

THE VEGETATION OF THE RED SEA COAST NORTH OF JEDDA, SAUDI ARABIA

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(With Plates 16-19 and one Figure in the Text)

I. INTRODUCTION

In a previous paper the vegetation of the Red Sea coast south of Jeddah was described (Vesey-FitzGerald, 1955). The present paper deals with the coastal plain and hills north of Jeddah, and includes the eastern slopes of the Red Sea mountains, which appear to be partly shadowed from the monsoon rains, as well as the more western parts of the central Arabian uplands. A characteristic of the area is that the monsoon rains (August-October) are usually not sufficient to benefit the vegetation; and during the hot summer the herbage dries up and trees lose their foliage. Nevertheless, a varied assemblage of halophytes, which is not well represented south of Jeddah, vegetates and flowers during the hot season and gives a deceptively green aspect to parts of the coastal plain and upland valleys.

A traveller who leaves Jeddah along the coast road to Yenbu and Medina, or passes through Mecca on the road to Taif, will see very different vegetation from one who goes south towards Qunfidah or Gizan and then ascends into the mountains. The present paper gives an account of what the former will see. It is of course impossible to draw a sharp line between these different types of vegetation, but the divisions are convenient and sufficiently clear in the field to be recognizable. Moreover, the vegetation provides a very good indication of the probable climatic sequence of rainfall and drought and other conditions which are of importance to the welfare of the fauna in arid regions. In particular the incidence of the desert locust (*Schistocerca gregaria* Forsk.) is closely correlated with the type and condition of the herbage and it was in connection with the study of the environment of this insect that the following survey was made.

II. THE RAINFALL

The coastal plain and highlands to the north of Jeddah receive some rain from the westerly depressions which may be attracted by the low pressure over the Red Sea, but which are fewer in number and appear later than farther east. Therefore the amount of cyclonic rain brought to this area is probably less than that falling farther east. However, the precipitation is supplemented by rains brought in winter and spring by southerly winds from the Red Sea, the effect of which must be enhanced by orography in the Hejaz highlands, but occasionally rains fail for several years. The southern part of the Hejaz highlands extends into the region which receives summer rains from the south-west monsoon, but these rains hardly extend to the east of the watershed. The coastal plain around Jeddah receives only irregular rains which probably depend on the southerly winds blowing up the Red Sea. Rainfall here is often greater in spring than in winter but the summers are rainless. At Yenbu rain is said to be very irregular, but there may be precipitation during the winter although never during the summer. Rain is most irregular in the hills below 600 m., but showers fall

during November and December and sometimes during the early months of the year, with periodically renewed vigour during April or May. It is not unusual for rains to fail altogether, especially the later ones, sometimes for several years in succession. In the vicinity of Jeddah the wadis may come down in flood during July and August as a result of monsoon rains in the highlands, but this is somewhat exceptional, and certainly most unusual beyond the tropic. The high peaks of Jebel Radhwa, how-

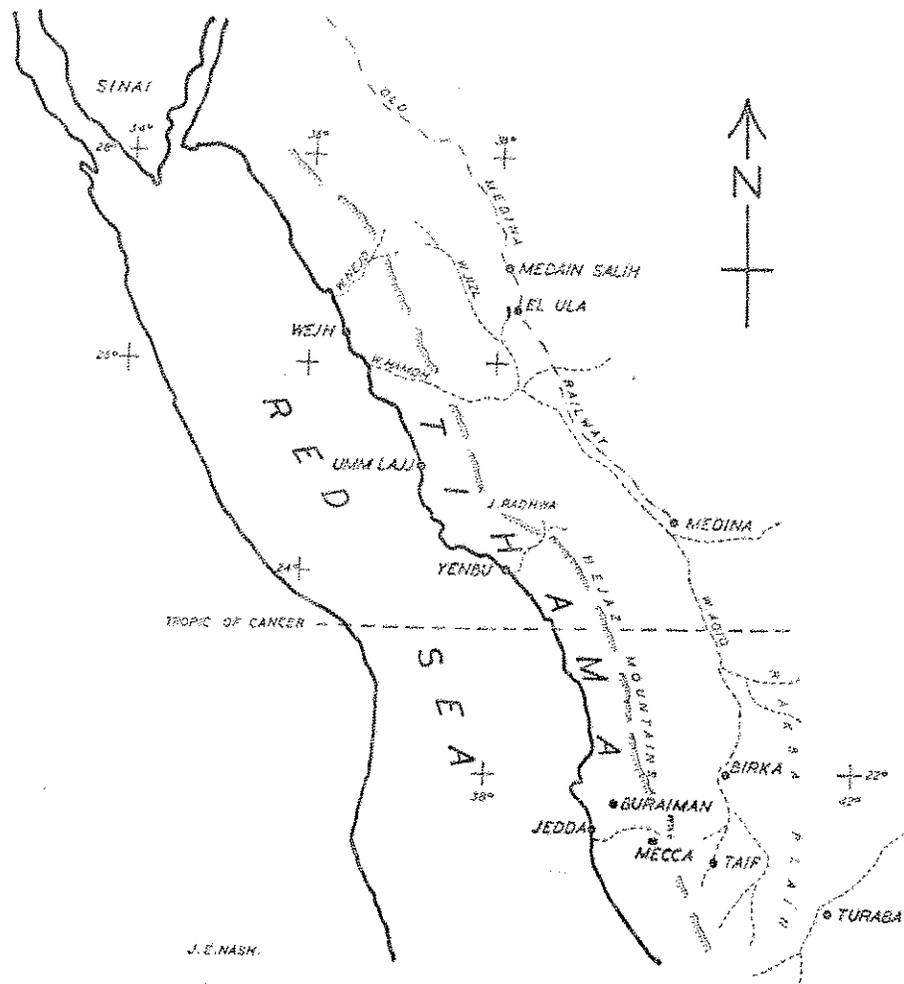


Fig. 1. The Red Sea coast of Saudi Arabia, North of Jeddah.
(Scale 1 cm. = 84 km.)

ever, are said to receive thundery rain even during the hot season. At El Ula ($26^{\circ} 35'$ N., $38^{\circ} 15'$ E.) and Medain Salih ($26^{\circ} 45'$ N., $38^{\circ} 15'$ E.) rain falls during the winter and spring, heavy showers being sometimes known as early as the end of October. The upland plateau, east of the Red Sea hills, and as far north-west as Affif (43° E., 24° N.) and east and south-east towards Turaba ($41^{\circ} 30'$ E., $21^{\circ} 15'$ N.) is an area of scanty winter rain and light early-summer thunder showers. In the Turaba area

rains are very occasional and probably in the form of local heavy showers. As far south as Bisha ($42^{\circ} 30' E.$, $20^{\circ} N.$) the influence of the monsoon is felt and rain is expected during July to August, and heavy showers may fall during April.

In the highlands the following additional evidence of rain has been collected chiefly from Birka ($40^{\circ} 45' E.$, $22^{\circ} 10' N.$; 1500 m.). Rain fell during November or December 1944, because at the end of December the wadi at Birza ($40^{\circ} E.$, $21^{\circ} 55' N.$) was flowing and the cistern at Birka was full. And in May 1945, the cistern was again full having dried up in the interim period. Once again during October and November 1945, the wadi was flowing and the cistern full, both having been dry during the summer. A member of the Saudi Arabian Mining Syndicate stated that he remembers some rain falling in the highlands north of Jedda during every month in one year but that such an occurrence is exceptional and long droughts are more usual.

