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X.—*The Musci and Hepaticæ of the Pyrenees.*
By RICHARD SPRUCE*.

[With three Plates]

BEFORE entering upon an enumeration of the Musci and Hepaticæ of the Pyrenees, it will be proper to indicate the sources from which it has been derived. I have not been able to find any trustworthy record of mosses gathered in the Pyrenees previous to the time of Bridel, who in 1803 visited the Pyrénées Orientales and the northern part of Catalonia, where he discovered his *Bartramia stricta*, *Barbula chloronotos* and some others. Of Bridel's mosses I have seen only a very few, communicated by Professor Arnott from the herbarium of M. Requen. In the 3rd edition of the 'Flore Française' (1815) several Pyrenean stations of mosses are recorded, on the authority of DeCandolle, Ramond, Dufour and Grateloup. The two botanists last-named have since that period continued to pay occasional botanical visits to the Pyrenees, almost up to the present time, and to their liberality I owe specimens of such mosses as they collected. In 1825 the eastern and central Pyrenees were visited by our distinguished countrymen, Messrs. G. Bentham and G. A. Walker-Arnott, and the latter gentleman has kindly communicated to me specimens of nearly all his Pyrenean mosses, a few only of which he has noticed in "A Tour to the South of France and the Pyrenees," inserted in the 'Edinburgh New Philosophical Journal' for April 1826. Still later, from 1828 to 1830, the eastern Pyrenees were at various times partially explored by Dr. C. Montagne, whose knowledge of general Cryptogamy is unrivalled, and his discoveries, including numerous lichens and not a few mosses, were announced by himself in the 'Archives de Botanique,' tom. 1. (1833), under the title of "Notice sur les Plantes

* Read before the Botanical Society of Edinburgh, Jan 11th, 1849.
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Cryptogames récemment découvertes en France," &c. Most of these I have had the opportunity of examining. In 1835, Dr. Grateloup began to publish in the 'Actes de la Société Linéenne de Bordeaux,' tom. vii., a "Cryptogamie Tarbelienne, ou Description succincte des Plantes cryptogames qui croissent aux environs de Dax, dans le Dépt. des Landes," in which were to be comprised all the Cryptogamia growing within 25 leagues of Dax, a district which would include the extreme Western Pyrenees; but it proceeded no farther than the publication of the Characæ, Filices and Hepaticæ, for specimens of most of which I am under obligation to Dr. Grateloup. About the year 1843, MM. Philippe and de Lugo, two botanists residing at Bagnères-de-Bigorre, began to collect the mosses and Hepaticæ of the neighbouring mountains, and on the occasion of my visit to that city, two years afterwards, they put into my hands, without reserve, specimens of all they had succeeded in finding. A few mosses have also at different times been gathered in the Pyrenees by MM. des Moulins, Durieu, Gaston-Sacaze, and probably by others of whom I have not heard, and of whose labours I cannot therefore make that honourable mention which is their due. In 1845 came my own visit to the Pyrenees, undertaken principally (though not solely) for the purpose of studying the Musci and Hepaticæ, and extending through a period of nearly eleven months. It will not be without use if I here briefly retrace my steps, as some repetition will be thereby avoided, and an opportunity will be afforded of indicating the position of certain localities, the names of which are of frequent recurrence in my catalogue, though too obscure to be found in an ordinary map*.

I arrived at Pau, the *chef-lieu* of the Dept. of the *Basses-Pyrénées*, and the ancient capital of Béarn, in the early part of May 1845, and my first herborization in the Pyrenees was made on the 13th of the same month. My excursions comprised, besides the woods, &c. adjoining the town of Pau, the villages of Jurançon, Gélos, Rontignon and Narcastet, lying on the southern bank of the Gave de Pau, with the valleys running up from them to the southward, among what may be called the skirts of the Pyrenees; and the village of Bilhères, lying south of the same river. From the 29th to the 31st were devoted to a visit to Oloron, at the entrance of the Vallée d'Aspe, along which runs one of the most frequented roads into Spain. On the 11th of June I again left Pau for St. Sever, in the Landes, on a visit to Dr. Léon Dufour, the eminent naturalist, where eight days were usefully spent in exploring the neighbouring *landes*, especially

* For a fuller account of my tour consult the 'London Journal of Botany,' vol. v. p. 134.

those of Mugriet (Commune of Souprosse) a few miles distant from St. Sever, and on the opposite side of the Adour. Returning thence to Pau, I again started on the 25th for Laruns, a little town lying about 26 miles to the southward, near the upper extremity of the Vallée d'Ossau, and midway between the Eaux Bonnes and the Eaux Chaudes. Here commenced my acquaintance with the *real* Pyrenees. My excursions included the Pic de Ger and the Montagne Verte, the former overlooking the Eaux Bonnes from the south and the latter from the north; the Gorge de Hourat, conducting to the Eaux Chaudes, and watered by the Gave de Gabas; the Gave de Valentin, which uniting at Laruns with the Gave de Gabas, forms the Gave d'Ossau; the village of Béost and the hameau of Bagès (celebrated as the residence of Gaston-Sacaze, the shepherd-botanist). Descending the Vallée d'Ossau and again taking Pau in my way, I proceeded on the 8th of July to Argélez, in the Dept. of the *Hautes Pyrénées*. The following day was given to the herborization of Pierrefitte, on the south side of the valley (or rather *plain*) of Argélez, and at the confluence of the gorges of Luz and Cauterets. On the 11th I ascended to Cauterets, where I remained until the end of the month. My excursions from it were to the Pont d'Espagne and Lac de Gaube, ascending the Val de Jéret along the banks of the Gave de Marcadaou; to the valleys of Lutour and Combascou, and to Mont Lizé. On the 2nd of August, accompanied by Dr. Southby, a compatriot enthusiastic in the pursuit of natural history, I crossed the central chain by the Port de Cauterets to the baths of Penticosa in Aragon. In this excursion, which occupied four days, numerous interesting flowers, but scarcely any mosses, were added to my collection. Returning to Cauterets, and descending from thence to Argélez, on the 8th I again ascended to Luz, at the entrance of the valley of Barèges. From Luz I visited the celebrated Chaos and Cirque de Gavarnie, the Vallée d'Estaubé, &c., but my bryological collections were not much swelled thereby. On the 20th I crossed the Tourmalet to Bagnères-de-Bigorre, in the valley of the Adour. My stay was but short, for the present, and my only excursion of importance was to the flowery Mont Lhiers. The 27th and 28th of the same month were taken up in walking through the mountains, by way of the Hourquette d'Aspin, the Vallée d'Aure and the Port de Peyresourde, to Bagnères-de-Luchon, in the Dept. of the *Haute Garonne*. During my stay here of five weeks, I explored the whole of the magnificent Vallée du Lys (lateral to the valley of Luchon) with its four lakes and twenty-four cascades, and I ascended the lofty mountain of Crabioules (mountain of *crabes* or *izardes*) which bounds it on the west, as far as the snow-line on the 1st and 2nd of October. Before this time I had visited the

mountain of Superbagnères, which rises from the back of the town, the gorge of Esquierry ("le jardin des Pyrénées"); the Lacs d'Oo (Lac de Séculéjo and Lac d'Espingo) lying between Mont Crabioules and the Vallée d'Aure; the Vallée de Burbe (in which is the Bois de Gouerdère), and, passing through the Port de Portillon at its extremity, the upper part of the Vallée d'Aran in Catalonia; and on the 10th, 11th and 12th of September, passing through the Bois de Sajust and the Port de Bénasque (in the central chain), I had ascended the Maladetta in Aragon. Leaving Bagnères-de-Luchon and the Haute Garonne on the 4th of October, I returned to Bagnères-de-Bigorre, and occupied myself until nearly the end of the month in exploring its environs, by which my collection of pleurocarpous mosses was much enriched. The localities examined were the rocks of Bédât and Salut, close by the town; Mont Lhieris and the woods of Gerde and Asté at its base; the Gorge de Labassère; the Vallée de Lesponne with Lac Léhou (otherwise Lac Bleu), and a tributary valley (Ardalos) extending to the base of the terminal cone of the Pic du Midi. The autumn being unusually prolonged, and the summits still clear of snow, I undertook another expedition to the Basses Pyrénées, and on the 1st of November proceeded again to Laruns, where I remained until fairly driven away by the coming of winter. Besides the localities visited in summer from this station, I now examined the Vallée de Béost, which leads across the Col de Louvie to the Vallée d'Argélez; the upper part of the Gave de Valentin towards the Col de Tortes; the mountain (Goursi) which shades Laruns on the south; and Gabas, near the base of the Pic du Midi. Driven from the mountains, my next destination was, by way of Pau, to Dax (*Aqua Augustæ Tarbellicæ*) in the Landes (*Ager Syrticus*), where I arrived on the 18th of November. In the midst of almost unceasing rain I visited in this rich district the ophitic rocks of St. Pandelon on the banks of the Luy (a tributary of the Adour), the chalk rocks of Tercis, and the woods of Saubagnac and La Torte. Having devoted a fortnight to a re-examination of the neighbourhood of Pau, I returned early in December to Bagnères to winter. In the Pyrenees, as throughout nearly all the rest of Europe, the winter of 1845-6 was remarkably mild, and by the month of February the lower mountains were quite clear of snow. I availed myself of this circumstance to explore the district almost completely, and in one instance to make, in company with M. Philippe, an excursion of four days (from the 5th to the 8th of February) into the heart of the mountains, for the purpose of examining the back of the Pic de Mont-Aigu and the Vallée de Castelloubon (otherwise V. de Gazos), which is separated by only a narrow ridge from the valleys of Luz and Argélez. Even at

