

## VEGETATION OF THE RED SEA COAST SOUTH OF JEDDA, SAUDI ARABIA

By DESMOND FOSTER VESEY-FITZGERALD

*International Red Locust Control Service, Abercorn, Northern Rhodesia*

(With Plates 6-12 and one Figure in the Text)

### I. INTRODUCTION

The following paper describes the vegetation of the Red Sea hills and coastal plain of Saudi Arabia south of Jedda. The whole area is within the tropics and is more or less influenced by the incidence of monsoon rains. In these respects it differs from much of the rest of the Arabian peninsula which is either outside the tropics and receives winter rains, or is in general more arid. The area forms a convenient botanical unit for study because although several of the formations described are more widespread in the peninsula, others characterized by deciduous trees or certain succulents are not found elsewhere in Saudi Arabia. At the same time some associations of *Chenopodiaceae* and of spring annuals which are characteristic of extra-tropical Arabia are absent from the coastlands south of Jedda.

The vegetation was examined during five years' work on the ecology of the desert locust in Arabia, and these observations showed that plant distribution was largely conditioned by the incidence of rain, by the topography and by the drainage, and that, in the absence of other records, the vegetation provided the best indication of these aspects of the locust environment.

In the following account each plant formation is classified by reference to the species, to the growth form of its characteristic members and to the habitat it occupies. In this way it is hoped that a comprehensive picture of the vegetation of the mountains and coastal plain has been presented without burdening the text with too much botanical and topographical detail.

### II. THE RAINFALL

The coastlands south of Jedda have three main rainy periods, but the precipitation during any of them may be light, erratic and local, or it may fail altogether over a period of years. Monsoon rains are expected during August, and it seems that in the mountains from 300 m. upwards these may be tolerably reliable; at higher elevations, 1200 m. and above, especially around summits, they may be accompanied by a considerable incidence of cloud which greatly enhances their value to the vegetation, due to the reduction of moisture loss by evaporation. At higher elevations also, where the climate is somewhat cooler, the precipitation probably has more value than lower down where it coincides with the hottest period of the year, at which time the heat of the sun largely discounts the benefit from the rain. The precipitation appears to be mainly in the form of violent afternoon thunder showers, which may be fairly regular during August and continue during September and even October as well. In the afternoons during these months high cumulus anvils build up over the hills and often result in a downpour of extremely local

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distribution. Such storms certainly occur in the highlands as far north as Taif but apparently hardly ever extend to the east of the watershed.

The second rainy season occurs during the cool season at the end of the year and is presumably related to the cyclonic rains which occur in the northern interior of Arabia at this season. They are more reliable in the more northern (Jeddah to Qunfidah) section. These cyclonic rains are supplemented by rains brought by southerly winds blowing up the Red Sea against the Hejaz highlands, and these latter are more regular in the southern (Qunfidah to Gizan) section.

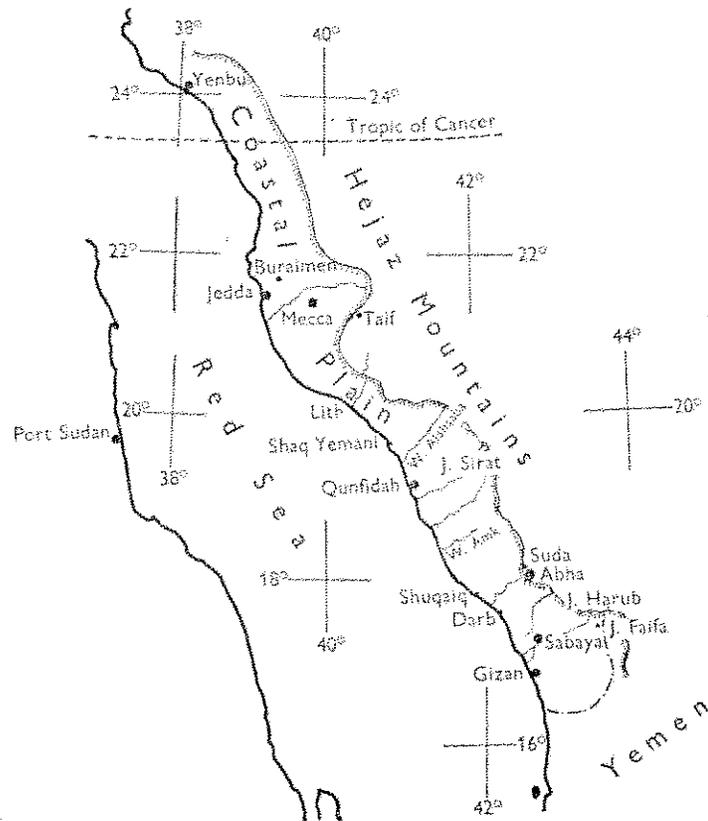


Fig. 1. Map of the region referred to in the text.

Lastly come the early summer rains in the nature of heavy local thunderstorms which fall in the mountains and sprinkle parts of the coastal plain. Aspect is also important and there is reason to suppose that the parts of the range which face south (for example the Jebel Harub,  $17^{\circ}15'N.$ ,  $42^{\circ}50'E.$ , to Jebel Faifa,  $17^{\circ}15'N.$ ,  $43^{\circ}05'E.$ , section) receive heavier precipitation than where the main axis runs more north and south. The mountain rains have more than local importance because they cause extensive floods at certain seasons. Such floods are of regular occurrence in the Qunfidah area, fairly regular in the Lith area, but spasmodic from Jeddah northwards. The floods surge down the mountain valleys and flow along water courses across the plain; finally they spill out over a delta area and may even pour into the sea by way of distributary channels which break through the coastal dunes.