In the highlands the following seasons and rains are recognized by the inhabitants. '*Gid*', about two months (June 10th to early August), usually a dry period, though light afternoon showers are often experienced along the watershed ridge, but these showers are largely non-effective since they fall on warm stony ground and so evaporation is rapid. Some moisture may, however, become trapped in crevices between boulders, and green vegetation may be found at this season. '*Kharif*', $1\frac{1}{2}$ to 2 months (August to September) during which monsoon rains may come from the south-east but they are chancy and not usually sufficient for planting. However, floods are expected at this season in the wadis draining inland towards Bisha. Next comes '*wasm*', fifty days (October 1st to November 20th), followed by '*shita*', 3 months (November 21st to February 21st). The heaviest rain of the year is expected during '*wasm*' or early '*shita*', coming from south-west, and these showers may be widespread and include both the Tihama and Bisha side of the highlands. '*Smah*', fifty days (February 22nd to April 10th), is usually a dry period, followed by '*seif*' (last part of April to beginning of June) during which medium rains from the north-east are expected. It seems that these '*seif*' rains are the most usual ones falling on the trans-mountain plateau, i.e. from Bisha to Ashaira ($40^{\circ} 40' E.$, $21-45' N.$) but even so they may fail or be extremely local for years on end.

III. DESCRIPTION OF THE AREA

The area consists of three topographical zones. First there is the coastal strip, known as the Tihama (the 'hot place'), which lies at sea level, or is raised slightly, due to recent deposits of silt washed down from the mountains or to sand blown up into dunes by the wind. The shore is flat, but in several places creeks penetrate the land, and since practically no flood water flows into the sea, corals occur in these inlets which in less arid countries would only be found in the open sea.

The second zone is the mountain range known as Hejaz ('stony hills'), which reaches heights exceeding 2000 metres to the south-east of Mecca, but is less continuous, less precipitous and less high towards the north. The Hejaz mountains are in general composed of granite and crystalline rocks with numerous caps of young eruptive rocks. They comprise a wilderness of rocky valleys and eroded, stony slopes which rise to jagged peaks between 1000 and 1500 m. high. Jebel Radhwa ($38^{\circ} 20' E.$, $24^{\circ} 35' N.$), rises to 1800 m. The western slopes of the mountains north of Jedda are less steep than those to the south, although in many places the escarpment face is cliff-like for several hundred feet. The eastern slopes are always more gentle, and are

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drained towards the upland plateau, which itself lies at a mean elevation of some 1000 m. The eastern drainage eventually finds its way westwards through the mountains to the Red Sea by way of several valleys, among which the most important is the Wadi Hamdh which collects the drainage of the eastern slopes of the mountains south of Taif (40° 25' E., 21° 20' N.), via the Wadi Aqiq, and carries it to the sea a short distance south of Wejh (28° 25' E., 26° 15' N.). It must be most unusual, however, for any of these drainage lines to flow throughout their length or to deliver a flood into the sea.

The third zone is the upland plateau which extends to the interior eastwards from the Hejaz range. This is composed of detritus washed from the mountains and laid down as a level plain, the surface of which is interrupted by extinct volcanic cones and extensive lava flows and outcrops of granite and crystalline rocks similar to the Hejaz mountains. The vegetation of this area is characterized by the incidence of *Acacia*, a genus which extends beyond the tropic in a northerly direction to the frontier with Jordan, in a north-easterly direction to Hail and in an easterly direction as far as Jebel Tuwaiq. The drainage of much of the area is bad and much interrupted, but in general tributary to the through drainage from the eastern slopes of the main range to the Red Sea coast which was mentioned above. Along many of the drainage lines there is little evidence of surface flow, but their courses are indicated by the incidence of salt bushes. This is discussed more fully below.

IV. THE VEGETATION

(a) *The Olea-Tarchonanthus association*

The western slopes of the Hejaz mountains within the tropics, up to and including the summit juniper woods were described in a previous publication (Vesey-Fitz-Gerald, 1955). The eastern slopes of these hills in the vicinity of Taif are characterized by a *Olea-Tarchonanthus* association which is only represented within a narrow and fragmentary zone on the steeper western escarpment which falls to the Red Sea. This association may include some elements with affinities to the ancient Mediterranean forests (Zohary, 1947), but the dominant species appear more closely to link it with rather similar formations in the highlands of East Africa, such as the extensive *Tarchonanthus* scrub found in parts of the Rift Valley of Kenya.

The eastern slopes of the Hejaz mountains, at elevations above about 1500 m., are composed of a jumble of huge boulders enclosing numerous caverns and sheltered crevices; they culminate in high ridges and towering granitic outcrops, the latter standing 500 m. above the valleys which all drain to the north-east towards the plateau of the interior. The vegetation on the inland slopes of the higher mountains to the south of Taif forms practically 100 per cent coverage between the boulders and is composed of a 'brushwood' of small evergreen, or partially deciduous, trees averaging 6 to 10 m. high, together with a ground cover of herbs and grasses. It is apparent that this association vegetates on cool season precipitation, but also remains in flower, and with foliage, during the summer months.

Olea chrysophylla, an evergreen tree with coriaceous leaves, is the characteristic and usually dominant species. *Olea* descends to about 1500 m. along the transmontane valleys where it is met with as an occasional heavily browsed shrub, but it never overlaps with *Acacia asak* which itself loses dominance on hill slopes above 1500 m. *Tarchonanthus camphoratus*, practically everywhere co-dominant with