that season we were able to reach an altitude of 7000 feet, and might easily have gone higher, but the ground at that height, though almost clear of snow, was frozen to the depth of several inches, and the waterfalls were changed into sheets of ice. The chief localities examined near Bagnères, and not previously named, are the forests of Transoubât and of L'Escaladieu (the latter on the road to Toulouse); the valleys of Campan, Serris and Trébons; the Bois de Lagaillaste and the Camp de César, both near the village of Pouzac; the *Côtes schisteux* of Loucrup and the Bois de Montgaillard, on the road to Lourdes. These examinations enabled me to add extensively to the list of mosses previously observed by MM. Philippe and de Lugo. Finally quitting Bagnères early in March, a last visit to Pau rendered my collection of the mosses of the Western Pyrenees still more complete; and in proceeding thence to Paris, two days spent at St. Sever with the excellent Dufour, afforded me rarities unobserved the preceding year.

In this *résumé* of my wanderings I have avoided alluding to the species collected, but it will be seen, by tracing my track on the map, that I executed a network of journeys sufficient to explore pretty fully the tract of mountains traversed, extending from the Vallée d'Aspe on the west to the Vallée d'Aran on the east, and to enable me to state with considerable confidence the amount and distribution of species within these limits.

Since my return from the Pyrenees I have had a few additional species and habitats from my friend Philippe, and also from M. Schimper, who passed through part of the Pyrenees in 1847 on his way into Spain.

It must in conclusion be acknowledged, that it is only botanists resident in the Pyrenees who have it in their power to present to the world a complete flora, whether Phanerogamic or Cryptogamic, of these mountains. Botanical geography is a subject that can be but very imperfectly studied in the cabinet, and in sitting down to arrange the materials collected on a distant expedition, one always finds some deficiency, some essential observation omitted, which, to a person on the spot, might be supplied by travelling possibly only a few paces.

General considerations on the structure, &c. of the Pyrenees.—The Pyrenees may be aptly compared to an immense barrier, raised by nature's hand for the separation of two nations, and extending from sea to sea. The transversal ridges which spring here and there from the central chain may be considered as the buttresses, or as the outworks of this great fortification. The area occupied by these mountains lies between 3° 20' E. and 2° 0' W. long. (from Greenwich), and from a little north of the 43rd parallel nearly to the 42nd. Their direction, from the

Mediterranean to the Bay of Biscay, is nearly W. by N. ; and their length, from Cape Creux to the Port des Passages, is about 270 English miles. It is well known that the Pyrenees have at the latter limit reached but half their length, and that their continuation constitutes the elevated ridges of Bizcaya, Asturias and Galicia, up to their real termination at Cape Finisterre ; at present, however, we have only to do with that portion which separates France from Spain, and to which the name " Pyrenees " is popularly limited.

When attentively considered, the Pyrenees will be found to consist of *two* chains : the *western*, which increases in altitude from the ocean to the Maladetta (10,722 ft.*), its highest point, whence it rapidly sinks to the opposite sea ; the *eastern* commencing north of the Maladetta, with hills of slight elevation, increases in height as it approaches the Mediterranean, not far from which is Mont Canigou (8652 ft.), one of its loftiest summits. From the point of dislocation is thrown off to the northward a remarkable embranchment, which separates the basin of the Garonne from that of the Adour, giving birth to the latter river, and stretches through the Dept. of the Hautes Pyrénées a little way into that of Gers : its highest point is the Pic du Midi de Bigorre (9000 ft.). Some geologists (as M. Reboul) have traced several distinct axes of elevation in the Pyrenees ; and M. Elie de Beaumont supposes that they have been upheaved at four distinct epochs, though the great mass owes its elevation to only the third of these, which was posterior to the chalk formation. The fourth epoch of elevation is perceivable only in the localities where serpentine (*ophite*) appears.

The loftiest summits of the Pyrenees are nearly all out of the central chain ; the Maladetta, the culminating point of the whole range, is to the southward of it ; as is also Mont Perdu, the next in altitude. The depressions (called " Ports " in the medial ridge, and usually " Cols " in the transversal ones) are all of considerable elevation, often from 7000 to 9000 feet, and there are only two passes practicable for carriages, one at each extremity of the chain. On the southern or Spanish side the ascent is more abrupt than on the northern side, where two ridges (at least) parallel to the medial ridge, and yielding to it very little in height, are usually distinctly traceable. The Spanish Pyrenees are also watered by fewer streams, have fewer lakes, and are less clad with forests than the French. On both sides the valleys are in most cases steep ; the *basins* we successively encounter in

* The altitudes are all in French measures, and I have given very few, for besides that I had not the opportunity of determining any myself, the altitude of the same mountain, as stated by different observers, often varies considerably.

ascending them are usually small, and occupied either by lakes, or by alluvium deposited by the descending streams. In only two cases have I seen hollows filled with peat, one on Mont Goursi in the Basses Pyrénées, and the other at the head of a small valley, lateral to the Vallée de Lesponne in the Hautes Pyrénées.

The line of perpetual congelation in the Pyrenees, I assume from my own observations to be at an average height of nearly 9000 feet, or more than 1000 feet higher than in the Alps. One authority, now before me, fixes it at 8718 feet, and Ramond estimated it at from 8100 to 8400 feet, which I do not hesitate to say is much too low. It varies however considerably with the degree of exposure and even with the form of a mountain, and the snow is uniformly found to melt less, and consequently to descend lower in an eastern exposure than elsewhere. Hence, even on the highest mountains, the band of perpetual snow is not more than from one to two thousand feet broad.

The streams which take their rise on the *southern* slopes of the Pyrenees flow nearly all into the Ebro. On the *northern* slopes, the space lying opposite the western half of this drainage of the Ebro is occupied by the Adour and its tributaries, while the space corresponding to the eastern half, extending from the source of the Adour to that of the Arriège, is occupied by the upper part of the basin of the Garonne. In the extreme eastern angle, on both the northern and southern side, are various small streams which run directly into the Mediterranean. This drainage of the rivers would seem to afford us the basis of a division of the Pyrenees, for the purpose of estimating the distribution of plants on their surface; but on trial such a division will be found intractable, and I prefer another which separates the plants into more distinct groups, and corresponds very nearly with that adopted by the *botanistes sédentaires* of the Pyrenees. I divide the Pyrenees into *three districts*, the *Western*, the *Central*, and the *Eastern*, the limits of which I proceed to define.

The *Central Pyrenees* are comprised between the upper part of the Gave de Pau, from its source at the Cirque de Gavarnie as far as to the bridge of Lourdes, on the *west*; and Mont Maladetta and the Vallée d'Aran, watered by the infant Garonne, on the *east*; or from the meridian of Greenwich* to about 50 minutes of east longitude. This district includes, in France, the upper part of the Dept. of the Haute Garonne and most of the upper part of the Hautes Pyrénées; in Spain, part of Aragon and a very small angle of Catalonia. It is watered by the upper

* The village of Luz, in the valley of Barèges, is exactly in the longitude of Greenwich.

branches of the Adour and Garonne, and contains the highest mountains and the deepest valleys in the Pyrenees, as well as the most extensive forests. Glaciers of great extent are found in this district only; the principal are those which occupy the northern slopes of the Maladetta and Crabioules.

The *Western Pyrenees* extend from the Central to the ocean at Bayonne and St. Jean de Luz. They include, in France, the Dept. of the Basses Pyrénées and part of the Landes, stretching as far as the Adour at St. Sever and Dax, besides a small portion of the Hautes Pyrénées; in Spain, a small part of Navarre and most of the northern part of Aragon. This district extends farther to the north than either of the others; it is consequently colder at the same altitude, and in the sandy plains bordering on the Adour and the ocean the climate is much more humid.

The *Eastern Pyrenees* are comprised between the Central and the Mediterranean. In France they occupy the whole length of the Depts. of Arriège and Pyrénées Orientales; in Spain, nearly all the northern part of Catalonia. This district is the most southern, the warmest and driest, and the most denuded of forests of the whole three*.