## III. DRAINAGE, SOILS AND WIND

The drainage system comprises the catchment area, which is a region of denudation where the environment may be drier than the climate imposes due to excessive run-off; the zone of transportation of alluvium from the hills, where places with better water and soil conditions usually prevail, though desiccation and denudation may occur; and finally the region of deposition, starting with gravels nearest the hills, then the coarse grits, and lastly the fine sands and silts. In the case of all such deposits the moisture from local precipitation is supplemented by accumulation from a wider area. Natural ledges and cultivation terraces, sand dunes and ridges, due to the fact that they form natural dams, and the delta area generally, including empoldered fields, all benefit in this way. In certain places, especially near the coast, free drainage may be lacking and be replaced by evaporation with the consequent accumulation of salts.

There is virtually no development of a true soil in many places, but the physical nature of the substratum is of great importance because this not only influences the absorption and retention of moisture but also its stability in relation to the wind. Near the coast, on-shore winds are usual and consequently the finer particles of detritus, which have been carried by the drainage towards the sea, tend to be blown back inland by the wind. These particles are built up into mounds and dunes, which may remain barren and dynamic (cup dunes), or become fixed by vegetation. In the absence of a marked tide, the wind also influences the low-lying beach by causing the water to flow backwards and forwards and thus levelling the shore line and impregnating the land with salt. Very slight variations in the declivity and exposure are often marked by striking changes of the vegetation.

## IV. THE VEGETATION

(a) *The watershed zone*(1) *The mountains*

The peaks on the watershed reach elevations of over 2000 m. in the vicinity of Taif and over 3000 m. southwards towards Abha. Monsoon rains, though always irregular, may fall during August, and local cool season rains are expected throughout the mountains. Spring rains, in April or May, are usually light. The highlands fall away precipitously towards the west, and steep-sided gorges drain from the brink of the precipices towards the Red Sea, but towards the east the slope is more gentle and long flood channels drain through the hills towards the inland plateau. Juniper woods, except where they have been cut out, clothe the summits, and from their dark green foliage the general name of 'el khudara (the green belt) is given to the watershed zone.

At Suda (42° 20' E., 18° 15' N.; 3000 m.) the boulder-strewn slopes are covered with woods of *Juniperus procera* which are thickest along the lip of the main precipice where they form a pure stand. Elsewhere the woods are more open due to exploitation and clearing for cultivation. Most of the existing trees are of shrubby growth, 5-7 m. high and probably secondary, although a few specimen trees of 10-15 m. and with a bole 4 m. in circumference are occasionally seen. The trees are usually festooned with lichens. Woody herbs and grasses form a somewhat open understorey growth in the juniper woods, *Euryops arabicus* being the characteristic perennial herb and *Themeda triandra* a common grass.

*(b) The escarpment and foot-hills*

The view inland from Qunfidah on a clear day comprises the whole terrain from the coastal plain to the high summits which form the rim of the central Arabian plateau. In the foreground lies the coastal plain about 30 km. in width and rising from sea level to 80 m. To the east of the plain rise the foothills, 100 to 300 m. at a mean distance of 40 km. from the coast. To the east again rise the jagged spurs of the intermediate mountain-ranges, 1000-1500 m., at a mean distance of 60 km., and in the background the ridge of the Jebel Sirat, 2000-2500 m., at a mean distance of 90 km. and running approximately parallel to the coast line.

From the high ridge the country falls precipitously for about 700 m., and then the steep slopes are drained by deep gorges to the upper tributaries of the main water-courses. The south wind eddies up these valleys and condenses into cloud and mist at the brink of the precipice during the rainy seasons. Robust herbage covers these steep slopes but trees are often absent. Typical plants are *Lavandula dentata*, *Solanum* spp., *Senecio* sp., a rock rose with large showy yellow flowers, and *Abutilon* sp. (yellow flowers), which together with other herbs form a natural rockery of great beauty.

Between 1500 and 1000 m. trees occur on the hillsides at orchard spacing (10-50 m.), among which *Acacia asak* is very abundant, and *A. etbaica* frequent, together with a few deciduous trees, mostly *Commiphora schimperi*, *C. myrrha*, *Grewia velutina* and others, all of which become more closely spaced in gullies. In fact in some gullies the trees are almost thick enough to form a light woodland.

The ground cover, composed of cushion grasses and herbs, is rich and varied. *Blepharis persica* is dominant over wide areas. The common grasses include *Andropogon distachyus*, *Aristida coerulescens*, *A. obtusa*, *A. hirtigluma*, *Bromus fasciculatus*, *Cenchrus ciliaris*, *Chrysopogon aucheri*, *Cymbopogon schoenanthus*, *Danthoniopsis barbata*, *Eragrostis papposa*, *Hyparrhenia hirta*, *Pennisetum setaceum* and *Tetrapogon villosus*. Woody herbs and dwarf shrubs are also present, including the yellow flowered *Pegolettia senegalensis*, which is frequent in local patches, and *Cissus rotundifolia* covers the rocks like ivy. Along the watercourses at this elevation, the willow-leaved fig, *Ficus salicifolia*, is very abundant and there are a few large (15 m.) trees of the sycamore fig, *Ficus sycamoros*. *Adenium* sp. also occurs, but only as a squat plant wedged between the boulders. Vines are a feature of the jungle-like wadi fringe, with *Cissus rotundifolia*, and the beautiful white flowered *Clematis wightiana* is also seen occasionally.

At 1000 to 500 m. elevation the rainfall is probably in the nature of comparatively frequent showers of short duration, and on the steep stony slopes run-off is excessive. Therefore periodic drought occurs and the perennial herbage is somewhat xerophytic.

