

A SKETCH OF THE BOTANY AND GEOGRAPHY OF NORTH BURMA

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PART III

CONTENTS

XI. Mixed Temperate Forest	133
(a) Bamboo Forest	135
(b) Moss Forest	137
XII. Silver Fir Forest	...	...	...	...	137
XIII. Rhododendron Scrub (Sub-Alpine Scrub)	...	...	...	...	140
XIV. Alpine Turf and Scree	...	...	...	...	143
XV. Summary	...	...	...	...	147

XI. MIXED TEMPERATE FOREST.

This is essentially an all-forest transition zone between Broad-leaved Forest and Silver Fir Forest. It includes a mixture of broad-leaved trees, evergreen and deciduous, together with several conifers, but especially *Tsuga dumosa*. It is *par excellence* the zone of oaks, magnolias, tree rhododendrons, epiphytic rhododendrons, maples, cherries and ilex. It is also the first zone in which laurels cease to count, although there are still a few left. Nevertheless it is not a well-marked type of forest, having many species in common with the zones above and below it. Its tree rhododendrons help to distinguish it from the cool Temperate Rain Forest below, its mixed conifers distinguish it from the Silver Fir Forest above; although the uppermost belt of the Mixed Temperate Forest is sometimes almost pure hemlock (*Tsuga*).

Two fairly constant datum lines are furnished by (1) altitude above which frosts are prevalent in winter and (2) the altitude above which, on the average, snow lies for an appreciable time. The former may be taken as about 7,000 feet, and it fixes the lower limit of the Mixed Temperate Forest. The latter is about 9,000 feet, and it fixes the upper limit. Sometimes as in the Hpimaw hills, Subtropical Pine Forest passes above into Mixed Temperate Forest, sometimes Temperate Pine Forest does the same, as in the Adung valley. In the former, Mixed Temperate forest begins below, in the latter above 7,000 feet. The Conifers of the Mixed Temperate Forest, with the exception of *Larix Griffithiana*, do not ascend above 10,000 feet. They include *Taiwania cryptomerioides*, *Tsuga dumosa* and *Picea brachytyla*. In the Adung valley very fine specimens of *Larix*, *Tsuga* and *Picea* occur at 8,000 feet mixed with smaller, but still large birch and maple (*Acer tetramerum*, *A. flabellatum*) and groves of *Rhododendron magnificum*. A little higher gnarled trees of *R.*

arizelum are met with, often in pure stands. The forest here is diverse, with small trees and shrubs in great variety, not only rhododendrons, but also species of *Euonymus*, *Berberis*, *Enkianthus*, *Clethra*, *Lyonia*, *Acer*, *Ribes*, *Sorbus*, *Photinia*, *Hydrangea*, *Sarcococca* and many more; and although there are no alpenes, there are many early summer flowering woodland herbaceous plants, including colonies of *Iris Wattii*, species of *Arisaema*, *Polygonatum*, *Primula* (two or three species), several orchids, *Ophiopogon*, *Viola*, *Souliea vaginata*, *Androsace Henryi*. But it is the great variety of deciduous trees which is remarkable, they are more numerous here, just before the broad-leaved forest finally passes over into pure Coniferous Forest, than anywhere else. The mixed forest too has a familiar northern appearance and is astonishingly beautiful in May, when the trees are in young leaf of many colours; the rhododendrons in bloom and the green carpet of woodland herbs is spread. Among deciduous trees are *Tetracentron sinense*, a large tree common along the rocky banks of the Adung river, *Fraxinus*, *Zanthoxylum*, *Prunus brachypoda*, *P. Kingdonwardii*, and the beautiful carmine cherry, *P. cerasoides*, *Magnolia rostrata*, *M. mollicomata*, *Acer Wardii*. Eight or ten species of oak occur (*Lithocarpus* and *Quercus*), some evergreen. Perhaps the most easily recognised are *Lithocarpus pleiocarpa* and *Quercus lamellosa*, the latter ascending in stunted form along the crests of the ridges to over 8,000 feet, mixed with *Rhododendron Martianum*. Another common oak is *L. xylocarpa*. Most of the oaks however have a range of 3,000 feet or more and extend well down into the cool temperate zones or Temperate Pine Forest. Nevertheless associated with *Ilex* (of which characteristic species are *I. melanotricha*, *I. dipyrina*, *I. yunnanensis*, *I. burmanica*) *Magnoliaceae*, *Tsuga dumosa* and other trees, they form a type of forest which is easily recognised.

Mention must be made of a big tree, *Zanthoxylum*, which grows on Imaw Bum above the Ngawchang valley, unnamed because found flowerless and leafless (future explorers should look out for this) and of *Viburnum Wardii*, *Berberis hypokerina*, *Gamblea ciliata*, *Acer Wardii* and *Sorbus Harroviana*, all characteristic of Mixed Temperate Forest.

But the most interesting and unexpected discovery in the Mixed Temperate Forest was *Cornus suaedica*, which I found at about 9,000 feet altitude in July 1937 above the Nam Tamai, the first purely Arctic plant, other than one or two grasses, recorded from Sino-Himalaya. Another interesting find in the same place was *Stylophorum*—a plant hitherto known only from the Eastern Himalayas.

