VI.—*On the Climate and Vegetation of the Temperate and Cold Regions of East Nepal and the Sikkim Himalaya Mountains.* By J. D. Hooker, M.D., F.R.S.

The following notes were collected, and have here been thrown together, with the view of facilitating the cultivation of Himalayan plants, and of those of Sikkim and the adjacent mountains of Nepal in particular, by supplying accurate data obtained on the spot, relative to the various conditions of soil and exposure, the degrees of temperature and amount of humidity under which they flourish in their native country.

As the genus Rhododendron is the most prominent of these plants, and that about which inquiries are constantly directed to me, I shall commence with a description of it, prefacing this with some observations, which are called forth by a visit to several nurseries where many species are cultivated with more or less success.

The Sikkim species of Rhododendron have now all been described, as far as they are known, and with few exceptions figured, in a manner that will ensure the recognition of our seedlings when they blossom; but it must not be expected that the flowers, so impatiently looked for, will in all or perhaps in most cases equal, in number and size, those of the drawings made on the spot, which were in many instances from the choicest bouquets that could be procured over a large extent of country.

Unexampled success has attended cultivators in the germination of the seeds. Seedlings have been raised in quantities; but whereas in some cases the young plants have, with few exceptions, been all reared, in others the whole crop has been lost through injudicious treatment. The different kinds are at present kept together and treated alike; there is no discrimination exercised in their culture; the same amount of light and heat as is given to the natives of 6000 and 7000 feet elevation, which are in full leaf throughout the year, is also given to those from 15,000 feet, whose vegetative organs are in activity for only five or six months of the twelve. This course will eventually prove prejudicial, for it is not possible that the alpine kinds can long endure the excitement of perennial heat and moisture.

Variation.—There is a prevailing disposition to limit the species of this genus by characters presented in the seedling plants, and to argue, from my inability to pronounce arbitrarily on the same in our greenhouses, the probability of there being fewer or more species than of names received with the seeds. In some cases an undue value is given to these names. Slight varia-

tions in the strength of the stem, colour, texture, and hairiness of the leaf, are regarded as certainly indicating specific differences; whilst other kinds are considered as the same, because undistinguishable in their present infant condition. Some of the latter certainly resemble one another in foliage, even when full grown, but are nevertheless totally distinct in flower and in fruit. I may instance R. *cinnabarinum*, R. *camelliæflorum*, and R. *Maddeni*, as one case in point; R. *campylocarpum* and R. *Thomsoni* as another; R. *campanulatum* and R. *fulgens* as a third instance of species being often so alike in the leaf, as generally to puzzle me when I had nothing else to judge by; and yet there is in the two former cases little affinity between them. My attention was drawn to this point throughout a residence of many consecutive months (including the flowering and fruiting seasons of the Rhododendron) at elevations varying from 8000 to 16,000 feet. It is especially between 10,000 and 14,000 feet that the genus prevails; several species comprising three-quarters of the bulk of the vegetation above the forest-region (12,000 feet). There Rhododendron wood supplies the native with fuel, and, from its tough nature and property of being easily worked, with many domestic utensils, poles for his tent, stools, saddle, bowl and spoon; the bark is used as that of the birch is in arctic regions, and the leaves serve as plates and wrappers for butter, curd, and cheese. It is the traveller's constant companion throughout every day's march; on the right hand and on the left of the devious paths, the old trees and bushes are seen breast high or branching over head, whilst the seedlings cover every mossy bank. At 13,000 feet the flanks of the snowy mountains glow with the blood-red blossoms of R. *fulgens*, whilst the beauty of R. *campanulatum* and the great elegance and delicacy of the white bells of R. *campylocarpum* excite the more admiration from their being found in such regions of fog and rain. Yet with all these advantages of position, and that of an intimate knowledge of the species, I was constantly at a loss to distinguish to which species the seedling plants belonged, especially when they grew intermixed, or to recognize others when distant from their parents.

Not only does the very variable nature of the foliage render it exceedingly difficult to recognize even the best known kinds by these organs, but the species themselves run into races, stirpes, or constant varieties, assuming under certain circumstances characters inherited by the seedlings. This is habitually the case with those that have considerable ranges in elevation; they alter their habit materially (as willows do in our own country), and there is more apparent difference between the robust, hardy, rusty-leaved, dark-coloured seedlings from an

alpine locality, and the young plants of the same species from wooded regions lower down, than between some widely distinct species. I have hereby been led into much error in my illustrated work on Sikkim Rhododendrons, which I shall endeavour to remedy in the present essay.

Hybridization in a Native State.—It has been insisted that many of the so-called species of this genus are naturally-produced hybrids. This is by no means clear to me, though I am far from denying its possibility, and I am aware of the many obvious facilities for such a process: it shares the plausibility of all hypotheses against which negative proof only can be brought to bear. A gardener's opinion is in such cases of value, as he can best appreciate the power of an agent he employs himself with great effect, and to which the attention of botanists is being drawn through the pages of this Journal especially. Considering, however, the consequences which have attended the process of hybridizing Rhododendrons in our gardens, it appears to me that were such an operation actively pursued by nature, or tardily throughout a series of years, in the Rhododendron region of the Himalaya, the species would be in the condition of *Salix*, *Rubus*, *Rosa*, *Mentha*, and many other familiar examples of hopelessly entangled assemblages of species. Where the Rhododendron "scrub" prevails, it is impossible for any but very strong growing plants to establish a footing; a mule would have little chance of a flourishing existence and numerous offspring in so dense a mass; but the prevalence of land and snow-slips often lays bare broad tracts of land, which are for years but scantily clothed with vegetation. From the constant local changes of surface that hence ensue, there is no want of opportunity and space for hybrids to establish themselves. Believing it probable that this genus has survived slow but great changes in the physical geography and climate of the country, especially with relation to the snow-level, I cannot but conclude that varieties, perhaps permanent ones, may have been induced, which are now regarded as species; and this has prompted me to unite some plants from very different elevations which, though varying much, present no well-marked specific characters. Such are R. *elæagnoides*, R. *salignum*, and R. *oboratum*. All these I include under Wallich's R. *lepidotum*, to which a range in elevation of upwards of 7000 feet is consequently given, but I cannot trace the influence of hybridization in itself or any allied species. It is accompanied by twenty congeners in its ascent from 7000 to 15.000 feet, but except that its flowers vary from yellow to a dirty purple, at various heights, neither it nor they present any characters that can be attributed to hybridization. R. *fulgens* is the most suspicious-looking plant in this respect,

having the leaves of R. *campanulatum*, and capitula and flowers of a scarlet variety of R. *arboreum*; but considering how variable R. *campanulatum* is in colour, and that it assumes a denser capitulum in its variety *æruginosum* (which I published as a species), I should be more inclined to rank R. *fulgens* as a permanent variety of that species than as a mule between it and a plant with a totally dissimilar leaf, which is comparatively tender, and which grows 4000 feet lower down. The principle of hybridization is a dangerous one to admit heedlessly in these cases, and should only be resorted to as a forlorn hope, when every other attempt to account for the Protean habits of an assemblage of species has failed: such I cannot consider to be the case with the Sikkim Rhododendrons; and though I do not abandon the idea in theory, I shall not adopt it in this emergency.

Epiphytical Habits of some Species.—Much undue importance has been given to the fact of some kinds growing habitually epiphytically (R. *Dalhousiæ*, R. *camelliæflorum*, R. *pendulum*), and it has been supposed that much difficulty must attend their cultivation. Having occasionally seen all these species growing on rocks, and the two latter sometimes becoming erect, and that always in exposed but very moist localities, I have been induced to attribute their predilection for the branches of trees to their weak habit and want of light elsewhere. Being plants of the forest region, and unable to contend against the vigorous undergrowth that prevails there, the offspring of such seeds as fall on the ground are choked, whilst the perennially humid atmosphere supports such as sprout on the mossy limbs of trees, where they receive the stimulus of light. R. *Dalhousiæ*, for instance, which is never found on the ground in the woods of Darjiling, grows in thousands on the clay and mould banks of the roads which are cut through the forest, the young plants coming up in profusion as soon as the cuttings are made: these, however, seldom attain any size, from the too great exposure of the soil, which in the dry season rapidly parches during a short day's heat. In Dr. Campbell's garden at Darjiling there is a perpendicular bank, 15 feet high, exposed to the west, and partly sheltered from the south-west by a house. R. *Dalhousiæ* has annually appeared on this, the seeds being imported by winds or birds from the neighbouring forest. The seedlings, however, perished till within the last two years, since which time abundance of *Lycopodium clavatum* and a *Selaginella*, with *Marchantia*, retain so constant a supply of moisture that the plants now flourish and flower in perfection. Though not equal to the herbaceous, the number of small shrubby forest plants that grow on the trees in these damp regions is very great, especially the orchideous. Those that do so most habitually are species of *Vaccinium*

(*serpens* and others). These are all provided with soft woody swellings on the root, of all sizes, from that of a nut to the thickness of a man's thigh, which, though structurally the same as other parts of the root, serve as reservoirs for a great quantity of fluid destined to nourish the plant in the drier season of the year. These plants never grow on the ground, properly speaking, but often on exposed rocks, where the use of these tubers is more evident, and it is a part of their economy to be so provided. The Rhododendrons have never such organs, and there is no difference between the root of a specimen grown on the ground and one from a mossy tree-trunk. Such species as are habitually epiphytical require a lighter soil, with plenty of moss, and a very damp, humid, equable temperature; and will, I am sure, present no insuperable obstacles to the cultivator.

Soil.—There is in this respect little variety throughout Sikkim, and, as far as vegetation is concerned, it may be divided into vegetable mould and stiff clay—each, as they usually occur, remarkably characteristic in composition of such soils.

The clay is uniformly of great tenacity, and is, I believe, wholly due to the effect of the atmosphere on crumbling gneiss and other rocks. It is tenacious, seldom friable, and sometimes accumulated in beds 14 feet thick, although more generally of only about 2 feet. In certain localities, beds or narrow seams of purer felspathic clay on vegetable matter occur in it, probably wholly due to local causes. An analysis of that near Darjiling gives about 30 per cent. of alumina, the rest silica, and a fraction of oxide of iron. Lime is wholly unknown as a constituent of the soil, and only occasionally seen as a stalactitic deposit from a few springs.

The vegetation has always good drainage, from the broken nature of the subjacent highly-inclined stratified rocks: with the Rhododendrons of the second zone this is especially the case, and they thrive luxuriantly on the soil overlying old moraines.

A layer of vegetable earth almost invariably covers the clay for the depth of 3 to 12 or 14 inches. It is a very rich black mould, held in its position on the slopes of the hills by the dense vegetation, and accumulated by the banks of small streams to a depth at times of 3 and 4 feet. R. *arboreum* is one of the few species that seem to avoid this soil, but, I think, in appearance only—that species loving exposure, and therefore occupying a comparatively poor dry soil, over which other things do not extend. I have seen R. *arboreum* and *barbatum* growing on the margins of pools of water, in what is almost bog earth; but pools and bogs are rare in Sikkim, and of very local occurrence. The following is an analysis of an average specimen of

the surface-soil of Darjiling, made for me by my friend C. J. Müller, Esq., of that place :—

A.—Dry Earth.

Anhydrous.	83·84
Water	16·16
	100·0

B.—Anhydrous Earth.

Humic acid	3·89
Humine	4·61
Undecomposed vegetable matter . . .	20·98
Peroxide of iron and manganese . . .	7·05
Alumina	8·95
Silicious matter, insoluble in dilute hydrochloric acid	54·52
Traces of soda and muriatic acid . . .	••
	100·0

C.—Soluble in water, gr. 1·26, consisting of soda, muriatic acid, organic matter, and silica.

The soil from which this example was taken was 12 inches deep; it abounded to the eye in vegetable matter, and was silicious to the touch. There were no traces of phosphates or of animal matter, and doubtful traces of lime and potash. The subsoil of clay gave only 5·7 per cent. of water, and 5·55 of organic matter. The above analysis was conducted during the rainy month of September, and the sample is an average one of the surface-soil at 6000 to 10,000 feet. There is, I think, little difference anywhere in the soils at this elevation, except where the rock is remarkably micaceous, or where veins of felspathic granite, by their decomposition, give rise to small beds of kaolin.

At elevations above 10,000 feet, the rocks are generally much harder, the gneisses and schists are baked by metamorphic action, and more granitic rocks prevailing, a lighter and more sandy soil is met with. Towards the southern parts of Sikkim, the copious rains wash away at once the scanty annual deposit of humus at these great elevations: there is consequently no sward or peat; the plants, shrubby and herbaceous, growing out of a generally naked soil in tufts. In the northern parts, again, there is a considerable accumulation; and at equal and greater elevations a sward of *Cyperaceæ* and *Gramineæ* are found, nourishing a tolerably rich Flora. Further north still, in the Tibetan climates, at 15,000 to 17,000 feet, the climate is too dry for anything but an arid Flora, except along the borders of streams.

Generally speaking, I conclude that a rich light vegetable

mould of loam and peat, with good drainage, are necessary for the shrubby plants of these regions.

On the Species.—Since the preparation of the several parts of the illustrated work on the Sikkim Rhododendrons, my opinions, which were then far from fixed as to the limits of some of the species, have changed, with the many additions to the localities, &c., I have collected. When the first part was published, I had only seen single specimens of some of the species figured; and without books of reference of any kind, I was unable to determine their names; the specimens and drawings sent differed so widely from cultivated individuals, and from the indifferent herbarium specimens attainable, that they were pronounced new, and published accordingly. The results of a careful study of all my species and specimens are, that of those figured in the first part, R. *Campbelliæ* does not differ from R. *arboreum*, R. *lanci-folium* from R. *barbatum*, R. *Wallichii* from R. *campanulatum*, and R. *Roylei* from R. *cinnabarinum*.

In the second part a synoptical view of all the Indian species is given, in which some of these errors are indicated, and the species are thrown into groups defined by characters I still think natural and constant. In this and in the concluding (third) part 22 more Rhododendrons are figured as species, several of which were regarded by myself as well-marked forms or varieties only, and as such worth figuring, but which were published with the provisional specific names I attached to them. To these I shall allude hereafter. Lastly, I have gone over the Bhotan collections of Mr. Griffith, and identified all his 14 species with my own, except the one figured by Dr. Wight as R. *grande*. Of this I find no specimen in the set of Griffith's plants given to Sir W. Hooker, except it be the R. *Hodgsoni*, which I can hardly reconcile with the plate and description in Dr. Wight's Icones. Dr. Wight's R. *Griffithii*, on the other hand, I find to be founded on a very starved state of R. *Aucklandii*, a name which I waive.

Bhotan borders upon Sikkim to the eastward, and presents the same characters of humidity in that western part (whence Mr. Griffith's specimens were procured) as Sikkim does. Its lower and outer ranges of hills, however, being drier (from reasons hereafter to be explained), it does not appear to be so rich in Rhododendrons, and hence probably no peculiar species are found; for to the eastward of Bhotan again, in the "Durrung" country, other species have been discovered by Mr. Booth.

I shall now give a list of the 27 Sikkim species known to me, arranged in natural groups, with such brief characters as are necessary for determining them when they shall flower. An account of the geographical features of Sikkim will follow, and a division

of the country into zones, each inhabited by a different vegetation of Rhododendrons and other plants. Some more general description of the species, with remarks on their appearance, habits, and relations to soil, climate, &c., will naturally be brought in there; and I shall conclude with a rather minute account of the climate, temperature, &c., of the three zones of the Himalaya, which may be termed Temperate, Alpine, and Arctic, and which are best defined by the limits attained by *Coniferæ* and *Rhododendrons*.

Synopsis of Species.

§ I. *Calyx* 0. *Corolla* broadly bell-shaped, 10-lobed. *Stamens* 18 to 20 (rarely 10). *Ovary* usually hairy or viscid, or both, many celled.—Trees with large leaves, and white or pale coloured densely clustered flowers.

1. R. *Falconeri*—a tree; leaves very large and coriaceous, obovate or oblong, blunt, on very stout leaf-stalks, smooth, shining above, with sunk netted veins, below covered with thick rusty down; flower-stalks viscid; flowers white, in dense heads; stamens 16; style thick, with a club-shaped broad stigma.—*Sikkim Rhod.*, Pl. X.

2. R. *argenteum*—a tree; leaves very large, obovate, oblong, sharp, narrowed into the thick leaf-stalk, quite smooth on both sides, silvery below; heads rather loose, 10-flowered; flower-stalks short, downy; flowers white, broadly bell-shaped; stamens 10; ovary downy, about 16-celled.—*Sikkim Rhod.*, Pl. IX.

3. R. *Hodgsoni*—a large bush; leaves broad, elliptical, obovate or oblong, on stout leaf-stalks, sometimes heart-shaped at the base, smooth and shining above, somewhat silvery below, with closely appressed down; heads 15 to 30 flowered; flower-stalks short, downy; flowers broadly bell-shaped, 8 to 10 lobed, pale purple; stamens 16 to 18; ovary downy, 16-celled.—*Sikkim Rhod.*, Pl. XV.

§ II. *Calyx* cup-shaped, more or less broad and deep, very obscurely lobed. *Corolla* 5-lobed. *Stamens* 10 to 16. *Ovary* 6 to 16 celled.—Shrubs with large flowers, and quite smooth leaves.

4. R. *Griffithii*, Wight (R. *Aucklandii*, *Sikkim Rhod.*, Pl. XI.)—leaves on rather long foot-stalks, oval, oblong, sharp, somewhat cordate at the base, quite smooth on both sides; flowers few, on long foot-stalks; calyx a broad open disc, unequally 5-lobed; corolla white, with a broad tube, and 5 very

broad spreading lobes; stamens 12 to 18; ovary glandular, 12-celled.

5. R. *Thomsoni*—a bush; leaves at the end of the branches, orbicular or broadly oblong, rounded at the end or terminating in a short point, on rather long leaf-stalks, heart-shaped at the base, quite smooth on both sides, rather glaucous below; head 4 to 6 flowered; flowers deep crimson, drooping, on long foot-stalks; calyx cup-shaped, sometimes tubular, unequally lobed; tube of the corolla rather long, bell-shaped, lobes recurved, notched; stamens 10; ovary quite smooth, 6 to 10-celled.—*Sikkim Rhod.*, Pl. XII.; and R. *candelabrum*, Pl. XXIX.

§ III. *Calyx* of 5 leaves, or deeply 5-lobed. *Corolla* funnel or bell shaped. *Stamens* 10 to 18. *Ovary* 5 to 6 celled.—Trees or shrubs; sometimes epiphytes, with the leaves often covered with small scales.

6. R. *Dalhousiæ*—a slender shrub; young leaves with long hairs, the older ones elliptico-obovate, blunt, smooth above, rather glaucous below, and dotted with very small scales, narrowed at the base into a leaf-stalk which is sometimes a little hairy; flowers 3 to 5 in a head, nodding; sepals oblong, blunt, hairy on the margin; corolla bell-shaped, with a broad tube and 5 moderately spreading lobes; stamens 10; ovary 5-celled.—*Sikkim Rhod.*, Pl. I. and II.