What the slopes lose by run-off, the valleys gain by seepage and flood; therefore the scenery in the foothills is characterized by the contrast between the rather dry slopes and green fertile valleys.

Small *Acacia* trees occur on the dry stony slopes, in some cases being almost close enough to form a light woodland in favoured places, and several species are represented. *Acacia mellifera*, *A. etbaica* and *A. asak* are almost everywhere abundant in the hills but not so common at lower elevations; *A. tortilis* and *A. ehrenbergiana* occur on the stony slopes but are really the characteristic trees of the lowland valleys; *A. nubica* and

*A. hamulosa* are quite common shrubs or small trees on the stony slopes. In sheltered glens, especially those with a north-east aspect, deciduous trees are numerous, with *Commiphora myrrha* and *C. schimperi* abundant, the trees often spaced as close as 6 × 6 m. though they do not form a canopy.

Below 500 m., *Acacia chrenbergiana* becomes the dominant tree in the valleys and tussocks of *Panicum turgidum* occur in sandy-silty places. *Adenium* sp. (here forming small trees 3-4 m. high), is abundant on the rubble banks, with occasional *Sansevieria* sp., while *Salvadora persica* is found in the wadi fringe. Vines are also very prevalent in the wadi fringe vegetation, which is also choked with luxuriant herbage including *Abutilon* sp., *Commelina* sp. (with blue flowers) and various mesophytic grasses.

Below 300 m. the foothills become much drier and correspondingly more barren. These hills are sparsely covered with small *Acacia* spp., *Euphorbia cuneata* and *Commiphora opobalsamum*. Ground herbage is usually scanty, but *Anisotes trisulcus* may be abundant.

The fringe of gravels and silts along the base of the foothills to the north-east of Sabiya (17° 10' N., 42° 30' E.) appears to enjoy a rather special rainfall due to the fact that the range faces the south wind, and although it is probable that the precipitation is not very great at such a low elevation (100-200 m.) the plain certainly benefits by run-off from the higher slopes.

The vegetation of the spurs and gravel is an open 'orchard' (see sections 3 (a) and 3 (c)), but in the more favoured places along the base of the slopes, which receive the run-off, and in sheltered valleys between the last spurs of the mountains, an open monsoon woodland is developed. These woodland patches may be extensive and along the watercourses a narrow fringe of quite large trees is found. The groves are, however, much interrupted by open pans of hard and eroded, sun-baked silts and gravels, which are bare during the greater part of the year, thus giving the formation a somewhat impoverished appearance. After rain, however, there is a considerable growth of mesophytic grasses and herbs, especially under the shade of trees and within thickets.

The woodland, although open in nature, with only a very poorly developed canopy, is distinctly stratified. The larger trees which stand between 8 and 15 m. high, comprise *Acacia asak*, *Dobera glabra*, *Delonix elata* and *Hyphaene thebaica*. The next storey, which ranges between 4 and 6 m., includes such small trees as *Commiphora simplicifolia*, *C. myrrha*, *Acacia tortilis* and *A. chrenbergiana*. The shrubby *Gymnosporia senegalensis* is also frequent in this category and *Adenium arabicum* here reaches a sufficient size to be included as a second storey tree. Next comes a 2 m. stratum composed of shrubs which tend to cluster together to form thickets; amongst these *Anisotes trisulcus* is very abundant and certainly one of the most characteristic plants of the association (Pl. 11, phot. 12). Clumps of *Sansevieria* spp. are to be found in these thickets together with a few succulents such as the spurge *Euphorbia triaculeata*. A rich and varied ground cover of grasses and herbs comes up after rain, especially the monsoon rains, but it is equally rapidly dried up by the hot sun after the rainy period is over, so that for the greater part of the year no green herb carpet is found between the groups of trees and shrubs.

Along the wadis an even thicker fringe of vegetation occurs which includes many tall (15 m.) trees such as *Tamarindus indica*, *Phyllogeiton discolor*, *Ziziphus spina-christi* and *Hyphaene thebaica*, in addition to fine specimens of the other species already noted. Everywhere the vegetation is festooned and bound together with vines and scrambling plants, amongst which the most characteristic are of a semi-succulent nature such as

*Cissus quadrangularis*, *C. rotundifolia* and, most curious of all, *Adenia venenata*, which is very local.

The whole forms a typical monsoon association and it vegetates after the August (hot season) rains when it may be seen at its best, although it undoubtedly remains green during the cool season right up to the end of the year, especially if it is refreshed by further rains in the interim.

A peculiar association, characterized by many succulent types, occurs along the base of the foothills and up the valleys (between 200 and 500 m.) around Jebel Harub (17° 15' N., 42° 50' E.) and Jebel Faifa (17° 15' N., 43° 05' E.). The plants grow on ancient detritus from the mountains, which consists of boulders, rubble and compacted silt. The various plants tend to form thickets with bare stony spaces between, which is an unusual peculiarity of the association since in most other Arabian formations more or less even spacing of the plants is the rule. The most noticeable are several cactus-like *Euphorbia* and *Caralluma* spp., supplemented by *Anisotes trisulcus*, *Adenium arabicum*, *Aloe* sp., *Sansevieria* sp. and *Cissus quadrangularis*.