The great Rhododendron Belt which is 5,000 feet deep, extending between 7,000 and 12,000 feet throughout North Burma is already well developed by the time we enter this zone; it reaches its zenith in the Silver Fir Forest. One of the most characteristic species of the mixed temperate zone is the un-Rhododendron like small tree *R. Genestierianum* with bunches of tiny plum-purple flowers and willow-like leaves, snowy white beneath. There are also the epiphytic yellow-flowered shrubs, *R. butyricum* and *R. seinghkuense*. The Sikkim *R. triflorum* occurs in the Adung valley, and *R. megacalyx*

has its *locus classicus* near Hpimaw. Between February and June this Rhododendron Belt is extraordinary rich in bird life, many of them directly cross-pollinating the flowers. Every Spring a great wave of bird life passes up the Adung valley. Many no doubt are summer residents; but the valley may also well be one of the main migration routes to the north. It may be remarked that snakes are peculiarly abundant between 6,000 and 8,000 feet in the Adung valley and appear to take heavy toll of eggs, and of young birds, many of which build their nests close to the ground.

The climate has been sufficiently indicated. Above 7,000 feet frosts, at least in the open, are usual in winter; above 9,000 feet snow lies under the trees for some weeks. Spring and Autumn are well-marked seasons, Summer and Winter hardly less so.

Endemics in the Mixed Temperate Forest are: *Berberis hypoharina*, *Prunus Kingdonwardii*, *Ilex melanotricha*, *I. burmanica*, *Sorbus paucijuga*, *S. verticillata*, *Rhododendron butyricum*, *R. seinghkuense*, *R. vesiculiferum*, *Eurya Wardii*, *Photinia rufa*, *Acer taronense*. Although *Taiwania eryptomerioides* is by no means endemic, its occurrence along the Burma-Yunnan frontier is one of the most interesting facts in the geographical distribution of plants, a clear example of discontinuity across 2,000 miles of apparently suitable country between Formosa and Yunnan. We may infer that it is a geologically ancient species—a living fossil—and that its ancient distribution was far wider than it is today.

Its existence along this north-west-south-east line also points to an important line of migration during glacial times.

XI (a). BAMBOO FOREST.

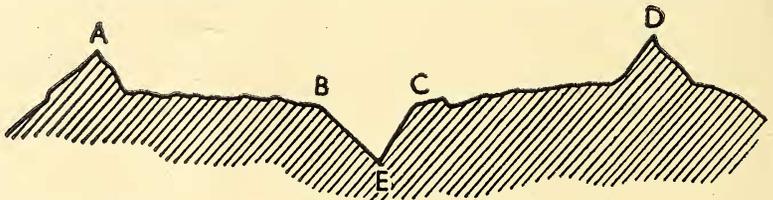
Bamboos are an important constituent of the undergrowth of every type of forest seen in North Burma with the exception of Subtropical Pine Forest. In the lowest hill cultivation (500-2,500 feet) at least, the place of the destroyed forest is usually taken by bamboo (e.g. *Dendrocalamus Hamiltonii* along the 'Nmai Hka valley on the road to Htagaw, and on the Putao road). Whether this bamboo forest is permanent or not it is impossible to say. *Dendrocalamus Hamiltonii* flowers at irregular intervals, but it appears to die after flowering, and it is possible that the forest would come back if left to itself. Again at 7,000-8,000 feet, fire appears to encourage invasion by bamboo, as in the Chawngmaw valley below Imaw Bum.

Many species and genera of bamboo are included in the various zones. Most of them—above 5,000 feet probably all of them, are gregarious, notably species of *Arundinaria*. Very little is known about these. In the valley of the Nam Tamai, at 3,000-4,000 feet, several large tufted species occur; but the majority grow from long horizontal rhizomes, and are gregarious. The so-called 'cane brake' frequently met with in the alpine regions is a dwarf very hardy bamboo of what genus I do not know, probably *Phyllostachys*. Although permanent seres of bamboo jungle are frequent at low altitudes, and great areas of forest with gregarious bamboo as the principal undergrowth commonly occur (e.g. on the flanks of Imaw Bum), I have restricted the term Bamboo Forest to a special formation met with in certain places at 9,000 feet more or less. Here a

moderate sized bamboo growing in ill defined clumps in close proximity to one another, interrupted by scattered trees, is the chief constituent of the forests.

Of its status I know little, but it appears to be confined to the zone I have called Mixed Temperate Forest (7,000-9,000 ft.) between the zone of *Pinus excelsa* (where that occurs) and *Abies*, and is associated with another local development of that zone to which I have applied the name Moss Forest.

Bamboo Forest, as here defined, is probably local, but it is not uncommon. I have several times marched through it along a switch back ridge which maintains the same average altitude for two or three miles, where the spur seems to mark the floor of the old glacier valley before the rivers began to cut out their deep V-shaped notches. This ancient valley floor is found at about 9,000 feet, and is indicated by the comparatively level spur between two much steeper pitches, as seen in the figure below. Thus, ascending to the crest of a main range *via* a spur, there is first a steep climb out of the new valley into the old valley, then a much more gentle ascent along the spur, for two or more miles, to the base of the range, and finally a steep climb up the flank of the range to the crest. This is shown in the diagram, which represents a section from east to west across the Nam Tamai valley lat. $27^{\circ} 30'$ (not drawn to scale).



AD = old (ice) valley BC = new (water) valley EC. EB. = steep slopes.

The Nam Tamai flows at about 4,000 feet. The climb out of the valley to the ice shelf or floor of the old valley is 4,000-5,000 feet. From there to the foot of the range is a gradual rise of 1,000-2,000 feet finishing with another steep climb of 3,000-4,000 feet to the summit of the range. How far down the flanks of the spur the bamboo forest prevails I am unable to say for certain, but I have found little change 500 feet below the crest, the breadth of which does not usually exceed a dozen yards, though it is apt to widen out unexpectedly in places.

