

Some of the depressions have been filled with water, but are now quite dried up and only contain thick incrustations of sodium and magnesium sulphates or common salt (see above p. 11). On the banks of the small lakes *Salicornia* is dominant both in and above the water. Most of the specimens on shore were red, those in the water were generally green. Round the foot of each plant, including the dead ones, there was a granular mass of salt, which reached a couple of centimetres up the stalk. This must have been formed when the water was higher than now (analysis no. 4 p. 11). The following plant-species were found on the bank of the lake. *Aeluropus littoralis*, low and withered *Phragmites* (this was in the middle of July), *Scirpus affinis*, and in the water *Ruppia maritima*. In a few places, a little way from the banks, low Tamarisk bushes, *Alghagi Camelorum* and *Hali-mocnemis villosa* were mixed with the *Salicornias*.

These few observations will indicate that the vegetation is mainly the same as on "Ssor", and that the difference between "Batpak" and the former is therefore scarcely of any oecological or phytogeographical importance, at any rate if the water-plants of the lakes are left out of consideration.

"Takyr" is the name given to flat depressions, often of great extent (several kilometres) and which in a dry condition have a hard, clayey and slightly saline surface. They are often found in depressions among the dunes. In spring they are under water and from this fine particles of material transported by water or wind are laid down. Thus, by degrees, stratified water-loess is formed and prevents the water from sinking into the ground. When "Takyr" are dry, the bottom is hard like a threshing floor and the surface cracks and peels off in crusts. These flats are, as a rule, perfectly devoid of vegetation, because, RADDE suggests, they dry up late in the year and at a time when seeds cannot germinate on account of the heat of the sun. I have never seen plants on "Takyr", but RADDE mentions that on certain low sand-hills which rise above the water during spring, a few *Chenopodiaceae* may be found. Along the margins, that is where the water first subsides, a poor "Wermuth-flora" (*Artemisiae*), is also said to exist, and the stiff-leaved grass *Crypsis aculeata*

is said to grow here. These latter species indicate that "Ta-kyr" is also closely related to the Clay-desert.

From what has been said about the Salt-deserts, we can deduce the following characteristics of the formation: it consists of annual or perennial Halophytes of which a few are dwarf-bushes, very few are bushes (*Tamarix*) and none are trees. The plants grow scattered on a very saline soil. There is no spring flowering period but all the plants vegetate throughout the summer or, at least, far into it. This last feature I regard as the chief distinguishing characteristic between this formation and the Clay-desert.

The formation does not fall in with GRISEBACH'S Salt-steppe or BORSZCZOW'S Salt-desert both of which occur to some extent in the Clay-desert. This is indicated by the fact that both authors mention trees and bushes as constituents of the vegetation.

CHAPTER 7

The formation of the Clay-Deserts.

Clay-deserts are distinguished here as areas which have a clay substratum, and which do not contain salts to the extent that they to a greater amount come to view on the surface. This concept is to some extent identical with "The area of the Clay-deserts" in BORSZCZOW, but parts of his Salt-desert also belong here. ANTONOW'S formation of the "Loess-steppe" belongs here, likewise "the Clay-desert" with the exception of the saline places, which are here classed under the preceding formation.

According to many authors, Clay-deserts are very extensive in the lowland of Transcaspia (comp. BORSZCZOW above p. 25, and ANTONOW p. 32), and RICHTHOFEN regards them as "the true normal steppes of Central-Asia".

The soil of the Clay-deserts differs from that of the Salt-deserts by its greater dryness. When these two formations are found together, the Salt-desert always occupies the deeper parts. The saline ground-water cannot diffuse up to

the surface of the Clay-desert, therefore no salt, or only a little, crystallises out there. It must be kept in mind that the ground-water in the desert is almost always saline, and that fresh water is only found in the underground streams which have washed out the salts from the water-bearing layers (BAER 1856 p. 47).

The clay forming the surface of the desert is mostly loess in the southern parts. Pure compact clays (Aralo-Caspian formations?) are also said to occur in the Clay-desert (BORSZCZOW, see p. 25), but I have not seen any.

The Loess includes a proportion of fine sand, sometimes quite as much sand as clay or even more, and it frequently contains mica. (OBRUTSHEW, cited by RADDE 1899 p. 19). It is moreover unstratified, rich in lime, very porous and totally devoid of stones. When water is present, loess is a very fertile soil for vegetation. Below it, at a depth of 7—10 metres, layers of sand are generally found alternating with thin layers of clay containing gypsum.

Because of its porous structure loess absorbs water easily, but as the surface-soil is generally compact, that only absorbs water to a slight degree. The result is that the water from precipitation easily runs off, or remains on the top and evaporates. As loess has in addition a high water-capacity (59.5 per ct. of dry weight, CLEMENTS), the upper layers retain the water absorbed, so that it does not penetrate deeply and is therefore exposed to rapid evaporation¹⁾. According to WYSOTZKI (cited by RAMANN p. 402) there is found under the "live" layer, which contains the water of precipitation, a "dead" layer with its water-content unchanged, below this follows the layer containing ground-water (if there is any). Accordingly loess is not favourable to tree-growth as it prevents water from sinking down to where the tree-roots can get it (comp. above p. 48).

It is likewise of importance that loess being a rather fine-grained soil retains the water, so that the roots of plants can only absorb a proportionately small percentage. The percentage available to the plants CLEMENTS calls Chresard, as

¹⁾ KOSTYTSCHIEFF p. 113, ISMAILSKY p. 24, RAMANN 1905 p. 415.

opposed to Echard, the percentage retained by the soil and which the roots cannot absorb even if the plant wilts. According to CLEMENTS (p. 31) loess can absorb 59.3 per ct. (of its dry weight), and of these 49.3 per ct. are Chresard, 10.1 per ct. Echard.

In the case of clay CLEMENTS gives 9.3 per ct. Echard, SACHS has 8 per ct. (Vorlesungen, 2. Aufl. p. 239). Sand can absorb much less water, but on the other hand, almost all the water is available for the plants: the Echard is very small (Comp. E. GAIN 1895).

The capillarity of loess is considerable, so that where ground-water occurs it is able to raise this higher than sand, although the rate of movement is slower. On the one hand this process brings the deeper-lying water within reach of shorter roots, but on the other hand it promotes the evaporation of ground-water in loess as compared with that in sand.

Since the surface of loess is even and fine-grained, more water will evaporate from it than from a sand-surface (RAMANN p. 262). Another factor which promotes this is that loess has a dark colour and is therefore strongly heated by the sun. MIDDENDORFF records the following surface-temperatures on a sunny day in May. On loess 62° C., on a white salt-incrustation 45° C. The lower temperature of the salt-incrustation is due to combined evaporation and reflection.

Thus it will be seen that loess under dry conditions is as unfavourable to vegetation as it is favourable when water is present.

The maximum of precipitation (p. 17) for the areas we are considering occurs during winter or spring, whereas the summer is practically rainless, but very hot. The plants of the clay-desert which live through the summer in a vegetative condition cannot be adequately supplied by the small proportion of the comparatively limited spring rain which remains in the clay-soil. These plants, the Summer-Plants, must therefore supplement their water-supply from the saline ground-water. Thus one finds that in the true dry Clay-deserts where neighbouring mountains do not make the conditions specially favourable, the plants are almost all Halophytes. Conspicuous amongst them are many *Chenopo-*

diaceae both annuals and perennials. These plants do not die or go to rest till the autumn. SCHIMPER calls such plants "Ground-Water Plants".

Another group of plants satisfy their water-requirements from the precipitation of the winter and spring, the melting snow and rain-water which is stored in the upper layers of the soil. When the dry hot time comes (in May—June) most of the available water (Chresard) from these strata evaporates, and they become very dry. What water remains becomes more concentrated and saline through evaporation (BERNATSKY p. 209), and as the plants dependent on the water in the upper layers — the Spring-Plants — are not xerophilous or only slightly so, the increasing heat soon makes them wither. Before this takes place, however, their development is finished, and they have dispersed their seeds. Most of the spring-plants are annuals or ephemerals, as VOLKENS terms them, but there are also some bulbous plants and other perennials, especially in the more favourable localities. These perennials go to rest when summer comes, and assimilate and bloom only in spring.

This distinction between a spring-vegetation and a summer-vegetation has long been known for many deserts and steppes. (It is also present, though perhaps less pronounced, in the whole region of temperate winter-rains). GRISEBACH (1872 I p. 449) has already recorded *Artemisia* as one of the few perennials ("Stauden") which vegetate through the summer, and he also states that most annual plants die quickly during the spring, whereas some annual *Chenopodiaceae* live through the summer, blossom in the autumn, and do not die till the frost sets in. — The spring-flora of the South-Russian steppe has been described among others by GRUNER and TANFILJEV, that of Egypt by VOLKENS, and that of the desert-territory of western North-America by MAC DOUGAL, THORNER and others. Here we find two maxima of ephemeral plants corresponding to the two rainy seasons of winter and summer.

We shall first describe the Transcaspian Clay-desert in its Spring aspect, and afterwards attempt to present a picture of the more sombre aspects of Summer and Autumn.

Certain forms of the sand-desert also have these two aspects, and one finds here in places a quickly fading Spring-vegetation; this is referred to in chap. 9.

The spring-flowering period of the Clay-desert attains its richest and finest development at the foot of the mountains, for instance at the Persian Kopet Dagħ and the western Thian-Shan. In such places the amount of water is greater than on the plains, and this causes in itself a richer vegetation of spring-plants. Moreover there is often cultivated land at the foot of the mountains, and weeds from there along with plants from the neighbouring mountain slopes mix with the plants of the desert (KORSHINSKY see p. 36). Such deserts, rich in vegetation, TANFILJEV calls Loess-Desert-Steppe (the exact term used is not easily translated from Russian!). "Semi-Desert" will be used to indicate them in the following account.

A sketch of such an area has already been given (p. 44). In spring it certainly does not resemble a desert. Looking at the mass of flowers one obtains an overpowering impression of richness, vigour and luxuriance. A closer examination, however, reveals traces of the desert nature.

The plants do not form a close carpet or they do so only in patches, whereas in other places the soil is quite naked especially where salts crystallise out as a light dusty covering which gives the soil a greyish colour. Here and there among the fresh-green flowering plants one finds a grey *Artemisia* or an almost leafless low chenopodiaceous bush; they are still very backward in their development and one can see that their season is still to come. In a few places there are small stretches of moving-sands in the midst of the flower-decked area; these are bare or scantily covered with scattered coarse tufts of grass or low grey bushes.

The following is a list of the plants which bloom during the spring in the Semi-desert, together with a short summary of the characters they have in common.

Grasses are the principal constituents of the vegetation, and of these *Poa bulbosa* is by far the most dominant, that and the less important *Hordeum secalinum* are the only perennial grasses. The shoots of *Poa bulbosa* have, as is well

known, a bulbous swelling at the base, and the resting buds on this are well protected both against drought and cold. I have always found the ears viviparous. Other grasses of importance are: *Apera interrupta*, *Trisetum Gaudinianum*, *Festuca ciliata*, *Nardurus tenuifolius*, *Koeleria phleoides*, *Triticum Aegilops* and *orientale*, *Agropyrum squarrosum*, *Schismus minutus*, *Bromus tectorum*, *oxyodon* and *Danthoniae*, *Hordeum*

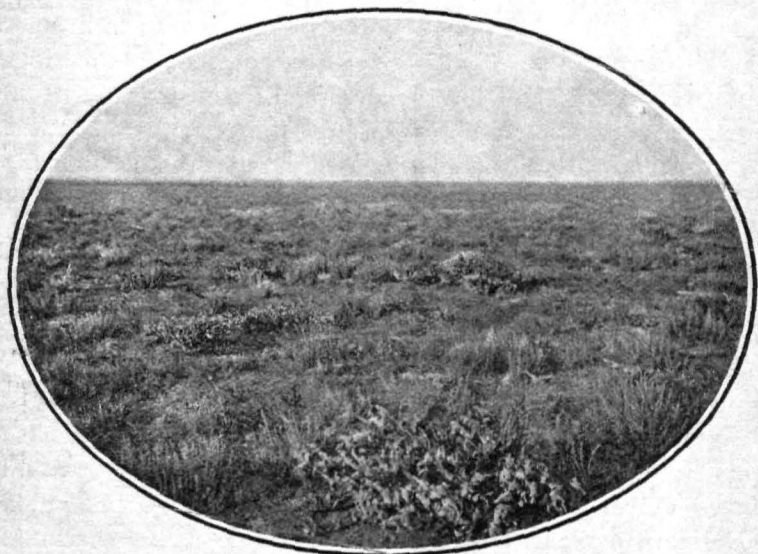


Fig. 4. Semi-desert at Chawast N. E. of Samarkand. In the foreground half-withered leaf-rosettes of *Ferula Asa foetida*. *Artemisia* sp. dominant, with *Poa bulbosa*, *Haplopyllum lasianthum*, *Carum turkestanicum*, *Eremostachys labiosa*. Month of May.

crinitum and *secalinum*, *Boissiera bromoides*. All these grasses are annuals, rather low-growing, scarcely a foot high, and with flat leaves.

