TRANSACTIONS

OF THE

PERTHSHIRE SOCIETY OF NATURAL SCIENCE.

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VOLUME III.

1899 TO 1903.

PERTH:

PUBLISHED BY THE SOCIETY,
AT THE PERTHSHIRE NATURAL HISTORY MUSEUM.

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I.—*List of the Rhynchota of Perthshire.*

By T. M. M'Gregor and G. W. Kirkaldy.

PART I.

(Read 10th November, 1898.)

This list has been compiled from all the records known to us, particularly from those published by Mr. M'Gregor in these *Transactions* (Vol. II., 1895, pp. 10-17) and augmented by an examination of our own collections and those of the late Dr. F. B. White.

Fifty-two species are enumerated, belonging to the Cimicidæ (= Pentatomidæ), Berytidæ, Tingitidæ, Reduviidæ, Hebridæ, Gerridæ, Corixidæ, Notonectidæ, and Nepidæ. Coreidæ, Aradidæ, and Naucoridæ are not, as yet, recorded; and while the aquatic and semi-aquatic species are well represented—numbering more than 60 per cent. of the total British list—the land species [of the families enumerated] are almost entirely absent.

Although more thorough collecting has been done in Perthshire than in any region of similar size in Scotland, a very great deal yet remains to be done before we can gather a clear idea as to the extent of its Rhynchota-fauna. It will be noticed that the bulk of the collecting has been made in three districts, viz.: the immediate vicinity (five or six-mile-radius) of the Fair City, around Pitlochry, and Rannoch Moor; while such undoubtedly rich localities as the Trossachs and the Forfar border, for example, appear to be absolutely untouched.

A very valuable work could be done by an enthusiastic entomologist, with a fair amount of leisure, who would take up, say, the aquatic and semi-aquatic forms—*Corixa*, *Gerris*, *Acanthia (Salda)*, etc., and thoroughly work out their distribution in Perthshire, not only geographically, but noting also the elevation above sea-level of the lochs, ditches, etc., from which they were collected. Perthshire is a specially interesting district for such work. If we draw a line roughly from Alyth to Gartmore, we find that south of this line (that is the south-east portion of the County), the land is almost entirely less than 500 feet above sea-level; while north of the line, the greater portion is more than 1000 feet above sea-level, rising in many places to even three and four times that altitude. It is known even now that the Rhynchota-faunas of these two divisions are very different, although of course overlapping considerably.

Among the species not yet recorded from Perthshire, which we think will reward close collecting in the less worked parts, may be mentioned: *Acalypta* [*Orthostira*] *cervina* (Germ.), *A. parvula* (Fall.), *A. nigrina* (Fall.), *A. macrophthalmus*[1] (Fieb.), *Dictyonota strichnocera* (Fieb.), *Aradus depressus* (Fabr.), *Gerris thoracicus* (Schumm.), *Ilyocoris* [= *Naucoris*] *cimicoides* (Linn.), *Corixa affinis* Leach [*atomaria auctt*], *C. lugubris* (Fieb.), and *C. selecta* (Fieb.)

An asterisk (*) denotes a species not previously recorded from Perthshire; two asterisks—a species not previously noted from Scotland. The figures refer to the months in which the species has been found. Where our nomenclature differs from that adopted in Mr. Edward Saunders' "Hemiptera-Heteroptera of the British Islands" (1892), the latter is inserted in square brackets.

We hope to communicate a list of the remaining families of the Heteroptera and the Homoptera at an early date, and trust that the publication of this enumeration will prove a further incentive to entomologists residing in the County. We have only to add that we will be glad to render all possible assistance to intending workers at this order who will apply to us,

T. M. M'Gregor,

8 Rosslyn Place, Glasgow Road,

Perth, Scotland,

AND

G. W. Kirkaldy,

St. Abb's, Wimbledon,

Surrey, England.

[1] This specific name is usually written "macrophthalma" under the impression that it should agree with *Acalypta*; the former, however, is a noun, viz., "big-eye."

CIMICIDÆ [=PENTATOMIDÆ].

1 Sehirus biguttatus (Linn.) Pitlochry (Norman); Rannoch (Marshall).
2 Dolycoris [Pentatoma] baccarum (Linn.) Kinnoull Hill (on *Hesperis* and *Verbascum*) 8 (White).
3 Piezodorus lituratus (Fabr.) Perth (broom and furze), autumn (White).
4 Pentatoma [Tropicoris] rufipes (Linn.) "Perthshire" (White); Birnam, Scone (M'Gregor).
5 Cimex [Picromerus] bidens, Linn. "Perthshire" (White).
6 Asopus punctatus (Linn.) Kinnoull Hill (on Blaeberry), 5 (White); Rannoch (Marshall).
7 Zicrona cærulea (Linn.) Muir of Durdie (?) (White).
8 Acanthosoma interstinctum (Linn.) [=dentatum, de Geer];[1] Ardargie, birch, 9, and Ballinluig (M'Gregor) Pitlochry, 8-9 (Beaumont).
9 griseum (Linn.) [=interstinctum auctt], Ardargie, birch, 9 (M'Gregor); Pitlochry, 8-9 (Beaumont).

BERYTIDÆ.

10 Berytus signoreti, Fieb. "Perthshire" (Norman).
11 minor, Herr.—Schäff., Pitlochry (Norman).

TINGITIDÆ.

12 Piesma quadrata, Fieb. Banks of the Tay at Invergowrie (under stones), 4 (White).
13 Derephysia foliacea (Fall.) Minkie Moss (White).
14 Monanthia humuli (Fabr.) "Perth" (White); Quarrymill Den (White).
15 Tingis cardui (Linn.) Aldie, Almond Valley, Ballinluig, common throughout Perthshire, 7 (M'Gregor).

REDUVIIDÆ.

16 Ploiariola [Ploiaria] vagabunda (Linn.) Minkie Moss (Scots fir), 9 (M'Gregor); Pitlochry, 8-9 (Beaumont).
17 Nabis flavomarginatus, Scholtz. Almond Valley and Methven Moss (M'Gregor); Pitlochry (Norman); Rannoch (Marshall); Stanley, 3 (M'Gregor).
18 limbatus, Dahlb. Rannoch (White); fairly common throughout Perthshire (M'Gregor).
19** lineatus, Dahlb. Almond Valley, 6 (M'Gregor).
20 ferus (Linn.) Bankfoot, 8 (M'Gregor); Perth (White).
21 rugosus (Linn.) Almond Valley, 6 (M'Gregor).

[1] See Horvàth, 1899, "Rev. d' Entom.," XVII. [1898], p. 276.

GERRIDÆ [HYDROMETRIDÆ].

22 Hebrus ruficeps, Thoms. Minkie Moss, 6 (sphagnum) and Methven Bog, 9 (White and M'Gregor).

23* Hydröessa [Microvelia] pygmaea (Duf.). Methven Bog, 8 (M'Gregor and Kirkaldy).

24 Velia rivulorum (Fabr.) [=currens auctt]. Almond Valley and Minkie Moss, 3 (M'Gregor); rock pools in Killiecrankie Pass, and Methven Loch, 8 (Kirkaldy). [Macropterous examples not uncommon.]

25 Gerris costæ, Herr.—Schäff. Aldie, by Methven, 5, Birnam (White); hills above Dalguise, Methven Bog, 6, Tyndrum, 4 (M'Gregor); Glen Tilt, 8 (Kirkaldy); Pitlochry (Norman); Rannoch (M'Lachlan, Marshall, and Rye).

26 aspera (Fieb.) Pitlochry (Norman).

27 lacustris, (Linn.) Stal. Almond Valley and Ballinluig (M'Gregor); Pitlochry (Norman).

28 odontogaster (Zett.) Dalguise and Methven Bog, and common on pools at Methven Moss, 3, 5 (M'Gregor); Pitlochry (Norman); Rannoch (White).

29 rufoscutellatus, Latr. Pitlochry (Norman).

30** Hydrometra stagnorum (Linn.) "Perthshire" (M'Gregor).

CORIXIDÆ.

31 Micronecta [Sigara] minutissima (Linn.) Almond Valley, Methven Loch, 6, and Woody Island (M'Gregor).

32 Cymatia [Corixa] bonsdorffii (Sahlb.) Ballinluig, 7 (M'Gregor); Methven Moss, 5 (White).

33 Corixa praeusta, Fieb. Methven Bog and Moss, 8 (M'Gregor); Methven Loch, 8, and Loch Tilt, 8 (Kirkaldy); Rannoch, 6 (Marshall, Rye, and White).

34 concinna, Fieb. Perth, 5 (M'Gregor); Pitlochry (Norman).

35 fossarum, Leach. Almond, Ballinluig, and Stanley, 7 (M'Gregor); Methven Loch, 8 (Kirkaldy).

36 scotti, Dougl. and Scott. Ballinluig, 7 (M'Gregor); Rannoch (White).

37 moesta, Fieb. Ballinluig and Loch Ordie, 7, Methven Bog and Moss, 6 (M'Gregor); Rannoch (White).

38 nigrolineata, Fieb [fabricii auctt]. Almond, 4 (M'Gregor); Glen Tilt, Perth, and Rannoch (White); Rannoch (Rye).

39 limitata, Fieb. Perth (Reuter).

40 Corixa venusta, Dougl. and Scott. Almond Valley, 8 (M'Gregor); Pitlochry (Norman).

41 semistriata, Fieb. Almond Valley, 5 (M'Gregor); Methven Loch, 8 (Kirkaldy); Perth (Reuter).

42 lateralis, Leach [hieroglyphica auctt]. Perth, 6 (M'Gregor).

43 striata (Linn.), Fieb. Almond (M'Gregor); Invergowrie (White); Methven Loch, 8 (Kirkaldy).

44* falléni, Fieb. Ballinluig, 7 (M'Gregor); Methven Loch, 8 (Kirkaldy).

45 distincta, Fieb. Methven Loch, 8 (Kirkaldy); Perth, (Reuter and White).

46 sahlbergi, Fieb. Methven Bog and Moss, 6-8 (M'Gregor); Methven Loch, 8 (Kirkaldy); Rannoch (White).

47 linnéi, Fieb. Rannoch (White).

48 carinata, Sahlb.[1] Dalguise, 4 (M'Gregor); Pitlochry (Norman).

49 geoffroyi, Leach. Almond Valley, 8 (M'Gregor); Methven Loch, 8 (Kirkaldy).

NOTONECTIDÆ.

50* Plea leachi, M'Greg. and Kirk., n. n. (=minutissima, Fabr., auctt).[2] Woody Island (White).

51 Notonecta glauca, Linn. Ballinluig and Perth (M'Gregor); Methven Loch, 8 (Kirkaldy).

* var. marginata, Müll., Kirk. [furcata auctt]. Ballinluig, 7 (M'Gregor).

NEPIDÆ.

52* Nepa cinerea, Linn. Methven Loch, 8 (Kirkaldy)—one nymph, now in Perthshire Natural History Museum.

[1] *C. germari*, Fieb., [*intricata*, Dougl. and Scott] has long been confounded with this species (see Kirkaldy in "Entomologist," 1898, November), and probably occurs in Perthshire.

[2] As *Notonecta minutissima*, Fabr., was not *N. minutissima*, Linn., and was therefore preoccupied by it, Leach was wrong in employing the specific name for his genus *Plea*. N.B.—Fabricius was under the impression that his insect was identical with that of Linnæus, so that the case is different from that of *Sigara lineata*, Fieber [see Kirkaldy, 1898, "Entomologist," pp. 3, 4], as Fieber distinctly states (Abh. böhm. Ges. Wiss., V., 7, p. 218) that his insect is not that of Fabricius. We have followed Stals's precedent in *Naucoris poeyi*.

II.—*The Flora of Durdie and Arnbathie.*

By James Menzies.

(Read 8th December, 1898.)

The district of which the Flora forms the subject of this paper lies near the summit of the Sidlaws, and has an elevation of about 600 feet above sea-level. It is distant from Perth about four miles and is reached by a road from near Bonhard, passing Balcraig. This road crosses the district and leads into the Carse of Gowrie at Pitroddie. The whole district forms a plateau or table-land, a considerable area of which is under cultivation. There are, however, several large stretches of moorish ground.

Along the wayside to the right lies Durdie Muir. Farther west is more moorish ground, broken up into great rounded knolls, with hollows between, in which the winter rains gather, and which even in summer remain moist.

Lying to the east of the road, and separated from Durdie Muir by a deep valley, is Arnbathie, characterised by the same conditions of knolls and hollows. In the heart of this ground is Arnbathie Loch, a sheet of water of no great extent nor depth, and nearly covered, at least in summer, with vegetation. The soil of the locality, being derived from rocks rich in lime, magnesia, soda, and other alkalies, is fairly fertile, while in some places accumulations of boulder clay give the subsoil a more retentive character.

The district has always been attractive to lovers of nature. The entomologist, the ornithologist, and the botanist have all pursued their favourite studies here, while the ordinary visitor, who cares for none of these things, finds pleasure in the freedom of the moors, the pure bracing air, and the magnificent prospect which the locality affords of the surrounding country, and which can hardly be passed over in a paper of this kind without some attempt at description.

Standing on the high ground a little beyond Arnbathie, and looking southwards, a glimpse of the blue waters of the Tay is caught at a point below Newburgh. Beyond the river rise the smooth, green summits of the Ochils, and in the background the hills of Fife, with the Easter and Wester Laws standing out in bold prominence. Looking to the east, the high peaks of the Sidlaws, the Giant's Hill, and King's Seat attract attention; while northwards the eye ranges over the valley of Strathmore to where Blairgowrie and Alyth seem to nestle at the base of the hills.

Looking westwards the woods of Scone and St. Martins lie at one's feet, while across the valley Birnam Hill and Craiglea are seen.

To the south-west the dark band of the Dupplin woods bounds the prospect, and the eye loses itself on that long stretch of level country traversed by the Crieff railway.

Many well-known peaks of the Grampians can be recognised, amongst which the broad crest of Ben Lawers and the sharp peak of Schiehallion stand out in marked contrast, while all round north and west the mountains tower range behind range, till mountain-tops and clouds seem to blend on the far horizon.

The flora of my district is not a rich one, if the presence of rare plants be taken as a standard of reckoning. The whole district is closely pastured, so that no plant which is suitable as food for grazing animals has any chance of maintaining an existence. Indeed, it may be said that, with a few exceptions, the whole flora of the moors, apart from the grasses, consists of plants which are disliked by animals, or to which they are indifferent. A visitor to the district, approaching it by way of Balcraig, will, if familiar with it, take a foot-path through the wood which skirts the base of the hill on which the monument to Lord Lynedoch is situated. This foot-path shortens the road considerably. At the end of the foot-path, just before entering the moor, the first object of interest which presents itself to the botanist is the wood anemone, *Anemone nemorosa*, some fine patches of which grow here. The flowers seem to have a deeper tint in their petals than those of the same species growing at lower elevations. On leaving the wood, in a tiny streamlet, *Carex disticha* is seen growing. It is noticeable that this particular Carex does not occur in any other part of the district. At this point the whin, *Ulex europæus*, and the broom, *Cytisus scoparius*, become prominent botanical features. The whin wreathes the rocky knolls to their summits. No soil is too shallow nor situation too exposed for this hardy legume, and at a time when other vegetation is still dormant the golden blossoms brighten the whole landscape.

Proceeding along the road which crosses the moor, many of our common wayside plants are seen. Here, protected by a fence, are *Lotus corniculatus*, *Lotus major*, *Lathyrus pratensis*, *Trifolium medium*, *Lathyrus macrorrhizus*, *Galium verum*, *Scabiosa succisa*, *Achillea Ptarmica*, the sneeze-wort—in which it is difficult to recognise the parent stock of the fine *Achillea*, the pearl of the nurseryman—*Achillea Millefolium*, *Senecio sylvaticus*, *Rhinanthus Crista-galli*, and *Vaccinium Myrtillus*, the blaeberry of Scotland, the bilberry of England, and the whortleberry of North America—the whole wayside being remarkable for its wealth of flowers.

Entering the moor by the gateway, the visitor finds himself in a moist hollow. Here the sweet-scented orchis, *Habenaria conopsea* is found growing plentifully—the white form of the plant, however, is absent—also *Orchis maculata*, *Polygonum viviparum*, and *Trollius europæus*, the globe flower.

Ascending to the higher ground, *Habenaria chloroleucha*, Rid., the butterfly orchis, raises its faintly yellow flowers above the short grass, while near by grow *Erica tetralix*, *Erica cinerea*, and *Calluna vulgaris*, ling or Scotch heather. Though found over the entire district, *Calluna* is always cropped close to the ground. Turning westwards, a part of the moor is found almost entirely monopolised by the bog asphodel, *Narthecium ossifragum*, growing so close as to form a carpet of starry yellow flowers. A little farther on *Genista anglica* occurs. I have found this plant in several spots on the moor, but it is far from being abundant. A part of the moor here is very barren, almost the only vegetation being the hard rush, *Juncus squarrosus*, and a few tufts of the spike rush, *Eleocharis cæspitosus.* It soon improves, however; the whin becomes frequent, and in the grassy glades between the clumps *Ranunculus acris* is seen, together with *Hypochæris radicata* and *Leontodon autumnalis*, two members of the Composite family which seem indifferent alike to soil and situation.

Bending closer to the hills, the dry knolls are found carpeted with *Hieracium Pilosella*, *Thymus Serpyllum*, the wild thyme, and *Galium saxatile*, the heath bedstraw; while in the rocky niches the rock-rose, *Helianthemum vulgare*, grows freely and is quite a feature of the moor in its season. *Antennaria dioica*, the cat's-foot, occurs sparingly; *Pedicularis sylvatica* is plentiful in all the damp hollows and is one of the commonest plants in the district. *Euphrasia officinalis*, the eye-bright, is abundant. This little plant is a parasite on the roots of grasses. Kerner says it is called the milk-thief by the German peasantry, from a belief that, in years when the eye-bright abounds, it injures the pasturage. He, however, does not share this belief. Occasionally, too, I have seen the tiny *Linum catharticum*, and a starved form of *Ranunculus auricomus*, the goldie-locks. This latter plant may be a survival from the time when the presence of trees on the moor afforded it more suitable conditions of existence. The cudweed, *Gnaphalium sylvaticum*, also grows here, and it is worthy of note that, though not common on the moor, yet, in a small field lying in pasture last year, at the base of the hills, I saw the plant in such abundance as to form no inconsiderable part of the whole vegetation.

In a marsh where a small burn has cut for itself shallow ruts in the soft soil, *Saxifraga aizoides* grows, associated with *Pinguicula vulgaris*, *Parnassia palustris*, *Lychnis Flos-cuculi*, *Hydrocotyle vulgaris*, *Potamogeton natans*, *Montia fontana*, and, most conspicuous, the marsh thistle, *Cnicus palustris*, with its purple flowers. Here and there the beautiful heads of the quaking-grass, *Briza media*, attract attention, and *Molinia cærulea*, the moor-grass, is represented by a few spikes, for, contrary to what might have been expected, this is not a common grass in the locality. Still keeping westwards, the field gentian, *Gentiana campestris*, is found, but, though well protected from grazing animals by the bitter properties which characterise its species, the gentian is not a common plant here. In the plantation which forms the western boundary of my district, conifers of various species predominate, but the alder prevails where the ground is damp. In a ditch within the fence, *Mentha sativa* is found, and, here and there, *Blechnum boreale* and *Lastrea Filix-mas* have effected a lodgment; while in a moist open glade *Viola palustris* occurs in fine form, freely intermingled with *Viola sylvatica*—an association I have seen nowhere else.

Taking the road through Arnbathie, the red-tinted buds of the St. John's wort, *Hypericum pulchrum*, and the nodding blue flowers of *Campanula rotundifolia*, the blue bell of Scotland and hare bell of England, attract the eye, growing amidst the now sombre-hued whins, while at the roadside are patches of *Bartsia Odontites*. On the left, a huge, rocky knoll tempts investigation. At its base, *Avena pratensis* raises its tall spikes, and, in a clump of broom, the field scabious, *Scabiosa arvensis*, is seen—a rare plant here, however. Higher up the knoll are a few small specimens of the speedwell, *Veronica arvensis*, with *Polygala vulgaris*, the milk wort, in all the colours which characterise that variable plant; and here and there the Burnet-saxifrage, *Pimpinella Saxifraga*, remarkable for the night-position assumed by the flower heads, which droop until they point downwards instead of upwards,—a characteristic seen in only one other of the *Umbellifers*,—while on the summit *Viola lutea*, with its relatively large flowers, is found sparingly. Turning to the swampy ground in the vicinity of the loch, a few plants of *Pedicularis palustris* are seen, and the tiny *Sagina nodosa* is plentiful; *Triglochin palustre*, the arrow-grass, and *Senecio aquaticus* occur sparingly, and *Caltha palustris*, the marsh marigold, but the specimens of this latter plant are very much inferior to the succulent ones found on the tidal banks of the Tay. On the margin of the loch, *Orchis latifolia* and *Parnassia palustris* grow. At the northern end, in a bed of *Sphagnum*, *Drosera rotundifolia* and *Viola palustris* are found together.

In the loch itself, *Comarum palustre*, the cinquefoil, grows; *Ranunculus heterophyllus* spreads its white flowers over the shallow end, while in the deeper part *Menyanthes trifoliata*, the buck or bog bean, is found in great abundance. This plant, which does not flower freely in some situations, is here seen at its best, and, in the early summer, when it sends up thousands of spikes of milk-white flowers, with their beautifully fringed filaments, the face of the loch is quite transformed. Later in the season the flowers of the bog-bean give place to the silky tufts of the cotton-grass, *Eriophorum angustifolium*.

The swampy ground is pre-eminently the home of the Carex family. Although a few sedges are found growing all over the district, here the following species occur in a social state,—*Carex dioica*, *C. pulicaris*, *C. echinata*, *C. glauca*, *C. panicea*, *C. flava*, *C. vulgaris*, and, in the loch, *C. ampullacea*, *C. limosa*, *C. teretiuscula*, and *C. filiformis*, the latter growing so far into the water that, except in a very dry season, it can be seen with difficulty.

In conclusion, I will add a few words about the grasses. Besides those which I have already mentioned, there are three prevalent forms on the moor—*Nardus stricta*, the common mat-grass, *Festuca ovina*, and *Agrostis vulgaris*. After these *Holcus lanatus*, in damp spots, *Aira cæspitosa*, *A. flexuosa*, *Anthoxanthum odoratum*, and *Triodia decumbens*, are common, while at Arnbathie I have found *Cynosurus cristatus*, the common crested dog's-tail grass, in abundance.

III.—*The Feathered Tenants of our Buildings.*

By Lieut.-Colonel W. H. M. Duthie.

(Read 8th December, 1898.)

After the middle of August there is a feeling of Autumn in the air; every sight and sound about us conveys an unmistakeable meaning that the departure of summer is at hand; the hum of labour is heard in the fields, for harvesting is in full swing, and barns and stackyards are filling fast; the foliage of the woods is still green, but here and there a conspicuous patch of colour shows where an early frost has touched a weak or wounded branch, and gives us a sample of the glorious garments of variegated hues which the trees will soon assume; already, the hedgerows are reddening with the fruit of hawthorn and wild rose, and the rowans are radiant with their clusters of scarlet berries; the bloom of the foxglove is over, and ragwort and knapweed, and other autumn flowers, mingle with the tall grasses which fringe the roadsides.

> "And now, with treble soft,
> The redbreast whistles from a garden croft,
> And gathering swallows twitter in the skies."

The birds, which never fail to remind us of the changing seasons, tell us plainly now that the summer is passing away; their very silence in copse and woodland is eloquent. The Cuckoo has gone the Swifts have left or are leaving for other climes, and birds of gregarious habits are congregating in ever-increasing numbers; we hear the young Curlews calling to one another as they sail over us on their way from the moorland to the sea, and large flocks of Peewits pass across the sky glittering like diamonds as the sunlight strikes their pure white under-plumage between each beat of their broad, dark wings. These signs of movement and migration point to the ending of the nesting season, and doubtless most of our birds have by this time completed their domestic duties, but some few are still employed, as we know by the young voices in the shrubberies clamouring for food, and by the swallows' nest above our heads. One brood has already flown from their nest, and a second family is nearly ready to follow suit; we can see the parents among a host of others, old and young, skimming below us, their purple backs gleaming as they twist and turn among the beds of asters and begonias on the lawn. They are very busy and constantly fly up to the nest with their mouths filled with insects to cram into the four little gaping mouths always ready for more; the old birds are sometimes assisted in the feeding by the young of the first brood, for time is precious, and every effort must be used to hasten the growth and development of the nestlings, whose tiny wings, not yet taught to spread, will soon be wafting their owners away from our shores at the rate of hundreds of miles in a day.

Towards the end of September the great gatherings of the Swallows take place; cold nights and scarcity of food are the chief causes which bring them together and unite them in one common bond of sympathy and fellowship; within each little breast, a strange overpowering force is at work urging flight—the one remedy which nature provides—and they are bracing themselves for the effort. Some have already accomplished the long mysterious journey and have returned, but to the multitudes of the young birds of the year the way is unknown, and many start without a guide.

Ignorant as we are of the language of the lower beings of creation, and of their power of imparting their experience and sensations one to another, we can only guess at what is going on when we listen to the earnest twitterings of the Swallows as they sit on roofs and telegraph wires before their final departure from our country. We shall not see them start, but some day we shall miss them; when the right moment comes they will shoot up into the clear, frosty air and vanish, and, bridging over time and space, will drop down into the warmth and sunshine of another world.

None of our feathered tenants receive a warmer welcome than the Swallows, and their kinsfolk, the House Martins, and none reciprocate more fully the hospitality we so willingly offer them, for there is no doubt that those who survive the many dangers which beset their migratory journeys return to their old haunts again and again, and repair the nest of former years. Their home-coming in April, the date of which can be calculated to within a few days, brings with it a whiff of southern air, and corresponds with the time, when our trees are bursting into leaf, when

> "The Peewit wheels and dips
> On heights of bracken and ling,
> And earth into her leaflet tips
> Tingles with the spring."

Soon after their arrival, a rapid survey of the old habitation is made on the wing, with perhaps a momentary rest on the crumbling ruin in order to form an estimate of the work required to be done; then we see to advantage the chestnut throat, and the long pencil-like tail feathers, as the bird presses its breast to the nest.

The survey completed, the work of building at once begins, and we note the industry of the birds as they fly to and fro with little dabs of mud, which they moisten at the stable pump or in the village pond far away. In the case of a new nest, the perseverance displayed is often marvellous, when, time after time, the foundation gives way from want of adhesion to the wall, and all has to be begun afresh. When the nest is built, and the time for lining it has arrived, we can assist and enjoy at the same time a glorious sight of mimic falconry, if we scatter some feathers from the window, and watch the eager birds swoop and seize them as they float in the air.

The eggs of the Swallow are white, speckled with brown and grey spots; those of the Martin, like all eggs laid in darkness, are pure white, for the Martin, not content with the shallow, open nest of the Swallow, prefers a roof over its head, and builds close under an eave, leaving a small aperture at the top for ingress and egress. Unfortunately, this snug little abode excites the cupidity of another of our tenants, the House Sparrow, who fiercely attacks the rightful owners, drives them away, and either adapts or appropriates the whole structure for its own use, or breaks through its walls and steals the warm lining of feathers to add to the comfort of its own home; the marked decrease of the Martin in Britain of late years is undoubtedly owing, in a great measure, to this aggressive action on the part of the Sparrow, which, if unchecked, must ultimately banish the Martin from our houses.

The Sparrow himself is a most persistent follower of man, and looks upon our houses as his own property—building his nest under the eaves, in the ivy, at the top of a water-pipe, or wherever it suits his taste or convenience. It is an untidy structure, as everybody knows—a bower of grass, lined with a plentiful supply of feathers, wool, string, bits of paper, and any warm material which may be at hand. Three or four broods are commonly produced in a season, and, as each brood consists of five or six young birds, the enormous and accumulating increase of the Sparrow has become a serious cause of anxiety to farmers. It is true that the young birds are fed chiefly on caterpillars, so that for about three months in the year a certain amount of benefit is conferred upon agriculturists and gardeners; but it has been proved by experts that 75 per cent. of the adult sparrows' food is corn of some kind, and it is stated on the authority of those who have carried out investigations under the direction of the Board of Agriculture, that "the amount of national loss by reason of damaged crops, and serviceable birds driven away, may be estimated, without fear of exaggeration, at from one to two millions a year."

In Canada and the United States of America no protection is afforded to the House Sparrow, and in some districts a price is placed upon his head. In Great Britain his name appears on no County Council Schedule for protection under the Wild Birds' Preservation Acts, and the question arises whether stronger measures should not be adopted to check this increase.

In spite of his faults, the Sparrow is a cheery and amusing bird to have as a neighbour, and in his absence we should miss the morning chirp, and the busy gossip which goes on under our windows in the evening at roosting time.

A near cousin of his, and very like him in appearance, is the Tree Sparrow *(Passer montanus)*, which sometimes builds in out-houses and old ruins. This bird is more local and less abundant than the ubiquitous *Passer domesticus.*

One of the first sounds to be heard at the house in the morning is the long-drawn-out whistle of the Starling; he is sitting on the weather-cock preening his feathers, and as the first rays of the sun strike the glittering vane he looks like a piece of metal himself, shining with a lustre of green and purple and gold. He is constantly singing in a vague sort of way fragments of other birds' songs, now a note or two of the Blackbird, now we hear a sound that seems to come from the farm-yard, followed by such a good imitation of the Curlew that we are at once transported in imagination to the moors or to the seashore.

Starlings are fond of nesting on our houses but are not encouraged owing to their unclean habits and their partiality for building in chimneys. As soon as the young birds have left the nest they are seen feeding with their parents on the lawn, where they are joined by other families reared on the premises; they soon extend their range, going to the meadows where the sheep are, and they join the Rooks in their foraging expeditions. They are the most social and gregarious of birds, and as separate families gather into flocks, so these flocks in the same way congregate, and, if the district is favourable to their tastes, countless hosts of Starlings are found consorting together.

Among our most constant summer friends at the house is the little Spotted Fly-Catcher, one of our latest incoming migrants to arrive; very quietly and unostentatiously they take up their quarters and build on the same wall, where old and new nests may be seen close together in the creepers. While one sits on the reddish-brown eggs, the other takes up a position on a branch of a tree, or on a rose standard, whence it darts out in pursuit of insects, capturing them with a sharp click of the beak; this is a very familiar sound on a warm, still day.

Besides the above regular tenants of our buildings, we may often reckon on the Blackbird, Song Thrush, Wren, and Redbreast (the latter would doubtless build inside a room if allowed, so tame and fearless of man has this general favourite become), and, if the growth of creepers is suitable, the Goldfinch, which, alas! is becoming very rare, will make its nest among the flowers of jasmine and honeysuckle. Some of the Titmouse family also appropriate a snug crevice between the wall and a verandah, and bring up a brood in perfect trust, being mindful of the many meals they have enjoyed on the window sills during the winter months. To invalids and the aged who are compelled to remain indoors, and who lie awake in the early hours of morning, these house-haunting birds afford special interest and delight. They watch the Swallows come and go, they know the language of every bird and when it is going to speak; they hear the first chirp which announces the dawn, the prelude to the concert which gradually swells as each new chorister wakes up to sing; and, when the evening shadows lengthen on the lawn, they hear the busy conversation of the Sparrows in the laurels, and watch that dark cloud suspended in the sky in the same place every night, ever changing in shape and density as it floats about, now black and compact, now airy and indistinct, till suddenly it falls to the earth like a pall as the thousands of Starlings composing it, with a swift downward rush, seek the osier beds by the river side to settle for the night.