7. R. *Edgeworthii*—a straggling shrub, generally growing on the branches of trees; branchlets leaf and flower-stalks densely covered with a thick tawny down; leaves elliptical ovate, very sharp, bright green and shining above, reticulated with sunk veins; flowers 2 to 3 together, large, white; flower-stalks short; sepals woolly, blunt; tube of the corolla rather short, lobes large and spreading; stamens 10; ovary very woolly, about 5-celled.—*Sikkim Rhod.*, Pl. XXI.

8. R. *barbatum*, Wall.—a small tree; leaves elliptical, lanceolate, sharp, blunt at the base, with stout leaf-stalks which have generally long bristles; quite smooth on both sides, paler below; flowers in dense heads, pale blood-red; flower-stalks short; sepals oblong, blunt, viscid; stamens 10; ovary viscid and hairy, 5 to 8-celled.—*Sikkim Rhod.*, Pl. III.; and R. *lancifolium*, Pl. IV.

9. R. *ciliatum*—a low rigid shrub; branches leaf and flower-stalks covered with stiff spreading hairs; leaves on short foot-stalks, elliptical, obovate, very sharp, bright green above, the margins and mid-rib with stiff spreading hairs, paler and rather glaucous below, dotted with small scales; flowers 4 or 5 to-

gether, pale purple, on stout short flower-stalks; sepals broadly ovate, blunt, ciliated at the margin; corolla bell-shaped, with spreading recurved lobes; stamens 10; ovary scaly, 5-celled.—*Sikkim Rhod.*, Pl. XXIV.

10. R. *glaucum*—a small slender shrub; branchlets leaf and flower-stalks and the leaves generally on both sides, calyx and ovary dotted with small scales; leaves obovate, lanceolate, pointed, narrowed into a slender leaf-stalk, bright green above, very glaucous below; flowers 6 or 8 in a head, pale pink purple; sepals oblong, sharp; corolla bell-shaped, dotted with small glands, and hairy inside at the base; stamens 10; ovary 5-celled.—*Sikkim Rhod.*, Pl. XVII.

11. R. *pumilum*—a very small, slender, sparingly-branched Alpine shrub, with creeping stem and erect branches, which, as well as the flower and leaf stalks, under side of the leaves, calyx and ovary, are dotted with small brown scales; leaves small, on very short foot-stalks, broadly elliptical, blunt with a short point, margin recurved, dark green above, glaucous below; flowers nodding, solitary, or 2 to 3 on long erect stalks; sepals blunt; corolla bell-shaped, rosy, tube hairy, lobes short, rather spreading; stamens 10; ovary 5-celled.—*Sikkim Rhod.*, Pl. XIV.

§ IV. *Calyx* small or none. *Corolla* bell or funnel shaped. *Stamens* 10. *Ovary* 5 to 10 celled.—Shrubs or small trees, generally smooth.

12. R. *arboreum*—a tree; leaves very coriaceous, lanceolate, acute, cordate at the base, or narrowed into a stout petiole, bright green above, reticulated with sunk veins below, smooth and silvery, or covered with a rusty down; flowers in dense heads; calyx none; corolla bell-shaped, white, pink, or blood-red; stamens about 10; ovary 7 to 10 celled.—*Sikkim Rhod.*, R. *Campbelliæ*, Pl. VI.

13. R. *niveum*—a small tree; branchlets and underside of leaves leaf and flower-stalks thickly covered with white wool; leaves obovate, lanceolate, blunt or sharp, on short foot-stalks, quite smooth above, opaque; flower-stalks short; capsules short, downy, 6-celled.

14. R. *campanulatum*—a densely branched shrub; branchlets leaf and flower-stalks and underside of leaves more or less covered with a thick down; leaves obovate, sharp or blunt, cordate at the base, on stout leaf-stalks, smooth and bright green above, sometimes also almost smooth below; flowers 8 to 10 in loose heads, rose or lilac, sometimes spotted; flower-stalks rather long; calyx with 5 short blunt teeth; corolla bell-shaped, with

recurved lobes; stamens 10; ovary quite smooth, 5 to 8 celled. —R. *Wallichii; Sikkim Rhod.*, Pl. V.; and R. *æruginosum*, Pl. XXII.

15. R. *fulgens*—a small bush, differing only from R. campanulatum in its dense heads of blood-red flowers, which resemble those of R. arboreum; and in the capsule, which is broader and of a fine purple colour.—*Sikkim Rhod.*, Pl. XXV.

16. R. *lanatum*—a small tree; branchlets flower and leaf-stalks underside of leaves and ovary densely covered with a whitish wool; leaves obovate, blunt with a short point, narrowed into a short foot-stalk; flowers 6 to 8 in a loose head, nodding; flower-stalks rather long; calyx of 5 small blunt teeth; corolla broadly bell-shaped, pale straw colour, with purple spots inside; stamens 10; ovary 5-celled.—*Sikkim Rhod.*, Pl. XVI.

17. R. *Wightii*—a large branching shrub; leaves elliptical, lanceolate, sharp, narrowed below into a stout downy leaf-stalk, smooth and bright green above, covered beneath with a closely pressed reddish down; heads large, rather loose, and many flowered, on downy foot-stalks; calyx of 5 very small teeth; corolla broadly bell-shaped, 5-lobed at the base, straw-coloured, spotted above with red; stamens 10; ovary glandular and downy, 10-celled.—*Sikkim Rhod.*, Pl. XXVII.

18. R. *campylocarpum*—a shrub, with slender branches; leaves ovate or oblong, blunt with a short point, heart-shaped at the base, smooth and shining above, paler and rather glaucous below; leaf-stalks slender, as are the flower-stalks, which, as well as the calyx and ovary, are more or less covered with glandular hairs; flowers nodding, 5 to 10 in loose heads; calyx of 5 small rounded lobes; corolla broadly bell-shaped, with spreading lobes, pure white or pale straw colour; stamens 10; ovary 5-celled.—*Sikkim Rhod.*, Pl. XXX.

§ V. *Calyx* of 5 short lobes or teeth, the upper sometimes elongated. *Corolla* funnel-shaped, tube narrow. *Stamens* 10 to 20. *Ovary* 5 to 10-celled.—Shrubs with the leaves scaly on the underside.

19. R. *Maddeni*—an erect twiggy shrub; branchlets leaf and flower stalks underside of leaves calyx and ovary thickly studded with small scales, which are also scattered over the tube of the corolla; leaves elliptic, lanceolate, sharp at both ends, bright green and shining above, tawny below; flowers nodding, white, very large, 2 or 3 together, on short stalks; tube of the

corolla elongated, with 5 spreading lobes; stamens 18 to 20; ovary 10-celled.—*Sikkim Rhod.*, Pl. XVIII.

20. R. *cinnabarinum*—a shrub with slender branches; underside of leaves leaf and flower stalks calyx and ovary studded with small scales; leaves ovate or oblong, lanceolate, sharp at both ends, rather opaque, green above, tawny or rusty coloured below; flowers rather small, nodding, 4 to 8 together, in loose heads; calyx lobes very variable in size; corolla brick-red, tube long, lobes rounded, spreading, rather sharp; stamens 10; ovary 5-celled.—*Sikkim Rhod.*, Pl. VIII.; and *R. Roylei*, Pl. VII. (neither very characteristic figures).

§ VI. *Calyx* of 5 lobes. *Corolla* with the tube very short and swollen, the lobes spreading, concave. *Stamens* 8 to 10. *Style* short and curved. *Ovary* 5-celled.—Generally small shrubs, sometimes epiphytes. Leaves (except in R. pendulum) densely scaly.

21. R. *camelliæflorum*—a slender shrub, generally pendulous from the branches of trees; branchlets flower and leaf stalks under surface of the leaves calyx and ovary densely dotted with small scales; leaves elliptical, lanceolate, sharp at the end, generally blunt at the base, bright green above, brownish beneath, on short stout foot-stalks; flowers solitary or 2 together, on short curved stalks; sepals thick and blunt; corolla white, of a firm thick texture, dotted with scales; stamens 16; filaments short and thick; ovary 10-celled.—*Sikkim Rhod.*, Pl. XXVIII.

22. R. *pendulum*—a very slender shrub, generally hanging from the branches of trees; branchlets leaf and flower stalks calyx and ovary densely covered with a rusty-brown wool, under which are scattered scales; leaves elliptical, blunt with a short point, on very short leaf-stalks, bright green and shining above; flowers 2 together, small, white; sepals membranous, oblong, blunt; corolla sparingly scaly outside; tube short; lobes large, spreading; stamens 10; filaments woolly; ovary 5-celled.—*Sikkim Rhod.*, Pl. XIII.

23. R. *lepidotum*, Wall.—A small branching bush; the branchlets leaf and flower stalks leaves generally on both sides calyx and corolla externally more or less dotted with white or rusty brown scales; leaves obovate, lanceolate, or oblong, on short petioles, of a pale or lurid green colour; flowers terminal, solitary, or 2 to 3 together on slender erect stalks; sepals 5, blunt; corolla pale or deep yellow, or purple; tube short, globose; lobes spreading, concave, the upper more or less spotted; stamens

8; ovary 5-celled.—*R. salignum; Sikkim Rhod.*, Pl. XXIII. A.; *R. elæagnoides*, Pl. XXIII.; *R. obovatum*, part 2, page 6.

24. R. *vaccinioides*—a small, very slender, sparingly branched shrub, sometimes epiphytical, with the branches scarred; branchlets leaf and flower stalks and underside of leaves sparingly scaly; leaves coriaceous, obovate, blunt or notched, narrowed into a short stalk, quite smooth and bright green above, paler below; flowers solitary, terminal, on slender stalks; sepals ovate, blunt; tube of the corolla short, hairy inside, white; lobes spreading, rounded; stamens 10, exserted; filaments hairy; ovary 5-celled.—*Sikkim Rhod.*, part 2, page 3.

§ VII. *Calyx* of 5 short lobes. *Corolla* with the tube short, funnel-shaped, lobes long, narrow, spreading. *Stamens* 8. *Style* slender. *Ovary* 5-celled.—Small scaly shrubs, with Azalea-like flowers.

25. R. *virgatum*—a slender erect shrub; branchlets leaf and flower stalks underside of leaves calyx and ovary densely studded with scales; leaves linear, oblong or ovate, sharp or blunt with a short point, rounded or cordate at the base, on short foot-stalks, bright green and shining above, glaucous and sometimes rusty below; flowers 2 to 3 together, nodding on rather long stalks, yellow or pale purple; calyx lobes rounded, ciliated; corolla variable in size, tube short, conical, lobes 5, oblong, blunt; stamens 8 to 10; ovary 5-celled.—*Sikkim Rhod.*, Pl. XXVI., A.; and *R. triflorum*, Pl. XIX.

26. R. *setosum*, Don—a very small shrub; branchlets leaf-stalks and margins of the leaves bristly; these parts, as well as the flower-stalks both sides of the leaves calyx and ovary densely scaly; leaves on short foot-stalks, small, oblong or obovate, deep green above, rather glaucous below; flowers red-purple, 2 to 4 together, terminal on rather short stalks; sepals 5, oblong, blunt; tube of the corolla very short, lobes linear, oblong, spreading; stamens 8 to 10, exserted; ovary 5-celled.—*Sikkim Rhod.*, Pl. XX.

27. R. *nivale*—a small, depressed, prostrate, spreading shrub, with very woody stem and branches, everywhere studded (except the corolla) with scales; leaves crowded, very small, elliptical, blunt, almost sessile, lurid green; flowers terminal, solitary, on very short stalks; sepals 5, oblong, blunt; corolla pink purple, tube very short, hairy inside, lobes oblong, blunt; stamens 8 to 10; anthers large; ovary 5-celled.—*Sikkim Rhod.*, Pl. XXVI., B.

§ VIII. *Calyx* of 5 membranous sepals. *Corolla* salver-shaped, tube slender, short, cylindrical, lobes flat, spreading. *Stamens* 6 to 8, within the tube. *Style* short. *Ovary* 5-celled.—A small scaly shrub.

28. R. *anthopogon*, Don—the only species.

If from a consideration of the species themselves we turn to that of the country they inhabit, it will be found that a great part of it is characterized by perennial humidity, which is excessive during the summer months. It will be seen, also, that the degree of humidity varies in different parts of the country, and that the rain-fall is unequally distributed; also that elevation is to a great degree a relative term, equal altitudes having different climates in various parts of Sikkim, with a dissimilar vegetation. To explain these points, it is necessary to give some account of the natural features of the Sikkim Himalaya Mountains, which seem to be little known, or generally misunderstood by those who have sought information respecting the management of Rhododendrons, through the various horticultural periodicals. Except these points are clearly understood, it will be impossible to appreciate the conditions under which the species grow.

Sikkim is included in a section of the Himalaya Mountains about sixty miles broad from east to west, where it is bounded respectively by the mountain states of Nepal and Bhotan. Its southern limits are easily defined, for the mountains rise rather abruptly from the plains of Bengal, as spurs of 6000 to 10,000 feet high, densely clothed with forest to their summits. The northern and north-eastern frontier of Sikkim is beyond the region of Rhododendrons, and is not a natural but a political line, drawn between itself and Tibet. Sikkim is nearly due north of Calcutta, and only 400 miles from the sea at the Bay of Bengal; its latitude being 26° 40′ to 28° N., and longitude 88° to 89° E. The greater part of the country between Sikkim and the sea is a dead level, occupied by the delta of the Ganges and Burrampooter, above which the slope is so gradual to the base of the mountains, that the surface of the plain from which the Himalayas immediately rise is only 300 feet above the sea. The most obvious effect of this position is, that the prevailing southerly wind reaches the first ranges of hills loaded with vapour. The same current, when deflected easterly to Bhotan, or westerly to Nepal and the north-west Himalaya, is intercepted and drained of much moisture, by the Khassya and Garrow Mountains (south of Assam and the Burrampooter) in the former case, and the Rajmahal hills

(south of the Ganges) in the latter. Sikkim is hence the dampest region of the whole Himalaya.

Viewed from a distance on the plains of India, Sikkim presents the appearance—common to all mountainous countries—of consecutive parallel (wooded) ridges, running east and west, backed by a beautiful line of snowy peaks, with occasional breaks in the foremost ranges, through which the rivers debouch. Any view of the Himalaya, especially at a sufficient distance for the distant snowy peaks to be seen overtopping the outer ridges, is very rare, from the constant deposition of vapours over the forest-clad ranges during the greater part of the year, and the haziness of the dry atmosphere of the plains in the winter months. At the end of the rains, when the S.E. monsoon has ceased to blow with constancy, views are obtained, sometimes from a distance of nearly 200 miles. The angle subtended by the giant peaks is so low (not a degree) that they appear like white specks very low on the horizon, tipping the black lower and outer wooded ranges, which always rest on a belt of haze, and from the density, probably, of the lower strata of atmosphere, are never seen to rest on the visible horizon. The remarkable lowness on the horizon of the whole stupendous mass is always a disappointing feature to the new comer, who expects to see dazzling peaks towering in the air. Approaching nearer, the snowy mountains sink behind the wooded ones long before the latter have assumed gigantic proportions, and when they increase in size, they appear a sombre, lurid grey-green mass of vegetation, with no brightness or variation of colour. There is no break in this forest caused by rock, precipice, or cultivation; some spurs project nearer, and some valleys appear to retire further into the heart of the first great chain that shuts out all the country beyond. No pines whatever are seen on the outer range of Sikkim, both soil and climate being far too damp in the rainy season; nor are the colours of the foliage so varied and bright as the more perennially humid forests of tropical shores, from the want of any abundance of such palms as *Caryota*, tall *Arecæ*, and of *Artocarpi*, or of orange-groves.

As it is not my purpose to discuss here the tropical, or lower zone of Sikkim, I shall at once transport the reader to the north side of the first range of mountains. From here it will be seen that the appearance of parallel ridges is due to the inosculating spurs of long tortuous ranges that run north and south throughout the whole length of Sikkim, dividing deep wooded valleys, which form the beds of large rivers. The snowy peaks still look like a long east and west range of mountains, at an average distance of 30 or 40 miles from the outer range. Advancing into the country, this appearance proves equally deceptive, and the range of snow

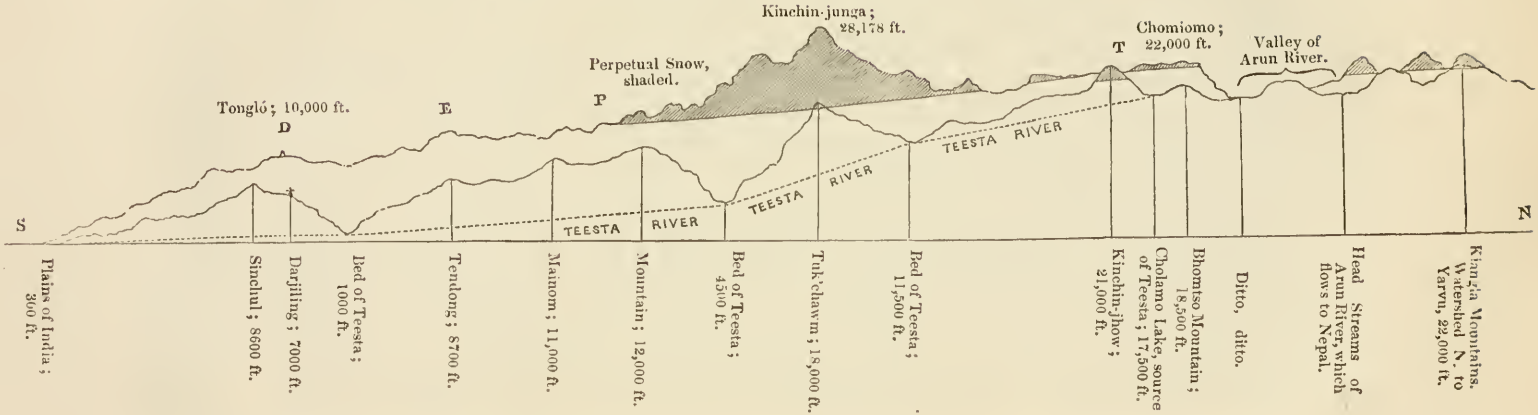
is resolved into isolated peaks, situated on the meridional ranges, at distances varying from 30 to 80 miles from the observer; their snowed spurs, projecting east and west, cross one another, and being uniformly white, and all brought by perspective into one line, they appear to connect all the peaks into one grand unbroken range of snow. The rivers, instead of having their sources in the snowy mountains, all rise far beyond them; many of their sources are upwards of 100 miles in a straight line from the plains, in a very curious country, loftier by far in mean elevation than the meridional ridges which run south from it, and though so lofty, comparatively unsnowed. This rearward mountain region is Tibet, and into it all the Sikkim, Nepal, and Bhotan rivers lead, up to a watershed whose discharge to the northward is into the Yarou-Tsampu river, which becomes the Burrampooter of Assam. Tibet is a very arid mountain mass, the southerly wind being exhausted of vapour by these long ridges long before reaching it. The maximum range in latitude and elevation of the Himalayan vegetation is determined very much by the length of the rivers, which, rising in Tibet as small streams, increase in size as they receive the drainage from the snowed parts of the ridges that bound them in their courses. Their banks, between 8000 and 14,000 feet, are generally clothed with Rhododendrons, sometimes to the almost total exclusion of other woody vegetation, especially near the snowed mountains—a cool temperature and great humidity being the most favourable conditions for the luxuriant growth of this genus.

