**Zeitschrift:** Veröffentlichungen des Geobotanischen Institutes Rübel in Zürich

**Herausgeber:** Geobotanisches Institut Rübel (Zürich)

**Band:** 14 (1939)

**Artikel:** Some comparisons between the vegetation of Morocco and Australia

**Autor:** Osborn, T.G.B.

**DOI:** https://doi.org/10.5169/seals-307293

# Some comparisons between the vegetation of Morocco and Australia.

(With 4 text figures and plates.)

By *T. G. B. Osborn,* University of Sydney, New South Wales.
Now University of Oxford, England.

The object of the present paper is to compare certain features of the Moroccan vegetation, as seen during the 8th I. P. E., with that of climatically similar parts of Australia. It is assumed that the reader is already familiar with the main outlines of the tour itself. Of necessity a short description of certain features of the Australian climate and topography must be given in order successfully to make the comparisons involved.

Morocco is a large country, roughly the size of France, Australia is a continent about three quarters the size of Europe. One must, therefore, select some definite part of Australia from which to draw comparisons.

The State of South Australia is not quite twice the size of Morocco (roughly one million sq. kms. as against 520,380 sq. kms.). Of all the Australian states it agrees best in geographical position and climate. It lies between 26 ° and 38 ° S. latitude, Morocco between 28 ° and 36 ° N. latitude. Only comparisons drawn from the middle portion of South Australia will be used. The northern part lies within the influence of the tropic and so has a summer rainfall. It is, therefore, unsuitable for comparison with a country having such a pronounced «winter rainfall» as Morocco. That part of South Australia lying south of lat. 36 ° may be neglected also. It is rather level land, much of it consisting of relatively recently fixed sand dunes, and climatically influenced by its proximity to the ocean. One is left with a compact land mass for comparison about the size of French Morocco. In this area the rainfall, which varies from only 100 mm. par annum to nearly 1670 mm., shows a definite winter maximum; December to March inclusive being the driest months.

In general the climate of Morocco is much more extreme in its alternation of wet and dry seasons than that of South Australia.

Only in the east and south of the Atlas, and in the mountains themselves, does any appreciable percentage of the rain fall during the four dry months, June—September (Emberger and Maire, 1934, p. 105). Along the littoral and in meridional and septentrional Morocco the rainfall during that period is 10 % or less of the annual total. Adelaide (535,7 mm. av. annual rainfall) has 16 % during the comparable dry months, December—March (fig. 1). North of Adelaide, the influence of summer rains of a monsoonal type is much more apparent, with a consequent flattening of the graph of mean monthly rainfall (fig. 4). To this extent the climate of arid Australia might seem to be less extreme. But on the other hand, if the arid parts of Morocco can expect a regular rainfall each year, this amount, small though it be, may help to explain why it is possible to grow crops on an annual rainfall which would be hopelessly inadequate in South Australia. Emberger and Maire do not discuss the reliability of the rainfall in Morocco. At present there are only a few stations at which records have been kept for sufficiently long periods for such an investigation. In South Australia rainfall records have been kept for 40—90 years and more. The isolog of 50 % rainfall reliability cuts across South Australia (Andrews, 1932). In the arid parts it is between 50 % and 40 % only.

An Australian visitor is at once impressed by the diversity of climate and vegetation type to be found within short distances in Morocco. The explanation lies in the physiography of the two countries. Morocco has many mountain ranges with peaks up to 4,000 m. and over. Only in the south eastern corner of Australia is there any land over 2,000 m. and in the area of South Australia selected for comparison there are only a few points over 1,000 m. But these rise from plateaux of 300 m. altitude so that the difference in elevation is not sufficient to influence the climate of an arid region to any extent. Nowhere in Australia can one see such a sequence of vegetation zones as on the line Taroudant (252 m.) to Tizi N Test (2,200 m.), in 90 kms., or Aïn Sefra (1,075 m.) to Aïn Aissa (1,670 m.) in a much shorter distance.

In spite of these obvious physiographic differences no Australian visitor can fail to be impressed by the general similarity of the landscape in certain parts of Australia with Morocco. This similarity is seen both in some of the cultivated areas and also in portions of the arid and desert regions. It seems worthwhile putting on record, therefore, certain comparisons between Australian types and the vegetation as seen round Oran and Rabat, the cultivated areas round Kasba Tadla, the *Argania* forests, the steppe near El Kelaa and portions of the Sahara. There is nothing in Australia to compare with some of the more spectacular features of the Moroccan vegetation. There are no cool wet coniferous forests in Australia, so that there is no homologue of the cedar forests seen near Azrou and Ifrane. The southern temperate rain forests of Victoria and Tasmania are not comparable. Further, there is nothing to compare with the succulents of the Sous. In the whole of Australia there is but one stem succulent, *Sarcostemma australe,* which nowhere gives a character to the vegetation.

*Activities of Man.*

In both Morocco and South Australia the primitive vegetation types of forest, scrub or steppe have been modified by peoples following agricultural or pastoral pursuits. In Morocco, this activity has gone on for many centuries, in South Australia, for at most 100 years. The population of Morocco today is about ten times that of South Australia, it has about a million more sheep, seven times as many cattle, and some three million goats, therefore it is easy to realise that the incidence of the biotic factor has been much more severe. Large parts of South Australia are today but little altered from their original state. It is, then, easy to study the original vegetation type side by side with its modification by settlement. In Morocco, it seems probably that most of the land which can be cultivated has, at sometime or another during the past thousand years, been under the plough many times.

Wherever in Morocco European-style cultivation of cereals or vines has been undertaken on a large scale, the results have been that the Moroccan and Australian landscapes are extraordinarily similar. Thus my notes made on the railway journey from Oran to Rabat record of e. g. the plain behind Oran, at Ste. Barbe du Telat railway station and on nearing Port Lyautey, «it might be anywhere in the Lower North of South Australia», i. e., the district about 150 km. north of Adelaide. One observes the same large areas of crops or fallow, 30—40 hectares in extent, vineyards of considerable size backed, in places, by low smooth rounded hills. The illusion is helped when one observes almonds, peaches, apricots, figs, oleanders, etc. in the gardens with, frequently, eucalyptus trees planted by the roadside or along a dry water course.

Owing to the presence of a large naturalized element from the Mediterranean region in the flora of the agricultural parts of South Australia, it frequently happens that the very weeds are the same. Thus, the following, collected on 30th March 1936 in Oran on some waste land by the barracks, might have been expected in any South Australian township at a comparable season of the year:

*Bromus madritensis*
*Hordeum murinum*
*Oryzopsis miliacea*
*Oxalis cernua*
*Malva parviflora*
*Hedypnois cretica*
*Carduus tenuiflorus*

To these, round many an Australian township, might be added species of the following genera, most of which were, indeed, collected on the excursion behind Oran that afternoon:

*Stipa*
*Polypogon (Monspeliensis)*
*Lepturus (incurvatus)*
*Juncus bufonius*
*Emex*
*Polygonum aviculare*
*Papaver (hybridium* and *Rhoeas)*
*Diplotaxis*
*Sisymbrium*
*Erodium (moschatum)*
*Medicago*
*Trifolium (angustifolium* and *tomentosum)*
*Anagallis*
*Echium*
*Marrubium vulgare*
*Hypochoeris*
*Urospermum picrioides*
*Centaurea militensis* and *calcitrapa*
*Kentrophyllum*
*Silybum marianum*
*Onopordon*

None of the foregoing genera, except *Stipa, Lepturus* and *Juncus,* is indigenous to Australia. Yet individual species of certain of the genera, e. g. *Echium, Marrubium, Centaurea, Kentrophyllum, Silybum,* are so abundant as to form locally prominent elements in the flora.