It is remarkably easy to get along these ridges, and there are plenty of possible camping sites, with here and there a water hole. The outstanding characteristics of this Bamboo Forest are, firstly, the occurrence of clump forming types of bamboo, unusual at this altitude. Secondly the few trees met with, always widely spaced; thirdly the almost complete absence of any other undergrowth except small fragile herbaceous plants which come up during the rains, such as *Anemone*, several orchids, *Cruciferae*, *Carvophyllaceae*, *Ranunculus*. It is astonishing to see so much good soil unoccupied. It can hardly be due to shade—vegetation flourishes in just as little light elsewhere. Many bamboos even in the dry weather contain

free water in their joints—quite potable. From November on, it is not unusual for the haulms to split longitudinally, with a sharp crack, and I have on occasions seen a pint of water shot out. It may be that on dry ridges this is an appreciable source of water for the forest. What species, if any, regularly contain water, is a matter for investigation.

XI (b). MOSS FOREST.

What may be called Moss Forest, where all the tree trunks are heavily padded and swathed with moss, in which grow epiphytic species of *Vaccinium*, *Rhododendron*, *Gaultheria*, *Aeschynanthus*, also a tiny *Utricularia* is a special development of the Mixed Temperate Forest. It comprises a number of broad-leaved trees mostly deciduous, several species of tree rhododendron, and very few conifers. The undergrowth consists of bamboo with the gregarious fern, *Lomaria* and scattered herbaceous plants such as *Arisaema*, *Elatostema*. Many of the trees have large leaves, e.g. *Magnolia rostrata* and *M. Campbellii*, *Rhododendron sino-grande*, species of *Acer*; on the other hand *Ilex intricata* with tiny leaves and *Betula* are equally characteristic. Shrubs include *Eurya*. Tremendous granite cliffs largely bare, often outcrop in this zone, shrubs found growing in cliff crevices are *Symplocos*, *Berberis*, *Edgeworthia Gardneri*, *Viburnum*, *Cotoneaster* and *Rhododendron*. Alpines hardly exist, though a dainty white flowered *Allium* is not rare. The Moss Forest is open and not difficult to penetrate, if one keeps out of the gullies, though one's way is often barred by unexpected cliffs. The altitude is too-high for *Pinus excelsa*, not quite high enough for silver fir, not quite right for hemlock.

XII. SILVER FIR FOREST.

Even before we reach the Silver Fir Forest we are within the zone which enjoys a hard winter with heavy snowfall, the snow lying for a month or more, at least in the neighbourhood of high mountains, e.g. the Adung valley at 9,000 feet. For the next 3,000 feet there is little change in the outward appearance of the forest which is dominated by Silver Fir (*Abies Fargesii*). Looking across an alpine valley at the steep slope opposite, one sees nothing but a solid phalanx of fir, tier above tier reaching up to the clouds or to the snow, with here and there a solitary larch. One would scarcely suspect that there were any broad-leaved trees, so solid does the fir forest appear,—viewed, that is, from the outside. Seen from within it is rather different; and it is probable that there is almost as much rhododendron as fir—though the rhododendrons are not all of one species. Occasionally when the mountain side is unusually precipitous and rocky, the rhododendrons come to the surface so to speak, and in Spring provide an indescribable blaze of colour where countless thousands of trees and bushes are lit up with pink, purple, scarlet, yellow and white blossom. But more often the rhododendrons are hidden, or an occasional bush is visible. There are deciduous trees, maples and birch, even magnolias also scattered about, mostly below 10,000 feet; they are generally

shorter than the firs. No zone is more easily recognised than this one. Silver Fir either grows by itself forming practically pure fir forest, or not at all. It brooks no rival, conifer or broad-leaved tree. Between 8,000 and 9,000 feet, one may find half a dozen big conifers, vying with each other; but when Silver Fir appears, everything else makes way and it has the field to itself—except of course for rhododendrons, and as already said a few smaller and more scattered broad-leaved trees.

Rhododendrons include *R. sino-grande*, *R. sidereum* and *R. arizelum*, all common in the Hpimaw hills. In the Adung valley, there are also *R. niphargum* and *R. Beesianum*. The highest of all tree rhododendrons, *R. praestans*—belongs rather to the next higher zone, although it does not occur apart from *Abies*.

The first sub-alpine rhododendron met with is the small bush-like, rock-loving *R. Beanianum* with gorgeous waxy blood red flowers, which occurs at the lower limit of fir forest in the Seinghku valley. The Sikkim *R. fulgens* I found in the Nam Tamai valley in 1937.

In these big alpine valleys there is plenty of ground on which trees will not grow—boulder beds, cliffs, bogs, and the like. The higher we climb, the more the fir forest is broken up into isolated wedges separated by screes and alluvial fans¹, which owing to the mechanical effects of avalanches, are always devoid of trees. Above 10,000-11,000 feet, these fans, which are more fully described later, are the abode of a specialised alpine vegetation.

Fir Forest under the conditions prevailing is open, and many shrubs as well as alpine flowers and thickets of *Arundinaria* grow amongst the trees. Here are found species of *Cotoneaster*, *Berberis*, *Ribes*, *Lonicera*, *Salix*, *Spiraea*, as well as *Rhododendron*. *Corylus ferox* and *Sorbus Wardii* are characteristic small trees of the lower zone. *Myricaria* grows thickly with *Arundinaria* along the banks of streams, and in autumn many of the shrubs such as *Berberis*, *Lonicera*, *Cotoneaster*, *Sorbus* are covered with blue, scarlet or white berries making a fine display. Patches of meadow begin to appear both in the valley where the ground is boggy, or on ridges and slopes. In the cold Chawngmaw valley on the north-west flank of Imaw Bum, firs descend below 9,000 feet and there are extensive patches of open meadow above the torrent, where alpine herbaceous plants grow, notably *Lilium giganteum*, *Meconopsis paniculata*, *Notholirion campanulatum*, *Allium*, *Lactuca*, *Solidago*, *Ligularia* and twining *Aconitum*. Here the clash between meadow and forest is at least in part due to human interference, for the forest is periodically set fire to (without felling) in winter by the hunting tribes. Bamboo struggles with meadow for possession of the vacant ground, especially along the crests of the spurs, where forest has either been burnt or will not grow. *Nomocharis pardanthina* is abundant here. In a patch of boggy meadow I found a colony of *Meconopsis* growing with *Omphalogramma*.