The source of this humidity is the southerly or sea wind, which blows steadily from May till October in Sikkim, and prevails throughout the rest of the year, if not as the monsoon properly so called, as a current from the moist atmosphere over the Gangetic delta. This rushes north to the rarefied regions of Sikkim, up the great valleys, and does not appear materially disturbed by the north-west wind, which blows during the afternoon of the winter months over the plains, and along the flanks of the outer range, and is a dry surface current, due to the diurnal heating of the soil. When it is considered that this wind, after passing lofty mountains on the outer range, has to traverse 80 or 100 miles of alps before it has watered all the Rhododendron region, it will be evident that its moisture must be expended before it reaches Tibet.

Let the accompanying woodcut represent two of these long meridional ridges, from the watershed to the plains of India, following in this instance the course of the Teesta river, from its source at 19,000 feet to where it debouches from the Himalaya at 300. The lower rugged outline represents one meridional ridge, with all its most prominent peaks (whether exactly

SOUTH. Section of the Sikkim Himalaya along the course of the Teesta River, from its source in Tibet to the Plains of India (about 120 miles).—True Scale. NORTH.

The same on a Scale in which the Heights are three times greater than on the True Scale.



or not on the line of section); the upper represents a parallel ridge, of greater mean elevation, further west, introduced to show the maximum elevation of the Sikkim mountains, Kinchinjunga (28,178 feet) (K) being represented on it. A deep valley is interposed between these two ridges, with a feeder of the Teesta in it, which runs south from Kinchin, and turning west enters the Teesta at R. The position of the bed of the Teesta river is indicated by a dotted line from its source at T to the plains at S; of Darjiling, on the north flank of the outer range, by D; of the first point where perpetual snow is met with, by P; and of the first indications of a Tibetan climate by C.

A warm current of air, loaded with vapour, will deposit the bulk of its moisture on the ridge (8000 feet) D. Passing on, little will be precipitated on E, whose elevation is the same as that of D, but much at F (10,000 feet), where the current being further cooled has less capacity for holding vapour than it had at D, and is further exhausted. When it ascends to P (15,000 feet) it is sufficiently cooled to deposit snow in the winter and spring months, more of which falling than can be melted during the summer, it becomes perennial. At K (20,000 feet) very little falls, and it is doubtful if the southerly current ever reaches the prodigiously elevated isolated summit of Kinchinjunga (28,178 feet);* but all that does, is evaporated or retained as snow. The amount of surface above 20,000 feet is, however, too limited and broken into isolated peaks to drain the already nearly exhausted wind current, whose condensed vapours roll along in fog beyond K, are dissipated during the day over the arid mountains of Tibet, and deposited at night on the cooled surface of the earth.

Other phenomena of no less importance than the distribution of vapour, and more or less depending on it, are the duration and amount of solar and terrestrial radiation. Towards S the sun is rarely seen during the rainy season, as well from the constant presence of nimbi aloft, as of fog on the surface of the ground. An absence of both light and heat is the result in the parallel of K; and at C low fogs prevail at the same season, but do not intercept either the same amount of light or heat; whilst at T there is much sunshine and bright light. During the night, again, there is no terrestrial radiation between S and P; the rain either continues to pour—in some months with increased violence—or the saturated atmosphere is con-

* I believe that the utmost elevation the S.E. monsoon attains is 23,000 feet, and that only where the whole mass of land is immensely elevated. A perennial westerly wind appears by the clouds' motions to blow at the top of Kinchinjunga.

densed into a thick white mist, which hangs over the redundant vegetation. A bright starlight night is almost unknown in the summer months at 6000 to 10,000 feet, but is frequent in December and January, and at intervals between October and May, when, however, vegetation is little affected by the cold of nocturnal radiation. In the regions north of K starlight nights are more frequent, and the cold produced by radiation is, at 14,000 feet, often severe towards the end of the rains in September. Still the amount of clear weather during the night is small; the fog clears off for an hour or two at sunset as the wind falls, but the cold north returning current chills the air again soon after, and rolling masses of vapour are hence flying overhead or sweeping the surface of the earth throughout the summer nights. In the Tibetan regions, again, bright nights and even sharp frost prevail throughout the warmest months.

Referring again to the cut, it must be borne in mind that neither of the two meridional ridges runs in a straight line, but that they wind or zigzag like all mountain ranges; and that spurs from each ridge are given off from either flank alternately, and that the head of a spur on one side answers to the source of a river (*i.e.*, the head of a valley) on the other. These rivers are feeders of the main stream, the Teesta, and run at more or less of an angle to the latter. The spurs from the east flank of one ridge cross, at their ends, those from the west flank of another; and thus transverse valleys are formed, presenting many modifications of climate with regard to exposure, temperature, and humidity.

The roads from the plains of India to the watershed in Tibet always cross these lateral spurs. The main ridge is too winding and rugged, and too lofty for habitation throughout the greater part of its length. The river channel is always very winding, unhealthy for the greater part of the year below 4000 feet, and often narrow, gorge-like, and rocky. Villages are always placed above the unhealthy regions, on the lateral spurs, which the traveller keeps crossing throughout every day's march; for these spurs give off lesser ones, and these again others of a third degree, whence the country is cut up into as many spurs, ridges, and ranges, as there are rills, streams, and rivers on the mountains.

Though the direction of the main atmospheric current is to the north, it is seldom in reality felt to be so, except the observer is on the very exposed mountain tops, or watches the motions of the upper strata of atmosphere. The lower currents of air rush up both the main and lateral valleys, throughout the day; and from the sinuosities in the beds of the rivers, and generally transverse directions of their feeders, the current often becomes an east or west one. In the branch valleys draining to the north

the wind still ascends; it is, in short, an ascending warm moist current, whatever course be pursued by the valleys it follows.

The sides of each valley are hence equally supplied with moisture, though local circumstances render the soil on one or the other flank more or less humid, and favourable to a luxuriant vegetation: such differences are a drier soil on the north side, with a too free exposure to the sun at low elevations, where its rays, however transient, rapidly dry the ground, and where the rains, though very heavy, are of shorter duration, and owing to the capacity of the heated air for retaining moisture day fogs are comparatively rare. In the northern parts of Sikkim, again, some of the lateral valleys are so placed that the moist wind strikes the side facing the south and keeps it very humid, whilst the returning cold current from the neighbouring Tibetan mountains impinges against the side facing the north, which is hence nearly bare of vegetation. An infinite number of local peculiarities will suggest themselves to any one conversant with physical geography, as causing unequal local distribution of light, heat, and moisture in the different valleys of so irregular a country —the amount of slope, and its power of retaining moisture and soil; the composition and hardness of the rocks; their dip and strike; the protection of some valleys by lofty snowed ridges, and the free southern exposures of others at great elevations.

One other peculiarity deserves especial attention, which is, the position of the great masses of perpetual snow. A reference to the woodcut will show that the same circumstances which affect the distribution of moisture and vegetation, determine the position, amount, and duration of the snow. The principal fall will occur, as before shown, where the meridional range first attains a sufficiently great elevation, and the air becomes consequently cooled below 32°; this is at a little above 14,000 feet, sporadic falls occurring even in summer at that elevation: this snow, however, melts immediately, as do the copious winter falls in the summer months. As the depth of rain-fall diminishes in advancing north to the higher parts of the meridional ranges, so does the snow-fall. Its permanence, again, depends on—1. the depth of the accumulation; 2. the mean temperature of the spot; 3. the melting power of the sun's rays; 4. the prevalence and strength of evaporating winds. Now at 14,000 feet, though the accumulation is immense, the amount melted by the sun's rays is trifling, and there are no evaporating winds; but the mean temperature is so high, and the corroding powers of the rain (which falls abundantly throughout summer) and of the warm and humid ascending currents are so great, that the snow is not perennial. At 15,000 feet, again, it becomes perennial, and its permanence at this low elevation (at P) is much favoured

by the accumulation and detention of fogs over the rank vegetation which prevails from S nearly to P; and by the lofty mountains of K, which shield it from the returning dry currents from the north. In proceeding north all the circumstances that tend to the dispersion of the snow increase, whilst the fall diminishes. At P the deposition is enormous, and the snow-line low—15,000 feet; whilst at T little falls, and the limit of perpetual snow is 19,000 and 20,000 feet. Hence the anomaly, that the snow-line ascends in advancing north to the coldest Himalayan regions. The position of the greatest peaks and of the greatest mass of perpetual snow being generally assumed as that of the ridge or watershed, travellers, arguing from single mountains alone, on the meridional ridges, have at one time supported, and at another denied, the assertion, that the snow lies longer and deeper on the north than on the south flank of the Himalaya ridge.

The great accumulation of snow at 15,000 feet, in the parallel of P, exercises a decided influence on the vegetation. The alpine Rhododendrons R. *setosum* and R. *anthopogon* hardly reach 14,000 feet, sometimes not 13,000 feet, in the broad valleys and round-headed spurs of the flanks of Kinchinjunga; whilst the same species ascend to 16,000, and one to 18,000 feet, at T. Beyond the latter point, again, the great aridity of the climate prevents their growth, and in Tibet there are generally none even as low as 12,000 and 14,000 feet. Glaciers, again, descend to 13,000 feet in the tortuous gorges which immediately debouche from the snows of Kinchinjunga, but no plants grow on the débris they carry down, nor is there any sward of grass or herbage at their base, the whole surrounding atmosphere being chilled by enormous accumulations of snow, and the summer sun rarely warming the soil. At T, again, the glaciers do not descend below 16,000 feet, but a green sward of vegetation creeps up to their bases, dwarf Rhododendrons cover the moraines, and herbs grow on the patches of earth they carry down, which are thawed by the more frequent sunshine, and by the radiation of heat from the unsnowed flanks of the valleys down which these icy streams pour.

Looking eastward or westward on the map of India, the phenomenon of the perpetual snow is regulated by the same laws. From the longitude of Upper Assam in 95° E. to that of Kashmir in 75° E. the lowest limit of perpetual snow is about 15,000 feet, and the mass of Rhododendrons affect the most humid localities near it, at 12,000 to 14,000. Receding from the plains of India and penetrating the mountains, the climate becomes drier, the snow line rises, and vegetation diminishes, whether the elevation of the land increases or decreases, plants reaching 17,000 and 18,000 feet, and the snow line 20,000 feet. To mention extreme cases: the snow level of Sikkim in 27° 30′ is at 15,000

feet, and of vegetation at 14,500; whereas in lat. 35° 30′ Dr. Thomson found the snow line 20,000 feet in Karakorum, and vegetation up to 18,000 feet—features common also to Sikkim in lat. 28°.

Of the Sikkim Rhododendrons I have little further to say except with reference to the individual species, and I shall therefore arrange these in three groups, according to the elevations they inhabit, adding such notes upon each as may prove useful in their determination and assist in their cultivation. No species that I am aware of extends much below 6000 feet in Sikkim, or in the Himalayas generally, though, according to Mr. Griffith, R. *arboreum* is found below 4000 on some of the dry rocky outer ranges of Bhotan. In this respect, however, the latter country is very exceptional, and demands a passing notice. The Khassya mountains, as I have elsewhere shown, shield the lower ranges of Bhotan from the effects of the southerly monsoon; they rise to an average height of 5000 feet, extending (as the Garrows, westward, and Jyntea hills, eastward) for about 250 miles parallel to and 60 miles south of the Bhotan Himalaya, the intervening valley being that of the Burrampooter river. The monsoon from the Bay of Bengal is in this longitude a S.S.W. one, and after traversing 200 miles, partly of the Sunderbunds and partly of a very peculiar marsh district called the Jheels, it discharges an amount of water on the abrupt southern face of the Khassya which, as a rain-fall, I believe has no parallel in the world, amounting to between 400 and 500 inches a-year. Suddenly deprived of one-third of its water, the current pursues its course northward, traversing 30 miles or so of hills, whereby it is cooled; while it is again warmed in the moist valley of Assam. What is thence carried on to the Bhotan Himalaya is not condensed on the mountains till it reaches a considerable elevation, 5000 feet and upwards, where it is cooled and deposits moisture abundantly. The Bhotan Himalaya is therefore very dry below 5000 feet, and humid above that, but never so much so as Sikkim.

R. *arboreum* is found at 4500 feet on the Khassya (but not near the southern edge of the range), and ascends to 7000 feet. There are several other Khassya species, all avoiding the southern parts, though one of them descends to 2000 feet on the north flank. Most of the species, as well as those of the Malay peninsula, Java, and Borneo, belong to the same section with R. *cinnabarinum*, having comparatively long tubes to the corolla and small calyces, or none.

The Borneo species* gathered by Mr. Low on Kini Balu,

* Many of these species will be figured shortly in Sir W. J. Hooker's 'Icones Plantarum.'

below 8500 feet, belong here; and I may conclude this long discussion with the remark, that though the Himalaya is so rich in species, it may prove that in this respect it only partakes of the flora of the Malay islands. Thirteen kinds found below 8500 feet, on a mountain unexplored beyond that height, and in a country but once ascended so high, argues a profusion of species in the mountainous regions of that island of which we can form no adequate idea.

I. Species of the First or Lower Zone, answering to the Temperate latitudes; 6000 to 10,000 feet.

1. R. *argenteum*.—Distribution and range: *East Nepal* and *Sikkim;* 8000 to 10,000 feet; confined to the dampest regions.

It forms a tree 30 feet high; trunks solitary, or two or three together, spreading, branched above, the bark pale, and the branches leafy at the apex. Leaves very beautiful in the leaf-buds, at first enveloped in erect and silky scales, so closely imbricated and so large as to resemble the cones of some species of pine; the outer or lower scales broad and coriaceous, glabrous, of a reddish-brown colour, the innermost ones oblong-spathulate, pubescent. When fully developed the leaves are among the largest of the genus, 6 inches to a foot long, 3 to 5 inches broad, full green above, beneath silvery white. Bracteas deciduous, densely silky. Flowers 2 to 3 inches long, 2 to 2½ inches in diameter, inodorous, always white.—In the silvery underside of the foliage, but in nothing else, this resembles R. *arboreum*, while the blossoms are often as large as those of R. *Dalhousiæ*. On Sinchul, the higher parts of the mountain, from 8000 to 9,000 feet of elevation, are more or less clothed with it; on Tongló, as it approaches 10,000 feet, it is suddenly replaced by R. *Falconeri*. It seemed to be shy of flowering in the season of 1848, for it was with difficulty I could then procure sufficient specimens to complete my drawing; in 1849 it flowered profusely, and, with the white magnolias, formed at a considerable distance a conspicuous object amid the lurid green vegetation of the mountains.

2. R. *barbatum*.—Distribution and range: *Kemaon*, *Nepal*, *Sikkim*, and *Bhotan;* 8000 to 11,000 feet; confined to the dampest wooded regions.

A tree 30 to 40 feet high, branched from the base. Leaves, in the very young state, sparingly hairy and ciliated; when fully developed, 5 to 7 inches long, and from 1½ to 3 inches wide, elliptical-lanceolate, acute, rather broader above the middle,

the margins reflexed and rough from the presence of small harsh hairs; the nerves sunk on the upper surface; dull but full green above, paler and quite glabrous beneath, and destitute of scales or down. Petioles sometimes quite deprived of hairs. Flowers moderately sized, blood-colour, collected into a compact globose head 4 to 5 inches in diameter. Bracteas oblong or ovate, the inner ones silky, all more or less glutinous.—One of the most beautiful of the Himalayan species, but variable in size and habit. I have seen it forming a low shrub in mossy swamps, and then entirely destitute of bristles on the leaf and flower stalks; in such a state it was figured and described as R. *lancifolium*.

3. R. *arboreum*.—Distribution and range: *throughout the Himalaya*. 5000 to 10,000 feet. Most frequent in the drier valleys and ridges.

Of this well known species no description is necessary: it abounds in the inner ranges of Sikkim, descending to 5000 feet beyond the first great ridge; on that ridge, on the other hand, it is very rare, never descending below 7500 feet, and only appearing in exposed places. It prefers a drier soil and locality than most other species. The leaves are very variable in shape and in the form of their base, which tapers into a foot-stalk or is cordate; their under surface is generally silvery white, but as the species attain higher elevations they become yellower, and finally rusty underneath, as in the variety *Campbelliæ*. The seedlings partake of the habit, colour, and texture of their parents in a remarkable degree, whence the difficulty of recognizing R. *arboreum* under several very common forms in our nurseries. A jelly is made from the flowers of this plant in the N.W. Himalaya, but I have never seen the preparation. The honey of wild bees is at the flowering season said to be poisonous in Sikkim, but opinions are divided as to whether R. *arboreum* or R. *Dalhousiæ* is to blame; if either, I suspect it to be the former, which alone is abundant near the localities where the bees abound.

After a very careful examination I have come to the conclusion that the R. *Campbelliæ* is only a variety of this; and I further include the R. *nobile*, Wall.; R. *Nilagaricum*, Zenker; and R. *Zeylanicum*. Its geographical distribution is therefore Ceylon, the peninsula of India, the Khassya mountains and the Himalaya mountains from Upper Assam nearly as far west as the Indus; between the elevations of 5000 and 10,000 in Bhotan, Sikkim, Nepal, and Kemaon, but only between 5000 and 7000 elsewhere. It is not found in the valley of Kashmir, but on the south flanks of the mountains bounding that valley on the south.

4. R. *niveum.* — Distribution and range: *Sikkim* — 10,000 to 12,000 feet—in moist valleys of the interior.

This species forms a tree so similar to R. *arboreum*, that I much doubt its being distinct. The snowy white down is peculiar, as are the short capsules, and in my ignorance of the flowers I rest its claims upon these characters alone. I have not recognized young plants in cultivation.

5. R. *Dalhousiæ.*—Distribution and range: *East Nepal*, *Sikkim*, and *Bhotan* (Griffith)—6000 to 9000 feet—in humid forests, generally growing on limbs of trees.