Similarly, the landscape round Kasba Tadla is like parts of South Australia; some comparison between this place and Yongala (S. Australia) is made below.

Throughout that part of Morocco which we visited the results of the activities of the indigènes and their flocks were very obvious. The indigènes' agricultural methods are small scale, with primitive implements but these are backed by tremendous man-power[1] and by the intensive grazing of sheep and goats. The effects have been wide-spread, if sporadic, since many of the indigènes are essentially nomadic. The results appear to be that the vegetation over huge areas has been modified to an extreme degree, though, because of the nomadic habit, there appears to be much partial reversion and development of secondary seres. Notably there has been a destruction of forest. In Australia, 70 or even 30 years of European occupation has meant the almost complete destruction of woody types in a district. And this by only a handful of white people; the aboriginals, of course, had no agriculture. The much larger indigène population in Morocco, with its proportionally greater wood requirements, operating over centuries, must have acted far more seriously. Moreover, such destruction, once begun, is always cumulative in its effects.

Nevertheless, experience in Australia makes one cautious in accepting, in every case, the statement that this valley or that plateau in Morocco was once forest or even scrub. The broad valleys of alluvial soil in parts of Australia are, and primitively were, either treeless or lightly timbered compared with the surrounding hills. This applies to the plateau (300—400 m.) Burra-Peterborough in South Australia, to the great plain of the Riverina (about 100 m.) in south western New South Wales, to the valleys around Canberra (about 550 m.) and so on. The great basaltic district west of Melbourne has interest for comparison with the basalt covered plateaux near Timhadit. This part of Victoria, though it has an annual rainfall of over 600 mm., always was destitute of trees except on the outcropping hills or in the gorges cut through the basalt sheet. The occurrence of this treeless basalt plain, surrounded by areas that were, and in many places still are, Eucalypt forest, makes one hesitant about regarding the plateaux around Timhadit as «Cédraies dé-

[1] e. g. The hand weeding of small plots of cereal crops noticed on April 10, 1936 between Oued el Abra and Beni Mellal.

gradées» owing to the combined action of man and his flocks. Maire (1924, p. 105) states that he has evidence of the former occurrence of *Cedrus*. Even so, these may have been occasional trees and not the pure cedar forests such as were seen upon the volcanic cones which project so strikingly above the plateau. The periphery of these small cedar woods, so far as we examined them, was composed of a belt of *Quercus ilex* scrub, heavily grazed. I did not see evidence that regeneration of the cedars was taking place centrifugally, though it was obvious inside the crater.

The recurrent shifting cultivation over large portions of Morocco has undoubtedly led to much soil erosion both by wind and rain. It is to the former that one attributes many of the exposures of travertine limestone, the «croûte désertique», on the coastal plain, e. g., from Azemour southwards. This concretionary limestone, whether it be in blocks giving almost a hamada surface, as at Safi, or in more or less compacted nodules as seen in many exposures, looks very familiar to anyone who has seen the «mallee» soils of Australia. Similar large scale exposures of travertine may be seen in many parts of South Australia, e. g., near Moorlands or Morgan on the Murray River, on the «West Coast» (i. e. west of Port Lincoln) or around wells or in overgrazed areas in semi-arid and arid districts. There the limestone, which was originally buried to a depth of from a few cms. to half a metre or more, has become exposed owing to wind erosion, a «drifting» of the surface soil following upon the destruction of the native flora. On the Pearson and Franklin Islands (Osborn, 1922 and 1923) the limestone sometimes lies directly upon the granite platform of which the islands are built, all the soil having been blown away, cf. Emberger and Maire (1934, p. 183) who comment upon the occurrence in the Haouz of Croûte upon a silicious base.

The temptation to interpret the croûte in Morocco as the illuvial (B) horizon of a zonal soil is irresistable, and when, as at Safi, there is clay, with indications of gypsum (magnesium sulphate) below it, the soil type seems remarkably like the peculiarly Australian soil type known as the «mallee soil» (Prescott, 1931).

*Soils.*

Anything more than a most cursory glance at the soils was impossible on so extensive and rapid a journey as was the 8th I. P. E. But the impression was gained that an interesting and fruitful field awaits investigation in the relation between soil types and vegetation in Morocco. In Australia, where so much natural vegetation is left in a more or less undisturbed state, it has been possible to construct vegetation and soil maps of the continent (Prescott, 1931) from the combined information in the several Government Land Survey Departments.

In Morocco, where so little undisturbed vegetation is left—almost none in any district where cultivation is at all possible—this could not be done. But, when the profiles of the Moroccan soils have been examined, it seems probable that a careful comparison of them with certain Australian types would be well worth undertaking, particularly in the arid—semi-arid regions. It is only possible here to draw attention to the profiles which happened to be exposed at some of the halts.

1. Near Beni Mellal (about 13 km. to the West. April 10, 1936. Av. Ann. rainfall 500 mm.).

Deep trench cut by roadside. Wide alluvial plain, good crops of wheat and barley, *Zizyphus* and *Ferula* on some neglected patches.

Profile $A_1$. dark chocolate-brown, light loam, some humus and fungus mycelium — 9 cms.

$A_2$. chocolate brown, heavier, kneads into a paste when moist — 50 cms.

$B_1$. lighter brown, small calcareous concretions scattered for 120 cms. +

$B_2$-C paler clay-loam.

The distinction between the eluvial and illuvial horizons is clearly seen in the photograph (Pl. XII, fig. 1), as are the calcareous concretions. Two, larger than any noticed in situ, lie beside the road on the left of the picture.

This type of soil has many features recalling the red-brown earths of South Australia, the most important wheat soils. Though they occur in districts that were some of the first to be settled, areas are still to be seen uncleared and unploughed. The vegetation is an open savannah forest, occasionally natural grassland. The chief tree is *Eucalyptus odorata,* undershrubs absent, *Danthonia penicillata* and *Stipa* sp. are important grasses.

2. Near Bir-Jedid — St Hubert (April 4, 1936. Rainfall about 400 mm.)

Exposure in road-side cutting—gently rolling country—crops, wheat and barley, many herbaceous annuals. Pl. XII, fig. 2.

Profile $A_1$. dark red-brown, light loam, humus present 5—7 cms.
$A_2$. lighter red to coffee colour, sandy and crumbles—45 cms.
$B_1$. light red to coffee colour, scattered calcareous nodules, some thin sheets of more or less calcified material —60 cms.
$B_2$-C. yellowish, cheesy consistency.