Public buildings, churches, and old ruins are favourite nesting haunts of many birds, and of these none is more attractive and none affords a fitter sanctuary than one of our grand Gothic cathedrals; its vast size, and height towering above all neighbouring objects, like an isolated rock in the ocean, gives a sense of security and seclusion; its multitudinous turrets and pinnacles offer convenient perching places and points of observation, while under its numerous and massive buttresses which support the main building ample shelter and protection is afforded. Its tall steeple piercing the sky is not scorned by the Peregrine who sometimes makes its eyrie there, and the Kestrel is often seen hovering above the tower calling to its young who lie on a slab below. Pigeons which have deserted the dovecots have long been established there, and rear an independent race, scarcely to be distinguished from the wild stock from which they have originally sprung. Swallows and Martins build in rows under sheltering cornices of carved stone, and Starlings make their nests in chinks and crevices in the walls, and in the deep interstices of sculptured foliage and branches; while vulgar Sparrows are born in the arms of saints, or in the open mouths of grotesque gargoyles. There, also, we have the noisy, buoyant Swifts, their presence being an indication of long, summer days, for their sojourn with us is short; arriving in May, they leave again in August, after producing one brood. They build a slight nest, and lay two white eggs, under the slates or in a hole at some dizzy height, from which they launch their offspring into that world of air in which they spend their lives. Now dashing round the tower, now diving into the town below, they rush along in small parties screaming in mad flight; down the street they fly, round the chimney pots, and up to the cathedral tower again—always on the move, restless, impetuous, boisterous, the very impersonation of the hurricane. Observers have noticed Swifts late on a summer night rise vertically in the air and soar up into the sky till they were lost to view, and, although the watchers waited till darkness fell, they were not seen to return—where they went, and for what purpose, is unknown.

In contrast to the rapid rush of the Swifts is the quiet jerky flight of the Jackdaws as they pass from one part of the building to another; no mere summer tenants are these, but well-established residents, for they and their forbears have lived here continuously since the church was built in the centuries ago; and whenever we walk through the precincts, at whatever time or season, when the limes are scented and full of bees, or when their bare branches are seen against the grey, wintry sky, the one certain sound we hear is the sharp metallic "jack-jack" of the daws. There is a halo of romance about the Jackdaws, for they seem, more than other birds, to link the present to the past.

Every ruin has its own family of Jackdaws, who hand down the tradition of the place. On our approach to the old border castle, they fly out of the ivy-clad keep to meet us, and perform the same gyrations as their ancestors did in the old days when the drawbridge was lowered and the portcullis raised to admit the armed party home from a raid; and the Jackdaws which haunt the cloisters of the old abbey, and litter the nameless graves of abbot and friar with the superfluous rubbish of their nests, are of the same stock as those which were in possession when the now roofless aisles resounded with the rhythmic melody of chant and psalm, and when a bell, long since hushed, spoke in silvery accents from the belfry tower.

Some of the tenants of our buildings are much oftener heard than seen, but must not on that account be forgotten. When other birds are flying about, or basking in sunshine, the Owls are sitting in the darkest recess of belfry or barn waiting for the close of day, when they issue forth on soft, muffled wings to earn their livelihood. Of the four kinds of owls which breed in Britain, the White or Barn Owls are the most domestic; as their name denotes they are fond of a barn or out-building for their home, and wise is the farmer who encourages such useful birds to remain on his premises, or to occupy an "owl-tree" on his ground. The Tawny or Wood Owls will sometimes build their nest on a building, especially if it is well furnished with old, thick ivy, but they prefer the solitude of the dark woods, and a hollow tree or a rabbit burrow, for their nesting site.

Owls have suffered much persecution in the past, and in some districts have been nearly annihilated owing to the prejudice of certain game preservers, but happily now the tide has turned in their favour, for, under the Wild Birds' Protection Acts of 1880 and 1894, we find that every county in the United Kingdom has placed the Owls on the schedule for protection, and most of the counties preserve their eggs. Gamekeepers are hard to convince, but the key of the matter is in their own hands and is offered by the birds themselves in the undigested particles of their food disgorged and enclosed in pellets which are dropped in the vicinity of their haunts and are open to the inspection of all who seek them. Let the keepers, then, examine every pellet they find and honestly note down the result of their investigations and no adverse verdict need be feared; rats and mice, voles, small birds, and beetles will be found to be the principal food devoured by Owls. There are black sheep in every flock, and the Owls are no exception to this rule, and if one of them is caught in the act of carrying off a young chicken or a young pheasant let him be destroyed at once, but the crime of an individual should not be deemed a sufficient reason for condemning the whole race.

The birds which we have briefly considered are familiar to us all, for they are those which, having long lost their natural fear of man, take up their abode with us in full assurance of protection, which in the majority of cases is not withheld, and so they have become tame and confiding. Others there are which may be described as accidental tenants, birds of a wild and shy nature which, although found nesting in places which were once human habitations, do not take possession of these until man has long deserted them, and when ruin and decay have well-nigh obliterated their artificial character, rendering them, as far as the birds are concerned, indistinguishable from the natural rocks by which they are surrounded; thus the Wheatear finds a home in the heaps of stone which once supported the roof of a shepherd's cottage on the moor; Puffins breed in the honeycombed walls of the old prison on the Bass Rock, and in one of the islands of the Outer Hebrides there is a ruined village where Fork-Tailed Petrels are the sole inhabitants.

The Cormorant has been found nesting on an old tower, and Ospreys, normally tree nesters, are fond of a ruined castle near water, where they find a substantial foundation for their bulky nest. Many traditional places are pointed out in Scotland where this fine fishing eagle used to breed, but now, with the exception of a stray bird or two haunting them for a few days on migration, most of these old eyries know their former owners no more; two only at the present time are tenanted, and these are happily well protected by the proprietors of the estates on which they occur—Mr. Cameron of Lochiel, and Mr. J. P. Grant of Rothiemurchus—to both of whom has been awarded the silver medal of the Zoological Society of London, "in recognition of their efforts to protect the Osprey in their respective districts." The site of one is on a Scotch fir on an island at Achngarry, and the other at the island stronghold on Loch-an-Eilean. With regard to the latter haunt, so strict has been the supervision exercised by successive proprietors that, for more than twenty years, no boat has been allowed on the loch while the Ospreys are nesting, and no exception is made—the laird himself foregoing the pleasure of his boat in order to keep the birds quiet, and protect them from egg-stealers who, in former years, caused the birds to desert, and in recent times have done their best to frustrate the efforts of those who desire to preserve them.

In spite of these precautions an occasional break has occurred from time to time in occupation, owing to accidents or to fatal combats between the birds themselves, but it is hoped that they are now thoroughly re-established at the old island castle.

Their presence there adds a special charm to this romantic spot, and a visit in early summer time to the lovely loch which lies embosomed in the deep solitude of its wooded hills is made doubly attractive by the wild scream of the Osprey which is heard as she rises from her nest and flies in wide circles overhead. The island is within a hundred yards of the shore, and if we sit still under the fir trees which fringe the water's edge we can watch all the movements of these rare and beautiful birds within easy range of our glasses.

The great increase of the Jackdaws, which are co-tenants at the castle, is much to be regretted. They constantly mob the Ospreys when they leave or return to their nest, and if not reduced in numbers they may eventually, by this irritating conduct, drive the Ospreys away.

The Jackdaw belongs to a strong and increasing race, and, like the House Sparrow, is rude and overbearing in his manners; he is suspected of having contributed in no small degree to the almost total extinction of the Chough in Great Britain, and we must take care that another valuable bird is not lost to us by his means.

It is well that we should exercise a controlling influence over the feathered tenants of our buildings and regulate their numbers in proportion to their habits and powers of increase, in order that the weaker birds, which are often the most valuable, may be specially safe-guarded and preserved.

IV.—*On the Protection of Wild Birds in Perthshire.*

By Col. CAMPBELL.

(Read 10th November, 1898.)

It is not twenty years since this country became alive to the necessity for something being done in the way of legislation for the protection of wild birds, and in 1880 the first decided step was taken. There had been legislation of a kind before—which, however, was found to be unworkable in practice,—and an Act was passed in that year, which, along with subsequent ones, may, it is hoped, be the means of preserving to us many of the rare and interesting birds whose extinction was threatened, if not actually consummated. I say consummated advisedly, for have we not an instance in the Capercaillie of a bird formerly a native of the Highlands of Scotland which, in the last century, was ruthlessly exterminated, but which, owing to its reintroduction by the Marquis of Breadalbane in 1837, and through being carefully preserved, has again become common, and is gradually extending its range all over Scotland.

Previous to 1880, owing to the increase of the population, the breeding areas of our wild birds were slowly but surely, being curtailed; the wide plains of Wiltshire and Dorsetshire, where, in former years, the Great Bustard roamed in comparative security, were being reclaimed or built upon; and the immense fen lands of Lincoln, Norfolk, and Cambridge, where the Ruff, the Avocet, the Great Grebe, and other wading and aquatic birds found a home, were being gradually drained and turned into arable land. Added to these causes was the fact, that, with the increase of the population, there came also a proportional increase of men who took a special interest in ornithology, and who evinced their interest by striving to procure, in every way possible, specimens and eggs of all our rarer birds.

As an instance of the extent to which this enthusiasm was carried, I may mention rather an amusing anecdote told me by a well-known ornithologist. He and another exterminator employed a man to watch a pair of Kentish Plovers (now, I am sorry to say, a very rare species), and to wire to them in London when the eggs were laid, so that they might have the satisfaction of going down and taking the nest for themselves. He got the wire and went to tell his friend, but found to his disgust that the latter had also had a wire, and had forestalled him by taking the first train to the Romney Marshes! I make no comment on the above incident; but it became very evident that the wholesale destruction of our rarer wild birds and their eggs would eventually lead to their extermination, and consequently the following acts for their protection have been passed. The Act for the Protection of Wild Birds, passed in 1880, repealed "An Act for the Protection of Wild Birds," "An Act for the Protection of Certain Wild Birds during the Breeding Season," and "An Act for the Preservation of Wild Fowl," which, though in the Statute Book, appear to have been honoured more in the breach than in the observance. The Act of 1880 is a short, but, in some respects, an amusing document. Section II. defines the words "Wild Birds" as "All Wild Birds" which, I need not say, would have been a satisfactory though somewhat big order; but this is qualified by a schedule specifying the birds to be protected, and this schedule certainly does not include "All Wild Birds." The first on the list, the American Quail, is, as its name implies, not a British species, but a comparatively recent importation from across the Atlantic. The second on the list is the Auk. I do not know whether the compiler of this schedule had the Great or Little Auk in his mind's eye, but neither of these birds could by any possibility come within the scope of the act, as the latter is a comparatively rare visitor from the far north which appears erratically in severe winters, and disappears before the 1st of March; whilst, as most folks know, the Great Auk is extinct, and has not been seen in the flesh for the last fifty or sixty years. I find that there are 85 birds named in the schedule, but the same bird appears under different names; thus the Night Jar is named four times under different aliases, the Guillemot and Puffin have two, and a considerable number have one. I can quite understand the necessity of putting in this schedule the local designations of the birds intended to be protected, but whilst they were about it, all, or at least as many local names as possible, should have been given. For instance, the Eider is known along the east coast of Scotland from Orkney to Northumberland as the "Dunter Duck," and what Scottish ploughman would comprehend the word "Lapwing" or its other English alias "Peewit?"

I have indeed heard of an erudite statesman who did not understand what a "Peewit" was. Had it been called by its Scotch designation, a "Peese Weep," he would doubtless have known what was meant. Of course, it must be admitted that the simple words "Owl," "Tern," "Wild Duck," etc., may be meant to cover many different species; but perhaps it would have been better had the species, which it was intended to protect, been named. For instance, the word "Gull" takes in fourteen species; and, whilst there are gulls which are harmless, there are likewise gulls which are mischievous, gulls which are rare, and which should be protected, and gulls which are common and which do not require it.

One of the provisions of the Act of 1880 was the naming of a close time, from the 1st of March to the 1st of August, during which period the birds named in the schedule could not be taken alive or killed, but no provision was made for protecting their eggs. The Act of 1880 was amended to a very slight extent in 1881, the Lark, you will be glad to hear, being added to the scheduled list.

The next legislation on the subject was in 1894, when an Act was passed amending the Acts of 1880-81. The chief alterations were the giving power to a Secretary of State,—in Scotland the Scottish Secretary,—"on application being made by a County Council," (1st) to prohibit the taking or destroying the eggs of Wild Birds in the county or any part of it, and (2nd) making the Act apply to any species of Wild Bird *not* included in the schedule of the Act of 1880. The most important provisions of this Act were (1st) the placing of the responsibility for protecting Wild Birds in the hands of the County Council, and (2nd) the clause relating to the taking or destroying their eggs.

Then in 1896 an Act was passed extending the powers given to the Secretary of State, so as to enable him to issue an order "Prohibiting, for special reasons mentioned in the application,"—the application being of course that of the County Council,—"*the taking or killing of any particular kinds of Wild Birds during the whole or any part of the period of the year* to which the protection of Wild Birds under that Act does not extend," or "the taking or killing of *all* Wild Birds in *particular places* during the whole or any part of that period." This was a very important amendment, for, as already stated in the Act of 1880, the close time was to be from 1st March to 1st August, whereas by this Act the protection may be extended over the whole year, and may be made operative in particular places.

I have given you as succinctly as possible a resumé of the Acts for the protection of Wild Birds, and will now proceed to explain their operation so far as it has gone, and the benefit which it is hoped may accrue from their application in the future.

You may remember that at a meeting of our Society, held on 8th

April, 1897, we drew up a report on the subject and petitioned the County Council to apply to the Secretary for Scotland for an order for the protection of certain birds, and I think we are much indebted to that body for the promptitude with which they acceded to our request, and for the trouble and expense to which they were put in carrying out our wishes. The result was that Lord Balfour of Burleigh issued an order on 9th December, 1897, protecting the following birds, and this order, being for one year only, remained in force to the end of last year.

The order was to this effect:—(1) The taking or destroying the eggs of the following species of Wild Birds is prohibited throughout the entire County of Perth during the currency of this order, viz., Black-throated Diver (*Colymbus arcticus*); Dotterel (*Eudromias morinellus*); Dunlin (*Tringa alpina*); Eider Duck (*Somateria molissima*); Goldfinch (*Carduelis elegans*); Goosander (*Mergus merganser*); Great-Crested Grebe (*Podiceps cristatus*); Golden Plover (*Charadrius pluvialis*); Golden Eagle (*Aquila chrysaëtus*); Kingfisher (*Alcedo ispida*); Kite (*Milvus ictinus*); Owl, Barn (*Strix flammea*); Owl, Long-Eared (*Asio otus*); Owl, Short-Eared (*Asio accipitrinus*); Owl, Tawny (*Syrnium aluco*); Osprey (*Pandion haliaëtus*); Pochard (*Fuligula ferina*); Red-Breasted Merganser (*Mergus serrator*); Sheldrake (*Tadorna cornuta*); Shoveller (*Spatula clypeata*); Snipe, Common (*Scolopax cœlestis*); Stock-Dove (*Columba œnas*); Teal, Common (*Querquedula crecca*); Tufted Duck (*Fuligula cristata*); Tern, Common (*Sterna fluviatilis*); Widgeon (*Mareca penelope*); Wild Duck (*Anas boschas*); Woodcock (*Scolopax rusticola*); Bullfinch (*Pyrrhula europæa*); Linnet (*Linota cannabina*); Siskin (*Chrysomitris spinus*).

(2) The taking or destroying the eggs of the Lapwing (*Vannellus cristatus*) is prohibited throughout the entire County of Perth after the 15th day of April in each year during the currency of the order.

(3) The "Wild Birds Protection Act, 1880," shall apply within the County of Perth during the currency of this order to the following species of Wild Birds, as if they had been included in the Schedule to the said Act, viz., Bullfinch (*Pyrrhula europæa*), Golden Eagle (*Aquila chrysaëtus*), Linnet (*Linota cannabina*), Kite (*Milvus ictinus*), Osprey (*Pandion haliaëtus*), Siskin (*Chrysomitris spinus*).

Last year Lord Balfour of Burleigh took as it were the bull by the horns, and, instead of waiting for applications from the County Councils, drew up a comprehensive scheme for the protection of Wild Birds in this country, and asked the County Councils to apply to His Lordship as Secretary for Scotland to put it in force. For this purpose, Scotland was divided into two parts—Northern and Southern. The Southern division had for its Northern limit the Counties of

Fife, Kinross, Clackmannan, Stirling, and Dumbarton; and the Northern division was bounded to the South by Forfar, Perth, and Argyllshire. There were also three lists of different birds compiled, one for the Northern division, one for the Southern, and one applicable to the whole of Scotland. These proposals were submitted to the different County Councils throughout Scotland. I understand that, with one or two exceptions, all the Counties of Scotland have fallen in with the scheme and have applied for the birds named in the schedules applicable to their division to be protected. I gather, however, from some correspondence which has appeared in the *Dundee Advertiser*, that our neighbour Forfarshire has not accepted the scheme, at least so far as some of the birds are concerned. This is most unfortunate, as it will lead to birds which we in Perthshire are anxious to see protected being shot or trapped if unwittingly they cross the march and trespass in the neighbouring county. A Perthshire Golden Eagle becomes a Forfarshire bird directly he goes over the border, and may then be killed with impunity. This is virtually a loss to the county, which does not wish one of its rarest and most beautiful birds to be exterminated.

It is to be hoped that, when the question of bird preservation comes to be reconsidered, better counsels may prevail and that the whole of Scotland will be unanimously in favour of the protection of those birds which, without such protection, will inevitably become extinct. When these proposals came out Mr. M'Leish kindly sent me a copy and asked me to report upon it. On going over it, I saw that the following species, viz., the Dunlin, Golden Plover, Goosander, Merganser, Linnet, Siskin, and Stock Dove, which were included in the list of birds to be protected last year, did not appear in the proposed scheme, either in the list applicable to the whole of Scotland or in that for the Northern Division, which includes Perthshire; and I considered it my duty to draw attention to the fact. I have no doubt that there was a good reason for their exclusion, though I myself cannot understand why birds which it was thought necessary to protect in 1898 should be left out in the cold in 1899. The Perthshire County Council would not in 1897 have made application for those birds to be protected, had there not been good grounds for their doing so. The Dunlin and Golden Plover are much rarer birds than the Lapwing, whose eggs, I am glad to say, are to be protected after the 15th April. The Goosander and Merganser breed in the county when they are allowed to do so, which, owing to the depredations of egg collectors, is, I am sorry to say, not often the case. The Stock Dove, which first appeared in this district of Scotland more than ten years ago, is still an uncommon species, very local in its distribution; and the Siskin, which breeds in the county, though now included in the protection order for the Southern Division of Scotland, may, since the first of this month be taken in Perthshire by any bird catcher with a call-bird and a bunch of limed twigs.

Whilst I thought it right to point out these facts, our Society felt that, rather than have the scheme wrecked by attempting to have it revised and those birds if possible introduced, it would be preferable to accept it in its entirety. I trust, however, that a note may be made of these birds with the view to their being included in any future scheme, and that when this is done they may again find a sanctuary in the County of Perth.

The two greatest enemies bird protectors have to contend with are egg collectors and bird catchers.

I have no scruples of conscience in taking a nest required for our museum, in which we wish to have a complete collection of the Fauna of Perthshire, but I do object most strongly when anyone, for his own selfish ends, makes a clean sweep of as many clutches of eggs as he can lay his hands on. I know of one individual who, for three years in succession, took the eggs from a Golden Eagle's eyrie, and he would have gone on if the proprietor had not caused the nest to be destroyed before the eggs were laid, and thus induced the birds to forsake the site and betake themselves to a more inaccessible cliff. Tentsmuir in Fife was, and I hope will be again, a perfect paradise for birds, but the depredations of egg collectors and of the salmon fishers who live close to the shore have played sad havoc amongst the birds and greatly reduced their numbers. The country is very open and yet so broken up by sand hills that it is almost impossible to protect it, notwithstanding the efforts made by Mr. Mackenzie, the proprietor, who has done his utmost to put a stop to this nefarious practice. A few years ago, I caught three urchins who had their handkerchiefs full of the eggs of Terns, Ring Plovers, and other birds, and I understand there is a ready sale for these eggs in St. Andrews. Last summer I met a St. Andrews' student who told me all about a well-known professional egg stealer. This man regularly watches the rabbit holes where the Sheldrakes breed till he sees the birds going in, then marks the holes with stakes, and when the eggs are laid digs them out.

Then these birds have, I understand, to pay a heavy tax to the salmon fishermen. I have been told that for a month or six weeks they have been in the habit of living on wild birds' eggs. Can it be wondered at that the number of breeding birds on Tentsmuir has diminished? Whole tracts of ground which used to be covered with Terns' nests are now deserted. Ten years ago I found five Eiders' nests in one day. Last year when I went over the same ground I did not find one. Then professional bird catchers do incalculable mischief among our smaller birds. A few years ago, the

Bullfinch was quite common on Kinnoull Hill and Kinfauns: now I hardly ever see it. One day I met a bird catcher on Perth Bridge and asked him where he was going, whereupon he said he was going all the way to St. Martins, as it was not worth his while now to try to catch Bullfinches on the Hill. I know this bird is still common enough in some districts, and I myself would not object to a gardener shooting an odd Bullfinch which was destroying his fruit buds; but the wholesale catching of them, and thus denuding our woods of one of our most beautiful birds, is most reprehensible, and, I trust, that, with regard to this class of poaching, the Secretary for Scotland's order may be rigorously enforced.

We all know that the Skylark, in spite of being scheduled in 1881, has steadily diminished in numbers during the last ten years. It is common enough in winter, but the birds we see then are, for the most part, foreigners—migrants which come over in flocks from the Continent, and leave again in the spring. Many theories have been propounded to account for this diminution in the numbers of our breeding birds, but I am confident that bird-catchers have a good deal to do with it. The Skylark is much appreciated as a cage bird, and is more easily caught than almost any other bird.

Our chief object with regard to bird protection should, I think, be to awaken an interest—not an exterminating but a preserving one—amongst all classes who in their daily life have opportunities of seeing and watching the habits and instincts of our wild birds. There are, we all know, men in this county who are keen and ardent naturalists, and we have also a Museum in our midst which, as Sir William Flower said when he opened it, was "second to no local museum in the country." We may well be proud of our Museum; and, whilst we owe a deep debt of gratitude to those who came to the front when money was required for building and enlarging it, we are also specially indebted to many of the landowners in Perthshire for the generous way in which they have contributed, by sending specimens of the fauna of the county to enrich the cases in our rooms.

I feel sure that, as so many proprietors take a warm and intelligent interest in the ornithology of Perthshire, they will also do what lies in their power to carry out the Secretary for Scotland's order. If influence is brought to bear on foresters, gamekeepers, gardeners, shepherds, etc., I am confident that those who, frequently through ignorance, break the law will in future respect it. If the Society approve, I would suggest that you should send a letter to proprietors and others who are interested, asking them to use their influence towards the enforcement of the order, together with a copy of it.

There is also another class whom I think we should endeavour to enlist in our cause. I allude to professional naturalists.

The issuing of orders for the protection of Wild Birds and their eggs will be practically inoperative if these birds can be regularly killed and sent in to bird-stuffers to be preserved. I have spoken to two of the leading bird-stuffers in Scotland, and they quite agree with my views. If a stop could be put to the stuffing of scheduled birds, it would, I am sure, to a great extent do away with the incentive to shoot them. With regard to eggs, every one knows that a properly authenticated British specimen of an eagle's or other rare bird's egg fetches a much higher price in the market than a foreign one, so I think we may well ask what is the benefit of expending money, time, and trouble in passing laws for protecting Wild Birds and their eggs, if these laws are openly and flagrantly violated.

In conclusion, I think we, as members of a Society which takes considerable interest in this subject, owe much to Lord Balfour for having dealt with a most difficult question in so able and practical a manner, and I am sure we all hope that the efforts now made for the protection of Wild Birds may meet with that success which they undoubtedly deserve, not only in Perthshire, but through the length and breadth of Scotland.

V.—*A Naturalist's Notes on the recent Voyage of the "Blencathra" to the Arctic Regions.*

By William S. Bruce, F.R.S.G.S.

(Read 9th February, 1899.)

On the 1st of May last year Mr. Andrew Coats of Paisley set sail with his yacht "Blencathra" for the Arctic Seas. He had previously sailed in various parts of the world, but was now for the first time going to the Arctic Seas. He asked me to accompany him in order that I might make such observations and collections as would be interesting to science. Very gladly accepting his offer, I forthwith began to make all the necessary preparations for such a voyage. Mr. Coats was good enough to provide me with an excellent outfit. Among other articles, I procured a 10-ft. beam trawl of the ordinary pattern, but specially weighted on the foot, so as to be more sure of it falling right side up in greater depths. This it never failed to do in depths up to 140 fathoms. I had besides this a trawl patterned after that which was used on board the U.S. ship "Blake" during her memorable cruises from 1877 to 1880.

This latter is a double-headed trawl, the advantage of which is that whatever way it falls it always falls right side up. It is the same pattern as that used by His Serene Highness the Prince of Monaco, with whom I afterwards sailed to Spitzbergen and the Greenland Seas in his yacht the "Princesse Alice." This must be regarded rather as a dredge than a trawl, for the foot ropes are taut, and I have actually torn up rocks *in situ* from the bottom, and have brought up great boulders from 100 fathoms fully two hundredweight in weight. One day it brought up nearly two tons of rock, and so great was the strain on the mizen boom from which the trawl was hanging that we feared any moment something might give. On coming to the surface it was necessary to get over the ship's side, rip up the net, and lift the stones out one by one. I wish now I had kept the largest, which took five of us to lift out, in order that you might have seen it to-night. In spite of the mass of rocks, the haul was a very rich one, and most of the material was intact, for a very large rock had filled the mouth of the funnel, and had thus saved the specimens at the *cod-end* from being utterly crushed. There were three dredges, a very small one and a larger one, both of the parallel sided pattern, and a triangular one. Five hundred and sixty fathoms of flexible steel wire, $1\frac{1}{4}$ inch in circumference, was also an important item for the working of the trawls, in addition to a reel for holding the same.

The "Blencathra's" steam winch, which was to haul in the trawl, is forward of the foremast, so we had the reel placed close to it; from this the wire rope was passed aft by a series of blocks, so that the trawl was lowered away astern from the mizen boom.

In addition I had made three traps, two small and one larger, as I had found this method of fishing invaluable when I was in Franz Josef Land in 1896 and 1897. In these I was disappointed during the cruise of the "Blencathra," the reason being undoubtedly that their frames were this time made of metal instead of wood. While I was in Franz Josef Land I resolved to make some traps, knowing what success the Prince of Monaco had had by using them in his Mediterranean and Atlantic cruises. Of necessity I had to make them of wooden frames, and weighted them with stones to make them sink. Wishing to have them less cumbersome this time, I had galvanized iron frames made, of sufficient weight to allow them to sink without adding stones; the frames also were thus less conspicuous. But, alas! this time my catches were very small. Later on I mentioned my experience to the Prince, and he told me that the first traps he used were made of metal and his catches were small; but during one cruise he had lost all his metal traps, and was forced to make one with a wooden frame instead. His catch on

Plate I.—The Yacht "Blencathra" in the Ice of Barents Sea.

this and other occasions was so very much richer than previously, that since then he has used traps with wooden frames, and has always had successful catches.

Another important part of the outfit was a sounding machine. There was already a reel sounding machine for sounding in depths up to 100 fathoms, with a Kelvin Depth Recorder, but this possibly would not be enough for the soundings which we were about to take. We had therefore to seek for a sounding machine for sounding in greater depths, and eventually chose the Lucas sounding machine, capable of sounding in depths down to 4000 fathoms. Two coils of wire, each of 2500 fathoms, and the necessary sounding weights, tubes, etc., completed this outfit. Three deep-sea reversing thermometers, Mill's deep-sea water bottle, Buchanan's hydrometer, and the ordinary ship's meteorological outfit were taken. Besides these, plenty of bottles, jars, and tubes, methylated spirit, formalin, etc., for biological work.

As the deep-sea sounding machine had not arrived on the 1st of May, I did not sail with the yacht, but waited for a week, and then took the mail steamer from Newcastle to Bergen, and after a slow but enjoyable trip through the fjords, where we called at over sixty places, I met the "Blencathra" at the end of May in Tromsö. There were on board Messrs. Andrew Coats, James Glen, Andrew Arthur, Hugh Parry, Dr. Cockburn, and myself. Two days before I arrived, Tromsö neighbourhood was white with a fresh fall of snow, and those who were now steering to still higher northern latitudes for the first time began to wonder what terrors of cold they were about to face. Special suspicion fell upon myself, for, before leaving, I had pointed out the geniality of an Arctic summer, how plants in full bloom made brilliant displays of colour, and how one could often lie out on some rock and bask in the warm sun. On the other hand, I had taken with me an extremely warm Russian sledging coat of reindeer skin. Why was I taking that coat if we were to enjoy summer weather? It was certainly suspicious, but perhaps we might, through some unforeseen accident, have had to spend a winter as well as a summer, then the coat would have been extremely useful. It is always well to be on the safe side. A hundred summer cruises may be made to the Arctic, and from ninety-nine a return will be made the same season, but the hundredth season comes, you are caught, and it is well for you if you have plenty of provisions, fuel, and warm clothing on board. In view of this happening, Mr. Coats took with him an extra year's provisions, besides furs, so that even if the vessel had been wrecked, or frozen in, we should have spent quite a comfortable winter.

On the second day after my arrival we left Tromsö for the north, calling at Hammerfest and Haaningsvaag, from which latter place, according to Dr. Sneider of Tromsö Museum, I have been the first to collect a number of Coleoptera. Aker Fjord was next visited in order to see a typical example of the wonderful Bird-Bergs of Norway, so vividly described by Brehm, Faber, and others. Kittiwake gulls, herring gulls, puffins, common guillemots, and razor-bills were there to be seen in thousands, reminding me of the still more remarkable cliff at Cape Flora, Franz Josef Land, where myriads of Kittiwakes, Bruennich's guillemots, little auks, and dovekies resided during the summer months. Thereafter we steered for Nova Zembla, and on the 30th of May, at 8 p.m., we saw the ice blink. At 11 o'clock we sighted the "first ice," and in half-an-hour the vessel came up to it. At midnight we were steaming through loose brash ice. The temperature of the air was 29·1 deg. F., that of the surface of the sea 31·1 deg. F. There was a light breeze from the eastward and the typically overcast sky of the Barents Sea. Our course was E. ½ N. during that night, and we continued to work through a considerable amount of ice. At 10 a.m. next day we sounded in 100 fathoms with no bottom. Up to this day, and for some days after, I was busy getting everything in order for observations of various kinds. On previous occasions I found the type of book used for taking observations, which is supplied by the British Meteorological Office, cumbersome, and not well suited for ship work. I therefore resolved to try a form of slip, modelled after that used by the Scottish Meteorological Society at Ben Nevis Observatory, with alterations necessary for observations taken on board ship instead of on *terra firma*. This I found entirely satisfactory. Throughout the voyage I took meteorological and general observations every four hours, the first mate usually assisting me with those at 4 and 8 a.m. On this 31st day of May I took my first surface tow-netting. I dragged the net from 6.30 till 7.30 p.m., and procured a green slimy mass composed of diatoms and nauplii, besides other material. In order to be able to use the tow-net at all times without fear of collecting material thrown overboard, Mr. Coats had a boom rigged out for me from the fore-rigging, from the end of which the net dragged about midships. Among other birds, we saw ivory gulls to-day. Surely these interesting birds must have some breeding place nearer than Cape Mary Harmsworth or Wiche Islands.[1] I will not be surprised if they are found to breed in Nova Zembla or Kolguev, or both. Besides the ivory gulls, other birds were noted and some seals. At midnight I threw

[1] I call these islands by the names given to them by their discoverer, the British voyager Edge, in 1617, and not by that given them after the voyage of Von Henglin and Graf Zeil in 1870—viz., King Charles Islands, in honour of the King of "Würtemberg,"—or by Professor Mohu, after Charles XV., King of Sweden and Norway.