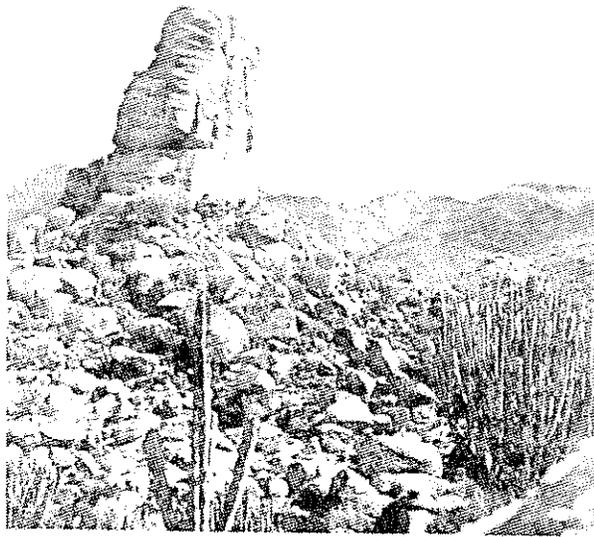
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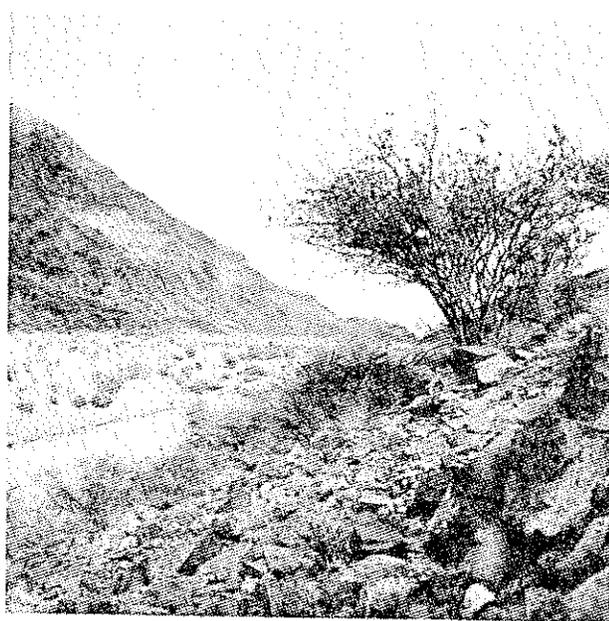
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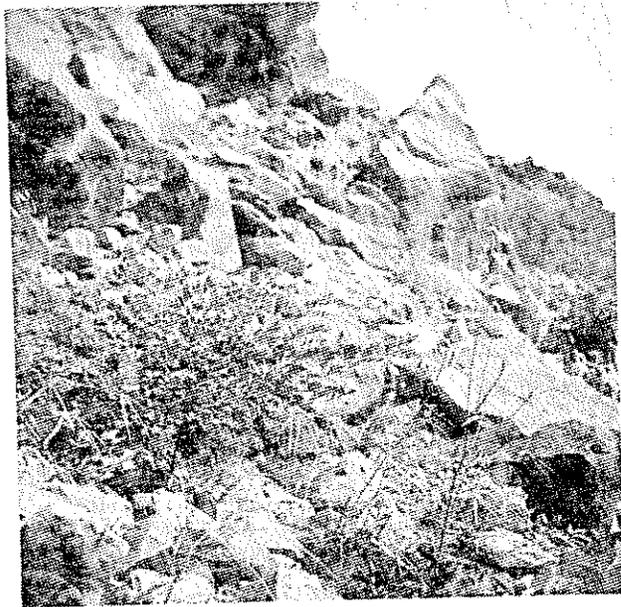
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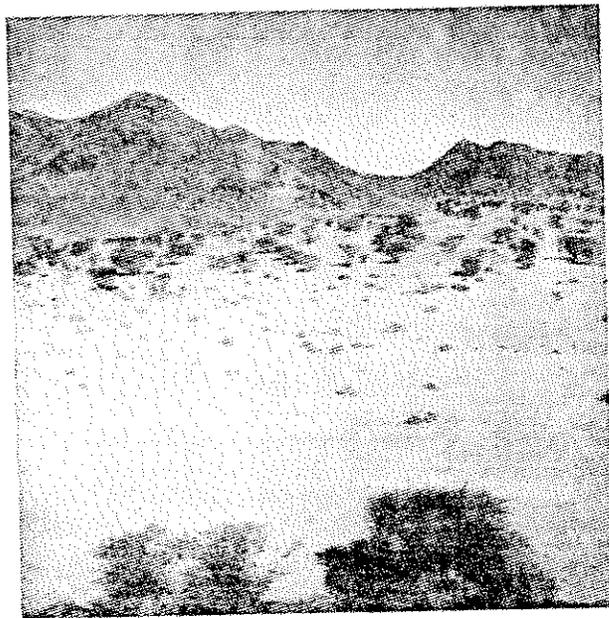
Phot. 1. Colony of *Euphorbia ammak* round a granite pinnacle, near Taif, Hejaz mountains.



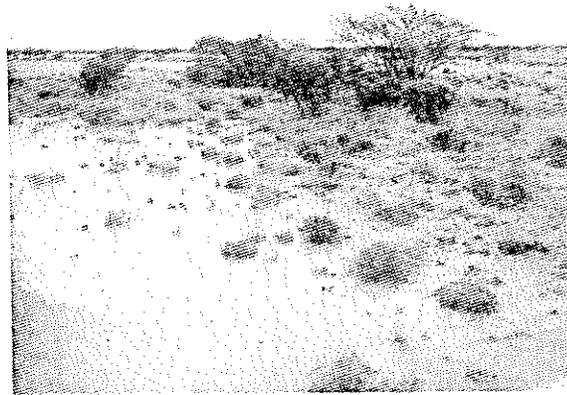
Phot. 2. Small tree of *Acacia mellifera* on steep, boulder-strewn slope. Note barren appearance of distant hillside.



Phot. 3. Perennial herbs, vegetating and flowering after rain, on the slopes of the rocky foothills. *Cleome paradoxa* (right) and *Indigofera coerulea* (left).



Phot. 4. Trees of *Acacia tortilis* and small salt bushes (*Chenopodiaceae*) growing on alluvial fan below rising ground. Hejaz mountains, north of Jedda.



Phot. 5. Rain storm passing over Rakba plain, showing low sheet-flow water is held against accumulations of wind-driven sand caught by established vegetation. Small tree of *Acacia tortilis*, tussock grasses and *Indigofera spinosa*.



Phot. 6. Fringing vegetation of the Wadi Aqiq showing large *Acacia* trees, and shrubs of *Withania* and *Lycium*. The ground herbage has been completely grazed out by stock.



Phot. 7. Sandstone country in vicinity of El Ota, showing evenly-spaced dwarf shrubs of *Haloxylon salicornicum* and scattered trees of *Acacia tortilis*.



Phot. 8. Wadi mouth on coastal plain near Yeabu. Luxuriant growth of halophytes, *Suaeda* and *Halocnemum*, on fine alluvium. Dunes of wind-piled sand (in background) flank the drainage line.

Olea, is a spindly tree which appears to retain its foliage throughout the season, and is conspicuous by reason of the white underside to its leaves. *Pistacia palaestina*, a rather larger tree, up to 13 m., is very characteristic of, and apparently confined to, this association although it is never abundant. *Juniperus procera* first makes its appearance at about 1700 m. on the trans-montane slopes, but is never abundant or of robust growth until towards the watershed ridge at 2000 m. where it rapidly increases in abundance and vigour and soon assumes dominance.

The remaining species of the 'brushwood' association seldom reach the dignity of trees although they grow into quite robust shrubs. *Dodonaea viscosa* is a very abundant shrub 1 to 2 m. high and is one of the most characteristic plants of the association; it first makes its appearance in wadis at little above 1500 m. in the upper limit of the *Acacia asak* zone, and increases rapidly in abundance with the elevation until its foliage, which is evergreen, colours the hillside. *Euclea kellaui* (Ebenaceae) and *Carissa edulis* (Apocynaceae) are other common evergreen shrubs.