The "flowering herbs" include a number of annuals. The poppies first attract the eye: *Roemeria rheoadiflora*, *Papaver arenarium* and *pavoninum*. Then one sees a great number of *Cruciferae* (*Malcolmia africana* and *Bungei*, *Alyssum marginatum* and *linifolium*, *Sisymbrium*-species, *Goldbachia laevigata*, *Leptaleum filifolium*, *Cryptospora falcata*, *Euclidium syriacum*, *Chorispora tenella*); also *Boragineae* (*Anchusa hispida*, *Arnebia*

linearifolia, *Asperugo procumbens*, *Lappula*-species, *Heliotropium europaeum*, *Onosma hispidum*, *Nonnea picta*), *Umbelliferae* (*Aphanoplema capillifolia*, *Carum confusum* and *turkestanicum*,

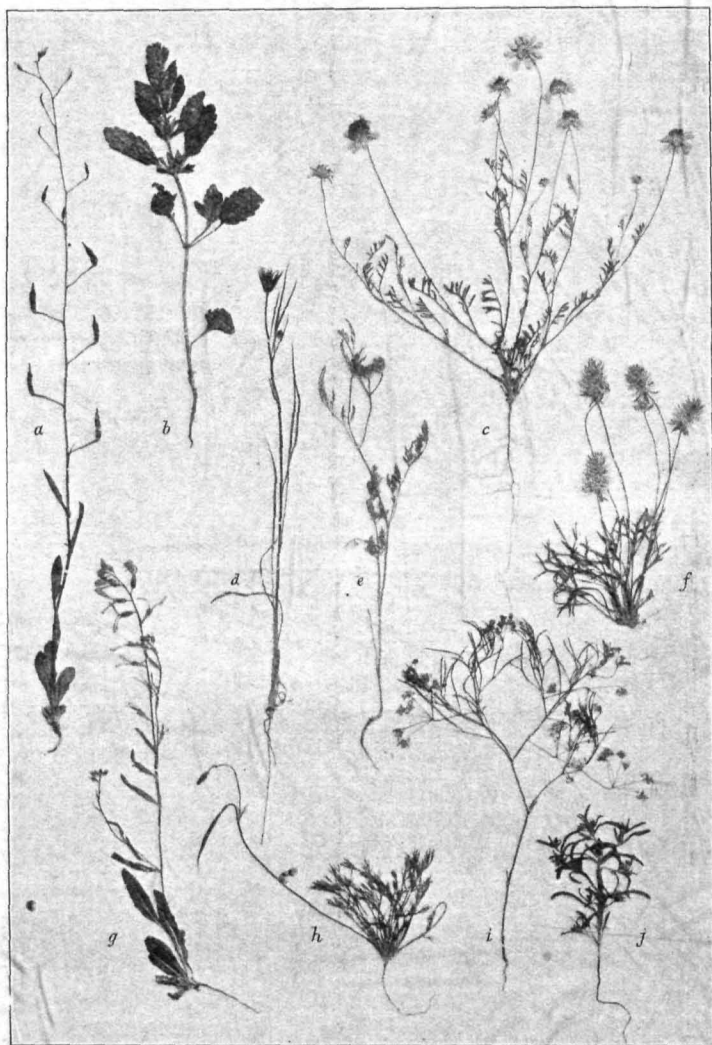


Fig. 5. Representative ephemeral plants from Clay-desert: a, *Goldbachia laevigata*. b, *Lallemantia Royleana*. c, *Malricaria lamellata*. d, *Koelpinia linearis*. e, *Caulalis leptophylla*. f, *Ceratocephalus orthoceras*. g, *Malcolmia Bungei*. h, *Hypecoum pendulum*. i, *Acanthopleura capillifolia*. j, *Lappula spinocarpos*.

Caucalis leptophylla), and *Labiatae* (*Hypogomphia turkestanica*, *Lallemantia Royleana*, *Ziziphora tenuior*). The following will illustrate various other common families of annuals: *Spinacia*

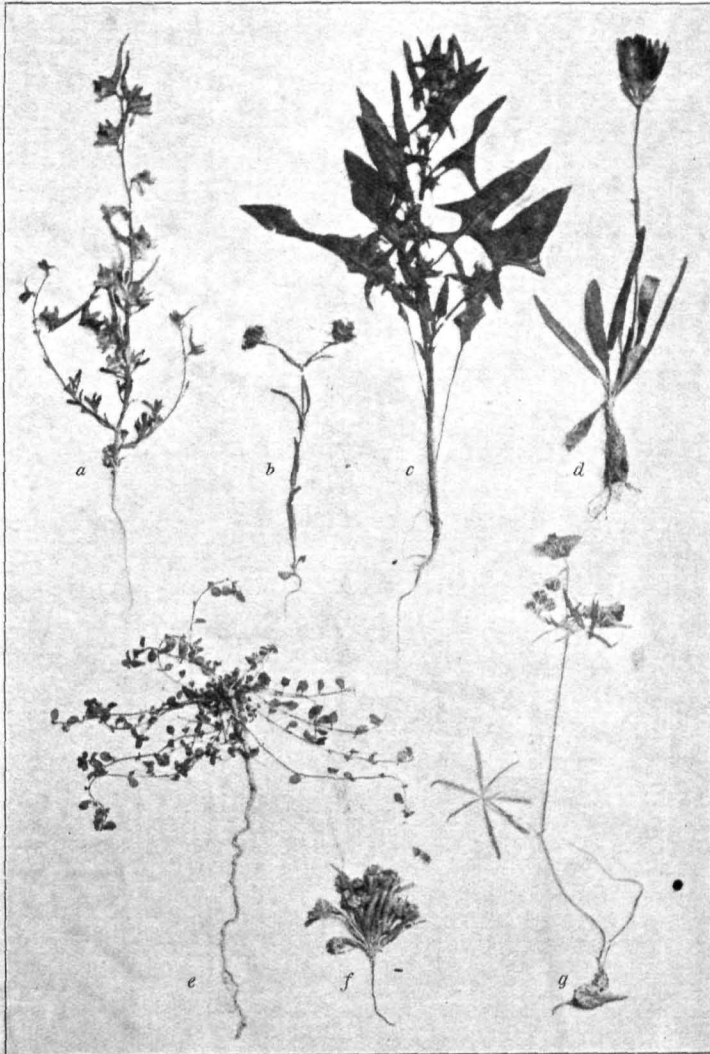


Fig. 6. Ephemeral and perennial Spring-plants from Clay-desert. a, *Delphinium persicum*. b, *Valerianella turkestanica*. c, *Spinacia tetrandra*. d, *Gentiana Olivieri*. e, *Andrachne telephiodes*. f, *Plantago lachnanta*. g, *Geranium tuberosum*.

tetranda, *Koelpinia linearis*, *Matricaria lamellata*, *Ceratocephalus falcatus*, *Hypecoum pendulum* and *trilobum*, *Trigonella*

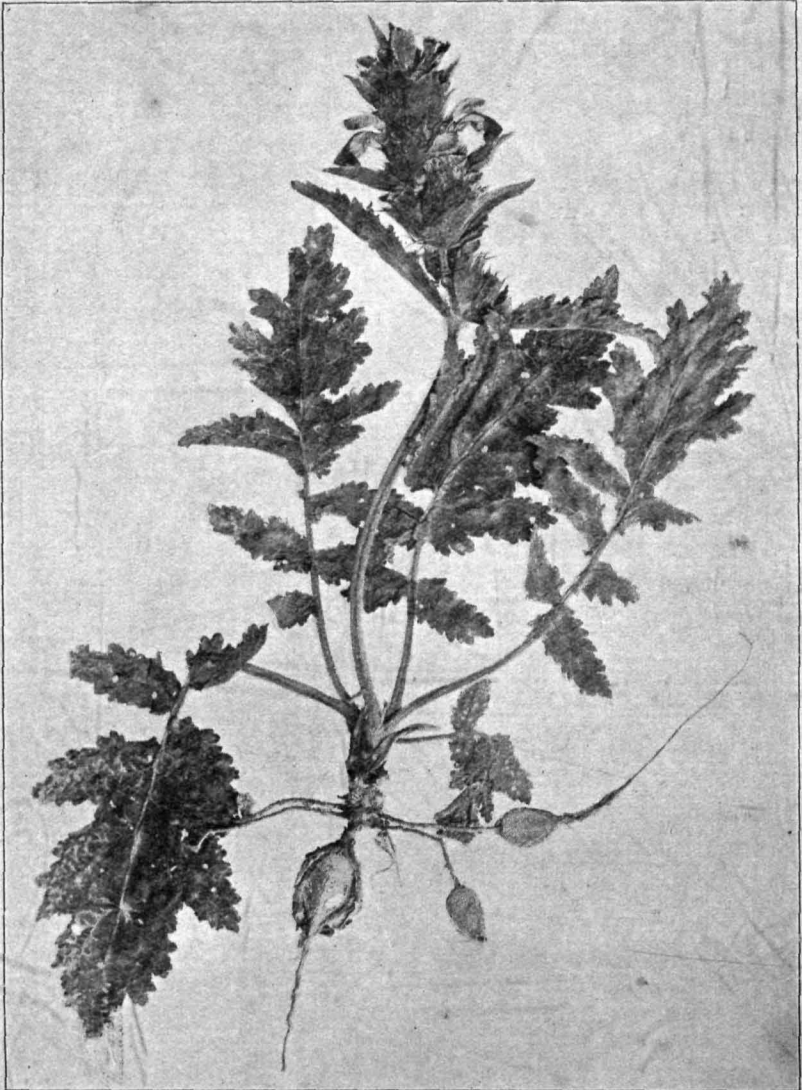


Fig. 7. *Eremostachys labiosa*. May.

monantha and *longiflora*, *Euphorbia pygmaea*, *Galium tricornu*, *Delphinium rugulosum* and *persicum*, *Nigella integrifolia*, *Astra-*

galus filicaulis and *camphylotrichus*, *Plantago lachnantha*, *Tri-
bulus terrestris*.

Here and there in patches are found the stiff-haired
Chenopod *Halocharis hispida*, or *Bassia sedoides*, and often
on saline spots there is the very small succulent *Tetradiclis
tenella*.

Noteworthy amongst the perennials which bloom in
the spring are a fine red *Tulipa* sp., *Ixilirion Pallasii*, with
blue blossoms, *Allium Tschulpian* and other species, *Gagea
reticulata*, the tuberous geophytes *Geranium tuberosum* and
Leontice incerta, besides *Iris caucasica*, *falcifolia*, etc.

Eremostachys labiosa (fig. 7), a foot-high Labiate with
handsome Acanthus-like foliage and large light flowers is so
plentiful in places that the green grass is dotted over; it has
tubers and is a hemicryptophyte like *Ferula Asa foetida*.
This latter also dominates large areas in some places with
its large yellowish-white compound umbels rising a metre or
more above the ground, in other places it is represented
only by rosettes of large dissected leaves which are already
turning yellow at the end of May; the plant has tubers and
thick rhizomes.

Rheum tataricum occurs locally spreading its large bossed
leaves, a metre wide over the ground. I have not seen it in
bloom, but to judge from an illustration published by TAN-
FILJEV (1903 p. 390) the inflorescence is strongly branched
and rather low. In the middle of May the leaves are already
turning yellow.

Other hemicryptophytes found during spring in the semi-
desert are: *Astragalus Alopecias* with vigorous prostrate shoots
which have multipinnate silver-white leaves and dense yellow
flower-heads, *A. sogdianus*, *A. macronyx* with its yellow
blossoms on short stalks at the base of the long leaves, *A.
mucidos*, *flexuosus*, *orbiculatus*, *Petunnikowii* and other species,
Solenanthus petiolaris, *Gentiana Olivieri*, several species of *Scor-
zonera* with tubers, *Taraxacum* sp. *Dianthus crinitus* and *an-
gustatus*, *Ranunculus Sewerzowii*, *oxyspermus* and other species,
Haplophyllum lasianthum, *Lepidium Draba*, *Andrachne tele-
phioides*, *Onosma hispidum*, *Achillea micrantha*, *Cachrys didyma*,
Carex stenophylla var. *desertorum*, species of *Carum*, *Peucedanum*,

Tragopogon, etc. Here and there may be seen the erect blue inflorescences of the parasitic *Orobanche amoena*.

The plants just mentioned belong to the Spring-plants. Both annuals and perennials are represented, the former being predominant. The perennials are either bulbs, tuberous geophytes or hemicryptophytes. Rhizome-geophytes seem to be absent, with the exception of *Carex stenophylla* which is generally a sand-plant; nor is the stiff clayey soil favourable to them.

The spring-plants, with the exception of *Ferula Asa foetida*, are low, ranging from a few centimetres up to about 30 cm, and they are as a rule soft pliant erect herbs with no pronounced xerophytic structure (see figures 5, 6, 7). A frequent character is that the leaves or the leaf segments are narrow, linear or sometimes filiform (*Leptaleum*, *Euphorbia pygmaea*, *Valerianella*, *Koelpinia*, *Caucalis*, *Aphanopleura*, *Carum confusum*, *Peucedanum* &c.), and generally hairy. The *Astragalus* species have multipinnate leaves, *A. mucidus* with about 20 pairs of leaflets, *A. macronyx* about 30 pairs.

Plants with broader, elliptical or ovate leaves are less common, for instance *Euclidium syriacum*, *Malcolmia africana*, *Goldbachia laevigata*. The leaf-blade in most of them is downy or setaceous, while *Alyssum marginatum* and several *Cruciferae* have stellate hairs. *Cousinia* and *Galium tricornae* are thorny. A good many plants occur which are glabrous or nearly so, for instance: *Koelpinia*, *Trigonella*, *Valerianella*, *Aphanopleura*, *Peucedanum*, *Goldbachia*, *Spinacia*, *Hypocoum*.

Erect and short stems are the most common. The occurrence of a number of plants with prostrate stems (e. g. *Arnebia decumbens*, *Trigonella*, *Galium*, *Leptaleum filifolium*, *Andrachne telephioides*) is a natural feature of a vegetation which is not dense; between the plants there is enough space and light for prostrate stems. These do not apparently give off roots; there are neither above-ground runners nor subterranean ones.

A few rosette-plants occur, both annuals and perennials. Annual rosette-plants are represented by *Hypocoum*, *Plantago lachnantha*, *Ceratocephalus*, perennials by *Taraxacum*, *Gentiana Olivieri*. There are several semi-rosette-plants (RAUNKJÆR 1905

p. 390) i. e. plants with the greatest number and the most vigorous leaves placed at the base of the stalk: *Ranunculus oxyspermus* and *Sewerzowi*, *Eremostachys*, *Astragalus macronyx* and *sogdianus*, *Cachrys didyma*, and to these may be added a number of ephemerals e. g. *Malcolmia Bungei* and *africanum*, *Sisymbrium pumilum*, *Goldbachia laevigata*.

The presence of rosette and semi-rosette plants is also in accord with an open plant covering, since a dense vegetation will favour plants with elongated shoots and high-placed leaves.

As regards the floral features, small flowers seem to be more abundant than large ones, and white and yellow flowers are more frequent than blue or red although the red species, such as the poppies and tulips, are often prominent when they occur in masses.

Some idea of the diversity of the spring vegetation of the Semi-desert may be obtained from the following representative lists of plants made in various localities.

1. At Bami west of Askhabad; April 24th: *Poa bulbosa*, *Roemeria rhoeadiflora*, and a red species of *Tulipa* are dominant. Other species: *Asperugo procumbens*, *Euclidium syriacum*, *Malcolmia africana*, *Myosotis* sp., *Hypocoum trilobum*, *Spinacia tetrandra*, *Ixilirion tataricum*, *Iris caucasica*, *Lepidium Draba* and *perfoliatum*, *Trigonella monantha*, *Sisymbrium Sophia* and *pannonicum*, *Koelpinia linearis*, *Matricaria lamellata*, *Papaver arenarium*, *Anagallis* sp. and a few grey *Artemisias*. Beside a house were some willow-bushes with catkins, but no leaves.