This soil differs from that at Beni Mellal, amongst other things, in the more abundant calcareous concretions in the $B_1$ horizon and in the leaching down of the clays with the result that the A horizons are lighter and more sandy. In both cases the rainfall is about the same, but St-Hubert is only some 10 km. from the sea. The interest of these facts will be considered in connection with the next soil profile, seen near Safi.

Emberger stated that the primitive vegetation at St-Hubert was a scrub, with no dominant but including *Pistacia atlantica.* It would seem to have been an extension of his Olivier-Pistacia-Palmier nain-Lentisque (Emberger, 1931, map and p. 27).

3. Near Safi (April 4, 1936. Rainfall 351 mm.).

Deep exposure in cutting by road leading down from cliff to sea. Top of cliff much disturbed, largely limestone exposures giving almost a hamada surface with sandy soil between. Pl. XIII, fig. 1.

Profile $A_1$. virtually absent, reddish-yellow sandy soil in places.
$B_1$. massive travertine blocks giving in places hamada surface—some rubble—separate calcareous concretions below. 40—60 cms.

$B_2$. reddish-yellow clay—shows obvious cracking in bottom two-thirds. 180 cms.

C sandy loam.

This exposure is extremely like a profile in portion of the «mallee» districts of South Australia.

«Mallee» soils are, according to Prescott, one of the major soil groups of Australia. They occur largely within the zone of winter rainfall and the influence of the Southern Ocean. The presence of the illuvial clay horizon in these soils is presumably due to a solonization process, not podsolization, for the rainfall is insufficient. It has been suggested that there is a constant accession of cyclic salt borne in the off-ocean winds. These «mallee» soils cover many thousands of sq. km. of land in South Australia between 35° and 37° S. latitude. They are also found in Victoria and the adjacent parts of New South Wales. They are developed between the 200—500 mm. isohyets. Mallee is a distinct vegetation type, having a high percentage of shrubs and woody undershrubs of a sclerophyll type, but of very diverse floristic composition (Wood, 1929). The dominant over most of the areas is one or more of several *Eucalyptus* species, having a natural «coppice» habit, a number of equivalent stems arising from a large woody root-stock at or below ground level. The stems branch infrequently in their lower part but bear a characteristic leafy canopy top.

In South Australia, the Mallee soils are also found north (on the arid side) of the 200 mm. isohyet in the wide valleys of the peneplains. There the characteristic vegetation is a shrub steppe of various Chenopodiaceae notably *Atriplex vesicarium* or *Kochia* sp. (Osborn, Wood and Paltridge, 1932). The occurrence of this shrub-steppe vegetation on mallee soils with a low rainfall lends interest to the soil profile described below.

4. Between Marrakech and El Kelaa (about 70 km. NE Marrakech. April 10, 1936. Rainfall circa 300 mm.).

Exposure in a small running watercourse, upper portions obviously disturbed by floods at various times. Vegetation type shrub-steppe.

PLATE XII

F i g. 1. Soil profile near Beni Mellal — see text p. 174.
The junction of the A and B horizons is clearly seen about the level at which a sample is being taken. The scattered calcareous concretions are obvious to the right of this. Two large blocks of concretionary limestone are on the bank to the left.

F i g. 2. Soil profile near Bir-Jedid-St. Hubert — see text p. 175.
The scale object, the sheath of a knife about 15 cms. long lies near the junction of the A and B horizons. Calcareous concretions are obvious to the right, and more or less calcified layers cross the picture.

Fig. 1. Soil profile near Safi — see text p. 175.
The scale object, a knife, of which about 12 cms. is exposed, is stuck into the soil in the $B_1$ horizon to the right of and below a massive block of *croûte*.

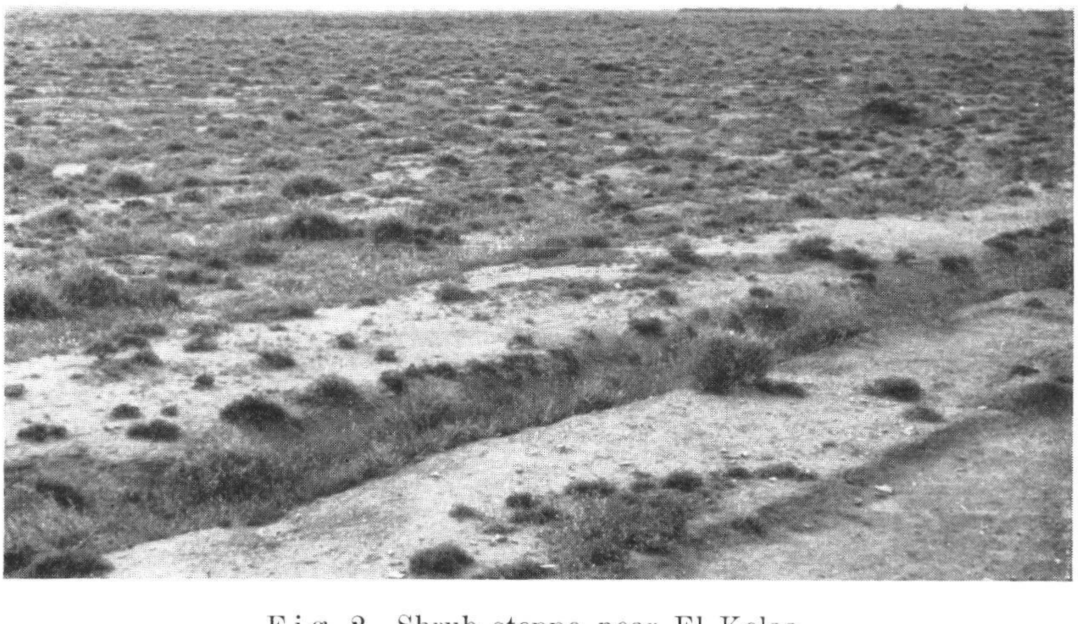

Fig. 2. Shrub steppe near El Kelaa.
*Atriplex halimus* and *Salsola oppositifolia* co-dominant.

Profile $A_0$ light red-brown silty loam, some suggestion of humus. 5 cms.

$A_0'$ alluvium and gravel. 5 cms.

$A_1$ absent—presumably eroded by floods, n. b. constitution of the $A_0'$ layer.

$B_1$ separate irregular calcareous concretions in dense band. 8 cms.

$B_2$ sandy loam, light brown (cocoa coloured) definitely more clay than in A layers, no calcareous concretions. 60 cms. +

The vegetation is discussed below, page 186.

5. Near Timensur (41 km. south of Agadir. April 6, 1936. Rainfall 100—200 mm.).

Exposure in pit by roadside—level plain—some crops, barley nearly ripe, date palms. Occasional big Arganias near towns. Much bare plain with yellowing therophytes and scattered *Ononis natrix*. It was said that this area might have been one time *Argania* forest.

Profile A pale brown, light cocoa colour, sandy loam. 10 cms.

$B_1$ nodular travertine, more or less compact rubble, but not in big blocks. 40—50 cms.