As a ground storey, woody herbs are abundant but the species represented in the 'brushwood' association are completely different from those found at lower elevations on the *Acacia asak* dotted hillsides; all spiny species are absent. The Composite, *Psiadia arabica*, is the most characteristic plant in this class and others include *Lavandula coronopifolia*, *Senecio* sp., *Salvia* sp. and *Orostegia* sp., this last often growing to a height of 2 m. Several species of Asclepiadaceae are rather characteristic of the association, including *Sarcostemma viminalis*. Among other climbing plants noticed were *Asparagus mitis* and *Jasminum* sp. At the time the area was visited (December, with no cool season effective rain) plants were not in flower and, so, many of them could not be recognized with certainty. Tufted grasses, Acanthaceae, and other herbs evidently come up in great abundance after rain. The foliage of several of the trees and shrubs belonging to this association exude a viscous substance which causes the specimens to stick to papers while they are being pressed.

The vegetation is even more varied in favoured places. In crevices, under boulders and other sheltered places, some of which may still be moist even though there had been no recent rain, a variety of ferns, mosses and liverworts grows, while the rocks themselves are dappled with encrusted lichen patches. In valleys and on the lower parts of slopes, trees of *Ficus salicifolia* are abundant, forming green thickets, and a species of *Acacia* occurs, but in general, spiny plants are unusual in this association. Colonies of *Lachnophyllis oppositifolia* (Loganiaceae), a rather large tree 10 m. high, are found in gorges, both at 2000 m. and in wadis towards the lower limit of the zone occupied by the association. Thick clumps of a trunkless dwarf wild date are abundant in silty wadis between 1500 and 2000 m. although date cultivation is not possible in the mountains. Dense stands of the grass *Saccharum spontaneum*, the shrubby composite, *Pluchea* sp. and the Labiate, *Mentha longifolia* are also characteristic of the wadi beds draining this area towards the eastern interior. A very curious and isolated colony of *Euphorbia ammak* occurs around the base of a prominent granitic pinnacle at Sakharah south of Taif (Phot. 1). This conspicuous cactus-like plant reaching the dimensions of a tree - 10 m. high - although very abundant in this one situation was not seen anywhere else in the vicinity. A similar unique colony of another cactus-like spurge, *E. thi* (or close to it), was also found on a rocky hillside at 1700 m.

The mountain 'brushwood' association appears to be rather sharply defined from other associations and to occupy a rather narrow zone (about 25 km.) between about 1500 and 2000 m. on the eastern slopes of the higher parts of the watershed. To the east

it does not overlap with the *Acacia asak* association at all except for a few elements which may straggle down valleys passing between hillsides dotted with the *Acacia*. Towards the heights of the watershed ridge the brushwood rapidly (though there is considerable overlap) gives place to juniper woods. At passes, not much above 2000 m., the association finds a way across the watershed to the precipitous western slopes and there covers many areas and ledges above the 1500 m. contour below which it contacts the *A. asak* association again. The 'brushwood' association, at least in a well-developed condition, may be favoured by the terrain. The great boulders on the steep slopes undoubtedly prevent erosion, conserve water, and possibly break fire, but otherwise there appears to be no reason to regard it as an edaphic grouping of plants. It is somewhat strange therefore that practically no trace of it was seen in the Asir highlands (Latitude 18° N.), although there the greater elevation may partly account for its absence, and also, since the small trees and shrubs provide excellent firewood, it may have been entirely eliminated by the relatively greater population of Asir. However, very distinct traces of the association (including many species not seen elsewhere) were found on 'waste land' at about 1200 metres on Jebel Faifa (17° 15' N., 43° 05' E.).

(b) *Hejaz foothills: Acacia mellifera and other species on steep slopes*

The monsoon woodland on the western slopes of the Hejaz mountains south of Jeddah in which *Acacia* spp. are associated with *Commiphora* spp. has been described (Vesey-FitzGerald, 1955). Notice is now taken of the *Acacia* associations of the eastern flank of the Red Sea hills and of both sides of the watershed to the north of Jeddah, and of the interior plateau. There are several aspects of this vegetation which suggest that it has affinities with the drier parts of East Africa, such as the lower levels of the Rift Valley in Kenya.

During dry periods the herbage of the foothills is most inconspicuous and the rocky, boulder-strewn slopes appear excessively barren to the casual glance (Phot. 2). Upon closer inspection, however, small shrubby trees, completely bare of foliage, are seen to be widely scattered on the hillsides. *Acacia* spp. and *Euphorbia cuneata* are frequent and some trees of *Commiphora opobalsamum* reach the northern limit of their range in the hills between Jeddah and Yenbu. The shrub *Cadaba glandulosa* is evergreen, and its dark green foliage is a conspicuous feature in some places on the lower slopes. *Caralluma*, probably *retrospiciens*, is frequently associated with this bush. A fairly even stippling of dry woody herbs and grass tussocks, which are inconspicuous among the boulders, indicates that there are seasons when the herbage is more luxuriant, and even after prolonged drought it is quite surprising how many signs of plant growth can be found by diligent searching.

After rains fall, there is a grand flush of plant growth, and many plants, formerly dry, become recognizable, while others, not evident before, come up. The small trees which dot the stony hillsides, formerly almost invisible in their dry leafless state, become green and conspicuous. *Acacia mellifera* is the commonest tree on the lower hillsides, with *A. hamulosa* and *A. tortilis* usually abundant; *Commiphora opobalsamum*, a small tree with very aromatic foliage, is frequent; and *Euphorbia cuneata* is also abundant. But the most noticeable changes are in the annual and perennial herb vegetation. The hillsides become tinged with green, especially along the base of the slopes where colonies of *Asphodelus tenuifolius* grow abundantly, and *Forskalea tenacissima* is very widespread, these nettle-like plants coming up between the rocks

everywhere on the gritty ledges. *Euphorbia arabica* is characteristic of the area: its dry woody root-stocks sprout vigorously and its slender-leaved seedlings come up abundantly. A variety of annual grasses grows, including *Aristida adscensionis*, *A. hirtigluma*, *A. meccana*, *Cenchrus pennisetiformis* and *Enneapogon elegans* among the most abundant species. The dry, dusty tussocks of *Cymbopogon schoenanthus*, which are very characteristic of stony gullies, become green as soon as they are soaked by rain. Among the woody herbs, which now form a natural rockery of great beauty (Phot. 3) are included the white woolly-flowered *Aerva javanica*, the yellow-bloomed *Cleome brachycarpa*, *C. paradoxa* and *C. scaposa*, and the purple spiked *C. hanburyana*, each growing in compact colonies. Leguminosae are well represented with *Indigofera spinosa*, the most characteristic perennial herb of the hills and rubble plains, *I. coerulea*, *I. tritoides*, *I. disjuncta*, *Tephrosia nubica*, *T. encomptosperma*, and *Cassia holosericea*. The large family of Compositae, which is so dominant in central Arabia, is here but poorly represented by *Hochstetteria schimperi*. Zygophyllaceae, by contrast, is one of the most important groups with *Zygophyllum simplex*, *Tribulus longipetalus* and *Fagonia parviflora* all common. The Labiates include *Leucas inflata*, *Salvia aegyptiaca*, and Scrophulariaceae, *Lindenbergia sinaica*. Other common plants which were identified include *Corchorus depressus*, *Polygala irregularis*, *Morettia parviflora*, *Anticharis glandulosa*, *Cometes abyssinica* and *Andrachne asper*.