The seeds of this species have germinated as freely as any, and the young plants are making rapid progress in a cool moist house. The young leaves are very hairy, which character and their tenderness distinguish them. They most resemble R. *ciliatum*, but the latter is more hairy, of a darker colour, and rigid texture.—A straggling shrub, 6 to 8 feet high, generally growing, like tropical Orchideæ, among moss, with ferns and Aroideæ, upon the limbs of large trees: the stems clothed with a reddish, papery bark, the branches straggling in distant whorls; each branch bearing its leaves and flowers only at the extremity. Leaves few, spreading or reflexed, about $4\frac{1}{2}$ to 5 inches in length, footstalk about $\frac{1}{2}$ an inch long, the margin plane (not revolute), the upper surface darkish green, inclining to yellow; beneath paler, dotted with very small, scattered, rusty-coloured scales. Flowers 3 to 7 in a terminal, umbellate head, the spread of which is greater than that of the leaves. Corolla $3\frac{1}{2}$ to $4\frac{1}{2}$ inches long, and as broad at the mouth; at the contracted base of the tube are 5 deep pits. Lobes of the limb nearly equal, very broad, rounded, waved, spreading. The flowers are white, with an occasional tinge of rose, in size and colour almost resembling those of the white Bourbon Lily (*Lilium candidum*); in age they assume a delicate roseate tinge, and sometimes become spotted with orange, which rather adds to their beauty than detracts from it. They are lemon-scented, and very fragrant.

6. R. *Griffithii.*—Distribution and range: *Bhotan* and *Sikkim*—7000 to 9000 feet—in the valleys and ridges of the interior only, where the climate is drier.

It forms scattered bushes, 4 to 8 feet high, branching from the base, where the trunk is 6 inches in diameter. Branches suberect, copiously leafy. Bark smooth and papery. Leaves variable in size and breadth, but large for the size of the plant, 4 to 10 inches long; margin plane, often tinged with yellow; upper

surface light full green; the under paler, slightly glaucescent. Flowers the largest of the genus, variable in size, terminal, 3 to 5 together, inodorous. Peduncles rather slender, longer than the petioles, red or green. The calyx represents a shallow, concave, irregular, subrhomboid-shaped platter, 1½ inch in its greatest diameter; the back marked with slightly elevated, radiating lines, glossy, as if varnished. Corolla white, tinged with pink, veiny, of a firm, rather fleshy texture: tube short for the size of the flower, yellowish and rose-colour towards the base, the mouth very wide, lobes exceedingly large and spreading. I have measured some only 3 inches across, but others 5 and 5½ inches in diameter!—I have found but few plants of this superb species, and in these the inflorescence varied much in size. The specimens from which the drawing in Sikkim Rhod. (under the name of *R. Aucklandii*, Pl. XI.) was made were from a bush covered with blossoms, growing in a rather dry, sunny exposure, above the village of Choongtam. The same species also grows on the skirts of the pine-forests (*Abies Brunoniana*) above Lamteng, and it is there conspicuous for the abundance rather than for the large size of its blossoms.

When I described this plant I was not aware of its being the R. *Griffithii* of Dr. Wight's Icones Plant. Ind. Or., the drawing of which seems to have been prepared from very bad materials. The great size of the corollas figured in the "Sikkim Rhododendrons" may be due to the individual being sterile, for I found the anthers to contain little or no pollen.

7. R. *Edgeworthii*.—Distribution and range: *Sikkim*—7000 to 9000 feet—in forests of the dampest regions.

Leaves 2 to 4 inches long. Corolla white, often tinged with blush or pale yellow: the tube rather short, widening much at the mouth, slightly curved, the limb unusually large, more than 4 inches across, spreading, of 5 nearly equal, rounded, slightly emarginate lobes, crisped at the margin, delicately veined on the surface.—A truly superb species, from the size of the flowers and their roseate tinge on a white ground, also from the variety of rich colour in the leaves, bracteas, stipules, calyx, &c., while the very wrinkled surface of the leaf adds much to its beauty. In its floccose character and foliaceous calyx it resembles *R. pendulum;* but in the size and shape of the flowers it approaches R. *Dalhousiæ*, next to which I would place it. The majority of my specimens were obtained from the land-shoots or slips in the rocky ravines, which bring down in their course those pines on the limbs of which this species delights to grow.

8. R. *Maddeni.* — Distribution and range: *Bhotan* (?) and *Sikkim*—where it was found in the inner and drier valleys only, and very rarely there, at 6000 feet elevation.

A shrub 6 to 8 feet high. Leaves abundant, of a coriaceous substance but flaccid, 4 to 7 inches long, frequently pendulous. Corolla 3½ to 4 inches long, and as much across the limb, very handsome, white with a faint blush chiefly on the upper lobe, rather fleshy, but firm in substance; in shape much more contracted than is usual with the Himalayan species: the limb very large, spreading, of 5 nearly equal, rounded, entire lobes, slightly crenato-undulate at the margin, delicately but obscurely veined. The foliage and flowers are faintly odorous.

This species clearly belongs to the same natural group as R. *cinnabarinum;* from which, however, the very large white flowers, the numerous stamens, and ten-celled fruit abundantly distinguish it.

9. R. *ciliatum.* — Distribution and range: *Sikkim* — 9000 to 10,000 feet—in rocky valleys of the interior.

This forms a small very rigid shrub, growing in clumps 2 feet high, generally in moist rocky places. Odour faintly resinous and pleasant. Corolla 1½ inch long, nearly as much across at the mouth; tube rather contracted below, limb 5-lobed, colour pale reddish-purple; upper lobe obscurely spotted. Allied to R. *barbatum*, but widely different in stature, habit, and the scattered scales on the under surface of the leaves. I have not observed it in other valleys than those flanked by snowy mountains, where it is common, scenting the air in warm weather. The scales (as in its congeners) are orbicular, sessile, attached at the centre, formed of 3 concentric series of cells surrounding a central one, in which a resinous fragrant oil is secreted.

10. R. *virgatum.*—Distribution and range: *Bhotan* and *Sikkim*—7000 to 9000 feet—in damp valleys of the interior.

Under this I have included two species figured in the "Sikkim Rhododendrons" which are perhaps only extreme varieties. The characters common to both are a slender twiggy habit, a height of 3 to 6 feet, glaucous leaves, and a perfect identity in all essential characters of inflorescence and fruit. The shape of leaf is a variable one in all cases, as are the size and colour of flower, upon which characters R. *triflorum* was founded. The latter is by far the handsomer plant, and grows at lower elevations. The following remarks apply to it:—

Var. *triflorum* forms a shrub 4 to 6 feet high, with erect and rather twiggy branches. Leaves frequently pendulous, on rather short, slender petioles ($\frac{1}{3}$ of an inch long), ovato-lanceolate, approaching to oblong or elliptical, 2 or 3 inches long, the margin a little recurved, substance rather thin, upper surface smooth and shining, under quite glabrous and glaucous, but so beset with ferruginous scales as to partake of that colour. Peduncles generally 3 together, terminal, $\frac{1}{2}$ to $\frac{3}{4}$ of an inch long, slender, erect. Corolla greenish-yellow, in shape much resembling that of the common garden Azaleas, having a somewhat obconical tube very open at the mouth, and a limb of 5 spreading oblong entire segments, which are slightly veiny, nearly 2 inches across the lobes.

R. *virgatum* itself has stems and branches 4 feet high, scarcely the thickness of a crow-quill. The leaves are in form and size like those of *R. glaucum*. Flowers solitary, rarely in pairs, and axillary; the pedicels 2 to 3 lines long, covered with sheathing, deciduous, coriaceous, brown scales, which are longer than the pedicel, very rigid in texture, downy on the back. Corolla a pale red-purple, smaller than that of Var. *triflorum*, but of the same form; the tube short, narrow, and obconical, the segments narrow and spreading.

11. R. *vaccinioides*.—Distribution and range: *Sikkim* —6000 to 8000 feet—in very moist situations of the outer and inner valleys.

The flowers of this species were unknown to me when I published the second Fasciculus of the "Sikkim Rhododendrons," and I consequently placed the species in a wrong section of the genus. An excellent drawing, prepared by my friend the late Mr. Cathcart, represents the flower and fruit; it will shortly be published in Sir W. Hooker's Icones Plantarum. In the synoptical account of the species given above I have associated it with R. *camelliæflorum*, &c., with which it further agrees in its frequently epiphytical habit. It is not now alive in this country, and, being of no beauty, it may be long before it is so. In the neighbourhood of Darjiling it is very abundant.

A small, very slender, straggling species, sometimes pendulous from trunks of trees, and then 2 feet long, of a bright green colour, and so like a common Sikkim species of Vaccinium (V. *obovatum*, Wight, Icon., t. 1193) as not to be distinguishable at first sight. Stems no thicker than a dove's quill, rough with tubercles, indicating the former position of scales, which still clothe the branchlets, petioles, and more sparingly the under surface of the foliage. Leaves coriaceous, $\frac{3}{4}$ to an inch long, obovate or even spathulate, the blade narrowed downwards to

the very point where it meets the stem; upper surface a bright green, lower paler. Flower-stalks as long as the leaves, slender. Flowers nodding, white, nearly half an inch across, of the same form as those of R. *setosum* and R. *lepidotum*, having a short, swelling, almost spherical tube, and spreading or recurved round lobes. Stamens projecting far beyond the tube. Seed-vessels curved, unlike those of any other species, being slender and membranous, pale-brown, an inch long, scarcely $\frac{1}{8}$ in diameter, valves linear, a little scaly on the back.

II. Species of the Middle or Alpine Zone, answering to the Alpine region of Southern and the Subalpine of Middle and Northern Europe, to the climates of the Scotch Fir, &c. (10,000 to 14,000 feet).

12. R. *Falconeri*.—Distribution and range: *East Nepal* and *Sikkim*—9000 to 12,000 feet—in moist forests.

A tree 30 feet in height; 2 or 3 trunks springing from the same point, often 2 feet in diameter. Bark pale and smooth; branches few, spreading, leafy at the tops; young leaves clothed with velvety down, and when in bud concealed by downy glutinous scales, of which the outer are subulate, the inner ovate. The perfect leaves are very coriaceous, from 8 to 20 inches long, and 5 to 12 inches wide, the upper side glossy green, but fading into yellow at the margins, which are quite plane (not recurved) beneath; clothed with a short, dense, pale, ferruginous down, except on the mid-rib and reticulated veins. Leaf-stalks long and very thick, plane and glabrous above, clothed beneath with dark rusty down. Heads small, composed of numerous white, densely placed flowers. This is a most striking and distinct species, of which the foliage resembles the ferruginous-leaved *Magnolia grandiflora*. The dense many-flowered head, the multiplication of the lobes of the corolla, and of the stamens and fruit-cells, and the exserted style, bring it very near R. *grande* (Wight's Ic. Pl., vol. iv., t. 1202), a Bhotan species found by Mr. Griffith; but the foliage is totally different.

The flowers and leaves of this species usually attain a much larger size than those represented in the "Sikkim Rhododendrons."

13. R. *Hodgsoni*. — Distribution and range: *East Nepal*, *Bhotan*, and *Sikkim*—10,000 to 12,000 feet—in humid forests.

A small tree, from 12 to 20 feet, branching from the base,

main branches as thick as the human thigh, spreading horizontally 20 or 30 feet every way, interwoven with the adjacent plants and shrubs. Bark smooth, pale flesh-coloured, flaking off in broad membranous patches. Wood white, very close-grained, soft yet tough, neither warping nor splitting, but, in consequence of the great compression of the larger branches, rarely affording a sample a foot square. Leaves terminal on the end branches, ample, spreading, 12 to 18 inches in length, of a singularly thick coriaceous texture, glabrous and bright glossy green above; beneath, all except the thickened costa, clothed with a pale silvery white, rarely ferruginous, closely appressed wool, but which is easily rubbed off by the finger, and is often itself evanescent. Heads 4 to 6 inches in diameter, of several delicate, pale purple or rose-coloured flowers. Flower-stalks short, viscid, often downy. Corolla large, the tube 1½ inch long, broadly campanulate, the base depressed at the insertion upon the flower-stalk, the margin of the depression lobed, limb spreading, 2 to 2½ inches across, 8-lobed. This, and its associate the *Abies Webbiana*, I have always regarded as characteristic plants of 10,000 to 12,000 feet in all the interior parts of Sikkim. *R. Hodgsoni*, in this respect, ranks with *R. arboreum* and *R. Campbelliæ*, being found in a loftier zone of Rhododendrons, succeeded by the arctic one of *R. anthopogon*, *R. setosum*, *R. elæagnoides*, and finally, far above the ordinary limit of phænogamic vegetation, by *R. nivale*, which is found at an elevation of 18,000 feet. Within the limits assigned to the present species, the traveller's attention is continually arrested by its magnificent and brilliant deep green foliage, as large as that of *R. Falconeri*. In summer the leaves spread all around the plant; in winter they are rolled up, shrivelled, and pendulous from the tips of the branches. It is found alike at the bottom of the valleys, on the rocky spurs or slopes of the hills, in open places, or in the gloomy pine-groves, often forming an impenetrable thicket, not merely of twigs and foliage, but of thickset limbs and stout trunks, only to be severed with difficulty, on account of the toughness of the wood. As it is easily worked, and not apt to split, it is admirably adapted for use in the parched and arid climate of Tibet; and the Bhoteas make from it cups, spoons, and ladles, and the saddle, by means of which loads are slung upon the "yak." The leaves are employed as platters, and serve for lining the baskets which contain the mashed pulp of *Arisæma* root (a kind of Colocass); and the customary present of butter or curd is always enclosed in this glossy foliage.

14. R. *Thomsoni* (and R. *candelabrum*). — Distribution and range: *East Nepal* and *Sikkim*—11,000 to 13,000 feet—in moist valleys.

A bush 6 to 10 feet high, or in damp woods 15 feet, but then spare and woody. Lower branches stout, a foot in diameter; upper slender, leafy at the extremities. Leaves 2 to 3 inches long, very broad, much resembling those of R. *campylocarpum*, only that in the latter the leaf-stalks are often glandular, here never; the texture of the leaves is coriaceous, but not very thick, the colour pale green, below sub-glaucous, everywhere quite glabrous. Flowers in a head of 6 or 8 together from the ends of short branches among the leaves, on stalks an inch or more long, which radiate, as it were, from a centre, spreading horizontally, or curving downwards. Corolla remarkable for its almost unrivalled deep blood-red colour and glossy surface, yielding only to R. *fulgens;* deeper coloured than that of R. *arboreum;* the tube elongated, often vertically compressed, 2 inches long; the limb large, spreading, 5-lobed, the lobes notched, upper ones spotted. This species is perfectly inodorous. In the base of the corolla is secreted much honey, which is not considered poisonous, like that yielded by R. *Dalhousiæ* and R. *argenteum*. The two latter species are said to render deleterious the wild honey which is collected during their flowering season.

15. R. *Wightii*.—Distribution and range: *East Nepal* and *Sikkim*—12,000 to 14,000 feet—alpine valleys, abundant.

A small shrubby tree, yielding, in beauty of inflorescence, to none amongst the yellow-flowered group to which it belongs. The trunks are often as thick as the thigh, and branch very much both upwards and outwards, forming a thickset shrub of 10 feet high. Leaves 6 to 8 (rarely 10) inches long, $2\frac{1}{2}$ to 3 broad, very coriaceous, more plane than is usual in the genus, bright green above, beneath covered with a very closely appressed opaque wool of a deep rufous colour, rarely pale and nearly white in the young foliage. Heads much larger than those of R. *arboreum*, 12 to 20-flowered, the flowers not densely packed. Bracteal scales chesnut-brown, very coriaceous and viscid. Flowers have a faint honeyed smell; foliage inodorous. This exceedingly handsome and abundant species replaces the R. *Hodgsoni* in ascending the mountains, and is the most prevalent species at 12,000 and 13,000 feet, conspicuous at all seasons for its large foliage, of a rusty cinnamon-colour beneath, and for its viscid buds.

16. R. *campanulatum*. — Distribution and range: *Kemaon*, *Nepal*, *Sikkim*, and *Bhotan*—10,000 to 14,000 feet—where it is abundant in all parts of Sikkim.

This well-known species is commonly cultivated in our gardens, and requires no particular description. It is wholly inodorous, and the flowers are very variable in colour, being of a deeper or paler lilac, often spotted inside the corolla. The variety I have called *Wallichii* is nearly destitute of wool on the under-surface of the leaf, and R. *æruginosum*, another variety, differs only in the purple capsules and curious verdigris-green colour of the young foliage. This and the following are the great ornaments of regions above 12,000 feet, where they often cover the flanks of the valleys with their rich green foliage and gaudy blossoms.

17. R. *fulgens*. — Distribution and range: *Sikkim* — 12,000 to 14,000 feet—in the valleys of the interior.

This superb species vies with R. *Thomsoni* in the colour of its dense capitula of flowers. The foliage entirely resembles that of R. *lilacinum*, the flowers those of R. *arboreum*.

18. R. *lanatum*. — Distribution and range: *East Nepal* and *Sikkim*—10,000 to 12,000 feet.

A large shrub or small tree, with the trunk 6 inches in diameter at the thickest part, irregularly and repeatedly branching; branches much gnarled and bare of leaves, covered with a dark-coloured rugged bark, very different from the prevailing beautiful papery clothing of the genus; where it breaks off from the younger branches, however, it exposes a delicate pink inner bark, whilst the branchlets are densely clothed with a soft, appressed cottony wool. The latter, generally of a white or tawny colour, is uniformly spread over the leaf-stalks, flower-stalks, ovary, and the under surface of the leaves, also extending to the upper surface, along the midrib, and to the very base in a less degree. The leaves are confined to the ends of the branches, $3\frac{1}{2}$ to 5 inches long, by about 2 inches broad, obovate or elliptical, obtuse, the colour a full yellowish green. Leaf-stalks short, thick, very woolly. Heads terminal, of 6 to 10 rather large, inclined flowers. Flower-stalks $1\frac{1}{2}$ inch long, thickened. Corolla ochroleucous or pale sulphur-colour: the tube broad-campanulate (like that of R. *Wightii*); within, above, and 3 of the upper lobes in part sprinkled with red dots; limb 2 to $2\frac{1}{2}$ inches across, of 5 nearly equal, very spreading, rounded, entire, obtuse lobes. In the dense wool on the under side of the leaves, this species may be compared with R. *fulgens* and R. *æruginosum* among the

large shrubby kinds, and with R. *Edgeworthii* and R. *pendulum* among others.

19. R. *campylocarpum*.—Distribution and range: *East Nepal* and *Sikkim*—11,000 to 14,000 feet—common in alpine valleys.

A small bush, averaging 6 feet in height, rounded in form, of a bright green hue, and which, when covered with its delicate inflorescence, claims precedence over its more gaudy congeners, and has always been regarded by me as the most elegant of the Sikkim Rhododendrons. The flowers have a pleasant honeyed scent, and a resinous, sweet odour is exhaled from the stalked glands of the leaf and flower stalks, calyx, and capsules. Leaves on slender stalks, $\frac{3}{4}$ of an inch long, coriaceous but not thick in texture, 2 to $3\frac{1}{2}$ inches long, $1\frac{3}{4}$ to 2 inches broad; in all characters, except the evanescent glandular hairs and spherical buds, undistinguishable from those of R. *Thomsoni*. Flowers horizontal and nodding. Corolla campanulate, delicate in texture, tinged of a sulphur hue and always spotless, nearly 2 inches long, broader across the lobes, which are finely veined. The stalks of the capsules radiate horizontally from the ends of the branchlets, and the capsules themselves curve upwards in a semicircular arc; they are about an inch long, always loosely covered with stalked glands.