$B_2$ pale yellowish-brown, not clayey, does not form paste on wetting—no change to 100 cms. +

This region was one of the driest visited outside the Sahara. The rainfall at Tiznit is but 164 mm. Presumably the pronounced winter maximum (over 90 %) makes cultivation possible. In South Australia cultivation would be impossible with so low a rainfall. The vegetation types would be either Chenopodiaceous shrub-steppe on deep alluvial soils such as above or open scrub of *Acacia* or *Eremophila* on the shallow soils of the hills. Tree growth would only occur by the water courses.

*Sub-humid or temperate-Mediterranean type.*

The excursion made March 21, 1936 to the slopes of Santa Cruz, a hill west of Oran, involved a walk up wooded slopes that in many ways recalled the foothills of Mount Lofty near Adelaide. Of course, the dominant *Pinus halepensis* is quite different from any Eucalypt in size and shape. It was rather in some of the subordinates that the similarity was to be found. The small yellow flowered rock roses *(Helianthemum)* are paralleled by various species of *Hibbertia* which have a similar yellow open corolla. *Micromeria* at once recalled the Australian genera *Westringia* or *Prostanthera*. *Lavendula Stoechas* is naturalized in parts of the Adelaide district, so is *Echium plantagineum* which in the spring covers large portions of the lower slopes with a blue-purple mantle. *Bromus* sp. and *Erodium* sp. are widely spread naturalized therophytes in South Australia.

There is a close parallel between the climate of Rabat and Adelaide, both in rainfall an in range of temperature. These data

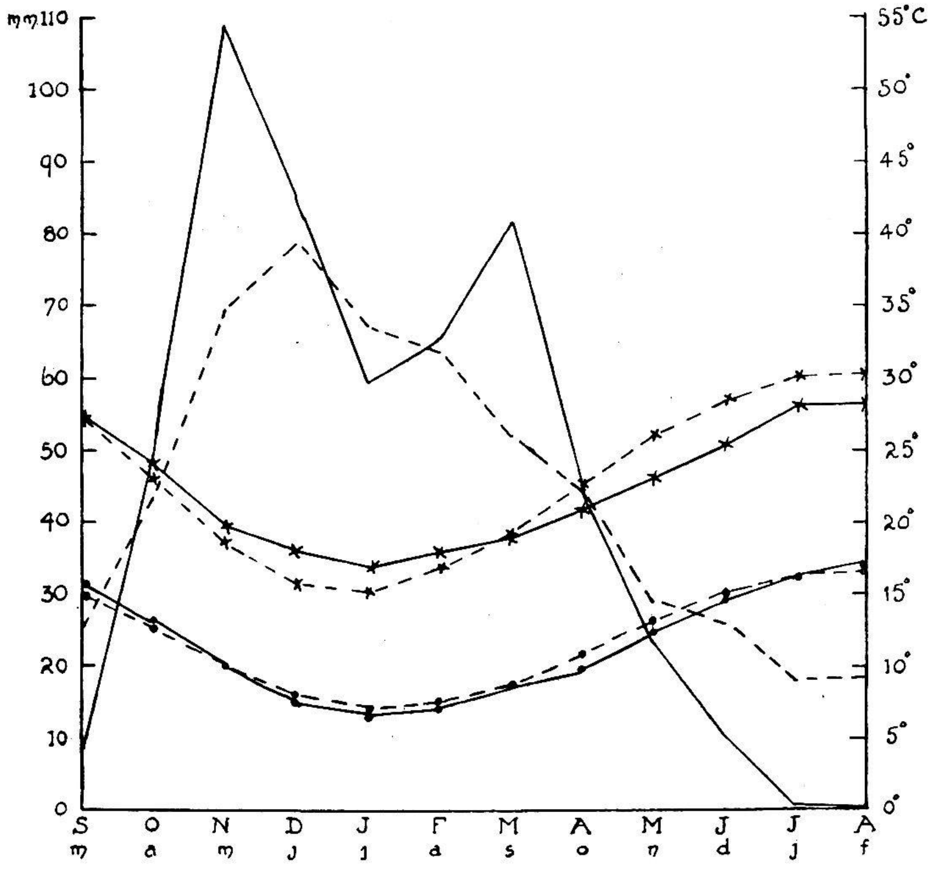


*Fig. 1.* Graphs of rainfall, mean maximum and mean minimum temperatures for Rabat and Adelaide.
Rabat 64 m. altitude, mean annual rainfall 535 mm. (16—17 year's records).
Adelaide 43 m. altitude, mean annual rainfall 535,7 mm. (92 year's records).

In all figures the curves for Moroccan stations are given in a continuous line, for Australian, in a broken line. On the mean maximum temperature curves the readings are marked x, on the mean minimum curves thus . The initial letter of the months is given in capital letters for Moroccan stations, in small letters for Australian.

are expressed in the graphs (fig. 1). The data for Rabat are taken from Emberger and Maire (1934), those from Adelaide from the figures of the Commonwealth Meteorological Bureau (Anon. 1933). The Australian figures are arranged so that March corresponds with September in Morocco, April with October and so on. In this way the close agreement of the two sets of curves is apparent. The rainfall graphs for these two places show least agreement, though the total annual rainfalls are almost the same, Rabat 535 mm. (mean of 16—17 years), Adelaide 535,7 mm. (mean of 92 years). The Rabat curve has a pronounced double peak with maxima in early Autumn and Spring with almost no rain in July and August. In Adelaide the maximum is in June (early Winter). There is no second peak, though there is a flattening of the descending curve in July—the driest months, January and February, have each of them 18 mm. of rain.

The forest of Mamora as examined by us was largely a regenerating stand of *Quercus suber*—one could not judge the height to which the trees might ultimately grow. With it was *Pirus mamorensis*. It was clearly the dry phase of the *Quercetum suberis* described by Emberger (1931). Near Adelaide, its equivalent would probably be forest of *Eucalyptus leucoxylon* or *Eucalyptus fasciculosa*. Both these are smooth barked «gums», hence the appearance, quite apart from the foliage, is very different. The rough barked eucalypts, e. g. *Eucalyptus obliqua* or *Eucalyptus capitellata* only occur with a higher rainfall. One gains the impression that the shade cast by the cork oaks is greater than that of the pendant leaved, more or less canopy topped eucalypts. There is in Australia a diverse collection of sclerophyllous undershrubs (Adamson and Osborn, 1924). Of these the Hakeas have no equivalent in Morocco. Shrubby Leguminosae, *Pultenea, Daviesia, Dillwynia* are paralleled by *Cytisus, Sarothamnus, Ulex;* for similarity of habit, n. b. the species *Daviesia ulicina*. The parallel between certain flower forms in the Dilleniaceae and Cistaceae has been mentioned. *Thymelaea lythroides* and *Daphne Gnidium* are not unlike species of *Pimelia* belonging to the same family. In Australia, no single species of undershrub gives the same character to the scrub as did *Lavendula Stoechas* to that part of the forest of Mamora examined.

On the other hand, the smaller clumps of *Chamaerops* seen from a distance suggest the low growing *Xanthorrhoea semiplana.* Both areas are rich in geophytes—mainly Liliaceae and Orchidaceae in Australia. The Australian geophytic species of *Drosera* have no equivalent in Morocco. Annuals are not a feature of this type of community in Australia.