In the watercourses which drain the area the herbage is more robust, and signs of vegetative growth and flowering may be found even after long periods of drought. It was noticeable that in the silty gullies surrounding the Locust Control headquarters at Buraiman, 39° 10' E., 21° 40' N., from which stock was excluded for several years, the growth was rich and the number of species which could be collected was greater. The evergreen shrub *Cadaba glandulosa* is particularly abundant in some of the drainage lines, and it may be found at least sparingly in flower at any time of the year. *Abutilon pannosum* and *A. fruticosum* are characteristic of this habitat and may be found with green leaves and even in flower far into the dry season. Tussocks of *Panicum turgidum* and cushions of *Cymbopogon schoenanthus* choke the silty gullies. The *Panicum* seldom becomes completely dry and new shoots grow vigorously after rain. Other typical plants of this habitat are *Farsetia longisiliqua*, *Colocynthis vulgaris*, *Kohautia caespitosa* var. *schimperi*, *Pergularia tomentosa*, *Ochradenus baccatus* and *Ecbolium viride*. Shrubby trees of *Acacia ehrenbergiana* are also frequent in the lower reaches of the watercourses.

(c) *Hejaz mountains: Acacia asak and other species at elevations between 800 and 1500 metres*

The zonation of the vegetation of the Hejaz mountains is influenced by elevation, latitude and aspect. Consequently the divisions between the different associations are never clear cut. The association which is being considered in this section occurs in general between elevations of 800 and 1500 m. At higher elevations it is replaced by the *Olea-Tarchonanthus* association and the *Juniperus* woodland (see page 550). The mountains to the north of Jeddah do not exceed 1500 m. in many places, and so here the *Acacia asak* association is usually the mountain formation, and the brushwood and Juniper woods are not found except on isolated summits. At lower elevations overlooking the Red Sea to the south of Jeddah, the *A. asak* association merges into the 'monsoon woodland' type, *Acacia-Commiphora*, and to the north of Jeddah at lower elevation the dominant tree, *Acacia asak*, is replaced by *A. mellifera*, *A. hamulosa*

and *A. tortilis* (see previous section). On the eastern side of the range, at lower elevations, the *A. asak* association gives place to the *A. tortilis* association of the upland plateau (see next section), but it persists on ridges of high ground which run out on to the plain, as well as the outlying ranges of hills.

The present association differs from the last chiefly in the greater luxuriance and density of the vegetation and by the dominant acacias being different species, namely *A. asak* the characteristic species of the zone and *A. etbaica* usually an abundant associate. The species of *Acacia* noted in the previous section may all occur as well, especially at the lower elevations and in particular habitats, such as ravines and silt pans. There are others which are more restricted to the mountain valleys. As in the previous section, the vegetation forms a natural rockery with scattered small trees at 'orchard spacing' with an irregular understorey of perennial woody herbs and a variety of perennial cushion plants or annuals, many of them grasses, which become green after rains.

Far to the south, in Asir, near Abha (43° 05' E., 17° 00' N.) the hillsides of the eastern slopes at 1500 m. are steep and covered with loose shale. The small trees are spaced at 3 to 20 m. and *A. asak* and *A. etbaica* are co-dominant. But the 'monsoon woodland association', characterized by the incidence of *Commiphora* sp., also occurs here in places with a more sheltered aspect. *Blepharis persica* (Acanthaceae) and *Pulicaria adenensis* (Compositae) are very abundant ground-storey plants, and other herbs are mostly cushion-plants which are only green after rain. This area is relatively closely settled and undoubtedly fuel gathering and browsing have materially affected the vegetation.

A little farther north, at 1300 m. above Bisha (42° 30' E., 20° 00' N.), the jagged hills are of granite, basalt or shale. Among the granitic hills there are bold outcrops of rounded boulders and slabs with sheltered niches in which there is soil where the moisture is much augmented by run-off from the rock faces. These places are very favourable for plant growth. Small trees are necessarily scattered but *Acacia asak* and *A. hamulosa* are both frequent, and some stunted specimens of *Delonix elata*, *Euphorbia cuneata* and the shrub *Lycium persicum* occur. Herbs and grasses are very varied. Among the former the most usual species are *Aerva javanica* (Amarantaceae), always abundant, *Morellia parviflora* (Cruciferae), *Fagonia parviflora* (Zygophyllaceae), *Pulicaria schimperi* (Compositae), *Reseda muricata* (Resedaceae), *Monsonia heliotropoides* (Geraniaceae), *Glossonema edule* (Asclepiadaceae) and *Cienfuegosia welshii* (Malvaceae). The grasses are abundant but due to the prevalence of boulders they never form a sward; *Aristida hirtigluma* is very abundant, but other species, including *A. obtusa*, also occur.

The slopes of the basalt hills in this region are covered with loose polished black rock fragments and so there must be a considerable run-off of surface water though the stones may be expected to conserve moisture beneath them. There are also many out-cropping ledges and dykes which form natural terraces. Trees are nearly absent from this area, though *Acacia hamulosa* and *A. tortilis* occur on the lower slopes. Their absence gives the hills a very barren appearance during much of the year, but after rains a waving carpet of grass, chiefly *Aristida hirtigluma*, clothes the slopes. Other herbs are scarce though the same species as have been noted above may be found sparingly.

In the vicinity of Taif (40° 25' E., 21° 15' N.; 1300 m.), *Acacia asak* is found to be co-dominant with *A. hamulosa* and *A. ehrenbergiana* is abundant in the larger ravines,

and *A. tortilis* on the spill-out areas. *Blepharis persica* and *Indigofera spinosa* are the commonest ground-storey perennials, and other herbs are characterized by long tap-roots, a rosette type of growth and a vegetative period following rains. The incidence of these key-species and growth forms demonstrates a greater intrusion from lower zones at this more northern station, but it should be noted that in spite of the probable activities of fuel gatherers from the towns and villages, the rather greater coverage by the herbage suggests a more favourable environment. The trees are spaced at about 30 m. and the woody herbs, which are usually quite robust, at less than 1-metre intervals. In an enclosure where prickly pear had been planted and from which stock were excluded, the natural herbage even in the dry state formed practically a 100 per cent coverage between the boulders. The road from Taif towards Jedda passes through basalt hills with similar vegetation. Below 1200 m. *Acacia asak* becomes noticeably less abundant, leaving *A. hamulosa* as the dominant species, and other trees, notably *Euphorbia cuneata*, *Commiphora opobalsamum*, the shrubby *Lycium persicum* and, on more gentle slopes, *Acacia tortilis*, all become more frequent.

The foregoing paragraphs have traced the incidence of the *A. asak* association on the eastern slopes of the Red Sea hills to the south of Jedda.

Along the Mining Syndicate road which runs northward from Jedda to the interior, passing through Usfan (39° 20' E., 22° 00' N.) and Birka (40° 45' E., 22° 10' N.), *A. asak* is already co-dominant with *A. hamulosa* at 700 m., but here the higher ground is capped with lava flows which are broken up into a sheet of boulders known as 'harra', and in this habitat *A. asak* appears to be absent. In the 'harra' there is much level ground even at 1200 m. and *A. ehrenbergiana* and *A. tortilis* are the co-dominant species, with *A. hamulosa* present, but not usually abundant. North of the tropic, in the mountains beneath Jebel Radhwa (38° 20' E., 24° 35' N.) jagged ridges and conical peaks of granitic and crystalline rocks rise well above 1000 m. The mountain sides here are much more barren and in general the vegetation is restricted to the valleys. In such places, *Acacia* spp. are well represented but the trees are dry for long periods at a time and in general the several species are difficult to recognize, and in particular *A. asak* was not seen. Judging by the associated herbage it would appear that the vegetation of the valleys more resembles that of the plateau which is considered in the next section.