A rough sketch of the mineralogy of the Pyrenees, so far as it is connected with the distribution of plants, will conduce to a more complete idea of the peculiarities of these divisions. The igneous rocks of the Pyrenees do not, as in the Alps, constitute some of the loftiest mountains, and the highest point at which I am aware of the existence of granite is on the summit of the Pic du Midi d'Ossau (9186 ft.), unless it attains the summit of Néouvielle (9696 ft.), as some maintain. In the eastern part of the Western Pyrenees it constitutes the mass of the mountains above Cauterets, especially those which include the valleys of Combascou, Lutour and Jéret, and the Lac de Gaube; from whence it passes (by the Vallée d'Azun, &c.) into the upper part of the Vallée d'Ossau, where I have observed it from below the Eaux Chaudes to the Pic du Midi, and on the circumjacent mountains, in which it is the predominant rock. From the Vallée d'Ossau it dips at once so profoundly as not to be observed in the deepest parts of the Vallée d'Aspe, or in any of the valleys to the westward, until it reappears near Bayonne, in the *massif* of Cambo. In the Central Pyrenees it appears in the valley of Barèges (continued from the valley of Cauterets) and about the base of the Pic du Midi de Bigorre; but, with this latter excep-

* I should add, that great part of the Arriège is still a *terra incognita* to me, and I especially commend its exploration to resident cryptogamists. Probably, from its containing some very lofty summits, as the Pies of Mont-calm and Estats, both its character and its vegetable products would require the western part of it to be annexed to our Central district.

tion, it rarely attains the surface in the neighbourhood of Bagnères-de-Bigorre. Near Bagnères-de-Luchon it appears in most of the valleys and at the base of the mountains. From the Central Pyrenees it passes into the Eastern, where, especially in the Dept. of Pyr. Orientales, it constitutes a very large proportion of the surface. In the granite I include gneiss, and possibly some other rocks whose internal structure is of nearly the same character.

Mica-slate (*schiste-micacé*) I have observed in the Western Pyrenees only in the valley of Caunterets, especially at the base of the Monné and on Mont Lizé. Thence it passes into the Central district, where it constitutes the terminal cone of the Pic du Midi, the Pic de Mont-Aigu, and all the adjacent mountains. The wall of rock which supports the waters of Lac Lehou is of mica-schist, and in general the embankments of all the lakes in the Pyrenees are of this rock or of granite. In the Eastern Pyrenees the mountains on the western side of the river Aude are of mica-schist, and I am not aware of its occurrence elsewhere.

Slate (*schiste-argileux*) may be regarded as the most important rock in the Pyrenees, appearing as it does in every part of them. In the W. Pyrenees I have observed it in the Vallée d'Ossau; also near Argélez, where it is the predominant rock, extending from thence along the gorge of Luz to the valley of Barèges, where it meets the mica-schist and other primary rocks. Ascending from Argélez by the valley of Caunterets, it extends (though not uninterruptedly) to the very summit of the central chain. The Port de Caunterets and all the other passes which have fallen under my notice are (as in the Alps) excavated in slate-rock, which is often very siliceous, and cleaves with difficulty in at least two directions. From Caunterets the slate passes into the Central Pyrenees, descending almost to their bases, and attaining the ridge of the central chain, as at the Port de Bénasque, &c. In the Eastern Pyrenees it would seem to occur chiefly about the base of the mountains, skirting the granitic nucleus. The lower mountains in the Pyrenees, whose chief constituent is clay-slate or grauwacke, have commonly rounded summits, and are covered with herbage; but the loftier ones, and especially those of the medial ridge, have a bolder aspect; their sides are furrowed by deep ravines, and their summits are serrated and peaked. When closely examined they are found to be in a state of continual decomposition and degradation, probably from the dissemination of iron pyrites in these rocks.

Transition-limestone (*calcaire de transition*) constitutes also its proportion of the surface of the Pyrenees. In the W. Pyrenees it forms the principal part of the ridge of the central chain, lying to the south of the Pic du Midi d'Ossau. From the val-

ley of Caunterets it would seem to be entirely absent, but it re-appears in the Central Pyrenees in the great valley of Barèges, where it extends from the bottom of the valley of Gèdre to a little beyond the lake of Gavarnie, and plunges under the immense mass of alpine limestone of the Marboré. The lower hills near B.-de-Bigorre, especially the Pic de Lhicris, are formed almost entirely of it, and here it often presents itself in thin beds, alternating with clay-slate. In the upper part of the valley of Luchon, and in all the surrounding mountains, I do not recollect to have observed any calcareous rock. In the E. Pyrenees, transition-limestone would seem to occur amongst the granitic formations in detached masses (accompanied however by slate) chiefly in the neighbourhood of Villefranche and Prats de Mollo, and in the Corbières. The ascents of mountains of transition-limestone are interrupted by escarpments, which are rarely of great elevation.

Of secondary rocks, the only one which I shall have occasion to mention is oolitic limestone (*calcaire alpin*). To this rock the Pyrenees owe some of their grandest features, as it forms escarpments in some instances considerably exceeding a thousand feet in altitude, as at the Cirque de Gavarnie, the termination of the Vallée d'Estaubé, &c.; but wherever it attains the alpine region (as in the instances just cited) I have found it quite destitute of mosses, probably from its exposed position, above the region of forests. It is only in the lower hills of the Western Pyrenees, especially near Pau, where it occurs as a conglomerate, that the alpine limestone has afforded me any cryptogamia. Some of Dr. Arnott's mosses from the Pyr. Orientales, judging from the fragments attached to the specimens, have been gathered on alpine limestone.

Trap-rocks I have remarked in the Pyrenees in small detached masses, but I have gathered cryptogamia only on a rapidly decomposing ophite at Labassère near B.-de-Bigorre, and at St. Pandelon near Dax.

This brief sketch of the chief rocks of the Pyrenees is confessedly very imperfect; it is also designedly *superficial*, for it is only by the surface-rock that plants whose roots rarely penetrate to the depth of an inch can possibly be influenced. The position, too, of any rock in the geological series cannot be said to have anything to do with the distribution of plants, though the presence of a certain mineral is in many cases essential to their existence. From my observations in the Pyrenees and elsewhere, I have ascertained pretty accurately what mosses require a matrix containing *carbonate of lime*; these will be specified as they occur. They have obviously no preference for primitive, transition, or secondary limestone, but they are always most abundant and

luxuriant on limestones of which the surface rapidly decomposes ; hence the older limestones, which in the Pyrenees are often transformed into marble, are never in that state prolific in mosses. Of those species which absolutely *refuse* to vegetate on limestone (and they are not very numerous), some are found on a great variety of rocks ; but probably when carefully examined these rocks would be found to contain some one element, essential to all the species making choice of them. *Silex*, for example, seems necessary to certain *Grimmia* ; and there are a few mosses rarely found except on rocks containing a large proportion of iron. It is scarcely necessary to mention that many mosses are never found on rocks at all, but by exception, some preferring the bark of living trees (*cortical*) and others decayed trunks or logs (*lignal*).

Distribution of Musci and Hepaticæ in the Pyrenees, according to latitude and longitude.—The distribution of plants on any given portion of the earth's surface requires to be estimated both *horizontally* and *vertically*, and if the surface to be considered extend through several degrees of latitude, the two modes will require to be exhibited both separately and in combination. It is obvious that a comparison of the vegetation of any portion of the earth with that of any other portion, or of the whole, must always be incomplete, until the whole of the earth's surface shall have been examined. Hence the following account of the distribution of Musci and Hepaticæ in the Pyrenees can only be regarded as approximatively correct. I enumerate 390 Musci and 91 Hepaticæ in the Pyrenees. Taking the whole number of Musci known in the world to be 2400 (which is rather over than under the limit), and of Hepaticæ to be 1200, this would show the Pyrenees to possess nearly one-sixth of the entire family of Musci and but one-thirteenth of the Hepaticæ, or twice as great a proportion of the former as of the latter. But this proportion is very nearly what we should arrive at in comparing the Musci and Hepaticæ of Europe with those of the rest of the world, so much more numerous are Hepaticæ in the southern than in the northern hemisphere.

The species which attain absolutely their northern limit in the Pyrenees seem to be only the four following :—

Hypnum aureum.
Bryum platyloma.

Tortula cæspitosa.
Southbya tophacea.

Those which attain their southern limit are apparently much more numerous ; but when the mountains of Spain come to be fully explored, the list will probably be somewhat lessened ; and I ought to acknowledge that, possessing no complete list of the Cryptogamia of Italy, I may have assigned the Pyrenees as the southern limit for a few species which in reality extend farther

south in Italy. So far however as I can ascertain, the following species have their southern limit in the Pyrenees:—

Hypnum umbratum.	Mnium spinulosum.
Pyrenaicum.	medium.
plicatum.	Aulacomnium androgynum.
flagellare.	Physcomitrium acuminatum.
striatum.	Tortula alpina.
cæspitosum.	latifolia.
crassinervium.	aciophylla.
Vaucheri.	papillosa.
pumilum.	Dicranum fulvum.
campestre.	longifolium.
Starkii.	Sauteri.
Mühlenbeckii.	Arctoa fulvella.
pratense.	Anodus Donnianus.
Haldanianum.	Orthotrichum Bruchii.
heteropterum.	rivulare.
catenulatum.	urnigerum.
Sprucei.	Hedwigia imberbis.
trichophorum.	Grimmia anodon.
planifolium.	curvula.
Isoetecium rufescens.	sulcata.
chryseum.	atrata.
Leskea rostrata.	Encalypta commutata.
longifolia.	rhabdocarpa.
Anacamptodon splachnoides.	Polytrichum sexangulare.
Mielichhoferia nitida.	Fissidens grandifrons.
Catoscopium nigratum.	Sarcoscyphus adustus.
Bartramia marchica.	Alicularia compressa.
Bryum acuminatum.	Jungermannia sphærocarpa.
polymorphum.	Genthiana.
Zierii.	cordifolia.
concinatum.	Lyoni.
Ludwigii.	Francisci.
obconicum.	Lejeunia ovata.
julaceum.	Frullania fragilifolia.
Mnium spinosum.	Dumortiera irrigua.