¹ Strictly speaking a scree is a cone of fragments split off from the cliff above, building itself up without any other assistance, while an alluvial fan is detritus washed down from a gully in the cliffs. In the snow bound alps of North Burma this distinction is largely lost.

There are few climbing plants in the Fir Forest, *Clematis Spooneri* not ascending above 10,000 feet; and few epiphytes except moss, one or two small ferns, and a minute *Utricularia* (*U. orbiculata*). A large edible red coloured fungus is common on *Abies* in the Adung valley. Apart from *Pinus*, the only other conifer to form pure stands in North Burma is hemlock (*Tsuga dumosa*), which occurs at the base of the Fir Forest sometimes forming a well-defined belt. Otherwise it forms a link between the mixed conifers of the Upper Temperate Forest and the Silver Fir Forest.

Above 10,000 feet numerous primulas occur amongst the many scattered shrubs. One of the first to appear is *P. sikkimensis*. But primulas are never so profuse in this damp climate as they are further east in China or further north in Tibet. The dainty little *P. eucyclia* which grows on wet cliffs at 9,000 feet is endemic. With it is sometimes found *Asteropyrum peltatum*, a curious little plant of the family *Ranunculaceae*. *P. Agleniana* (the pink flowered var. *thearosa*), which is known only from the Seinghku valley, grows in rocky gullies, and from the same place is recorded the first known example of *P. calthifolia*, a rare plant here, but common in the Mishmi hills of the Assam frontier. Another endemic is *Rhododendron myrtilloides*, found at one spot in the Chawngmaw valley, at under 9,000 feet, which is remarkably low down for a dwarf rhododendron of the *Campylogynum* type. It probably occurs higher up. There is also *R. imperator*, another dwarf from 10,000 feet, found once only in the Seinghku valley.

So we can picture the high rocky alps of North Burma as a dynamic landscape, rent by deep, steep gorges through which torrents tumble and roar over boulders, under snow beds, while waterfalls and avalanches crash over the cliffs, and down the glens. The top forests consists of silver fir and rhododendron, frequently interrupted by steep alluvial fans, chequered with alpine meadow, surrounded by precipices. In early summer, when all the mountain-scuppers are foaming with the snow melt, the dark and sombre forest is illuminated by the flowers of millions of rhododendrons, many of which are found also in the loftier mountains of western China or in the Assam Himalayas, or in Tibet. Comparatively few of the Sikkim rhododendrons are found in North Burma, though several are represented by allied species. The same is true of primulas; *P. sikkimensis* and *P. Wattii*, the last rare, are the only Sikkim species known so far. Alpine shrubs include besides many species of rhododendron, *Lonicera myrtillus* and *L. cyanocarpa*, *Ilex intricata* and *I. Georgei*, *Sorbus filipes* and *S. Rehderiana*, *Prunus mugus* and *Magnolia globosa*, all growing within the limits of Fir Forest below 12,000 feet.

In the meadows, alpine herbaceous plants—*Primulus*, *Iris*, *Nomacharis*, *Cremanthodium*, *Sævertia*, occur in great numbers rather than in variety. That is equally true of the dwarf rhododendrons in the more strictly alpine region. No one who has seen the drifts of sunny yellow *Primula melanodanta* or purple heath of "Lapponicum" rhododendron can ever forget it. Yet it does not compare with similar colour displays in eastern Tibet.

At 12,000 feet, and often far below, the valleys are snow bound till May or June, although the cliffs stand out naked, and south facing

slopes may be clear of snow. There is no definite Spring; Spring and Summer are one. True, some rhododendrons flower in April or May, in the snow, but it must be remembered that their flower buds were completed the previous year. They need only water and sunshine to stretch them. Some gentians likewise flower in October or November, when the berries on the leafless honeysuckles are ripe, and the leaves of the barberries have turned scarlet, and those of the larch, champagne yellow. But the bulk of the vegetation is at rest, outwardly at least, half the year. Summer temperatures are moderate. It can be very hot *in the sun*, for a short time at 10,000 or even at 12,000 feet in July, but the average summer temperature above 10,000 feet is no more than cool temperate. June is cool or even cold, by reason of the great amount of snow melting, and this be it remembered, in a lower latitude than Cairo or Florida.

Undoubtedly the most prominent characteristics of this zone are variety of scene and movement—violent movement, falling rocks, crashing rivers, rushing avalanches, with wind, and rain and snow—and occasionally sunshine.

Endemics are: *Primula eucyclia*, *P. siphonantha*, *Gaultheria minuta*, *Sorbus Wardii*, *Rhododendron imperator*, *R. Beanianum*, *R. pruniflorum*, *R. myrtilloides*, *Leptodermis Wardii*, *Berberis burmanica*.