(d) *The upland plateau: Acacia tortilis and other species, at about 1000 metres*

This association occurs on terrain of gentle relief where detritus washed down from the mountains is spread out by periodical floods. These spill-outs are called 'seyals' and in such places the association is best developed (Phot. 4). The same association of plants is also found along the base of the hills where the slopes are gentle, and it is essentially similar to the *Acacia-Maerua* association which has been described on the Tihama plain south of Jedda at elevations little above sea level (Vesey-FitzGerald, 1955). *Acacia* trees extend north-eastwards of the tropic at least to the Jebel Tuwaiq (45° 00' E., 26° 00' N.) and the Jebel Shama (42° 00' E., 27° 00' N.) but the species represented at these limits have not been satisfactorily determined.

The characteristic tree of this association is *A. tortilis*, which varies considerably in growth form, and further study may reveal that two species are represented, but for the purpose of the present discussion they are considered as habitat modifications of the single species. Other species of *Acacia* also occur, usually in special

environments, and some of them extend to the farthest limit covered by the genus. A constant, though sometimes not very abundant, associate of *A. tortilis* is *Maerua crassifolia* which, however, does not extend so far outside the tropic as *Acacia*.

The country to the east of the Red Sea mountains above Mecca is known as the Rakba plain. This is a more or less level area with a mean elevation of about 1000 m. and composed of a firm gritty alluvium. Rocky spurs from the Hejaz mountains extend into the plain and the eastern horizon is more or less closed by isolated ranges of hills, but everywhere the highland is intersected by broad flood courses which merge into the open plain. Rather small, 2 to 3 m., many-stemmed, flat-topped shrubs of *A. tortilis* dot the plain in every direction. The shrubs are widely spaced, at least 20 m. apart and usually more, but there are always extensive empty spaces so that in a distant view the small trees appear to be congregated in scattered groves. Growth is closer along drainage lines and the larger watercourses may have a more or less continuous fringe of large trees. Small trees of *Maerua crassifolia* are of frequent occurrence, and shrubs of *Lycium persicum* common. Other *Acacia* spp. occur, for example *A. nubica* forms colonies in shallow silty pans, *A. ehrenbergiana* and *A. raddiana* occur chiefly in the shallow drainage lines. All these species, together with large trees of one or more other species of *Acacia* which have not been determined, are found in the fringes of the larger watercourses.

There are many dwarf shrubs on the alluvial plain. Salt bushes, *Salsola baryosma* and *Sedilizia rosmarinus*, which grow evenly spaced at 1 to 2 m. intervals, form colonies towards the perimeter of the flood-plains where the flood water collects and evaporates. Other shrublets tend to be arranged in bands where sandy material swept from the barren stretches of the plain accumulates round them. There is very little penetration of rain into the hard plain of gravel or silt and consequently considerable flow across the surface. This water tends to be dammed by the ribs of sand, and to accumulate against them and then slowly to sink in (Phot. 5). This irrigates the bushes which consequently grow more robustly and as a result hold up more wind-driven sand to form a bigger dam. Thus there is a continuous process in operation which causes the vegetation to grow in irregular patches, unless the slope of the land is sufficient for a definite drainage system to be developed in which case the herbage is densest in the runnels as has been noted in the foregoing paragraph.

Several species of perennial tussock grasses are very characteristic of the plain. The aromatic *Cymbopogon schoenanthus* is the most abundant species and forms dome-shaped tussocks which become tinder-dry during periods of drought but vegetate immediately after rain; *Lasiurus hirsutus* is also common and forms larger and looser tussocks; *Eleusine compressa* is an important species because it binds the wind-driven sand with its rhizomes; *Aristida plumosa* is the commonest of several cushion grasses which produce a green ground cover after rain. *Panicum turgidum* occurs in this area but is not so generally distributed as elsewhere. The climate of the plain is never too cold for growth, so the herbage becomes green whenever there is rain, but the 'seif' (April-June) rains seem to be the most important ones. These rains fall in the form of heavy thunder showers of short duration, and the run-off, collected as has been explained against the ribs of sand, sinks into the soil. During the summer the surface of the plain becomes very hot and precipitation tends to 'steam' off the surface of the gravel so that less water accumulates against the ribs of sand. However, at this season it is very evident that these sand belts, especially when they are shaded by vegetation, are important in water conservation, which promotes the growth of herbage and also

the germination of seeds during the summer. The tussock and cushion type of growth of the grasses is evidently advantageous under these conditions since it permits rapid development to the flowering stage whenever opportunity arises after rain. Herbs, other than grasses, which grow in this situation are characteristically tap-rooted perennials with rosette-like sub-aerial development. These are often browsed to ground level by stock during periods of drought, but they sprout vigorously from the crown of the root after rain. Common species are *Indigofera spinosa* (Leguminosae); *Pulicaria crispa* (Compositae); *Tribulus longipetalus* and *Fagonia parviflora* (Zygophyllaceae); *Corchorus* sp. (Tiliaceae); *Commicarpus plumbagineus* (Nyctaginaceae); *Euphorbia granulata* (Euphorbiaceae); and *Morettia parviflora* (Cruciferae). Annuals are practically absent, but in some of the spill-out silt beds near the ranges *Blepharis persica* (Acanthaceae) and *Arnebia decumbens* (Boraginaceae) are very abundant, and a green flush of *Aristida plumosa* may also be seen.

The major drainage lines support more varied and robust vegetation. The Wadi Aqiq (40° 40' E., 22° 00' N.; 1000 m.) is fringed by large trees resembling *Acacia abyssinica*, and probably other species, which are 15 m. high and with a girth of 2 m. at breast height (Phot. 6). Smaller trees of *Macrura* spp. and *Capparis decidua* (Capparidaceae), together with shrubs of *Calotropis procera* (Asclepiadaceae), *Withania somnifera* and *Lycium persicum* (Solanaceae), form a thick-set understorey. Rope-like lianes are a feature of these woody groves, the commonest species being the *Commicarpus plumbagineus*, *Cocculus pendulus* (Memispermaceae), and a species of Cucurbitaceae. Mistletoe parasitizes the large trees. Domestic stock delights to shelter in the woody fringe so the ground herbage is nearly always grazed or trampled out.