It was particularly interesting to see the habitat of *Isoetes hystrix* and *Ophioglossum lusitanicum* in view of the occurrence of *Isoetes Drummondii* and *Ophioglossum coriaceum* in the Adelaide district (Osborn, 1918). The habitats of the Ophioglossums were closely comparable. The Australian Isoetes had a different soil type.

There are very extensive salt marshes on the coast near to Adelaide. The middle zones (Osborn and Wood, 1923) show a general similarity with the middle zones of the small salt marsh examined at the mouth of the Oued Bou Regreg. In Australia the tidal river margin has the mangrove *Avicennia officinalis.* Behind this is developed a shrubland of *Arthrocnemum arbuscula* with the perennials *Suaeda australis* and *Salicornia australis.* This is the region which compares well with the zone of *Arthrocnemum glaucum* accompanied by *Suaeda maritima* var. *perennis* near to Rabat.

*Fertile Plateaux.*

The plateau of the Kasba Tadla district, with its extensive areas of cultivation, much of it on European methods, strongly resembles parts of South Australia near Peterborough. This district is an elevated peneplain. There are low rounded hills, not heavily timbered, and great wide valleys. Originally these were virtually treeless, the only extensive area of savannah in South Australia.

In figure 2 rainfall and temperature graphs are given for Yongala, a small town near Peterborough, and Kasba Tadla. The altitude of these two places is about the same. Yongala has the lower rainfall, 360 mm. against 424 mm., but the shapes of the two curves show general agreement, with differences of the same type as were noticed previously between the rainfall graphs of Adelaide and Rabat. The mean maximum temperature graphs show that Yongala is about 10° C cooler in both the hot and cold seasons. The mean minima curves are closely parallel, the temperatures at Yongala being consistently slightly cooler, as much as 7 ° C in the Autumn.

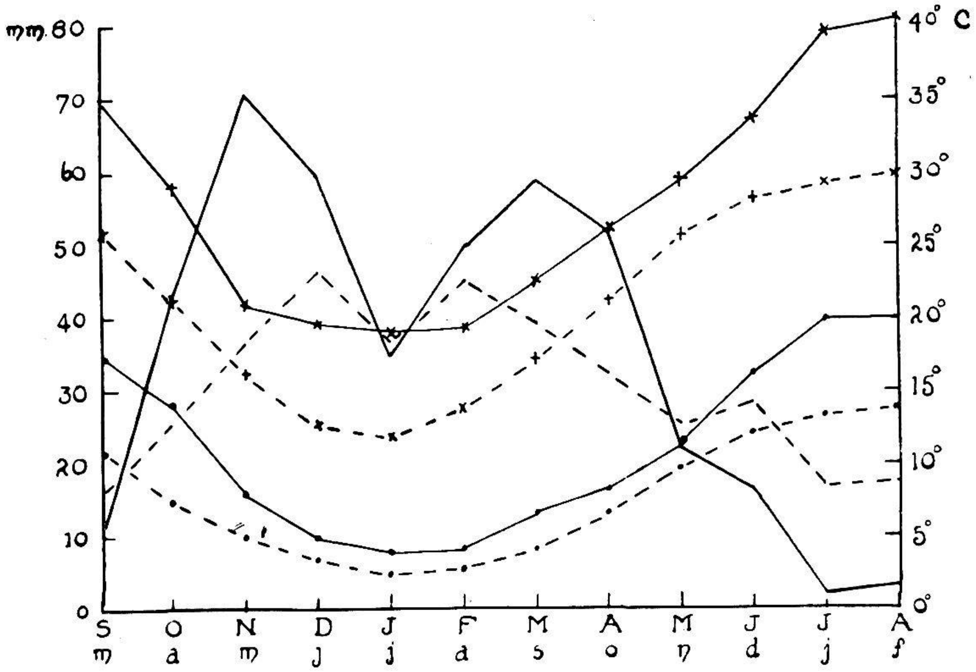


*Fig. 2.* Graphs of rainfall, etc. for Kasba Tadla and Yongala. Kasba Tadla 505 m. altitude, mean annual rainfall 424 mm. (12 year's records). Yongala 513 m. altitude, mean annual rainfall 367 mm. (50 year's records).

This part of South Australia is interesting for two reasons. First, because of the natural grassland which primitively existed there, and secondly, because of the transitional type of woodland developed on the hills.

The grasslands consist of various species of *Danthonia, Stipa, Panicum, Calamagrostis* and *Themeda,* all low growing, except the last. There are still extensive sheep pastures in the area, variously modified by such spontaneous introductions as *Erodium moschatum, E. botrys* and *E. cicutarium, Medicago* sp., etc. *Glycine, Goodenia, Arthropodium, Anguillaria,* and various orchidaceae are important native perennials, the monocotyledons providing a geophytic element.

As the shallower soils of the hill slopes are reached, woody plants make their appearance, usually as a very open woodland.

In places there are extensive groves of *Callitris propinqua* and *C. glauca,* especially on the lower slopes. *Eucalyptus oleosa,* sometimes as a tree to 10 m., but often in the natural coppice or «mallee» form, occurs, either pure or in association. Often there is a mixed scrub including, with the foregoing, *Acacia pycnantha, Acacia calamifolia, Bursaria spinosa, Eremophila longifolia, Myoporum platycarpum, Cassia Sturtii, Dodonaea* sp.

It was interesting to notice the transition from the heavy cultivation around Kasba Tadla to degenerate scrub and finally much modified *Tetraclinis articulata* forest. This was seen on April 11, 1936 during the first 50 km. on the Khenifra road. Following the farmed land there was an outer fringe of indigène cultivation nearing the foothills, the usual small plots of ploughed land alternating with rough grazing or even scrub. This at first was largely *Rhus pentaphylla* with *Chamaerops. Urginea* was a common geophyte and *Ferula,* which had been seen growing like a crop on neglected fallow, persisted, though lower growing and not so floriferous.

Within 25 km. there was an open scrub-woodland of *Pistacia* and *Ceratonia,* less *Rhus,* but scattered bushes of *Zizyphus,* clumps of *Chamaerops, Lavandula* and many annuals. This type of scrub degenerated into poor grazing land with scattered *Chamaerops* and a wealth of flowering annuals in many places; in others, it was cleared and cultivated. There was abundant evidence of heavy erosion. Travertine limestone exposures were common, showing that the upper horizons of the soil had been removed. To judge from the burden of red soil in the Oum er Rbia this process is still actively going out. At about 50 km. from Kasba Tadla, degenerate *Tetraclinis* woodland with some *Juniperus phoenicea* was reached. It would be hard to say how far this forest may formerly have extended towards the plain or even what may have been the one time extent of the scrub. My field note here reads, «The plough seems to have been at some time over any area that an indigène could plough». If the relatively inhospitable soils of the hills have been so much cultivated, how much more so the rich soils of the plains? These naturally, would have been the first to be exploited centuries ago. Their primitive flora must always be a matter of surmise. It is interesting to speculate whether, on the basis of an Australian parallel, some of them may not originally have been savannah.