2. North of Dshisak at the foot of West-Thianshan; May 7th: *Poa bulbosa* and a grey strongly aromatic *Artemisia* in places form the whole vegetation.

3. Other places (near Balan Hur) are much richer, and in addition to *Poa*, poppies and tulips, one finds *Ixilirion Pallasii*, *Carex stenophylla*, *Malcolmia Bungei*, *Cryptospora falcata*, *Euphorbia pygmaea*, *Leptaleum filifolium*, *Astragalus sogdianus*, *macronyx*, *mucidus*, *Solenanthus petiolaris*, *Gentiana Olivieri*, *Eremostachys labiosa*, *Ranunculus Sewerzowi*.

In the true clay-desert, which is drier than the semi-desert, I had no opportunity of seeing the spring-vegetation. That ephemeral species also occur here is known from BASINER, BORSZCZOW (see above p. 26) and RADDE. From the last named author (1899, p. 26) is taken the following description of an area near the eastern shore of the Caspian Sea, visited on April 28th:

“Ist diese Sandzone passiert, so kommt man, direkt nach N. wendend, auf festerem Lehm, zum Teil mit Salzgründen und in die elendeste Salsola- und Artemisien-Steppe oder besser gesagt: Wüste.”

And later on he says:

“Die arme Flora bietet immer dasselbe, im Ganzen kann man hier kaum 15 Arten finden. *Gagea reticulata* steht in Samen, *Hordeum murinum*, *Boissiera bromoides*, dieselbe Kamille, dieselbe *Allium* wie bei Tschikislar, *Ceratocephalus falcatus*, *Geranium oxyrhynchum*, *Plantago arenaria* W. K. und die gelbbraune langbehaarte *Kochia scoparia* im Jugendzustande, sowie der schöne *Astragalus macrotropis* wurden hier gesammelt. Alles das miserabel, nur ein Paar Zoll hoch, eine *Statice*, die jetzt schon blüht, *Salsolen* und *Artemisien* nur strichweise häufig. Man vergesse nicht dass diese Zeit für die hiesige Flora die Glanzperiode ist, Ende Mai ist alles mit Ausnahme von *Salsola* und *Artemisien* todt. Es gibt zwar an einigen wenigen Stellen Vertiefungen grösseren Umfangs, die infolge geringer Feuchtigkeit etwas besser bewachsen sind, aber nirgends sieht man den Versuch einen schwächlichen Rasen zu bilden, es fehlen sogar die Sand-*Carices*. In solchen Vertiefungen konnten *Lepidium* *Draba* und hier und da als Seltenheit *Lep. perfoliatum* existieren.”

On comparing this with the accounts given by BASINER and BORSZCZOW, it will be seen that the difference between the Semi-desert and the true Clay-desert lies in the varying degree of dryness, correlated with a less or greater abundance of the spring-vegetation. Ephemeral species and spring-perennials occur in both places. Since the summer and au-

tumn vegetation is similar in the two forms of desert there is no reason for distinguishing between "Clay-desert" and "Loess-steppe", as has been done by ANTONOW.

In the middle of May the Semi-desert is already beginning to turn yellow, and many of the spring-plants have even dispersed their seeds in April. Towards the end of May almost all the plants of non-xerophytic structure have withered or are withering rapidly, and the summer-plants make their appearance. Our illustration (fig. 4) shows the rolled-up withered yellow leaf-rosettes of *Ferula Asa foetida*, while many grey *Artemisia* bushes are not yet in bloom. The surface soil in this place was cracked by drying, but at a depth of 7 centimetres the loess was still dark with moisture. Thus it seems to be the dryness of the air rather than that of the soil which kills the spring-vegetation.

As June advances, any spring-plants left become so dry and brittle that they fall to pieces when touched. They soon disappear entirely and then the semi-desert becomes a true desert similar to the clay-desert proper. The two desert forms will therefore in what follows be treated together under the latter designation.

The surface in places is perfectly bare, but as a rule it is spotted over by scattered summer-plants. Generally only a single species or very few species occur together in each locality, different ones in the different places. The number of summer-plants is extremely limited, and a review of them is soon made.

Artemisiae often constitute the whole of the summer-vegetation; BORSZCZOW records *A. fragrans* and *monogyna*, but specimens I brought home were identified as *A. herba alba*. In any case the species are closely related to *A. maritima*: silver-white, aromatic undershrubs, strongly branched at the base. This mode of growth (a "Wermuth-Steppe") is seen in the illustration (fig. 4), and it may be uniform over large areas.

In other places *Salsola rigida* is the principal species. Its growth-form is between a shrub and an undershrub, half a metre high, dry and twiggy in appearance, and generally with many dead branches; its leaves are rigid and cylindri-

cal. This is also the type of growth-form of *Haloxylon Ammodendron*, *Salsola Arbuscula* (figures 12 and 38), *subaphylla* and *verrucosa*, when these species grow in the clay-desert, but they have quite a different appearance when growing in the sand-desert. Low shrubs of leafless *Ephedra alata*, species of *Calligonum* and the succulent, salt-excreting *Reaumuria oxiana* are similar in type. *Smirnowia turkestanica* and various species of *Astragalus* (*A. Ammodendron*, *paucijugus*, *unifolius*) are shrubs, sometimes a metre high, with inflated pods and poorly developed foliage. *Smirnowia* has small entire circular leaves, while the *Astragalus* species have leaflets which fall off quickly, leaving a persistent leaf-rachis.

In places where the ground-water is not too deep (e. g. near oases or rivers) the following are characteristic shrubs: Fresh green or greyish Tamarisks; the narrow-leaved *Nitraria Schoberi* comparatively rich in foliage; *Halimodendron argenteum*, a silver-leaved thorny leguminous bush with large inflated pods; *Halostachys caspica* and *Halocnemum strobilaceum* both bushes with Salicornia-like shoots; *Prosopis Stephanianum* a low mimosa-bush with pinnate leaves (probably occurs also in very dry places); *Lycium ruthenicum*; the broad leaved *Capparis spinosa*, and the spiny rosaceous *Hulthemia berberifolia* (I am not quite certain whether the last two vegetate during summer). There are also *Frankenia hirsuta*, *Heliotropium dasycarpum*, *Statice suffruticosa*, *Alhagi Camelorum*, all regarded as undershrubs and mostly found in the more favorable localities along with the perennials *Peganum Harmala*, *Zygophyllum Eichwaldii*, *Pluchea caspica*, *Inula caspica*, *Dodartia orientalis* (leafless) and *Cressa cretica* one of the *Convolvulaceae* well covered with a foliage of grey salt-excreting leaves.

As summer-plants of the dry clay-desert we should include the Chamaephytes¹⁾ *Anabasis aphylla* and *salsa*, *Arthrophyllum subulifolium*, *Nanophytum erinaceum* and *Noaea spinosissima*, all leafless or thorny-leaved stunted undershrubs; also *Anabasis eriopoda*, a leafless Hemicryptophyte¹⁾, and finally a number of annuals.

¹⁾ See chapter 12.

These last include *Frankenia pulverulenta*, *Crozophora gracilis* one of the low *Euphorbiaceae* with flat leaves densely coated with hairs, *Carduus tenuiflorus*, the fragrant *Lachnophyllum gossypinum* a Composite semi-rosette plant, and a few other species.

By far the greater majority of the annual summer plants belong to the *Chenopodiaceae*. They are almost all succulents and amongst them one can distinguish between various types. The first type is the Thorny Leaf-Succulents whose representatives (*Salsola Kali*, *sogdiana*, *aperta*, *Androssowii*) have spiny pointed leaves with water-storing tissue in the middle. The second type is the Thornless Leaf-Succulents (*Salsola crassa*, *lanata*, species of *Halanthium*, *Halimocnemis macranthera*, *pilosa* and *villosa*, *Piptoptera turkestanica*, *Suaeda* &c.); these have succulent, often hairy cylindrical thornless leaves which still retain their function as the most important organs of assimilation. The third type, which I propose to call Bracteole-Succulents, are characterised by a distinct water-translocation (BURGERSTEIN, MESCHAYEFF) i. e. the plants sacrifice certain of their own organs to support the others, and in this case the foliage-leaves are drained of water and wither, while the plants concentrate their vigour on the inflorescence. Each floret of this is surrounded by three spoon-shaped bracteoles, namely the subtending leaf and two prophylls. These three organs are very succulent with their outer layers developed as green tissue, and they, with some assistance from the green stems, take the place of foliage leaves in assimilation. At the same time they protect the florets which sit squeezed in between them (see fig. 8 and 78).

The Bracteole-Succulents include *Salsola incanescens*, *spissa* and *sclerantha*, *Halimocnemis Karelini*.

These species are good examples of the type, and later in the summer they show scarcely a single foliage-leaf. The whole plant is beset with small globular bodies (the florets and their bracteoles), so that they have a characteristic appearance (fig. 8). Fleshy bracteoles around the flower are also frequent in the other types, but the appearance of the plants is

very different when the foliage-leaves are present. Along with the Bracteole-Succulents may be mentioned *Ceratocarpus are-*

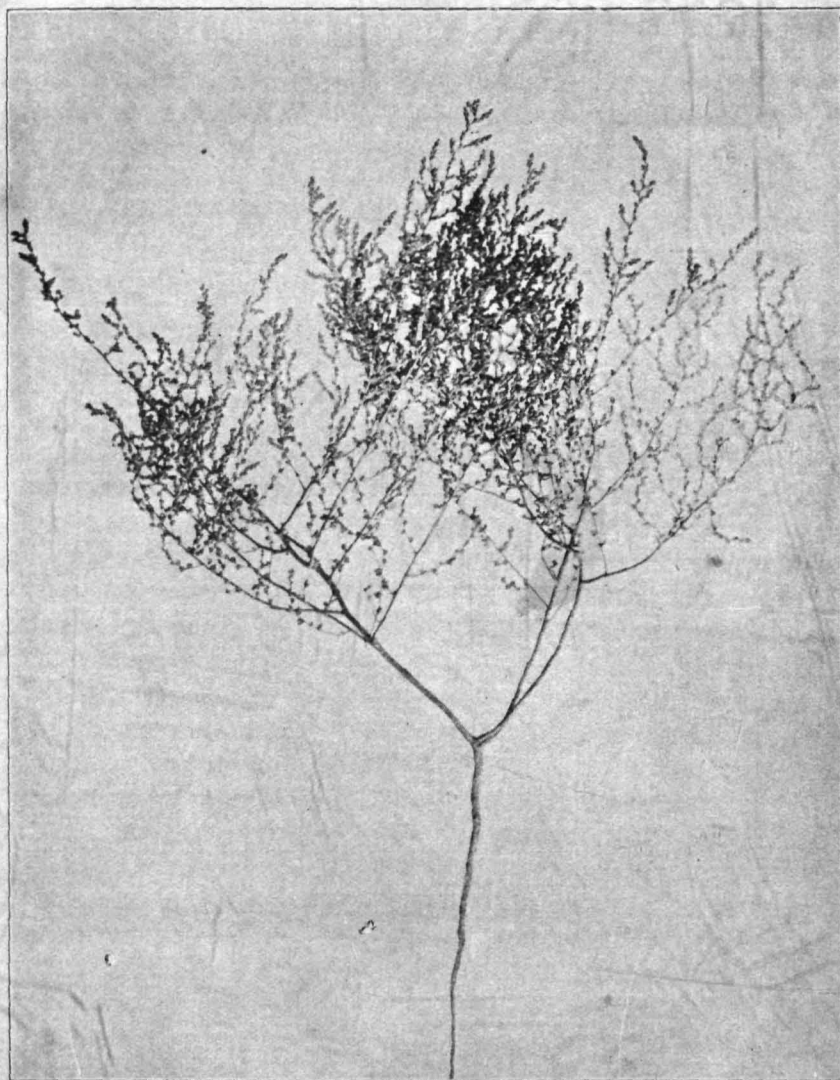


Fig. 8. *Salsola spissa*, an annual bracteole-succulent. June.

narius a plant of frequent occurrence many places in the clay-desert. Its flat, spiny non fleshy leaves lose all their parenchyma during the summer and become reduced to thorns,

assimilation being taken over by the two connate spiny prophylls. The whole plant forms a spiny ball sometimes as large as 30 centimetres in diameter and of a grey colour. (See fig. 66).

Under the Summer-plants should also be grouped a red Lichen, *Lecidea decipiens* which in some places is common on the surface of the loess.

The structure of the Summer-phanerogams will be dealt with later (chap. 13), when the different types of desert-plants are described. Here it is only necessary to give some of the more important features. The species which grow in the most favourable localities, where the ground-water is not too deep, are generally these with relatively the richest foliage: *Tamarix*, *Halimodendron*, *Prosopis*, *Peganum*, *Zygophyllum*, *Pluchea*, *Inula*, *Alhagi* have all distinctly green leaves and flat, with the exception of those of the *Tamarix*. None of them however have much foliage, nor does it cover the stems. In *Alhagi* only the oldest leaves persist, so that the upper shoots look like leafless spiny branches.

The plants of the dry desert may be grouped as follows: Succulents, Bracteole-Succulents or Leaf-Succulents, the last including *Salsola Arbuscula*, *subaphylla*, *rigida* and *verrucosa*, *Reaumuria*; leafless Stem-Succulents such as *Haloxylon*, *Anabasis* and *Calligonum*; deciduous shrubs like the species of *Astragalus* where other organs take over the work of assimilation; and finally plants with narrow leaf segments coated with hairs (*Artemisia*). All the species from the dry clay-desert belong to very xerophytic types, many have in addition a halophilous stamp (cylindrical assimilation-organs with aqueous tissue in the middle). In a case such as we are now considering it may be difficult, perhaps impossible, to distinguish between the xerophytic and the halophytic; which structural adaptations are due to desiccation and which to salinity of the ground-water can only be positively determined by experiments.

The usual aspect of the clay-desert in summer is a flat or slightly undulating surface, brown and dry, here and there with slight incrustations of salt, bare or scantily covered with scattered xerophilous plants which are herbs or small shrubs

rarely higher than half a metre. The following are the most common: Saxaul, *Salsola rigida*, *Artemisia*, *Halostachys* and *Halimodendron*. — In depressions salt-deserts are found which are white with salt and produce their own particular vegetation closely related to that of the clay-deserts.