Few species can be expected to attain their eastern limit in the Pyrenees (lying as they do on the *western* side of Europe), and I can find only these six, of which all but one (*Fissidens grandifrons*) had been previously supposed to be confined to our own islands:—

Hypnum cæspitosum.	Lejeunia ovata.
Tortula papillosa.	Frullania fragilifolia.
Fissidens grandifrons.	Dumortiera irrigua.

The number of Musci and Hepaticæ which are not found anywhere to the westward of Europe, either on the continent of America or in the intermediate islands, is considerable, and they mostly attain their western limit in the British Isles. Some species which reach their western *European* limit in the Pyrenees (not being found in the British Isles) reappear in N. America, under nearly the same latitude: such are *Hypnum Haldanianum*,

Leskea rostrata and *attenuata*, *Physcomitrium acuminatum*, *Tortula cæspitosa*, *Dicranum fulvum*, *Fissidens grandifrons*, &c. *Tortula chloronotos* reappears in the isle of Teneriffe. There are only the following species whose occurrence westward of the Pyrenees has not yet been recorded :—

Hypnum Pyrenaicum.	Tortula inclinata.
Vaucheri.	Encalypta ligulata.
Isothecium Philippianum.	Buxbaumia indusiata.
Bryum polymorphum.	Plagiochila Pyrenaica.
Mnium medium.	Scapania apiculata.

Of the few mosses which grow on the southern slope of the Pyrenees, only one species (*Tortula cæspitosa*) was not found at all on the northern. The Spanish Pyrenees have in fact a peculiarly arid aspect (to the eye of a cryptogamist), and correspond well with the distant view I have had of the dry and naked sierras of Spain*.

If we now compare the three districts of the Pyrenees, above defined, one with another, we find a considerable number of species peculiar to each. The following mosses, gathered in the *Western Pyrenees*, were none of them observed in the Central and Eastern Pyrenees. [Those species marked with a (†) are peculiar to the sandy plains of the Landes.]

Hypnum strigosum.	Physcomitrium ericetorum.
megapolitanum †.	acuminatum.
cæspitosum †.	Tortula ambigua †.
trichophorum.	papillosa.
Catocopium nigratum.	latifolia.
Bryum Tozeri.	cæspitosa.
cæspiticium.	Trichostomum luridum.
erythrocarpon.	subulatum †.
torquescens.	Dicranum spurium.
platyloma.	Weisia cirrhata †.
Muelleri †.	Wimmeriana.
Mnium spinosum	Gymnostomum calcareum.
Funaria corvexa †.	Ptychomitrium pusillum.
Entosthodon Templetoni †.	Orthotrichum crispulum.

* Cavanilles, in his 'Observaciones sobre la Historia Natural, &c. del Reyno de Valencia (Madrid, 1795),' amongst all the localities which he so minutely describes, mentions but one of bryological promise, where he observed the *solitary moss* which enters into his catalogue of the plants. In speaking of the mountains of Valldigna (p. 218) he says, "Los montes por donde están expuestos al mediodia son secos, y que no hay fuentes en sus raices : al contrario las faldas septentrionales de todos ellos están sembradas de sitios húmedos y frondosos, y en las raices nacen fuentes abundantes. . . . En el valle de Barig son innumerables las fuentes que nacen desde Aldaya hasta Puigmola. . . . En estos sitios húmedos y sombríos está siempre viva la naturaleza, cubierto el suelo de vegetales, y casi siempre de flores : allí se disputan las plantas el terreno. La doradilla (*Ceterach*), el polipodio comun, el pteris (*Pt. aquilina*) y la jungermania allanada (*Jg. complanata*) ocupan las hendeduras de las peñas."

Orthotrichum patens.	Southbya tophacea.
urnigerum.	Jungermannia curvula.
Conomitrium Julianum †.	minuta.
Buxbaumia aphylla †.	dentata †.
Sphagnum cuspidatum †.	Lejeunia ovata.
compactum †.	calcareæ.
Alicularia compressa.	Frullania fragilifolia.

The whole of the following were observed only in the *Central Pyrenees* :—

Hypnum Pyrenaicum.	Dicranum fulvum.
flagellare.	majus.
aureum.	falcatum.
falcatum.	Arctoa fulvella.
Haldanianum.	Campylostelium saxicola.
heteropterum.	Brachyodus trichodes.
planifolium.	Anodus Donnianus.
depressum.	Seligeria recurvata.
Neckera pumila.	Anœctangium compactum.
Entodon cladorrhizans.	Zygodon conoideus.
insidiosus.	Orthotrichum rivulare.
Isoetecium Phillipianum.	Grimmia anodon.
striatum.	funalis.
Leskea rostrata.	sulcata.
longifolia.	Fissidens osmundioides.
Hookeria lucens.	Tetrodontium Brownianum.
Anacamptodon splachnoides.	Sphagnum acutifolium.
Bartramia marchica.	squarrosum.
Bryum pyriforme.	Sarcoscyphus adustus.
longicollum.	Jungermannia Schraderi.
Ludwigii.	Genthiana.
julaceum.	pumila.
concinatum.	cordifolia.
cirrhatum.	divaricata.
Mnium lycopodioides.	connivens.
medium.	Lophocolea minor.
Dissodon Frœlichianus.	heterophylla.
Anacalypta latifolia.	Harpanthus scutatus.
Tortula vinealis.	Chiloscyphus polyanthos.
Ceratodon cylindricus.	pallescens.
Distichium inclinatum.	Dumortiera irrigua.

The following species are peculiar to the *Eastern Pyrenees*, and when the *Hepaticæ* of that district come to be ascertained, the list will undoubtedly be extended :—

Hypnum fluitans.	Tortula subulata, var. inermis.
recognitum.	gracilis.
Fabronia pusilla.	Orthotrichum Sturmii.
Bartramia stricta.	Grimmia plagiopoda.
Bryum bimum.	trichophylla.
Tortula mucronifolia.	Polytrichum sexangulare.
alpina.	

In glancing over the above lists, we cannot fail to be struck with the great number of species, especially of pleurocarpous mosses, peculiar to the central district. The obvious and true

explanation of this is to be found in what is above remarked respecting the depth of the valleys and the extent and density of the forests; pleurocarpous mosses demanding in the latitude of the Pyrenees a great deal of shade.

A few species, occurring in both the Central and Eastern Pyrenees, were not observed in the Western. They are:—

Hypnum reflexum.	Desmatodon nervosus.
Mielichhoferia nitida.	Dicranum longifolium.
Bryum polymorphum var. curvisetum.	virens.
Timmia megapolitana.	Grimmia atrata.
Trichostomum tophaceum.	Cinclidotus aquaticus.

The list of species wanting to the Eastern Pyrenees, but observed in both the Western and Central, is so very large that I forbear to insert it, feeling assured that when the former district comes to be explored as the two latter have been, it will be found much less deficient than this list would show it. Three mosses, *Amblyodon dealbatus*, *Tortula marginata* and *cuneifolia*, growing in both the Eastern and Western Pyrenees, have not hitherto been observed in the intermediate district.

Were I now asked to name a moss characteristic of the whole Pyrenees, I should say at once *Fissidens grandifrons*, Brid. (the *Dicranum palmiforme* of Ramond), which is a conspicuous ornament wherever moist calcareous rocks are found, but is scarcely met with out of the Pyrenees*. Amongst the Hepaticæ, *Jungermannia acuta* is scarcely less abundant, growing on the same sort of rock. The following species may also be considered respectively characteristic of our three districts, viz. *Southbya tophacea* of the Western, *Isothecium Philippianum* of the Central, and *Bartramia stricta* of the Eastern.