20. R. *cinnabarinum*. — Distribution and range: *East Nepal*, *Sikkim*, and *Bhotan*—10,000 to 12,000 feet—in valleys and on the tops of mountains in very damp regions.

Under this species I include R. *Roylei* of the 'Sikkim Rhododendrons.' Neither of the figures give a good idea of the plant, which forms a rather elegant bush, about 8 feet high, conspicuous in May and June from its elegant blossoms, which form very loose and graceful heads of long pendulous flowers. The figures of R. *cinnabarinum* and R. *Roylei* are from stunted specimens growing in very exposed situations; the leaves are not usually reticulated except under these circumstances, and are rather membranous, of a glaucous green below and rather bluish above. Flowers, 4 to 6 in a head, $1\frac{1}{2}$ inch long, with a narrow, funnel-shaped tube, and slightly spreading broad lobes, which are sometimes rather sharp at the point. It is universally considered poisonous to cattle and goats: of the latter I have seen many die from eating either of this or of a species of *Andromeda*, which latter is notorious for this property throughout Sikkim, Nepal, and N.W. Himalaya. If employed as fuel, the smoke causes the eyes to inflame and the cheeks to swell.

21. R. *glaucum*.—Distribution and range: *Sikkim* and *Bhotan*, in moist rocky places. 10,000 to 12,000 feet.

This constitutes a small shrub of the average height of 2 feet. Branches scarcely so thick as a goosequill, yellowish-brown, often glaucous-white, the younger ones scaly. Leaves rather crowded at the extremities of the branches, 1 to 3 inches long, usually 1 to 1½ inch broad, on short stalks, upper side deep green, when old naked above, below remarkably glaucous, almost white, and quite dotted with copious little scales, which in the young state cover the whole leaf, and at all times abound on the bracteas, bud, flower-stalks, and especially on the sepals. Flower-stalks 7 to 8, almost in an umbel at the ends of the branches, erect, an inch or more long, rather slender. Flowers erect or inclined, pale pinkish-purple. Corolla rather more than an inch long, and about as broad in the widest part, tube campanulate, limb moderately spreading, of 5 nearly equal rounded notched lobes. The remarkable glaucous colour of the underside of the leaves, and the great development of the calyx, readily distinguish this species. In foliage it closely resembles R. *virgatum*, but the inflorescence and calyx are widely different. The whole plant has a powerful resinous smell, due to exceedingly small globules of a pale yellow colour which exude from beneath the little scales on the underside of the leaves. These scales are very curious; the majority are smaller, pale-coloured, exhibiting several concentric circles of small, nearly uniform cells; the larger are bristly at the margin, and consist of a centre or disc of small cells surrounded by a limb or margin of radiating elongated ones.

22. R. *pumilum*.—Distribution and range: *Sikkim*.—Alpine slopes. 12,000 to 14,000 feet.

The smallest of all the Sikkim Rhododendrons. Its slender woody stem roots among moss, *Andromeda fastigiata*, &c., ascends obliquely, and bears a few spreading branches, 3 to 4 inches in length, rising above the surrounding vegetation. Leaves, chiefly from the upper ends of the branches, ½ to ¾ of an inch long, bright bluish-green above, below scaly, as is the short stalk, and glaucous. Flower-stalks moderately slender, erect, 1 to 3 on the ends of the branches, and rising 1½ inch above the base of the superior leaves, firm and woody, much elongated, and straight to the very top when in fruit. Flowers inclined or almost drooping. Corolla ½ to ¾ of an inch long, rose-colour, campanulate, very delicate, externally downy, and obscurely glandular; the tube rather broad, the limb of 5 nearly equal, moderately spreading, roundish entire lobes. An extremely elegant species,

and apparently very rare; for I have only gathered it twice, and each time in the wildest districts of Sikkim, where its elegant flowers appear soon after the snow has melted, when its pretty pink bells are seen peeping above the surrounding short heath-like vegetation, reminding the botanist of those of *Linnæa borealis*. It has a faint and agreeable odour like that of R. *glaucum*, to which it has many points of resemblance.

23. R. *camelliæflorum*.—Distribution and range: *East Nepal*, *Sikkim*, and *Bhotan*.—In moist fir woods.—9000 to 12,000 feet.

This very curious species is more allied, in some respects, to the section including R. *lepidotum* than to any of the others; in foliage it resembles R. *Maddeni*, though much smaller; and also R. *cinnabarinum*, from which the dried flowerless specimens are not easily distinguishable. The same very stout midrib, which runs through and forms the point of the leaf, is common to all these. Stems 2 to 6 feet long, seldom thicker than a goose-quill; branches long, generally pendulous, though when growing on cliffs often obscurely so. Leaves, as usual in the genus, at the ends of the branches, differing in little but size from those of R. *Maddeni*, 2½ to 3 inches long. Flower-stalks axillary or terminal, very short and stout. Corolla sparingly scaly, 1½ inch across, of a very thick texture, pure white with a faint rosy tinge, all the segments obtuse and entire. The similarity between the flower and that of a single (wild) *Camellia* has suggested the trivial name. Odour, as in all the scaly species, more or less strongly resinous according to the heat of the day.

24. R. *pendulum*.—Distribution and range: *Sikkim*.—9000 to 11,000 feet.—In humid forests.

Stems 3 to 4 feet long, sparingly branched, branches scarcely stouter than a crow's quill. Leaves chiefly confined to the ends of the branchlets, on short stalks, spreading, smooth and shining above, the margins a little recurved, 1½ to 2 inches long and about ¾ of an inch broad, below densely clothed with ferruginous wool. Flower-stalks 2 to 3 from the ends of the young leafy branches, very short, but longer than the leaf-stalks, ferruginously shaggy, bearing 1 or 2 linear bracteas. Flowers small. Corolla pure white, about an inch in diameter, externally scaly, tube very short, gradually expanding into the nearly equally 5-lobed limb: lobes rounded, waved at the margin, entire. This species is inodorous, very distinct, although allied to R. *camelliæflorum*, the scaly character of that species here giving place to a dense fulvous or ferruginous wool. Growing, as it

does, an epiphyte, upon the trunks of trees in the gloomy and impenetrable forests, it is difficult to find.

III. Species of the Upper or Arctic Zone, from 14,000 to 18,000 feet, answering to the Arctic latitudes beyond the wooded regions, the islands of the Polar Seas, Iceland, Spitzbergen, &c.

25. R. *lepidotum*.—Distribution and range: *Rocky mountains and valleys in Nepal, Sikkim*, and *Bhotan*.—8000 to 16,000 feet. R. *lepidotum elæagnoides, oboratum*, and *salignum*, of the 'Sikkim Rhododendrons.'

This curious and very variable species abounds at 14,000 to 15,000 feet, but also extends as low as 8000 feet in moist valleys. It forms a slender or stout twiggy shrub, 1 to 4 feet high, branching from a stout tortuous stock; the branches as thick as a crow-quill, rather scattered, bearing tufts of branchlets at the top. It often grows in widely-extended clumps, much as heather does, but never so extensively; and emits, in sunshine, a powerful resinous odour. Leaves of a pale glaucous green, lighter underneath, and sometimes ferruginous where the scales abound; $\frac{1}{2}$ to $1\frac{1}{2}$ inch long. Flower-stalks more or less elongated, $1\frac{1}{2}$ to 2 inches long, slender. Corolla yellow or dirty purple, $\frac{1}{2}$ an inch across the lobes; scaly, especially on the outside of the tube; the upper lobes are spotted with green.—The odour of this plant is strongly resinous, and rather sweetish and pleasant. Its common name is "Tsaluma," or "Tsuma," amongst the Bhoteas. The description in De Candolle (Prodr., vol. vii., p. 724), if, as I do not doubt, it refers to this plant, is very erroneous. The leaves cannot be called "ferruginous below," in the same sense as applied to R. *anthopogon*, &c., nor are there any bristles or hairs at the bases of the leaves; nor have I observed more than 8 stamens, the typical number in this very distinct group.

26. R. *anthopogon*.—Distribution and range: *Kemaon, Nepal*, and *Sikkim*—12,000 to 16,000 feet—abundant, especially in the drier climates.

This interesting species has been figured from plants introduced by Dr. Wallich, which flowered in England. It is a strongly and far more disagreeably scented plant than R. *setosum*. This, the *Palu* of the Bhoteas, shares with the *Tsallu* (R. *setosum*) the blame of exciting the dreaded headache and nausea attending ascents to the elevations of the Eastern Himalaya. In the Herbarium its permanent odour is more disagreeable than that of any of the genus. Its flowers are extremely beautiful, both from the membranaceous, translucent texture of

the delicately nerved corolla, and from the varied tints of the blossoms, which on first opening are of a rich blush-colour, insensibly passing into pure white, and finally becoming faintly tinged with sulphur.

27. R. *setosum.* — Distribution and range: *Kemaon*, *Nepal*, and *Sikkim* — 13,000 to 16,000 feet — most abundant in the drier valleys of the interior.

Stems from 8 to 12 inches high, much branched, branches covered with a papery bark. Leaves small, copious towards the ends of the branches, $\frac{1}{3}$ to $\frac{1}{2}$ an inch long, coriaceous, dark green above, pale and glaucous beneath, hairy on the recurved margin. Flower-stalks $\frac{1}{2}$ to 1 inch long, 3 to 5 from the ends of the numerous branches, erect. Corolla bright red rose-colour, $1\frac{1}{2}$ inch across, 5-partite, the tube very short; the lobes spreading, oblong, waved at the margin.—A small and elegant shrub, resembling *Rhodora*, especially in the flowers, except that these are more abundant and brighter coloured; and the foliage is box-like and evergreen. It is the *Tsallu* of the Sikkim Bhoteas and Tibetans, who attribute the oppression and headaches attending the crossing of the loftiest passes of Eastern Himalaya to the strongly resinous odour of this and of R. *anthopogon*, Wall. (*Palu* of the natives). The species certainly abounds near the summits of all the passes, and after hot sunshine fills the atmosphere with its powerful aroma, far too heavy to be agreeable, and greatly aggravating the discomforts of toiling in the rarefied medium of these elevations. In its late flowering (June and July) and early fruiting (October) it is well adapted to the brief and distinctly circumscribed summer of these regions; whilst its powerful odour and copious resinous secretions equally indicate a drier climate than is enjoyed by most of its congeners. The hand, on being passed over the foliage and branches, becomes covered with the clammy exudation, of which it long retains the scent. A useful volatile oil, of no less marked a character than that of the American *Gaultheria* (now in great demand by the perfumers), might probably be obtained from the foliage by distillation.

28. R. *nivale.*—Distribution and range: *Sikkim Himalaya*—in the dry valleys of the interior—at elevations of 16,000 to 18,000 feet.

The hard woody branches of this curious little species, as thick as a goosequill, straggle along the ground for a foot or two, presenting brown tufts of vegetation where few other plants can exist. The branches are densely interwoven, and wholly depressed, being raised barely 2 inches above the soil. The surface

of the branchlets and foliage is covered by small scales of a rather bright ferruginous-brown. Leaves $\frac{1}{6}$ to $\frac{1}{8}$ of an inch long, pale green. Corolla $\frac{1}{4}$ of an inch across the lobes, of a purple colour. The whole plant is very odoriferous. It appears indifferent to the changes of climate, remaining buried under many feet of snow for eight months of the year; whilst at other periods the soil around it is heated to 150°. In the most genial weather snow-storms are of frequent occurrence; they do not, however, injure its blossoms, which remain open until fertilization has taken place. This species attains, I believe, a loftier elevation than any other shrub in the world. Its nearest allies are R. *setosum* and R. *Lapponicum*, from which latter it differs in its smaller stature and solitary sessile flowers.

It is now my purpose to enter into some details respecting the temperature and climate of the three zones of the Sikkim Himalaya, to which the Rhododendrons are chiefly confined. The information on this head is not so satisfactory as is desirable, owing to the want of a series of observations having been continued throughout the year anywhere, except at Darjiling itself, and there for but a few hours daily through one year. The mean annual temperature of that locality at 7000 feet may be considered as very nearly 53°, probably rather below than above it, this result being deduced from the daily maxima and minima, which, I think, gives too high a result, from local causes which I shall hereafter explain. The monthly means, on the other hand, vary much year by year, and with small differences of position, owing chiefly to the variable amount and unequal distribution of the rain-fall and cloud, and the great power of the sun's rays when unobstructed. The wonderful equality of temperature throughout the 24 hours from May till October is only disturbed by the sun's rays, which raise the thermometer 20° in a very few minutes, and sometimes for an equally short period of the whole day. During the height of the rains the mean temperature varies but a few tenths of a degree (June 61·2°, July 61·4°, August 61·7°), and there is no radiation by night of any consequence. Whilst, therefore, a short sunshine raises the thermometer for a few minutes 10° above the mean of the 24 hours, the minimum thermometer never falls more than 3° to 4° below the same mean, whence it follows that the mean of the whole day cannot be indicated by that of the maximum and minimum, as shown by a self-registering thermometer. Again, the maximum of heat occurs during the rains very generally before noon, often before 10 A.M., the forenoon being the least

cloudy part of the day, and the fogs that obstruct the sun's rays afterwards being both denser and of much greater perpendicular height than is supposed usual with this phenomenon. Cloudless afternoons are very rare in any month, and quite unknown during the warm ones, so that the mean yearly temperatures of 10 A.M. and 4 P.M. coincide within half a degree (10 A.M. 56·2°, 4 P.M. 56·7°), differing as much as 2° in the month of February only. In the cold weather, again, the maximum occurs in the afternoon. The mean temperature of the year coincides nearly with the 8 A.M. temperature, as far as I can ascertain.

My own observations were taken hourly at Darjiling, for, on the average, 18 hours of the day, during the rainy season of 1848, with many breaks however. From the end of October, 1848, to the latter part of January, 1849, I was travelling in East Nepal and in Sikkim between the elevations of 4000 and 17,000 feet. January, February, and April of 1849 I spent near Darjiling; March on the plains at the foot of the hills. From the beginning of May till Christmas, 1849, was wholly spent in travelling at all elevations above 4000 feet, but chiefly in regions above 6000 feet, and for several months between 12,000 and 14,000 feet; during September at 15,400 feet, and in October I spent a few days at 16,700 to 17,000 feet. The spring of 1850 (January to May) was passed in and about Darjiling. During all these excursions I made the study of climate second alone to botany. I recorded observations at certain hours, which were those adopted at the Calcutta Observatory (5° due south of Sikkim), and at many of which hours my friend, J. Muller, Esq., made comparative observations of pressure, temperature, and wet-bulb at Darjiling. My first proceeding, after halting or camping, was to hang the instruments in a very accessible place screened from radiation; and I endeavoured to observe hourly, when at liberty to do so; isolated observations in such circumstances being generally useless. I have taken the results of the comparison of a multitude of such observations, with coincident ones at Calcutta and Darjiling, as the basis of my calculations for the temperature, &c., of the zones above 7000 feet, checking them by various methods that suggested themselves. The computations in many cases are excessively complicated and laborious, but during my stay in Sikkim I was materially assisted in this, as well as in the preliminary calculation of several hundred altitudes by barometer, by Mr. Muller, the experienced accountant of the Calcutta Mint, to whose friendship I am very largely indebted, and but for whose generous aid and encouragement I should perhaps never have undertaken the distracting task of working out general results from the materials I accumulated. These broken series of comparative observations

have, if sufficiently numerous, a value when properly reduced, and are indispensable to the horticulturist; they give, within certain limits, the difference of temperature due to the difference of altitude for the month in which they are taken; and if a few days of several months, or a considerable portion of either equinoctial month (March or October), are spent at one place, the results give useful approximations to the mean annual temperature.

The results thus obtained have been checked by ground temperatures, taken by burying a brass tube 2 feet 6 inches to 3 feet in exposed soil, sinking in it, by a string or tied to a slip of wood, a thermometer whose bulb is well padded with wool. This, after a few hours, indicates the temperature of the soil, which has a definite relation to the mean temperature of the month, and further, has an obvious practical application to the growth of plants. Such a tube and thermometer I usually caused to be sunk wherever I halted, if even for one night, except during the height of the rains, which are so heavy that they communicate to the earth a temperature sometimes above that of the air. I cannot too confidently recommend this simple plan to travellers, for the double purpose of getting an approximation to the mean monthly temperature by a few observations, and of finding that of the soil. One such observation is worth a hundred of such as are paraded in the works of travellers, as taken with a thermometer hung inside a tent, or to a tree, &c., the majority of which are not worth recording. With regard to other observations, the wet bulb and barometer were invariably registered with the temperature, and the minimum spirit thermometer set every night. Of maximum thermometers I tried many, but never kept one long in working order. A radiating thermometer in a parabolic reflector, and others placed on cotton and grass, were frequently exposed, and I found no material difference between that laid on cotton and that in the reflector. The black-bulb thermometer was often observed, and a large series of actinometer observations taken; these have not been computed, nor the dew-points from the wet-bulb temperatures, the correction (p-f') always required at considerable elevations being laborious. I have, however, computed as many as to convince me that the cultivator may assume the mean state of humidity given for Darjiling, which I have computed (on monthly means of 1835 observations), as applicable to both the upper zones—the difference of humidity between 7000 and 14,000 feet being that the excessive rain-fall of the lower station, and great capacity for moisture of the lower warmer strata, do not extend proportionally to the upper, whose cooler atmosphere, however, holds less vapour in suspension. In all three zones the atmosphere is generally well loaded with humidity.

Distribution of Temperature in the Three Zones.—A remarkable uniformity prevails throughout the year at the lower zone, there being, at 7000 feet, but 22° difference between the mean temperatures of the hottest and coldest months; whilst in London, with a lower mean temperature, the equivalent difference is 27°. In the second (middle zone) at 11,000 feet this difference is equal to that of London. In the upper it is still greater, the climate becoming excessive at 15,000 feet, where the difference amounts to 30° at least.

Between 6000 and 10,000 feet, *i.e.* throughout the first zone, I find the mean annual temperature decreasing with the elevation at the rate of 1° to every 320 feet.

Between 10,000 and 14,000 feet at 1° to every 350 feet.

And between 14,000 and 18,000 feet at 1° to every 400 feet.

This gives—

Altitude.	Mean Shade.	Mean Warmest Month.	Mean Coldest Month.	Mean Daily Range of Temperature.	Rainfall, in inches.	
11,000 feet .	40·9	50·0	24·0	20·0	40·0	1° = 320 feet.
15,000 feet .	29·8	40·0	11·0	27·0	20·0	1° = 350 feet.
19,000 feet .	19·8	32·0	0·0	35·0	10·0	1° = 400 feet.

15,000 feet being the limit of perpetual snow where that phenomenon advances farther south in Sikkim, and 19,000 feet the limit of perpetual snow in Tibet. Supposing the same law to apply (which I exceedingly doubt) to heights above 19,000 feet, 2° would be the mean annual temperature of the summit of Kinchinjunga, altitude 28,178 feet, the loftiest known spot on the globe.