XIII. RHODODENDRON SCRUB (SUB-ALPINE SCRUB).

This is a transition zone between forest and alp, characterised by a great variety of rhododendrons, from big trees to dwarf undershrubs. Rhododendron scrub and alpine herbaceous might also be regarded as two aspects of the same climax formation—the one confined to sheltered, the other to exposed slopes. But if we take that view, which is the climax formation? The tree-rhododendrons and large bushes together with *Acer caudatum* and species of *Sorbus*, which are conspicuous at 11,000-12,000 feet, can hardly be regarded as alpine, although a great many herbaceous alpine and undershrubs like *Cassiope* also grow here. The only alternatives to recognition of a scrub climax are to include the 11,000-12,000 feet belt in the forest zone, or to extend the alpine belt below 12,000 feet so as to embrace it. Neither is satisfactory. Therefore the simplest solution seems to me to be to recognise the existence of a distinct climax formation between the two, dominated by *Rhododendron*—one which I have often recognised in the field (Seinghku, Adung and Gamlang valleys). So far as *Rhododendron* at least is concerned it is a climax formation; more species grow here than in any other zone of equal depth. Both above and below this zone they begin to fall off, although still plentiful. Within the limits of the Silver Fir Forest, several tree-rhododendrons make their appearance. *R. sino-grande* stops below 10,000 feet, *R. arizelum* below 11,000 feet, its place taken by *R. Beesianum*, often mixed with *R. niphargum* though the last named occurs lower down also. Then *R. praestans* appears at over 12,000 feet in the Adung valley, the highest of all tree species. But from 11,000 feet to well over 12,000 feet, *R. selense*, a small tree or large bushy shrub, growing gregariously, dominates the scene.

It lines the river banks, forms impenetrable thickets on steep slopes, invades the fir forest. In full bloom, with flowers of many shades of pink and cream, it is a gorgeous sight. At about the same altitude, where the fir forest is becoming disjointed, another bush species, *R. cerasinum* is commonly seen. But it is the dwarf rhododendrons growing in boggy ground, or rocky slopes exposed to the sea and warm up-valley wind which attract our attention. In North Burma there are at least a dozen species of dwarf rhododendron, half of which are characteristic of this belt, and nearly all of which are gregarious, growing very like heather in Scotland, but with flowers of many colours. They belong to different sections of this large genus, known as 'Lapponicum', 'Anthopogon', 'Sarcocolla' and others, with several species of each section.

Generally speaking, at these altitudes it is wind rather than cold, which is hostile to tree growth, and lack of water rather than wind which is hostile to scrub growth. For this reason forest survives further up the flanks of the big alpine valleys than along the bottom. It faces out in narrowing bands divided by belts of scrub. Still further up the valley similar belts of scrub alternate with screes to slope the more exposed slope, while the more sheltered slope is all scree and barren cliffs. The normal tree line may be taken as 12,000 feet though isolated stands of silver fir and an occasional larch are found higher. Thus at 12,000 feet forest, scrub, and alpine herbaceous abruptly dovetail into one another. A very slight change of aspect is enough to alter the vegetation type.

The scrub does not always consist entirely or even mainly of rhododendron. Sometimes a pure stand of *Betula utilis*, the stunted close-growing trees not more than 10-12 feet tall is found. Elsewhere a mixed scrub of *Rhododendron*, *Juniperus*, *Berberis*, *Spiraea*, *Rosa sericea* with small bushes of *Sorbus* and *Prunus* adds variety to the scene. Lining the bank of the river, such as the Adung between 11,000 and 12,000 feet, will be *Myricaria esculenta* and *Arundinaria* as well as *Rhododendron*.

A feature of the scrub above 11,000 feet, when growing on steep slope, is the way the trunk at first grows out horizontally or even inclined downwards parallel to the slope before becoming upright. This is a mechanical effect produced by pressure on the young plant, which is laid flat each year by the weight of snow, until strong enough to resist. This is well seen in *Betula utilis* and in several species of *Rhododendron*, not however 'dwarf' rhododendrons. The latter are always either prostrate like *R. repens*, or erect, bushy under-shrubs. It is almost impossible to get through such scrub without hacking one's way foot by foot. Another impenetrable form of scrub is furnished by a small species of *Arundinaria* with solid stems, which ascends above the tree line, occurring in gullies and on ridges and slopes too austere for Silver Fir.

Between 11,000-12,000 feet, which I have called the Rhododendron Scrub Belt after its dominant feature, are found not only more than 20 species of *Rhododendron*, but a large number of herbaceous alpine plants also; in fact with few exceptions the entire alpine herbaceous flora. They grow scattered or in colonies, larger and smaller, in patches of meadow along the banks of streams, on sandy river flats, on alluvial fans and screes, in marshes, on cliffs or amongst trees,

scrub, and dwarf rhododendron heath; while every large boulder which has come to rest in the valley, brought hither by some long vanished glacier, forms a home for them. Primulas abound, sometimes in colonies like *P. melanodonta* and *P. sikkimensis* or scattered like *P. Genestieriana* and *P. muscarioides*. Other colony forming plants are *Cypripedium tibeticum*, *Nomocharis Souliei*, *Omphatogramma Souliei*, *Caltha palustris*. Many species form compact clumps, which are really small close colonies. *Iris kumamonensis*, *Polygonum Griffithii*, *Sedum*, *Saxifraga* (several species), *Pedicularis* (several species). The cushion habit is simply this clump forming tendency carried to extremes, so that the clump springs from one rhizome and forms a single unit. More scattered are *Trollius*, *Scabiosa*, *Morina*, *Valeriana*, *Geranium*, *Thalictrum*; *Meconopsis betonicifolia pratensis*, *M. polygonoides* and other species, *Salvia*, certain *Pedicularis*, *Potentilla*, *Habenaria*, *Lloydia*, *Fritillaria* and most *Compositae*, *Umbelliferae*, *Gramineae* and *Papilionaceae*. The dwarf rhododendrons are however the most notably gregarious plants in this zone. Above 11,000 feet there is little competition between species; the formations are mostly open. But there is competition between formations—a vegetative rather than a floristic competition. It requires very little additional shelter to turn an alluvial fan with an herbaceous flora into a belt of scrub, or to cover a scrub belt with trees. And in a region so dynamic such changes take place comparatively rapidly.