Distribution of Musci and Hepaticæ in the Pyrenees, according to altitude.—We come next to treat of the vertical distribution of plants, the most interesting branch of *Phytostatics*. In attempting to define our zones of altitude by natural boundaries,

* It will not be out of place to mention here a curious circumstance relating to this moss. Its fruit has never yet been found, and even its flowers were unknown when it was figured in the 'Bryologia Europæa.' A few years ago, Mr. Sullivant discovered female plants at the Falls of Niagara, and in 1846 he published the specimens in his beautiful 'Musci Alleghanienses' (no. 186). In Jan. 1846, a single tuft of male plants was found by myself and M. Philippe on a dripping limestone rock near Bagnères, and the inflorescence will be described in the proper place. These are all the flowers that have ever been found, and it will be a remarkable circumstance if it be ascertained (as this would seem to show) that *only the male plant exists in Europe, and only the female in America!* The obvious conclusion would be that the plant never had fruited, and without artificial aid never would fruit. It has, however, ample means of maintaining and spreading itself without the aid of seeds.

that is, by certain plants which constitute a marked feature in them, it would seem at first sight a great advantage could we select in every country the same species for this purpose; but a little research will suffice to show us the impracticability of this. To go no farther than the Alps; near as they are to the Pyrenees, and similar as their vegetation is in many respects, there are yet important differences. While, for instance, there is no tree in the Alps above the region of the spruce-fir (*Pinus Abies*, L.), in the Pyrenees there is above this a broad and well-marked belt of Scotch fir (*Pinus sylvestris*, L.). Again, there is in the Alps, above the limit to which the oak ascends, a zone in which the birch (*Betula alba*, L.) is the predominant tree; but in the Pyrenees the birch is excessively rare; indeed I do not at this moment recollect having anywhere seen it where I could be certain it had not been planted, and I perceive Mr. Bentham includes it in his catalogue with a mark of doubt. It would also be quite impossible to define any of our climatal zones in the Pyrenees by the distribution of the *heaths*, as has been done for the British Isles by Mr. Watson in his 'Cybele Britannica.' The only "heath-clad hills" I have seen in the Pyrenees, reminding me of our English and Scottish hills, are some of the lower mountains around Bagnères-de-Bigorre, and here the prevailing species is *Erica vagans*, though *Calluna vulgaris* occurs also, sparingly. The latter species seems never to penetrate far into the mountains. Again, *Erica tetralix* is not found at all in the Central or Eastern Pyrenees, but only in the Western. The only heath I have remarked near Bagnères-de-Luchon is *Erica cinerea*. *E. arborea* is abundant in the valley of Argèlez and its tributary valleys (Castelloubon, &c.), but is absent from the Central Pyrenees, while it reappears in several parts of the Eastern. It has been shown by M. des Moulins ("État de la Végétation sur le Pic du Midi de Bigorre, &c.;" 'Recueil des Actes de l'Académie Royale de Bordeaux,' 1844), that several species of *thistles* occupy zones of altitude in the Pyrenees which are easily ascertained, and he has actually constructed a scale of the distribution of fourteen species in the Pyrénées Centrales, showing the altitudes at which they appear and disappear. But were this scale taken as the basis of a climatal arrangement (which M. des Moulins by no means proposes), how would it assist us in comparing the flora of the Pyrenees with that of Lapland, where according to Wahlenberg, "Cardui in sylvis admodum rari, omnesque fere inermes sunt. De cætero quoque plantæ vel frutices *aculeati* in Lapponia non crescunt, &c."?

In comparing two distant portions of the earth's surface with each other, in both of which the same plant is extensively distributed, we are not hence to conclude that the zone which it oc-

cupies has in both countries the same *average annual temperature*. Were this the case, such discrepancies as the following would be inexplicable. On Mount Etna, the beech, the birch and the Scotch fir are said to occupy the same zone. In the Pyrenees the beech ceases before the Scotch fir begins, and in the Alps the birch is said to fail even below the spruce-fir. But in Lapland the birch extends far above the Scotch fir, and in fact ascends higher on the mountains than any other tree. Assuming the correctness of these observations (which for Lapland and the Alps cannot be questioned), we are bound to conclude that there are peculiarities of constitution in certain species which enable them to ascend proportionally higher in one latitude than in another*. In other words, an *alpine* flora is not necessarily an *arctic* flora, in its character. Hence the saying of Linnæus, "Plantæ diversæ indicant altitudinem perpendicularæ terræ," must be regarded not as an *axiom* but as a *problem*, the complete solution of which still remains to be effected.

It will readily be admitted that all our artificial arrangements,

* The discussion of this *idiosyncrasy* would demand an entire volume, but Wahlenberg's explanation of it (*Flora Lapponica*, Introd.) is worth quoting, and should be borne in mind in comparing the flora of the Pyrenees or of the Alps with that of Lapland. "Valde probabile mihi videtur a calore meridiano vegetationis gradum præcipue pendere" (p. xlix, l. c.)—"Temperies tantum illa æstivalis in vegetatione producenda efficax, constituit clima, ejusque gradus determinat." (p. lii.)—"Aliæ plantæ longam magis, quam calidam æstatem sibi exposcunt: ubi temperatura æstivalis media per tres menses gradum 8°·5 (Centigr.) haud attingit, ibi hordeum haud ad maturitatem pervenire potest. Hoc quidem jam dudum infra Enontekis contingit; sed nihilominus tamen arbores variæ æstate brevi et calida hujus regionis contentæ sunt: Betulæ enim et Salices alpes versus longe altius læte propagantur. Arbores coniferæ fere ac Hordeum æstatem longiorem quamquam temperatiorem, requirunt, itaque longe altius ascendunt in alpibus Helveticis quam Betula, &c. Ex observationibus thermometricis allatis constat, æstatem in alpibus Helveticis, etiamsi temperatior sit, fere longiorem esse, quam in alpibus Lapponicis; et pro certo scimus, temperaturam mediam omnium mensium per totum annum eo magis æquabilem esse in montibus Andium Americæ meridionalis, et igitur omnes arbores, calidiorem quam longiorem æstatem requirentes, ibi crescere desinunt duplo longius infra limitem nivalem quam apud nos; sed Hordeum aliaque Cerealia temperie moderata 7 vel 8 graduum contenta, si ea modo longior sit, duplo altius versus limitem nivalem ibi adscendunt quam omnes arbores." (p. liii.)

It is also well known that some plants will bear *forcing*, that is, will survive and flourish under constant excitement and irritation, much better than others; hence we could hardly expect any plant which will not bear some degree of forcing, to thrive in the rapid summer, with its long days and proportionally great meridional heat, of countries bordering on the Arctic circle; should it even subsist through the rigorous winter of that region.

I am sensible how much the absence of exact thermometrical observations takes away from the completeness of this sketch of part of the flora of the Pyrenees. I have none of my own to adduce, except a few made at the foot of the Western Pyrenees in the month of June, when I found the meridional temperature to often exceed 90° Fahrenheit.

whether phytostatical or phytological, are imperfect; yet they have all their use in placing the same object before us under different points of view. As regards the Pyrenees, I have judged it best under all the circumstances to adopt the climatal arrangement sanctioned by the usage of the most eminent resident botanists. The first exposition of this is to be found in the writings of Ramond, one of the earliest observers in geographical botany. He ascertained that the oak (*Quercus robur*) ascended from the plains to the height of 1600 metres; that the beech (*Fagus sylvatica*) occupied a zone of from 600 to 1800 metres; the fir (*Pinus Abies*) and the yew (*Taxus communis*) a zone of from 1400 to 2000 metres; and that the Scotch fir (*Pinus sylvestris*) commencing at the latter limit, ascended in its smaller forms (especially that called *Pinus Mughus* by Jacquin) as high as 2400 metres. Above this limit (he observes) there are no more trees. Here commence *shrubs, with dry leaves, and mostly pro-cumbent or prostrate stems*, which are concealed under the snow during the winter. Such are *Rhododendron ferrugineum*, various species of *Daphne*, *Passerina* and *Globularia*, *Salix herbacea* and *reticulata*, &c. Leaving these, we meet humble herbs with *perennial roots, leaves in rosettes* and mostly *naked stems*: first in the series are *Gentiana campestris*, *Primula villosa*, *Saxifraga longifolia*, *Aizoon*, &c.; next, *Ranunculus alpestris*, *nivalis* and *parnassifolius*, *Androsace alpina*, &c.; lastly, *Ranunculus glacialis*, *Saxifraga cæspitosa*, *oppositifolia*, *androsacea* and *grænlandica* (Lapeyr., non L.): these, with lichens, reach 3000 or even 3400 metres, and extend to and even beyond the line of eternal snow. Guided by these observations of Ramond, and by others of his own, M. des Moulins, in the admirable memoir above-cited, has proposed to divide the Pyrenees into zones of altitude, as follows. The commencement of the *subalpine zone* he places at 4200 feet, about which altitude the cultivation of esculent vegetables (rye, potatoes, cabbages, &c.) ceases. It extends as far as 6000 feet, which is the upper limit of the growth of the spruce-fir and the beech*. The plants of the mountains, united with certain plants frequent in the plains, form the basis of its vegetation, and the real *subalpines* attain in it their greatest development both as to size and number. *Meadows* are scarce in this zone and do not occur above it.