*Arid Climate Communities.*

Emberger (1936) recognises two divisions of the arid climate type in Morocco, la forme douce and la forme froide. In the former the intensity of the aridity is moderated to some degree by proximity to the Atlantic Ocean. This reduces the extremes of temperature, and, particularly, maintains the mean minimum at a higher level than further inland. The character plant of this area is the low evergreen tree *Argania spinosa.* In the latter division the aridity is intensified because of the great fluctuations of temperature, and, especially, by the low minimum temperatures during the winter months. The vegetation types under these conditions are either *Acacia gummifera* and *Zizyphus lotus* scrub or steppes.

In comparing the Moroccan and South Australian arid climates, it will be convenient to take Marrakech (rainfall 285 mm. and altitude 460 m.) and Broken Hill (rainfall 243,3 mm. and altitude 305 m.). Broken Hill is actually in New South Wales, but it is close to the State boundary and is climatically similar to the adjacent parts of South Australia.

The graphs of average rainfall, mean maximum and mean minimum temperatures are given in fig. 3. The curve for rainfall at Broken Hill is flatter than that for Marrakech. In its wettest month it averages 20 mm. less rain than Marrakech in its wettest month, but in its driest month it averages 16 mm. of rain against 5 mm. at Marrakech. In the case of the mean maximum temperature curves, Marrakech is 3—5 ° C warmer than Broken Hill in the hottest and coolest months. The graphs of the mean minimum temperatures are practically coincident, Marrakech in its coldest month being about 1,0 ° C below Broken Hill. There is, on the whole, a close agreement, climatically between the two places. The difference is most marked in the distribution of the rain. In Morocco, there is a characteristic double peak corresponding to the Autumn and Spring rains and a very low minimum during the dry Summer months. In South Australia, there is a definite Winter maximum, but the effect of Summer rain of a monsoonal type is seen. When a considerable number of years is taken into account (42 in Broken Hill data) the rainfall during the Summer

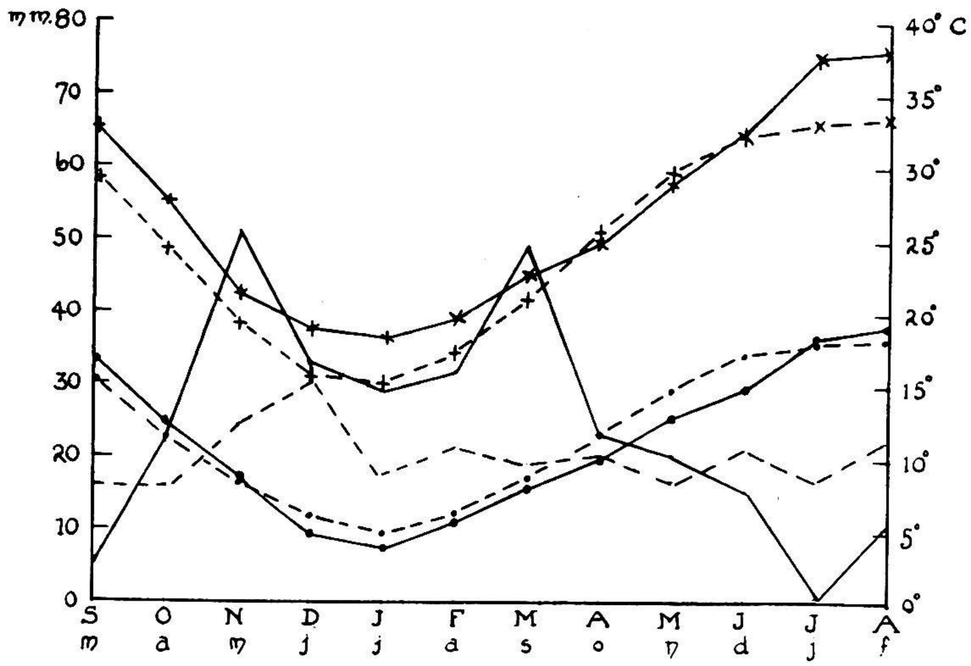


*Fig. 3.* Graphs of rainfall, etc. for Marrakech and Broken Hill. Marrakech 460 m. altitude, mean annual rainfall 285 mm. (16—17 year's records). Broken Hill 305 m. altitude, mean annual rainfall 243 mm. (42 year's records).

months fluctuates about 18 mm. per month. Comparisons between the rainfall distribution of other arid stations in South Australia and Morocco bring out this same feature.

In Broken Hill two distinct and unrelated climaxes are developed, scrub-woodland in the shallow immature soils of the hills and shrub-steppe on the deep mature alluvial soils of the plains. This feature is characteristic of the arid areas in South Australia. It has been referred to in the published work on Koonamore and will be discussed at length in a forthcoming paper by Osborn and Wood.

The hills scrub is typically an open woodland in which *Acacia aneura,* the mulga, is dominant. Other acacias, e. g. *Acacia tetragonophylla,* may be present. Commonly associated tall shrubs are various *Eremophila species.*

The plants of the steppe are various low perennial shrubs belonging to the Chenopodiaceae, especially *Atriplex vesicarium* which is often the only perennial visible for many kms. This plant has been considered in some detail by Osborn, Wood and Paltridge, 1932.

There is no seral connection between the Acacietum aneurae and the Atriplicetum vesicariae — they belong to distinct types each of which has its independent history. The former is an arid extension of the *Eucalyptus* forest developed upon the hills of the better rainfall areas. The latter is an arid extension of the mallee and is developed on the same type of zonal soil. Often the junction between the two formations is quite sharp, though at times it appears to be confused because of local edaphic peculiarities which need not be discussed here.

In arid South Australia there is no «softening» of the climate owing to proximity to an ocean. The slightly more favourable water relations of the hills allow the development of a tree community whereas, on the plains, only a steppe is developed in the same climatic area.

The *Argania* woodland of Morocco appears comparable with the *Acacia aneura* woodland in arid Australia. If the meteorological data available for Tamanar, which lies well in the Argania region between Mogador and Agadir, be compared with those of Broken Hill, there is a good agreement. The rainfall at Tamanar is 249 mm., Broken Hill 243,3 mm. The graphs differ in a similar way to those of Marrakech and Broken Hill. The mean maximum temperatures of Tamanar and Marrakech are almost the same, so that the comments made above about Marrakech and Broken Hill apply to Tamanar and Broken Hill. The mean minimum temperatures of all three places agree well except that during the Winter Tamanar is somewhat warmer than Marrakech (4,4° C higher in January), but only 3,2° C higher than Broken Hill during the comparable coldest month, July. It is to the elevation of the mean minimum temperatures in Winter that Emberger (1936, p. 622) attributes the adoucement of the arid climate resulting in the development of the Arganetum spinosae.

*Argania spinosa* and *Acacia aneura* both have an extensive range but both disappear in the more humid districts north and south of their respective territories. They are of similar height and rather similar form when young. An old Argania is much more massive than any tree in arid South Australia—except, of course, Eucalypts of the water courses. The foliage of Argania is remarkably dark green and broad compared with that of any tree in arid Australia. The foliage of *Acacia aneura* consists of somewhat narrow phyllodes, 3—7 cms. long and not more than 2—5 mm. broad, carried vertically and having a silvery sheen owing to the minute pubescence.