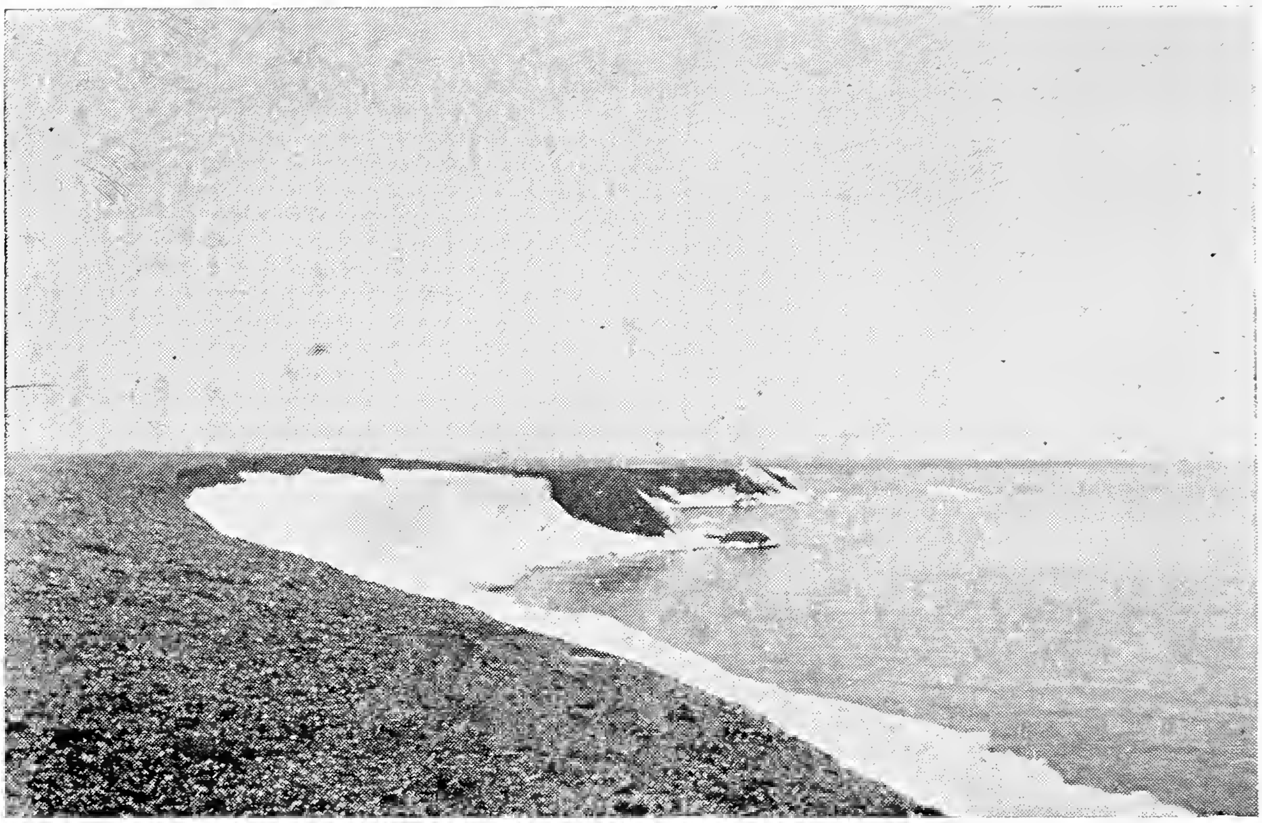


Plate 2.—Cape Cherni, Novaya Zemlya, Lat. 70 deg. 50 min. N., Long. 53 deg. 26 min. E.

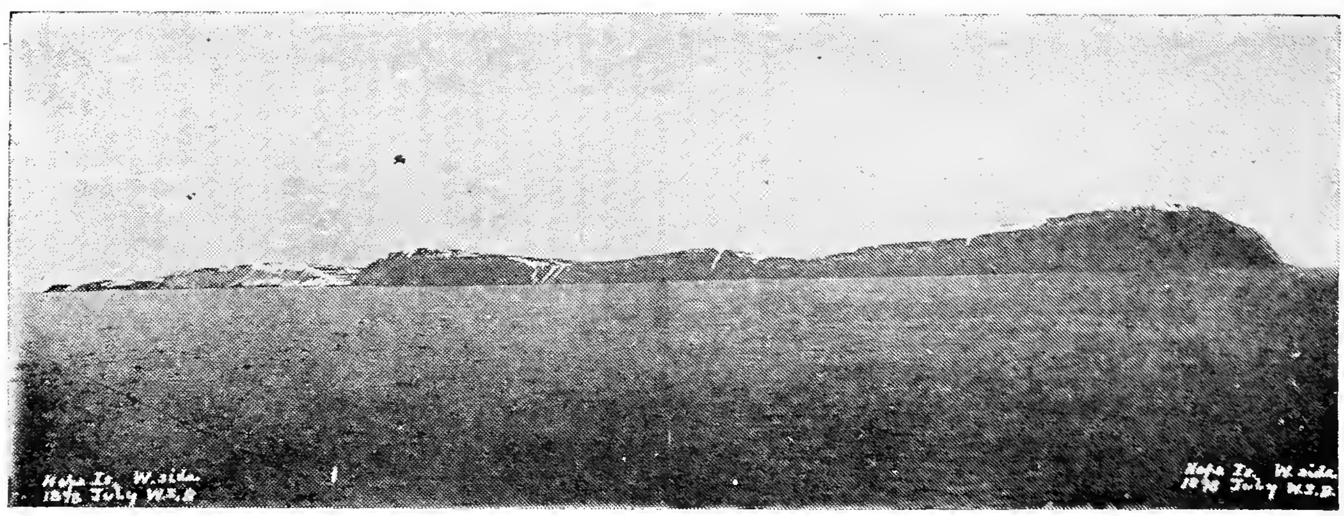


Plate 3.—The whole West Coast of Hope Island, Length about 13 miles, Height over 1000 feet.

over the first of a series of floats to indicate the direction and rate of currents. During 1896 and 1897 I also threw over a number of floats in the Barents Sea; none of these have yet been recovered. Soon after noon on the 1st of June the Captain reported seeing the coast of Nova Zembla from the masthead, viz., Razor Cape, 45 miles E. ½ N. But the ice was very tightly packed between us and the land. We had therefore to turn the ship's head southward along the edge of the tight ice, working our way in a zig-zag course among outer, looser pieces. At 11 p.m. we passed a walrus sloop which, like ourselves, was trying its best to get in to the land. A gale sprang up in the night which helped to break up the ice, and next morning we had a visit from the captain of the walrus sloop; he told us he had been out twelve days from Tromsö, that he had reached 73 deg. N. (which must have been much further to the westward than our present position), and had on board six bears, six seals, and a walrus. At 10 a.m. next day we were 35 miles off the land, and at 6 p.m. 42 miles off, in the vicinity of North Goose Cape. Many birds were passing in flocks to the north-eastward. By the 3rd of June, the Lucas deep-sea sounding machine was rigged up with its 2500 fathoms of wire, and at 8 p.m. we took our first sounding with it in 75 fathoms. Afterwards we had the trawl over for the first time. It was the small, double-headed trawl, modelled after that used by Agassiz on the "Blake." The catch was rich, including cœlenterates, echinoderms, crustaceans, molluscs, fishes, etc. No chance offering itself to get into the land during the next few days, we steered for Kolguev, and sighted it at 9.30 a.m. On June 7th, we "lay-to" six miles off the land, which was stretching between SSE. and WSW., and here the lead touched bottom in 20 fathoms on sand; there was a heavy swell running from the westward. There was no tight ice here, only a few pieces, with a great number of walruses. There were none of the "endless fields of pack-ice" which Colonel Fielden described for 1897 as late as the 5th of July, extending from Kolguev to Novaya Zemlya, nor was there any ice "resting on the north end of Kolguev." The whole coast of Kolguev was free of ice except those few loose pieces on the north coast which I have already mentioned. Here the sportsmen obtained a few very fine walruses, and I was able to make a number of biological and physical observations. All day long we saw plenty of ivory gulls, and this may be regarded as the first record of ivory gulls for Kolguev; indeed, I have little doubt that they will be found breeding there. On the 8th, 9th, and 10th we had bad weather and "lay to" before a strong gale from the NNW.; the ship rolled very heavily and I was in great distress, for, in spite of carefully stowing all my gear, it had got adrift in the forecabin, and spirit, formalin, and all kinds of precious things were mixed up together. This gale drove us far to the SSE., and it was not till noon on the 10th that we sighted the land. At midnight on the 10th we anchored in five fathoms about three miles off the land near the River Baroskikka, in the south-east of the island. The gale had now blown away altogether what little free ice there was, leaving only a few stranded pieces on the long stretch of sandy shore. I had traps lowered here as on several previous occasions, but caught nothing. This was undoubtedly due to having their framework made of iron instead of wood. On June 12th, we landed, but in rather an unfortunate place. Before us lay a long stretch of four or five miles of wet sand and lanes of water, with great masses of stranded pack ice. We could not have got across this and back again in anything like reasonable time, and we were not prepared to wait here, it might be, for several days, so we wandered about the wet sand and over the stranded ice for several hours. Several birds were shot, and Mr. Parry found a glaucous gull's nest with two eggs. There were several other nests of the same bird on the sand where it was raised slightly above the rest. I remained mostly at the sea edge and obtained a number of entomostraca, molluscs, and other things of zoological interest. Mr. Coats now resolved to attempt a landing on the north or west coast of the island, but again the wind freshened after we got round, and prevented us effecting another landing; eventually all thoughts of landing had to be abandoned, and, having circumnavigated the island, we steered a course for Novaya Zemlya. We passed through some drift ice in the early morning of the 16th, but at 3.30 p.m. the coast of Novaya Zemlya was sighted with no ice in view. We steamed north-westward along the coast, and at midnight had a fine haul with the trawl. We steamed along the coast without seeing a piece of ice. How different from the fields of ice which blocked our way just ten days ago! We went a little beyond South Goose Cape and then the ice stopped us once more; it was stretching right across our bows in a solid mass, so we turned and anchored at the south end of Kostin Shar, off Kostin Point, in ten fathoms. On June 19th, we landed at Cape Kostin; perhaps the point of greatest interest was obtaining the grey phalarope (*Phalaropus fulicarius*, Lin.), Mr. Reid and I each shooting one. This is a new record for the avifauna of Novaya Zemlya. Little stints (*Tringa minuta*, Leisler) were numerous, and we saw many of their nests, but it was too early for their eggs. There were also snow buntings, eiders and king eiders, swans, and divers. A solid floe was stretching across the Shar to the mainland, and every here and there were to be seen seals basking themselves in the sun beside their holes. On June 20th, there was a fresh breeze blowing and a heavy fall of snow lay upon the decks. Next day, midsummer day, however, it was fine, calm, sunny weather, and

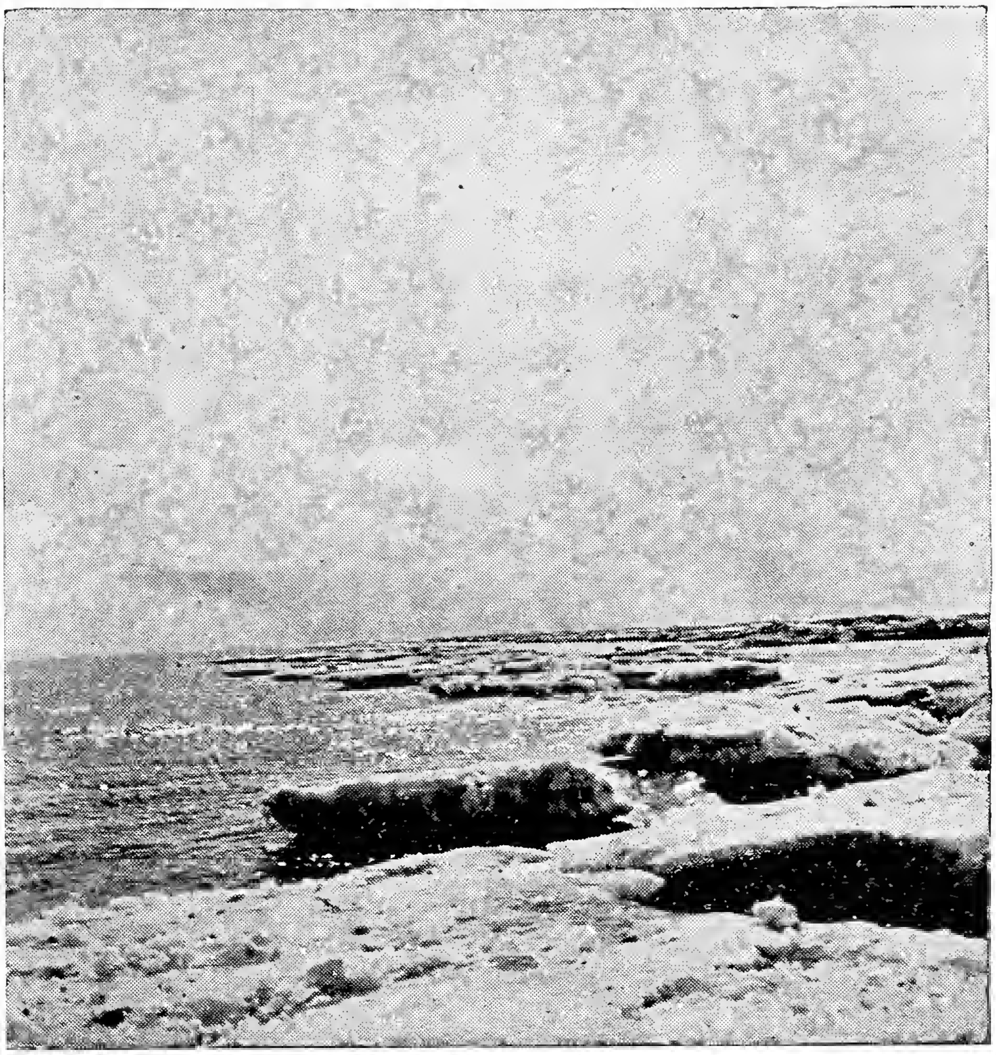


Plate 4.—S.W. Coast of Kolguev, near River Baroskikka.

everyone went ashore at Cape Cherni and good collections were made. Here we met two Russians from the Petchora district; they had been wintering and looked wretched specimens of humanity. More coal, fresh water, and provisions were now required, so we steered for Vardö. The breeze freshened, and on the morning of June 25th we ran into Vardö harbour before a strong gale of wind from the north.

It was well that we were in port, for the gale that had sprung up blew with great violence for more than thirty-six hours. Nearly a thousand craft were crowded into the harbour, and it was with difficulty that many held to their moorings. We remained in Vardö for a week, and during this time visited the mainland, as well as the neighbouring islands of Hornö and Renö, which are noted as breeding places of the eider-duck. These birds nest there in thousands, and one almost steps on them before they will reveal themselves by flying away. In addition to eider-ducks, there are a number of glaucous gulls (*L. glaucus*, O. Fabr.), and great black-backed gulls (*L. marinus*, Lin.), besides hosts of kittiwakes (*Rissa tridactyla*, Lin.) on the more precipitous rocks. There are puffins, razor-bills, cormorants, black and common guillemots as well. The herbage is remarkably rich, *Cornus suecica*, a pink lychnis, scurvy grass, and ferns being the most conspicuous. On Vardö Mr. Parry found three nests of the ringed plover (*Ægialitis hiaticola*, Lin.), and I found on the mainland a nest and eggs of Temminck's stint. At all these places I secured several species of insects, which will be described by Mr. Percy Grimshaw at a later date.

At length, on the 1st of July, we set sail once more for the ice. Our course lay in a more or less north-westerly direction towards Bear Island. Nordkyn, some fifty miles from Vardö, was abreast of us at six o'clock next morning, and at five o'clock on the afternoon of the 3rd we sighted Mount Misery, the highest hill in Bear Island (1758 feet), bearing W. by N., from the "Blencathra." We steamed round the north side of the island, and just before midnight dropped anchor in 14 fathoms on the west side. We lay there for the night, Mr. Coats intending to land the following day. Captain M'Kay, however, not finding the anchorage very suitable, moved round to the south, but as he found nothing in the way of a harbour, and feared a breeze, landing had to be abandoned; so, after circumnavigating the island, we turned our course to the more interesting and less known Hope Island. On the homeward voyage of Mr. Harmsworth's yacht, the "Windward," with the Jackson-Harmsworth Expedition, we had intended to land at Bear Island, but had failed on account of head winds; thus for a second time I was disappointed within twelve months. We had now gone 47 miles to the north-eastward when we were signalled by a very small Norwegian steamer.

Mr. Coats told the Captain to head towards her. She wanted to know her position; for more than a week she had been continually in fog—a not unknown occurrence in the Barents Sea,—and had quite lost her reckoning. We were soon able to give her the information she required, and each vessel went on its course, she to the southward, and we towards Hope Island. While yet as far as 44 miles from Hope Island, we sighted the land. Ice was now reported from the masthead, but it turned out to be a false alarm. At 4.30 p.m. we took a sounding in only 38 fathoms, with a bottom of small stones, on the bank that stretches the whole way between Bear Island and Hope Island, and which in some places is only 20 fathoms below the surface. Gradually we approached the island, and both Mr. Coats and myself had the good fortune to get very fair photographs of the south end, with its precipitous cliff slightly over 1000 feet. We steered round to the west side, where I got other two photographs of its entire west coast. Capt. M'Kay dropped anchor six miles off in 15 fathoms. At 11 p.m. Mr. Coats ordered the steam launch to be lowered, and taking also with us the small Norwegian seal hunting boat we steamed for the shore. There was a heavy swell running at the time, but the boat was let go from the launch, and Mr. Reid, myself, and two Norwegian sailors pulled fairly close in when our keel bumped on the bottom, but next minute we could not touch bottom with the oar. After spending nearly an hour we had to abandon the attempt, as landing meant certain immersion in the ice-cold water, and probable upsetting of the boat, with guns, ammunition, etc., as well as the probability of having to stay on shore for some days without provisions or dry clothing. There was nothing else to be done but to turn back again once more to the ship. Next day, before steering to the north-eastward, we had another haul of the trawl in 27 fathoms. Unfortunately the tail of the net fouled over the mouth of the trawl, and we got very little, although from the amount and variety that did come up I could see that the bottom was very rich in animal life. This was proved later on by a very rich haul which the Prince of Monaco obtained close by.

Mr. Coats now headed the "Blencathra" for the Wiche Islands, but, after steering in a more or less north-easterly direction we were stopped by ice which stretched across our bows, in 77 deg. 38 min. N., 28 deg. 46 min. E.: this was at four a.m., on July 7th. To reach Wiche Islands was now quite out of the question, Mr. Coats, therefore, spent a week in cruising right across the Barents Sea almost to Novya Zemlya along the ice edge, and thus mapped out the limit of the pack ice for the middle of July. Thick fog prevailed the whole time, but probably the opening towards Franz Joseph Land was in 40 deg. 15 min. E., where there was a bight in the ice stretching to 77 deg.

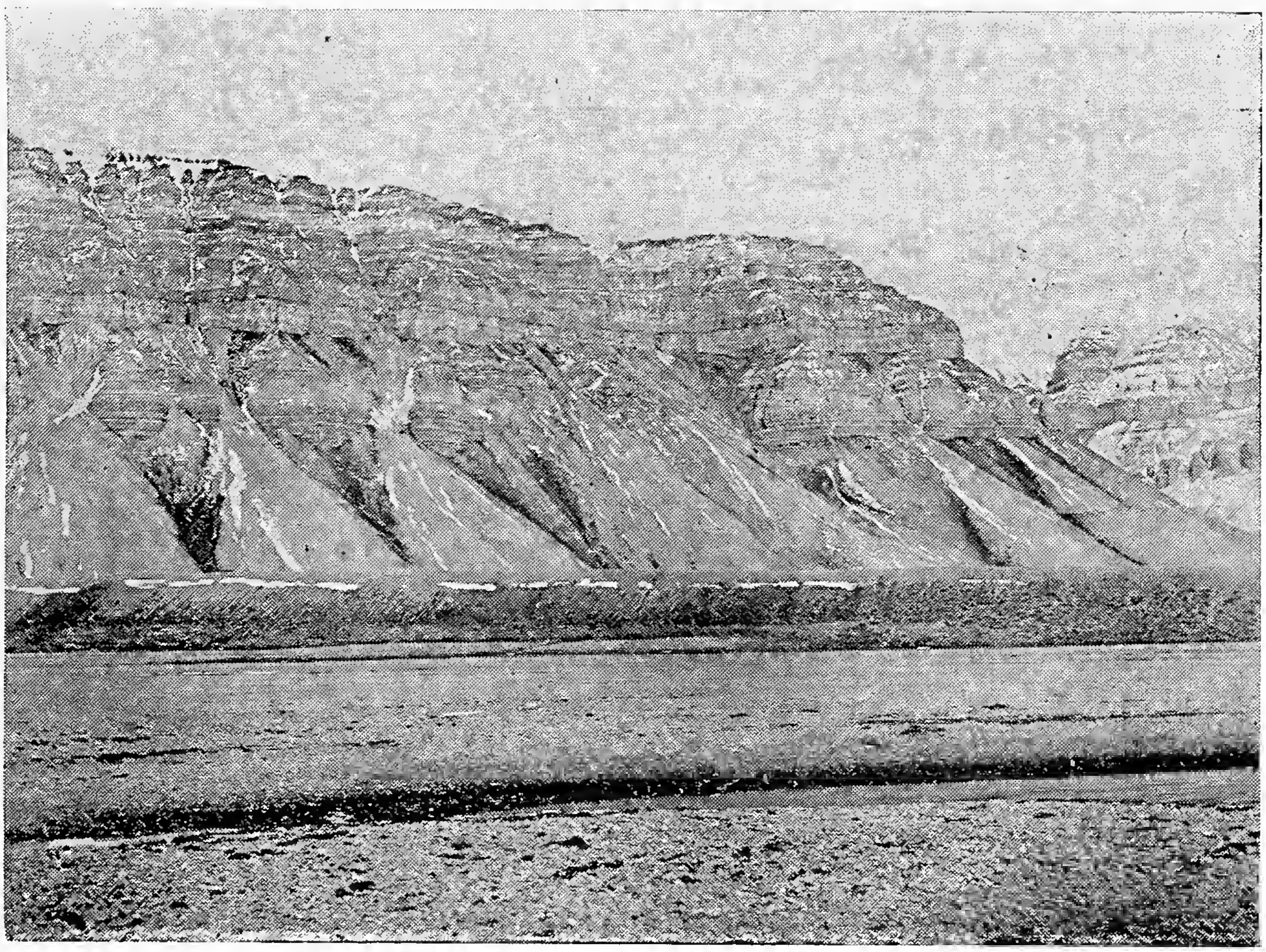


Plate 5.—Mount Temple, Sassen Bay, Spitzbergen (Raised Beaches in foreground).

35 min. N. latitude. The ice edge appeared to be very tightly packed, but had there been clear weather we should in all probability have seen here an opening which would have taken us to Bell Island or Cape Flora; as it was, we were not able to find a passage to the north. On the 14th of July, the "Blencathra" was once more to the south of the Wiche Islands, and at noon on the 15th we sighted Cape Hammerfest, bearing north by east-half-east. I shall not go into geographical details before a Natural History Society; suffice it to say that we saw all three Wiche Islands[1] quite clearly, namely, Swedish Foreland, King Karl Island, and the third island, Abel Island, which Mr. Pike described in 1897; and that we sailed over the westermost Johanson Island, which, together with the fact that in Mr. Harmsworth's yacht, "The Windward," we failed to see anything of the eastermost island in clear weather in 1897, entirely proves their non-existence. Captain Rudiger of the "Heligoland," and Dr. Nathorst of the "Antarctic," afterwards confirmed our observations, and Dr. Nathorst has made a very careful and detailed survey of the islands.

In this neighbourhood we killed five polar bears, and there were several seals to be seen, most of which were ground seals (*Phoca barbata*), though there were also a few floe rats (*Phoca fœtida*). One of the bears was caught in the act of eating a ground seal which he had caught; he had completely stripped the animal of its skin and blubber which he had eaten, and had crunched up the head. This, I believe, is all that a bear will eat of a seal, unless it is very hungry or the seal be a very young one, in which case it will eat everything, even the bones. Dr. Koettlitz, whilst in Franz Joseph Land, has found bones, teeth, and everything pertaining to a seal in some bear stomachs. The bears obtained by Mr. Coats were one male, one female, and one mother with two male cubs. Unfortunately, I have mislaid the measurements of the first two adult bears, but the length of each was under seven feet. It is interesting to note how large the cubs were to be still under the care of their mother; they were probably eighteen months old, and this is perfectly normal as far as my observations go. The measurements of the mother and two cubs were as follows, viz.—

	Mother. Centimetres.	Cub (Male). Centimetres.	Cub (Male). Centimetres.
Length, tip of nose to root of tail,	191 (6 ft. 3½ in.)	166 (5 ft. 5½ in.)	164 (5 ft. 4½ in.)
Length, including tail, ...	208	178	177
Chest, ...	136	116	112
Abdomen, ...	149	131	120
Brow, interorbital space, ...	26	24	21
Brow to tip of nose, ...	36	35	33

[1] For full details *vide* "With the yachts 'Blencathra' and 'Princesse Alice' to the Barents and Greenland Seas." "Scottish Geog. Mag.," Vol. XV., No. 3, March 1899, pp. 113—126.

A ground seal (*Phoca barbata*) taken on the 4th June off Novaya Zemlya weighed 280 lbs. and measured—

	Centimetres.
Length, tip of nose to root of tail, ...	163 (5 ft. 4 in.)
Length, including tail, ...	168
Chest (axillary girth), ...	128
Abdomen, ...	122

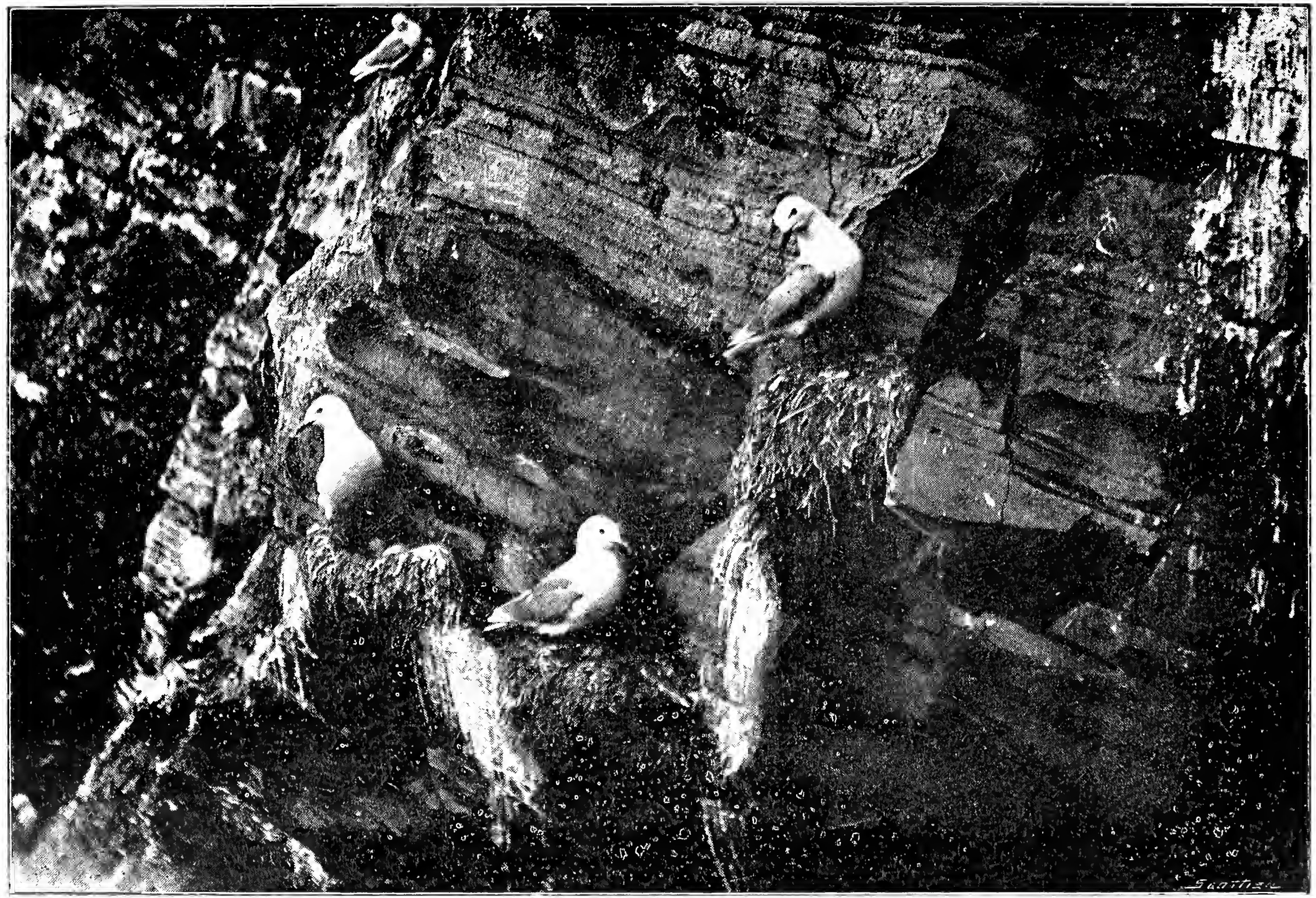
Of the 280 lbs., 150 was skin, blubber, and hind flippers.

As is usual when one kills a bear or seal, many ivory gulls came to feast on the carcases, almost immediately in this case; perhaps they were from the "gullery" described by Mr. Pike at Cape Wissenfils in 1897, or from that described by Captain Rudiger last year (1898) on the third island. On the whole, however, there was a considerable scarcity of life on this part of the Barents Sea; although I have also reported from time to time Bruennich's guillemots, little auks, kittiwake gulls, and arctic terns, and, whilst returning southward, off Edge Island, plenty of eiders and king eiders, Bruennich guillemots, fulmar petrels, kittiwake gulls, the pomatorhine skua, and black guillemots (*V. mandti*). At midnight of the 18th July, off Stone Foreland, Edge Island, I noted that plenty of Bruennich guillemots were travelling to the southward; it is, therefore, probable that they had seen their young into the water and were now seeking more southern latitudes. During this second cruise with the "Blencathra," I continued all the observations I had begun on the first, and, besides soundings, several hauls with the trawl were made down to 140 fathoms. The "Benthos" collection is very satisfactory. With the help of specialists at home and abroad, I hope soon to give a detailed account of the catches; as yet this is impossible as little more than the rough separating of species has been so far accomplished. The same must be said of the "Plankton" as well as the "Neckton." Altogether, I shall probably be able to record some 500 species.

The following is the record of observations and collections made at 249 stations:—

34 Hauls with dredge, trawl, tangle, and trap.
60 Gatherings of surface "Plankton."
88 Soundings, 57 being in new localities.
30 Salinity observations.
147 Floats, thrown out at 37 stations.

On the return of the "Blencathra" to Tromsö, on the 25th of July, I accepted the kind invitation of His Serene Highness the Prince of Monaco to return with him to the Arctic in his yacht the "Princesse Alice." It is beyond the province of this paper to describe that interesting voyage, but perhaps I may be allowed to say some-



Renö { Lat. 70° 10′ N. Long. 31° E.

Plate 6.—Kittiwake Gulls (*Rissa tridactyla*), with Nests and Eggs.

[Photograph by the Author.

thing about the successful landings His Highness made both at Bear Island and Hope Island.