The Growth-Forms of the Clay-desert in Spring are Mesophytes, including Ephemeral plants and Perennials with short-lived aerial shoots; while in Summer (and of course also in spring) we have Xerophytes, some small shrubs and undershrubs, others perennials and long-lived annuals.

As emphasized above, the chief difference between Clay-desert and Salt-desert is that the latter lacks the spring-aspect.

CHAPTER 8

The Formation of the Stone-Deserts.

ANTONOW has recorded (see above p. 35) a formation which he calls "Promontory or Stone-Steppe", said to be characterised by a special flora. This formation, according to the nomenclature employed here, cannot be termed steppe but must be called desert. Whether it is different from the clay-desert as regards its growth-forms I cannot determine with certainty because I have seen so little of the stone-desert. But it must be more correct to keep apart that which cannot with certainty be united, and therefore the stone-deserts will be considered here as a special formation.

The soil of the Stone-deserts is either rock, or gravel with stones, or a conglomerate. The layer of conglomerate, which is mentioned by ANTONOW, is probably the ordinary tertiary conglomerate of stones cemented together by a loess-like clay. Conglomerates of this kind are very common in Turkestan (WALTHER) at the foot of the mountains and higher up in the mountain-valleys.

Where the cement is loess, what was stated about loess as a soil (p. 57) holds good here. But the presence of numer-

ous stones makes the soil still more unfavourable to vegetation because the stones retard the absorption of water, reduce the capillarity and promote the conduction of heat in the soil. On the other hand they act favourably by reducing the evaporation from the surface (RAMANN).

The vegetation will only be described for the more important localities I have seen (all with one exception in summer).

At the base of Sultan Uis Dagħ, an isolated group of mountains near Chiwa (see map), I examined a desert strewn with loose pieces of slate, and dotted here and there with rocks *in situ*. This desert evidently corresponds to what VOLKENS calls "Kieselwüste" WALTHER and MIDDENDORFF call "Kieswüste". As in Egypt, so the desert here was almost devoid of plants. Only in depressions and where the number of stones seemed to be less, did various low undershrubs and dwarf-bushes occur: *Salsola rigida*, *Artemisia herba alba*, *Capparis spinosa*, *Atraphaxis compacta* and *Haloxylon Amodendron*, the latter being low shrubs about half a metre high. Less conspicuous were *Stellera Lessertii*, *Convolvulus fruticosus*, along with *Halimocnemis macranthera* and *Anabasis eriopoda*, two pronounced halophytes. In Ferghana, MIDDENDORFF found about one plant per square foot (l. c. p. 21) on the stone-desert.

The mountain itself, Sultan Uis Dagħ (Sultan Baba-ne Dagħ-e) consists of nearly vertical strata of a greenish clay-mica-slate, often impregnated with quartz. The surface in many places is covered by disintegrated matter, fine yellow clay and pieces of slate with a shiny tawny weathered surface. Everywhere was very dry, even the deserted beds of several streams, which were no richer in vegetation than the rest. The following plants were found scattered widely about: *Atraphaxis compacta*, *Salsola Arbuscula*, *Salsola rigida*, *Capparis spinosa*, *Artemisia* sp., all dwarf or undershrubs, also two withered annuals, a Composite and *Lepidium persicum* (?) and low trees of Saxaul less than a metre high.

At Kis-Kalá, a mountain with a ruined castle, on the right bank of the Amu Darya more to the south, I saw a desert where the soil consisted of very stony gravel and sand.

On this soil *Reaumuria fruticosa* was characteristic, a low bush with closely set minute leaves covered with salt-crystals. Some other species occurred on some small dunes, but these only appeared one at a time on the stony soil. (See chap. 11). The following Lichens were found on stones: *Sarcogyne perileuca*, *Placodium Paulsenii*, *Acarospora interrupta*. At Dana Sher Kalá not far from this place, there was a stony gravel plain with very scattered small bushes of *Salsola rigida* behind which hillocks of sand had drifted; this was the only species.

At Ak-Yar (also on the Amu Darya) there is an undulating plain of loess with splintered pieces of clay-slate and knolls of the same rock *in situ*. The following plants were scattered about, approximately 3 paces apart: *Salsola rigida* and *Arbuscula*, *Reaumuria oxiana*, Saxaul and rarely *Lycium ruthenicum*; all were stunted shrubs less than half a metre high. The herbaceous species included *Salsola carinata*, *Suaeda* sp. and *Lepidium obtusum*. Depressions with a stiff fissured clay were devoid of plants or bore only a few halophytes (*Halocnemum*, *Halimocnemis*).

At Pitnjak there was a gravel plain with *Peganum Harmala*, *Convolvulus eremophilus* and *Anabasis salsa*, very scattered.

At Kisel-Yi also situated south of Chiwa, we found hard clay hills with many white stones, quite bare except in the depressions where there were scattered plants of *Halimocnemis macranthera* (an annual summer-plant with thick leaves) *Salsola rigida*, low Saxaul bushes, *Artemisia*, *Alhagi Camelorum*. The last alone crept up the hillside here and there.

Near Andidshan (Ferghana), very stony loess about a foot thick formed a layer over stones and gravel. Here grew (May 27th) Tamarisks not more than a metre high, *Alhagi Camelorum*, *Crambe orientalis* (?), the thorny and silverhaired undershrub *Convolvulus fruticosus*, *Echinops* sp., *Astragalus* sp., etc.; the visit to this locality was a very brief one.

Other localities were observed where the soil was rock *in situ* or stone, but as these were covered by sand, partly shifting, and as it seemed to me that there the sand was mainly responsible for the character of the vegetation, they are not included here.

These observations indicate that the vegetation of the Stone-deserts is mainly characterised by xerophytic stunted shrubs and undershrubs. Whether spring-plants occur there, I cannot say.

The following are species found only in the Stone-desert: *Convolvulus fruticosus*, *Stellera Lessertii*, *Reaumuria fruticosa* and *Atraphaxis compacta*, all dwarf-bushes or undershrubs with small and flat leaves. The following seem to be common in the Stone-desert, though they also occur in other formations: *Reaumuria oxiana*, *Salsola rigida*, (one of the most frequent) *Arthrophyllum subulifolium*, *Artemisia* sp., *Convolvulus eremophilus*, *Capparis spinosa*.

CHAPTER 9

The Formation of the Sand-Deserts.

The soil of this formation is sand, at least on the surface. The sand varies in origin and age as stated in chap. 2¹), but these differences do not seem to play any essential part with respect to the vegetation (KORSHINSKY p. 8). The different aspects presented by the sand are of greater interest to the botanist. These have been described by MUSHKETOW, RADDE and SEMENOW, and the following survey of the various sand-landscapes is based on the observations of these authors.

1. Barchans, crescent-shaped, dirty yellowish or fawn-coloured dunes of inland sand. MUSKETOW states that they are generally 30—40 feet (ab. 9—12 metres) high, and may attain a height of a hundred feet (ab. 30 metres). SEMENOW gives 40 metres but I have rarely seen any higher than 10 metres and RADDE gives 30—35 feet (ab. 9—10 metres) as the maximum. The sand-grains are rather small. RADDE (1899, p. 16) gives 0.2—0.3 m. m. as the average size for Barchan-sand and Sand-steppe sand from Amu Darya and Kara

¹) See moreover ROMANOWSKI p. 52.

Kum, and at Dshideli MUSHKETOW found Barchan-sand with grains not exceeding 0.1 millimetre.

The sand always, in the Barchans and elsewhere, consists of quartz. A little mica is found in it, also varying quantities of clay (up to 30—40 per ct. on barchans in dry river-valleys), and frequently iron, small quantities of gypsum, calcite, etc. (RADDE 1899 p. 16).

The form of the Barchans has already been described (p. 7). RADDE's comparison of a barchan-landscape to a frozen stormy sea is a good simile except that waves are not regularly crescent-shaped. Standing on one of the summits and looking towards the north so that the concave sides of the barchans are turned towards one, this imposing waste is most awe-inspiring. As far as the eye can reach wave rises behind wave, crest behind crest. The barchans arise irregularly, often several in a group, their flanks blending so that the sharp crest-lines undulate up and down, in and out. Even a gentle breeze raises the fine sand from every crest, and the brownish sand-smoke from the bare dune-summits adds an additional weirdness to the waste landscape.

As the prevailing winds are northern or north-easterly the sand migrates towards the south and west and crosses the Amu Darya. This will be further dealt with in chap. 11.

2. Hummock-Desert, Hummock-Sand (in RADDE "Hügel-sand", in SEMENOW "désert de sable mamelonnée"). Rounded hills, quite low or fairly high, up to about 10 metres, with basin-shaped hollows between them, and with no windward and lee side. They are stationary dunes with a comparatively rich vegetation.

3. Desert of the sand-plains ("Sand-steppe", "steppes sablonneuses"), flat or somewhat undulating areas of sedentary sand.

4. Dune-chain sands ("Ketten-, Reihen-, Wall-, oder Streifen-sand" of RADDE, "déserts de sables en sillons" of SEMENOW). Parallel sand-hills formed by the grey or white sand of present or past times. Between the chains are valleys, ab. 45—200 metres (150—700 feet) wide, the soil of which is bare clay (Takyr). The valleys are crossed by lower dunes which run transversely to the main dune-chains. Dune-chain sands

are mostly found in the northwestern part of the lowland. They are comparatively well covered with switch-like desert-shrubs, *Carex physodes*, etc., and the sand-drift is of no great importance.

5. "Dunes", or recent accumulations of shifting greyish or white sea-sand occurring mostly along the coast of the Caspian, and generally arranged in chains which follow the direction of the wind.

Dune-chain sands and recent dunes, both formed by white or grey sea-sand, I have not seen, hence they are here left out of consideration, and only the different forms of inland-sand are dealt with.

The first point to be considered is sand as a soil for plants in comparison with clay.

In dry countries sand is, in some respects, more favourable to vegetation than clay.¹⁾ Water is quickly absorbed so that it has no time to evaporate. Less water will evaporate from a rough, coarse-grained surface of sand than from an even, fine-grained surface of clay. Because of the slight water-holding capacity of sand, the water is carried to greater depths, whence it does not rise easily to the surface owing to the poor capillarity of sand. The evaporation-surface of the water will therefore be situated down in the earth where it is protected by the overlying drier layers of soil (comp. LIVINGSTON 1906). Deep sand is a soil which suits plants with very long roots. The switch-shaped trees and shrubs generally occur here.

Though sand can absorb much less water than clay (14.3 per ct. of dry weight, loess 59.3 per ct. according to CLEMENTS, p. 34), almost all the water absorbed is available for the plants: "Echard" is only 0.3 per ct., "Chresard" 14 per ct. (comp. above p. 58). The figures vary of course somewhat according to the properties of the sand, especially the size of the grains (LIVINGSTON 1905), but I am not aware

¹⁾ *Fitting* (p. 251) also finds that the sand-plants of the Sahara have a lower osmotic pressure than the plants of the stone-deserts even when they belong to the same species.

that investigations on these conditions have been made in Transcaspia.

Where the sand forms a stratum over the loess it becomes of special importance. The water from precipitation will be let down through the sand into the upper layers of loess, whence it cannot evaporate because protected by sand, and yet it is still available for the roots of plants, if the sand is not too deep. The natural conditions are here specially favourable, and it is on sand over loess that the most luxuriant desert-vegetation is found during summer (see chap. 11). These conditions are now successfully imitated by man. In the dry parts of North America "dry farming" is conducted, the principle being that the subsoil, by the aid of special implements, is always kept solid, so that it can raise the water, while the surface-soil is kept loose so that it can protect the subsoil and itself lose the least possible amount of water through evaporation (see MATENAERS).

Though sand is more easily leached than clay, the underground water in the sand-desert is almost always salt, and gypsum crystals frequently occur in quantity at a depth of $\frac{1}{2}$ —1 metre (PALEZKIJ p. 36). Many of the sand-plants are also halophytic in structure.

Where no water is present the desert-sand is an exceedingly hot soil, all the more as it is not white but brown. The expedition recorded 53° C. on a summer's day just below the surface, but even higher temperatures might certainly be found.

Sand is more unfavourable to vegetation than clay, in this respect, that the sand is moveable. Sometimes the roots of the plants are laid bare, sometimes aerial shoots are buried, either of which conditions may kill the plant. The drifting sand-grains may also bruise young or unprotected plant-tissues and in this way cause injury. This has already received attention in the literature on European dunes, e. g. WARMING 1909.

The following description of the vegetation of the Sand-desert deals first with the more shifting deserts, afterwards with the stationary types. The desert is described in its

summer-aspect; then in its spring-aspect, which greatly reminds one of that of the clay-desert.

In the more shifting deserts there are areas with nothing of interest to the botanist. Hills and valleys of sand, not even a stone, nothing but sand. This is sorted out by the wind, the coarser and darker sand covers the gentle slopes of the windward side and the crests of the wind-billows, while the finer and lighter sand is found on the steeper lee side and in the valleys. These variations in shade increase the relief of the surface.

The first pioneer of the vegetation is "Selin", *Aristida pennata* Trin.¹⁾, so aptly called by ANTONOW the Conqueror of the Sand-desert.

Aristida pennata takes first place as a sand fighter. It grows quickly, and gives off many roots, many leaves, many branches, while its internal structure enables it to endure drought and sand-drift. It is more fully described later (chap. 13), but features of its biology may be indicated now.