Though *Acacia aneura* often grows associated with other woody plants, it is not infrequently the only phanerophyte with, after rain, an extensive ground cover of therophytes. *Argania,* as we saw it, was the only obvious phanerophyte over extensive areas.

The similarity of the shrub steppe seen between Marrakech and El Kelaa and parts of arid South Australia is very marked. On April 10, 1936, a halt was made about 70 km. from Marrakech nearing El Kelaa. Photographs (Pl. XIII, fig. 2) taken there could be matched in many parts of Australia. There is the same extensive plain with, in places, a level land horizon or, in others, one broken by rugged hills showing arid erosion. The soil profile observed at this halt has been described earlier and compared with soil profiles of the mallee and salt bush types from South Australia.

The vegetation type was a shrub-steppe composed of *Atriplex halimus* and *Salsola oppositifolia* in about equal proportions. The level extent of this low, grey-green shrubland was strikingly reminiscent of *Atriplex vesicarium, Kochia planifolia* plains described by Osborn and Wood (1923). The bare reddish soil between the bushes had a numerous population of annuals amongst which yellow flowered Crucifers and *Stipa retorta* would be paralleled in Australia by yellow Composites and *Stipa nitida.* These Chenopodiaceous shrub-steppes in arid South Australia are definitely non-halophytic (Osborn and Wood, 1923). Emberger and Maire (1934) remark that the steppe soils of the Moulouya, supporting *Atriplex halimus,* are not saline.

At this same halt, nearing El Kalaa on April 10, 1936, we found indications of a scrub in scattered bushes or low trees of *Zizyphus, Lycium intricatum* and *Acacia gummifera* over some of which *Ephedra* sp. was scrambling. My impression is that these were more abundant towards the low hills on the left-hand side of our road, probably to the north-west. The soil here was shallower and more stony than it was on the steppe. This development of a light scrub on shallow stony soil is what would be found in similar places in Australia. E m b e r g e r (l. c., 1936, p. 627) regards the climax at Marrakech as a light forest of *Acacia gummifera*. It would be interesting to know whether, in Morocco, there is any indication of such interdigitation of climax types on soils of different type and history as occurs in arid Australia.

The absence of tree-lined water courses in this part of Morocco is in contrast with the conditions in arid Australia. There, the water courses, which are usually dry except for a few days after rain, are characteristically lined by trees of *Eucalyptus rostrata* growing up to 20 m. in height. Smaller water courses may be fringed by *Casuarina lepidophloia*. Even little «washes» on the plain may be picked out by their line of larger and greener bushes of *Kochia pyramidata*. The absence of any regular fringe of woody plants along the water courses, some of which were running rivulets, between Marrakech and the Oued Tessaout was possibly another indication of the wood requirements of the indigènes. Occasionally trees of *Tamarix* were noted and the Oued el Abra had some *Populus alba*, but, in dry Australia, the tree-lined water course and the «gum creek» is a feature of the landscape.

*Desert.*

It is less easy to compare the vegetation of the driest parts of South Australia with that of the fringe of the Sahara than might at first sight appear to be the case. The difficulty results from the differences of topography and climate.

The driest part of South Australia lies around Lake Eyre—«lake» is a misnomer, for it is usually a saline mud flat. It is about a million hectares in extent and lies some 12 m. below sea level. Little of the land within the 125 mm. isohyet is much over 100 m. in altitude. Beni Ounif and Aïn Sefra are both at an altitude of over 850 m., and there are mountains of about 2,000 m. near to each of them.

The driest rainfall station in Australia was at Mulloorina, near Lake Eyre. It is now closed, but, during 21 years, it averaged only 102 mm. per annum. This is almost the rainfall of Bou Denib (109 mm.) on the edge of the Sahara. Detailed figures for rainfall and temperature at Mulloorina are not available. They are given (fig. 4) for William Creek (136 mm.), a place on the railway line about 100 km. west of Mulloorina, and compared

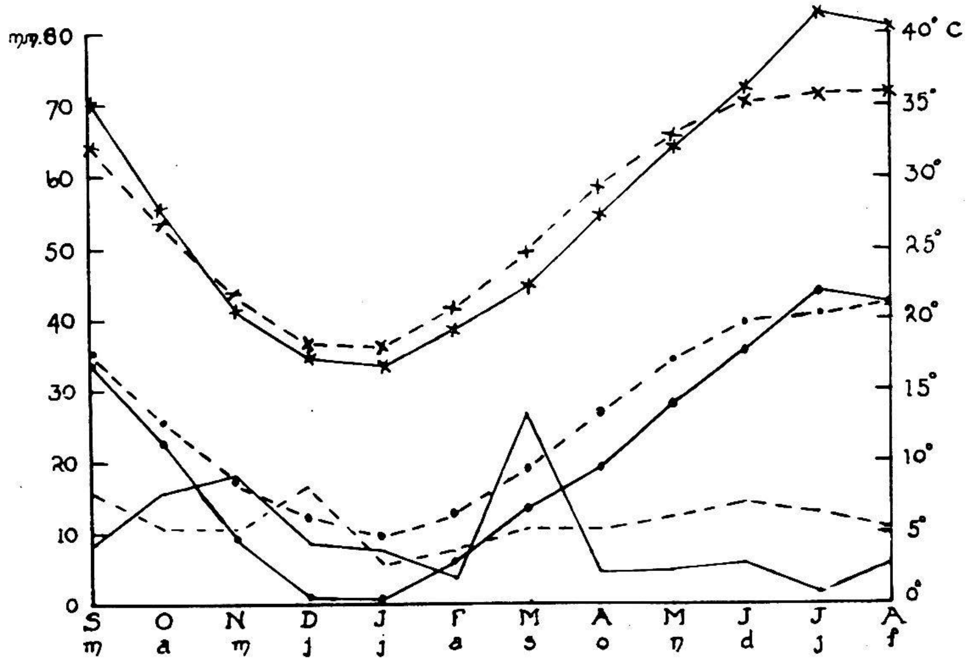


*Fig. 4.* Graphs of rainfall, etc. for Bou Denib and William Creek. Bou Denib 930 m. altitude, mean annual rainfall 109 mm. (8—9 year's records). William Creek 76 m. altitude, mean annual rainfall 136 mm. (57 year's records).

with those of Bou Denib. At William Creek, there is a slight maximum in June but the following two Winter months have actually the lowest averages. There are secondary rises in December and March, i. e., during the hot season, but the curve as a whole is a flat one. At Bou Denib, there are pronounced peaks at October—November and again in March, corresponding to the Autumn and Spring rains. This agrees with the double peaked type of curve for the rainfall of other Moroccan stations. The sudden peak for March, actually the maximum, is interesting, if it be a true one. (It must be noted that the records at Bou Denib are only for 8—9 years, those at William Creek for 57 years.) The rainfall of arid-desert South Australia has only a 40—50 % reliability, and mean figures, to be reliable, must be kept for a long time. It is a feature of the rainfall of these parts that falls may occur at almost any season which will affect the symmetry of the curve for years. Thus, one South Australian station had an average annual rainfall of 110 mm. based on 20 years observations. Yet it received 150,75 mm. during five days in November 1911. At Koonamore, with an average rainfall of 203 mm., we recorded, during the course of five years work, three separate falls of over 80 mm. in one day. On the other hand, we also recorded during the same period, 15 consecutive months with a total rainfall of only 44 mm. (Osborn, Wood and Paltridge, 1935).