It was on the morning of 30th July that the "Princess Alice" dropped anchor in 10 fathoms off the south-east of Bear Island at the foot of Mount Misery, and that we landed at the mouth of a small burn, since named by Dr. Nathorst's party "Russelfren." To the south of us was a weathered broken-down log hut, which, with the graves around it, told a tale of sufferings and death. To the north of us rose cloud-capped Mount Misery. Once ashore the different members of the party went in different directions. After securing examples of adult and young glaucous gulls, I made my way up Mount Misery by the southern ridge, but I did not ascend more than 600 feet on account of the thick mist which enveloped the hill at that height. Here I came across kittiwake gulls, fulmar petrels, puffins, and guillemots nesting in great numbers on a precipitous cliff. Most of the eggs were hatched, and some of the young birds were beginning to fly. I got a number of fossils *in situ* at this point. These are at present being identified, and will in all likelihood add considerably to our knowledge of the geology of this interesting island. I also collected a few plants, but on the whole this windswept island is not richly clad with vegetation. There are in the interior a number of fresh-water ponds, which are interesting to zoologists, and it would be well worth while staying there for some time to thoroughly investigate the fauna. In the evening we left for Hope Island, which we came upon in a thick fog, but such a good course had been steered that we headed straight for the south end, and anchored half-a-mile or less from it under the precipitous southern cliff. Next morning the "Princesse Alice" went round to the east side, anchoring about a mile from the shore, and we landed exactly opposite the place where we had attempted to land with Mr. Coats. This time it was quite calm, and there was no swell. Hope Island is described on the Admiralty Chart as "quite barren." But even without landing it was obvious that this was not correct, for from the "Blencathra" boat I could see plants growing on the west coast, and it was quite obvious that Richardson's skua (*Stercorarius crepidatus*, J. F. Gmelin) was breeding there, and that it was a resort for other birds. We recorded on the "Blencathra" Richardson's skua (probably breeding), glaucous gulls, little auks, looms (probably common and certainly Bruennich), black guillemots, great numbers of kittiwakes, and puffins. The whole party from the "Princess Alice" again dividing up, I, attended by a seaman, climbed to the summit in order to ascertain the height and structure of the island as far as possible. With some difficulty we managed to climb to the top, which, ending in a rotten shaley cliff of about 20 or 30 feet, crumbled away as we tried to climb it. We were now at an elevation of 870 feet. The island is table-topped, and cut up with gullies. At 730 feet I deposited a record in a cairn which we built. The highest part that we reached was 920 feet, further westward. I should say that the south end is slightly higher, having an altitude of about 1000 feet, that being the highest part of the island. On my way up I found a certain number of fossils. These bear some resemblance to those of the carboniferous period; but, as the report from the specialist in whose hands they are at present is not yet complete, it is hazardous to express an opinion. On my trip I saw rotges breeding, and almost certainly the pomatorhine skua (*Stercorarius pomatorhinus*, Tem.). I fired at one of the latter, but only knocked some feathers out of his wing, and did not get another shot at him. I also saw Arctic skuas, many ducklings, fulmar petrels, kittiwake gulls, and shot a black guillemot (*V. mandti*, Lin.) On the summit I found flies, snow fleas, a worm, green algæ, and other plants, and lower down more plants, which my friend Mr. Robert Turnbull has kindly examined for me. Since his list has been published, Mr. B. Leigh Smith tells me he obtained a number of plants when he visited Hope Island in 1873, which he presented to the British Museum. I am not aware, however, that any list has been published. Mr. Turnbull says, "The vegetation of that part of the island passed over was scanty, and even the lichens (luxurious elsewhere in the Arctic) were very much dwarfed. From the 'Princess Alice,' at the S.E. corner of the island, a portion of flat land appeared at a distance as green as a meadow, but there was no time to visit this comparatively rich area. A sample of soil and water from near the summit showed the red-snow alga (*Sphærella nivalis*), a species of merismopedia (one of the Schizophyceæ), desmids (cosmarium and calocylindrus types), several diatoms, and a zygnema (one of the Conjugatæ). From the rocks and soil generally were obtained four lichens, *Cetraria islandica*, L. (Icelandic moss); *Platysma nivalis*, L.; *Stereocaulon paschale*, Ach.; and *Sphærophoron coralloides*, Pers.; several mosses, but none in the capsule stage; and eight flowering plants, viz., a grass in flower (*Phippsia algida*, R. Br.); Iceland poppy in flower (*Papaver nudicaule*, L.); *Saxifraga oppositifolia*, L., in flower; *S. cernua*, L., in flower; *S. cæspitosa*, L., in flower; *S. Hirculus*, L., not in flower; *S. hieracifolia*, Waldst. et Kit., in fruit; and *Stellaria humifusa*, Rottb., not in flower. I am indebted to Colonel H. W. Fielden for help in naming the flowering plants from his large Arctic collection, and also for pointing out that *P. nudicaule* and *S. oppositifolia* are universally distributed throughout the Arctic, and that, along with *Cerastium alpinum* and *Dryas octopetala*, var. *integrifolia*, they share the position of growing in the most northern land yet reached by man, having been obtained at Lockwood Island, 83 deg. 24 min. N., by Lieut. Lockwood of the Greely Expedition."[1]

My thanks are due to Mr. Andrew Coats for his great kindness in enabling me to carry on the further researches in the Arctic Regions. It is with great pleasure and satisfaction I give an account of the voyages I made with him to a society which owes so much to another member of the same family, whom it has justly honoured by electing him as President. It is now nearly seven years ago that Mr. Henry Coates and his respected father bade me "good-bye" on the deck of the "Balæna," on my first voyage, when I sailed to the Antarctic Regions. I take this opportunity of thanking him for that and other encouragement he has given me, which has not been forgotten, and for presiding at my lecture this evening.

[We have to thank the Royal Scottish Geographical Society for kindly giving us the use of Plates Nos. I. to V. to illustrate the foregoing paper.]

VI.—*Notes on the Larch Disease.*

By Alex. Pitcaithley.

(Read 9th March, 1899.)

As is well known, the larch is a native of Switzerland, and appears to have been introduced into Britain in the seventeenth century, probably about the year 1629, though little notice seems to have been taken of it at that time, and not till fully one hundred years afterwards, viz., 1739, is there any authentic record of the tree, at which date it was re-introduced by Mr. Menzies of Culdares, some trees being planted by him in Glenlyon, while some also were planted at the same time at Dunkeld, Monzie, and Blair-Atholl, in Perthshire, and at Belladrum, in Inverness-shire.

The success attending the growing of larch by early planters of the tree, and more especially by the Duke of Atholl between the years 1800 and 1820, gave a great stimulus to tree planting all over Scotland, larch being introduced into almost every plantation. We have no record of any serious disease being observed in the larch of these earlier plantations, though there is no doubt that many failures occurred, as in large areas where there is great diversity of soil, etc., some parts are always found unsuitable to the successful growth of the larch. The majority of these earlier planted larches, however, succeeded well, and it was not until about the year 1830 that attention was drawn to the condition of some of the Atholl larch plantations. It may therefore be believed that about this time the larch disease

[1] *Vide* "Scottish Geog. Mag." Vol. XV., No. 3, March 1899, pp. 124, 125.

got established in our woods, and it has spread so rapidly over the country that at the present time it is questionable if there is a single plantation of larch in Britain which is not more or less affected, and in too many instances entire plantations have been destroyed, after every care had been taken and much money expended in their formation.

The failure of the larch has been one of the principal topics of discussion among proprietors, estate agents, and foresters for many years in connection with sylviculture, and its importance is only understood when one has fully considered and studied the matter.

Various opinions were held as to the cause or causes of the disease, such as "Frost in late spring and early autumn," "uncongenial soil," "larch bug," etc. Some authorities even blamed the nurserymen for selling an inferior, or, as they termed it, a *deteriorated* class of larch, raised from seed of unhealthy trees.

About twenty years ago the matter received serious consideration and discussion in the "Journal of Forestry," the outcome of which was that opinion seemed about equally divided between the larch bug and unseasonable frosts, as being the cause of the larch disease.

The larch bug first appeared in the Atholl larch plantations in 1785, and it was considered by the late Mr. John M'Gregor, head forester on the Atholl estates, and many other authorities, that there was a connection between it and the more deadly blister; in fact, that the former was the direct cause of the latter, and that an attack of bug was followed by blisters and fungoid growths.

The larch bug, *Chermes laricis*, is propagated by eggs; in spring the mother Chermes can be found on the twigs and stems of young larches at the base of the leaf knots laying these eggs. The bugs may be observed just before the leaves begin to appear, and they remain for a considerable time, as the eggs are laid slowly, sometimes only at the rate of about five per day. When hatched, the young immediately disperse over the foliage of the plant, piercing the leaves with their suckers, continuing till August or September, unless checked by weather, etc.

During the period that the mother Chermes is egg-laying, it is very evident that she draws sap for her sustenance from the tree. In a young plantation of larch the enfeebled appearance and backward condition of growth of the young leaves of infested plants is easily discernible, and can be observed with ease at a considerable distance, and this enfeebled growth is noticeable even a year afterwards. An attack of bug is always extremely hurtful to a larch plantation, and a severe attack will cause death.

In 1886 I observed on the roadside north of the village of Newtonmore, in Inverness-shire, a small plantation of larch badly infested with bug. The greater number of the trees subsequently died, and at that time there was no appearance of blister.

The larch bugs will attack trees of all ages. I have seen them in great numbers on seedling plants in the nurserybed and on trees of all sizes in the forest. Last year they were particularly abundant.

It is generally believed that small birds such as tits, gold crests, etc., prey upon these insects, but I am personally doubtful of this, as I have failed to discover that these birds frequent infested trees at the season when the insects are abundant, more than at other times.

Ants also get the credit sometimes of destroying the aphis, but I think it more probable that they simply visit these trees at that season for the sap exuding from the punctures caused by the Chermes, and not for the insects themselves.

It is not often that very serious damage is done by an attack of bug, except on young plants in the nursery, and these may be readily cleared by a mixture of paraffin and water, in the proportion of rather less than a wineglassful of oil to a gallon of water, and applied with a syringe. I have invariably found this an effectual cure, and one that does no injury to the plants if carefully applied.

In 1883 Prof. R. Hartig of Munich devoted a great deal of attention to investigating the origin and history of the larch disease, the result of his labours being that he gave to Germany the credit of discovering what the larch disease really is, as he showed that, instead of the blisters being the cause of fungoid growth (which, as already stated, was the belief of several practical men in this country), the fungoid growths were the cause of the blisters.

This work of Hartig's was translated into English in 1894 by Prof. W. Somerville, Newcastle-on-Tyne, and from this recent date only has the larch disease been in any way understood in this country. I consider there is some doubt as to its origin, or rather its establishment, in otherwise healthy plantations, but, as to the disease itself, there cannot now be any doubt that it is really a parasitic fungus, known as *Peziza Willkommii*, a brief description of which I may here give :—It is propagated by spores, as all fungi are; the fructifications producing these spores are cup-shaped, and are produced abundantly on the blisters when these are in a damp, humid atmosphere favourable to growth of fungi. These fructifications, when mature, produce vast numbers of most minute spores, which are wafted by wind to other trees, where they germinate upon receiving sufficient moisture; the vigorous ramifying rootlets or mycelia push into the bark, attacking and destroying the cells of the cortex, bast, and cambium. During summer the growth of the fungus ceases, and a layer of cork forms between the dead and sound wood, but in autumn the parasite again succeeds in entering the living bast, generally through the cambium, and thus gradually extends both vertically and longitudinally; but if the tree is vigorous it may not prove fatal for many years, and blisters of over fifty years' standing may be met with, while if the growth of the tree be slow, and circumstances be favourable for the rapid growth of the parasite, the whole circumference of stem or branch will soon be covered with the disease, and the tree or branch will immediately die above this point.

The shrinking and cracking of the affected parts in consequence of their death causes the outflow of resin so characteristic of the disease. The substances brought down the stem for the nourishment of the cambium, being forced round to the other side, cause a bulge opposite the affected parts, and this is more apparent on either side of the blister, which after some time appears as a hollow.

It is generally believed that the spores will not germinate with effect upon an uninjured tree, but on a wound, and these wounds may be caused by the spade or heel of the planter, by weight of snow on the branches, by hail during a storm, or by rabbits or other vermin barking the stems.

That injury is often caused to the stems of young larch in lifting from the nursery and tying the plants in bundles, or by the spade or foot of the operator in fixing them in the soil during the process of planting, cannot be denied, but such injury forms at once a callus and heals up, and, after most careful examination, I find that the disease scarcely ever attacks the plant at such a part. Nor do I think there is much in the theory of snow or hail wounding the tender bark or branches, as outbreaks of disease occur after seasons in which little or no snow falls, and on any or every side of the stems and branches; in fact it is generally in the most sheltered parts of a tree or even plantation that the disease is most prevalent.

As already stated, the larch bug, *Chermes laricis*, has always been mentioned by many authorities as being at least the primary cause of the disease, and, to a casual observer, this appears reasonable, as these insects are hatched at the base of the buds where the disease generally occurs, and there is little doubt that a certain wound is made by the mother chermes which the backward and stunted growth of the young leaves in spring show. Still one has to bear in mind that the warm sunshine which at the same time brings out the young leaves and the young chermes to feed on them, prevents the growth of *Peziza Willkommii*, and by the latter's season of growth, viz., autumn and winter, the wound on the larch caused by the bugs will long ago have been healed up; and besides, although the larch aphis and larch blister are undoubtedly often associated, yet very many cases of disease are found without the presence of the aphis.

That the disease is hereditary is a still more erroneous idea, and

I need in reference to this simply quote Hartig who is undoubtedly the greatest living authority:—"A transmission by inheritance of diseases to descendants is unknown in the vegetable world; one may without hesitation make use of the seeds of plants suffering from any conceivable disease for the propagation of new plants."

It may possibly be the case that on old bark the spores will not be able except on a wound to send down their germ tubes, but I am strongly of opinion that they possess the power on young bark, and it is on young shoots that ninety-nine per cent. of the disease is found. The age at which most plantations are affected ranges from five to ten years, and it is seldom that a part of stem or branch is affected beyond the age of four years, blisters generally appearing on three-year-old, sometimes on two-year-old wood. When the rarer cases occur of disease in older trees, there possibly may be wounds to admit its entrance; but, when plantations over ten years of age are affected, it is almost invariably the young shoots and lateral boughs that are diseased.

That the seat of disease is generally at the base of a branch or leaf spur is easily explained; for when the spores are carried by wind through a larch plantation they, after settling upon the stems and branches of the trees, will be carried down by the first shower of rain to the base of the branches, etc., where they are held and where there is also retained sufficient moisture to enable them to germinate. When once the disease is established in a young plantation it rapidly spreads, resulting generally in the total destruction of the crop, especially in damp, humid atmospheres and dense woods. It is only on ground naturally dry, with porous subsoil, and where early thinning takes place, that it is now possible to successfully grow larch. It has been stated that the disease is not now so prevalent as it once was, but unfortunately this is not the case. In Ireland it has done great damage and is fast spreading. In Wales it is more or less present in every young larch plantation. In England it is present on every estate where larch woods exist, and in very few cases can a larch plantation under twenty years of age be pointed out as being in a satisfactory state. In Scotland, the disease is very much on the increase, so that the growing of larch has become one of the most risky of speculations, requiring sound judgment on the part of the planter. In addition to my own observations, I have made enquiries as to the prevalence of the disease in this country. The most favourable reports I have received are from the estates of Taymouth, Garth, and Meggernie (where larch was first introduced), in Perthshire, the evidence here showing that an alpine position, with exposure, and open soil and subsoil, favours the healthy growing of larch. Mr. Gellatly, forester on Meggernie, informs me that in two plantations on that estate, situated on the hillside, and very exposed, he could find no trace of disease. These plantations are ten and sixteen years of age respectively, the soil being very thin loam on a gravelly subsoil, and are in a great measure isolated, the nearest old larch woods being about two miles distant.

In lower Perthshire, the disease is rapidly gaining ground. With the exception of some favoured sections, every plantation planted within the last twenty-five years has practically been destroyed, and it may now be considered useless to endeavour to raise pure larch woods in these districts with profit.

The successful growing of the tree can only be accomplished by careful selection of site, or by interspersing larches throughout deciduous woods (evergreen trees render the atmosphere too humid), where they will be isolated. No amount of acclimatisation is of any benefit in rendering the tree proof against attack, as plants growing spontaneously from self-sown seeds are as susceptible to disease as those raised from artificially-sown Scotch or Tyrolese seeds.

The disease has been known in the native larch forests of Switzerland from time immemorial, and its introduction to this country has undoubtedby been brought about through consignments of cones and seeds.

Within recent years a variety of larch has been introduced from Japan, *Larix leptolepis*, which is said to be free of disease in its native habitat, and it was hoped that this might take the place of *Larix Europea.* It is a much more rapid grower, and seems equally able to stand our winters; but in a small experimental plantation on an estate in Perthshire, formed but two years ago, I discovered, during last winter, several trees affected with blister, and this had happened even though there were only one or two old larches at a considerable distance from which the spores might have been carried. It may therefore be taken for granted that this new larch is also quite susceptible to the disease.

It now appears that few authorities recommend the planting of larch otherwise than at intervals throughout other woods, so as to isolate the trees, and thus escape infection from diseased plants, but it is questionable if the better system would not be to stamp out the disease by entirely clearing the crop of larch in this country. After a time the tree might be re-introduced, when it would be possible to have healthy plantations established, as in the eighteenth and beginning of the nineteenth century.

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VII.—*On the occurrence of Plutonic Complexes at Tomnadashan, Loch Tay, and at Cairn Chois, with Notes on the Geological Structure of the Surrounding District.*

By Peter Macnair,

Keeper of the People's Palace, Glasgow.

(Read 14th December, 1899.)

Before proceeding to describe the plutonic complexes seen at the above-named localities, let us glance for a moment at the general geological structure of the region in which they occur.

Tomnadashan is a hamlet situated on the southern shores of Loch Tay, about 2 miles to the north-east of Ardeonaig and $7\frac{1}{2}$ to the south-west of Kenmore. Cairn Chois, on the other hand, is a mountain rising to an elevation of 2571 feet above sea level, and is situated between the valley of the Turret on the east and the valley of the Lednock on the west; at both of these localities occur great protrusions of plutonic rocks, which have invaded the schists of that area, to the latter of which let us in the first place briefly turn our attention.

The schistose rocks in the neighbourhood of Loch Tay into which these later plutonic rocks have been intruded present many interesting features, at some of which we can only glance at present. Perhaps the best-marked zone of all the schistose rocks occurring in this area is that of the Loch Tay limestone, which is here seen outcropping both along the northern and southern sides of the loch. On the south side, the Loch Tay limestone may be seen in Glen Ogle, where it has been revealed by the deep cut which the stream has made into the overlying schists at this point. Traced from the head of Glen Ogle into the valley of Loch Tay, the limestone may be seen high up the side of Ben Leithan, being well exposed in the bed of the Auchmore burn, where the beds have a slightly rolling dip towards the south-east. From this point the outcrop of the Loch Tay limestone on the south side of the Loch stretches towards Creag Garb, a mountain 2084 feet above sea level, above Cloichran, on the southern side of Loch Tay. From Creag Garb the outcrop of the limestone runs down the western side of Glen Beich towards Loch Earn.

To the east of Ardeonaig, one of the large north-east and south-west faults enters Loch Tay, with a downthrow on the western side. In a quarry between Ardeonaig and Margmore the limestone is seen on the western side of the fault dipping towards the south-east.

On the eastern side of the fault the limestone is found capping the summit of Meal na Creig, where it has a *quâ-quâ-versal* dip, the underlying rocks being evidently arranged towards this point in a basin-shaped hollow.

On the north side of Loch Tay, as seen around Killin, the Loch Tay limestone has a well-marked dip of about 45° towards the north-west, and may be traced from the southern side of Sron Clachan, where it overlooks the Dochart, eastwards through Finlarig Woods and along the mountain sides to a point near Fearnan, where it has been cut off by the powerful fault already mentioned.

We have traced the position of the Loch Tay limestone in some detail, as it gives us a well-marked horizon from which to co-ordinate the different beds above and below it. The detailed work of the geological survey has also shown that the Loch Tay limestone may be followed across the whole breadth of the southern Highlands from sea to sea, and that it forms a well-marked base line from which to determine the relative positions of other zones of schists and altered rocks, with which it is evidently interbedded.

Both below and above the Loch Tay limestone there occurs a group of mica schists and quartz schists, with associated beds of grit, which we have called the middle arenaceous zone. Perhaps one of the most characteristic features of this zone of schists is the extent to which garnet has become developed within its rocks. It seems at first difficult to think that these garnets could in any way mark out a zone of rocks, yet that they do so seems to us to be quite clear, as a zone of garnetiferous schists can be traced across the southern Highlands, co-extensive with the Loch Tay limestone itself.

Another striking feature in the geological structure of this area is the frequent association of beds of hornblende schist and epidiorite with the Loch Tay limestone. Numerous sections may be seen on the north side of the Loch, as, for instance, in such streams as Allt an Tuim Bhric and the Lawers Burn, descending the sides of Ben Lawers and flowing into Loch Tay. Other fine sections may be seen at Finlarig, near Lochlin.

Let us now turn to a consideration of the Plutonic Complex seen at Tomnadashan on Loch Tay. Here the garnetiferous schists lying below the Loch Tay limestone have been invaded by an irruption of plutonic rocks, which cover an area extending from the shores of the loch up to about the 900 feet contour line.

The great mass of the rock, and that part of it which comes in contact with the surrounding schists, resembles in external appearance the ordinary grey dolerite seen in the neighbouring tertiary dykes where it comes in contact with the surrounding schists. It may be observed that a certain amount of contact metamorphism has been superinduced upon the latter rocks. The schists, besides being crumpled, are seen to be baked into a sort of hornstone or Lydian stone. From the occurrence of several isolated patches of this dark rock upon the hillside, it is also evident that the schists have been penetrated by apophyses and strings sent out from the main mass.

Examined microscopically, it is evident that this rock, though resembling dolerite externally, is of quite a different character, for it is at once seen to be made up of long prism-shaped crystals of plagioclase, a dark mica, probably biotite, with augite, magnetite, and pyrites, and, as Messrs. Cadell and Wilson point out, it may be provisionally classed with the mica-diorites or kersantites.

Within this mass of intrusive basic rock, and never, so far as we have yet been able to find, passing through the kersantite into the surrounding schists, occurs a rock of a wholly different character from that just described. It is of a strongly-marked pink colour, contrasting most effectively with the dull sombre colour of the basic rock. It is of a granitoid character, being in many cases quite coarsely crystalline, and consisting of orthoclase felspar, quartz, mica, and some plagioclase. It seems to us that the bulk of this more acid rock has been concentrated towards the centre of the surrounding basic rock, or kersantite, along the shores of Loch Tay. The intimate association of the two rocks can be best observed here. The kersantite and granitite—the latter being the name which we shall at present give to the acid rock—are seen to pass into each other in the form of strings, veins, and nodules, so that it seems impossible to attribute a priority to either of the two rocks, though Messrs. Grant, Wilson, and H. Mowbray-Cadell, in their paper upon these mines, distinctly consider the kersantite to be the older rock, into which the granitite has been intruded at some subsequent period; or, to use their own words, they say that the kersantite has in turn been pierced by a rock of totally different character, veins of which ramify in countless multitudes through the older mass.

The second Plutonic Complex to which we wish to draw your attention is that developed around Cairn Chois, and well seen in Glen Lednock. It presents in some points the same features as that seen at Tomnadashan, namely, an external mass of basic rock, with a central core of a totally dissimilar acid mass. The more basic rock here, as at Tomnadashan, seems to be in the greatest bulk, and to cover the greatest area. It can be seen at various points in the bed of the Lednock, from above the Devil's Cauldron to near Ballandalloch. Still further up the valley, it has been quarried near the farmhouse of Innergeldie, having been used to build the Melville Monument. From this point it can be traced still further up the glen to near the bridge at Spout Rollo. The streams descending from the side of Ben Chonzie, such as the Innergeldie burn, also exhibit fine sections of the more basic rock.

The rock shows a holocrystalline granitoid structure, being composed of a plagioclase felspar and green hornblende, and is consequently a diorite. At some points quartz is also present, sufficient perhaps to term it a quartz diorite.

Where the diorite comes in contact with the surrounding schists and altered arenaceous rocks, a still further metamorphism than that originally produced in the plication of these rocks may be observed. At many points the diorite may be seen sending veins of considerable size for a long distance into the surrounding sedimentary rocks, baking and altering the greywackes.

In the Lurg burn and its various branches to the east, descending from the sides of Cairn Chois, the central core of more acid rock may be well seen, the rock here being evidently a true granite, composed of quartz, felspar and mica.

We have not had an opportunity of minutely examining this part of the section, but, from what we did see of it, it seems to us that there is this striking difference between this intrusion and that of Tomnadashan just described, viz., that in the Cairn Chois complex we have a gradual passage from the more basic rocks around the edges to the more acid rocks of the centre, whereas in the Tomnadashan group the passage between the two rocks is so sharp and strongly marked that one could easily cover the line of demarcation with a pin head.

In conclusion, we now pass to some general considerations as to the conditions under which these plutonic complexes have been erupted. We may note, in the first place, the views advanced by Mr. F. Ordernheimer in a paper entitled, "On the Mines and Minerals of the Breadalbane Highlands," published in 1841, in the Transactions of the Highland and Agricultural Society. In this paper he says, speaking about the Tomnadashan rocks, "The igneous rocks on the south side of Loch Tay are chiefly composed of compact felspar porphyry in the most striking varieties, and of greenstone. Both rocks, porphyry and greenstone, are closely connected together at Tomnadashan and Ardtalnaig, at about equal distance from the east and west ends of Loch Tay. At this place there is quite a mixture, each forming veins and nodules in the mass of the other. This mixture occurs in the middle of the eruption of the greenstone and the porphyry. Towards the borders of the space occupied by these rocks a separation takes place, the greenstone occupying the east side, the granitic porphyry the west. It is not very possible to ascribe a previous age either to the greenstone or to the porphyry, *they seem to be contemporaneous*, and the series of greenstone in porphyry and of porphyry in greenstone may be veins of secretion, or an accumulation of similar masses in tabular spaces out of a *mixed compound of minerals in a melted state.* These veins of secretion do not require the supposition of rents and fissures of secondary origin. They are only the effect of an arrangement in the interior of the mass, perhaps caused by an electrical polarity, which may be suggested to exist in a compound of melted materials of different natures."

Gustav Thost, in a paper communicated to the Geological Society of London in 1860, gives a description of the mines at Tomnadashan, and in this paper he distinctly advocates the view that the granite, or, as he calls it, the porphyry, was erupted into the greenstone after the consolidation of the latter, and consequently at a later period. He thus at once traverses the position of the former writer upon these rocks (Ordernheimer). A quotation from his paper will explain his position. He says, "All the facts there obtained support the supposition that after the mica schists had been broken through by the greenstone a powerful vein of porphyry was erupted, for the greenstone, while remaining unchanged in position and character on the east and west sides of the porphyry vein, has near its middle part not only been deranged by mechanical force, but has also been often altered by chemical agency into a substance exhibiting the mixed characters of greenstone and porphyry, with transition from one to the other."

The above quotation leaves us in no doubt as to the views of its author, and we find Messrs. Wilson and Cadell, in the paper already referred to, adopting a similar theory to account for the phenomena there seen. It will be our purpose in the remaining part of this paper to see whether, on the one hand, the views originally propounded by Ordernheimer, and afterwards advanced by Dakyns and Teall, to account for a somewhat similar plutonic complex seen in another part of Perthshire, or that originally given by Thost, and afterwards supported by Messrs. Cadell and Wilson, be the most likely solution of the enigma.

Fifty-one years after the publication of this theory of the origin of these plutonic complexes by Ordernheimer we find his views revived by Messrs. Dakyns and Teall, and advanced to account for similar phenomena seen near Inverarnan on the confines of Perthshire and Argyllshire, where a plutonic complex of a similar character to those already described occurs. These authors have shown that in this area we have a central core of granite passing outwards through an intermediate series of rocks, as hornblende, biotite, granite, tonalite, and diorite, which finally give place along the margin of the boss to rocks of an ultra basic character, including pikrites, etc. To account for this complex of rocks, they suppose that they were all erupted as one magma, and that, during the cooling of the magma, the more basic rocks cooled first around the edges of the boss, this being succeeded by a gradual cooling of the more acid types towards the centre of the intrusion.

In the Cairn Chois complex we have undoubtedly a case similar to that described by Messrs. Dakyns and Teall, and one which may be accounted for upon the same principles as those advanced by these authors. The Tomnadashan complex, on the other hand, presents in the sudden and strongly-marked passage of the basic rock to the acid rock a feature which appears to militate strongly against the supposition that the Tomnadashan complex could, like the Cairn Chois complex, have been segregated out of one magma.

We can only sum up here our reasons for supporting the view of the earliest writer, namely Ordernheimer, that both the acid and basic rocks of this complex were erupted as one magma. These reasons are as follows:—

(1) It is a remarkable fact that the acid rock never seems to pass from the basic rock into the surrounding schists. If the acid rock were a later intrusion, there would be no reason for its being thus confined to the surrounding basic rocks, whereas, on the supposition that they were both segregated out of the one magma, this relationship is at once accounted for.

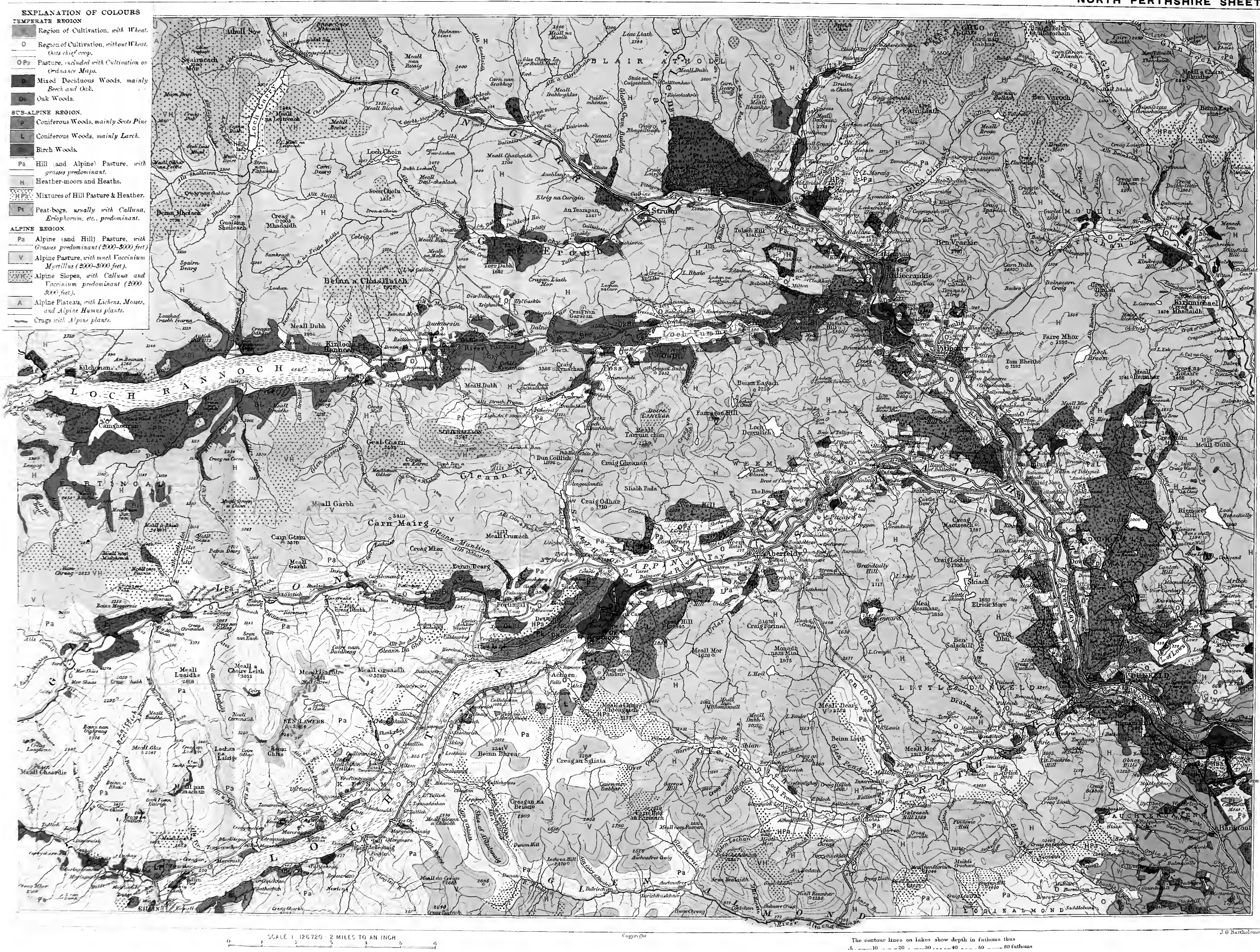
(2) Notwithstanding the statement of Thost that the acid rock is often seen to alter the basic rock, both mechanically and chemically, when it comes in contact with it, I have never been able to find any traces of contact metamorphism. When examined microscopically, the kersantite in contact with the granite exhibits exactly the same character as it does when over a mile away from the actual contact.