The upper limit of phenogamic vegetation coincides with a mean temperature of 30° on the south flank of Kinchinjunga, and of 22° in Tibet; in both cases animals and perennial-rooted herbaceous plants are to be found at elevations corresponding to these mean temperatures, and even at higher elevations in sheltered localities. I have assumed the decrease of temperature for a corresponding amount of elevation to be gradually less in ascending (1° = 320 feet at 6000 to 10,000 feet, and 1° = 400 feet at 14,000 to 18,000 feet). My observations appear to prove this, but I do not regard them as conclusive; supposing them to

be so, I attribute it to a combination of various causes, especially to the increased elevation and yet unsnowed condition of the mass of land elevated above 16,000 feet, as is shown in the woodcut (p. 85); also to the greater amount of sunshine there, and to the lesser density and height of the fogs which obstruct the sun's rays at all elevations. In corroboration of this I may mention that the difference of temperature is much less in summer than in winter, 1° of Fahr. being equivalent to only 250 feet in January between 7000 and 13,000 feet, and to upwards of 400 feet in July. Again, at Darjiling (7500 feet) the temperature hardly ever rises above 70° in the summer months, yet it often rises even higher in Tibet at 12,000 to 14,000 feet. On the other hand, the winters, and winter nights especially, are disproportionately cold, the thermometer falling upwards of 40° below the Darjiling temperature at 6000 feet above that elevation.

The diurnal distribution of temperature is equally and similarly affected by the presence of vapour in the three different zones. The lower zone is first clouded, because the lower ranges, of 6000 to 10,000 feet, first receive the diurnal charge of vapour-loaded southerly winds; the middle gets more of the sun's rays, and the upper more still. Though the summer days of the upper zone are warmer than their elevation would indicate, the nights are not proportionally colder; for the light mist of 14,000 feet, which replaces the dense fog of 7000 feet, effectually obstructs nocturnal radiation, though it is less an obstacle to solar radiation. Clear nights, be it observed, are as rare at 14,000 as at 7000 feet, the nights being rainy, if windy; or, if calm, cold currents descend from the mountains, condensing the moist vapours of the valleys, whose narrow floors are at sunrise bathed in mist at all elevations in Sikkim. The rise and dispersion of these dense masses, and their collection and recondensation on the mountains in the morning, is one of the most magnificent phenomena of the Himalaya, when viewed from a proper elevation; it commences as soon as the sun appears on the horizon.

The mean daily range of the thermometer at 7000 feet is 13° in cleared spots, but considerably less in wooded, and certainly one-third less in the forest itself. At 11,000 feet it amounts to about 20°, and at 15,000 feet to 27° (London 17·5°). These values vary widely in the different months, being much less in the summer or rainy months.

At 7,000 feet it amounts to		8°–9°	in	Aug. and Sept., and	17°	in Dec.
11,000	,,	12°	,,	,,	30	,,
15,000	,,	15	,,	,,	40	,,
London	,,	20	,,	,,	10	,,

Temperature of the earth.—This, at 2½ to 3 feet depth, varies with the temperature of the month, but is hardly affected by the diurnal variation, except in extreme cases. In summer, throughout the rains, May to October, the temperature is that of the month, which is imparted by the rain to the depth of 11 feet during severe continued falls (of 6 to 12 inches a day), on which occasions I have seen the buried thermometer indicating a temperature above the mean of the month. Again, in the winter months, December and January, it stands 5° above the monthly mean; in November and February 4° to 5°; in March it is a little below the mean temperature of the month, and in October above it; April and May being sunny, it stands above their mean temperature; June to September a little below the mean temperature of each respectively.

In the middle and upper zones the sunk thermometer always stands considerably above the mean of the month, the sun's rays being more powerful and frequently felt, the rain less; and the earth, being cooled less by nocturnal radiation than it is warmed by solar, accumulates heat to a certain depth. Thus in January, at 13,000 feet, I have found it 17° above the mean temperature, though the soil was frozen hard for 16 inches; and in July, at the same elevation, 7·5° above the mean temperature. In August I have seen it + 8° at 12,000 feet, in September + 7·4° at 15,400 feet, and in October + 12° at 16,800 feet; in July +7·6° at 12,800 feet, and in October + 10·5° at the same spot; in December + 9° at 13,500 feet with several inches of frozen soil. It is probable that the intense winter cold of the upper zone does not materially affect the soil at 3 feet depth, for there is always a sufficiently deep covering of snow after the second week of January to protect the soil from excessive cold.

Solar radiation.—From a multitude of desultory observations with the black bulb thermometer, I conclude that at 7000 feet, 67° above the temperature of the air is the average maximum effect of the sun's rays on a black bulb thermometer* throughout the year, amounting rarely to + 70° and + 80° in the summer months, and more frequently in the winter. These results, though greatly above what are obtained at Calcutta, are not much, if at all, above what prevail at the foot of the hills and up the Gangetic valley. This effect is greatly increased with the elevation. At 10,000 feet, in December, at 9 A.M., I saw it mount to 132° with a diff. of +94°, whilst the temperature of shaded snow hard by was 22°; at 13,100 feet, in

* From the mean of very many observations I find that 10° is the average difference between two otherwise equal and similar white and black bulb thermometers at the level of the sea.

January, at 9 A.M., it has stood at 98°, diff. + 68·2°, and at 10 A.M. at 114°, diff. + 81·4°, whilst the radiating thermometer on the snow had fallen at sunrise to 0·7°. In December, at 13,500 feet, I have seen it 110°, diff. + 84° ; at 11 A.M., 11,500 feet, 122°, diff. + 75°. In November, 9 A.M., at 13,500 feet, 112°, diff. + 82°. This is but a small selection from many, of the extraordinary power of solar radiation in the coldest months at great elevations. It is accompanied by a great increase of solar light, as I found by means of the black glass photometer.

Two phenomena particularly obstruct the solar light and heat —the clouds and fog from the end of May till October, and the haze from February to May. On the former I have dwelt sufficiently at length. Two months alone are usually clear, one before and one after the rains, when the air, though still humid, is transparent. The haze has never been fully explained, though a well-known phenomenon. On the plains of India, at the foot of the hills, it begins generally in the forenoon of the cold season, with the rise of the west wind, and, in February especially, obscures the sun's disc by noon; frequently it lasts throughout the 24 hours, and is usually accompanied by great dryness of the atmosphere. It gradually diminishes in ascending ; it cannot be said to prevail at 7000 feet, and I have never experienced it at 10,000. At 7000, however, it very often, in April, obscures the snowy ranges 30 miles off, which are bright and defined at sunrise, and either pale away or become of a lurid yellow-red, according to the density of this haze, as they disappear at 10 A.M. I believe it always accompanies a S.W. wind and dry atmosphere in Sikkim.

Nocturnal radiation.—This is even a more difficult phenomenon for the traveller to estimate than solar radiation, the danger of exposing instruments at night being always great in wild countries. I have used the parabolic reflector and white cotton most frequently, and find no material difference in the means of many observations of each, though often 1° to 2° in individual ones. Avoiding radiation from surrounding objects is very difficult, especially in wooded countries. I have also tried the radiating power of grass and the earth ; the latter generally is lower, the former higher than the thermometer exposed on cotton or in the reflector, but much depends on the surface of the herbage and soil. Snow radiates the most powerfully of any substance I have tried ; in one instance, at 13,000 feet, in January, the thermometer on snow fell to 0·2°, which was 10·8° below the temperature at the time, grass showing 6·7°, and on another occasion to 1·2°, when the air at the time (before sunrise) was 21·2°, and the difference 20°. I have frequently made this observation, and always with a similar result ; it may

account for the great injury plants sustain from a thin covering of ice on their foliage, even when the temperature is but little below the freezing point.

The power of terrestrial radiation increases with the elevation, as does solar radiation, but not in an equal proportion. At 7000 feet there is little radiation during the rains; the nights are almost invariably cloudy—3° to 4° is the mean maximum, but it is not on one night out of six that there is any radiation. From October to December the amount is greater = 10° to 12°, and from January till May greater still, reaching 15°. During the winter months the effect of radiation is often felt throughout the clear days, dew forming abundantly at 4000 to 8000 feet in the shaded bottoms of narrow valleys, into which the sun does not penetrate till 10 A.M., and from which it disappears at 3 P.M. I have seen the thermometer in the reflector fall 12° at 10 A.M. in a shaded valley. This often produces an anomalous effect, causing the temperature in the shade to fall after sunrise; for the mists which condense in the bottoms of the valleys after midnight disperse after sunrise, but long before the sun reaches the valleys, and powerful radiation ensues, lowering the surrounding temperature. A fall of 1° to 2° after sunrise of air in the shade is hence common in valleys in November and December. The excessive radiation of the winter months often gives rise to a curious phenomenon; it causes the formation of copious dew on the blanket of the traveller's bed, which radiates to the tent roof, and this inside an open or closed tent. I have experienced this at various elevations, from 6000 to 16,000 feet. Whether the minimum temperature was as high as 50° or but little above zero, the effect is the same, except that hoar frost or ice forms in the latter case. Another remarkable effect of nocturnal radiation is the curl of the alpine Rhododendron leaves in November, which is probably due to the freezing and consequent expansion of the water in the upper strata of cells exposed to the sky. The first curl is generally repaired by the ensuing day's sun, but after two or three nights the leaves become permanently curled, and remain so till they fall in the following spring.

Many alpine plants resist a great degree of radiation; the *Cyananthus*, especially, I have observed to be uninjured by a minimum temperature of 31·0° lowered 12·0° by radiation, in the month of September, at 15,500 feet; and yet this is one of the most delicate as well as beautiful of Himalayan blossoms. As a general rule, however, the commencement of the September and October radiation is the signal for the extinction of the alpine herbaceous vegetation.

I have elsewhere said that the nocturnal radiation of the

English spring months is the great obstacle to the cultivation of many Himalayan plants; it is not hence to be inferred that there is no similar amount of radiation in the Himalaya, for, on the contrary, in April its amount is much greater than in England, equalling 13° of difference frequently, and I have seen 16° at 7500 feet; but the minimum temperature at the time is 51°, and the absolute amount of cold hence immaterial. The mean minimum of London is 38·0°, and when lowered 5·5° by radiation the consequent cold is very considerable. Mr. Daniell, in his admirable essay on the climate of London (the perusal of which first gave me an interest in these pursuits), mentions +17° as the maximum effect of nocturnal radiation ever observed by him; I have had +20° from the surface of snow, and I have registered + 13·0°, + 14·0°, + 15·5°, and + 16·0° in April at Darjiling; nearly as much at 6000 feet in February; once +12·0°, twice +13·0°, and once +14·2° in September at 15,500 feet; +10° in October at 16,800 feet; +11·0°, + 12·0°, and nearly + 13·0° in January at 7000 feet; + 10° to + 14·5° repeatedly in February at that elevation, and + 12° to + 14·7° at 10,000 feet in November on several occasions.

To conclude, though nocturnal radiation does occur frequently, and has on the whole a much more powerful effect in Sikkim than in England, I doubt if the mean effect of all the months in Sikkim would equal that of London, from so many more nights being cloudy, which cloudy atmosphere and the comparatively high temperature of the nocturnal radiating months are what a Himalayan vegetation wants in England.

Winds.—Of the Himalayan winds there is little to be said affecting the horticulturist. The southerly moist, warm current is perennial, except during the spring months, when occasional S.W. squalls or moderate day winds blow. The nights are usually calm, or return cool winds sweep gently down the valleys. The northerly winds are said to bring snow; in December to February they appear to me to be local phenomena, and are under currents from the snowed regions, which condense and freeze the lower strata of the main current. Heavy gales occur at the equinoxes in the Himalaya as all the world over, but I have never experienced cyclones or hurricanes. Midsummer and midwinter are also generally characterised by storm and rain.

Atmospheric pressure.—It has long been surmised that an alpine vegetation may owe some of its peculiarities to the diminished atmospheric pressure; and that the latter being a condition which the gardener cannot supply, he can never successfully cultivate alpine plants in general. I know of no foundation for this hypothesis; many plants, natives of the level of the sea

in other parts of the world, and some even of the hot plains of Bengal, ascend to 12,000 and even 15,000 feet on the Himalaya, unaffected by diminished pressure. Any quantity of species from low countries may be cultivated, and some have been for ages, at 10,000 to 14,000 feet, without change. It is the same with man and the lower animals; innumerable instances may with ease be adduced of pressure alone inducing no appreciable change, whilst there is an absence of any proof to the contrary. The phenomena that accompany diminished pressure are the real obstacles to the cultivation of alpine plants, of which cold and the excessive climate are perhaps the most formidable. Plants that grow in localities marked by sudden extremes of heat and cold are always very variable in stature, habit, and foliage. In a state of nature we say the plants "accommodate themselves" to these changes, and so they do within certain limits; but for one that survives of all the seeds that germinate in these inhospitable localities, thousands die. In our gardens we can neither imitate the conditions of an alpine climate, nor offer others suited to the plants of such climates.

Light.—The plants of the different zones are very differently situated with regard to this element. The forest region, which so uniformly extends to 12,000 feet, shuts out much light from the plants that grow in it, and such are generally pale-coloured or white,—as, amongst rhododendrons, R. *Hodgsoni*, R. *camelliæflorum*, R. *argenteum*, R. *Falconeri*, &c. &c. On the other hand, many of the most gorgeously coloured ones abound in the sunniest and lightest spots, as R. *fulgens*, R. *arboreum*, R. *Thomsoni*. Still it must be recollected that many species eminently abundant in the sunniest exposures are pale flowered, as R. *Wightii*, R. *campylocarpum*, R. *lilacinum*, and R. *Griffithii*; and that some gorgeous species are very frequent in deep woods, as R. *arboreum* itself, R. *Thomsoni*, R. *barbatum*, R. *cinnabarinum*, and that their colour is not materially lessened, except the shade be unnaturally deep. It is hence difficult to appreciate the direct influence of sunlight on the individual plants in the Himalaya. If on the other hand we compare all the species as there existing, with their congeners in higher latitudes, it becomes evident that the balance in favour of gorgeous colouring is greatly on the side of the Himalaya; which renders it probable that the more direct sun's beam of lat. 26° to 28° has an influence which its slanting rays in high latitudes have not. This is a very interesting subject for future investigation; it cannot be satisfactorily dealt with, except by accurately estimating the number of coloured species in two well-marked localities. One remarkable fact has already come prominently before me, which is, that the R. *ciliatum*, now flowering abundantly at Kew, has larger

blossoms than I ever saw it to have in the Himalaya, but of a paler hue by far than any of the red-coloured series in Sikkim, except R. *anthopogon*,—judging from colour alone, I should not have recognised it. May is its flowering season in its native locality, and a purplish red the colour I have been accustomed to see it.

Sikkim climate as compared with London.—The colder winters and warmer summers are the prominent differences of the London climate, as the following comparison shows:—

	Mean Temp.	July.	January.	Range.	Mean Max.
London	50·0	63·2	36·0	27·2	71·0
Darjiling	53·5	61·4	40·0	21·4	65·3

	Mean Min.	Extreme Max.	Extreme Min.	Extreme Diff.
London	34·2	94·0	−4·5	98·5
Darjiling	38·2	71·0	25·5	46·5

The extreme Darjiling data given here are not low enough for the minimum, or high enough for the maximum; but they give a sufficient approximation. At 10,000 to 11,000 feet, where most species of rhododendrons grow, the climate in its main features of great extremes approaches nearer to the English; but the mean temperature (40°) is too low. Our summers are much too hot for the plants of that elevation, and our winters being too mild, they make shoots earlier in spring than in the Himalaya, which are cut off by frosts in April. Though the temperature is more uniform in Sikkim, it presents one curious anomaly, which is, that an accession of 8° of temperature occurs in March, above February, the parallel of which does not occur till June in England, which is 8° warmer than May. This brings the rhododendrons so early into flower at 7000 feet, and keeps the radiating thermometer always above freezing for the rest of the spring.

Again, there is in London nearly 20° of average difference between the day and night temp. of April, and 22° in May,—months wherein 15° and 13° are the corresponding Darjiling differences. This is a very powerful obstacle to the cultivation out of doors of many otherwise very hardy Himalayan plants, which are impatient of sudden changes, and incapable of bearing sudden, sharp frosts in March and April.

As the flowering season advances and fruit-setting comes on, the temperature in Sikkim becomes more markedly uniform, the mean difference between day and night being, in May, 13°; June, 11°; July, 10°. In London it is not so: May, 22°; June, 21·6°; July, 21·6°. Turning again to the autumn solstice, the sudden fall of temperature occurs both in Sikkim and London in November, and amounts in each to upwards of 7°; but whereas the difference between day and night is increasing in Sikkim, it decreases in London, a circumstance which may affect the ripening of seed, by checking the vegetative organs.

I have here taken the Darjiling elevation of 7000 feet as the standard of comparison between the Himalaya and London, and of course it is understood that I here speak of the cultivation of species of that zone; but as most of the Himalayan plants have a range of fully 3000 feet, which equals a mean annual difference of temp. of about 10°, it follows that localities with a mean annual temp. of 46° to 56° are in that one respect suited to the cultivation of species of the lower zone. It must also be borne in mind, that the temperatures are less uniform above 7000 feet in Sikkim, than at that particular elevation where the maximum of moisture prevails.

Seasons, general remarks on.—These, throughout the Himalaya, partake more or less markedly of the hot and cold, or wet and dry of the plains of Bengal, with this exception, that the dry westerly wind which sweeps across the plains during many of the winter months is scarcely felt in Sikkim, or in the afternoon only in occasional puffs from the S.W. The southerly wind blows steadily from May till November, but is not uniformly moist at all seasons; it attains its maximum of humidity in July and August, when, being warmest, its capacity for transporting moisture is also greatest. From November till April, calms and light winds prevail, with occasional gales. Electric disturbances are most frequent from March to May, and again at the end of the rains; they are however almost wholly confined to the foot of the hills and outer ranges.

The rainy season commences with a spring fall in April or May, which is the flowering seasons of all the rhododendrons, and of most of the magnolias of the lower zone (7000 to 10,000 feet). A remarkable uniformity of humidity and temperature now prevails at all elevations, till the fruiting season, which occurs in September at the upper zone, in October in the middle, and November and December in the lower zone. The rains have fairly "set in" by the middle or end of May, and the rhododendron flowers are withered within a month of their flowering, that is, by the beginning of June in both lower and middle zone, and but little later above 14,000 feet; for though they bud so late in the alpine regions, vegetation proceeds there much more rapidly.

In the upper zone May is the budding month, and the resinous scales that envelop the rhododendron flowers are no sooner thrown off than the leaves are expanded, and the flowers follow with that rapidity which is so characteristic of an arctic spring, and indeed of all excessive climates.