After germination it forms a number of basal scale-leaves through whose sheaths the fibrous roots break out. The foliage leaves follow on short internodes so that their sheaths form a "Tunic" (HACKEL), the one sheath lies over the other, with only a short apex free, so that the expanded leaf-blades are close-set one over another. In the axils of the scale-leaves lateral shoots quickly appear covered by their "tunics". The young plant thus forms a close tuft with the oldest shoots in the middle (fig. 9), and as the tufts grow older they become coarse leafy tussocks half a metre or more in diameter. When the sand drifts over, the plant pushes upwards with longer internodes, and new lateral shoots with basal roots are continually being formed, so that the plant is fixed in the sand almost right up to the surface. The lateral shoots

¹⁾ This plant has been named at different times *A. pungens* Desf., *A. pungens* var. *pennata*, *A. pennata* and sometimes it has been regarded as two species *A. pennata* and *A. pungens*. It is certainly closely related to the Sahara form *A. pungens*, being distinguished from it mainly by its more slender growth and by longer branches of the panicle. I do not think there is any reason for calling specimens with shorter panicle-branches *A. pungens*. The Transcaspien specimens are certainly all the same species

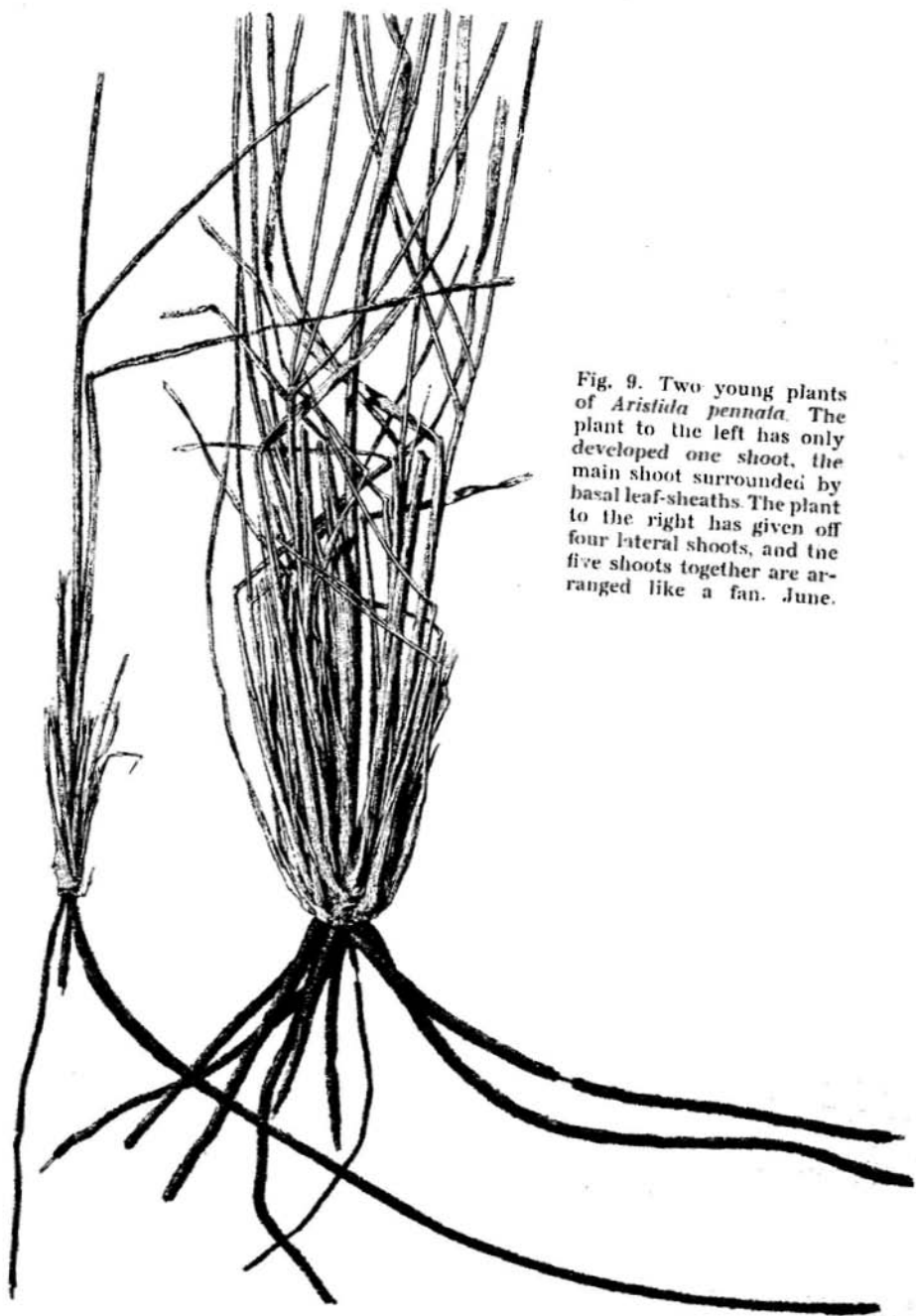


Fig. 9. Two young plants of *Aristida pennata*. The plant to the left has only developed one shoot, the main shoot surrounded by basal leaf-sheaths. The plant to the right has given off four lateral shoots, and the five shoots together are arranged like a fan. June.

continue to grow and to struggle against the sand after the older main shoots have flowered. Horizontal runners are not formed, so far as I know. According to PALEZKIJ, *Aristida* forms two kinds of roots, long horizontal anchoring roots, and shorter perpendicular absorbing roots. The roots are protected by a "sand-stocking" or cover in which the other root-tissues are loosely enclosed. The leaves are able to roll up like those of *Psamma*, and have green tissue on the protected upper surface.

In the shifting sand-desert, all other vegetation is dependent on the presence of *Aristida pennata*.

This plant is not merely a sand-binder, but plays an even more important part because its dense tufts are practically the only place, where seeds of other plants can secure a foothold. PALEZKIJ has drawn attention to this fact, and I have frequently observed, that the fruits of the switch-bushes find a resting place in the *Aristida* tufts where they are retained amongst the leaves and shoots and are frequently covered by sand. These fruits easily roll about in the wind so that they would hardly ever germinate in the shifting desert if it were not for the tufts. In more stable parts, the conditions are more favourable and there is generally sufficient vegetation for the fruits to establish themselves.

The plants which come next after *Aristida*, and perhaps some of the annuals, are the switch-bushes, a very characteristic type. In the sand-desert the most hardy is the Sand Acacia (*Ammodendron Conollyi* (fig. 10) and *Karelini*). It occurs as slender trees or low shrubs standing hundreds of metres apart. Grey in colour, it has small narrow leaves thickly coated with silky hairs, and light passes through the crown so that only a slight shade is cast (see LIPSKY 1911 tab. 1). In the valleys between the barchans it may form a tree with a trunk and elegant hanging branches, but sometimes where the barchan has swept over the trees only the tops of the crowns are seen protruding above the sand. The strength of the Sand Acacia lies in its height, its long roots (19 metres, PALEZKIJ) and its small leaves.

If this plant can hold its own and produce seeds from the butter-coloured one-seeded samaras which ripen in May,



Fig. 10. *Ammodendron Conollyi*. A flowering branch (on the left) and a fruiting branch (June). The dead axes of the inflorescence complete the year-growth of this shoot.

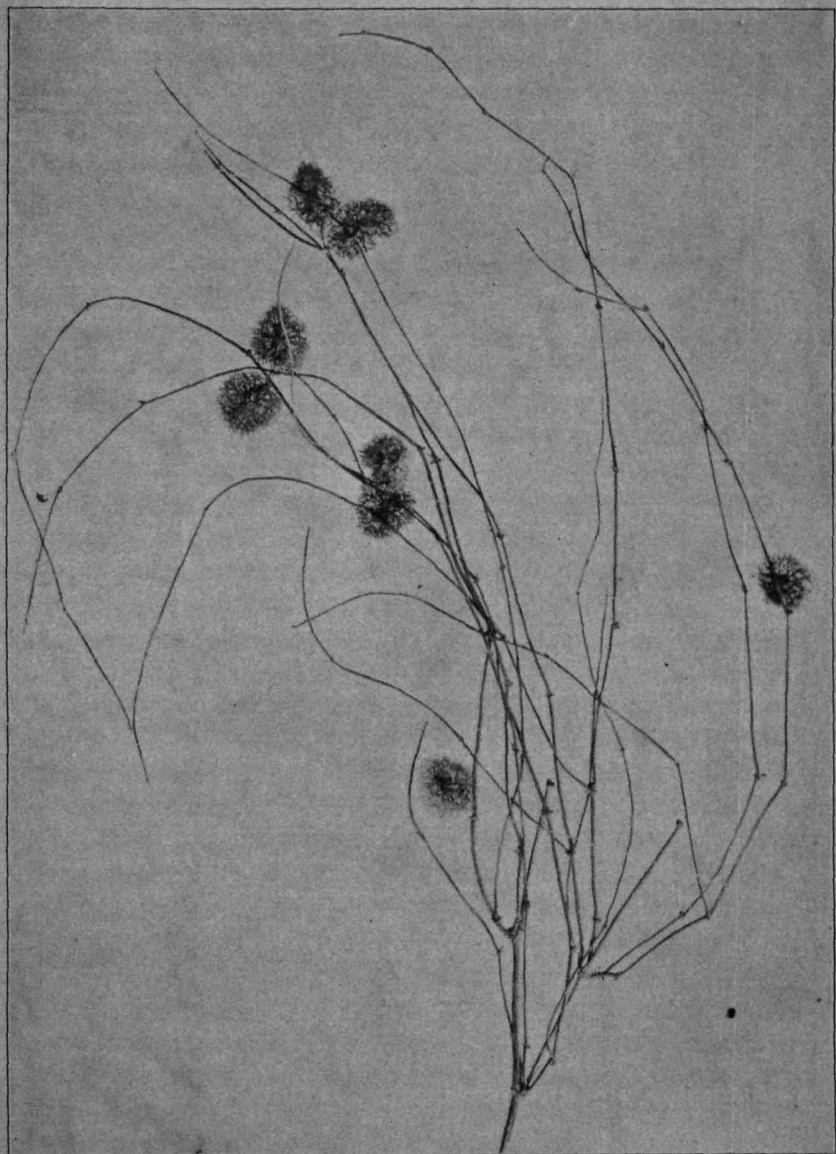


Fig. 11. *Celligonum Caput Medusae*. Fruit-bearing branch, which has lost some of the fruits. End of May.

and if these are allowed to germinate, then the vegetation (if such a word can be employed) becomes by degrees somewhat denser and other species appear. First and foremost come other switch-bushes: *Calligonum*, *Salsola Arbuscula* and *subaphylla*, *Eremosparton*, Saxaul and sometimes *Ephedra alata*. A desert covered with these shrubs is a most characteristic sight; to describe it the following lines by KORSHINSKY l. c. p. 4) may be cited:

"They are bushes or small trees, from 1 to 4 or 5 Arshins high (0,7 — 2,8 — 3,5 metres¹⁾, very characteristic both in their appearance and in their mode of growth. Their stems as a rule are short, bent and often very irregularly shaped on account of deep and long furrows. The branches are generally white or greyish, the leaves narrow and greenish-grey. Frequently there are no leaves at all, and they are replaced by the young branches which contain chlorophyll. Most of these ligneous plants grow very slowly and have an exceedingly hard but brittle wood, this is especially the case with Saxaul. These low trees stand widely apart, they do not cast the least shade, so that the soil under them is almost as dry and unfertile, almost as scorched by the rays of the sun as if there were no trees at all.

No comparison is possible between this bushland and forest or scrub in temperate areas, and on the whole none of the expressions used in literature or science are adequate to describe them. They form a special type of vegetation, so unique and characteristic that I cannot believe it will ever fade from the memory of any one who has had a single opportunity of seeing it."

Only two of the switch-like trees and bushes have a luxuriant green appearance. They are *Salsola Arbuscula* and *S. subaphylla* (figures 12 and 13), especially the former. This plant has already been described (chap. 6) as frequent in dry clay-deserts, where it is a dry, stiff, prickly bush about half a metre high with short hard shoots and stiff plump leaves.

¹⁾ This description deals with vegetation on more stable soil where the trees and bushes are lower. O. P.

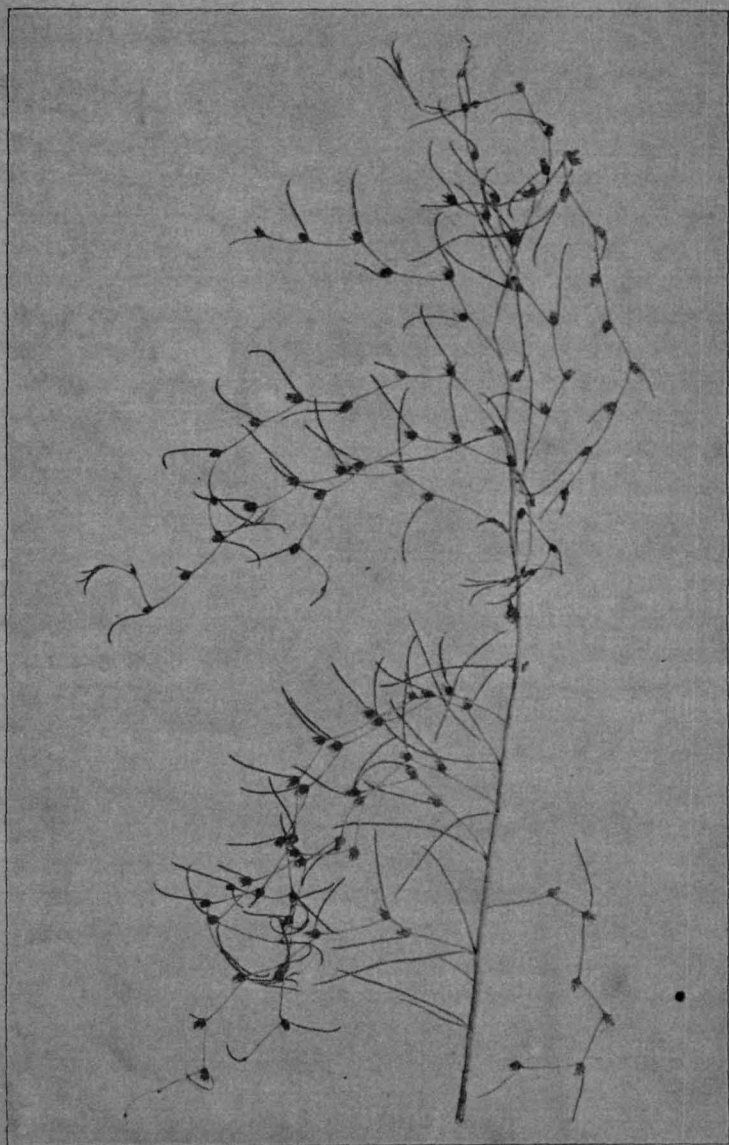


Fig. 12. *Salsola Arbuscula* var. *longifolia* (The Sand-desert form). Part of a year's shoot with flowering branches. September.

But when it grows in the moving-sand desert, it becomes a small tree, more than 4 metres high, and with long, pliant shoots and leaves (comp. fig. 12 and fig. 38). The foliage is comparatively rich; it is a green tree sufficiently dense to cast a shade.

The plant is very hardy and can endure being covered by sand, a process which only hastens its already precocious growth, and (according to PALEZKIJ) roots are formed from the buried parts of the stem. He also states that he has measured roots 15 metres in length, many of them horizontal. Whether suckers are formed from them I do not know. I have seen a tree from which the sand had been blown away, so that it had fallen and lay on the slope of a dune with some of the branches buried. The plant, however, was perfectly fresh, still fixed by its roots and it had given off new roots from the buried branches.