To some extent this association may be secondary, and it is certainly grazing-resistant since it occurs on denuded slopes around settlements. Monsoon precipitation is probably never regular or prolonged so low down, but on the other hand the base of the foothills appears to be an area very frequently 'splashed' by local afternoon thunder showers not only during the three main rainy periods but also during the intervening months, and it seems very likely that this type of vegetation is a manifestation of such frequent light showers alternating with periods of scorching sunshine. Few data were obtained on the main vegetating and flowering period of the succulents, except that it may be staggered and prolonged. During October and November, for example, when the area was examined, the *Aloe* was in full flower, the *Cissus* spp. with flower and fruit, the *Adenium* with flowers, the cactus-like Euphorbiaceae and Asclepiadaceae mostly sparingly in flower, and the *Sansevieria* had no flowers or fruit.

#### (2) *The drainage system*

The most varied and some of the most luxuriant vegetation of the region is associated with the drainage system. The vegetation of the Wadi Alahsaba, which reaches the sea some 16 km. north of Qunfidah and is typical of the region, has been examined in some detail.

Within the foothills at an elevation of about 200 m. and about 16 km. from the sea, the wadi passes between the last stony slopes of the foothills which support an open 'orchard' of *Acacia tortilis* and other species, with various widely spaced perennial woody herbs between the loose boulders.

The watercourse is liable to surging floods, so that much of the bed is swept bare of plant life. Nevertheless, trees of *Acacia* spp. grow on the gravel banks and shrubs of *Leptadenia pyrotechnica* and tussocks of *Panicum turgidum* colonize beds of silt. On the fringing banks *Acacia* orchard is well-developed with *A. ehrenbergiana* the characteristic and most abundant species present.

Where the watercourse debouches on to the plain a very well-marked channel is cut across the deposit of boulders and gravel which borders the foot of the hills. The main

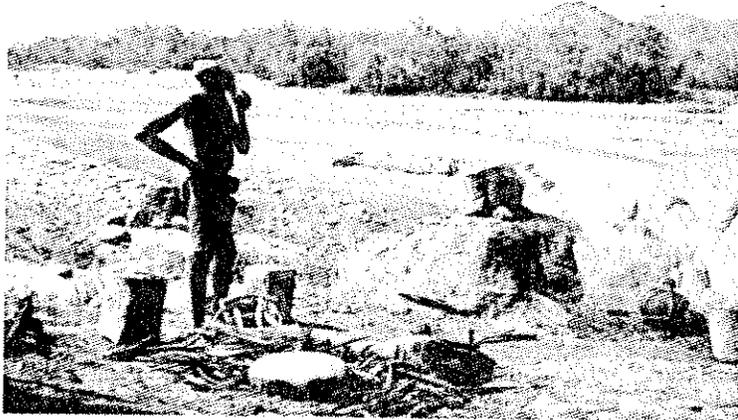
watercourse in this part remains bare of vegetation due to scouring, but dense fringing thickets of *Salvadora persica* and groves of *Tamarix* sp. are a feature of this reach. Behind the immediate wadi fringe, on gravelly and silty soil with surface gullies, *Acacia ehrenbergiana* is still the dominant tree, while others usually present include *Ziziphus* sp., *Delonix elata* and *Ficus* sp.

Farther down, where the stream flows more gently across a plain of silty alluvium, only the finer muds are transported by the slackened flood and there is a considerable amount of deposition of coarser material. Banks of silt fill the wadi bed and a close fringe of *Tamarix* encloses the watercourse (Pl. 6, phot. 1). The flood often escapes over the low banks into the groves, covering a wide area with a deposit of silt which is colonized by thickets of *Suaeda monoica* scrub. These silt-beds become eroded and are then colonized by *Salsola* sp.

At the commencement of the delta, two factors become important: first, the deposition of silt by the water, and secondly, subsequent piling of the same by wind. The main watercourse divides into distributary channels which together cover a wide area of flood plain where standing water collects for a short time and, after drying, the soil becomes cracked and flaky. The characteristic plants are *Tamarix* sp., *Suaeda monoica* and *Cadaba rotundifolia* which grow in thickset clumps and often stand on mounds (Pls. 6-7, photos. 2-4). In most cases the incidence of these mounds is due to the vegetation protecting an existing silt deposit from subsequent scouring by flood water. This is seen to be the case if an exposure of the base of the mound is examined, when it will be seen that the silt is laid down in the form of lamellated planes indicating sedimentation. The branches and twigs of the trees, however, tend to trap wind-driven sand, so that the surface layer of the mound is normally composed of loose sand and the mound itself is dome-shaped and tends to grow with the plant. Other species which are quite usual in this area and are also to be found on large dome-shaped mounds are *Acacia ehrenbergiana* (probably where there is a coarser gritty or gravelly substratum); *Salvadora persica* (more sandy-silty places, Pl. 8, phot. 5); *Capparis decidua* (especially the drier wadi mouths from the region of Lith northwards); and *Leptadenia pyrotechnica*.

The distributary channels become blocked by small cup dunes, the concave (leeward) sides of these facing E.N.E. These dunes are quite barren but *Suaeda monoica* usually occurs sparingly in the enclosed silty depressions. In the event of the flood being strong enough to reach the sea, channels are forced through this barrier of small dunes and the water runs over salty flats which are alternately swept level by the wind and washed by the sea (Pl. 8, phot. 6). Large areas of these flats are barren but elsewhere seaside plants are found on them.

There is a number of similar wadis which drain from the hills across the coastal plain, and their flood plains produce an almost continuous zone of alluvium along the coast. This zone is of considerable width about the wadi mouths but narrow along the intervening stretches. The coastal belts receive even less rain than areas along the base of the foothills, though dew is often heavy at night. This zone is essentially an area of evaporation from the deeper layers of the soil and probably therefore the soil is salty. The action of the wind on the loose dry silt has a winnowing and piling action, so that the surface becomes sandy and extremely hummocky, while the underlying, compact silt beds are frequently exposed in hollows. The characteristic dwarf shrub of this area is a salt bush, apparently a species of *Salsola*, which covers wide areas and forms practically a pure



Phot. 1. Wadi Alahsaba showing scoured channel and fringe of *Tamarix* sp. Primitive still in foreground for obtaining 'Stockholm tar' from tamarisk logs.