The distribution of the seasons in the three zones is very peculiar, and gives rise to some anomalies that have puzzled naturalists. From the middle of October to that of May, vegetation

is torpid above 14,000 feet, and indeed almost uniformly covered with snow. From November till the middle of April, vegetation is also torpid in the middle zone (above 10,000 feet), except that a few trees and bushes do not ripen all their seeds till December. The three winter months (December, January, and February) are all but dead in the lower zone (above 6000 feet), the earliest appearance of spring at Darjiling (7000 feet) being at the sudden accession of heat in March. From May till August the vegetation in each zone is (in ascending order) a month behind that below it; 4000 feet being about equal to a month of summer weather in one sense. I mean by this, that the genera and natural orders which flower at, say 8000 feet in May, are not so forward at 12,000 feet till June, nor at 16,000 feet till July. After August, however, the reverse holds good; then the vegetation is as forward at 16,000 feet as at 8000 feet. By the end of September most of the natural orders and genera have ripened their fruit in the upper zone, though they have flowered as late as July; whereas October is the fruiting month at 12,000, and November below 10,000 feet.

The Rhododendrons offer good instances of this :—

16,000 to 17,000 feet, R. *nivale* flowers July; fruits September.
13,000 to 14,000 feet, R. *anthopogon* flowers June; fruits October.
11,000 to 12,000 feet, R. *campanulatum* flowers in May; fruits in Nov.
8,000 to 9,000 feet, R. *argenteum* flowers in April; fruits in December.

And so it is with many species of *Compositæ* and *Umbelliferæ*, and indeed of all natural orders, some of which I have on the same day gathered in ripe fruit at 13.000 to 14,000 feet, and found still in flower at 9000 to 10,000. The brighter skies and more powerful and frequent solar radiation at the greater elevations, account for this apparent inversion of the order of nature.

I shall conclude this long essay with some notices of the vegetation of the months in the three zones specified, assuming the elevations of 7000 feet, 11,000 feet, and 15,000 feet, as typical of the three. I shall commence with March, which begins the new year as far as vegetation is concerned at 7000 feet.

March.—In the lower zone, in which alone vegetation is active, the mean temperature is 50·7°, or 3° below the mean of the year, and 8° to 9° warmer than February. The mean maximum is 58·4°; 68° is the extreme temperature attained in the shade, and 120° in the sun, from my very insufficient data for solar radiation in this month. The mean minimum is 43°; the greatest cold 37°; and when aided by radiation 27·8°; with a maximum difference of 9° between the minimum thermometer

and radiating one. The mean daily range is 15° to 16°, and the thermometer at 3 feet depth stands at 50°. The dew-point is 45·8° ; the mean humidity 0·8° to 0·9°, and the rain-fall about an inch, which generally comes in heavy showers of rain and hail, sometimes of sleet at the equinoxes.

This is eminently the spring month at Darjiling. Laurels and maples bud and leaf, together with many other trees, but not oaks. The ground is often covered with the long leaf bracts of the *Tetrantheras*. The large white *Michelia* flowers, Cherry abundantly, white *Rhododendron* (*argenteum*) and the scarlet (*arboreum*) in sunny spots. An early leafless *Cœlogyne* is common on the rocks (*C. præcox*?), the small blue gentian covers the ground on grassy banks, with the yellow *Fragaria Indica*, *Tormentilla*, a few violets, a pretty blue *Mazus*, and some few *Rubi*. The *Michelia*, cherry, and rhododendrons are, however, the only conspicuous plants of this season and elevation, with a pretty *Disporum* in the woods. In the garden peaches are in full flower, and many plants of the cold season of India, such annuals especially as belong to too cold or dry a climate to survive the damp heat of May and June if sown then—stocks, for instance. Most other garden flower seeds and bulbs are planted now, as well as vegetables ; the young plants sown previously require transplanting and protection from the hail, which occasionally cuts up tender plants terribly. Potatoes are planted out. Table vegetables are still abundant of the ordinary kinds. Insects commence their attacks on the gardens.*

April.—Mean temperature 56° ; of maxima 64°, and minima 48° ; extremes 68° and 38°. Extremes of radiation—solar 125°, terrestrial 33°. Extreme differences—solar 66°, terrestrial 16°. The mean daily range is nearly 16° ; sunk thermometer 60° ; dew-point 50° ; and saturation 0·80°. Rain 2·5 inches.

Most of the trees leaf and many flower in this month, as laurels, oaks, chesnuts, *Hydrangea*, birch. The smaller blossomed *Michelia* and the large magnolias flower in profusion, and the woods at 8000 to 9000 feet in some years look mottled with their great white and red flowers. Maple leaves are broad and red. Birch hangs its catkins. Some pretty and conspicuous shrubs flower, as *Adamia cyanea*, a *Viburnum*, white honeysuckle, the beautiful purple *Stauntonia*, several white and pink *Rubi*, a very sweet *Daphne* in the woods (of which paper is made), and the curious genus *Helwingia*. On the ground *Arisæmas* appear in profusion, and many other herbaceous plants leaf, as *Aralia*, *Paris*, and *Polygona*. Yellow strawberry,

* I am indebted to my friend Dr. Campbell, the superintendent of Darjiling, for most of the garden memoranda of the month.

Tormentilla, violets, and the ground-raspberry are common, with several *Dispora*, *Ophiopogon*, *Melissa parvifolia*, and *Isopyrum*; beautiful white-flowered leafy *Cœlogynes* adorn the moist rocks, which, with a very fine *Cymbidium* on the trees, are common at and above 6000 feet.

Little is doing in the garden more than was in March; sowing and planting out go on with activity. English strawberries flower abundantly, as do currants.

May.—Mean temperature 56·6° (only 1° above April). Means of maxima 65·3°, and of minima 50°; extremes 69° and 38°. Extremes of radiation — solar 125°, terrestrial 40°. Mean daily range 13·3°; dew-point 50°; saturation 0·91°. Rain 9 inches, falling in sharp showers late in the forenoon or afternoon of about half the days in the month. More falls in the night than in the day.

The botanist may reap a rich harvest in this month, the jungle and mountain plants between 6000 and 10,000 feet coming into flower in rapid succession. Of these the trees are—

Yew (probably identical with English).
Maples, various.
Apple and several *Pyri*.
Photinia.
Manglietia.
Lauri, various.
Symplocos.
Alder.
Large-leaved oak.
Hydrangea.
Sauranja.
Englehardtia.
Walnut.
Euonymus.
Myrsineæ, various.
Olea.
Podalyria.
Ash.

The great magnolias and michelias, and large white Rhododendron (*argenteum*), are all past flower.

Of shrubs there are many and beautiful species—

Limonia.
Stauntonia.
White Rose (*Webbiana*).
Sarcococca.
Aucuba.
Symplocos.
Gualtheriæ.
Vaccinia.
Rhododendrons.
Rubi, several (the yellow-fruited now abundantly ripe).
Indigofera.
Cotoneaster.
Adamia.
Smilax.
Ribes.

Woody climbers.
Stauntonia.
Sauranja.
Kadsura.
Sphæros temma.
Sabia.
Myrsineæ sp.
Holostemma.
Smilax.
Jasminum (white).

Herbaceous plants are common, but being annuals they are comparatively backward; the chief are—

Dentaria.
Viola.
Anemone.
Potentilla.
Fagopyrum.
Paris.
Trillium.
Euphorbia.
Androsace.
Tiarella.
Chrysosplenium.
Ophiopogon.
Coriaria.
Fumaria.
Dielytra.
Corydalis.
Many and splendid *Arisæmas*.
Panax (2 herbaceous sp.).
Some fine *Hedychia*.
Roscoea.
Streptolirion.

A leafless purple *Cœlogyne* (*C. Wallichii?*) is abundant, and makes a gorgeous show on the trees, as do the white-flowered leafy species.

The gardens at Darjiling are very gay during this month—roses, poppies, snapdragons, heartseases, larkspurs, pinks, and lupines. Strawberries ripen, and continue in fruit for two months. The cucurbitaceous vegetables are planted, as melons, cucumbers, squash, &c. Those planted in autumn are now producing abundantly, as peas, French beans, salads, turnips, and cabbages.

Middle Zone.—In this region spring is only now established; much less rain (one-third less) falls above 10,000 feet, in the position marked P in the woodcut, than at Darjiling. Snow occasionally sprinkles the forest, but what falls does not lie on the ground. On the other hand, the winter's snow, still abundant at 12,000 feet, is rapidly melting, and the rivers rise daily. The different pines, *Abies Webbiana*, *Brunoniana*, and the larch flower, as do *Viburnum*, willow, and juniper. Very few herbaceous plants are advanced, of which the chief are a purple *Dentaria*, and some other *Cruciferæ*, primroses, *Anemone*, *Ranunculi*, a *Gentiana*, two large *Arisæmas*, a purple *Saxifraga* like *ciliata*, *Cotoneaster*, *Potentilla*, and *Podophyllum*.

Upper Zone.—So little snow falls here, comparatively speaking, that the passes even of 18,000 to 19,000 feet are open this month, but vegetation has made little progress, the soil being frozen in many places. Even the grass is not long enough to be cropped by cattle or sheep.

June.—Mean temperature (7000 ft.) 61·2°; of maxima 66·7°, and minima 55·8°. Extremes 71° and 51·5°. Extremes of radiation—solar 126°, terrestrial 47°. Extreme differences—solar 62°, terrestrial 4·8°. Mean daily range of temperature, 11°. Mean dew-point, 59·5°; saturation 0·93°. Rain 26·964 inches (mean of 5 years—maximum 32·68 inches, minimum 12 inches), distributed, in 1849 (when 32·688 inches fell), over every day but 7, and every night but 3. Between sunrise and sunset 12·593 inches fell; during the night 20·035 inches. The showers, though heavy and frequent, do not combine to form a continuous downpour at any time, and there is a good deal of sunshine from 8 to 10 A.M., and often at sunset also.

The flowering season of most of the trees at 7000 feet is now over, but many shrubs blossom, as *Polygala*, *Xanthoxylon*, *Indigofera*, a *Magnolia* with white sweet-scented globe flowers, *Spiræas*, *Hydrangea*, yellow jasmine, various *Araliaceæ*, *Neillia*, *Leycesteria*, and shrubby *Polygona*; *Pyri*, many and shrubby; *Rosaceæ* generally; some laurels and *Viburna*, vines. Of herbs, balsams now appear prominently, with *Streptolirion*, *Ge-*

rania, great-flowered *Aristolochia*, *Parochætus*, *Smilacina*, *Convallaria*, and *Dispora*; some fine *Scitamineæ*, *Parnassia*, *Potentilla anserina*, *Arum* and *Arisæmas*, *Monotropa*, *Pyrola*, *Pieris*, yellow *Crawfurdia*, *Iris*, *Campanula*, *Balanophora*, *Habenariæ*, and some curious terrestrial orchideæ, as *Cyrtosia*. Wild brambles are abundant, and several kinds are very good. *Elæagnus* berries ripen.

In the gardens the rains damage the unprotected flowers sadly. Cuttings are taken of rose, sweet-william, and pink. Such flowers as will blossom after the rains are now sown, as sweet-peas and lupines. Tulips flower, but not very well, as does the *Fuchsia*. Transplanting goes on actively. Table vegetables of all kinds are abundant and good, but flavourless.

Middle Zone.—I spent the greater part of this month above 11,000 feet, a little to the north of the position of Kinchinjunga, in well-wooded valleys, &c. The weather was uniformly cloudy, misty, and rainy; but the showers were never excessive, and only 6 inches fell, or one-half less than at Darjiling. The trees in flower are generally of the same genera as flowered at 9000 to 10,000 feet last month, and the species are in many instances the same, as *Pyri*, birch, one oak, willow, a maple, holly (forming a bush); *Abies Webbiana* cones are a splendid purple, those of the larch red brown, and of *P. Smithiana* green; junipers form berries. A white cherry, Loniceras, *Symplocos*, and *Pieris*, are the chief flowering trees. Of shrubs there are other Loniceras, Potentillas, Rhododendrons, *Araliaceæ*, 2 currants, willows, *Andromeda*, *Gualtheria*. Primroses are the glories of the herbaceous vegetation, appearing in profusion, yellow, white, and purple; beautiful anemones and ranunculi flower, with *Thalictra*, some *Berberris*, a splendid single-flowered *Meconopsis*, several *Cruciferæ*, *Tamarix* (creeping), *Sibbaldiæ*, *Fritillaria*, *Orobanche*, small *Paris* and *Trillium*, *Pinguicula*, *Parnassia*, *Allium*, *Morina*, *Ophiopogon*, the great *Rheum*, *Juncus*, and *Luzula*. Rhododendrons many.

Upper Zone.—Towards the end of this month the grass is well grown in the valleys, at 13,000 to 16,000 feet, and the cattle are driven up to the grazing grounds. A few plants flower above 15,000 feet, as *Anemone*, *Primula*, *Astragalus*, *Parnassia*, and *Picrorhiga teeta*.

July.—Mean temperature 61·4°; of maxima and minima 65·5° —57·3°; extremes 70°—56°. Extremes of radiation, solar 130°, terrest. 3·52°. Extreme differences, solar 62°, terrest. 3·5°. Mean daily range of temperature 8°. Dew-point 60·7°. Saturation 0·97°. Rain-fall 25·336 inches (mean of 5 years, maximum 33, minimum 17·915). In 1848, 21·605 inches fell; it rained every day but one, 12·22 inches per day, and 9·235 between

sunset and sunrise, there having been 18 rainless nights, but only five occasions on which none fell between sunrise and sunset.

The beautiful scarlet *Buddleia* at 9000 to 10,000 feet, and a fine *Erythria* at 6000 to 7000 feet, are the only remarkable trees I have noted as flowering during this month in the lower zone, except a *Saurauja*. Of shrubs, the chief are *Hyperica Deutzia*, *Philadelphus*, *Neillia*, and many that flowered late in the previous month, together with the beautiful red rose. Herbaceous plants succeed one another rapidly; magnificent Balsams, *Cyrtandraceæ*, Begonias, *Scitamineæ*, and *Æschynanthus* abound, with *Mimulus*, *Torrenia*, *Campanula*, *Codonopsis*, *Thalictra*. The gigantic lily, and various terrestrial *Orchideæ*, as *Calanthe*, *Habenaria*, *Spathoglottis*, *Neottia*, and *Serapias*. *Epilobia* are common. *Circeæ*, *Valeriana*, *Notochæte*, the purple *Convolvulus*, white-flowered *Polygona*, and *Cucurbitaceæ* begin to flower. Acorns, holly, and laurel berries are fully formed; *Labiatæ* bud, as do *Compositæ* and *Urticeæ*.

In the garden there are still heartseases, lupines, sweet peas, roses, evening primroses, dahlias, sweet Williams, hollyhocks, mallows, snap-dragons, and marigolds. The kitchen-garden shows radishes, cress, cabbages, squash, and other Cucurbitaceæ; French beans and peas, but sparingly; cabbages, brocoli, and cauliflower abundant. Weeds grow apace and keep the gardener busy.

Second, or Middle Zone.—I spent much of this month at 12,000 to 16,000 feet elevation, and further north than in June. The rain-fall I found reduced to little more than 6 inches; it rained however nearly every day, three times as much falling at night as during the day. Between 10,000 and 14,000 feet vegetation has advanced during this month with marvellous rapidity. The short grass and herbage of open spots, especially at 10,000 to 12,000 feet, are replaced by a rank growth, 6 to 8 feet high, of *Thalictra*, tall *Astragalus*, grasses, and *Cyperaceæ*, *Euphorbiæ*, a superb yellow and a purple *Meconopsis*, each with racemes 1 to 2 feet long of blossoms as broad as the palm of the hand; gigantic *Heraclea* spring up 9 feet high whilst fruiting, with twiggy *Bupleura*, *Dipsacus*, *Convallariæ*, *Dispora*, and *Smilacina*, *Cimicifuga*, *Rumex*, and various Compositæ not yet in flower, bound together by masses of *Cuscuta* and *Codonopsis*. Amongst these grow, but more sparingly, *Balanophora*, *Morina*, *Gerania*, large *Cynoglossa*, many *Pedicularis*, *Hypericum*, and *Gamoplexis*, together forming complete thickets of herbage. In more open places, at greater elevations, 12,000 to 13,000 feet, *Cypripedium*, *Epipactis*, and small *Orchideæ* are very abundant, with tufted *Astragali*, *Lloydia* (two species),

other *Pediculares*, *Triglochin*, *Callitriche*, *Veronica*, *Campanula*, *Saxifraga*, *Draba*, small *Morina*, *Parnassia*, *Rheum*, *Thermopsis*, a *Saussurea* with bladdery bracts, *Anisodinus* flowers, Berberry begins to fruit, as do *Pyri* and *Lonicera*. Agriculture is little pursued at this elevation, *Fagopyrum* crops flower at 12,000 feet, and barley sown two months before is fully in ear, or, if sown in the end of May, in flower early this month. Radishes and turnips are in leaf at 15,000 to 16,000 feet, and their tubers formed. Potatoes flower.

Third, or Upper Zone.—There is much snow still in July, even on the rearward mountains, where the perpetual snow-line is at 18,000 feet; still most of the shrubs that are found above 14,000 feet are in flower, as *Spiræa*, *Lonicera*, *Potentilla*, willow, juniper, berberry, and an occasional rose. *Ranunculaceæ* abound, *Ranunculus*, *Delphinum*, *Aconitum*, *Caltha*, many *Astragali* flower, with *Corydalis*, *Hypecoum*, *Myosotis*, *Parnassia;* many *Pedicularis*, *Sibbaldia;* small *Primulæ*, *Alsineæ*, and *Cruciferæ;* the alpine purple *Meconopsis*, *Morina*, *Androsaces*, *Picrorhiza*, *Nardostachys*, *Gymnandra*, *Dracocephalum*, *Veronica*, *Sedu*, *Cassiope*, and *Menziesia*. The single-spiked *Carices* and *Poæ* flower, *Festuca*, *Aira*, *Hierochloe*, *Stipa*. In Tibetan regions a nettle abounds at upwards of 16,000 feet, and some *Artemisiæ* are the only early Compositæ in flower.

August.—Mean temperature (7000 feet) 61·7°; of maxima 66·1°, and minima 57·4°; of daily range 8·7°. Extremes 70° and 54·5°; of radiation—solar 133°, terrestrial 50°. Extreme differences—solar 62°, terrestrial 3·5°. Mean dew-point 60·4°; saturation 0·97. Rain 29·454 inches (means of 4 years 33·320 and 24·510 inches). In 1849 26·811 inches fell, and it rained every day but one, 10·802 inches falling after sunrise, and 16 after sunset. In the interior, on the other hand, at the same elevation, I experienced only 12·45 inches of rain, of which 8·29 fell in the night, and 4·16 during day. It rained, however, more or less nearly every day.