(3) The apparent mechanical displacement of the kersantite can, we think, be accounted for quite as well by the principle of the segregation out of the two rocks from the one magma. In fact, the apparent intrusion of the granite into the kersantite is entirely deceptive. We hold with Ordernheimer that there is no evidence to show the priority of either of the two rocks involved in the complex.

BOTANICAL SURVEY OF SCOTLAND

By Robert Smith, B.Sc., University College, Dundee.

NORTH PERTHSHIRE SHEET.



VIII.—*A Day with the Terns.*

By Lieut.-Colonel W. H. M. Duthie.

(Read 11th January, 1900.)

The Terns *(Laridæ)* or Sea Swallows, as they are familiarly called, like the real Swallows *(Hirundinidæ)*, are always welcomed in this country, not only as harbingers of warmth and sunshine, but also because their presence lends an additional charm to the beauty of our coast scenery. Few sights are more fascinating for a lover of birds to watch than the manœuvres of a flock of Terns engaged in fishing on a summer day; compact in form, with long graceful wings, and short legs easily stowed away in flight, they have a perfect mastery over the air, while their light bodies and webbed feet render them equally at home on the water, and, as they float between the blue of sky and sea, their plumage of dazzling white and pearly grey, which most of their order assume, harmonises with fleecy clouds and with the crests of curling waves. They are a large family, and no less than thirteen of their kind are included in the list of British birds which visit our shores—some regularly, some occasionally, and some very rarely.

Five of this number are regular summer visitors, and not very long ago there was a sixth, the Black Tern, which used to breed in considerable numbers in some of the fen counties of England. It has now ceased to do so, owing partly to over-molestation and also to the fact that the draining of marshy land has gradually deprived it of its favourite nesting-places. A few individuals are observed from time to time visiting the old haunts, attracted there, perhaps, by hereditary instincts, and even as late as 1858 their eggs have been found, which encourages the hope that if the spring arrivals were left in peace, instead of being shot down and stuffed as "rarities," they might be induced to remain to form the nucleus of a restored British colony.

They are fairly abundant on the other side of the English Channel, and we need not travel far to find them in the nesting season. If we leave London at night we may spend the next afternoon on a Dutch mere punting along narrow waterways between forests of tall reeds, the home of Spoonbills and Purple Herons, where the great Reed Warblers chatter all day long, and where many former British nesting birds, now rare stragglers to our shores, may be met with; here we may watch the dusky forms of the Black Terns hawking for dragon flies or hovering over beds of flowering waterlilies, amongst which their floating nests, composed of withered leaves and stalks, each with its complement of small dark-brown eggs, are safely moored.

The five species of Terns which nest in Great Britain are the Sandwich, the Arctic, the Common, the Little, and the Roseate Terns. They lay their eggs on shingly beaches, among sandhills, on rocky islands far out at sea, and sometimes on inland waters; from the Scilly Isles to Caithness on all suitable ground near the coast, and also in Ireland, colonies of one or other of their kind may be found.

The Sandwich and Little Terns are easily distinguished by their size, the former being the largest and the latter the smallest of our British-breeding Terns; the Roseate is the rarest and most beautiful, with its white under-plumage stained with a tint as delicate as the light of early dawn upon the snow.

The Common and the Arctic Terns are the most familiar to us, the former being more plentiful in the south and the latter in the north of our islands; sometimes their breeding haunts overlap, and both species are found on or near the same ground. When seen together they may be readily distinguished, the Arctic Tern being darker in plumage than the other. There are also other points of difference, such as the colour of the beak and the length of the legs, but these can only be ascertained by handling the specimens. As regards size they are almost identical, and when seen separately it is almost impossible, except for an expert, to identify them; the eggs, which vary much in colour, shape, and markings in each species, are not of much help in deciding the matter, but it may be mentioned that the normal eggs of the Arctic are rather smaller than those of the Common Tern. The Common Tern often breeds near fresh water, inland, but the Arctic Tern seldom leaves the sea-shore for that purpose. All the family are very shifty in their habits, and do not submit to over-persecution. I have known a place in Scotland where one summer thirty-two nests of the Sandwich Tern were counted, and on visiting the ground three years afterwards not a single bird was seen. The eggs, so easily found, besides being taken by mercenary egg collectors, are gathered by fishermen and others for food, and unless this is judiciously done, the Terns are certain to desert the neighbourhood. It is not easy to protect many of these nesting-places along the coasts, as the foreshores are often more or less open to the public; but, besides the famous sea-bird sanctuaries on the Farne Islands, there are several other localities on private property where the "terneries" are well and carefully preserved.

It is most satisfactory to note the increasing interest which has been taken in birds of late years by the public, and the growing desire for their protection. The Wild Birds Protection Acts, 1880-1894, are still imperfect, but they provide a framework capable of being built up and filled in by the energy and determination of those who desire to see the spirit of the legislation carried out. In some districts much good has already been done by individual effort.

The Press has shown itself an active ally of the birds, and another most valuable and powerful agent in their favour is the Society for the Protection of Birds. This Society was founded in 1889, "called into existence," as stated in its circulars, "by the pitiless destruction which has for long past been carried on all over the world, hundreds of thousands of birds being sacrificed yearly, especially during the winter season, to supply the demands of a barbarous fashion in dress and decoration." Formed originally for a special object, the Society is extending its scope, and is interested in all methods adopted for the preservation of the feathered race. It is now a strong and well-organised body, having many influential persons and some of our best-known ornithologists on its committee of management, and by its last year's report it showed a roll of over 20,000 members. It has branches all over the United Kingdom and Ireland, in the Colonies, and also in America; it corresponds with various foreign societies, and, owing to the efforts now being made in many of the countries of Europe, "it is not without hope that in time an International Union may be established to promote and increase interest in the preservation of birds." With all these agencies at work, we may surely look forward, not only to checking the present rapid diminution of some of our rarer birds, but also to winning back some of our lost ones.

Among many pleasant days spent with the birds, none are more cherished in the memory than those passed with the Terns and with their numerous associates on the sea-shore; this is partly owing to the season of the year, for the Terns are such late breeders that the Wild Duck has reared a brood, and the young Curlews are shifting for themselves on the moor, before the Terns are ready to lay their eggs on the warm sand beside the sea.

On a fine day in June, when summer weather is established, let us start for the sandhills. The wild roses are in full bloom in the hedges, the well-grown grass ripening for the scythe rises and falls before the breeze like ocean waves, and Larks are singing as they only do sing near the sea. Leaving the cultivated ground, we thread our way through a wood composed chiefly of Scotch firs, which, owing to a scanty soil and an exposed situation, have been little favoured. The trees are stunted in growth, and those on the outskirts are quite deformed, their trunks being bent and twisted to one side, and with all their upper branches and foliage matted together, they turn away from their tormentor, the prevailing S.E. wind. Looking over golden masses of sweet-smelling gorse, which forms a fringe to the wood, we see the long line of sandhills two miles away, and the blue sea beyond; the intervening space is made up of an undulating plain of sandy soil, which Nature is gradually clothing and beautifying. This process is most interesting to observe. The bent grass begins the work by threading its way in long curving lines, holding the sand together within its folds, and, as the surface hardens, there is formed over it a network of lichen and moss, into which are collected seeds of all sorts carried there by the wind, by insects, and by birds; and in due time clover and wild thyme, potentilla with its yellow flowers and long red trailers, purple violets and vetches, and other plants varied in character and colour add to the effect of this lovely carpet which Nature is ever weaving.

The older-formed portions of the ground are thick with heather, dwarf willow, and grasses; there is a good sprinkling of birches, and the winged seeds of the Scotch firs float over from the wood and find congenial soil for germination; rabbits abound, and are seen scuttling about in all directions.

It is a curious fact that the wild seedlings of the Scotch fir are not touched by rabbits or deer, but if nursery plants are introduced it is necessary to wire them in or they will be destroyed by these animals.

This moorland wilderness is the haunt of many waders. One of their scouts, probably a Curlew, gives a signal of our approach, and the air is filled with wild cries. Redshanks are the most vociferous, dashing round us or hanging on drooping wings above our heads. The strange purring note of the Dunlin goes on unceasingly, and we hear the low melancholy pipe of the Golden Plover, sounding sometimes quite close, sometimes far away, as these excellent ventriloquists try to lure us from their brood. Several birds are running before us, feigning lameness or broken wings, and practising all their various devices to entice us away from their young, but we are not taken in by these manœuvres. We are well aware that numbers of tiny fluffy creatures are concealed in the grass close beside us, some, indeed, at our feet, and we know that these cries and calls are the parents' signals, well understood by their chicks, to keep quiet and to lie low.

If we retire for a short distance, and wait patiently, concealing ourselves as best we may, we shall soon see little round balls of down on long stilty legs against the skyline of the hillocks, moving about in the grass; on our approach they vanish, and their whereabouts must be carefully marked with the eye or we shall fail to find them; soon one is discovered, then another, lying very flat, with throat and chest pressed close to the ground, quite motionless, their backs harmonising perfectly with the colour of their surroundings.

It is marvellous how this instinct of self-preservation is acquired by these ground-born birds from the moment they leave the shell. They are easily caught at first, as they make no movement till the hand is upon them, but when released they run with great rapidity, threading their way with much skill through heather and grass, and often elude capture a second time.

Vegetation becomes scarcer as we approach the sea, and the level spaces between the sandhills are filled up with fine gravel, where Ringed Plovers love to lay their eggs. The last defences of the land, which are ever shifting and changing in the constant struggle which is being fought out with the sea, consist of a high natural wall of sand, with buttresses thrown out at either side, clothed with rank bent grass. We climb cautiously up the near slope in the hopes of seeing some birds under shelter on the other side; but, if any are there, they receive notice to quit, for a pair of Oystercatchers, whose young we have no wish to disturb, dash over our heads making the shrillest of uproar. These birds, like Curlews and Peewits, are most annoying both to naturalists and sportsmen, as they so frequently appear at a critical moment and spoil a stalk.

From the top of the bank we meet full in our faces the fresh air of the sea, laden with its odours of brine and sea-weed; the tide is low, and our eyes wander over a vast expanse of shining sands, chequered with numerous pools and rivulets reflecting the bright light of the sky. Here multitudes of birds of different kinds, which cannot be seen or identified all at once, are scattered about, enjoying the rich banquet which the sea has provided. Those grey objects on the dry ridge, which look like lumps of clay or mud, prove through the medium of our glasses to be Gulls in the mottled plumage of youth; some are pluming their feathers, but the greater number are sitting down fast asleep, satiated with food. Far away, on a spit of shingle, are long black lines of Oystercatchers; these, like the sleeping Gulls, are yearlings who have not yet taken up the responsibilities of domestic life. A few Hooded Crows are busy foraging, and numbers of Ringed Plover are running about like mice on the wet sands. Just beyond the margin of the sea, where the crisp waves come tumbling in, fleets of Eider drakes, conspicuous in their arctic dress, are floating, and white Gulls sail above them in the air, or bob about like bits of foam on the water. The sea sparkles as if sprinkled with diamonds, and across the firth a distant outline of rocky coast edges away, the farthest points being doubled by mirage. A few brown sails of fishing-boats serve to intensify the delicate grey tones of sea and sky and shore.

Descending from our high position, we walk along on the seaward side of the dunes, on a firm dry floor of broken shells, for the most part white and bleached, but in some places, where fragments of mussel shells are lying, there are patches of blue like reflections from the sky.

We soon hear the high-pitched fretful cry of a solitary Tern, a note different from that of any other bird, and unmistakable. This bird was evidently the sentry on duty, for, immediately, a whole troop of these graceful creatures come streaming over the bank, swooping and darting and circling in the air, and screaming close over our heads : we have come upon a nesting colony of Arctic Terns.

Before looking for their nests we climb the bank again and watch them carefully as their white bodies flash and gleam in the sunlight. When directly overhead they seem almost transparent, owing to the light showing through their outspread wings and forked tails. Some of them, full of anger and alarm, dash past quite close to us, showing their coral bills and black-crowned heads, and as long as we remain they continue to hover and float about us, sometimes at a great height, looking like specks of silver dust, and they never cease uttering their scolding scream. The nests are easily found, for the birds have themselves betrayed their positions. They are depressions in the sand among tufts of long grass ; some of them are substantially lined, others have merely a slight wisp of grass encircling the eggs.

Continuing our walk, the Terns see us off their ground, and for a time there is comparative silence, and we are soon interested in another sort of bird. A pair of Shelldrakes, splendid studies in black, green, chestnut, and white, with scarlet beaks and feet, suddenly appear and settle quite close to us, only to rise every now and then and settle again. There is evidently some other cause beyond our presence which makes them so confiding. This we discover is a brood of ten little ducklings waddling along the sand, and splashing through the pools, hurrying to the sea ; the parents, who have been covering their retreat, join them as soon as they reach the water, and the whole party soon float away out of sight.

These strange birds form a link between the Geese and the Ducks. The plumage of both sexes is almost alike ; that of the female, although less brilliant, is too conspicuous to admit of their brooding in the open with impunity. Nature, therefore, prompts them to lay their eggs in holes in the sand, either in tunnels which they excavate for themselves or in rabbit burrows, where they are safely concealed from the prying eyes of their enemies.

On wading across to a spit of shingle, which is only accessible at low water, we disturb another colony of Arctic Terns, and the same screaming and uproar is the result. Their eggs, with no attempt at a nest, lie among the stones and sea wrack above the line of high tide mark; some of the clutches are so close together that the sitting birds must almost touch one another. Here also we fall in with a small number of Little Terns. Their call, a double note, is sharper and less plaintive than that of the other Terns. After a very careful search we find their eggs, small and round like grey pebbles. Here, again, we find no nests; nesting materials seem to be used or dispensed with by the Terns according to the nature of the ground. When the eggs are laid on yielding sand, a little dry grass prevents them from sinking or rolling away.

The time has passed quickly while we have waited and watched, and perhaps photographed some of the various objects which have interested us. The tide has turned, causing a restless movement among the birds; the sleeping Gulls wake up and scatter, and, as the rippling waters flood the sands, the Oystercatchers shift their quarters, and small parties of Peewits, Dunlins, and Ringed Plover hurry past us; and later on, when the shadows of the sandhills have crept farther over the grass, many Terns, which had left their eggs all day to the heat of the sun, come flying inland to settle on their nests for the night.

Returning homewards across the moor, we find the birds less noisy. Many of the young are possibly gathered safely under their parents' wings, and by the time we reach the wood again the strange chorus of wild-bird music, which we have listened to all day, is hushed. We still hear the murmur of the far-away sea breaking on the sands; it blends with the sound of the breeze in the fir branches, from which it is difficult to distinguish it, and to this soft accompaniment of wind and wave a Song Thrush, with rich clear notes, is singing the angelus. Bats are flitting about, and Owls are abroad.

> "The day is done, and the darkness
> Falls from the wings of night
> As a feather is wafted downwards
> From an eagle in its flight."

IX.—*Bird Life on the Sidlaws.*

By William Whyte.

(Read 11th January, 1900.)

In preparing a paper on Bird Life on the Sidlaws, I have thought it better to take my hearers for a ramble across the moor from Murrayshall to the Giant's Hill, and to deal with those birds that do not come so frequently under the notice of the casual observer.

We will take our ramble in the most interesting season of the year for studying bird life, that is, in the nesting time. At this time the moor is alive with birds of different kinds which have performed long journeys, many of them in order that they might reach their usual breeding haunts and rear their broods of little ones.

The ground we are to traverse is one long series of hill and marsh from the time we enter the moor until we reach our destination at the foot of the Giant's Hill. The hilly parts are covered with furze or coarse grass, with here and there patches of heather, and the hollows are wet boggy marshes, which afford excellent feeding and breeding ground for the birds which frequent these places. There are also one or two plantations and strips of fir, which are the haunts of quite a different class of birds from those last mentioned.

Before entering the moor we may notice the birds of a common kind in the hedges and trees which skirt the road, such as the Chaffinch, Greenfinch, Yellowhammer, Song and Missel Thrush, Blackbird, Redbreast, Blue Tit, Coal Tit, and Great Tit. One of the last-named for two successive years built her nest in the letter-box which stands inside the hedge at Parkfield, but on each occasion it was found and destroyed by some prying nest-hunter.

The Whinchat is the first bird that greets us after we enter the wicket gate. Sitting on a whin he gives a warning note to his mate, who is busy hatching her nest of pretty pale-blue eggs, faintly spotted with red, at the bottom of some whin. Rounding the hill we see a bird of large dimensions rise from the crest and fly off. We fix our eyes on a marshy spot in the hollow and walk straight for it; we are rewarded by seeing a female Curlew rise and fly silently away until she joins her mate, when their wild cries may be heard for miles around. We have no difficulty in finding her nest, which hardly deserves that name, and which contains four eggs of large size and of an olive-green colour, splashed with brown.

Creeping up the hill, we now look down on Arnbathie Loch. We notice a Heron standing at the edge, like some solitary sentinel guarding this lonely pool, while numerous Ducks, Gulls, Moorhens, and Coots may be observed feeding in the water. Having satisfied ourselves, we rise and walk down the slope. Immediately there is a general exodus: the Heron, with a harsh scream, rises, and, with two or three flaps of his broad wings, is over the hills and away, followed by the Ducks and Gulls, and in a few minutes the loch is tenantless, with the exception of the Moorhens and Coots, which dodge among the reeds and sedges. A Redshank starts from among the dry grass which grows round the margin of the loch, and, after a close search, we find her nest in a tuft of withered grass, the inside of which is cunningly hollowed out, leaving the outside fringe, which, however, entirely conceals the sitting bird and her four pretty eggs. The Reed Bunting attracts our notice with his black cap and white collar, and we are again lucky in finding the nest, with pretty dark-streaked eggs. I may mention that this bird stays with us only during the summer months; but I have seen three of them, a male and two females, on the 12th of January, again on the 6th of March, and near the same place, in the month of June, I have watched them feeding their young. The Little Grebe has built for two or three years on the loch. From the trees which surround the farm we now hear, for the first time this season, the welcome notes of the Cuckoo; he is flying from one tree to another, closely attended by a pair of Meadow Pipits, who appear to vie with each other as to who will pay him most attention, the Cuckoo meantime keeping up a conversation in a "squawkie" garrulous tone. There at one time appeared to be some difference of opinion as to whether the Meadow Pipit followed the Cuckoo from a feeling of amity or enmity, and a number of years ago there was a warm controversy in the *Scotsman* on this subject; but I think that any one who has watched the birds would be easily convinced that the Meadow Pipit is animated by no other feeling than one of devoted attachment to the Cuckoo. I may give one instance that came under my notice in confirmation of this. While I was walking through Methven Moss, with other four companions, in the first week in May last year, we heard the cry of the Cuckoo, and saw him fly along the railway accompanied by three small birds. They alighted on the telegraph wires, and, seeing the small birds fly about in rather a curious manner, we crept along the embankment and watched them closely through a pair of field-glasses. The Cuckoo kept emitting his soft pleasing notes at intervals, while two of the Pipits kept dropping down alternately to the Moss, returning in a little and presenting something in their bills which was greedily accepted by the Cuckoo; the third Pipit meantime kept presenting his bill, but as there was nothing in it, he received a lecture on deceit, delivered in a tone of voice which left nothing to be desired. This, I think, would go to prove that, not only does the Meadow Pipit adopt and rear the offspring of the Cuckoo, but that they feed the parent birds as well.

Leaving the loch, we make a straight cut for a plantation which stretches across the moor for about three-quarters of a mile to the foot of the Pole Hill. This hill, which at one time was wooded, is now bare, with the exception of the pole or flagstaff on the summit, from which it derives its name. The plantation affords shelter for some of the largest of our birds, including the Capercailzie, Blackcock, Pheasant, Woodcock, Magpie, Hoodie, Tawny Owl, and Wood Pigeon. The smaller birds are represented by the Golden Crest, Coal Tit, Creeper, Missel Thrush, and some of the more common kinds. The three first-mentioned are always found in company, and may be found wherever there are spruce or fir trees. Round the edge of the plantation there is a fine belt of heather, which is the breeding-place of two or three pairs of grouse, and, while passing through this, we observe a female sitting on her nest. My friend never having seen a nest of Grouse eggs we go close up to her, but she will not oblige us although I stroke her back and pull her wing, and I have actually to lift her off the nest and place her on the ground, when she takes a short flight and remains watching us. The nest is a full one of ten eggs, beautifully marked, and very hard set. Probably they would be hatched about two days later, and, as I afterwards ascertained, the young were successfully brought forth and reared. We now descend a long grassy slope, raising numerous Lapwings, and we hear the peep-peep of the Golden Plover, which, however, breeds but sparingly on the Sidlaws. At the foot of this slope stand the ruins of an old house with, as usual, one or two trees about it, on the largest of which the Hoodie has built its nest for many years. The Hoodie, or Common Crow, may be aptly termed the scourge of these hills, as hardly anything comes amiss to him, from a dead sheep to the young of the ground-building birds. I have started a pair of them on the hillside, and, wishing to know what they were about, I made for the spot, and found the newly-killed body of a young lamb with the warm blood trickling from a large cut in the flank. This had been done by the powerful bill of the Hoodies so that they might feed on the entrails. The shepherds tell me that a very young or weakly lamb has no chance with them. The Hoodie is also a notorious egg thief, and on some little hillock not far from his nest you may come across a little heap of egg shells of all kinds, with a large percentage of those of the Grouse among them. I have also seen a pair of these crows beating with their wings the branches of the spruce trees to frighten the Wood Pigeon from her nest so that they might steal her eggs, or, for the same purpose of egg-stealing, flying low over the moorland beating the ground like trained dogs. They are most cunning birds, and build on some solitary tree on the moor or on the fringe of some plantation, but never far in.

We now cross a dry dyke, and in doing so start a pair of Wheatears. We then make for a thin belt of fir trees, and find breeding here the whole of the predatory birds which frequent this part of the Sidlaws, namely the Tawny and Long-Eared Owls, the Hoodie, the Magpie, and the Kestrel Hawk. This Hawk and the Owls build no nests of their own, and are probably attracted to this spot by the nests of the Magpies and Hoodies which they readily appropriate.

We here cross the public road, which continues through a deep ravine over the braes of the Carse to the village of Rait. After crossing the road the moor takes a more bleak aspect, bare hill and marsh being the order of the day, with the exception of a birch wood which we visit, and, while climbing for a Hoodie's nest, the farmer comes along and asks us to destroy the four eggs which it contains and pull down the nest, which is no easy matter, as it is a most firm and compact structure. We have a chat with the farmer about birds. He, being an ex-gamekeeper, and having the prejudices of his class against Hawks, Owls, and birds of that kidney, considered it his duty to shoot them at sight; but he related an incident which showed that even he was not dead to those little touches of nature which make the whole world kin, and he assured us he would have given a good deal to have remedied it. It happened that, while coming along the moorland path in the gloaming for the purpose of shooting a rabbit, an object crossed the path in front of him; he fired and dropped it, and, on going up to it, he found he had shot a Tawny Owl. He knew the birds were nesting close by, and for three days he heard the piteous cries of the little Owlets for the mother who would return to them no more, and then there was silence. We leave the farmer with rather a better opinion of him, and continue our ramble, raising on our way a Mallard from her nest, full downed, and with eleven eggs. Further on, tapping a little sugarloaf-shaped whin, out popped a Teal Duck, and on opening out the whin there was disclosed a beautiful nest with nine eggs. We now hear high overhead the drumming of a Snipe, and, while passing through a bed of rushes, we get its nest. This is one of the prettiest nests of this bird that I have seen; it is quite clear of the ground, and is supported, or rather interlaced, with four or five of the upstanding rushes. In depth it is about four inches, and contains four eggs, very like the Redshank's in colouring, but of a different shape. Before leaving the moor we must not forget to mention the Linnet, whose pretty song and sweet calls have charmed us nearly the whole of our ramble; it breeds freely among the whins, its nest being very difficult to find, and generally containing four to five eggs.

We have now reached the Woods of Pitmiddle and the end of our journey, so far as this paper is concerned. This wood stretches for a long distance along the crest of a ridge on this side of the road that passes at the foot of the Giant's Hill, and at this end of it is situated the Gull Loch. This loch has two or three floating islands, on which hundreds of Black-Headed Gulls breed, while Ducks, Coots, and Moorhens are dotted plentifully over the surface.

We now make for the road, and return by Bandirran and Balbeggie. I may mention in closing that the late innkeeper at Balbeggie showed me a fine specimen of the Short-Eared Owl which was shot on Dunsinane Hill.

X.—*On the Alpine Flora of Clova.*

By Miss M. Thomas.

(Read 8th February, 1900.)

PART I.

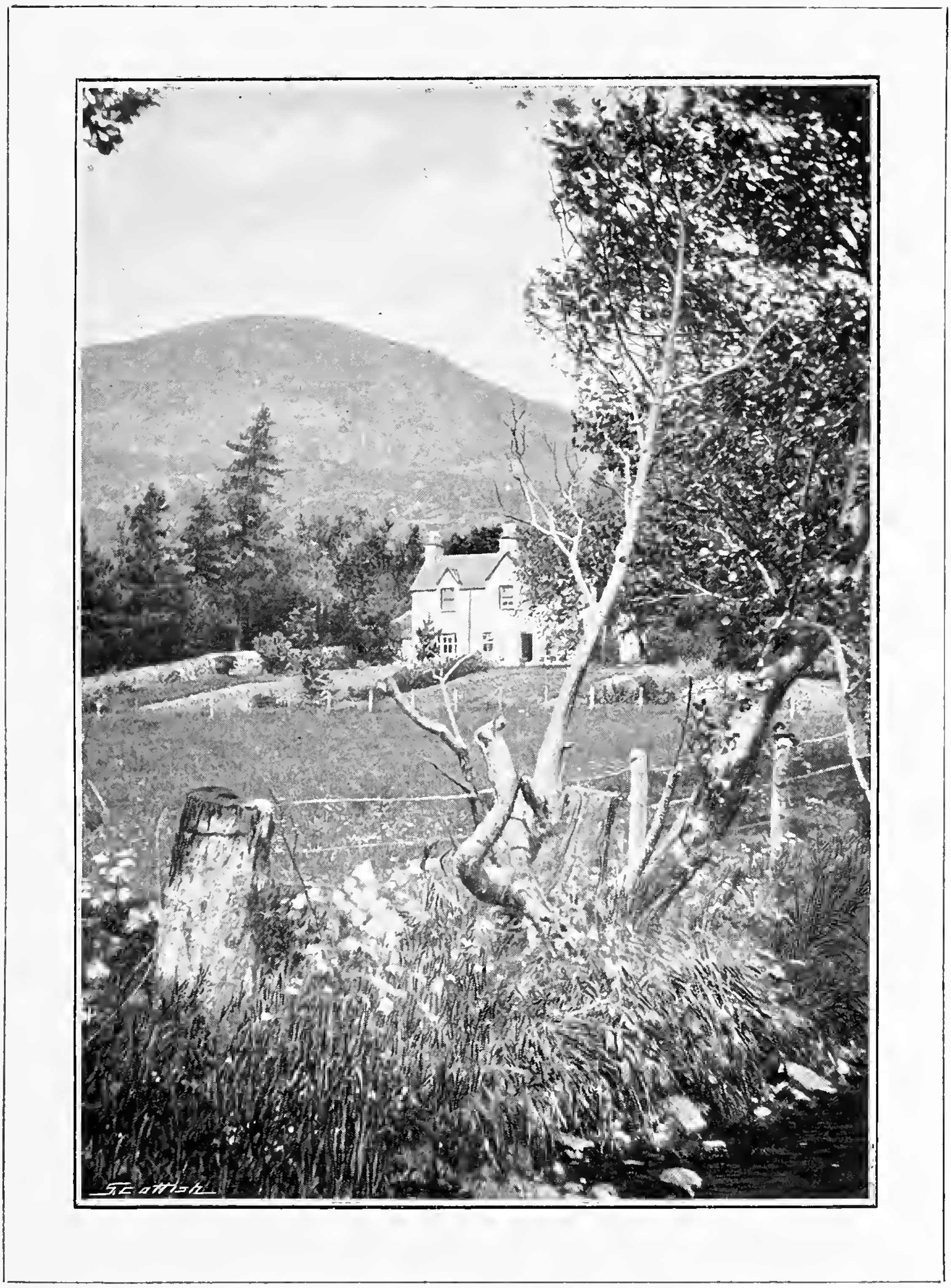
Clova is the name given to the glen cut by the river South Esk, one of the largest streams flowing from the Forfarshire Grampians. It is best approached from Kirriemuir, which lies five miles from the entrance. The lower part of the valley is not particularly interesting to the botanist, as the hills are relatively low and undulating. About ten miles up the glen we come to the Milton of Clova, which consists of a few cottages, a church, a school, and a most delightful inn. Here the valley becomes more picturesque, the mountains on both sides rising abruptly to altitudes even exceeding 3000 feet. These slopes and crags have been classic ground to the lover of Alpine Flora since the days when George Don, the famous Forfarshire botanist, first revealed their wealth, which can hardly be surpassed elsewhere in Britain.

Four distinct regions of vegetation can be distinguished in the district of Clova :—

1. The Valley Region, 2. The Heath Region,	Sub-Alpine.
3. The Plateau Region, 4. The Crag Region,	Alpine.

1. The Valley Region.

In the valley the flora consists partly of lowland and partly of sub-Alpine species. The lowland species seem here to possess flowers which are much deeper in colour and larger than the same species inhabiting the plains. This is well seen in the rock roses, vetches, and wild thyme. Several of the sub-Alpine species prefer a humus soil, and seem to thrive best upon the organic compounds arising from the decaying matter of which the humus is composed. Amongst these may be mentioned the moonwort fern, *Botrychium lunaria*, *Tofieldia palustris*, and several sub-Alpine orchids, such as *Habenaria albida* and *H. viridis*, and in particular *Malaxis paludosa*, the smallest British orchid. This last is very difficult to find, being only about an inch and a half high, and resembling greatly in colour the *Sphagnum*, among which it dwells. Its mode of reproduction is interesting, for, besides setting seed, it propagates itself by means of numerous buds which grow on the upper surface of the leaves, and form a fringe around the leaf margins.



The Manse, Clova.

2.—The Heath Region.

In Clova itself heather covers the hill slopes, especially on the north side, but as we approach the upper end of the glen and enter Glen Doll the heather almost ceases, the grass replacing it as dominant species on the hills.

Several plants with the Ericoid type of leaf, such as the heaths, the blaeberry, and crowberry, resemble many of our forest trees in having their roots always invested by a net-work of fungus threads called Mycorhiza, offshoots of which penetrate the epidermal cells. Sometimes the roots are so completely surrounded by the hyphæ of the fungus that direct absorption from the soil by the root-hairs is rendered quite out of the question. This is believed to be a case of symbiosis—that is to say, of two plants living together for mutual benefit. The fungus performs for the plant the function of root-hairs, and probably aids it in utilising the food-materials of the humus on which it grows, and in return receives part of its nourishment from the plant.

Besides heather, the following plants are characteristic of this region:—*Vaccinium* spp., *Empetrum nigrum*, *Arctostaphylos Uva-ursi*, and four different kinds of club-moss. *Rubus chamæmorus*, the cloudberry, is frequent at the higher altitudes, and in a few places—as, for example, near Loch Esk—the rare *Betula nana*, dwarf-birch, may be found.

Beside Loch Brandy, near the upper part of the heather region, there is a small pool containing some interesting aquatic plants, of which the chief are:—*Lobelia Dortmanna*, *Subularia aquatica*, and *Isoëtes lacustris*. The resemblance between their vegetative parts is so great that at first sight they might all be taken for one species, yet two are Phanerogams of widely-separated families, and the third a Vascular Cryptogam. Besides this outward resemblance, these plants have several points in common:—

(1) They all select for habitats quiet mountain pools.
(2) They grow submerged.
(3) Their leaves are simple, linear, and awl-shaped, and in each case arranged around the stem in the form of a close rosette.