Phot. 2. Delta area of wadi Doqa showing fine silt in distributary channels where *Pennisetum* millet is sown; *Tamarix* sp. (in foreground), *Crotalaria rotundifolia* and *Suaeda monoica*.

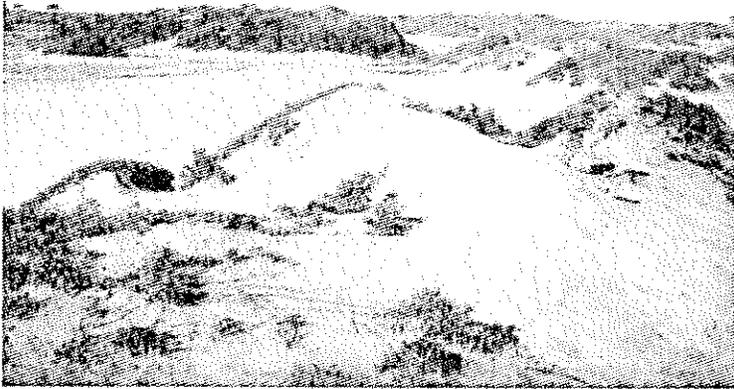
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Phot. 3. Wadi Alahsaba delta area showing sandy-silt furrows ploughed in preparation for sowing *Pennisetum* millet.



Phot. 4. Delta of wadi Alahsaba showing bushes of *Calaba rotundifolia* and stipple-spaced plants of *Dipterygium glaucum*; stubble of *Pennisetum* millet on wind blown sandy-silt in foreground.



Phot. 5. Wadi Shaq Yemani delta area showing shrubs of *Salicornia persica* partially overwhelmed by wind-piled sand. Note camels browsing in background.



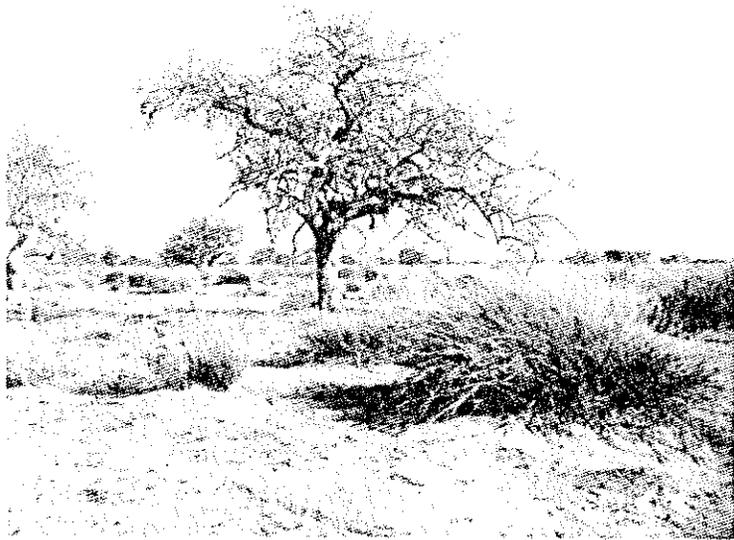
Phot. 6. Delta of wadi Doqa blocked by wind-piled sand dunes through which recent flood has cut a channel to the sea (marked by cartracks).



Phot. 7. Coastal zone south of Lith showing *Salsola* sp. shrublets forming pure stand at stipple-spacing on a hummocky surface of wind-blown sand.



Phot. 8. Khabt el Bagaar (near Sabiya), showing 'orchard' type of country with *Acacia tortilis* (flat-topped tree) and *Commiphora myrrha* and tussocks of *Lasiurus hirsutus*.



Phot. 9. Khabt el Bagaar (near Sabiya), showing *Commiphora simplicifolia*, a typical small tree, and tussocks of *Lasiurus hirsutus*.



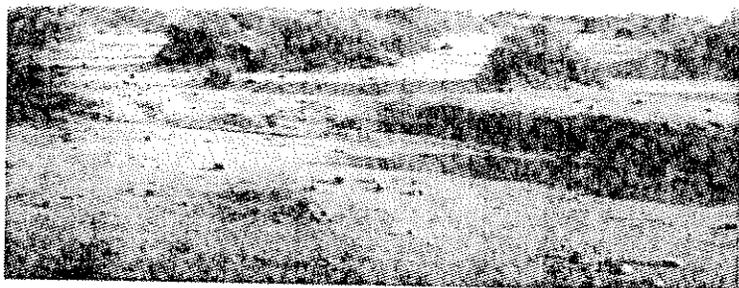
Phot. 10. Khabt el Bagaar (near Sabiya), showing thicker vegetation in silty gully. The trees (left to right) are *Delonix elata*, *Hyphaene* (scalling) and *Commiphora* sp.; tussock of *Lasiurus hirsutus* in foreground.