Vegetation in the lower region is at its fullest vigour. The common bracken (*Pteris aquilina?*) covers the ground, with a yellow *Cucurbitacea*. Many annuals that flowered in May and June are passing to seed, as *Cyrtandraceæ*, balsams, and begonias, but still many species are in flower. *Umbelliferæ*, which are rare below 9000 feet, flower, together with *Anemone vitifolia*, various *Hedychia*, some very magnificent. *Sparganium* blossoms, and *Colquhounia*, the small-flowered *Neillia*, *Ceropegias*, *Cuscuta*, many *Cucurbitaceæ*, especially *Trichosanthes*, tree *Araliaceæ*, the sweet *Buddleia*, *Ophelia*, *Clematis*, *Tricyrtis*, *Passiflora*, *Myrsine*, and *Embelia*, yellow honeysuckle,

Xanthoxylon, *Hypericum*, *Osbeckia;* a few thistles commence flowering, with gnaphaloid *Compositæ*, but not so freely or fully as *Eupatorium*, blue *Cichoraceæ*, *Myriactis*, *Callimeris*, two *Artemisias*, *Picris*, *Inula*, *Doronicum*, and *Mulgedium*. In open places at 8000 feet *Euphrasia*, *Drosera peltata*, *Neottia æstivalis*, *Dipsacus*, *Halenia*, and Erigerons flower.

In the kitchen-garden potatoes are planted with manure, and towards the end of the month the haulms of the early sorts wither, and the roots are stored. Table vegetables are abundant, with legumes of all kinds, turnips, radishes, carrots, lettuce, all varieties of vegetable marrows, squash, cucumbers, and asparagus, the latter generally small and woody. In the flower-garden are dahlias, marigolds, sunflowers, China roses, lupines, mignonette, larkspurs, rose-campions, œnotheras, heartsease, all thriving tolerably if protected from the rain, but it is better to keep them back till the following month.

There is little native cultivation carried on. Rice and other cerealia are in ear above 7000 feet, and maize is in flower just below that.

Animal life swarms in this month, especially insects. Cicadas and glow-worms ascend above 8000 feet. *Libellulæ*, *Tipulæ*, *Cynthia cardui*, and *Papilio Machaon* are very frequent at 6000 to 10,000 feet. Mosquitoes in myriads and countless leeches, with sandflies, swarm at 6000, and ascend to 8000 feet, the leeches and sandflies to 12,000. Swampy places become feverish even at 6000 feet.

Second, or Middle Region.—Above 9000 feet vegetation is also in its prime, from the abundance of *Compositæ* which adorn the skirts of the woods and open places, especially beautiful senecios, thistles, *Mulgedium*, *Aplotaxis*, *Dolomiæa*, *Ligularia*, and *Saussurea*, *Callimeris* and abundance of *Erigeron*, *Doronicum*, *Clematis* blossoms freely. Gentians, *Halenia*, *Ophelia*, &c., are all in bloom, with the most of the *Umbelliferæ*. Saxifrages form masses of golden blossoms at 12,000 to 13,000 feet, mixed with *Cyananthus*, *Codonopsis*, *Scrophularia*, *Polygona*, *Fumaria*, and *Corydalis*, *Oxyria*, *Primula denticulata*, *Salvia*, *Delphinia*, tall aconites, terrestrial *Orchideæ*, *Lilium Thomsoni*, *Verbascum*, and many other European genera.

Third, or Arctic Zone.—Some beautiful primulas are still only in flower, near the snow, at 15,000 feet, with many species of *Corydalis*, *Nardostachys*, *Chrysosplenium*, *Menziesia*, *Seda*, *Saussurea*, *Parnassia*, yellow *Drabas*, and *Androsaceæ*, at the southern passes, which, being in a more rainy climate, are backwarder. In the northern or drier parts, again, *Artemisiæ* appear, with *Delphinium Brunonis*, various *Cyananthi*, *Vero-*

nisa, *Kœnigia*, 6 potentillas, *Anaphalis*, *Serratula*, and many grasses, carices, and *Junci*.

September.—Mean temperature (7000 feet) 60° ; of maxima 64·7, and minima 55·2 ; of daily range 9·5°. Sunk thermometer 60°. Extremes of temperature 70° and 51·5° ; of radiating thermometers—solar 142°, terrestrial 47·5°. Extreme differences—solar 70°, terrestrial 10°. Mean dew-point 58.5° ; saturation 0·95°. Rain 15·762 inches (mean of four years 20·375 and 13,410). In 1849 15·675 inches fell, 3·621 by day, and 12·054 by night. It rained all the month except on 5 days, but most frequently at night. The first fortnight of this month is usually a continuation of the August humid weather, when it holds up for a week or so previous to the equinox, which is ushered in by violent electric disturbances and heavy gales.

The most prominent botanical feature of the month is the abundance of *Labiatæ*, especially *Plectranthi*, *Elsholsia*, *Craniotome*, *Colquhounia*, *Prunella*, *Ajuga*, *Scutellaria*, *Nepeta*, and *Melissa* ; and graphaloid compositæ, especially species of *Anaphalis*, whiten the ground in some places. *Osbeckia* is in full bloom, with white and shrubby polygonums. Many *Urticeæ* flower, but they are insignificant green plants. March and April flowering species are generally in seed. *Acanthaceæ*, of which there are very few, flower.

In the garden the vegetables are, besides those of August, more *cruciferæ*, as kohl-rabi and savoys, with tomatoes and capsicums. Peas and beans are sowed for early crops, with cabbage, turnip, beet, radishes, and spring crops of all kinds. Peaches redden and fall off the trees without ripening. Strawberry-beds are cleaned and runners planted ; rose-cuttings made. Rice and other cerealia are cut at 4500 feet, but not higher.

Second, or Middle Zone.—I passed the latter part of August and beginning of this month at 11,000 feet, considerably north of Kinchinjunga, in a very moist valley, with patches of snow in gulleys at 12,000 feet, where, however, the rain-fall was less than half that at Darjiling. From the 8th to the end of the month I camped at 15,400 feet, and experienced only 1·67 inches, whilst 9·993 fell at Darjiling. A good deal of this was in the form of snow, which lay for several days at 16,000 feet, as early as the 9th. At the equinox the snow lay three days around my tent, but melted again. In the more southern parts of Sikkim (in the position of P on the woodcut) the September snow-fall sometimes lies till the following April or May. The weather was constantly misty and foggy at my position, but was always clear though cloudy when I went into Tibet. This is a fruiting month everywhere above 13,000 feet; the barley and Fagopyrum crops are cut, and turnips and radishes gathered ;

the cattle are driven down to 12,000 feet early in the month, and to 10,000 feet towards the end. Dandelion, *Erigeron*, and other compositæ are still in full flower.

Fourth, or Upper Zone, above 15,000 feet.—Many plants continue in flower early in the month and to beyond the middle, as beautiful *Cyananthi*, Gentians, *Elsholsia*, *Caltha*, *Taraxanem*, *Prunella*, curious *Lactuceæ*, *Saussureæ*, and *Serratulas*, *Leontopodium*, and other Gnaphaloid compositæ. Small *Polygona*, *Primulæ*, and indeed all June and July flowering plants, ripen their seeds. By the 21st vegetation may be said to be at an end, the grasses change colour, and severe frosts set in. Birds migrate south, and the Hoopoe and various small birds are occasional visitants on their passage to warmer climates.

October.—Mean temperature (7000 feet) 58°—of maxima 66·5°, minima 49·5°; daily range 17°; sunk thermometer 59°; extremes of temperature 68° and 43·5°; of radiating thermometers — solar 133°, terrestrial 32°; extreme differences from temperature of air—solar 65°, terrestrial 12°. Mean dew-point 52·5°; saturation 9·88. Rain-fall 8·66 inches (mean of four years 17·964 and 5·50). This is one of the most variable months in the year as regards the distribution of both heat and moisture. Fine weather almost invariably follows the equinoxial gales, and sometimes lasts. October has been described to me as a glorious, cloudless month, without a drop of rain. In 1848 there was more bad weather than good, with heavy squalls, thunder and lightning, and nearly 18 inches of rain fell. In 1849, again, very little rain indeed fell, but the month was so uniformly foggy and damp, that the rains were not considered over till November; yet during twenty days no rain fell at all. The same irregularity marks this season at all elevations, and I experienced more rain at 13,000 feet, in an almost Tibetan climate, than fell at Darjiling, owing probably to the condensation of the southerly wind over the September snow-fall, which had already lowered the snow-line in some parts of Sikkim.

In the lower zone there are still plants to flower, as *Prinsepia*, the beautiful blue *Crawfurdia*, *Eleagnus*, and *Balanophora polyandra*. Various species of *Clematis* also flower, with *Camellia*, *Eurya*, *Cuscuta*, *Symplocos*, *Prunus*, *Wightia*, a late-flowering *Michelia*, *Aplotaxis*, the superb *Luculia gratissima*, fragrant *Olea*, *Bucklandia*, *Eleagnus*, and many parasitical *Orchideæ*. The apple and other wild fruits ripen.

In the garden the early frosts are apt to do injury; potatoes should be all housed; celery is planted out in trenches; cabbages and kohl-rabi in drills. The garden should be all cleaned and weeded for planting spring vegetables before the end of the month.

The natives gather in all crops between 6000 and 8000 feet this month, including the various millets, which yield 200 to 400 fold, and the unirrigated rice grown in slopes, and producing 80 fold on the average.

Second, or Middle Zone.—Above 14,000 feet the scene is more wintry than autumnal, but below that many *Compositæ* and *Umbelliferæ* continue in flower, and some in fruit; the *Coniferæ* all have fully formed cones; some *Clematis* flower with *Prinsepia*, and blue *Crawfurdia* and the nut. The larch leaves turn yellow and then red previous to dropping. Belts of scarlet girdle the forests from the abundance of berberries, whose leaves change colour. The birch turns golden yellow, *Pyri* and maples red and yellow, whilst the *Abies Webbiana* and junipers are still black, the grass brown, rhododendrons a bright verdegris green. Of the latter some species throw out a few flowers, but most are in seed, as are wild currants, cherries, berberries, apples, hips, and Stauntonia, which latter affords the best wild fruit of this region and that below it, except *Rubi*.

November.—Mean temperature (7000 feet) 50°—of maxima 56·5°, minima 43·5°: daily range 13°. Sunk thermometer 54°. Extremes of temperature 63° and 38°; of radiating thermometers, —solar 123°, terrest. 30°: extreme difference from temperature of air—solar 68°, terrest. 12°. Mean dew-point 46·5°; saturation 0·89°. Rain-fall 0·4°. This is the least rainy month of the year, sometimes no rain falls, and it seldom exceeds a few tenths of an inch. Drought is sometimes experienced, with a bright clear sun by day and sharp frost at night. The sun's rays are very powerful, considering how low the temperature is, but the air is bracing and pleasant, like an English April.

The *Bucklandia* flowers in this month at 6000 to 7000 feet, a magnificent tree as regards form and foliage; *Wightia*, a scandent Bignoniaceous tree, also blossoms profusely, bearing no leaves, and forming immense masses of red in the forest; *Pittosporum* blooms, and a *Prunus* like *Padus*, whose leaves are excellent fodder for cattle. Alder is in catkin, and the yellow *Daphne Gardneri*, a very beautiful plant, scents the air; nettles flower profusely, and *Cuscuta*, with the great shrubby *Teucrium*. All crops are now housed, and wheat and barley sown at 9000 feet to be reaped in May.

In the upper regions the snow-line descends to 14,000 feet.

December.—Mean temperature (7000 feet), 43°; of maxima 51·6°, and minima 34·9°; daily range 16·7°; sunk thermometer 48°. Extremes of temperature 56° and 32·5°; of radiating thermometers—solar 108°, terrestrial 26°. Extreme differences from temperature of air—solar 77·2°, terrestrial 10°. Mean dew-point 30°; saturation 0·61°. Rain-fall 0·45. This month

is sometimes very dry; it was unusually so in 1837, when Dr. Chapman's register was kept: his reduced wet bulb observations are those from which I have worked the dew-points. Hoar frost is of almost nightly occurrence in December, but the cold is never extreme. About Christmas a storm is experienced, and a great quantity of snow falls in the upper regions, at as low elevations as 9000 feet, where I have seen 3 feet: much of this melts, however, owing to the warmth of the soil.

January.—Mean temperature (7000 feet) 40°; of maxima 47·2°, and minima 32·8°; daily range 14·4°; sunk thermometer 45°. Extremes of temperature 56° and 29°; of radiating thermometers—solar 119°, terrestrial 16°. Extreme differences from temperature of air—solar 72°, terrestrial 12·7°; mean dew-point 34·3°; saturation 0·84°. Rain-fall 1·718 inches; mean of three years 0·30 and 4·27. January is generally a stormy month, with bitterly cold, often violent winds, hail, sleet, and sometimes snow at Darjiling, and as low as 6000 feet, never lying beyond a few hours at the latter elevation, and it is rare for 3 inches to remain as many days at 7000 feet. Much snow falls about the middle of the month in the upper regions, the ground being covered several feet deep at 13,000 feet, and the snow-line is lowered to about that elevation, and does not recede from that till April or May. I found the soil at this elevation frozen for 16 inches, but warm below that, and as high as 34·5° at less than 3 feet deep.

February.—Mean temperature (7000 feet) 42·1°; of maxima 50°, and minima 34·2°; daily range 15·8°; sunk thermometer 47°. Extremes of temperature 57° and 25·5°; of radiating thermometers—solar 124·0°, terrestrial 23·°. Extreme differences from temperature of air—solar 78°, terrestrial 15·3°. Mean dew-point 36·7°; saturation 0·85°. Rain-fall 0·916; mean of three years 2·047.

This is also a stormy and cold month, with a good deal of thunder and lightning, hail, and sometimes snow. Turnips, carrots, beet, and cabbage are the chief garden vegetables; peas blossom freely in spite of the weather; tender plants are protected by matting; artichokes and rhubarb are manured; lupines, marigolds, and stocks are still in flower. Snow that falls at 11,000 and 12,000 feet remains till April: there are no plants of any consequence in flower above 6000 feet.

I append a meteorological register of the separate months for convenience of reference, but at the same time must remind the reader that it does not pretend to strict accuracy. It is founded upon observations made at Darjiling by Dr. Chapman in the year 1837, for temperature and wet bulb only; the other data and some modifications of the above are supplied from a very careful

collection of a multitude of observations of my own. The means of the month are taken by meaning the daily maxima and minima, which I think gives too high a result. Those for terrestrial and nocturnal radiation are accurate as far as they go, that is to say, they are absolute temperatures taken by myself, which may, I believe, be recorded in any year, but much higher are no doubt often to be obtained. The dew-points and saturations are generally calculated from the mean of two day observations (10 A.M. and 4 P.M.) of the wet bulb thermometer, together with the minimum, or are taken from observations of Daniell's hygrometer. The dew-point and temperature are assumed to coincide only at the hour of minimum temperature; but as they do coincide for, on the average, 10 hours of every 24, this method obviously gives too low a dew-point. On the other hand, the wet bulb observations, or hygrometer, were never taken at the hours of greatest dryness; and as I find the mean of the temperatures of 10 A.M., 4 P.M., and the minimum to coincide within a few tenths with the mean temperature of the whole year, I assume that the mean of the wet bulb observations of the same hours will give a sufficiently accurate approach to that of the 24 hours. The climate of Darjiling station has been in some degree altered by extensive clearances of forest, which render it more variable, more exposed to night frosts and strong sun, and to drought, the drying up of small streams being one direct consequence. My own observations were taken at Mr. Hodgson's house, elevated 7450 feet, the position of which I have indicated at p. 2 of this volume (in a note), where the differences of climate due to local causes are sufficiently indicated to show that in no two spots could similar meteorological results be obtained. At my station, for instance, the uniformity of temperature and humidity is infinitely more remarkable than at Dr. Chapman's, possibly from my guarding more effectually against radiation, and from the greater forest about Mr. Hodgson's house. I have not, however, ventured to interfere with the temperature columns on this account. Such as they are, I believe they afford amply sufficient data for the horticulturist who is anxious to exert his skill and ingenuity in the cultivation of Himalayan plants in general, and especially of Sikkim ones, though they will little avail him except he be previously master of the climate of England, for which purpose I would most strongly urge the study of Mr. Daniell's essay before alluded to, and the many papers in this Journal and elsewhere of Mr. Thompson, of the Horticultural Society's Gardens, which contain a vast amount of valuable matter, carefully collected and extremely well arranged.

—	Mean Shade.	Max. Shade.	Max. Sun.	Greatest Diff.	Mean Max. Shade.	Minim. Shade.	Minim. Rad.	Greatest Diff.	Mean Minim. Shade.	Mean Daily Range of Temp.	Sunk Therm.	Mean Dew Point.	Mean Dryness.	Force of Vapour.	Mean Saturation.	Rain in Inches.
January .	40·0	56·0	119·0	72·0	47·2	29·0	16·0	12 7	32·8	14·4	46·0	34·3	5·1	·216	·84	1·72
February	42·1	57·0	124·0	78·0	50·0	25·5	23·0	15·3	34·2	15·8	48·0	37·2	3·9	·239	·87	0·92
March .	50·7	66·5	120·0	60·0	58·4	37 0	27·8	8·7	43·1	15·3	50·0	45·8	5·8	·323	·82	1·12
April .	55·9	68·5	125·0	66·0	63·7	38·0	33·0	16·0	48·1	15·6	58·0	49·8	6·6	·371	·80	2·52
May . .	57·6	69·0	125·0	65·0	65·3	38·0	40·0	10·0	50·0	15·3	61·0	54·4	2·7	·434	·91	9·25
June . .	61·2	71·0	126·2	62·2	66·7	51·5	47·0	4·8	55·8	10·9	62·0	59·5	2·0	·515	·93	26·96
July . .	61·4	69·5	130·0	62·0	65·5	56·0	52·0	3·5	57·3	8·2	62·2	60·7	0·8	·535	·97	25·34
August .	61·7	70·0	133·0	62·0	66·1	54·5	50·0	3·5	57·4	8·7	62·0	60·4	1·1	·530	·96	29·45
September	59·9	70·0	142·0	70·0	64·7	51·5	47·5	10·0	55·2	9·5	61·0	58·5	1·4	·498	·95	15·76
October .	58·0	68·0	133·0	65·0	66·5	43·5	32·0	12·0	49·5	17·0	60·0	52·5	4·2	·407	·86	8·66
November	50·0	63·0	123·0	68·0	56·5	38·0	30·0	12·0	43 5	13·0	55·0	46·5	3·2	·331	·90	0·11
December	43·0	56·0	108·0	77·2	51·6	32·5	26·0	10·0	34·9	16·7	49·0	31·8	10·6	·198	·69	0·45
Mean .	53·5	65·4	125·7	67·3	60·2	41·3	35·4	9·9	46·8	13·4	56·2	49·3	3·9	·383	·88	122·26
London .	49·9	.	.	.	58·5	.	.	.	41·3	17·2	.	44·5	5·6	·342	·83	24·2
Sikkim Extreme	.	71·0	142·0	78·0	66·7	25·5	16·0	15·3	32·8	17·0	.	.	10·6	·535	·97	29·45
Extreme London	.	94·4	130·0	39·0	74·0	−4·5	−12·0	13·0	31·9	22·4	.	.	8·5	·482	·93	2·97