Salsola subaphylla is somewhat similar in appearance, but has coarser and less dense foliage and neither in height nor age does it come up to the other species. Somewhat saline soil is the most favourable for this plant.

Both species blossom freely in the late summer and in September they bear large clusters of broad-winged perianths carrying the fruits.

These two species, particularly the former, play an important part in the operations for binding the sand along the railways.

Calligonum (figures 11, 27, 28) and *Eremosparton aphyllum* (figures 23, 24) are both leafless i. e. the leaves are reduced to quite small scales, and both are shrubs or small trees attaining a height of about 4 metres. They have long roots (PALEZKIJ measured roots of 4₂₅ metres in a year-old specimen of *Calligonum Caput Medusae*) and both plants can form root-suckers.

They are both sand-plants — *Calligonum*, however, not exclusively — and they endure the sand-drift very well. Of the many species of *Calligonum* (see list in chap. 12), *C. Caput Medusae* is the most important. It flowers in May or June and already in June one finds the curious globular reddish fruits set along the slender twigs. The fruits are achenes

twisted like a screw and with several rows of long many-pronged bristles spread out in every direction and quite stiff when ripe. The fruit thus appears as a kernel set in the midst of a globular transparent meshwork, the diameter of the whole being 2—3 cm. (See fig. 28). These fruits are exceedingly mobile and roll away at the slightest breath of wind.

The fruit of *Eremosparton* is a one-seeded woolly-haired pod, one centimetre long. The red blossoms open in May or June and form small racemes, but only the earlier blossoms set fruit as the later ones are shrivelled up by the heat.

Saxaul or Sasák (*Haloxylon Ammodendron*) (fig. 14) only thrives well where the sand has a subsoil of clay or limestone. Under favourable conditions it may become a tree of 7 metres. Often, however, it is a much-branched shrub. As the growth is slow, this species does not stand sand-drift very well, and the young, soft, leafless shoots are also bruised and damaged by the sand-grains¹).

These switch trees and bushes have the following characters in common (other details of morphology and internal structure are given in chap. 13). They are small trees or bushes; the Sand-Acacia and Saxaul occasionally become larger trees (8 metres).

All of them have their leaves much reduced. *Ammodendron* has flat leaves, but they are small and thickly coated with silky hairs. The *Salsola* species have cylindrical chenopodiaceous leaves with central water-tissue. In *Calligonum*, *Eremosparton* and *Haloxylon* the leaves are reduced to small scales, and the assimilatory functions are performed by the stems alone.

The first-year shoots are frequently branched, sometimes

¹) Saxaul is said to form vast bushlands ("forest", comp. LIPSKY above p. 28) east of Lake Ara¹ (Wladimirskaja). The trees here are said to attain a height of 16—18 feet and have a thick tap-root. Saxaul often occurs here together with rushes and is supposed to stand in a certain relation to the Syr Darya (Jaxartes) inundation area. "The Saxaul forests everywhere begin as a low thorny scrub along with Tamarisks, then they become bushlands and finally forests." (MIDDENDORFF p. 308). — LIPSKY (1911 p. 14) denies that the growth of Saxaul is necessarily slow.

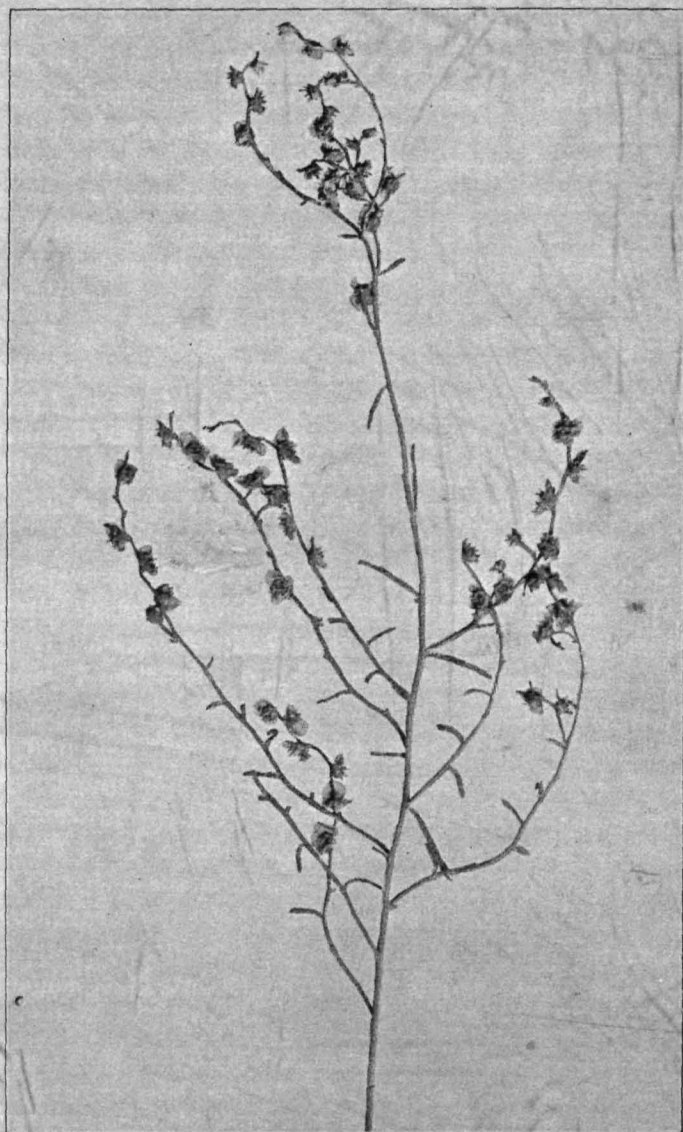


Fig. 13. *Salsola subaphylla*. Part of a year's shoot with branches. The fruits are ripening. September.

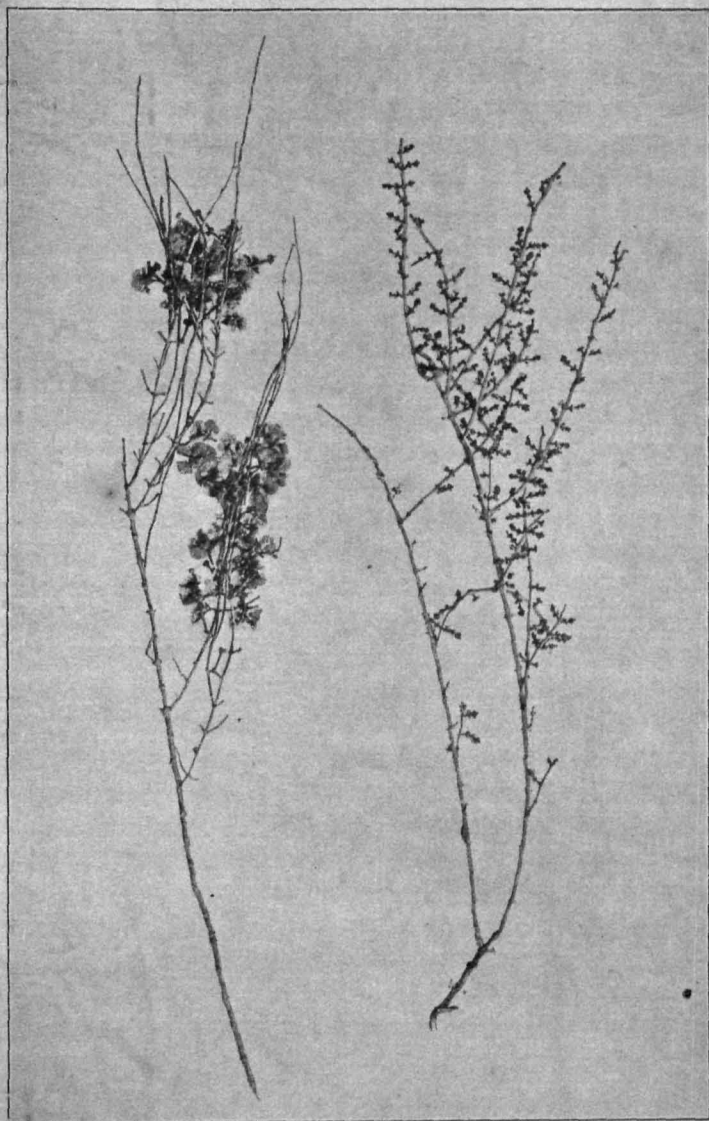


Fig. 14. *Haloxylon Ammodendron*. Fruit-bearing branch and flowering branch.
November and April. (Afghanistan).

bearing several series of branches. The vegetative branches are annual like the floral ones, and may therefore biologically be regarded as leaves which fall off at the end of the vegetative period.

The perennial as well as the annual branches are often closely bunched together owing to the formation of new branches year after year at the same place. The younger branch-tips are often pendant and wave in the wind (*Ammodendron*, *Haloxylon*, *Salsola Arbuscula*).

They have all long roots. The fruits in every case contain one or at most a few seeds, and are so formed that they fly or roll easily before the wind, hence one finds them massed together in sheltered places.

To the bushes and trees given above for the Sand-desert, the following may be added which like Saxaul are rather plants of clay soils and do not thrive so well on pure deep sand: *Smirnowia turkestanica*, *Astragalus Ammodendron*, *paucijugus*, *unifolius*, *Ephedra alata*, Tamarisks and probably others.

The switch-shaped trees and bushes (and *Aristida*) are however rarely the only living plants in the Sand-desert. Between the dunes where there is a certain amount of shelter, the soil in many places is sufficiently stabilised for the growth of hardy herbaceous plants. These are not places where there is clay soil between the dunes — such belong to the formation of the clay-desert, — but where there is sandy soil somewhat sheltered and therefore not shifting. Here grow a number of annual and perennial herbs which are more xerophytic and less halophytic in type than the clay-plants. They occur scattered about, and frequently they have a hard struggle for existence where the sand blows away or drifts over them.

One of the most frequent is *Heliotropium Radula*. This like *H. sogdianum* which also occurs, has a thin horizontal rhizome, sometimes of considerable length (2,5 metres and more), and lying close under the sand-surface; it puts forth numerous aerial shoots, which generally form hairy leaf-rosettes arranged in a row, similar to the rosettes of our *Carex arenaria*. (Fig. 63). Long-jointed shoots bearing inflorescences

may also be found. The rhizomes are sometimes laid bare, one I saw being 132 centimetres long and only attached at one end, but still living. When the plant is buried by sand, a new aerial shoot is formed from an axillary bud of one of the higher leaves and terminates in a rosette on the sand. (Fig. 22). But these shoots do not endure the sand-drift very well, and I have seen specimens buried again which were dead. The long rhizomes may be regarded as a means of defence; with the aerial shoots widely distributed there is always a possibility that some of them may escape destruction by the sand-drift. The hairs on the leaves also probably give some protection against bruising by sand.

Living in the Sand-deserts are also a number of plants of the type of *Salsola Kali*, i. e. spiny hard plants with a limited amount of assimilation tissue. These include both annuals and perennials, mostly the former. The following are the most noteworthy amongst those I have seen.

Horaninowia ulicina (fig. 70) is an annual. From the summit of the long straight lignified root, there arise a number of stems 20—30 centimetres in length, which lie on the surface of the ground. The leaves are opposite, acicular and spiny, and bear in their axils dwarf-shoots or long-shoots. The dwarf-shoots appear as bunches of thorns (see figure 70) and when long-shoots are formed they bear the groups of thorns. Should this plant be covered by sand, the dwarf-shoots elongate and become long-shoots, which struggle to reach the light, while the main-shoots may be seen to change their direction and to grow obliquely upwards, until they again emerge above the surface.

In more favourable places the species has longer leaves and is more erect (*var. longifolia*). The leaves and young stems are coated with stiff, viscous hairs amongst which sand-grains are often retained; these hairs must limit the mechanical effects of the sand-drift.

Agriophyllum minus (fig. 72) is also an annual. Large specimens become strongly branched. The leaves are grass-like flat, dry, multicostate, stellate-haired and thorny-pointed; all bear dwarf-shoots like bunches of thorns, or long-shoots which carry the thorny shoots. The leaves more especially

the lower ones die early, but the axillary shoots remain active (Translocation of water).

Closely related to the last is *Agriophyllum latifolium* (fig. 74). The chief difference is that this plant has broad, opposite ovate or almost circular leaves with long stalks, and the primary vein terminates in a thorn. The upper leaves all show transitions towards the narrow, grass-like leaf of the preceding species. All the leaves support long-lived bunches of thorns as in the former species.

Salsola Kali also belongs to this type together with the allied species, *S. sogdiana* (fig. 76) and *aperta*, also *Cornulaca Korschinskyi* (fig. 68) and *Arthrophytum subulifolium*, all thorny-leaved, stiff, branched plants, and annuals except the last which is an undershrub. *Acanthophyllum elatius*, an undershrub with prostrate branches and stiff, thorny leaves, should also be included here. *Ceratocarpus arenarius* (fig. 66), frequently a clay-plant, may also be found on sand; it is exceedingly branched and thorny and is generally globular in shape. The parenchyma dies away, but the midrib remains as a long, pointed thorn (comp. above p. 72 and chapt. 13).

Convolvulus erinaceus, an undershrub very abundant locally in the Sand-desert, also assumes the globular form. In spring it has true narrow foliage leaves at the base, but later on only scales are present and the work of assimilation is entirely carried on by the branches. The first-year shoots are strongly branched and geniculate at the nodes, and their branches of the later (1—2—3) sequences are thorns which bear a single flower. The plant forms a leafless thorny ball, it can attain a height of 40 centimetres and has very long roots. I have seen pieces several metres long, laid bare above the sand, and although only fixed at one end they were giving off fresh shoots. If the plant is buried the upper branches grow upwards through the sand.

Convolvulus eremophilus has a similar structure, but it is less strongly branched and less thorny.

Euphorbia cheirolepis an annual plant with small, bright green and glossy, spatulate and spiny toothed leaves belongs to another type. The same green colour distinguishes the vigorous, broad-leaved and very thorny *Cousinia annua* which

attracts attention by its glossy snow-white stems. This plant I found in a deep valley amongst the dunes on a shifting sand-desert almost devoid of vegetation; there were only a few specimens and only in this particular valley. This illustrates the very scattered occurrence of the various species; one must examine a great number of localities before a thorough knowledge of the flora of the desert is acquired. Each locality presents only a few species of trees, shrubs or herbs. Other examples of this will be referred to in chap. 11.