3. The Plateau Region.

To the north of Glen Clova the hills reach a uniform elevation of over 2500 feet, and present the appearance of a wide undulating tableland. Here on the broad hill-tops, and in the relatively shallow valleys between them, are found many of the Alpine plants. Alpine mosses and lichens (including *Cetraria islandica)* are characteristic of this region. Amongst them occur patches of such species as *Loiseleuria procumbens*, *Gnaphalium supinum*, *Juncus trifidus*, *Salix herbacea*, *Carex rigida*, &c. The rare *Lychnis alpina* is a member of this association on the summit of Little Culrannoch in Glen Doll.

4. Plants of the Alpine Crags.

Some of the more frequent plants inhabiting this region are given in the following list:—*Epilobium alpinum*, *Cerastium alpinum*, *Thalictrum alpinum*, *Potentilla rubens*, *Sedum rosea*, and *Oxyria digyna*. These species all grow luxuriantly on the crags above Loch Brandy.

On the crags above Loch Wharral two very interesting grasses are to be found, namely *Alopecurus alpinus* and *Phleum alpinum*. This was the first station in which *Alopecurus alpinus* was discovered in this country. It has a very wide distribution, occurring throughout the mountains of North Europe, North Asia, and America, and reaching even as far south as the Andes of South Chili.

Glen Doll and its branch, Corrie Phee, are particularly rich in the flora of the Alpine crags. The best botanising ground is on the slopes of Craig Rennet and Craig Maid and the ravine of the White Water. In one day's botanising we came upon a hillside covered with *Linnœa borealis* and *Pyrola secunda*, and near the foot of the cliffs masses of *Lycopodium annotinum*, whilst on a rocky ledge higher up, and requiring much hard climbing to reach, grew some dainty plants of *Erigeron alpinus*. A few of the other rare plants found here are well worthy of remark. *Oxytropis campestris* occurs, completely covering the front of a projecting rock with southern exposure, an exceptional exposure for Alpine plants, which generally seem to prefer the corries and slopes that face the north or that lie from N.E. to N.W., as a southern exposure would dry them up too quickly. *Lactuca alpina* (Alpine Sow-Thistle) is one of the largest of the Alpine flowers. It grows by one of the mountain streams, and has purple blossoms, which begin to flower at the top of the spike and develop downwards, lasting only for a very short time.

In the case of a few of the Alpine plants, we find that not only do they grow on the mountains, but they are also found at sea-level—*e.g.*, *Armeria maritima* and *Cochlearia officinalis*. *Saxifraga oppositifolia* and **Dryas octopetala* occur mainly on mountain crags, but occasionally also at sea-level. *Plantago maritima* and *Silene maritima* are found in the mountains, at sea-level, and also in certain stations intermediate between the two. It is probable that the lessened

* I did not find *Dryas octopetala* in Clova, but it is recorded for that district.

competition for food and freer space on the hill-tops and by the sea accounts for this peculiar distribution.

The time of vegetation and flowering of the Clova Alpines seems to be short; I should say altogether about three months. It has been determined that the seeds of many Alpine plants germinate at 2° C. (about 35° F.), a temperature which is not reached in the Clova region at the highest altitudes till about the month of April. *Saxifraga oppositifolia*, *Silene acaulis*, and *Loiseleuria procumbens* flower early, but it is not till July that Scotch Alpines reach perfection of foliage and blossom. Composites like *Lactuca alpina* and *Saussurea alpina* flower late, but, as a rule, by August the flowering time is past for most of the plants.

PART II.

Adaptation to Environment.

Although in the mountains the Alpine plants have comparatively few rivals to contend with, yet the conditions of life are hard and extreme, for they are alternately exposed to drought and to moisture, to the heat of the sun, to frost and cold winds. The adaptations to these severe conditions are of very varied character. Here I shall briefly consider some of the most marked. Many Alpine species are of low dwarf growth, forming, when woody, small stunted bushes, and when herbaceous, closely packed moss-like cushions or rosette-like whorls. We can see transitions to these dwarf forms in the trees and shrubs of the valley, which, as the altitude increases, become more and more stunted. It has been suggested that the dwarf growth is a protection from any injury that might be caused by the pressure of the snow. There are other explanations, however, that seem more probable. To any one who has experienced a strong wind while botanising on a hill side, it will be easy to realise that dwarf stunted forms are best adapted to hold their own there. Since, too, the ground is relatively much warmer than the air, the plants nestling close to it will profit by the extra heat.

In these dwarf shrubs the leaves are usually very small, very thick, and with a rounded and entire margin, presenting as small a surface as possible for transpiration. The vegetative shoots are usually short, but if they attain any length they are generally low-lying, growing close to the ground. Thus the advantages gained by these lowly dwarf plants can be summed up as follows :—

(1) They are less liable to suffer from the violence of stormy winds;
(2) A covering of snow protects them from the severity of winter frosts.
(3) They can utilise better the heat of the earth.

Of dwarf plants we have many examples in Clova; of the woody kinds we have the heaths, *Vaccinium* spp., *Loiseleuria procumbens*, and several Alpine willows, such as *Salix herbacea* and *Salix reticulata*.

Many Alpine plants possess tough leathery leaves, which are usually evergreen, with the stomata sunk in deep grooves on the under side and protected by hair. The evergreen forms can utilise favourable temperature and light in all seasons of the year, whilst in some cases the leaves may store the assimilated products. Examples of evergreen forms are *Vaccinium Vitis-Idæa*, and *Linnæa borealis*. The Crowberry, *Empetrum nigrum*, mimics the true heaths, and in many respects bears the very closest resemblance to them in its vegetative structure. Like the true heaths, it has narrow leaves, with their margins turned back so far that they almost meet. Close-set hairs fill up the narrow cleft, thus forming a very effective protection for the transpiring surface.

Several of the Alpines are succulent plants with thick fleshy leaves, typical *Xerophytes*, and admirably adapted to withstand drought. In these the maximum of space for water storage is combined with the minimum of surface for water transpiration. *Sedum roseum* and *Oxyria digyna* are examples of these succulent plants.

Certain Alpine plants are protected by a thick covering of hair. This adaptation is also a preventive against too rapid transpiration. The beautiful woolly leaves and catkins of *Salix lanata* and *Salix Lapponum*, two Alpine willows, afford perhaps the best examples of this.

In Alpine regions many leaves show a strongly-developed palisade tissue, and are of a very deep green shade; with this tissue the plant acquires greater assimilatory energy, which compensates for the dwarf growth.

The leaves of some Alpine plants are of a Pinoid structure, as those of *Juniperus communis*, the juniper. The stomata here form one longitudinal band upon the upper surface of the leaf. Amongst herbaceous plants, the same type occurs in *Silene acaulis* and is also found in the *Lycopodia*. The stomata in *Silene*, however, are only very slightly depressed, if at all, and there are no protective hairs. Transpiration must then be reduced by the nature of the epidermis and the small number of stomata.

Alpine plants are excessively vivid in colour. This is partly connected with the purity of the atmosphere and the strong illumination in summer. It has been suggested that the bright colour and large size of many of the flowers—that is to say, the relatively greater development of the reproductive parts—may be correlated with the poorer development of the vegetative system in severe Alpine habitats.

In the colour of plants it has been asserted that according to development reds come after yellow, crimson after red, and the highest development of all is reached in the flowers that are blue. Although we find all shades and colours among Alpine flowers, yet blues and pinks perhaps predominate, and one writer throws out the suggestion that with the dwarf vegetative growth all the energies of the plant are thrown into the inflorescence, and we get as a side result the crimsons and blues of our mountain flowers.

Another colour characteristic of high mountain plants is the presence of much red cell sap or anthocyanin. Warming considers that this is a protection against the intense light. Kerner brings forward a very interesting theory, namely, that the anthocyanin absorbs the heat rays of the sun. He shows that high Alpine forms have abundance of anthocyanin on both leaf surfaces, and that certain grasses which in the valley have pale-green glumes have up in the mountains a deep violet tinge owing to the amount of anthocyanin developed. He considers that the sun's beams, which get stronger the higher we ascend, are changed into heat in the anthocyanin cells. This heat is passed from the glumes to the seeds within, and aids their growth and development. This is also seen in certain sedges and rushes, such as *Carex atrata*, *Juncus trifidus*, and *Juncus triglumis*, which have dark violet or even almost black scales covering the flowers. To support this view, Kerner points out that many plants whose floral leaves are white when growing in the valley are tinged red or purple by anthocyanin when found growing on the high hills. This has been seen in *Trientalis europæa*, *Achillea Millefolium*, and the bracts of *Cornus suecica*. In these cases the anthocyanin probably plays the same part as in the grasses and sedges. Kerner also remarks that many plants which develop white flowers in summer, like the common white dead nettle, have, towards autumn, these white flowers tinged usually with purple, and that the common daisy in winter has its ray florets tinged with red.

As mentioned above, the flowering season is very short, and annuals, which must germinate, grow, and conclude their flowering and fruiting in the course of one short summer, run the risk of failing to reproduce their seed, and, therefore, of dying out in that station. Hence we find comparatively few annuals in the mountains, and a very large percentage of perennials. Some plants, which are annuals in the plains, become perennials in the mountains, or are replaced by species which are perennials. Annuals need a greater amount of heat for blooming and for the ripening of their seeds, whereas, with the perennials, it is not so important that the seeds should be ripened each year.

In connection with the shortness of the Alpine summer and the chance of failure of seed production, it is interesting to note that a number of species form vegetative bulbils instead of flowers. This may be seen in *Polygonum viviparum*, certain viviparous grasses, and *Junci*, and in some Saxifrages, such as *Saxifraga stellaris* and *S. cernua* (this latter Saxifrage is not found in Clova but on Ben Lawers). On a single spike of *Polygonum viviparum* all possible stages of development can often be seen from perfect flowers right down to bulbils which, while still on the spike, have thrown out small green leaves. An early fall of snow or a sharp frost might come on and overtake the plant before the seeds could possibly be ripened and dispersed; but the bulbils can much better withstand severe weather, and can also be produced more rapidly and with less heat than is required by the seed in development.

In mountainous districts it has been said that there is a scarcity of insects, which would be another reason for the increased vegetative reproduction. Hermann Muller, the great authority on plants and insects, says, however:—"I have not been able to convince myself that Alpine flowers are on the whole less frequently visited and crossed by insects than are those of the plain." Self-fertilization is certainly prevalent amongst Alpine forms, and seems to become more so as the altitude is increased.

PART III.

On the Origin of the Alpine Flora.

These questions of adaptation to environment and of local distribution form only a few of the many problems that may be suggested by the study of Alpine plants. When the wider distribution of these plants is considered, it is observed that an Alpine Flora of similar character inhabits all the mountain ranges of Europe, but is absent from the intervening plains, and that this mountain flora is similar to that of the Arctic shores.

How are these isolated groups of Alpine plants related? Whence and when came the British Alpine Flora? What was its mode of transport? These questions have frequently been discussed before the Society,* but since within recent years much new light has been thrown upon them, and has somewhat modified the generally accepted views, I propose to consider briefly the various theories which have been advanced for their solution.

* P. Macnair on the Geological Factors in the Distribution of the Alpine Plants of Perthshire. (14th April, 1898.) *Trans. P.S.N.S.*, Vol. II., p. 240-249.

Dr. Buchanan White on the Origin of the Flora of Perthshire. (12th March, 1891.) *Proceedings P.S.N.S.*, Vol. I., p. c.

Prof. Edward Forbes, in 1845, was the first to propound a scientific theory concerning the origin of the Alpine Flora.

He believed that during the Glacial Period, while the greater part of Great Britain, as he supposed, was covered with ice and snow, and only the mountain tops stood out like islands in the middle of an Arctic sea, icebergs from Norway, freighted with boulders and soil containing seeds and plants, were stranded on the shores of these mountain islands. Dr. Buchanan White has said concerning this theory, "Edward Forbes was a great man, and the first to show the origin of the Alpine Flora, but he was wrong in this 'iceberg' theory, simply because the glacial geology of Europe had not been worked out at all."

Since the time of Edward Forbes, a theory has been propounded by Dr. James Geikie (1877 and 1881), which is now accepted by many scientists.

According to this theory, the whole of Scotland, Ireland, and that part of England from the Thames and Severn northwards were, during the Glacial Period, covered with a thick ice sheet. At the same time an immense sheet of ice stretched right across the whole of Northern Europe almost as far south as the 50th parallel of Latitude, filling up the bed of the German Ocean, and reaching to the British ice sheet. In these Arctic conditions no plant, no animal, could survive except in the far south, and even there the conditions were not temperate but Arctic, so that the vegetation fringing the ice sheet would probably be composed of Alpine and Arctic species.

At the end of the Glacial Period, however, a milder climate supervened, and as the ice receded the plants followed, occupying the land from which the cold had driven forth their ancestors. At the same time there seems to have occurred a great elevation of the land, so great that the bed of the German Ocean was converted into dry land, and a passage afforded by which plants and animals could enter Britain. The first plants to occupy the dry bed of the German Ocean would be the Alpines, those nearest to the retreating ice sheet, and having entered, these plants would spread over the whole of Britain.

Later on, by the same route, the Germanic Flora arrived on our eastern shores, and crowded out the Alpines. From the plains they were pursued to the hills, and from the hills to the mountains, where it would seem as if they were to be crushed out altogether. But up in the mountains the Alpine plants find conditions of life which place them more nearly on an equality with their pursuers, and here through thousands of years they have lived and held their own.

This, then, is the generally accepted view, but during the last few years botanists have begun to doubt the total annihilation of life during the Glacial Period, and the necessity of restocking the land with a fresh flora and fauna in Post-Glacial times. The modern view seems to be that the Alpine Flora probably existed in many parts of of Europe both before and during the Glacial Period. This change of opinion began with Continental botanists, and may be dated from 1888, when Warming published his essay on the Flora of Greenland, although before that time similar suggestions had been thrown out by Professor Blytt, Mr. Ball, and other eminent botanists. Professors Warming and Nathorst both hold that many flowering plants have survived in Greenland through the rigour of the glacial times, and Drude maintains the same for the Scandinavian Flora.

It is generally recognised that the conditions of Great Britain during the Glacial Period were very similar to those of Greenland at the present day, and Drude asks, "Where now do we find such trackless wastes? [as were supposed to have existed during the Glacial Period]. Greenland, Franz Josef Land, Grinnell Land, situated in high Arctic latitudes, all have a flora composed of flowering plants and cryptogams."

Colonel Fielden, the Arctic traveller, in an essay on the plants of Spitzbergen, maintains that many species there outlived the Glacial Period.

More recently Mr. Bulman suggests that possibly a considerable Arctic and Temperate Flora similarly existed in the southern parts of England and Ireland, and that the effects of the Glacial Period have been overrated.

During last year (1899) two new works appeared dealing with this subject. One of these, by Mr. Clement Reid of the Geological Survey, treats the question from the historic standpoint, tracing the Alpine Flora in the deposits of fossil remains from the Glacial Period upwards. He agrees with Professor Geikie in thinking that no Temperate Flora could have existed during such extreme conditions, but he does not require for his theory the presence of a complete land connection with the Continent. He considers that we have as yet under-estimated the capabilities of seed dispersal of plants, and holds that most of the species have entered Britain since the Glacial Period by means of their natural modes of dispersion. The other work is that of Professor Scharff of Dublin on the "History of the European Fauna," where it is maintained that the Alpine Flora of Great Britain was Pre-Glacial. The author considers that the Alpine plants probably made their first appearance before the Glacial Period, having migrated from Greenland to Scotland by means of a land connection between these two countries by way of Scandinavia and Spitzbergen.

ROBERT SMITH, B.Sc.

(By kind permission of Messrs. James
P. Matthew & Co., Dundee.)

This is how the question stands at present—undecided and still open to debate. Time alone will show the value of these various modern theories, and as it is a question of great importance to all British botanists it will be interesting to see what will be written on this subject during the next few years.

XI.—*Plant Associations of the Tay Basin.*

By Robert Smith, B.Sc., University College, Dundee.

(Read 8th February, 1900.)

PART II.*

In the first part of this paper the chief plant associations of the Tay Basin are described, and are considered in relation to the natural botanical sub-division of that area. Since that part was written I have been able to survey the district more fully, and to prepare a map of a portion of it, showing the distribution of the more important associations. The present part has been written to explain the chief features of this map, and to indicate some of the more important results that may be deduced from it.†

The principle upon which this map is based will be seen to be quite different from that of "floristic" maps, where the object is to show the actual areas of distribution in such a way that they may be easily compared. Those maps are of importance in the consideration of questions of the dispersion and migration of species. The present map, on the other hand, is not primarily concerned with the precise limits of the individual species, but shows rather the distribution of a number of selected communities of plants which exist associated in nature. The species forming these communities are held together by their common requirements, and thus each association becomes indicative of a particular *ensemble* of environmental conditions.

In Part I. it was shown that the most natural sub-division of the vegetation was into the four following regions :—

I. Littoral Region.
II. Lowland or Temperate Region.
III. Sub-Alpine Region.
IV. Alpine Region.

* Part I. appeared in the *Trans. Perthshire Soc. Nat. Sc.*, Vol. II., Part VI. (1898), pp. 200-217.

† A full account of this method of mapping will be found in my papers on the "Botanical Survey of Scotland":—I. Edinburgh District, *Scot. Geog. Mag.*, Vol. XVI., July, 1900, pp. 385-415; II. North Perthshire District, *Scot. Geog. Mag.*, Vol. XVI., Aug., 1900, pp. 441-467. (Also reprinted separately).

With the Littoral Region we have nothing more to do in this paper, as it is not represented in the district under consideration. The other three have been selected as the fundamental divisions of the present map. The general characters of each of these regions and of their more important sub-divisions will now be considered in turn.

Temperate or Lowland Region.

This might be called the Region of Cultivation, as most of its area is under cultivation, and its upper limits are best indicated by the limits of the cereal crops. It might also be called the Region of Deciduous Trees, as these make up most of the arborescent vegetation, and probably in primitive times occupied the greater part of the area.

Since the cereal crops differ in their requirements with regard to temperature and moisture—wheat preferring warmer and drier parts than barley or oats,—this region may conveniently be sub-divided into two sub-regions:—

(1) With wheat cultivation.
(2) Without wheat cultivation.

The wheat region hardly passes 500 feet in altitude. It includes the driest parts of the district, and has an average summer temperature of over 56 deg. F. It occupies only a very small part of the present area, and is quite excluded from the Highland portion. There, except in the lower parts of the valleys, the temperature is much diminished, and the rainfall is often considerable. Oats and barley grow better than the richer wheat, oats being cultivated in several parts up to an altitude of 1250 feet, while traces of cultivation occur, for example, on Beinn a' Ghlo, near Craig Choinnich Lodge, up to 1500 feet. As a rule, cultivation extends to a higher elevation on the side of the valley with a southern exposure, than on that facing the north. This will be seen in almost any part of the valleys, but particularily in the vicinity of Loch Tay, Blair-Atholl, Pitlochry, and Kirkmichael.

The flora of the cultivated area is largely made up of introduced species, many of which are more or less casual in their occurrence. A distinct diminution in the number of these species is observable as the altitude is increased. The data which have been collected in the *Flora of Perthshire* by the late Dr. Buchanan White permit us to estimate the number of species occurring in each sub-region of cultivation. Thus, out of some 280 species which may be regarded as inhabitants of cultivated ground, only about 100 are found in the upper parts of the region above the limits of wheat cultivation, or above 500 feet in the Highland valleys.

The chief characters of the deciduous woods included in the Temperate Region have been already treated of in Part I. The map shows that in North Perthshire the beech and mixed deciduous woods do not usually pass 700 feet, although small patches and isolated trees may be found over 900 feet. Oak woods will be seen, on the other hand, to reach 1000 feet in some parts, as, for example, near Kenmore, and isolated oaks occur even higher.

In Part I. lists were given of the characteristic and conspicuous plants of these woods. Here these are supplemented by another list, enumerating those species found in the Temperate Region and not in the higher regions. This list has been divided into two parts to separate in a general way the more frequent species from the rarer species, which may be regarded as relics of a time of broader woodland area.

FREQUENT SPECIES PECULIAR TO THE TEMPERATE REGION.

Arenaria trinervis, L.
Hypericum perforatum, L.
Geranium pratense, L.
Ilex Aquifolium, L.
Prunus Avium, L.
P. Padus, L.
Rubus fruticosus, L.
Agrimonia Eupatoria, L.
Circæa lutetiana, L.
C. alpina, L.
Sanicula europæa, L.
Nepeta Glechoma, Benth.
Stachys sylvatica, L.
Lamium album, L.
Listera ovata, R.Br.
Allium ursinum, L.
Scilla festalis, Salisb.
Carex remota, L.
Bromus ramosus, Huds.
Brachypodium gracile, Beauv.
Agropyron caninum, Beauv.

RARE SPECIES PECULIAR TO THE TEMPERATE REGION

(Determined mainly from White's *Flora of Perthshire*).

Vicia Orobus, DC.—Kinloch-Rannoch and Glen Tilt.

Lathyrus niger, Wimm.—Killiecrankie.

Campanula latifolia, L.—Aberfeldy, etc.

Veronica montana, L.—Dalguise and Castle Menzies.

*Melampyrum sylvaticum, L.—In various localities.

Origanum vulgare, L.—Near Blair-Atholl.

Stachys Betonica, Benth.—Rumbling Bridge, Strathbran.

Neottia Nidus-avis, Rich.—Rumbling Bridge, Craigie Barns, Moness, near Kinloch-Rannoch, Pass of Killiecrankie, and Lawers Den.†

Epipactis palustris, Crantz.—Near Pitlochry and Blair-Atholl.

* *Melampyrum sylvaticum*, L.—The two following stations for this species are not recorded in the *Flora of Perthshire*:—(1) Atholl, near Falls of Fender (W. T. Calman, 1897, and R. Smith, 1898; (2) Rannoch, beside Frenich Falls (R. Smith, 1899).

† *Neottia Nidus-avis*, Rich.—This species has not, so far as I am aware, been hitherto recorded for Lawers Den. I found it there in July, 1900, growing amongst a thick mass of decaying vegetation under hazel bushes.

*Polygonatum verticillatum, All.—Near Pitlochry, Killiecrankie, and Blair-Atholl.

Convallaria majalis, L. — Near Pitlochry, Killiecrankie, and Glen Tilt.

Gagea fascicularis, Salisb.—Near Inver and Pitlochry.

Paris quadrifolia, L.—In a few stations.

Milium effusum, L.—Dunkeld, Moness, and Glen Tilt.

Calamagrostis epigeios, Roth.—Near Dunkeld.

Festuca sylvatica, Vill.—Strathbran, Inver, Acharn, and Allt Girnaig.

Bromus giganteus, L.—In a few stations.

Scolopendrium vulgare, Symons. Acharn and Killin.

Equisetum hyemale, L.—Kenmore.

Sub-Alpine Region.

This region is mainly composed of hill pasture and moorland, with scattered woods of pine, larch, and birch. Its lower limit may be regarded as being indicated by the upper limit of cultivation, approximately about 1000 feet. The line separating it from the Alpine region is more difficult to define, as the two regions often pass very gently into each other. In most European countries the upper limit of trees serves to indicate the end of the Sub-Alpine Region, but in Scotland the land has been so demuded of arborescent vegetation that only a very approximate estimate can be drawn from this indication. As a rule, distinct changes, with introduction of an Alpine element, can be observed about 2000 feet, or slightly above it. The last trees disappear about that altitude, Alpine species become mixed with the pasture and moorland species, and several characteristic forms there reach their upper limit of altitude. Thus the two species of heath, *Erica Tetralix*, L., and *E. cinerea*, L., cease about 2000 feet, and serve well in practice to indicate the upper limit of the lower region. Accordingly, on the map, the upper limit of the Sub-Alpine Region has, on most of the mountains, been drawn to follow the contour line of 2000 feet. On some of the mountains, however, such as those of the Breadalbane range, the Alpine pasture differs so very slightly from the Sub-Alpine, that both have been represented by one shade of colour.

Tree Associations of the Sub-Alpine Region.

The trees of this region occur, as a rule, in the lower parts, becoming rare, scattered, and stunted as the upper border is approached. Scots pine and larch form the woods of the larger valleys, but in the more remote parts birch is almost the only impor-

* *Polygonatum verticillatum*, All.—An additional station for this species besides those given in the *Flora of Perthshire* is—Atholl, near Falls of Fender (R. Smith, 1899).

tant species. Small patches of alder occur here and there, but nowhere sufficiently abundant to be represented on the map. The following notes on each of these associations will supplement the accounts already given in Part I.

Pine Woods.

The Scots pine is undoubtedly the native tree characteristic of this region, as it grows well in most parts, and remains of its earlier forest are found buried in almost every peat bog. The Black Wood of Rannoch, on the south shores of Loch Rannoch, is believed to be a still remaining part of the primitive Caledonian Forest, but elsewhere in the district the trees have been planted within a comparatively recent period. The Black Wood is somewhat thin now, and much mixed with birch, but it bears an aspect of antiquity suggestive of its primitive character, such as is quite foreign to most of the other pine woods of the region.

During the past century more larch has been grown than Scots pine, but the prevalence of larch canker, caused by the fungus *Dasyscypha (Peziza) Wilkommii*, Hartig, on the trees of the newer plantations, has checked its introduction, and at present the native pine is tending to replace it. The planting of the larch woods of the Atholl district was one of the greatest steps made by scientific forestry in the country. It was largely the work of John, fourth Duke of Atholl, who, between 1774 and 1826, planted as many as fourteen million plants, covering 10,324 imperial acres. The larch was first introduced into Scotland in 1738, and two of the first trees still stand beside the Cathedral at Dunkeld. For further particulars regarding the introduction of the larch the reader is referred to general works on the forestry of the country, and in particular to the work by Mr. Hunter on the woods of Perthshire.

It is quite probable that most of the land up to 2000 feet could, after careful study of the conditions, be made to bear coniferous trees furnishing good timber. None of the woods at present reach that altitude, the highest just passing 1800 feet, as, for example, Craig Hill, near Kenmore, or above Meggernie, in Glen Lyon. Both larch and Scots pine, however, grow better at somewhat lower elevations, and seem very similar with regard to their altitudinal requirements, the pine resisting perhaps somewhat better the extreme conditions at high altitudes. The altitudinal limit for isolated pine-trees given in White's *Flora* is 1900 feet in Atholl.

In Part I., whilst discussing the natural regeneration of woodland, it was mentioned that few statistics have been collected regarding the distances to which the winged seeds of the Scots pine may be carried from the parent plant, and 115 metres, the distance given by

Fliche, was the only one quoted as reliable. Since then I have been able to make some measurements on Tentsmuir in Fife, which seem to show that the seeds may be carried and germinate as far as 886 yards (810 metres) from the parent tree. Similarly Birch seeds were found to be carried 489 yards.*

Birch Woods.

The area under birch woods shown on the map is interesting, since it represents that part of the woodland which is quite natural and self-sown. The birch tree springs up easily and quickly on the clearings of pine or oak woods, on moorland and on pasture, so long as these are not too closely grazed. If allowed full scope, it would cover much of the Sub-Alpine Region. It reaches a considerable altitude, small patches on the mountains south of Loch Rannoch touching 2000 feet, whilst isolated examples—for example, on Beinn a' Ghlo above Glen Tilt—are found as high as 2300 feet. The trees at these extreme altitudes are, however, usually small and stunted, compared with those found in the valley.

In Part I. the list of associates of the birch was not given, since, as was stated there, "the trees afford little shade, and the associated species are largely those of the bare heaths." In some parts, however, especially in the river valleys, the birch woods may have almost as rich a vegetation as the oak woods. In such a case a few oaks usually occur amongst the birches, and seem, from their good condition, to be growing in quite favourable circumstances. The birch woods between Loch Tummel and the Falls of Tummel may serve as a good example of this type. They owe their richer character to the shelter, moisture, and good drainage of the narrow deep valley. The trees are in good condition, and most are of a mature age. Besides oak, numerous hazel, willow, alder, rowan, and ash trees are mixed with the birch, and seedlings of birch, rowan, and ash are frequent. Where the ground is open, the flora certainly approaches that of the moor, with heather, heath, or bog myrtle as dominant species, according to the state of soil moisture. But under the shade of the trees the chief social species are grasses and the bracken (*Pteris aquilina*). This last is by far the most conspicuous plant, forming a close thicket of waving fronds, spreading away into the depths of the wood as far as the eye can penetrate. In some parts the fronds are so tall that it is quite possible by only slightly stooping to pass quite under them. The grasses which form the carpet where the bracken is not too dense are mainly:—

* For details of the measurements the reader is referred to a communication on the subject in the *Ann. Scot. Nat. Hist.* ("Seed Dispersal of *Pinus sylvestris* and *Betula alba*"), 1900, pp. 43-46.

Anthoxanthum odoratum, L.	Agrostis vulgaris, With.
Holcus mollis, L.	Festuca ovina, L.
H. lanatus, L.	

and rarely—

Nardus stricta, L. and Briza media, L.

The following are some of the chief associates :—

Anemone nemorosa, L.	Vaccinium Myrtillus, L.
Ranunculus acris, L.	Primula acaulis, L.
Viola Riviniana, Reich.	Gentiana campestris, L.
Polygala vulgaris, L.	Veronica officinalis, L.
Hypericum pulchrum, L.	V. Chamædrys, L.
Oxalis Acetosella, L.	Melampyrum pratense, L.
Trifolium repens, L.	Stachys sylvatica, L.
Lathyrus montanus, Bernh.	Teucrium Scorodonia, L.
Rubus idæus, L.	Ajuga reptans, L.
Fragaria vesca, L.	Plantago lanceolata, L.
Potentilla Fragariastrum, Ehrh.	Polygonum viviparum, L.
P. silvestris, Neck.	Myrica Gale, L.
Galium saxatile, L.	Habenaria conopsea, Benth.
Scabiosa Succisa, L.	Anthyrium Filix-fœmina, Roth.
Hieracium Pilosella, L.	Lastræa Filix-mas, Presl.

The close correspondence between this list and that given for the oak coppice (Part I., p. 205) is very evident. This is what might be expected, when it is considered that the situation is similar to that of the oak coppice in other parts of the valley, and that there is little difference between the shade of a fairly thick birch wood and that of an oak coppice.

The woodland flora in general has a range of altitude similar to that of the trees, and many species cease before 2000 feet are reached. Those confined to the woods of the Temperate Region have already been given, and the following list contains the most of those which reach their highest altitude in the Sub-Alpine Region :—

Ranunculus auricomus, L.	Conopodium denudatum, Koch.
R. Ficaria, L.	Hedera Helix, L.
Stellaria nemorum, L.	Lonicera Periclymenum, L.
S. umbrosa, Opiz.	*Linnæa borealis, Gron.
S. Holostea, L.	Asperula odorata, L.
Geranium lucidum, L.	Valeriana sambucifolia, Willd.
Geum urbanum, L.	*Pyrola media, Sw.
Fragaria vesca, L.	*P. rotundifolia, L.
Potentilla Fragariastrum, Ehrh.	*P. secunda, L.
Epilobium montanum, L.	Primula acaulis, L.

* Rare species to be regarded as remnants of the primitive pine wood flora.

Scrophularia nodosa, L.
Digitalis purpurea, L.
Veronica officinalis, L.
Teucrium Scorodonia, L.
Ajuga reptans, L.
Ulmus montana, Stokes.
Alnus glutinosa, Medic.
Corylus Avellana, L.
Salix cinerea, L.
S. Caprea, L.
Populus tremula, L.
Orchis mascula, L.
Luzula vernalis, DC.
Carex pallescens, L.
C. sylvatica, Huds.
Holcus mollis, L.
H. lanatus, L.
Arrhenatherum avenaceum, Beauv.
Melica nutans, L.
M. uniflora, Retz.
Pteris aquilina, L.
Athyrium Filix-fœmina, Roth.

Several of the woodland plants may be found within the Alpine region, above 2000 feet, where the shelter of rocky ravines or crevices, or of heather or blaeberry, replaces that of the trees at lower elevations. The chief of these are given here, along with the highest altitudes recorded for them in White's *Flora*.