On some parts of the plain farther to the south where the rainfall is apparently more irregular more arid conditions prevail and the vegetation is restricted to the vicinity of outcrops where the trees are probably subsisting on subterranean water. The *Acacia* trees for instance may be found with green foliage and flowers without the incidence of rain at a time when the dwarf shrubs and grass tussocks remain dry or are absent. Elsewhere the plain is barren except in shallow pans which collect flood water, where tussock grasses and herbs occur. Where a major watercourse drains on to the plain from the mountains, a similar zonation of vegetation to that described on the coastal plain occurs (Vesey-FitzGerald, 1955). The Wadi Bisha (42° 30' E., 20° 00' N., 1200 m.) is typical. Within the last spurs of the foothills the bed of the watercourse is composed of coarse silt which is scoured by frequent floods so that no vegetation survives. There is, however, a much-interrupted fringe composed of *Calotropis procera* and *Leptadenia pyrotechnica*, and the usual *Acacia* spp. and *Ziziphus* sp. *Salvadora persica* and *Calligonum comosum* grow on large sandy mounds, with herbs such as *Rhazya stricta*, *Aerva javanica* and the grass *Pennisetum setaceum* on beds of finer silt. On the plain the flood water deposits a deep, dusty alluvium where the *Dipterygium glaucum*-*Panicum turgidum* association occurs, but is very poorly developed and very restricted compared with the coastal plain (Vesey-FitzGerald, 1955). Channels traverse the alluvium and these are fringed with *Tamarix orientalis*, which may have been planted, and *Haloxylon salicornicum* occurs here though this plant is not common within the tropics and is not found on the coastal plain. Beyond the limit of the flood the desert is very barren except for salt bushes, *Haloxylon* and *Salsola*, which suggest that the rainfall is not suitable for the development of the *Acacia tortilis* association.

(e) Mountains east of Wejħ: *Retama raetam* and associated plants

Along the route from Wejħ (36° 30' E., 26° 15' N.) to El Ula (38° E., 26° 40' N.), *Acacia asak* was not observed at all, and although Sudano-Deccanian trees, including other species of *Acacia* occur, there is also a considerable intrusion of Saharo-Sindian species of plants which give a changed aspect to the vegetation which is generally more scanty. The rainfall is probably too scanty to support the vegetation which is primarily dependent on sub-soil moisture, which is itself conditioned by topographical features. And the winter climate is probably more severe, though frosts are exceptional as is demonstrated by the fact that the carved façades of the tombs at Medain Salih (38° E., 26° 45' N.) have not been defaced by frost, like those at Petra in Jordan. The rocky foothills are practically bare, except for scattered small trees of *A. tortilis* on their lower slopes and in the valleys. The area was visited at a particularly dry time and no ground-storey herbage was seen on the hills, but small bushes of *Salsola forskalii* and dry tussocks of *Panicum turgidum* occurred in the wide valley bottoms and on plains of gritty alluvium. Within the mountains, *Haloxylon salicornicum* largely replaces the former in such habitats (Phot. 7) and grows rather evenly but widely spaced as a ground storey beneath the even more widely spaced trees of *Acacia tortilis*. In particularly favoured places, such as the vicinity of wells, the *Acacia* trees are bigger and often draped with the liane *Coccoloba pendulus*, and here there may be quite dense groves of the tropical Dom Palm *Hyphaene thebaica*, and thickets of *Capparis decidua*.

On the watershed, at about 1000 m., between the Wadi Nejd and Wadi Jizl (approximately 37° 15' E., 26° 50' N.), the vegetation is still sparse but rather more varied. Steep ridges, drained by silty gorges, rise some 300 m. above the pass. In the valley a large *Acacia* tree, resembling *A. abyssinica*, replaces *A. tortilis*, but *Haloxylon salicornicum* remains abundant though it grows less robustly than lower down. *Panicum turgidum*, *Rhazya stricta*, *Lycium persicum*, and such extra-tropical species as *Zilla spinosa*, *Ochradenus baccatus* and *Calligonum comosum* are found in the ravines. The stony slopes at this elevation are dotted with vegetation, including shrubs or small trees many of which are of the 'switch-bush' growth form, but several were in too dry a state for determination at the time when the area was visited. Characteristic of the area is the switch bush *Retama raetam* which is not found within the tropics and which as Zohary (1947) indicates has Irano-Turanian affinities. A few other shrubs which were determined included *Moringa peregrina*, *Rhus oxyacantha* and *Dodonaea viscosa*. *Acacia tortilis* was present but not common and no other species of *Acacia* was seen on the hillsides. Dwarf shrubs and woody herbs were frequent, including *Gymnocarpus decander* (Illecebraceae), which was very abundant; *Pycnocycla tomentosa*, another switch bush; *Acrova javanica*; *Lavandula* sp. and *Anvillea garcini* which is a northern species not found farther south in the Red Sea hills. *Indigofera spinosa*, which has been noted as such a common plant in the highlands farther south, was not seen. Herbs and grasses were not much in evidence during the dry period, but dry stands of *Blepharis persica*, *Asphodelus tenuifolius*, *Zozima absinthifolia* and *Anastatica hierochuntica* were seen, the last two species not being found farther south in the Red Sea hills. Cushion plants growing from woody root-stocks were frequent, such as *Andrachne telephiodes* and many of the grasses, which were in too dry a state for determination, also formed compact cushions.

(f) *The coastal plain north of Jeddah*

Some of the plant associations which have been noted on the coastal plain to the south of Jeddah (Vesey-FitzGerald, 1955) also occur between Jeddah and Yenbu. The *Acacia-Maerua* association is found on gravel detritus, but in a very depauperated form, the trees usually being widely spaced and extensive barren areas exist, while the prevalent Capparidaceae of the south are not at all frequent.

The tussock-grass savanna is more restricted in extent and as rain cultivation is limited to occasional seasons when the rains are good, only very small areas in the vicinity of Jeddah are cleared for planting. Therefore, the secondary *Dipterygium glaucum* phase only occurs for a short distance to the north of Jeddah but then the species is practically absent from the flora. The *Acacia-Commiphora* association is completely absent.

The most striking characteristic of the vegetation of the coastal plain north of Jeddah is the increase in the number of species of halophytes, especially near the sea (see section on beach vegetation) and in the drainage lines (see section on the Wadi Hamdh vegetation). On the sheet-eroded alluvial plain beneath the foothills, the raised areas of gravel are often bare due to perennial physiological drought resulting from excessive run-off and lack of penetration. The herbage is mostly concentrated in runnels and shallow silty depressions. Small trees of *Acacia tortilis* are very abundant though widely spaced and associated species are *A. asak* and *Maerua crassifolia*, though the latter becomes rare north of the tropic. Shrubs of *Lycium persicum* form colonies in silty depressions, and *Leptadenia pyrotechnica* grows in sandy debouchments. Tussock grasses are frequent in silty and sandy gullies, namely *Panicum turgidum*, *Lasiurus hirsutus* and *Cymbopogon schoenanthus*.

Salsola forskalii is the most abundant ground-storey dwarf shrub associated with the *Acacia* and it also colonizes soils beyond the limits occupied by the trees. Where lava boulders are exposed and erosion is less pronounced, *Acacia ehrenbergiana* and *A. asak* are more abundant, and *A. nubica* grows in silt-pans between the boulders. About 500 tons of charcoal a month are exported from the ports of Yenbu, Umm Lajj and Wejh, and this is produced mainly from the *A. tortilis* which partly accounts for the scarcity of trees in the vicinity of these towns.