The alpine region M. des Moulins divides into *three zones*. First, the *inferalpine*, which extends from 6000 to 7200 feet, and is characterized chiefly by the presence of *Pinus sylvestris*, which

* My own observations are here somewhat at variance with those of M. des Moulins. The beech has seemed to me to fail ordinarily some hundred feet below the fir, and in effect about the point where the latter attains its greatest development.

even in its most stunted form scarcely passes the upper limit. *Rhododendron ferrugineum* expires in this zone at from 6600 to 6900 feet, and above this altitude the herbage is composed chiefly of *Nardus stricta* (a grass common in the marshes of the Landes!) and of *Festuca eskia*, Ram. (*F. varia* γ. *crassifolia*, Koch; *Eskio*, *Jispet* and *Oursagno* of the mountaineers of the Pyrenees). Amongst the shrubs characteristic of this zone may be mentioned *Vaccinium Myrtillus* and *uliginosum*, *Empetrum nigrum*, *Sorbus chamaespilus* and *Salix Pyrenaica*; amongst the herbaceous plants, *Silene ciliata* and *Arenaria ciliata*. *Crocus multifidus*, which is a conspicuous ornament of the lower mountains (as around Bagnères-de-Bigorre), reaches the very summit of the inferalpine zone.

The *medialpine* zone extends from 7200 to 8400 feet. *Festuca eskia* attains the upper limit of this zone, but *Nardus stricta* fails below it. *Juniperus nana* is the giant of the vegetation, already so much contracted. Here the *weeds* which follow the traces of man and of the domesticated animals from the plains, cease to exist. The following species are abundant in this zone: *Statice alpina*, *Gentiana alpina*, *Potentilla nivalis*, *Cherleria sedoides*, *Silene acaulis*, *Iberis spathulata*, Berger., and *Pyrethrum alpinum*.

Lastly, above 8400 feet, in order to characterise the *superalpine* zone, we have merely to add to the plants of the middle zone a very small number of herbaceous plants, *all perennial*, and rarely descending into the medialpine zone. Such are *Ranunculus glacialis* and *parnassifolius*, *Stellaria cerastoides*, *Androsace alpina*, *Sibbaldia procumbens*, *Saxifraga grænländica*, Lap., and *S. androsacca*.

Thus far M. des Moulins. Of the zone below the subalpine, which I call the *Zona montosa*, he says nothing, because it was not necessary to his estimation of the flora of the Pic du Midi. It corresponds very nearly to Mr. Watson's "Agrarian Region," and were it our sole object to determine the distribution of Phanerogamia within its limits, it would be expedient to divide it into *three* zones, as M. des Moulins does the alpine region. Ascending from the plain, these zones might conveniently be separated, first by the upper limit of the cultivation of the *vine*, and secondly by that of *maize*, and the three divisions would be of nearly equal breadth. The cultivation of the vine in the Pyrenees is, as Humboldt observed it to be in South America, very nearly coterminous with the natural forests of chestnut-trees. It is true that chestnuts occur above the vineyards, but it is only sporadically; and so do vines occur here and there, trained to cottages in sheltered situations, considerably beyond the zone where they normally find a suitable climate. The cultivation of maize extends to about the point where the box

begins to flourish luxuriantly. For the purpose, however, of estimating the climatal distribution of mosses, it will rarely be requisite to divide the montose zone; and where I find occasion to speak of an *inferior* and a *superior montose zone*, it is to be supposed divided into two equal portions.

In order to enable any one to compare more completely the distribution of plants in the Pyrenees with that of the rest of Europe, and especially with that of our own islands, I add the names of several plants which I have myself observed in the various zones, of which many of them have appeared to me characteristic.

Planities (= Z_0). *Teesdalia nudicaulis*, *Helianthemum alyssoides* et *guttatum*, *Viola lactea*, *Silene bicolor*, *Lupinus angustifolius*, *Corrigiola littoralis*, *Illecebrum verticillatum*, *Hyoseris minima*, *Erica scoparia* et *ciliaris*, *Anagallis tenella* et *crassifolia*, *Pinguicula lusitanica*, *Phalangium bicolor*, *Avena Thorei*, *Agrostis setacea* et *elegans*, *Airopsis globosa*, *Cynosurus echinatus*, &c. &c.

Zona montosa (= Z_1). *Pars inferior*. *Ranunculus nemorosus*, *Anemone ranunculoides*, *Hepatica triloba*, *Geranium phæum*, *Saxifraga Geum*, *Asperula cynanchica*, *Prunella grandiflora*, *Stachys alpina*, *Euphorbia hyberna* et *dulcis*, *Cephalanthera ensifolia*, *Kœleria cristata*, *Melica ciliata*.

Zona montosa superior. *Potentilla micrantha*, *Orobus luteus*, *Saxifraga Geum*, *Astrantia major*, *Heracleum Pyrenaicum*, *Arnica montana*, *Cirsium Monspensulanum*, *Prenanthes purpurea*, *Soyeria lapsanoides*, *Scrophularia Scopolii*, *Erinus alpinus*, *Teucrium Pyrenaicum*, *Calamintha sylvatica*, *Rumex scutatus*, *Buxus sempervirens*, *Carex montana*, *Asplenium septentrionale*.

Zona subalpina (= Z_2). *Ranunculus aconitifolius*, *Spiræa Aruncus*, *Meconopsis Cambrica*, *Arabis alpina*, *Hutchinsia alpina*, *Cardamine latifolia* et *resedifolia*, *Viola cornuta*, *Dianthus Monspensulanus*, *Saponaria ocymoides*, *Geranium cinereum*, *Hippocrepis comosa*, *Trifolium alpinum*, *Sempervivum montanum*, *Saxifraga Geum* et *aquatica*, *Chærophyllum hirsutum*, *Sambucus racemosa*, *Galium vernum*, *Ramondia Pyrenaica*, *Scrophularia Scopolii*, *Digitalis purpurea* et *lutea*, *Linaria alpina*, *Veronica Ponæ* et *saxatilis*, *Tozzia alpina*, *Teucrium Chamædrydrys*, *Nigritella angustifolia*, *Lilium Pyrenaicum*, *Merendera Bulbocodium*, *Carex ornithopoda*, *Asplenium Halleri*.

Zona inferalpina (= Z_3). *Ranunculus Gouani*, *Helianthemum Celandicum*, *Viola biflora*, *Gypsophila repens*, *Geranium cinereum*, *Trifolium alpinum*, *Dryas octopetala*, *Geum Pyrenaicum*, *Potentilla alchemilloides* et *rupestris*, *Epilobium alpinum*, *Paronychia serpyllifolia*, *Saxifraga Aizoon* β . *minor*, *Eryngium Bourgati*, *Aster alpinus*, *Homogyne alpina*, *Carduus carlinoides*, *Crepis pygmæa*, *Jasione perennis*, *Erinus alpinus* var. *hirsutus*,

Veronica aphylla, *Bartsia alpina*, *Pedicularis comosa*, *Horminum Pyrenaicum*, *Pinguicula grandiflora*, *Androsace carnea et villosa*, *Primula integrifolia*, *Globularia nudicaulis et rupestris*, *Statice alpina*, *Salix Pyrenaica et reticulata*, *Luzula pediformis*, *Carex sempervirens*, *Festuca varia*, *Aspidium Lonchitis*, *Lycopodium Selago*, *Polypodium Phegopteris*.

Zona medialis (= Z_4). *Ranunculus alpestris*, *montanus*, *Pyrenæus*, *Cardamine bellidifolia*, *Draba aizoides*, *Sisymbrium pinnatifidum*, *Saponaria caespitosa*, *Arenaria purpurascens*, *Stellaria cerastoides*, *Cerastium alpinum*, *Cherleria scdoidea*, *Geum montanum*, *Potentilla nivalis*, *Rhodiola rosea*, *Saxifraga aretioides*, *bryoides et muscoides*, *Asperula hirta*, *Aronicum scordioides*, *Chrysanthemum alpinum*, *Erigeron alpinus*, *Gnaphalium leontopodium et supinum*, *Senecio Tournefortii*, *Crepis pygmæa*, *Taraxacum officinale var. alpinum*, *Campanula pusilla*, *Jasione perennis*, *Phyteuma hemisphæricum*, *Euphrasia minima*, *Pedicularis Pyrenaica et rostrata*, *Pinguicula alpina*, *Soldanella alpina*, *Daphne Cneorum*, *Veronica alpina*, *Juniperus nana*, *Juncus trifidus*, *Luzula spadicæ et pediformis*, *Carex Pyrenaica*, *Festuca varia*.

Zona superalpina (= Z_5). *Cardamine bellidifolia*, *Draba nivalis*, *Potentilla nivalis et Salisburgensis*, *Saxifraga bryoides, granulata var.*, *muscoides et grœnlandica, Lap.*, *Senecio Tournefortii*, *Gentiana alpina*, *Myosotis sylvatica var. alpestris*, *Pedicularis rostrata*, *Soldanella alpina*, *Statice alpina*, *Salix retusa et herbacea*, *Luzula spicata*, *Carex curvula et nigra*, *Agrostis vulgaris var. alpina*, *Sesleria disticha*.