Anemone nemorosa, L.,	2750 ft.
Viola Riviniana, Reich,	2800 ft.
Lychnis dioica, L.,	2500 ft.
Hypericum pulchrum, L.,	2700 ft.
Geranium sylvaticum, L.,	3000 ft.
Oxalis Acetosella. L.,	2800 ft.
Spiræa Ulmaria, L.,	2900 ft.
Rubus Idæus, L.,	2450 ft.
R. saxatilis, L.,	3200 ft.
Geum rivale, L.,	3000 ft.
Pyrus Aucuparia, Ehrh.,	2850 ft.
Angelica sylvestris, L.,	2800 ft.
Adoxa Moschatellina, L.,	3000 ft.
Pyrola minor, L.,	3700 ft.
Vaccinium Myrtillus, L.,	3900 ft.
Lysimachia nemorum, L.,	2700 ft.
Trientalis europæa, L.,	2500 ft.
Veronica Chamædrys, L.,	2400 ft.
Melampyrum pratense, L.,	3000 ft.
Mercurialis perennis, L.,	3300 ft.
Urtica dioica, L.,	2750 ft.
Listera cordata, R. Br.,	2500 ft.
Luzula maxima, DC.,	2800 ft.
L. campestris, DC.,	3000 ft.
L. erecta, Desv.,	3350 ft.
Poa nemoralis, L.	

and most of the species of ferns found in the district.

Hill Pasture and Moorland.

The term hill pasture has been here somewhat restricted to mean those parts of the mountain area where grasses predominate. The green or yellow colour of the grasses stands out clearly in the landscape from the brown or purple heather, and thus two main types of hill can be readily distinguished.

The Breadalbane range is a good example of the green type, and the Rannoch mountains of the brown. These two types have been distinguished by different colours on the map, so that the area occupied by each may be compared with the formations shown on the geological maps. These differences in vegetation seem mainly due to differences in the physical and chemical nature of the subjacent rock and soil. Where the soil is poor in mineral salts, such as that formed by the disintegration of sandstones or quartzitic rocks, or that composed of almost pure peat, the plant association is poor in number of species, and heather and its associates predominate. Thus, if the botanical map be compared with the geological map, it will be seen that the greatest areas of heather coincide with the poor quartzitic hills of Rannoch and Atholl, whilst the greatest areas of pasture, on the other hand, coincide with the rich schists, containing calcium, magnesium, and potassium, of the Breadalbane range. Beinn a' Ghlo, Beinn a' Chuallich, Beinn Mholach, and Schiehallion are all good examples of the heather type on quartzitic rocks; Ben Lawers, and the hills north of Kirkmichael, of the grassy type on limestones, and chloritic and mica schists. Some of the smaller patches of pasture occur closely associated with outcrops of limestone, as, for example, beside Loch Moraig, on Tulach hill above Blair-Atholl, near Loch Tummel, and in Glen Lyon. In some other cases, such as in Glen Tilt, the chemical nature of the soil does not seem so important in producing the grass association as the regular conditions of moisture on the well-drained slopes of the narrow valley.

The conditions of development of the heather association, shortly stated, seem to be the presence of a peaty soil poor in mineral content, which may be dry and unretentive, or wet and stagnant. The grasses, on the other hand, require a soil rich in minerals, which is well-drained on the surface, and with a retentive bottom layer.

There are still, however, other causes which determine the presence of heather or of grass. Thus, much of the hill-land adjoining cultivation is pasture, and has evidently been produced from the heather area through the manuring, regular cropping, and treading of the sheep. Regular burning seems in certain parts, on the other hand, to have increased the area dominated by the heather. These, however, I believe to be quite secondary causes, and to act rather towards emphasising the natural contrast between the types than to greatly alter the areas of distribution.

Fuller discussion of these questions I reserve for a paper dealing with a wider area than is here being studied.

Heather Association.

The heather association has been discussed in some detail in Part I. Sufficient emphasis, however, has not been laid upon the relation between this association and the peaty soil in which it is developed.

The exact part played by this peat in the economy of the heather plant is still doubtful. Microscopic examination of the roots shows, however, that root-hairs are awanting, and that the rootlets are closely invested by the filaments of a fungus, which also penetrates their epidermal cells. There may be some co-operation between this root-fungus *(mycorhiza)* and the heather plant, which enables the heather to utilise the food-stuffs of the peculiar humus in which it grows. Be this as it may, it is enough for our present purpose to recognise that the presence of the peat with the associated mycorhiza is an important factor in determining the area of distribution of the heather plant.*

The following associates of the heather agree with it in requiring humus for their development, and in a number of these at least—the *Ericaceæ*, *Orchideæ*, and *Empetrum*—a mycorhiza has also been been found in connection with their roots :—

Peat plants in dry conditions.	Peat Plants in moist conditions.
Potentilla silvestris, Neck.	Rubus Chamæmorus, L. (Alpine).
Antennaria dioica, R. Br.	Schollera Oxycoccus, Roth.
Vaccinium Vitis-Idæa, L.	Erica Tetralix, L.
V. uliginosum, L. (Alpine).	Myrica Gale, L.
V. Myrtillus, L.	Empetrum nigrum, L.
Arctostaphylos Uva-ursi, Spreng.	Malaxis paludosa, Sw.
Calluna Erica, DC.	Juncus squarrosus, L.
Erica cinerea, L.	Rhynchospora alba, Vahl.
Loiseleuria procumbens, Desv. (Alpine).	Carex magellanica, Lam.
Pyrola rotundifolia, L. (Alpine).	C. limosa, L.
P. media, Sw.	Molinia varia, Schrank.
P. minor, L.	
P. secunda, L. (Alpine).	
Listera cordata, R. Br.	
Nardus stricta, L.	
Lomaria Spicant, Desv.	

Since preparing the list of frequent associates of the heather which is given in Part I., I have greatly added to my field-notes, and now extend that list by the following species :—

Anemone nemorosa, L.	Rumex Acetosa, L.
Oxalis Acetosella, L.	Salix aurita, L.
Lotus corniculatus, L.	S. repens, L.
Gnaphalium sylvaticum, L.	Listera cordata, R. Br.
Crepis virens, L.	Orchis maculata, L.
Hieracium Pilosella, L.	Habenaria conopsea, Benth.
Arctostaphylos Uva-ursi, Spreng	Carex echinata, Murr.
Pyrola media, Sw.	C. Goodenowii, J. Gay.
P. minor, L.	C. pilulifera, L.
Melampyrum pratense, L.	

* For further information on mycorhiza the reader is referred to Frank's *Lehrbuch der Botanik*, Vol. I., p. 264, etc., Leipzig (Engelmann), 1892.

As I have pointed out elsewhere,* three well-marked varieties of the heather associates can be distinguished, namely—heath, heather-moor, and *Sphagnum*-moor. The driest variety, heath, occurs on those hills with a poor and unretentive soil, especially on steep slopes with a southern exposure. It is well marked on the Rannoch hills, on Beinn a' Ghlo, and on parts of Schiehallion. It can be easily recognised by the presence of *Erica cinerea*, *Antennaria*, *Arctostaphylos*, *Genista*, *Potentilla silvestris*, etc. On wetter localities, especially poorly-drained slopes facing the north, such as also occur frequently amongst the Rannoch mountains, the association takes the form designated heather-moor. *Erica Tetralix*, *Molinia varia*, *Scirpus cæspitosus*, *Juncus squarrosus*, and in the lower parts *Myrica Gale* are the species by which it is indicated. With extreme moisture the heather-moor passes into the "*Sphagnum*-moor," where living *Sphagnum*, sedges, *Empetrum*, *Eriophorum*, etc., constitute the dominant vegetation. This association reaches a great development in the wild moor of Rannoch lying to the west of the area we are considering. It is found in all the peat-bogs within our area, and the chief of these which are already represented on the one-inch map of the Geological Survey have been differently coloured on this map to distinguish them from the general heather association.

The variety of the heather-moor characterised by an abundance of the bog-myrtle (*Myrica Gale*) occurs particularly on the lower slopes of the valleys, especially on the badly-drained clearings in the birch woods. It is largely made up of marsh species, being transitional in some ways between the heather-moor and the true marsh associations. The following list from a clearing near Loch Tummel will show its general composition:—

Ranunculus Flammula, L.
Viola palustris, L.
Potentilla silvestris, Neck.
Drosera rotundifolia, L.
Scabiosa Succisa, L.
Calluna Erica, DC. (Not common).
Erica Tetralix. (Abundant).
Pinguicula vulgaris, L.
Habenaria conopsea, Benth.
Narthecium Ossifragum, Huds.
Juncus lampocarpus, Ehrh.
J. acutiflorus, Ehrh.
Eriophorum vaginatum, L.
Carex pulicaris, L.
C. echinata, Murr.
C. ovalis, Good.
C. flacca, Schreb.
C. flava, L.
Molinia varia, Schrank. (Most abundant species after Myrica Gale).
Sphagnum, spp.

Grass Associations.

The grassy covering of the hills varies considerably in composition according to the particular conditions present, and quite a

* Botanical Survey of Scotland, I., Edinburgh District, 1900.

number of different grasses may predominate. The good mountain pasture is mainly composed of *Agrostis canina*, L., *A. vulgaris*, With., *Anthoxanthum odoratum*, L., and *Festuca ovina*, L. On the best pastures, especially those near the borders of cultivation, these species are largely mixed with such finer grasses as *Poa pratensis*, L., *P. trivialis*, L., and *Cynosurus cristatus*, L. *Nardus stricta*, L., approaches the heather in its requirements, as it seems to grow best on dry, poor soil, with a certain amount of peat always present. It forms an association in some ways intermediate between the heath and the dry pasture. The association dominated by *Molinia varia*, Schrank., is, on the other hand, intermediate between the heather-moor and the wet pasture, as it seems to prefer a wet, ill-drained, peaty soil. *Deschampsia (Aira) cæspitosa*, Beauv., *D. flexuosa*, Trin., and *Holcus lanatus*, L., are all characteristic of disturbed ground, such as clearings in woods; the first occurs particularly where the soil is clayey and wet, the second where it is dry and peaty, the third on the better-drained clearings.

A good example of the *Deschampsia flexuosa* association may be seen in the clearings of the pine and larch woods, such as occur above Blair-Atholl. On one such clearing, near Loch Moraig, with a dry, sandy soil, the ground which has been most disturbed is mainly peopled by—

Deschampsia flexuosa, Trin.	Cnicus lanceolatus, Willd.
Holcus lanatus, L.	Veronica Chamædrys, L.
Ranunculus acris, L.	Rumex Acetosella, L.
Rubus idæus, L.	Urtica dioica, L.

The grass species second in importance on this clearing is *Festuca ovina*, L., which seems to be gradually replacing the dominant *Deschampsia flexuosa*. With it are associated such pasture species as—

Viola Riviniana, Reich.	Veronica officinalis, L.
Cerastium triviale, Link.	V. Chamædrys, L.
Rosa canina, L. (seedlings).	Luzula vernalis, DC.
Galium saxatile, L.	L. campestris, DC.
Scabiosa Succisa, L. (in moister parts).	

Mixed with this pasture is a good deal of small heather, which may, on the poorest parts, replace the grasses. Where it grows it is usually associated with—

Polygala vulgaris, L.	Erica cinerea, L.
Potentilla silvestris, Neck.	Hypnum Schreberi, L.

A few species characteristic of shady places manage to compete with the invading species, as, for example—

Anemone nemorosa, L.
Spiræa Ulmaria, L.
Rubus saxatilis, L.
Trientalis europæa, L.

Seedlings of birch, in most cases browsed down to the ground by sheep or rabbits, are struggling to reinstate the arborescent vegetation.

The general flora of the pasture area is large. It includes almost all the species of the heather area and many others besides. The complete list may be easily constructed from White's *Flora of Perthshire*. Here two type lists will be given, one from the south slopes of Ben Lawers between 1000 and 1500 feet, and the other from pasture above limestone rock near Balnabodach on Loch Tummel.

Pasture plants on south slopes of Ben Lawers, between 1000 and 1500 feet:—

GRAMINEÆ.

*Anthoxanthum odoratum, L.
*Agrostis vulgaris, With.
A. canina, L.
*Festuca ovina, L. (Chief species).
*Deschampsia flexuosa, Trin.
Sieglingia decumbens, Bernh.
Cynosurus cristatus, L.
*Molinia varia, Schrank.
Poa pratensis, L.
*Nardus stricta, L.

OTHER FAMILIES.

*Ranunculus acris, L.
R. repens, L.
R. bulbosus, L.
*Viola Riviniana, Reich.
Polygala vulgaris, L.
*Sagina procumbens, L.
*Linum catharticum, L.
Trifolium pratense, L.
*T. repens, L.
*Lotus corniculatus, L.
*Lathyrus montanus, Bernh.
*Potentilla silvestris, Neck.
*Alchemilla vulgaris, L.
Pyrus Aucuparia, Ehrh. (seedlings).
*Galium saxatile, L.
*Scabiosa Succisa, L.
*Bellis perennis, L.
Habenaria viridis, R. Br.
H. bifolia, R. Br.
*Narthecium Ossifragum, Huds.
*Juncus squarrossus, L.
*Luzula campestris, DC.
*Achillea Millefolium, L.
Hieracium Pilosella, L.
*Taraxacum officinale, Web.
*Campanula rotundifolia, L.
*Vaccinium Myrtillus, L. (small and scattered).
*Calluna Erica, DC. (small and scattered).
Erica cinerea, DC. (small and scattered).
Gentiana campestris, L.
Veronica officinalis, L.
*Euphrasia officinalis, L.
*Thymus Serpyllum, Fr.
Prunella vulgaris, L.
*Plantago lanceolata, L.
*Rumex Acetosa, L.

* Also found in the Alpine pasture between 2000 and 3000 feet on Ben Lawers.

*R. Acetosella, L.
*Orchis maculata, L.
Habenaria conopsea, Benth.
H. albida, R. Br.
*Scirpus caespitosus, L.
*Carex pilulifera, L.
Pteris aquilina, L. (scattered).

Pasture plants near Balnabodach, Loch Tummel, with lime in soil. Altitude, 700 to 900 feet:—†

GRAMINÆA.

Kœleria cristata, Pers.
Cynosurus cristatus, L.
Festuca ovina, L.
Poa pratensis, L.
Holcus lanatus, L.

OTHER PLANTS.

Helianthemum Chamæcistus, Mill.
Polygala vulgaris, L.
Trifolium pratense, L.
T. repens, L.
T. dubium, Sibth.
Lotus corniculatus, L.
Rubus fruticosus, L.
Alchemilla vulgaris, L.
Rosa, sp.
Galium verum, L.
Galium saxatile, L.
Bellis perennis, L.
Chrysathemum Leucanthemum, L.
Hieracium Pilosella, L.
Gentiana campestris, L.
Euphrasia officinalis, L.
Thymus Serpyllum, L.
Plantago lanceolata, L.
Pteris aquilina, L. (scattered).

Alpine Region.

As already stated, the Alpine Region may be regarded as beginning at 2000 feet, about which altitude the last of the trees are found, and a number of the characteristic Sub-Alpine pasture and moorland species cease. The changes, however, are usually gradual, and it is often about 3000 feet before the Alpine features of the landscape become conspicuous. Between 2000 and 3000 feet the vegetation is generally a poor pasture or moorland, with patches of Alpine species at the sources and on the sides of the streams, or in the shelter of the crags.

An even sharper contrast than in the Sub-Alpine Region is here seen between the poor Rannoch and the rich Breadalbane mountains, for now the subjacent rocks contribute more to the actual surface soil, being less covered up by superficial glacial deposits. Three main types of mountain between these altitudes have been distinguished on the map. The first is grassy, with an association of

* Also found in the Alpine pasture between 2000 and 3000 feet on Ben Lawers.

† This list does not pretend to be so complete as the other, but only aims at showing the chief species of the association.

plants hardly differing from the pasture of the Sub-Alpine Region except in the abundance of *Alchemilla alpina*, L.. It includes all the Breadalbane mountains, and on the map no distinction in colour has been made between it and the Sub-Alpine pasture. On Ben Lawers many of the species, which elsewhere cease below 2000 feet, here mount nearly to 3000 feet. On the list given above for Ben Lawers, those hill pasture species which also occur in the Alpine Region are marked with an asterisk. They constitute more than half the number.

The second type of mountain is also largely covered with grasses, but with the blaeberry (*Vaccinium Myrtillus*) very much mixed with them, and heather is still very sparse. This has been distinguished on the map by a special colour, and will be seen to cover several of the Atholl and Glenalmond mountains, such as Ben Vrackie, Farragon, Auchnafree, etc. Ben Vrackie and Farragon resemble Ben Lawers very closely in their geological structure, and were they of greater altitude they might be expected to have a similar vegetation, with grasses dominating over *Vaccinium*.

The third type is still poorer. Grasses are here relatively rare, and peat plants in contrast dominate. Heather, although abundant, is nowhere in very good condition, and is partly superseded as dominant species by *Vaccinium Myrtillus*. This mixture has been indicated on the map by colouring this association the same as that of *Vaccinium Myrtillus*, and dotting the heather colour over it.

The species of the heather association which I have found still lingering on in the Alpine Region are given in the following list. To each species is added the highest altitude at which it has been recorded in Rannoch or Atholl; the figures have been taken from White's *Flora*, except in a few cases (indicated by the initials R. S.), where I have found the species at higher altitudes in those districts than are given in that work.

Hypericum pulchrum, L.,	2600 ft.
Oxalis Acetosella, L.,	3000 ft.
Lotus corniculatus, L.,	2800 ft.
Potentilla silvestris, Neck.,	2900 ft.
Galium saxatile, L., (R. S.)	2700 ft.
Scabiosa Succisa, L.,	2600 ft.
Antennaria dioica, R. Br.,	2850 ft.
Campanula rotundifolia, L.,	3000 ft.
Vaccinium Myrtillus, L., (R. S.)	3600 ft.
V. Vitis-Idæa, L.,	3540 ft
Arctostaphylos Uva-ursi, Spreng.,	2350 ft.
Calluna Erica, DC.,	3100 ft.
Pyrola minor, L.,	over 2000 ft. (R. S.) 3700 in Breadalbane
Euphrasia officinalis, L.,	3000 ft.
Melampyrum pratense, L.,	3000 ft.
Thymus Serpyllum, L.,	2850 ft.
Rumex Acetosa, L.,	3757 ft.
R. Acetosella, L., in Breadalbane.	3300 ft.
Salix aurita, L.,	2600 ft.
S. repens, L.,	2800 ft.

Empetrum nigrum, L., (R. S.)	3600 ft.
Orchis maculata, L.,	2650 ft.
Juncus squarrosus, L.,	3000 ft.
Luzula campestris, DC.,	
Eriophorum vaginatum, Roth.,	3000 ft.
Carex pilulifera, L.,	2850 ft.
C. binervis, Sm.,	2600 ft.
Anthoxanthum odoratum, L.,	2800 ft.
Agrostis vulgaris, With., (R. S.)	2600 ft.
Deschampsia flexuosa, Trin.,	3700 ft.
Festuca ovina, L.,	"at all levels"
Nardus stricta, L., (R. S.)	2600 ft.
Lomaria Spicant, Desv.,	3000 ft.
Lastræa dilatata, Presl.,	3450 ft.
Lycopodium Selago, L., (R. S.)	3600 ft.
L. clavatum, L.,	2760 ft.
L. alpinum, L.,	3547 ft.

In addition to those species certain others are found which are almost peculiar to the heather and *Vaccinium* association between 2000 and 3000 feet. The chief of these are:—

Rubus Chamæmorus, L.

Cornus suecica, L.—This, as has already been pointed out by Dr. White, is in almost all its stations associated with *Vaccinium Myrtillus*, L.

Vaccinium uliginosum, L.

Loiseleuria procumbens, Desv.

Betula nana, L.

Lycopodium annotinum, L.

Above 3000 feet, and even on bare exposed places at lower elevations, such as the summits of hills, the ground is usually stony and sparsely covered with vegetation. Mosses and lichens dominate, in particular the woolly fringe-moss (*Racomitrium lanuginosum*), which on many of the steep mountain rubbles or "screes" forms the peat on which the Alpine humus plants develop. Stunted plants of *Empetrum*, *Vaccinium*, spp., *Lycopodium Selago*, are still frequent, and in addition certain species peculiar to these mountain ridges, such as—

Potentilla Sibbaldi, Hall, fil.
Gnaphalium supinum, L.
Salix herbacea, L.
Juncus trifidus, L.
Carex rigida, Good.

The characteristic Alpine flora is, however, mainly confined to the sheltered crags and wet places about 3000 feet. Its distribution, like that of the Alpine pasture and moorland, seems largely to depend on the physical and chemical nature of the rock giving rise to the soil. The comparative wealth of the Breadalbane range in Alpine species has long been well known, and as was pointed out by Mr. P. Macnair in 1898, the richest area corresponds to certain strata of sericite (chloritic) schist which run in a south-west to north-east direction through this district.

The following tables will illustrate the distribution of the Alpine flora throughout the district included in the map. Most of the localities required for their preparation have been obtained from White's *Flora*.

I. Species found on all three classes of mountain shown on the map, which are, however, most abundant on the Ben Lawers type.

Thalictrum alpinum, L.
Draba incana, L.
Cochlearia officinalis, var. alpina, Wats.
Silene acaulis, L.
Potentilla rubens, Vill.
P. Sibbaldi, Hall, fils.
Alchemilla alpina, L.
Saxifraga oppositifolia, L.
S. stellaris, L.
S. aizoides, L.
S. hypnoides, L.
Sedum roseum, Scop.
Epilobium alsinefolium, L.
E. anagallidifolium, Lam.
Cornus suecica, L.
Galium sylvestre, Poll.
Gnaphalium supinum, L.
Saussurea alpina, DC.
Vaccinium uliginosum, L.
Loiseleuria procumbens, Desv.
Oxyria digyna, Hill.
Betula nana, L.
Salix Lapponum, L.
S. herbacea, L.
Tofieldia palustris, Huds.
Juncus trifidus, L.
J. triglumis, L.
Luzula spicata, DC.
Carex pauciflora, Lightf.
C. rigida, Good.
Poa alpina, L.
Aspidium Lonchitis, Sw.
Pseudathyrium alpestre, Newm.

II. Species almost or quite confined to the Ben Lawers type of mountain.

Arabis petræa, L.
Draba rupestris, Br.
Erophila vulgaris, var. inflata, Hook. Also in Rannoch.
Cochlearia micacea, Marshall.
Cerastium alpinum, L. Also in Atholl.
C. arcticum, Lange.
C. trigynum, Vill.
Arenaria verna, L.
A. sulcata, Schlecht.
Cherleria sedoides, L.
Sagina Linnæi, Presl.
S. nivalis, Fr.
Oxytropis uralensis, DC. Also on Ben Vrackie.
Dryas octopetala, L. Also in Glen Tilt.
[Chiefly on calcareous rocks].
Saxifraga nivalis. Rare in Rannoch.
Saxifraga rivularis, L.
S. cernua, L.
S. grœnlandica, L.*
S. quinquefida, Haworth.
Sedum villosum, L.
Erigeron alpinum, L.
Gentiana nivalis, L.
Myosotis alpestris, Schmitt.
Veronica alpina, L. Also from Glen Tilt, and near Dalnaspidal.

* Ben Lawers (Druce, *Ann. Scott. Nat. Hist.*, 1898, p. 243).

V. fruticans, Jacq. Also from Glen Tilt.
Bartsia alpina, L.
Salix Arbuscula, L.
S. lanata, L.
S. Myrsinites, L. Also from Schiehallion, Craig Chailleach, and Blair Atholl.
S. reticulata, L.
Juncus alpinus, Vill. Also from the Atholl Mountains.
J. castaneus, Sm.
J. biglumis, L.
Kobresia caricina, Willd. Also on Ben Vuroch [Brebner].
Carex rupestris, All.
C. alpina, Sw.
C. atrata, L. Also on Farragon
C. ustulata, Whnl.
C. pulla, Good.
C. Grahami, Boott.
Phleum alpinum, L.
Deschampsia alpina, R. and S. Also on Beinn a' Ghlo.
Sesleria cærulea, Ard.
Poa glauca, Sm.
P. Balfourii, Parnell.
Woodsia hyperborea, Br.
Cystopteris montana, Link.
Pseudathyrium flexile, Newm.

III. Species not found on the Ben Lawers type of mountain.

Thlaspi alpestre, L.—Beinn a' Chuallich, on limestone.
Astragalus alpinus, L.—Ben Vrackie. This mountain approaches very near to the Ben Lawers type.
Phyllodoce cærulea, Bab.—Sow of Atholl.
Alopecurus alpinus, Sm.—Glen Tilt.

It was with some degree of hesitation that I decided to publish this second sheet, since, owing to the nature of the country and the prevailing climatic conditions, a uniform accuracy of detail in the survey of such an extensive area cannot be obtained without much labour and a considerable expenditure of time. To reduce or remove any error that might have arisen from this cause, I have made out lists of questions concerning the more difficult areas, and have sent them to correspondents in the district capable of making the requisite observations. In this way I have obtained two or more reports on each doubtful area, and with these have checked my own notes. Some errors are undoubtedly still to be found, but I trust they are small and do not affect the main features of the survey.

It is necessary to note that for the employment of this map in the field some little practice will be required to read the different aspects of the landscape. Thus, for example, a hill, which, as seen from one part on it, may appear heather-clad, may be found when viewed as a whole, or when traversed and carefully examined, to be really of the grassy type. The character of a doubtful hill has usually to be judged, both by a series of classified lists made at different parts, and by the general aspect as seen from a neighbouring hill.

For assistance in making observations or in distributing my lists of questions I have to thank the following ladies and gentlemen:—Miss M'Farlane, Turrerich, Glen Quaich; Mrs. A. Reid, Trinity

College, Glen Almond; Mr. Alex. Farquharson, Bridgend of Straloch; Mr. R. N. Kerr, University College, Dundee; Mr. John M'Donald, Amulree; Mr. Charles M'Intosh, Inver, Dunkeld; Mr. D. M'Naughton, Chesthill, Glenlyon; Mr. G. M'Pherson, Dalnacardoch, Calvine; Mr. James D. Ramsay, Banff; Mr. A. M. Rodger, Natural History Museum, Perth; and my brother, Dr. William G. Smith, Yorkshire College, Leeds.

I have in particular to acknowledge my great indebtedness to Mr. J. G. Bartholomew, who has not only taken much trouble in the reproduction of the map, but has in addition given me much invaluable advice regarding methods of survey and of cartographic representation.

REFERENCES.

Flahault, Ch. Essai d'une Carte Botanique et Forestière de la France. Annales de Géographie. Nr. 28, 1897, pp. 289-312 (avec une carte).

Fliche, P. Un Reboisement. Ann. de la Sc. agronomique française et etrangère. Tome I., 1888. 56 pp.

Hunter, Thomas. Woods, Forests, and Estates of Perthshire. Perth (Henderson, Robertson, & Hunter), 1883.

Macnair, P. The Geological Factors in the Distribution of the Alpine Plants of Perthshire. Trans. Perthshire Soc. Nat. Sc., Vol. II. (1893-98), pp. 240-249.

White, F. Buchanan. The Flora of Perthshire. Perth (Perthshire Soc. Nat. Sc.), 1898.

[Almost the last work of Mr. Smith was to revise and return the proof of the foregoing paper. In a letter which accompanied it he expressed a desire to see it in page form and to give it a final revisal. This, however, was not to be, for another day brought his all too brief life to a close.

Mr. Smith was passionately fond of field botany from early boyhood. This constant practice in the field, combined with a thorough scientific training, had rendered him an accomplished botanist. He took up the subject of Plant Associations with enthusiasm, and had planned a Botanical Survey of the whole of Scotland. What he actually accomplished is wonderful when we consider the amount of labour which it required, and that all of it had to be done in holidays and in spare time. Each year's experience, too, was always making him fitter for the work, so that every future survey would have been more thorough, more accurate, and more valuable than those which preceded. Those who knew him, and who were best able to judge, fully expected that his great ability and his unwearied ardour would enable him to take high rank amongst Scottish Botanists. But this hope has been doomed to disappointment. His career, so full of promise, was brought to a sudden end. Such an issue to such a life seems hard to short-sighted mortals, but it is useless to repine. We can only deplore, and sadly contrast what is with what might have been.

In the death of Robert Smith Scottish Botany has suffered a serious loss.—Editor.]

XII.—*A Contribution to the List of Perthshire Spiders.*

By WILLIAM EVANS, F.R.S.E.

(Read 12th April, 1900.)

The 1890-91 part of the *Transactions* of this Society (Vol I., pp. 207-221) contains an excellent paper by Professor J. W. H. Trail "On Spiders, with a List of Perthshire Species." In that List, which, in the author's own words, "must be regarded as a mere commencement of the subject," seventy species taken in the county, mostly by himself, are recorded.

The number of species of Spiders inhabiting Perthshire is in all probability not less than two hundred and fifty, but until the subject is thoroughly taken up by a resident naturalist anything approaching a complete list of them cannot be expected. Occasional visitors, like myself, to the county can only offer contributions to the list, such as that I now have the pleasure of submitting.

In the course of the past ten years I have made small collections of Spiders in the neighbourhoods of the following Perthshire localities, namely, Bridge of Allan, Callander, Aberfoyle, Comrie, Blair-Atholl, and Glen Farg: a few specimens have also been picked up in one or two other places. The number of species obtained amounts, I find, to one hundred and forty-five. Many of them are, no doubt, common, and generally distributed in the county, but in the present state of our knowledge of the subject I have thought it well to give my localities in every case. Prof. Trail's specimens were nearly all obtained at Dunkeld. Three of the localities in which I have collected, namely, Bridge of Allan, Callander, and Aberfoyle, are in the Forth drainage area, and most of my records from them have already been published in a paper on the Spiders of "Upper Forth," by Mr. G. H. Carpenter and myself (Ann. Scot. Nat. Hist., 1897). Besides the species taken by myself, the annexed list includes six others of which published records (not mentioned by Professor Trail) are known to me.

Of the one hundred and fifty-one species in the present list, ninety-five are additions to the list appended to Professor Trail's paper, three of them being, moreover, new to science in the opinion of the Rev. O. P. Cambridge, who is naming and describing them in the "Proceedings" of the Dorset Natural History and Antiquarian Field Club. On the other hand, Prof. Trail obtained fourteen species which I have not met with.*

* These are.—*Theridion denticulatum*, Wlk., *T. varians*, Hahn, *T. pictum*, Hahn, *Erigone pascalis* (Cb.), *Troxochrus scabriculus* (Westr.), *Diplocephalus beckii* (Cb.), *Linyphia hortensis*, Sund., *Singa pygmæa* (Sund.), *Epeira scalaris*, Wlk., *Xysticus lanio*, C.L.K., *Philodromus elegans*, Bl., *Trochosa picta* (Hahn), *Lycosa monticola* (C.L.K.), and *Heliophanus cupreus* (Wlk.).

The total number of species that have now been recorded from Perthshire is therefore one hundred and sixty-five.

I am deeply indebted to the Rev. O. P. Cambridge, F.R.S., and Mr. G. H. Carpenter, B. Sc., for much help in the determination of the specimens: all rare or critical forms, as well as examples of most of the common ones, have been submitted to one or other of these naturalists.

The nomenclature and arrangement here employed are the same as in recent papers by Mr. Carpenter and myself on the Spiders of the Edinburgh District and other parts of Scotland.

LIST OF SPECIES.

Those that have already been recorded for the county, in Prof. Trail's list, are marked with an asterisk.

DYSDERIDÆ.

**Harpactes hombergii* (Scop.)—Trossachs, July, 1861 (Rev. O. P. Cambridge, *Zoologist*, 1862, and *Entomologist*, 1877).

**Segestria senoculata* (Linn.)—Bridge of Allan, Callander, Aberfoyle, Rannoch, Blair-Atholl, Glen Farg; common.

**Oonops pulcher*, Templ.—Aberfoyle, September, 1897; Glen Farg, September, 1899, a good many.

DRASSIDÆ.

**Micaria pulicaria* (Sund.)—Pass of Aberfoyle, April, 1896, ♀; Foot of Loch Katrine, April, 1900, ♂.

Gnaphosa anglica (Cambr.)—Head of Glen Fender, near Blair-Atholl, September, 1899, a good many under stones on a bare moorland spot.