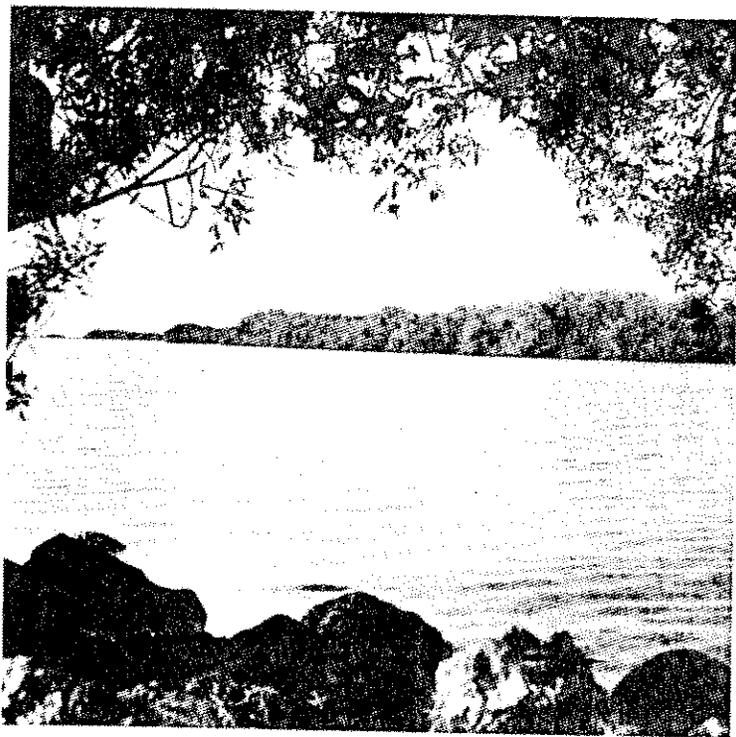
Phot. 11. Wadi Baidh (near Sabiya) showing palm grove of *Hyphaene thebaica* with tussocks of *Lasiurus hirsutus* and the woolly herb (white flowers) *Aerva javanica*.



Phot. 12. Open orchard type of vegetation on the plain near Sabiya. The large tree is *Dobera glabra* with shrubs of *Anisatos trisulcus* festooned with *Cissus quadrangularis* beneath; the small tree to the right is *Commiphora simplicifolia*; ground herbage dry.



Phot. 13. Secondarily eroded silt-bed in flood plain of the wadi Alahsaba showing gully, exposed pebbles and stipple-spaced shrublets of *Salsola* sp. on hummocks.



Phot. 14. Rakaba bay (south of Quidah). Showing coastal fringe of the mangrove, *Avicennia marina*.

*chyrum brevifolium*, *Eragrostis ciliaris* and *Mollugo cerviana*. The herb *Anastatica hierochuntica* forms localized colonies in the pans which become flooded as a result of sheet flow. The growth form of the herbs is characteristically a prostrate rosette with a long tap-root; for example, *Anastatica* has a spread of 8 cm. and tap-root 12 cm. long. The *Boerhavia* produces long prostrate stems and has a long tap-root, and a seedling *Indigofera* 5 cm. high had a tap-root 12 cm. long.

(b) *Tussock-grass savanna on aeolian deposits*

The surface of the sandy plain is undulating due to wind action, but no drainage system is developed. Low ridges, orientated in an east-west direction, traverse parts of it and near the coast small cup-dunes occur. The surface of such elevated parts is usually devoid of vegetation and in a dynamic condition, but during seasons of good rainfall a relatively rich annual herbage may spring up if the seed has survived the previous drought. In hollows, and over the more level hummocky areas, the climatic climax formation is tussock-grass savanna in which *Panicum turgidum* and *Lasiurus hirsutus* are the dominant grasses, but, due to the activities of cultivators, only comparatively small patches of this formation remain in many parts. Along the base of the foothills where the substratum is coarser, small scattered trees of *Acacia tortilis*, *Commiphora opobalsamum*, *C. simplicifolia* and *Euphorbia cuneata* occur, and herbs such as *Blepharis persica*, *Indigofera spinosa* and *Euphorbia triaculeata* are frequent (see section 3 (c) below).

In shallow hollows of the lower country near the coast a light orchard of trees is found, the species represented being *Acacia tortilis*, *A. chrenbergiana*, *Capparis decidua* and *Maerua crassifolia*. This association, with a marked dominance of *Acacia tortilis*, is often very pronounced in the vicinity of wells, and probably marks the reception area of a local drainage and seepage system (see section 3 (a) above).

Practically the whole of the tussock-grass formation is cleared from time to time for cool season cultivation of *Pennisetum* millet. The precipitation, however, is not sufficiently regular to allow speedy regeneration of the natural herbage and formerly cultivated land may remain so dry during subsequent seasons that no trace of the natural herbage is evident. As a result the plain is practically entirely covered with the sub-climatic formation dominated by *Dipterygium glaucum*. This species forms a pure stand, the individual plants being spaced at about 2 x 2 m. The *Dipterygium* is sometimes found to be quite green over extensive areas at the end of the 'summer' and before the incidence of 'winter' rains, which may indicate a localized light fall of monsoon rain. This supposition is supported by the fact that very small patches of millet may also be sown at this season, and also because in these areas certain herbs, with very long tap-roots and of sprawling rosette-like type of growth, form local green patches in low-lying places on the plain. Typical herbs in this latter category are several species of Leguminosae. It is worth noting, however, that these plants are completely absent from parts of the plain which have not been disturbed by cultivation.

(c) *Acacia-Commiphora orchard-tussock grass formation on the alluvial plain*

This formation which is closely allied to, and is in fact the monsoon counterpart of the *Acacia-Maerua* 'orchard' on the sheet eroded plain (see section 3 (a) above), has been examined at the area known as the 'Khapt el Bagar' between Darb (17° 45' N., 42° 15' E.) and wadi Baish (17° 30' N., 42° 30' E.).