Throughout the following catalogue of the mosses, the zones which each species occupies will be distinctly specified; and to enable me to do this in the smallest possible compass, I propose the notation of *zones* above indicated, that is to say, Z_1 for the first zone above the plain, Z_2 for the second, &c., and Z_0 for the plain itself. It is in many cases difficult to ascertain the zone in which a moss has normally its station, for in mountainous countries the seeds, &c. of mosses are carried down by the streams, precisely as those of flowering-plants are; but a large proportion of mosses are found *only* near streams, and that especially in a low latitude, where the requisite degree of moisture is more rarely met with. Hence certain mosses, natives of the alpine region, are occasionally found some thousands of feet below it. To take an instance in *Grimmia spiralis*, a species which is stated by the authors of the 'Bryologia Europæa' to have its "véritable habitat au-dessus de toute végétation forestière." Near Cauterets, opposite the baths of La Raillère, on the rude blocks of granite which are thickly strewn along the banks of the Gave de Marca-daou, this species forms large lax tufts, disfigured by the sand of

the stream, yet bearing a few capsules. This is far *below the commencement of the subalpine zone*; but in continuing to ascend the stream, until we emerge on the broken plain adjacent to the Lac de Gaube, where the only trees are a few scattered pines (i. e. *towards the upper limit of the inferalpine zone*), we find the same species, forming small compact tufts and bearing a profusion of fruit, growing on the same sort of rock, and often far removed from any stream. *Here it is obviously at home.*

The localities visited within Z_5 are for the most part entirely destitute of mosses, in consequence of the declivities being covered with *sliding* fragments of schistose rock. Two species of Hepaticæ, *Sarcoscyphus emarginatus* and *Alicularia scalaris*, common in the plains, ascend in varying forms nearly to the limit of perpetual snow, and with *Jungermannia julacea* form the sole representatives of the tribe in Z_5 . I must also observe, that nowhere in the Pyrenees do mosses and lichens ascend higher than *all* flowering-plants. Even above the line of perpetual congelation, wherever a rock peeps out of the snow (its sides being too steep for the snow to rest upon them), Saxifrages, and two or three other kinds of plants equally hardy, fix themselves in its crevices. This is also the case with lichens, but scarcely with *real frondose mosses*, and I very much doubt whether there be any region in the world (alpine or arctic) where mosses leave below them *every* phanerogamous plant, although we have long been taught to believe that such is the case. Ramond found flowers to accompany Mont Perdu almost to its summit.

I proceed now to exhibit in a tabular form a list of those Musci, Hepaticæ and Lichenes which have appeared to me characteristic of the various zones in the Pyrenees. I have considered a species characteristic of a particular zone for the following reasons: 1. It is either abundantly distributed in that zone throughout the chain, and scarcely seen above or below it; or, 2. It occurs at various (it may be distant) points of the chain, and nowhere abundantly, yet is always confined to one zone; or else, 3. It is distributed through several zones, but exists in its perfect state only in one. A few species flourish with equal luxuriance in two or more zones. Those mentioned for the superalpine zone were almost its sole occupants, and most of them were sterile. The species united by *brackets* were frequently grouped together *in one tuft*, so as to be taken up at once by the hand; or, in the case of crustaceous lichens, occupied the surface of *one stone*. The species printed in *italics* are considered peculiarly characteristic of the zone in which they are placed.

<i>Limes nivalis.</i>	MUSCI.	HEPATICÆ.	LICHENES.
Zona superalpina. (= Z ₆). 8400'.	<i>Polytrichum juniperinum</i> . sexangulare. { <i>Encalypta rhabdocarpa</i> . <i>Hypnum molluscum</i> var. { <i>Desmatodon latifolius</i> , var. <i>muticus</i> . { <i>Weisia crispula</i> var.	{ <i>Jungermannia julacea</i> . <i>Sarcoscyphus emarginatus</i> . <i>Alicularia scalaris</i> .	<i>Parmelia chrysoleuca</i> . <i>Lecidea atrobrunnea</i> . <i>Umbilicaria proboscidea</i> var. <i>Endocarpon miniatum</i> , var. <i>complicatum</i> .
Zona medialis. (= Z ₄). 7200'.	{ <i>Weisia crispula</i> var. <i>Dieranum Starkii</i> . <i>Arctoa fulvella</i> . <i>Grimmia sulcata</i> . <i>atrata</i> . <i>Tortula vinealis</i> , var. <i>nivalis</i> <i>Dissodon Frœlichianus</i> . <i>Anacalypta latifolia</i> . <i>Bryum turbinatum</i> , var. <i>latifolium</i> . <i>Hypnum plicatum</i> .	{ <i>Jungermannia julacea</i> . <i>Sarcoscyphus emarginatus</i> . <i>Alicularia scalaris</i> . <i>Gymnomitrium concinnatum</i> .	{ <i>Umbilicaria proboscidea</i> . <i>atropruinosa</i> . <i>Cetraria pinastri</i> . { <i>Cladonia vermicularis</i> . <i>gracilis</i> . <i>Lecidea Morio</i> . <i>confluens</i> . <i>Wahlenbergii</i> . <i>Parmelia ventosa</i> . <i>Peltigera crocea</i> .
Zona inferalpina. (= Z ₃). 6000'.	{ <i>Hypnum plicatum</i> . <i>Leskea incurvata</i> . <i>Tortula aciphylla</i> . <i>Dieranum Starkii</i> . <i>Desmatodon latifolius</i> . <i>Hypnum reflexum</i> . <i>callichrous</i> . <i>Grimmia spiralis</i> . <i>ovata</i> var. <i>alpestris</i> . <i>Timmia megapolitana</i> . <i>Bryum polymorphum</i> , var. <i>curvisetum</i> . <i>alpinum</i> . <i>capillare</i> var. 3. <i>Bartramia ithyphylla</i> . <i>Gymnostomum curvirostrum</i> . <i>Hypnum dimorphum</i> .	<i>Gymnomitrium concinnatum</i> . <i>Jungermannia albicans</i> var. <i>trichophylla</i> . <i>Mastigobryum deflexum</i> .	<i>Peltigera crocea</i> . <i>Lecidea Wahlenbergii</i> . <i>Parmelia ventosa</i> . { <i>Lecidea Morio</i> . <i>Parmelia badia</i> . <i>Biatora decipiens</i> .
Zona subalpina. (= Z ₂). 4200'.	{ <i>Hypnum dimorphum</i> . <i>Starkii</i> . { <i>Bryum acuminatum</i> . <i>Zierii</i> . <i>capillare</i> var. 2. { <i>Hypnum Crista-castrensis</i> . <i>uncinatum</i> . <i>Schreberi</i> . <i>salebrosum</i> . <i>Halleri</i> . <i>subtile</i> . <i>Isothecium striatum</i> . <i>Bartramia Halleriana</i> . <i>Trichostomum glaucescens</i> . <i>Campylopus longirostris</i> . <i>Grimmia elatior</i> . <i>Gymnostomum rupestre</i> . <i>Ptychomitrium polyphyllum</i> . <i>Grimmia ovata</i> .	<i>Mastigobryum deflexum</i> . { <i>Jungermannia trichophylla</i> . <i>curvifolia</i> . <i>reclusa</i> . <i>Scapania apiculata</i> . <i>Jungermannia nana</i> . <i>sphaerocarpa</i> . <i>lanceolata</i> . { <i>riparia</i> . <i>acuta</i> .	<i>Cetraria juniperina</i> . <i>Parmelia ventosa</i> . <i>Biatora lurida</i> . <i>Umbilicaria pustulata</i> .

4200'.	MUSCI.	HEPATICÆ.	LICHENES.
Zona montosa (= Z ₁).	Superior.	Plagiochila Pyrenaica. { Jungermannia acuta. Wilsoniana.	{ Parmelia fulgens. crassa. { Lecidea candida. vesicularis. Verrucaria maxima. { Opegrapha cerebrina. Verrucaria Dufourei.
	Inferior.	{ Isothecium repens. Hypnum Haldanianum. pratense. Teesdalii. { Leucodon sciurioides. Dicranum montanum. Tortula revoluta. chloronotos. Bryum atropurpureum. Grimmia criuita. Fissidens incurvus.	{ Jungermannia Wilsoniana. Southbya tophacea.
Planties. (= Z ₀). 0000'.	Hypnum illecebrum. Leptodon Smithii. Bryum torquescens var. Tozeri. Muelleri. { Entosthodon Templetoni. Tortula cuneifolia. Trichostomum subulatum.	Jungermannia Francisci. { Saccogyna viticulosa. Mastigobryum trilobatum. Reboulia hemisphærica. Riccia fluitans. natans.	Parmelia chrysophthalma. rubiginosa. Clementiana. Opegrapha elegans. Lyellii.

It was my intention to have given here a comparative view of the distribution of Musci and Hepaticæ in the Pyrenees and in the other great mountain-ranges of the world, as also with that of our own islands, but this introduction has already swelled to a tedious length, and I hasten to close it with a few general observations.

As there are certain flowering-plants which accompany the habitations of men and of cattle from the plains nearly to the tops of the mountains, namely, in the Pyrenees, *nettles*, *mallows* and *docks* (*Rumex Patientia*); so there are likewise certain mosses which cling with equal tenacity to these traces of civilization.