The most characteristic feature of the scrub belt is the enormous accumulation of snow in the main valleys, due to avalanching from the high cliffs on either side. At intervals the cliffs are split by deep gullies, and it is down these chutes that in the early months of the year the snow is shot, to pile up in beds from 20 to 50 feet thick in the valley. These snow beds survive till far into the summer. Small wonder that alpine plants are found so low as 9,000 feet. One curious result follows. Snow beds continue to melt even at 13,000 feet, till September or October in secluded valleys, whose higher slopes have for months been gay with flowers. As fast as the snow melts, seeds germinate and plants hitherto held back, start into growth at its edge, looking like flotsam left by the ebb tide. I have seen *Iris Delavayi*, which normally flowers in June, in full bloom in October at the edge of a snow bed whence it had lately been released. Snow beds occur as low as 10,000 or even 9,000 feet, but these are normally melted by June or July. Above 14,000 feet, the snow beds never completely melt—they are permanent snow-beds, which were once glaciers, but have since gradually dwindled till the pressure is no longer sufficient to form ice. These permanent snow beds help to keep the valleys cold, and the alpine flora in cold storage. The most striking example of their delaying action I have ever seen was in the Gamlang valley in October 1937. At an altitude of about 13,000 feet a big snow bed still filled the valley, which here ran east and west. The snow had long since disappeared from the south slope above the bed, which was covered with alpine plants in ripe seed, including *Primula sikkimensis*, *Iris Delavayi*, *Nomocharis pardanthina*, *Meconopsis betonicifolia*, *Trollius*, *Polygonum* and other plants. Across the valley, less than 100 yards distant, where the snow was still slowly melting on the north slope, all

these plants were in fine bloom looking as fresh and brilliant as though it were June instead of mid-October. Such plants which have been in cold storage all the summer, ready to burst forth the moment they are released (though often stunted as a result of the brief growing period) must not be confused with the genuine autumn flowering species such as *Gentiana givostriata* which normally flower in October-November.

From what has been said it will be realised that above 11,000 feet the growing season is short, the winter long. In the north where the Rhododendron Scrub zone is chiefly developed, snow lies for at least five months, not melting before June or July on sheltered slopes. On exposed slopes however, it is loosened and slides into the valley, covering up fresh ground. However plants growing on the exposed scree gain little by this device, suffering from shortage of water, which is constantly supplied on the sheltered slope by the slowly melting snow. Thus the average growing season is only about five and a half months (June-November).

Some rhododendrons flower as early as May, while still partly under the snow, but of course their flower buds were ready formed. The herbaceous alpine plants mostly flower during the height of the rainy season (July-August). Many *Compositae*, *Labiatae* and *Gentians* flower in the autumn (September-October) the last named though frozen stiff at night, frequently lasting in full bloom into the bright November weather. Undoubtedly the early summer is the Rhododendron season, early autumn the Gentian season—a point which the botanist, who is also a horticulturist will not miss.

The following is a list of Rhododendrons found between 11,000 and 13,000 feet in North Burma:—

RR. Beesianum, anthopogon, campylogynum, calciphila cerasinum calostrotum* chryseum, crebreflorum, hypolepidotum, eclecteum, keleticum* luridum, niphargum praestans, pumilum, pruniflorum, repens, saluense, selense, sanguineum, tephropeplum, trichocladum, chamaetortum* arizelum, tsarongense.* Those marked with an asterisk are endemic.

Other endemics in this zone are: *Meconopsis violacea*: *Cremanthodium Wardii* and *C. Farreri*.

XIV. ALPINE TURF AND SCREE.

There is no really satisfactory definition of an alpine plant. Alpine plants are usually associated with mountains and glaciers. But just as glaciers in high latitudes descend to sea level, so also do alpenes. However though alpine plants may defy definition, there is no doubt about the alpine region and the alpine flora in low latitudes like North Burma, where the necessary conditions occur only at high altitudes. In the remote regions of Alpine Turf and Scree along the rugged tops of the high ranges, no trees grow; even shrubs are scattered and stunted, but an occasional undershrub may be found nestling under a rock, almost as high as vegetation ascends. Plant formations are open, except occasionally where a sort of thin turf exists, or in rarer patches of meadow. Few herbaceous alpenes are gregarious, but some species of *primula* (e.g. *P. melanodonta*) occur

in solid drifts, containing hundreds or even thousands of plants, when in bloom visible a mile away. I have never seen in North Burma however the myriads of primulas one sees in the alpine meadows of Tibet, or in the Assam Himalayas. (*P. atpicoia* in the former; *P. Dickiana* and *P. Kingii* in the latter; none of these species have been found as yet in North Burma).