The plain is composed of gravelly detritus lying along the base of the foothills, and beds of silt, with a loose sandy surface, at the wadi Itwad debouchment. The surface slopes sufficiently to allow free drainage and as a result it is extensively scored by gullies feeding larger watercourses. The finer particles of silt and sand tend to be washed by sheet-flow, or swept by the wind from the more raised parts, leaving a surface of wind-polished pebbles which are embedded in a silty matrix, while the silty alluvium tends to collect in the gullies and is deposited on the lower ground nearer the coast.

The area is very arid; nevertheless trees and tussocks are evenly distributed and all evidence suggests that the vegetation is dependent on local precipitation which falls as hot season thunder showers supplemented by irregular cool season rains. Floods from the hills do not reach the area but flow in deep gorges, into which the local drainage also runs, but to what extent these floods may affect subsoil reserves of water is not known.

*Acacia spirocarpa* is dominant. It grows as a small flat-topped, many-stemmed tree averaging 5 m. in height. Three species of *Commiphora*, namely *C. myrrha*, *C. simplicifolia* and *C. opobalsamum* are also characteristic of the area (Pls. 9-10, photos. 8 and 9). The first two species of *Commiphora* have not been found north of Qunfidah and they are evidently less tolerant of very arid conditions. Their vegetating period is evidently largely governed by the incidence of rain; they have been found in full foliage during October, but should a dry period follow the monsoon rains the leaves fall much earlier.

*C. opobalsamum*, which is more characteristic of the drier fringes of the present formation, is found on the lower foothills behind Jeddah where it has been noted leafing and flowering following winter rains.

Another characteristic tree is *Euphorbia cuneata* which is abundant in the silty runnels and becomes very abundant in more continuously silty places where it even replaces the *Acacia* as the dominant tree species. This *Euphorbia* is deciduous. It has been found in full leaf and sparingly in flower during October but the main flowering season appears to be as late as December or January and it is bare again by February or March, but these periods evidently depend very much on the incidence of rain. This tree is also found on the drier fringe of the orchard formation, as for instance in the vicinity of the Akwa hills near Sabiya (spelt Sabaya in Fig. 1), where it abuts the treeless tussock-grass savanna of the coastal plain (section 3 (b) above). This species reaches as far north as Jeddah along the foothills where it has been observed to leaf and flower (after long months of complete dormancy) following November-December rains. It is interesting to note that all these four deciduous trees, both the *Euphorbia* sp. and the *Commiphora* spp., bear a marked superficial resemblance to each other. They are all small (4-5 m. high) trees with gnarled branches and smooth, light coloured, papery bark.

In addition to the above, certain evergreen trees and shrubs belonging to the Cappariaceae are present, such as *Maerua crassifolia*, *Cadaba longifolia*, and *C. glandulosa*. All these have a protracted flowering season; *Cadaba*, for example, flowers all the year round, even after prolonged drought.

In the larger drainage runnels, where the water relationship is better, several other trees are characteristic enough to be mentioned (Pl. 10, phot. 10). These include *Delonix elata*, a tall (13 m.) tree which has been found with foliage from October (probably also for a month or two before) to January and flowering as late as February; *Hyphaene thebaica*, the dom palm, in deep gorges; and *Grewia tenax*, *Zizyphus* sp., *Acacia chrenbergiana*, *A. hamulosa* and *A. seyal*, the last often quite a large (13 m.) tree in suitable places.

The grass tussocks which are so characteristic of the silty areas and of the runnels draining the gravels (though never present on the gravel itself) are of the species *Lasiurus hirsutus* and *Panicum turgidum*, the latter becoming very abundant nearer the coast. These grasses have been found green and in flower during October but their growth is entirely dependent on the incidence of rain and after a good season the stems remain green, and desultory flowering continues over a protracted period. In general, tussock grasses vegetate most vigorously after cool season rains.

Various perennial herbs such as *Aerua javanica*, *Indigofera spinosa*, *Corchorus depressus*, *Boerhavia repens*, and others are also to be found in silty areas. *Blepharis persica* is characteristic of the area and extends further on to the hot sterile gravel patches than any other species. The *Blepharis*, together with the other perennials, has been found green and in flower during October but was found to be quite dried up during visits made in January, the cool season rains having failed. Annuals are not a feature of this association, but *Aristida meccana* and a prostrate rosette *Euphorbia* sp. have been noticed, and other species may be more abundant after good rains.

The areas of gravel are practically barren and in this part the vegetation is confined to the drainage system. The beds of the watercourse have been cut below the level of the surrounding plain through the rubble deposit, to exposures of conglomerate, coral rock and dykes of basalt, the last forming barriers across the channels which hold back basins of perennial water. The most interesting gorge of this type is the wadi Baidh which crosses the plain 10 miles south-east of Darb and is fringed with luxuriant vegetation (Pl. 11, phot. 11). The most characteristic tree is *Hyphaene thebaica* which in places forms a dense palmetum of considerable extent. *Moringa peregrina* also occurs. On the banks there is an almost continuous stand of the coarse wiry grass *Desmostachya bipinnata* which is evergreen, and localized colonies of *Ricinus* sp. and *Calotropis procera*, the latter a widespread erratic species all over Arabia. The herb vegetation, including the beautiful blue flowered *Clitoria ternatea*, has mesophytic characters and thrives by the water-side quite independent of the local precipitation.

#### (4) The beach vegetation

Apart from the plant associations which have been described above, there is a number of other communities which are related to the sea shore.