In the vicinity of Umm Lajj (25° N., 37° 15' E.) rough limestone pavement is exposed at the surface and on this *Nitraria retusa* and *Zygophyllum decumbens* associated with *Gymnocarpus decander* are very abundant. *Cleome droserifolia* is frequent in gullies of the limestone country but the other Capparidaceae found so commonly within the tropics are quite absent.

(g) *The beach vegetation*

Although the rains are most irregular along the coast, the humidity is high and dew often falls at night. Brackish water occurs a few feet below the surface of the ground in most places.

The herbage is scanty and largely composed of salt bushes, Chenopodiaceae and Zygophyllaceae, which are more varied and more abundant than to the south of Jeddah. Along the beach just above high-water mark there may be an open fringe of *Atriplex farinosa* and on white coral sand of the coastal zone there is usually a fairly close stippling of *Zygophyllum coccineum*. The fleshy foliage of the latter is always green, and the plant appears to be quite independent of rainfall. It has a tap root

which descends for over one metre, and long cord-like laterals which extend for many metres into the sand. Other halophytes frequently associated with *Zygophyllum* are *Suaeda schimperi*, *S. volkensisii*, *Salsola* sp., *Anabasis setifera*, *Cornulaca ehrenbergii* and *Halocnemum strobilaceum*. All these plants are much more abundant on the extra-tropical stretches of the coast than within the tropics.

Coastal inlets are often bounded by salty flats or small dunes of coral sand. Some are enclosed by headlands of coral rock which are drained by sandy gullies. The coastal zone plants mentioned above often form colonies in which one species is dominant, or even forming a pure stand. The dominance changes suddenly, due probably to variations in the soil, both chemical and physical, such as salinity, compactness and nature of drainage, all of which frequently depend on very slight differences in elevation.

Salty flats along the coast are often bare, but in some places are stippled with dwarf shrubs and the presence of this vegetation causes hummocks of wind-blown sand to build up, thus providing habitats for other species. *Halopeplis perfoliata* colonizes the lowest flats which are often flooded by the sea, and the annual *Cressa cretica* encroaches far into the *Halopeplis* zone and may even be abundant there. A slight elevation allows a variety of other plants to become established, such as *Salsola* sp. which is abundant over wide areas near the coast and flowers during the summer. *Halocnemum strobilaceum*, the spear grass *Aeluropus* sp. form close stands, and *Limonium axillare* grows in closely spaced colonies over wide areas in depressions between decomposed coral rock. The latter has a long tap-root and is evergreen. Mangroves, *Avicennia marina*, are not common north of Jedda, but a few small shrubs of this species do occur in sheltered creeks even as far north as Yenbu.

At Yenbu (38° E., 24° N.), which is outside the tropics and very dry, salt-bushes form the characteristic coastal vegetation. The species represented vary sharply according to slight variations in elevation and soil type. *Zygophyllum coccineum* colonizes areas of coral rock and coral sand, and *Limonium axillare* and *Salicornia* sp. grow in low-lying places, where the sand is finer and stained a brownish colour. Areas of tawny silt in depressions are colonized by *Salsola baryosma* and *Anabasis setifera*, these fleshy shrublets being spaced at approximately 1-metre intervals. Both the last species have well developed tap-roots, and wind-driven sand tends to pile up into hummocks round the plants. The soil of the barren coastal salt flats is distinctly stratified. About 5 cm. of coral sand lies on the surface and below this there is a 10 cm. horizon of 'soda' crystals overlying a hard pan. *Halopeplis perfoliata* is the only plant that grows in such soils and even this species is widely spaced.

The dry estuaries of inland drainage lines, which are liable to very occasional flooding, are characterized by a tawny clay soil, which is usually dusty dry on the surface but moist below. Here the growth of halophytes is always luxuriant (Phot. 8), the plants surmount mounds and are spaced at about 2-metre intervals. The species represented in such places are *Suaeda monoica*, *S. volkensisii*, *Halocnemum strobilaceum* and *Limonium axillare* with often a sward of *Aeluropus lagopoides*. Restricted groves of shrubby *Tamarix* sp. also occur.

(h) *The Wadi Hamdh drainage: associations of halophytes*

In the vicinity of El Ula (38° E., 26° 40' N.) sand-stone country is encountered and the vegetation of this area is rather different and more resembles that of the

central Arabian sands, which it is proposed to discuss in a subsequent paper. Southwards along the old railway to Medina (39° 35' E., 24° 30' N.) the Wadi Hamdh, which reaches the sea to the south of Wejh (36° 30' E., 26° 15' N.) and is really a continuation of the Wadi Aqiq (see p. 550), is the dominant feature of the country.

In the Wadi Hamdh basin (38° 30' E., 25° 30' N.; 300 m.) the drainage lines are enclosed by jagged hills which appear to be quite barren although there may be some growth of annuals such as *Forskalea tenacissima* after periodical rains. *Asphodelus tenuifolius* forms stands along the base of the slopes, and *Anastatica hierochuntica* is usual in silty pans. The beds of grit and gravel spread out below the hills ('hamadas' of Zohary, 1944), support small trees of *Acacia tortilis*, spaced at approximately 20-metre intervals, with a rather evenly spaced ground storey of shrubby *Haloxylon salicornicum*. The finer alluvium is deposited on the more gentle slopes farther away from the hills, and this is drained by numerous runnels towards the central depression of the wide and shallow watercourse. Vegetation is more varied in the runnels. Besides the *Acacia* and *Haloxylon*, *Lycium persicum*, *Ochradenus baccatus*, *Cassia italica*, *Pergularia*, *Lepladenia pyrotechnica*, *Rhazya stricta* and *Panicum turgidum* are abundant in the runnels. *Maerua crassifolia* is rare so far north, and *Indigofera spinosa*, though locally well represented, is certainly not so abundant and widespread as farther south within the tropics.

The lower part of the valley comprises extensive salty flats on which species of Chenopodiaceae are dominant. *Suaeda* sp. and *Siedlitzia rosmarinus* are usually the commonest species and if there is a central watercourse it is often fringed with shrubs of *Tamarix* sp. Over wide areas of the flats, *Siedlitzia rosmarinus* forms a rather closely spaced pure stand, but several other species of salt bushes are certainly present but were not identified as they were not in flower.

SUMMARY

An account is given of the vegetation of the Red Sea coast to the north of Jedda, which is a continuation of a former paper dealing with the flora farther south. In the present paper the plant associations which occur immediately to the east of the Red Sea hills are also noted. The characteristics of rainfall of the region are briefly recorded and the main topographical features of the area are described.

The vegetation is divided into eight main associations, namely:

- (a) The *Olea-Tarchonanthus* association.
- (b) The *Acacia mellifera* association.
- (c) The *A. asak* association.
- (d) The *A. tortilis* association.
- (e) The *Retama ractam* association.
- (f) The associations of the coastal plain.
- (g) The associations of the beach.
- (h) The associations of halophytes.

Each is related to features of the environment in which it is found and the more important plants which characterize them are listed. It is emphasized that considerable overlap between several associations may occur and this is illustrated by descriptions of the herbage in certain localities. Throughout the paper the lessening influence of the monsoon climate towards the interior and farther to the north is

traced, and the gradual replacement of the tropical Ethiopian flora by a temperate Euro-Asiatic type is indicated.

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