It will be seen from the above description that the flora of the shifting Sand-desert is extremely poor. Looking over the desert from the top of a barchan, the eye is attracted by the scattered rough tussocks of *Aristida* and the switch or brush-like dwarf trees and shrubs, standing widely apart, particularly *Ammodendron* and *Calligonum* the most frequent and most enduring.

Only on closer examination does one find the herbaceous plants which hide in the valleys. These plants, already referred to, are ill-adapted to withstand sand-covering and are often smothered. But they endure desiccation, heat and the tear and wear of the drifting sand. This tear and wear is perhaps the reason why the plants of the more stable sand-desert are very rarely seen in the true shifting desert.

From the shifting sand-desert where the barchans hold their sway, we turn to a more stable type of sand-desert, the Hummock-desert (see p. 78), which RADDE compared to a dead sea with a swell on, and which he regards as a transitional form between the barchans and the flat deserts. The sand hills are round and generally rather low, RADDE states from a few feet up to 4—5 fathoms, i. e. about 10 metres at the most, which is, however, a considerable height. Where the hills are grouped closely together, the valleys between them are basin-shaped. Smaller crescent-shaped barchans may be present so that the sand-drift is not everywhere perfectly stabilised. The movement must however be slight in many parts, as indicated by RADDE finding on the hill-tops a lichen (*Urceolaria indurata* Wain.), a thin black and white coating over the surface of the sand.

The vegetation consists partly of the same species as on

the barchans, but they are differently developed, the trees and shrubs being weaker while the herbs are stronger. Another part of the vegetation consists of more exacting species including halophytes which grow in the valleys.

I look on the vegetation of the Hummock-desert as a sub-formation of the formation of the Sand-desert.

The vegetation is richer than on the barchans. The desert switch-plants are closer together than on the barchans, but they are smaller and generally take the form of shrubs, not trees. In such a Hummock-desert I found the average height of the bushes to be 2 metres and the distance between them from 7 to 20 metres. The conditions for germination are better, hence the greater density; on the other hand that acceleration of growth brought about by drifting sand is lacking, hence the smaller size.

The Sand Acacia (*Ammodendron*) is rarer here, while of general occurrence are *Salsola Arbuscula* and several species of *Calligonum* (these are difficult to determine without fruits). Amongst other plants present are Saxaul, *Eremosparton*, *Smirnowia*, bushes of *Astragalus*, and *Nitraria Schoberi* (which sometimes causes the formation of small dunes); *Lycium sp.* and *Reaumuria oxiana* are both halophytic bushes, generally occurring on clay, but also found in the lower parts of the sand-desert. Tamarisks occur on peculiar knolls of stratified sand which originate as follows: every year the Tamarisks cast numerous small twigs and flower-stalks over which a layer of sand drifts next summer; then comes another layer of branches and so on. The layers are generally exposed all the way round, and the slopes of the hill are more or less perpendicular. These low hills are generally circular, or the larger ones are elongated in the direction of the prevailing wind; their height is 2—4 metres. The bushes on them vary from half a metre to 2 metres high, and frequently have old and thick roots, which are exposed where the wind has destroyed the hill. On the other hand, hills of this kind may be buried in blown sand.

These Tamarisk-knolls are presumably remains of a former continuous tract of sandy soil now blown away except where the roots and shoots of the Tamarisks have

kept the sand at the old level. MAC DOUGAL (1908 pl. 2) gives a picture of a sand-hill formed in the same way by a species of *Rhus*.

All the herbaceous plants given for the shifting desert occur in the Hummock-desert, where they live under more favourable conditions, because less exposed to burial by the sand or to exposure by denudation. Amongst other herbs occurring in the Hummock-desert the most important is *Carex physodes* which, though mainly a spring-plant, yet plays a considerable part throughout the summer. It is a hemi-cryptophyte with sympodial, horizontal rhizomes, which together with the branched roots form a network in the surface-soil (fig. 15). The growth is so dense that during spring *Carex physodes* forms a green-sward in places. In June the leaves have already withered, and the resting summer-buds are hidden in a tunic of dead leaf-sheaths. The plant plays a prominent part in binding the sand, but it cannot contend against a severe sand-drift. This plant and *Aristida pennata* do not thrive together because the latter is only luxuriant in shifting sand, *Carex* where it is stable.

Alhagi Camelorum is very common in many parts of the stable desert. It spreads vegetatively by aerial shoots produced from long, horizontal roots. The part above ground is annual, poorly provided with leaves, thorny and often globular. It is very hardy, and when buried it forms new aerial shoots from the leaf-axils of the old shoot, while if the sand is blown away, new aerial shoots arise from the subterranean parts. *Alhagi* may occur as a plant of the dunes under apparently unfavourable conditions, but it seems to depend on the ground-water not lying too deep. Like many other plants in the neighbourhood of oases, it is used for fuel.

Other plants in the Hummock-desert are: *Tournefortia sibirica*, similar in habit to a *Lithospermum*, rather strongly hairy, with white blossoms and light fruits which the wind gathers together in sheltered places; *Convolvulus divaricatus* is woolly-haired with small cordate leaves; *Pluchea caspica* and *Jurinea derderioides* are thin-leaved knap-weeds; *Goebelia pachycarpa* is one of the *Papilionaceae* with pinnate hairy leaves; *Haplophyllum obtusifolium* is a bright green glabrous



Fig. 15. *Carex physodes*. April (nat. size).

undershrub with an offensive smell; *Artemisia*, an undershrub, and *Peganum Harmala* one of the *Zygophyllaceae* with a thick tap-root and prostrate branches. These species are all xerophytic in structure, but at the same time somewhat mesophytic since they are all comparatively leafy. The following species occurring in the lower sandy basins are halophytic in structure. *Cressa cretica*, a geophyte with salt-excreting leaves, *Zygophyllum*-species with thick leaves, *Tetradiclis tenella*, *Halimocnemis*-species, *Halanthium gamocarpum* and *Lipskii*, *Salsola crassa*, *spissa*, *sclerantha*, *Halostachys caspica* and *Euphorbia Turczaninowii*, the latter with thick glabrous foliage. Most of these are annuals (summer-annuals); *Cressa*, *Zygophyllum* and *Halostachys* are perennials. All except *Cressa* are stem-succulents, leaf-succulents or bracteole-succulents. Some are the same species met with in the clay-desert, and they all belong to the same types seen there. The lower saline parts of the Hummock-desert are thus very closely related to the clay-desert, as regards their vegetation; the two are scarcely distinguishable except by the soil.

In this connection we may quote a description by RADDE (l. c. p. 154) of the sand-areas near the border of Afghanistan (July 8th):

“Diese alten festen Sandberge ernähren keine Strauchart welche auf dem jüngeren zumteil noch wogenden Sande die ersten Bedingungen zum Haften desselben darbieten. Nur wo entblösster, beweglicher Sand lagert, finde ich wenige, schwächliche Exemplare von *Calligonum polygonoides* Pall¹⁾. Auf der ganzen Strecke sahen wir meistens eine Unterlage von jetzt vollständig vergilbter *Poa bulbosa*, welche die Pferde dennoch gerne fressen. *Alhagi Camelorum*, typisch und in einer niederliegenden Varietät in grau-grünen Kolorit wechselt mit *Peganum Harmala* ab. Beide bevorzugen den mehr lockeren Sandboden, auf dem alten festen werden sie schwächer und seltener, diesen liebt *Prosopis Stephaniana*, weite Strecken sind von ihm bestanden, dazwischen etwas *Heliotropium dasycarpum* und überall gelbes *Delphinium camptocarpum*, welches von der Sonne

¹⁾ *C. Pallasia* l'Hér. O. P.

zur Blütezeit getrocknet wurde, so dass die Blumen beim Berühren alle abbrachen und keine Samen gebildet wurden. Andere Gebiete sind mit einer lebhaft gelbgrünen, ausdauernden *Artemisia* (*Art. campestris* L.?) bestanden. Rasch durchlaufendes Feuer, welches die spärlichen *Poa*-Grasflächen vernichtete, beschädigte diesen Wermut mehr, als die senkenden Sonnenstrahlen, er treibt nun oben, wo das Feuer ihn verschonte. Eine hohe *Composite* (*Cousinia Raddeana* C. Wnk.) ist schon ganz abgetrocknet, sie wählt die Gehänge zum Standorte, der Wind verwehte weithin die abgebrochenen untenher weisfilzigen Blätter und Blütenstengel. In Löchern und Windstillen bilden diese sammt *Alhagi* grosse Haufen von totem *Burian*. Das duftende, wollig bedeckte *Lachnophyllum gossypinum* Bg. blüht noch nicht, erreichte bis 1 Fuss Höhe und brach aus dem abgesengten Boden überall aufs neue hervor. Eine hohe *Malva* (*Alcea sulphurea* Bois.) besteht in gedrängter Anordnung die östlich gekehrten Gehänge des Kuschk-Ufers, sie könnte prachtvolle Malwengarten bilden, wenn nicht auch an ihr die Sonnenstrahlen ihre vernichtende Macht geübt hätten, Blumen und Knospen sind vertrocknet. Als sechster Florentypus ist noch die stinkenden *Psoralea drupacea* Bg. zu erwähnen, welche namentlich in den Thalmündungen ausschliesslich bedeutende Strecken besteht."

From a botanical point of view the Hummock-desert is closely related to the Desert of the Sand-plains, the one which RADDE and SEMENOW call Sand-steppe and which the former author compares with "an almost calm sea". The type of landscape, as expressed by the name, is flat or slightly undulating expanses of sand. In places they are interrupted by bare "Takyr"-depressions or by moving-sands. The switch-shrubs are locally the dominant vegetation as in the hummock-desert; the same species, but here of still smaller stature, seldom higher than a metre. In other places there are no shrubs, except perhaps isolated bushes of *Salsola subaphylla*, and the vegetation consists then mainly or exclusively of herbaceous plants interspersed with a few dwarf-bushes such as *Prosopis Stephaniana* and *Lycium turcomanicum*. Most of the herbs take part in the spring-aspect described

later. The summer-vegetation on the whole has the same character as that of the hummock-desert, yet my impression, without having seen many localities of this kind, is that the annual *Chenopodiaceae*, more especially the succulent ones play here a minor part; this would be natural, since low and therefore saline places will rarely occur in an area which is almost level.

The minor place taken by annual succulent Summer-

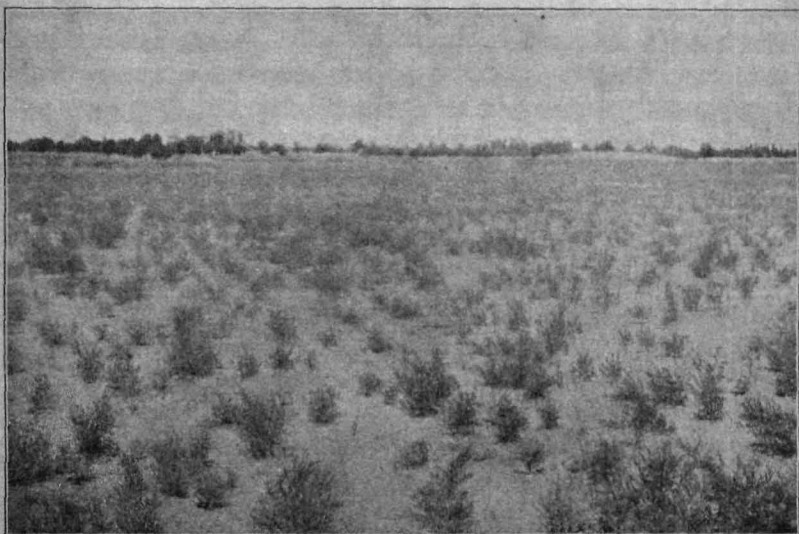


Fig. 16. A sandy and uncultivated area called "Reksar", near Buchara. *Alhagi Camelorum*, *Zygophyllum Eichwaldii*, *Peganum Harmala*, *Goebelia alopecuroides*, fewer *Suaeda pterantha*, *Salsola sclerantha*, *Atriplex dimorphostegium*, *Ceratocarpus arenarius*. May.

Chenopodiaceae in the level Sand-desert indicates some difference between this and the Clay-desert. As to growth-forms the two resemble each other, in having low shrubs, perennials, and ephemeral and other spring-plants.

The most common plants in the Sand-plain desert are *Alhagi Camelorum*, *Goebelia alopecuroides*, *Zygophyllum Eichwaldii* and *Peganum Harmala*. Fig. 16 shows a vegetation where these four species take the principal part, especially *Goebelia* with its multipinnate, white-haired leaves.

Other Summer-plants are *Kochia prostrata* and *stellaris*,

Bassia sedifolia, *Heliotropium Radula*, *Elymus sabulosus*, *Suaeda dendroides*, *Salsola sclerantha* and other species of *Salsola*, *Ceratocarpus arenarius*, *Cressa cretica*, *Haplophyllum* sp., *Artemisia*, perennial *Astragalus* spp., and the species of *Convolvulus* already mentioned. What was said about *Carex phytodes* under hummock-desert also holds good here, namely that, although a spring-flowering plant, it plays a part during summer in binding the sand by its rhizomes and roots.

The vegetation of the desert of the sand-plains may be comparatively dense (see fig. 16), but in other places, the plants are much more scattered; the plain may indeed be so bare that one must search for the plants. In spring, however, there is always a richer vegetation.

The majority of the species are the same as in the other forms of Sand-desert (sub-formations) and so are the growth-forms. In addition to small shrubs, the following types of herbs are found: thorny species (*Alhagi*, some species of *Salsola*, *Ceratocarpus*), hairy species (*Goebelia*, *Kochia*, *Bassia*, *Heliotropium*, *Salsola sclerantha*, *Artemisia*, *Convolvulus*), the succulent species are of minor importance (*Suaeda*, *Salsola*). Most of the species are perennials or undershrubs; the latter include *Kochia prostrata*, *Suaeda dendroides* (?), *Artemisia* and some species of *Convolvulus*. *Kochia stellaris*, *Bassia*, species of *Salsola* and *Ceratocarpus* are annual summer-plants.