The temperature graphs show a good agreement, Bou Denib being a more extreme climate. This is particularly seen in the low mean minimum temperatures recorded. These are 5—6° C below those at William Creek during the corresponding Winter months. It must be remembered, though, that Bou Denib lies at an altitude of 930 m., while William Creek is only 76 m. above sea level.

It appears to be the existence of this cold arid type of climate in the level uplands of Morocco which makes possible the extensive Alfa grass steppe. There is no equivalent to this in Australia. The only perennial grasses which give a characteristic vegetation type in arid and desert Australia are species of *Triodia.* These have quite a different growth form, developing as rounded cushions 1 m. or more in diameter and over 50 cm. in height. The *Haloxylon* plains as seen near Aïn Sefra have a general parallel in the saltbush (*Atriplex* sp.) plains which extend into Central Australia. There they are much less heavily vegetated than in the saltbush steppes further south. Occasional bushes of *Peganum Harmala* seen by dry water courses near Beni Ounif at once recalled the habit and habitat of *Nitraria Schoeberi* (also Zygophyllaceae) in Australia.

There is much «reg» desert in South Australia, where it is known as «gibber» plain. The «gibbers» are patinated and polished by sand blast as are the stones of the reg. Extensive areas of «gibber» plain may have no perennial vegetation at all. They are bare red-brown stony wastes during a drought, but rapidly covered by annuals or cryptophytes after a heavy rain, e. g. about 25 mm. There is no desert plant in Australia with the growth form of *Anabasis aretioides*. On the other hand, water courses traversing the gibber plains have a fringe of low trees, e. g., *Acacia cambagei* or *Acacia cyperophylla*, or shrubs, e. g., *Eremophila* sp.

Wind sorting of the soil has produced extensive sand dune areas in Central Australia. Inside the 125 mm. isohyet these have very little permanent vegetation. Their bases show a very open scrub of such shrubs as *Eremophila neglecta, Acacia tetragonophylla, Hakea leucoptera, Dicrastylis, Crotalaria,* with local patches of the tall *Spinifex paradoxus.*

At El Kheroua, small sand dunes (n e b k a) were seen. The occurrence of *Retama retam, Aristida pungens, Ononis glabrescens, Limonium Bonduelli,* etc. around these showed the existence of better water relations.

*Pistacia atlantica* was the only tree seen by the dry water courses of the Sahara fringe. It formed a small grove at El Kheroua. In desert Australia there is a much greater variety of woody species by water courses. In addition to the Acacias mentioned above, *Eucalyptus microtheca* may form trees as tall as 10 m. The place name El Kheroua is derived from the shrub *Vitex Agnus-castus.* The leaves of this are unexpectedly green and «mesophytic» looking for a plant of so arid a climate. *Adriana Hookeri,* popularly called «water-bush» in arid Australia from its supposed indication of fresh water near the surface, also has leaves that are thinner and greener than would be expected from its climatic range (A d a m s o n and O s b o r n , 1922).

Without expressing any opinion as to the biological significance of spines, it does seem worth noting that spiny or thorny chamaephytes are much more obvious in arid-desert Morocco than in comparable parts of Australia. *Limoniastrum Feei, Antirrhinum ramossissimum, Zilla macroptera, Astragalus numidicus, Launea* and the very wide spread *Zizyphus* are all spiny or thorny to a degree unknown in Australian desert plants. There, some of the solanums are spiny, and *Acacia farnesiana* and *Acacia Victoriae* have prickly stipules. These, together with the spinescent fruited *Bassia* sp. almost exhaust the list. It is true that the very wide spread *Hakea leucoptera* has pungent pointed sclerophyllous leaves, but these are not an indurated, chlorophylless armature. On the other hand, the very wide spread *Heterodendron oleifolium* and the frequent species of *Eremophila, Cassia* and *Sida* are not even notably hard leaved. It may also be added that the native fauna of Australia does not include any close grazing animals.

## *Bibliography.*


Adamson, R. S., and Osborn, T. G. B., On the Ecology of the Ooldea District. Trans. Roy. Soc. S. Aust. *46* (539—564), 1922.

— The Ecology of the Eucalyptus Forests of the Mount Lofty Ranges. ibid. *48* (87—144), 1924.

Andrews, J., Rainfall Reliability in Australia. Proc. Linn. Soc. N. S. W. *58* (95—100), 1932.

Anon., Meteorological Data for Certain Australian Localities. Melbourne: Council Sci. and Indust. Research. Pamph. 42 (55 p.), 1933.

Cannon, W. A., Plant Habits and Habitats in the Arid Portions of S. Australia. Carnegie Inst. Washington, Publ. 308 (139 p.), 1921.

Emberger, L., Notice Phytogéographique sur une partie de la Méséta. Marocaine septentrionale. Rabat, Inst. Sci. Chérifien (36 p.), 1931.

— Remarques critiques sur les étages de la Végétation dans les montagnes marocaines. Ber. Schweiz. Botan. Ges. *46* (614—631), 1936.

Emberger, L., et Maire, R., Tableau Phytogéographique du Maroc. Mém. Soc. Sci. Nat. Maroc. No. 38 (187 p.), 1934.

Maire, R., Etudes sur la Végétation et la Flore du Grand Atlas et du Moyen Atlas Marocains. ibid. No. 7 (220 p.), 1924.

Osborn, T. G. B., On the Habitat and Method of Occurrence in S. Australia of two genera of Lycopods hitherto unrecorded for the State. Trans. Roy. Soc. S. Australia *42* (1—12), 1918.

— A Sketch of the Ecology of Franklin Islands. Ibid. *46* (194—206), 1922.

— The Ecology of Pearson Islands. Ibid. *47* (97—118), 1923.

Osborn, T. G. B., and Wood, J. G., On the Zonation of the Vegetation in the Port Wakefield District, with special reference to the Salinity of the Soil. Ibid. *47* (224—254), 1923.

— On Some Halophytic and Non-Halophytic Plant Communities in Arid S. Australia. Ibid. (388—399), 1923.

Osborn, T. G. B., Wood, J. G., and Paltridge, T. B., On the Growth and Reaction to Grazing of the Perennial Saltbush, *Atriplex vesicarium*. Proc. Linn. Soc. N. S. W. *57* (377—402), 1932.

— On the Climate and Vegetation of the Koonamore Vegetation Reserve to 1931. Ibid. *60* (392—427), 1935.

Patton, R. T., The Factors controlling the Distribution of Trees in Victoria. Proc. Roy. Soc. Victoria *42* (154—210), 1930.

Prescott, J. A., The Soils of Australia in relation to Vegetation and Climate. Melbourne, Council Sci. and Indust. Research. Bul. *52* (71 p.), 1931.

Wood, J. G., Floristics and Ecology of the Mallee. Trans. Roy. Soc. S. Aust. *53* (359—378), 1929.