Individual alpine plants descend far below the tree line growing either in screes formed at the base of crumbling cliffs or colonising boulders in the torrent bed. In neither case do they have to compete with trees. But there is a limit below which they never descend; they have an individuality of their own as alpine. Rarely one finds an alpine which has strayed down a high North Burma valley so low as 8,000 feet, far from its accustomed haunts. (I once found a solitary plant of *Nomocharis pardanithina* not a very typical alpine, though it usually grows under alpine conditions, at 8,000 feet in the Adung valley.) At 9,000 feet one notices a few alpine or sub-alpine rhododendrons of more or less dwarf habit, generally colonising boulders, where there is only a film of soil. At 10,000 feet alpine are fairly numerous on screes, cliffs and exposed or soilless places generally, and in meadows occupying silted up lake beds or swamps and on river banks. It is not however till we reach 12,000 feet and forest begins to fail completely, that alpine, whether herbaceous or woody, dominate the landscape. Above 14,000 feet woody vegetation virtually ceases, but scattered herbaceous perennials persist for another thousand feet. Between 12,000 and 13,000 feet herbaceous alpine plants are found in every type of habitat in crevices of cliffs, on screes, on boulders, in the stony beds of streams, lining the high gulches, as well as in sheltered dips and hollows. They are annual, biennial or more commonly short-lived perennials. A few cliff dwelling species with woody rootstock are long-lived perennials.

Six specialised vegetative types occur:—

(i) *Mat plants*.—The creeping much branched stems form a thin spreading mat moulding itself to the form of the rock or soil, e.g. *Diapensia himalaica*, which forms a closed mat. Some of the prostrate *Gaultheria* from open mats. *Gentiana Wardii* forms a kind of mat. Amongst under shrubs, species of *Salix* and *Rhododendron* form definite mats, e.g. *R. repens*.

(ii) *Cushion plants*.—The short stem branches repeatedly, internodes are suppressed and the telescoped shoots, closely pressed together, form a solid hemispherical cushion in which the flowers appear like pins stuck in a pincushion. Cushion plants, e.g. *Arenaria polytrichoides* generally grow amongst loose boulders.

(iii) *Rosette plants*.—Internodes are suppressed, the leaves, lying flat on the ground, form a green collar surrounding the central mass of flowers. Mostly confined to Compositae which have exactly the right type of inflorescence to profit by the idea, eg. *Crepis*, *Lactuca Saussurea*, a few Umbelliferae, also *Geranium*. The Crucifer *Pegaeophyton* though semi-aquatic might also be regarded as a rosette plant.

(iv) *Woolly mantle plants*.—Stem and leaves are enveloped in long cottony or woolly hairs. From a little distance such plants

sometimes look like a pyramid or ball of white fluff. *Saussurea gossypifera* and other species and *Cnicus* sp. belong here and in a lesser degree, *Eriophyton Wallichii*.

(v) *Bulbous plants*.—Only *Fritillaria Roylei*, *Lloydia*, *Nomocharis* and one or two *Allium* produce bulbs. The soil is too cold and perhaps too wet for this type. Several orchids have pseudo-bulbs.

(vi) *Woody rootstock plants*.—These grow in cliff crevices. There is a thick woody rootstock clothed with the bases of old leaves and an immensely long tap root. The rootstock gives rise each year to a bunch of flowers and leaves, e.g. *Paraquilegia grandiflora*, *Potentilla peduncularis*. A quarter century seems no unusual age for such plants.

A fair number of alpine conform to one or other type; on the other hand, many species of *Primula*, *Pedicularis*, *Cremanthodium*, *Gentiana*, *Saxifraga*, *Iris* (the last two are inclined to form compact clumps and perhaps clump-forming might be counted as a seventh vegetative type)—*Pinguicula*, *Corydalis*, *Polygonum*, *Pleurogyne*, to mention a few make no visible concession to austerity. One can hardly argue that therefore adaptation is unnecessary, for who can say that in another 5,000 or 50,000 years the unadapted plants will not have completely disappeared, leaving only the well adapted? We may note in passing that biennials like *Meconopsis violacea* are rosette plants (unflowering) in their first year and so to speak annuals in their flowering year. As their seeds do not germinate till about May, and they are scattering their ripe seeds by October year, their life is confined within about 17 months.

Shrubs found in the high alpine region are chiefly dwarfed forms of those which occur in the zone below. *Salix*, *Juniperus*, *Rosa sericea*, *Potentilla fruticosa* at lower altitudes, and rhododendrons of the 'Lapponicum', 'Saluenense', 'Cephalanthum' and 'Neriiflorum' type and *Cassiope fastigiata* at higher altitudes. Several (endemic and near endemic) species are characteristic of the alpine zone, e.g. *R. calciphila*, *R. riparium*, *R. crebreflorum*, together with *R. repens*, *R. chryseum*, *R. sanguineum*, *R. saluenense* which are more widely distributed in Sino-Himalaya. As to *R. chryseum*, in Yunnan and usually also in North Burma, the flowers are, as one would suspect from the name, yellow, but a form occurs in the Adung valley, indistinguishable from typical *R. chryseum* except that the flowers are a deep plum purple. These two colour varieties cross freely in nature giving a whole range of charming apricots, salmon pinks and other shades.

The most conspicuous herbaceous families represented are: *Compositae*, *Boraginaceae*, *Rosaceae*, *Papilionaceae*, *Umbelliferae*, *Renunculaceae*, *Orchidaceae*, *Gramineae*, *Cruciferae*, *Crassulaceae*, *Cyperaceae*, *Caryophyllaceae*, *Primulaceae*, *Liliaceae*, *Gentianaceae*, *Scrophulariaceae*, *Saxifragaceae*, *Papaveraceae*, *Fumariaceae*, *Polygonaceae*: and the most numerous and notable plants met with are species of *Primula*, *Omphalogramma*, *Corydalis*, *Polygonum*, *Meconopsis*, *Anemone*, *Paraquilegia*, *Ranunculus*, *Draba*, *Caltha*, *Androsace*, *Gentiana*, *Arenaria*, *Lloydia*, *Pedicularis*, *Alchemilla*

Leontopodium, *Erigeron*, *Anaphyllis*. *Luzula*, *Pegaeophyton*. *Nomocharis*, *Iris*, *Cremanthodium*, *Saussurea*, *Aster*, *Saxifraga*, *Eriophyton*, *Cnicus*, *Gaultheria*, *Mortensia*, *Potentilla*, *Geranium*, *Vaccinium*, *Epilobium*, *Euphorbia*, *Viola*, *Diapensia*.