If a survey is made of the distribution of the growth-forms, more especially that of the annual summer-plants of the Sand-desert, it will be found that the annuals constitute the majority of the plants in the Shifting-desert, and a much smaller proportion in the Desert-plains. Of the herbaceous plant-species given above for each sub-formation, 62 per ct. in the shifting Sand-desert, 44 per ct. in the Hummock-desert and 25 per ct. in the Desert-plains are annuals. Though no very great importance can be attached to these figures owing to incompleteness of the plant-lists, yet they have a certain value because they confirm the results of direct observation. The latter has taught me, that in the shifting desert such herbaceous plants as are present are generally annuals,

whereas on the more stabilised sands these give place to perennials and undershrubs. This is only natural, for if the perennials have not, like *Aristida*, unusual powers of resisting sand-drift, they will sooner or later be smothered by a shifting barchan and very few, if any, will produce seeds during the first year; on the other hand, the annual plants with a shorter growth-period will have a greater chance of surviving and ripening seeds.

The difference in the numbers of annuals in Hummock-deserts and Desert-plains appears to be due to the annual halophytic *Chenopodiaceae* which occur in the depressions of the Hummock-desert, but seem to be of less importance in the Desert-plains.

Finally, attention is directed to the trees of the desert (the switch trees and shrubs) which as emphasised in the preceding pages, play the most prominent part and attain the richest development in the shifting desert, while they deteriorate where the sand is stable. Sand-drift seems to be a condition essential for vigorous growth in their case and also with *Aristida pennata*.

Making a mental comparison between the sub-formations of the sand-desert described, we see that they have many features in common both floral and biological, but that the differences between them are not altogether to be neglected. The most important common feature which unites them and which causes them to be regarded as sub-formations and not as formations is first the general occurrence of the desert-trees, though under a somewhat different form; secondly that the soil is sand, which is saline only in the depressions so that the true halophytes play a comparatively minor part except in these places.

The different forms of sand-desert are evidently historically related in that the one must have originated from the other. What has been the course of development? It has been already pointed out that RADDE (1899 p. 16) following OBRUTSCHEW regards the Desert-plains "the covered Sand-steppe" as the last stage in the metamorphosis of the sand; that the sand-hills, while being covered by vegetation, are gradually being levelled down through the agency of water, wind and

burrowing rodents. In the terms used by COWLES this metamorphosis is a topographic succession, due to topographical changes of the surface. KORSHINSKY regards the matter from a different point of view. His opinion (1896 pp. 6, 8) is that the "normal type" of sand-desert is the Desert-plain "level or undulating areas of sand" covered with *Haloxyylon*, *Salsola Arbuscula*, *Calligonum*, *Ephedra*, *Ammodendron* and *Eremosparton*, and during spring with a number of herbaceous spring-plants; this desert-tree vegetation KORSHINSKY regards not only as the most characteristic, but also as the original type (comp. above p. 36). He is of opinion that in former times a similar vegetation covered the whole area of sand, and that man is the agent of destruction to whose devastations the naked and shifting sand-desert is due. "As soon as we get away from roads and human habitations and reach more solitary places, we always find that the sand-surface becomes more closely covered with vegetation of trees or shrubs. These trees arrest the sand, not through their sand-binding roots, but through their size which modifies the force of the wind and screens the soil from its attacks. Under their protection a richer herbaceous vegetation is also developed." This development from stable to unstable desert through the agency of man must be termed a biotic succession (COWLES). This and the topographic succession mentioned above do not exclude each other.

Even if we allow that KORSHINSKY is correct, that man through felling trees for firewood and through his herds of cattle roaming about, has in many places laid bare the arrested sand and thus brought about the appearance of the naked desert, — it is still probable that the Desert-plains and the Hummock-desert have originated from the shifting-desert. In what other way could the hilly or undulating sand-desert originate? With OBRUTSCHEW and RADDE I consider it most natural to assume that the normal and natural development (the regional succession, (COWLES) not the topographic or biotic one) has taken place from Barchans to Hummock-desert and from the latter to Desert-plains. It is not correct as KORSHINSKY states that the stable desert is always found far from human habitations, for in such places I have seen wild sand-desert almost devoid of vegetation.

In this connection attention is drawn to the Taklamakan-desert where S. HEDIN travelled for days through a desert perfectly devoid of vegetation, and far away from any human habitations.

If it has been thus established that the development of the Sand-desert has in all probability been from Barchans to Hummock-desert and Desert-plains, that it has proceeded from the most shifting condition to the more stable, then we have at the same time traced the process of development of the vegetation. This process is expressed by the order in which the various sand-desert vegetations were described in the preceding pages, and it may be shortly summed up:

1. *Aristida pennata*.
2. *Ammodendron*, *Calligonum* and other desert trees. A few herbs, mostly annuals.
3. Desert-trees, smaller, but growing more closely. Several herbs, among which perennials are dominant. Annual halophytes in the valleys. (Hummock-desert).
4. Small desert-trees (or none). No halophytes (or few). (Desert of the Sand-plains).

To this process of development the definition of formation by Moss might be applied. What this author (1907 p. 12) terms a formation is:

"The series of plant associations which begins its history as an open or unstable association, and eventually becomes a closed or stable association."

Even if the Desert-plain be not closed, it is in itself stable, a terminal sub-formation, and the definition of formation given by Moss thus seems to be applicable to the Sand-desert as a whole. The definition of formation by Moss applied in this way, is employed here as a means of illustrating the unity of the sand-desert and to elucidate its metamorphosis. It must be emphasised, however, that I have grouped the different types of sandy desert in the same formation not because they constitute what might be called a historical series derived from each other in a definite sequence,

but because at the present time they agree on general lines as regards soil and growth-forms. More thorough knowledge of the vegetation would perhaps lead one to designate the different types of sandy desert as formations, or even to create more, e. g. a special formation for the vegetation of the valleys between the sand-hills. If one followed the concepts of CRAMPTON in a recent paper — published subsequent to the Danish edition of our memoir —, then the different types would be regarded as formations: the Barchan desert would be a migratory (or neogeic) formation whose substratum “owes its features to recent geological processes”, whereas the Desert of the Sand Plains would be termed a stable (or palaeogeic) formation; presumably the Hummock desert would also be a stable formation.

Though brought into existence in a different way, the development of the Sand-desert is similar to that of the dune-territories of northern Europe.

The Spring-aspect of the Sand-desert I hardly know from personal observation, hence the following account is mainly based on plant-lists and descriptions borrowed from KORSHINSKY and RADDE (1899). The Spring-plants are mostly found in the stable sand-desert, but they may also occur in the more shifting desert, especially in depressions where the moisture is greater, the clay-content larger, and the surface therefore firmer. Wherever the seeds are carried, there they must germinate when spring comes, and even on loose sand and under unfavourable conditions the ephemeral plants may still succeed in maturing their seeds; their precocious development comes here to their aid and is indeed their only means of preservation.

On stationary sand the spring-vegetation may be comparatively rich, yet nowhere does it form a carpet.

The only species which locally attempt to form a green-sward are *Carex physodes* and *Capsella procumbens*. The former has been frequently referred to already (see p. 97) as it plays a great part in binding the sand. It is already in flower in March and bears fruit in April, the fruiting ear is large and inflated so that it is easily rolled along by the wind. *Cap-*

sella procumbens is a small, delicate annual plant which disappears very quickly.

The remainder of the plants of the spring-aspect in the Sand-desert can be classed, like those of the Clay-desert under the groups: Ephemerals, Hemicryptophytes and Geophytes. The following species belong to the ephemerals which are the most abundant group: *Triticum squarrosus* and *desertorum*, *Danthonia Forskalei*, *Schismus calycinus*, *Bromus tectorum*, *Boissiera bromoides*, *Avena sterilis*, *Hordeum murinum*, *Papaver pavoninum*, *Hypecoum parviflorum*, *Capsella procumbens*, *Isatis minima* and *emarginata*, *Tetracme quadricornis* and *recurvata*, *Lachnoloma Lehmanni*, *Malcolmia circinnata*, *grandiflora* and *Bungei*, *Streptoloma desertorum*, *Euclidium syriacum*, *Octoceras Lehmannianum*, *Goldbachia laevigata*, *Chamaesphacos ilicifolium*, *Lallemantia Royleana*, *Anchusa hispida*, *Nonnea picta*, *Echinopspermum semiglabrum*, *Plantago lachnantha*, *Statice spicata*, *Valerianella Dufresnia*, *V. Szovitsiana*, *Crucianella filifolia*, *Erodium bryoniaefolium*, *E. oxyrrhynchum*, *Astragalus arpilobus*, *Ceratocephalus falcatus*, *Delphinium persicum*, *D. camplocarpum*, *Matricaria lamellata*, *Scorzonera glabra*, *S. hemilasia*, *Senecio subdentatus*, *Koelpinia linearis*, *Lactuca undulata*, *Heteroderis pusilla*, *Heteracia Szovitsii*, *Cousinia alata*, *tenella* and *minuta*, *Dipterocoma pusilla*, *Centaurea moschata*, *pulchella* and *phyllocephala*, *Silene nana*, *Psammogeton setifolium*, *Eremodaucus Lehmanni*, *Aphanopleura capillifolia*, *Diarthron vesiculosum*, *Atriplex dimorphostegium*.

Many species in this list occur also amongst the ephemeral plants of the Clay-desert. Those which I have not already remarked on in the Clay-desert are of the same type: low, mesophytic or slightly xerophytic plants, sappy and without much mechanical tissue, and almost all with small leaves or leaflets which are often more or less hairy. A few have glabrous leaves (*Senecio*, *Diarthron*). Thorns are found on *Cousinia alata* and *minuta*, *Centaurea phyllocephala*, *Centaurea Moschata*; a few others have rather broad leaves. *Heteroderis pusilla*, *Hypecoum* and some *Cruciferae* have rosettes.

A comparison between figure 17 and figures 5 and 6 will show that the ephemerals of the Sand-desert are of the same type as those of the Clay-desert.

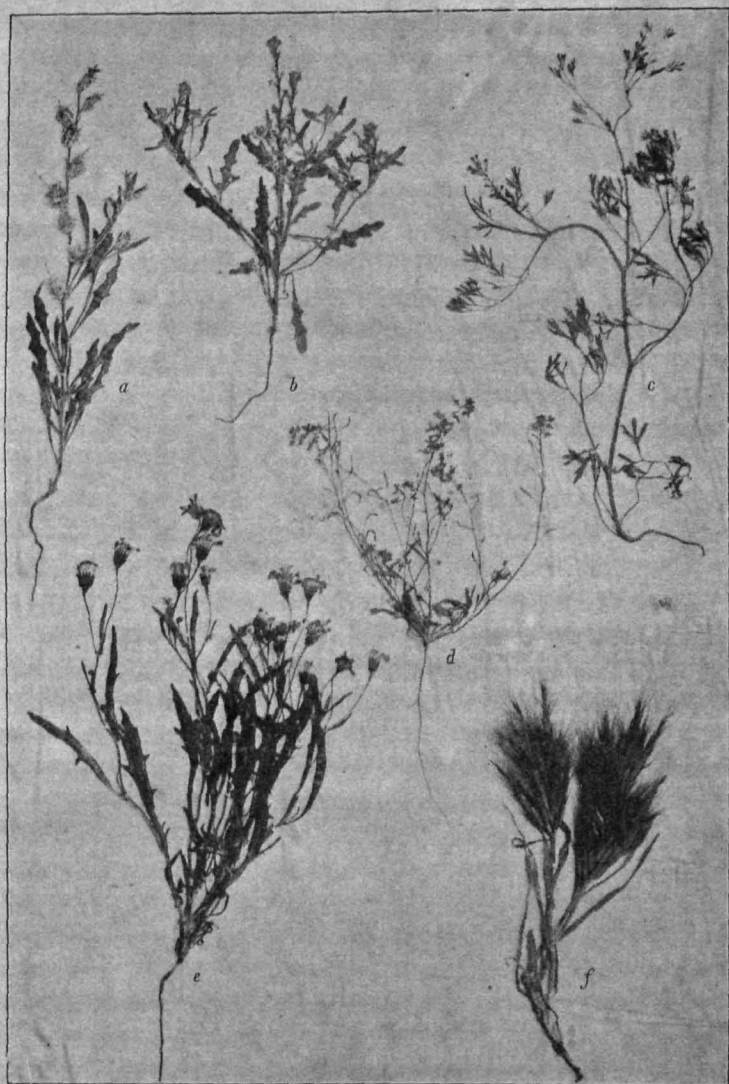


Fig. 17. Annual Spring-plants from Sand-desert: a. *Lachnoloma Lehmanni*.
b. *Tetrame recurvata*. c. *Fumaria Vaillantii*. d. *Streptoloma desertorum*.
e. *Senecio subdentatus*. f. *Boissiera bromoides*.

If we now consider the perennial Spring-plants, they will also be found to be the same species or species of a

similar type as the ones of the Clay-desert. There *Poa bulbosa* was the most important species, and in the Sand-desert it occurs locally in great quantities on stationary soil, but *Carex physodes* (and *C. stenophylla*) are here the chief species; the horizontal rhizomes of these species are well adapted for growth on a stationary sandy soil.

Other hemicryptophytes in the Spring-aspect of the Sand-desert are *Rheum tataricum* (see p. 56), *Eremostachys*-species, *Scorzonera pusilla*, *Astragalus ammotrophus*, *chiuensis*, *orbiculatus*. The species of *Astragalus* have multipinnate leaves as in the Clay-desert, the leaflets are hairy and elliptical or ovate.

A number of geophytes are recorded for the Sand-desert in spring: *Tulipa biflora* and *Androssowii*, *Allium caspicum* and *sabulosum*, *Rhinopetalum Karelini* (all *Liliaceae*), *Eminium Ledebouri* (*Araceae*), *Iris falcifolia*, *Linaria odora*, and the parasites *Phelipaea flava* and *trivalvis*, the former with an inflorescence which almost attains the height of a metre¹).

By comparing the plants mentioned, it will be seen that the spring-perennials of the Sand-desert are formed after the same type as those of the Clay-desert. It is possible that at any rate all the ephemeral species are common to both.

CHAPTER 10

The Riverside Thickets (Bushland).

My own observations on the Riverside Thickets only extend to those on the lower part of the Amu Darya, but thickets also occur along the rivers Tedshén and Murghab, etc. (ANTONOW, KORSHINSKY).

My knowledge of the Amu Darya was acquired during a boat-journey made by the expedition from Tshardshui to Chiwa and Kunja Urgentsh, a trip described by O. OLUFSEN in "Geografisk Tidsskrift" vol. 15.

¹) Figured by O. FEDTSCHENKO in Bull. Jard. Bot. de St. Pétersbourg VI 1906.