*Salsola* spp.\* occupy an irregular belt between the inland tussock-grass steppe and the sea-side zones. The plant is a compact dome-shaped woody shrublet, up to 0.5 m. high, which forms a pure stand (except for seasonal ephemeral annuals after heavy rain) and is rather closely spaced over very extensive areas. The turgid foliage is juicy throughout the year and indeed the plant vegetates and flowers during the hottest months; flowers have been found from June until as late as December, although not very frequently during the last months of the year. The shrubs may die out after a prolonged drought of two or three years' duration and regeneration has never been noted.

The *Salsola* grows on compact alluvium where former floods have laid down a deposit which is above the level of recent floods. Such silt-beds become eroded by wind-polishing and rain-gullying and the small embedded pebbles remain exposed on the surface (Pl. 12, phot. 13). The contorted woody tap-root often descends through a horizon of silty sand

\* Confusion exists in the determination of these plants. *S. forskalii*, *S. bottas* and *S. foetida*, all occur; the last being possibly conspecific with *S. imbricata*.

(into which laterals extend) to a hard, stained pan at a depth of 0.5 m. It is also a plant of the edges of the big mountain wadi spill-outs away from the main watercourses and seepage areas. It never grows on sandy areas, though wind-blown sand may accumulate round the shrublet. It is replaced by other halophytes on the lower, more salty areas at sea-level, but it sometimes occurs quite extensively in *Acacia* orchard.

At intervals along the coastal plain, the land has become raised slightly in relation to the level of the sea. At such places old reefs are found containing fossil corals in the position of growth. This is especially noticeable along the coast between wadi Amk ( $18^{\circ} 25' N.$ ,  $41^{\circ} 30' E.$ ) and Shuqaiq ( $17^{\circ} 44' N.$ ,  $42^{\circ} 02' E.$ ) where the fossil reef is also partly overlain by tongues of lava boulders.

The coral rock has been superficially decomposed into a fine tawny silt, which is soft and dusty when dry, and slimy when wet. The drainage of such areas is usually bad and surface flood water tends to accumulate in pans. There is some local transportation of surface-soil from raised areas, which action often keeps the coral-rock exposed, and there is a considerable accumulation of debris in hollows and over extensive flats which are slightly raised above the present level of the sea.

*Limonium axillare* colonies cover very wide areas of such soil, the small shrublets forming a pure stand and being rather closely and rather evenly spaced. This plant remains green throughout the year and some flowers are to be found over a protracted period, but the main flowering occurs during the last months of the year, without necessarily the incidence of rain. Nevertheless, it seems that this formation is dependent upon local precipitation, and after prolonged drought the plants tend to die out. The grasses *Aeluropus lagopoides* and *Desmostachya bipinnata* and salt bushes (Chenopodiaceae) closely fringe the *Limonium* community without necessarily being associated with it.

There is little tidal variation along the Red Sea coast but the wind often drives the sea-water far inland over level flats which become encrusted with salt as the surface dries. These areas are usually absolutely barren. All around the coasts of Arabia, *Halopeplis perfoliata* colonizes the fringes of such flats, this plant being able to tolerate greater salinity than any other species; in fact its short roots may be found embedded in a substratum composed almost entirely of soda-like crystals. *Halopeplis* forms a pure stand fringing the barren flats, but the plants are always widely spaced. The width of the *Halopeplis* zone is of course very variable, depending largely on levels. Where the coast is very flat it may be correspondingly wide, but where the land rises only a very slight amount above the level reached by sea-water, the *Halopeplis* belt may be narrow or quite absent. Like other salt bushes, this plant bears its inconspicuous flowers during the hot months of the year, but the flowering season is evidently prolonged because flowers have been noted as early as March and as late as October. The only plant which has been found associated with *Halopeplis* at all regularly is *Cressa cretica*, a small erect herb with numerous small leaves which is seldom found in flower, and is locally quite abundant on the saline flats. The landward side of the *Halopeplis* zone is encroached upon by a variety of other plants, mostly other halophytes. Where saline conditions are rather less extreme, and land floods rather than sea floods are a possibility, although evaporation rather than free-drainage occurs resulting in salt accumulation, robust mixed salt bushes on mounds become established, but the species have not been determined.

The coast south of  $18^{\circ} N.$  is characterized by a fairly continuous beach fringe of *Avicennia marina*, which will not tolerate a cool winter, and therefore does not extend

much beyond the tropic (Pl. 12, phot. 14). The mangrove fringe is backed by a rather narrow strip of bare salt flat which is bordered in those places reached by freshwater flood by tussocks of *Aeluropus* sp.

#### SUMMARY

The agencies influencing the flora of the Red Sea coast south of Jeddah are noted and it is shown that among them rain is the most important; the seasonal and topographical distribution of the rainfall is recorded. Aspect, drainage and the physical nature of the soil as factors of the habitat are discussed. It is shown that the drainage system divides the environment into three parts, the regions of denudation, transportation and deposition. The importance of floods from the mountains to the vegetation on the plain is recorded. The action of the wind is described and the effect of the local precipitation on the different types of land surface is noted. Beach zones, influenced by the sea, are mentioned.

The plant formations characteristic of each region, mountains, drainage system, plain and coast, are described. The influence of 'winter' and monsoon rains on the vegetation is indicated. A few specialized plant associations, including coastal communities, are also described.

The survey of the vegetation to the south of Jeddah was done while the author was Senior Locust Officer of the Middle East Anti-Locust Unit in Arabia. During this period of field work he received continual help and encouragement from Dr B. P. Uvarov, C.M.G., F.R.S., and his thanks are also due to his colleagues in the Unit with whom many interesting expeditions were made.

The herbarium material collected has been presented to the British Museum (Natural History) where the determinations were made, and special thanks are due to Miss D. Hillcoat, of the Botanical Department, for her untiring kindness in working through the specimens.

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