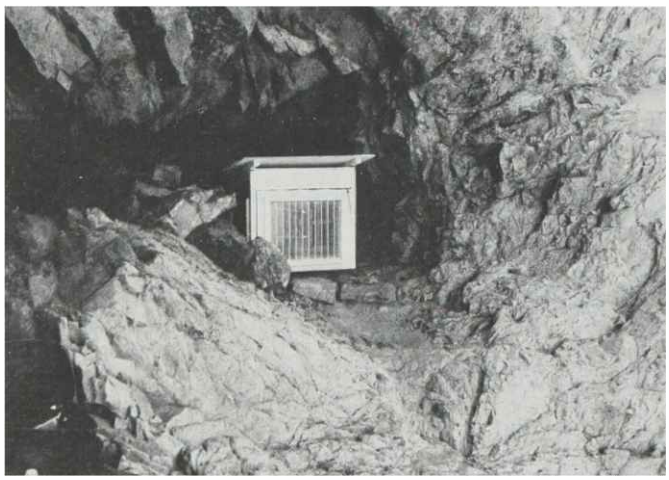

Figure 7. *General view of hygrothermograph shelter at Punta Cirio site.*

Table 1. Precipitation inside and outside *Idria* distribution area

	Annual total (mm)						
	Inside (by station)					Outside (by station)	
Year	Lower	Upper	Punta Cirio	Escon-dido		Colora-dito	Gray Hill
1974	40	60	57	41		53	53
1975	21	24	24	17		31	39
1076	56	64	82	54		78	145
1077	79	68	76	69		91	118
1978	206	193	214	173		248	282
Total	402	409	453	354		501	637
Mean	80[bc]	82[bc]	91[bc]	71[c]		100[b]	127[a]
Mean		(four stations)			81	(two stations)	114

[bc]*Means with different superscripts are significantly different at the .05 level using Duncan's Multiple Range Test.*

Table 2. Temperature and relative humidity inside and outside *Idria* distribution area

	Temperature (°C)			Relative humidity (%)		
Site	Mean	Std. error	Days sampled	Mean	Std. error	Days sampled
	Inside (by station)					
Escondido	42.79[a]	.151	893	40.44[b]	.402	900
Pta Cirio	42.30[b]	.142	859	41.89[a]	.430	906
	Outside (by station)					
Gray Hill	42.74[a]	.171	906	36.69[c]	.444	913
Coloradito	41.06[c]	.142	891	35.17[d]	.429	913

[a]*Means with different superscripts are significantly different at the .05 level using Duncan's Multiple Range Test.*

period all precipitation data cover the calendar years from 1974 through 1978 (Table 1).

Temperature and relative humidity. In order to express total relative humidity and precipitation, rather than merely their extremes, the thermograms and hygrograms were planimetered, recording the area between the bottom of each graph and the recorded temperature and relative humidity as the specific parameters (Table 2). With the thermogram 10°F was used as the base line; with the hygrogram 0% relative humidity was used.

In order to compare the means of the four sites, an unbiased estimate of the variability of the daily values of both temperature and relative humidity was needed. Box and Jenkins (1976) have shown that when observations are serially correlated the usual estimator of the variance is biased. The estimator is positively biased (too large) if the sequential observations are positively correlated and negatively biased if the sequential observations are negatively correlated. Thus the data should be filtered through an appropriate time-series model to obtain an unbiased estimate of the population variance. This was done with the data from the thermograms and hygrograms for each of the four sites.

Discussion

Of the three climatic factors evaluated, relative humidity, precipitation and temperature, only the first of these appears to be related to establishment

The rugged coastline south of Punta Cirio. The leaves and branches of Idria show in the lower right-hand corner.

of the cirio. Relative humidity at the two sites within the cirio's range was significantly higher at the .05 level than at the two outside its range (Table 2). This leads to the conclusion that establishment of *Idria* on the coast of Sonora is dependent on a comparatively high relative humidity.

In contrast, establishment in this area has not been shown to be related to mean-annual precipitation. The entire area represented appears to have a mean-annual precipitation favorable to establishment, a conclusion reached in part by comparing the precipitation data obtained in this study with data from Baja California. In the present study the average of the two gauges located outside the cirio distribution area was significantly greater (114 mm) than that of the four within its range (81). Yet it was only within, where rainfall was comparatively low, that the species has become established. In the supporting data from Baja California, 8 stations, all well within the cirio's area of distribution there, had an average mean-annual precipitation of 124 mm, with individual stations ranging from 90 to 155 mm (Hastings & Humphrey, 1968).

The present study also indicated no significant consistent differences in temperature between sites within, as opposed to those without, *Idria*. Thus, no relationship can be shown between *Idria* establishment and temperature.

This leaves relative humidity as the only known climatic factor essential to the cirio's establishment at this locale.

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