Perhaps the most typical habitat in the alpine zone is the scree, where at least half the known alpinæ grow. Screees are the product of a dynamic climate, where destruction of rock is greater than transport, resulting in accumulation of debris. The scree flora proper is the best expression of vegetation in the highest zone and is specially adapted to its mode of life.

A scree is a section of a cone, with a slightly convex profile. The apex of the cone is directly under the cliffs, the base in the valley, the whole being fan-shaped. The largest fragments roll furthest, hence at the base is a boulder bed, while the apex is dust. Thus the scree flora is stratified and decreases in size and variety from base to apex. At the base, there is a thick growth of undershrubs, which rapidly thin out upwards to be succeeded by a film of green, which gradually disappears and the upper part of the scree consists of rock dust only.

Amongst the boulders at the base of the scree grow species of rhododendron (*R. trichocladum* and others), *Lonicera*, *Spiraea*, thickets of dwarf bamboo, clumps of *Polygonum Griffithii* and other plants. Higher up comes a fairly thick zone of herbaceous plants, *Fritillaria*, *Compositae*, *Gentiana*, and a thin mat of prostrate *Gaultheria*. *Primula capitata* grows here, with *Cremanthodium*, *Eriophyton* *Saxifraga*. Higher still the vegetation wears thin, and presently peters out. On sheltered slopes however there are more rhododendrons and they persist to higher altitudes.

There is one character common to nearly all scree herbaceous plants, and that is a very long tap root. The need for it is obvious when we consider the structure of a scree which has an average slope of about 50°. The plant has to probe deep for water which rapidly sinks down into the loose material. It has also two anchor itself firmly in a substratum which is ever sliding. For this reason, the root often forms a T-brace. Screees occur mostly on the exposed side of the valley, or on both sides where the valley runs north and south, though a very slight tilt will serve to protect a slope from the rapid melting and sliding of the snow in early summer, which makes all the difference to its vegetation.

After the screees, the commonest habitat is the cliffs. Most of the rock in North Burma, above 12,000 feet, is granite or similar crystalline rock able to support very little vegetation. Great areas of cliff are utterly bare of plant life; even lichens. Occasionally, as at the head of the Seinghku valley limestone is met with supporting a more varied flora. On the whole the high alpine region is more remarkable for the numbers of plants of certain species than for variety. In the highest zone, the vegetative season is exceedingly brief, and only those plants which are fully adjusted to this fundamental fact can survive there. There is no Spring properly so called. Growth begins when the snow melts, literally, be it in May or in October, and ends with the coming of fresh snow in

November. Endemics are few. They include *Primula fea*, *P. triloba*, *P. chamaethauma*, *Pedicularis nana*.

XV. SUMMARY.

North Burma comprises the headwaters of the Irrawaddy and of its main tributary the Chindwin, included between the parallels of 25° and $28^{\circ} 30'$ and between the meridians of $94^{\circ} 30'$ and $98^{\circ} 40'$. It is a mountainous region covered with heavy evergreen forest, and has been very little explored. Originally a plateau (the 'Irrawaddy Plateau'), during the Pleistocene glaciation it was covered by an ice sheet, which drove out the Pliocene flora. Some of this flora probably escaped southwards and south-eastwards, down the Burma-Malay mountain arc. Meanwhile glaciers were ploughing out great valleys, and the dissection of the plateau was completed by water.

Following the retreat of the ice several streams of flora entered Burma from the south, south-west, south-east, and probably from the north-west also. An Indo-Malaysian flora spread up the valleys, a Chinese flora spread from the east and south-east, a Sino-Himalayan alpine flora established itself on the high ground.

Not many alpine endemics have been discovered, the Sino-Himalayan flora having spread far and wide over the mountains between Kashmir and China. But at lower horizons numerous endemics are found of Chinese and also of Indo-Malaysian affinity, particularly between about 4,000 and 9,000 feet altitude.

The flora of North Burma is an astonishingly rich one; it has undergone great vicissitudes of climate, has travelled far, and the present flora must have become stabilised in North Burma in comparatively recent times.

Eight major climax formations are recognised and three minor ones are regarded as subdivisions of the Temperate Rain Forest. Two other minor climax formations, found within the Mixed Temperate Forest zone may be no more than local associations.

It is believed that the flora is changing continuously as the many rivers cut deeper and deeper into their valleys and the Indo-Malaysian flora creeps northwards.

Certain highland areas of North Burma, such as Saramati peak, Ka-Karpo-Razi, and elsewhere in the 'Triangle' have never been touched by the botanist, and it is felt that valuable additions to our knowledge might be gained by visits to these places.

The literature of the country is scanty, and since almost all the principal collections¹ are to be found at the Natural History Museum London², the Royal Botanic Gardens, Kew, and the Royal Botanic Gardens, Edinburgh, a keen investigator could quickly get abreast of what is known, and add much to our knowledge.

¹ The Vernay-Cutting collection of 1938-39 from the Htawgaw area, comprising about 500 numbers is in the Herbarium of the New York Botanical Gardens. It was described by Dr. E. D. Merrill and others in *Brittonia*, December, 1941.

² My collection of 1937, containing about a thousand numbers, was partially destroyed when the Botanical Department was hit by incendiary bombs during the 1940 'blitz' on London.

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