The most notable are *Ceratodon purpureus* and *Funaria hygrometrica*. *Tortula ruralis* is associated with these until in the inferalpine zone it meets and is supplanted by *T. aciphylla*, which I have never seen away from the sheep-cotes and the huts of the shepherds. At about the same height *Hypnum rutabulum* and *Bryum capillare* give place to *Hypnum plicatum* and *Leskea incurvata*; these last, along with *Tortula aciphylla*, indicate the localities where the domesticated animals have taken up their temporary sojourn, throughout all the higher mountains.

The cryptogamic vegetation of the Pyrenees, taken in the mass, has great general resemblance to that of our own islands, especially of Ireland, and the species common to both attain nearly the same comparative altitude. Yet there are features in the former which would forcibly strike a bryologist accustomed only to the mosses of the British Isles. About the foot of the Pyrenees he would be struck with the luxuriant fructification of *Dicranum glaucum* and *Leucodon sciuroides*, the fruit of the latter being one of the greatest rarities of our islands; and he would equally remark the absence of *Bryum caespiticium*, of which I gathered only a single tuft, on a wall near Oloron; nor has it been observed elsewhere in the Pyrenees, though we are accustomed to look on it as the commonest of mosses. *Bryum cernuum* and *inclinatum* are almost equally scarce, though frequent with us and ascending high into the mountains. Were he next to climb the lower calcareous hills, he would see *Hypnum rugulosum*, *abietinum*, and *Leskea attenuata* profusely covering the scattered stones and rocks, and forming quite a marked feature even in the scenery. But he would miss *Hypnum undulatum* and the *Sphagna* which ornament our moist turfy hills; and if he ascended higher, he would probably see no *Splachna* or *Andreaea*. The rarity of the latter cannot be attributed to the southern latitude of the Pyrenees, for they exist even under the equator, as for instance on Mount Pichincha. The abundance of these two genera in the Alps of Switzerland must give a character to their vegetation wanting in the Pyrenees; and in general the Alps would seem to be much more mossy than the Pyrenees, above the region of forests, giving birth for example to an immense number of *Brya*, which in the Pyrenees are nowhere abundant above the inferalpine zone. This may reasonably be attributed to the more northerly position of the Alps, to their extending through a far wider zone of latitude, and not consisting like the Pyrenees of a single narrow chain; and to their greater humidity, which is probably dependent on the immense breadth of snow that perpetually covers them. The species described in this catalogue as new have none of them been observed in the Alps, with the exception of *Hypnum Pyrenaicum*, which was the only one noticed

above the subalpine zone; and there are a few other Pyrenæan mosses wanting to the Alps*.

Two *Jungermannia* exceedingly common in Britain, *Lophocolea bidentata* and *heterophylla*, are all but absent from the Pyrenees; and two others, *Jungermannia barbata* and *Ptilidium ciliare*, great ornaments of our mountainous districts, are altogether wanting. The latter attains its southern limit in the north of Italy; it is distributed throughout middle and northern Europe, but grows in greatest luxuriance within the Arctic circle. (Conf. Wahlenberg and the accounts of our Northern voyagers.)

According to Wahlenberg, there are in Lapland, as in the Pyrenees, extensive forests of *Pinus Abies* and *P. sylvestris*, and both descend into the plain; the former cease at the altitude of 800 feet and the latter at 1200 feet, indicating respectively the upper limits of the "regio sylvatica" and the "regio subsylvatica." But in the Pyrenees these trees ascend proportionally far higher than in Lapland; and that they do not occupy the same climatal zones we shall see by comparing the positions of a few mosses common to both countries. In the Pyrenees, *Tortula tortuosa*, *Bryum crudum*, *Didymodon capillaceus* and *Dicranum virens* are found in the region of coniferous trees, and are rarely seen above it; but these are precisely species mentioned by Wahlenberg as characteristic of his "Alpes inferiores," which are above the region even of the birch ("regio subalpina, Wahl."), and are characterized by the presence of *Betula nana*, *Diapenzia lapponica* and *Silene acaulis*. Yet the comparative altitudes attained by the mosses in the Pyrenees and in Lapland accord very nearly, and the species which ascend highest in the one for the most part do the same also in the other. Hence the zone occupied by a moss common to both has probably in both the same average *estival* temperature.

[To be continued.]

XI.—*Algæ Orientales*.:—*Descriptions of new Species belonging to the genus Sargassum.* By R. K. GREVILLE, LL.D. &c.†

[Continued from vol. ii. p. 434.]

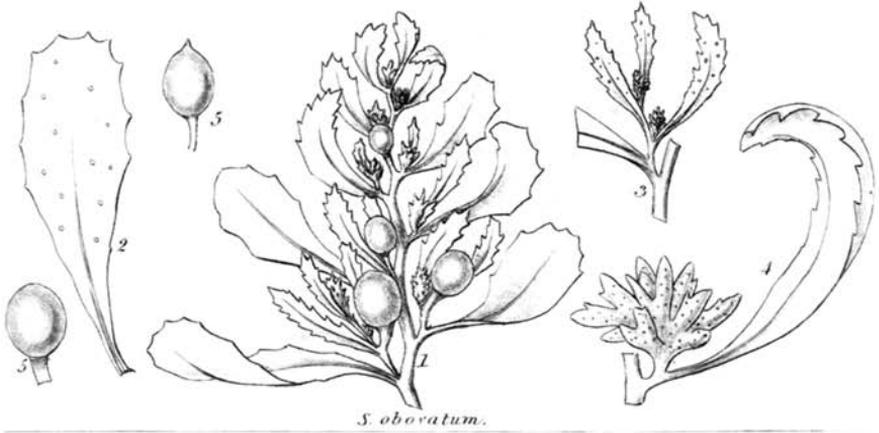
[With a Plate.]

WIGHTIANÆ.

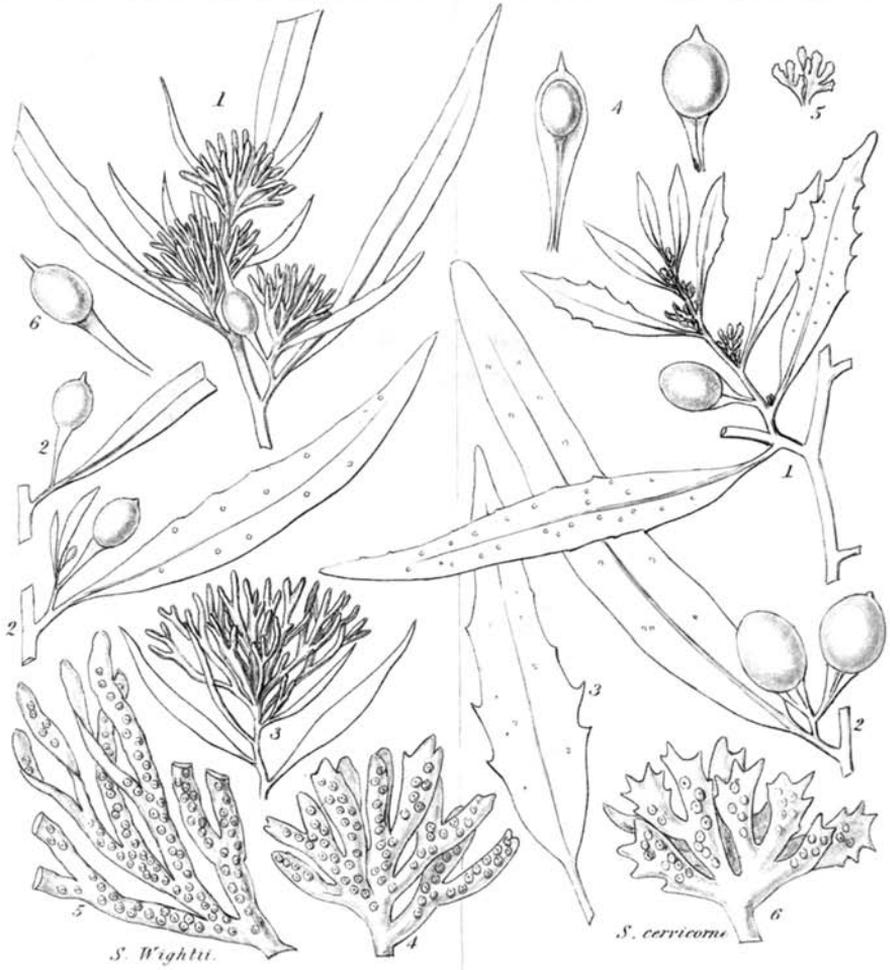
10. *Sargassum porosum* (nob.); caule cylindraceo, brevissimo, mucricato, ramis planis; foliis ovato-oblongis, subundulatis, inciso-

* The number of species which I have found in the Pyrenees new to the flora of France is considerable; but I cannot give a correct list of them, as I have not the dates of several species discovered in the Alps and Jura and nearly contemporaneously in the Pyrenees.

† Read before the Botanical Society of Edinburgh 14th Dec. 1848.



S. obovatum.



S. Wightii.

S. cervicornis.