Drassus troglodytes, C.L.K.—Aberfoyle, Glen Tilt, and on the Ochils near Glen Farg.

Drassus sylvestris, Bl.—An imm. ♀ *Drassus* from Blair-Atholl, September 1898, is referred by Mr. Cambridge to this form.

Drassus cupreus, Bl.—Callander, Aberfoyle, Loch Chon, Blair-Atholl, Glen Farg; common.

CLUBIONIDÆ.

Clubiona terrestris, Westr.—Bridge of Allan, Callander, Aberfoyle, Fenderbridge near Blair-Atholl; common.

Clubiona reclusa, Cb.—Callander and Aberfoyle; ad. ♀s in June and September, ad. ♂ in September, 1897.

Clubiona pallidula, Clk.—Callander, an ad. ♂, May, 1889.

Clubiona phragmitis, C.L.K. (*C. holosericea*, De G.?, Cambr.)—Callander, an ad. ♀, May, 1894; and an immature ♀ probably of this species was taken at Aberfoyle in September, 1897.

**Clubiona compta*, C.L.K.—Aberfoyle, May, 1896, and other dates.

Clubiona trivialis, L.K.—Callander and Aberfoyle, common; Fenderbridge.

**Clubiona diversa*, Cb.—Bridge of Allan, December, 1893, several adults of both sexes; Aberfoyle; Fenderbridge.

**Chiracanthium carnifex* (F.)—Callander, Aberfoyle, and Trossachs, not uncommon on heather; adults in May.

Zora spinimana (Sund.)—Aberfoyle, common among dead leaves in oak woods; adults in April and May, 1896.

**Anyphæna accentuata* (Wlk.)—Aberfoyle, a good many beaten off oaks; some adults in May.

Agroëca brunnea (Bl.)—Aberfoyle, a few adults in September, 1897.

DICTYNIDÆ.

**Dictyna arundinacea* (L.)—Callander, Aberfoyle, Blair-Atholl, Comrie, Glen Farg; common.

**Amaurobius fenestralis* (Str.)—Callander, Aberfoyle, Rannoch, Blair-Atholl, Glen Farg; common.

Amaurobius similis (Bl.)—Callander, Fenderbridge (ad. ♂), Glen-Farg.

AGELENIDÆ.

**Cryphœca sylvicola* (C.L.K.)—Bridge of Allan, Callander, Fenderbridge, Glen Farg; not uncommon. Has been recorded from Rannoch by the Rev. O. P. Cambridge.

**Tegenaria derhamii* (Scop.)—Callander, Aberfoyle, Comrie, Rannoch, Blair-Atholl, Glen Farg; the common house spider.

**Textrix denticulata* (Oliv.)—Callander, Aberfoyle, Rannoch, Blair-Atholl, Glen Farg; common.

Hahnia elegans (Bl.)—Glen Tilt, September, 1898, several adults of both sexes under stones in a wet, mossy spot.

Hahnia nava (Bl.)—Aberfoyle, July, 1900, ad. ♀.

**Hahnia montana* (Bl.)—Glen Tilt, September, 1898, ad. ♂; Glen Farg, September, 1899, several.

THERIDIIDÆ.

**Ero furcata* (Vill.)—Aberfoyle, May, 1897; Fenderbridge, September, 1898. This is the *Ero thoracica* of Prof. Trail's list.

Episinus truncatus, Wlk.—In April, 1896, I took a ♂ and 2 ♀s, not quite adult, near Aberfoyle, as recorded in "Annals Scot. Nat.

Hist.," 1897, p. 229. This seems to be the only occasion on which the species has been detected in Scotland.

**Theridion lineatum* (Clk.)—Callander, Aberfoyle, Fenderbridge, Glen Farg, Luncarty.

Theridion tepidariorum, C.L.K.—In orchid-houses, Bridge of Allan, December, 1893.

**Theridion sisyphium* (Clk.)—Callander, Aberfoyle, Comrie, Rannoch, Blair-Atholl, Glen Farg; common.

**Theridion pallens*, Bl.—Callander, May, 1894, a good many adults; Aberfoyle.

Pholcomma gibbum (Westr.)—Aberfoyle and Fenderbridge, Sept., a few of both sexes adult.

Pedanostethus lividus (Bl.)—Callander, Aberfoyle, Comrie, Fenderbridge; common.

Tapinopa longidens (Wid.)—Taken by the Rev. O. P. Cambridge near the head of Loch Katrine in July, 1861 (*Zoologist*, 1862).

Bolyphantes luteolus (Bl.)—Aberfoyle, Fenderbridge, and Glen Tilt (Forest Lodge); not common.

Bolyphantes alticeps (Sund.)—Falls of Tummel, 29th September, 1898, a few adults of both sexes obtained.

Drapetisca socialis (Sund.)—Aberfoyle and foot of Glen Tilt. Recorded from the Trossachs by Mr. Cambridge.

**Linyphia insignis*, Bl.—Bridge of Allan, Aberfoyle (common), and Blair-Atholl.

**Linyphia lineata* (L.)—Trossachs, July, 1861 (Mr. Cambridge). This is the *L. bucculenta* of Prof. Trail's list.

Linyphia clathrata, Sund.—Bridge of Allan, Aberfoyle, and Killiecrankie; adults in May, September, and December.

Linyphia marginata, C.L.K.—Found by the Rev. O. P. Cambridge, "in angles and interstices of the rocky banks" of Loch Katrine, 1st July, 1861 (*Zoologist*, 1862, and *Entomologist*, 1877). There seems to be no other record of the species from Scotland.

Linyphia montana (Clk.)—Callander, May, 1894, and Blair-Atholl, September, 1898, a few beaten out of juniper bushes. Is recorded from Rannoch by Mr. H. C. Young (Proc. Nat. Hist. Soc., Glasgow, Vol., III., p. 351).

**Linyphia triangularis* (Clk.)—Callander, Aberfoyle, Comrie, Rannoch, Blair-Atholl, Falls of Bruar, Glen Farg; common.

Linyphia peltata, Wid.—Bracklyn Falls and Pass of Leny, near Callander, and at foot of Glen Tilt; not uncommon.

**Linyphia pusilla*, Sund.—Callander, Aberfoyle (common), Rannoch (O.P.C.), Blair-Atholl, Glen Farg.

**Labulla thoracica* (Wid.)—Bridge of Allan, Callander, Aberfoyle, Falls of Bruar (September, 1898).

**Leptyphantes minutus* (Bl.)—Bridge of Allan, Trossachs (O.P.C.), Falls of Tummel (September, 1898, several adults).

Leptyphantes terricola (C.L.K.)—Bridge of Allan, Callander, Blair-Atholl.

Leptyphantes obscurus (Bl.)—Callander and Aberfoyle; a few specimens only.

**Leptyphantes expunctus* (Cb.)—*Linyphia lepida* of Prof. Trail's list. Females of this interesting species were common on juniper bushes on a hillside close to Blair-Atholl in the end of September, 1898. Only a very few males were obtained.

Leptyphantes cristatus, Menge.—Bridge of Allan, an adult male, December, 1893.

Leptyphantes blackwallii, Kulcz. (*Linyphia zebrina*, Cambridge's "Spiders of Dorset")—Aberfoyle and Fenderbridge.

**Leptyphantes tenuis* (Bl.) (*Linyphia tenebricola*, Cambridge's "Spiders of Dorset")—Callander, Aberfoyle, Blair-Atholl, Glen Farg; common.

Leptyphantes ericæus (Bl.)—Aberfoyle and Glen Tilt.

**Bathyphantes variegatus* (Bl.)—Callander, Aberfoyle, Comrie, Glen Fender. Glen Tilt; common.

Bathyphantes concolor (Wid.)—Callander, Aberfoyle, Rannoch (O.P.C.)

Bathyphantes approximatus (Cb.)—Common at a swamp between Callander and Doune, May, 1894.

Bathyphantes nigrinus (Westr.)—Aberfoyle, a few specimens only.

Bathyphantes dorsalis (Wid.)—Callander, Aberfoyle, Comrie, Rannoch (O.P.C.)

Bathyphantes gracilis (Bl.)—Aberfoyle, a few (including an ad. ♂), taken in September, 1897.

Porrhomma pygmæum (Bl.)—Hill behind Bridge of Allan, Dec., 1893, several (including an ad. ♂); Glen Farg, September, 1899, a few ad. ♂s; Callander, April, 1900, ♂ and ♀.

Hilaira uncata (Cb.)—In September, 1898, I took two adult males of this rare spider under stones at the foot of Beinn a' Ghlo. They were determined for me by Mr. Carpenter, and Mr. Cambridge has also examined one of them.

Tmeticus hardii (Bl.)—On 23rd September, 1898, I found an adult male of this interesting species running on a wire fence near Fenderbridge, Blair-Atholl. Hitherto it has been known in this country only from East Lothian, Berwickshire, and Cambridgeshire. Identification confirmed by Mr. Carpenter.

Tmeticus abnormis (Bl.)—Callander, May, 1889, May, 1894, and April, 1900, three; Loch Chon, April, 1896, one: all adult females.

Tmeticus rufus (Wid.)—Bridge of Allan, Callander, Aberfoyle, Loch Katrine (O.P.C.), Luncarty.

Tmeticus huthwaitii (Cb.)—Aberfoyle, May, 1896, one; Callander, April, 1900, one; both adult females.

**Tmeticus bicolor* (Bl.)—Bridge of Allan, Callander, Fenderbridge (common in September, 1898). Of var. *concinnus*, Thor.—by some authorities considered a distinct species—three examples (ad. ♂s) were taken at Fenderbridge in September, 1898.

**Microneta fuscipalpis* (C.L.K.)—Aberfoyle and Fenderbridge.

Microneta innotabilis (Cb.)—Bridge of Allan, Aberfoyle. The few examples found were all females.

Microneta viaria (Bl.)—Bridge of Allan, Callander, Aberfoyle.

Sintula sp. nov.—Mr. Cambridge is describing as the type of a new species a small female spider of this genus which I got at Comrie in April, 1899.†

Gongylidium rufipes (Sund.)—Head of Glen Fender, 26th Sept., 1898, two examples (ad. ♀s) under stones.

Gongylidium dentatum (Wid.)—Callander and Aberfoyle, four specimens (♂ and 3 ♀s).

Gongylidium fuscum (Bl.)—Aberfoyle, May, 1896, one; Callander, April, 1900, one; both females.

Gongylidium sp. nov.—A female *Gongylidium*, taken at Comrie in April, 1899, is being described by Mr. Cambridge as new to science.‡

Gongylidium retusum (Westr.)—Fenderbridge, September, 1898, two adult males.

Gongylidium apicatum (Bl.)—On 4th May, 1896, three examples (2 ♂s and a ♀) were taken among shingle at the side of the Duchray Water, a little beyond the Milton of Aberfoyle.

**Erigone atra*, Bl.—Callander, Aberfoyle, Fenderbridge, Glen Farg.

Erigone longipalpis (Sund.)—Blair-Atholl, Sept., 1898, one male.

**Erigone promiscua* (Cb.)—One (♂) taken at Blair Atholl, Sept., 1898, and another at Callander in April, 1900.

Erigone dentipalpis (Wid.)—Callander and Aberfoyle.

Lophomma punctatum (Bl.)—In marsh between Callander and Doune, May, 1894, one specimen, ♀.

**Neriene rubens*, Bl.—Bridge of Allan, Callander, Aberfoyle, Fenderbridge, Glen Farg, Methven; common.

Neriene rubellum, Bl.—Aberfoyle, Sept., 1897, a few adult males.

Gonatium bituberculatum (Wid.)—Near Doune, and at Aberfoyle.

Dismodicus bifrons (Bl.)—Near Callander, May, 1894, an ad. ♂ and several ♀s.

Typhocrestus dorsuosus (Cb.)—An adult male of this rare form was found on a fence at Fenderbridge, near Blair-Atholl, 23rd September, 1898. Determined for me by Mr. Cambridge.

**Lophocarenum nemorale* (Bl.)—Several adults of both sexes found among lichen on a dead tree at head of Glen Fender.

†*Sintula nescia*, Cambr., Proc. Dorset Field Club, Vol. XXI. (1900), pp. 19, 22, 32.

‡*Gongylidium gibbum*, Cambr., *loc. cit.*, pp. 19, 22, 33.

Cnephalocotes obscurus (Bl.) = *Walckenaëra obscura*, Blackwall's "Spiders of Great Britain and Ireland."—A small adult male spider which I obtained in Glen Farg on 21st September, 1899, belongs, Mr. Cambridge informs me, to this rare species. The only previous record of its occurrence in Scotland seems to be that of the late Morris Young from Renfrewshire ("Annals Scot. Nat. Hist.," 1894, p. 185). Quite recently (March, 1900) I took another example near Edinburgh.

**Savignia frontata*, Bl.—Bridge of Allan, Callander, Fenderbridge, Glen Farg.

Peponocranium ludicrum (Cb.)—Callander, Aberfoyle, Blair-Atholl.

**Diplocephalus cristatus* (Bl.)—Aberfoyle, April, 1896, an ad. ♂.

Diplocephalus permixtus (Cb.)—Aberfoyle and Glen Fender.

Diplocephalus fuscipes (Bl.)—Aberfoyle, Callander, Comrie, Blair-Atholl.

Diplocephalus alpinus (Cb.)—Aberfoyle, an adult male taken in April, 1896.

Tapinocyba? sp. nov.—In September, 1899, I took in Glen Farg a small male spider, which Mr. Cambridge believes is new to science, and which, while closely allied to *Tapinocyba*, will probably have to be made the type of a new genus. It will be described and figured by him in this year's *Proceedings* of the Dorset Natural History and Antiquarian Field Club.†

Wideria antica (Wid.)—Aberfoyle, April, 1896, one ♀.

Walckenaëra acuminata, Bl.—Bridge of Allan, Callander, Aberfoyle, Glen Tilt, Glen Farg.

Walckenaëra nudipalpis (Westr.)—Callander, April, 1900, one ♀.

Ceratinella brevis (Wid.)—Bracklyn and Leny, near Callander, several of both sexes.

Ceratinella brevipes (Westr.)—Aberfoyle, two ♀s; Callander, an adult ♂.

Maso sundevalii (Westr.)—Bridge of Allan, one ♀.

EPEIRIDÆ.

**Pachygnatha clerckii*, Sund.—Callander, Aberfoyle, Blair-Atholl.

**Pachygnatha degeerii*, Sund.—Bridge of Allan, Callander, Aberfoyle, Comrie, Fenderbridge, Glen Farg.

Meta menardi (Latr.)—In April, 1896, I found this fine spider in some numbers in Rob Roy's Cave, Loch Ard. In June, 1861, Mr. Cambridge obtained specimens at the foot of Ben A'an, Trossachs.

**Meta segmentata* (Clk.)—Callander, Aberfoyle, Comrie, Blair-Atholl, Glen Farg; common.

**Meta merianæ*, Scop.—Callander, Aberfoyle, Falls of Tummel.

**Tetragnatha extensa* (L.)—Callander, Aberfoyle, and Ochils near Glen Farg.

Tetragnatha pinicola, L.K.—In May, 1896, I took an ad. ♂ of

†*Evansia merens*, Cambr., Proc. Dorset Field Club, Vol. XXI. (1900), pp. 19, 23, and 38.

this form on the high moor between Aberfoyle and the Trossachs. Named for me by Mr. Cambridge.

Tetragnatha solandrii, Scop.—One on a gate a couple of miles east of Callander, April, 1900.

Singa hamata (Clk.)—Moor behind Callander Hydropathic, May, 1894, eight examples; between Aberfoyle and Trossachs, May, 1896, a number of females, some adult. Rare in Britain.

Zilla x-notata (Clk.)—Callander, one specimen ("Annals Scot. Nat. Hist.," 1893, p. 224).

**Zilla atrica* (C.L.K.)—Bridge of Allan, Callander, Aberfoyle Falls of Tummel, Fenderbridge, Glen Farg; common.

**Epeira cucurbitina* (Clk.)—I have taken this pretty green spider at Callander, Aberfoyle, and Falls of Bruar; and it is recorded from Rannoch by Mr. Cambridge.

**Epeira diademata* (Clk.)—Callander, Aberfoyle, Fearnan (Loch Tay), Blair Atholl, Glen Farg; common.

**Epeira cornuta* (Clk.)—Callander, Aberfoyle, and Loch Moraig near Blair-Atholl.

**Epeira quadrata* (Clk.)—This fine species is a particular favourite of mine, and I have noted its presence at Callander, Aberfoyle, Fearnan, Rannoch. Falls of Bruar, and on the Ochils west of Glen Farg. In the last-named locality it was common in rushy hollows in September, 1899.

**Epeira umbratica* (Clk.)—Blair-Atholl and Glen Farg, a few under loose bark on dead trees.

THOMISIDÆ.

**Xysticus cristatus* (Clk.)—Callander, Aberfoyle, Comrie, Fearnan, Blair-Atholl, Glen Farg, Luncarty; common.

Xysticus sabulosus (Hahn).—On 21st September, 1898, I captured an adult male of this uncommon species at an elevation of close on 3000 ft. on Carn Liath, Ben-a-Ghlo. It is a remarkably dark specimen, being nearly black, and Mr. Cambridge, who has confirmed my identification, tells me it is the darkest he has seen.

Xysticus bifasciatus (C.L.K.)—Two examples on bog-myrtle, Pass of Aberfoyle, September, 1897.

**Oxyptila trux* (Bl.)—Callander and Aberfoyle.

Oxyptila atomaria (Panz.)—Aberfoyle and Glen Tilt.

Philodromus lineatipes, Cb.—Taken in "Perthshire" by Mr. J. J. King (*Proc.* Glasgow Nat. Hist. Soc., III., p. 352, and Spid. Dors., p. 538).

**Philodromus aureolus* (Clk.)—Callander, Aberfoyle, Tulloch Hill (Blair-Atholl), and Falls of Bruar. Mr. Cambridge has recorded *P. cœspiticolis*, Wlk., which does not seem to be specifically distinct from the present form, from Rannoch.

Tibellus oblongus (Wlk.)—Loch Chon, April, 1896, and Aberfoyle, September, 1897; a few specimens only.

LYCOSIDÆ.

**Ocyale mirabilis* (Clk.)—I have taken this handsome species at Aberfoyle, Comrie, and Falls of Bruar.

Dolomedes fimbriatus (Clk.)—Taken at Loch Rannoch in 1858 by Mr. Foxcroft (*Entomologist*, 1877, p. 204). There seems to be no other Scottish record of this remarkably fine species. It is one of the largest of British spiders.

Pirata piraticus (Clk.)—Aberfoyle, Comrie, Fearnan, Glen Tilt, Methven Bog, Glen Farg; common.

Trochosa leopardus (Sund.)—One male under a stone in a marshy spot at Pass of Aberfoyle, April, 1896.

**Trochosa ruricola* (De G.)—Aberfoyle, April and May, 1896, two adult females.

**Trochosa terricola*, Thor.—Callander, Aberfoyle, Glen Fender, Glen Farg.

Trochosa pulverulenta (Clk.)—Callander, Aberfoyle, Comrie, Fearnan, Glen Fender, Schiehallion (O.P.C.); common.

**Trochosa andrenivora* (Clk.)—Aberfoyle, Ben A'an (O.P.C.), Fenderbridge, Glen Farg.

**Trochosa cinerea* (F.)—I have taken this fine species on sand and shingle banks by the Earn near Comrie, and by the Garry near Blair-Atholl. Adults are among the largest of British spiders.

Lycosa amentata (Clk.)—Callander, Aberfoyle, Comrie, Loch Tay, Ben Alder, Blair Atholl, Glen Farg, Luncarty; common.

Lycosa agricola, Thor.—Common on shingle, Duchray Water, above Milton of Aberfoyle, May, 1896; shores of Loch Rannoch, 1861 (O.P.C.)

Lycosa trailii, Cb.—In September, 1898, I captured a not quite mature male of this interesting species on Carn Liath, Beinn a' Ghlo, at an elevation of about 2500 feet.

Lycosa lugubris, Wlk.—Callander, Aberfoyle, Comrie, Trossachs (O.P.C.); abundant in the oak woods in warm, sunny days in May and June.

Lycosa pullata (Clk.)—Callander, Aberfoyle, Comrie, Fearnan, Ben Alder, Blair-Atholl, Glen Farg, Luncarty; common.

Lycosa nigriceps, Thor.—Bridge of Allan, Callander, Aberfoyle, Blair-Atholl.

Lycosa herbigrada, Bl.—Aberfoyle, one ♀; banks of the Garry near Blair-Atholl, several.

Lycosa palustris (L.)—Bridge of Allan, Callander, Aberfoyle, Blair-Atholl.

ATTIDÆ.

**Epiblemum scenicum* (Clk.)—Aberfoyle, Fenderbridge, and Glen Farg.

Epiblemum cingulatum (Panz.)—Near Callander, April, 1900, a ♂ not quite mature.

**Hasarius falcatus* (Clk.)—In oak wood behind Aberfoyle, three ♀s.

Neon reticulatus (Bl.)—Aberfoyle, a dozen specimens; Glen Tilt, several.

Euophrys erraticus (Wlk.)—Callander, May, 1889, one ♀; Glen Farg, September, 1899, a colony on a rocky bank in a sunny ravine.

[This Part, pp. 43-96, published 1st November, 1900.]

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1901.

XIII.—*On some Prison Birds.* By Col. Campbell.

(Read 8th November, 1900.)

When at the last Council Meeting I innocently proposed to write a paper on the above subject, my suggestion was received by the members with remarks which showed that my idea and theirs did not exactly coincide.

I trust, however, that the members of the Perthshire Society of Natural Science will not, from the title of this paper, be led into imagining that I am going to give them a dissertation on the human inhabitants of the General Prison, which, however interesting it might be from a psychological point of view, would, I think, be hardly a suitable subject for the Society to which we belong.

Some time ago I wrote an article on the Avi-fauna of the Tay basin, a much more difficult and comprehensive piece of work; but my object in contributing this article now is to show what a number of different species of birds may be found in a very small area.

The total extent of the ground within the walls of the Perth General Prison, including that covered by the buildings, does not exceed twenty acres, and, during the last seventeen years, I have from time to time taken notes of the various birds seen within these limits, which notes I have embodied in the following paper. I need not say that many of the birds I have observed are migratory, here to-day and gone to-morrow; but at the same time there are several species which make their permanent home within the bounds of the Prison, and seldom, if ever, go to any distance from the shelter of its walls.

I shall take them in the order in which they are arranged in our Museum, and commence with the Missel Thrush (*Turdus viscivorus*, Linn.), a common bird in my garden, where it generally appears in autumn and remains till spring.

The Song Thrush (*Turdus musicus*, Linn.) is also common, and breeds regularly.

The Red Wings (*T. iliacus*, Linn.) appear in the month of October, and in hard winters they generally remain till they have cleared the berries from the holly trees, when they depart in search of pastures new, and more congenial climes.

The Fieldfare (*T. pilaris*, Linn.), like the last-named species, is a winter visitant, but is not so common as the Red Wing. A winter seldom passes, however, without my seeing some of these birds.

I need not say that the Blackbird (*T. merula*, Linn.) is also very common, and frequents the gardens and grounds all the year round, I have noticed a most singular trait regarding this bird. As is well known, it generally breeds in bushes or trees, but in the Prison grounds and garden, where there are no trees, it adapts itself to its surroundings, and I have found a nest on the ground in a bed of rhubarb or in a heap of stones. For several years a pair have bred in a corner of a cell window, whilst others have invaded the Prison Chapel through the window ventilators and built their nests on the joists. I do not know what may be the average age of birds, but I have constantly seen a pied blackbird, since 1895 up to the present year, flying about the grounds at the back of the Prison.

The Wheatear (*Saxicola œnanthe*, Linn.) is a regular spring and autumn visitor, generally the latter, evidently seeking shelter from the strong equinoctial gales behind the walls and buildings of the Prison.

The Robin (*Erithacus rubecula*, Linn.) is very common, more especially in autumn and winter; but it is a matter of history that a pair once took shelter and built their nest in the Prison Chapel, in the pulpit, from which even the eloquence of the Rev. Mr. Baxter, the late Prison Chaplain, did not frighten them.

The Hedge Sparrow (*Accentor modularis*, Linn.) is a constant resident, winter and summer, and I have found its nest in a heap of brushwood in the garden, a rather uncommon site.

The Chiffchaff (*Phylloscopus rufus*, Salvin) and the Willow Warbler (*Ph. trochilus*, Linn.) I generally see every spring and autumn whilst they are on migration, but I once found a nest of the latter (9th June, 1895) in a bank on the military walk at the back of the Prison.

The Blue Tit (*Parus cæruleus*, Linn.) is very common, and I have found its nest in my own garden and in the old water tower.

The Great Tit (*Parus major*, Linn.) and the Coal Tit (*Parus ater*, Linn.) also occasionally pay me a visit, but neither of them is so common as the Blue Tit, and they do not breed with us.

I have seen the Wren (*Troglodytes parvulus*, Koch), but it is by no means common, being only an occasional visitor.

The Starling (*Sturnus vulgaris*, Linn.) is one of our commonest birds. Starlings breed in every nook and cranny, and are a great nuisance, as they build their nests in the water pipes, and, when these are all occupied, they wrench off the wire coverings of the cell ventilators, inside which they find a lodgment, from which it is by no means easy to eject them. In the autumn they assemble in thousands and take possession of the old water tower, where, with the jackdaws and sparrows, they find congenial and warm quarters. Last September I counted over two hundred. They were sitting on the ridge of the Prison roof, whilst several hundred more were located on the slates, evidently warming themselves in the last rays of the setting sun before betaking themselves to roost.

The Jackdaw (*Corvus monedula*, Linn.) is, like the last named, a resident species, and several pairs may generally be seen at the back of the Prison, where they nest in the old water tower.

The Rook (*Corvus frugilegus*, Linn.) frequents the grounds, and I once got a specimen of the Carrion Crow (*Corvus corone*, Linn.), which was shot by my son in January, 1896, when it was flying overhead.

The Swallow (*Hirundo rustica*, Linn.) has only once nested in the Prison, in 1891, when a pair built their nest on an arch underneath the male hospital, but it was unfortunately destroyed, and they never returned. The bird is common enough, however, flying about the grounds from spring to autumn. My first swallow this year was seen on the 23rd of April, the last on the 5th October.

The Martin (*Chelidon urbica*, Linn.) is likewise common, breeding in considerable numbers under the eaves and in the windows of the warders' quarters. I seldom see it, however, inside the inner grounds of the Prison.

The Greenfinch (*Ligurinus chloris*, Linn.) I have generally seen in pairs in spring and in family flocks in autumn, but, though so common, it does not breed inside the gates.

The House Sparrow (*Passer domesticus*, Linn.) is, I need hardly say, a very common bird within the precincts of the General Prison, and breeds wherever it can find a suitable place for its nest. It certainly does some harm in our garden, but I am confident that the mischief which it does is to a great extent compensated for. I constantly see sparrows searching for caterpillars on roses and currant bushes, and I have frequently seen them chasing and catching the common white cabbage butterfly, the caterpillar of which is so destructive to many of our flowers and vegetables.

The Chaffinch (*Fringilla cœlebs*, Linn.), though so common amongst the trees on the South Inch, within a hundred yards of the outer walls, is seldom seen inside, and I have known it to breed only on one occasion, in an apple tree in my garden.

The Linnet (*Acanthis cannabina*, Linn.) I have frequently seen in the grounds of the Prison during the spring migration, when its beautiful breeding plumage is most conspicuous, and renders the bird easily recognisable from any other species.

The White Wagtail (*Motacilla alba*, Linn.) and the Grey Wagtail (*Motacilla melanope*, Pall.) are frequently seen during the spring and autumn migrations, and I have seen the Pied Wagtail (*M. lugubris*, Lemm.) at all times of the year, even in hard frost and snow. I have also found its nest concealed amongst a heap of stones in the Prison grounds.

The Swift (*Cypselus apus*, Linn.) is, I think, one of the most interesting of birds. It is scrupulously regular in its arrival and departure, and one may always look for it, and be sure of finding it, in Perth on or about the 8th of May. Its exodus is even more punctual. The 12th of August is almost always the day on which the great body of the Swifts commence their southern flight. I have on several occasions seen this taking place. On the 12th August, 1892, about 7 p.m., I watched a flock consisting of more than a hundred birds flying in ever-widening circles, keeping up their harsh scream all the time in a most excited way, and gradually ascending until they were lost to both sight and sound. Again this year, at 8 a.m. on 12th August, I saw the same phenomenon, and in the afternoon not a Swift was to be seen. I thought they had bidden me good-bye for the year, but on the morning of the 14th I heard the well-known scream again, and on looking out saw, flying round my house, two birds, which, for some unaccountable reason, had lagged behind. That, however, was the last of them, and the 14th of August is the latest date on which I have seen the Swift in Scotland, though I have seen it in the South of England as late as 5th September.

I have heard it said that the story of the Swift being unable to rise, should it settle on the ground, is mythical; but I can vouch for the truth of it, as on one occasion I found a Swift flopping about in the garden and quite unable to rise, but, on my picking it up and letting it go from my hand, it at once found its wings and took to flight.

It was evident that the short clawlike feet, with the resistance caused by the long-winged primaries, did not give sufficient leverage to enable the bird to rise from the ground; but that, when released from my hands, it could at once make use of its wings, which it accordingly did. It breeds regularly under the eaves of my house.

The Brown-Headed Gull (*Larus ridibundus*, Linn.), the Common Gull (*L. canus*, Linn.), the Herring Gull (*L. argentatus*, Gmel.), and the Lesser Black-Backed Gull (*L. fuscus*, Linn.) are all common, more especially in autumn and winter, and range themselves in long lines on the walls of the Lunatic department. I have noticed after the breeding season that there is a large proportion of immature birds of the year. I have also had many opportunities of watching in spring the change of plumage from winter to summer, and again in autumn from the summer to the winter state. This can most readily be seen in the first-mentioned species. The conspicuous brown head is assumed between the 1st and the 10th of March, and in autumn it changes again to the light-coloured plumage of winter, between the 10th and 20th of August. These changes are not caused by the moulting of the feathers, but by an actual alteration of the colour.

The last species I have to record is a specimen of that rare and erratic bird, the Little Auk (*Mergulus alle*, Linn.), which was found in the grounds on 1st February, 1895, that severe winter which decimated the ranks of so many of our favourite birds.

From the above it will be seen that 31 different species have been observed; of these 14 have nested within the Prison precincts, 9 are regular residenters, and 22 are migratory or occasional visitors.

Since writing the above I should like to point out what a different state of matters there is with regard to the numbers of birds which one finds when travelling abroad. This autumn I visited the south of France, and spent three weeks in Auvergne. The country is an ideal one for birds, as there are lofty mountains, dense forests, and rich tracts of alluvial land watered by numerous rivers.

During my sojourn there, at La Bourboule, I saw only about a dozen rooks, a few jays, numerous martins, one or two larks, a kestrel, and two buzzards.

Not a single blackbird, thrush, or passerine bird of any kind did I see. Even the sparrow, which I have found wherever I have gone in this country, was conspicuous by its absence. This state of affairs is caused by the wholesale manner in which every bird, which can possibly be utilised for food, is trapped or shot. I can only say that I was thankful to get back to my native country where the chirp of the house sparrow was indeed a welcome sound.

In conclusion, I can only express the hope that these few notes may possibly be useful to the members of the Society, and may perhaps induce those, who have not yet paid much attention to the subject, to take an interest in that most interesting study—the study of birds.

XIV.—*History and Culture of the Grape Vine.*

By J. Leslie.

Part I.—History. (Read 13th December, 1900.)

Of all the luscious fruits that have been caused to grow in this world by the Bountiful Creator, I think there is not one that ranks higher as a health-giving, agreeable, and nourishing food for man than the fruit of the Grape Vine (*Vitis vinifera*, Linn.), the history of which we wish to consider for a little while this evening.

The Grape Vine belongs to the natural order *Vitaceæ*, a group of plants most of which are shrubs with a climbing habit. The Virginia Creeper (*Ampelopsis Veitchii*) is another well-known example of the same family. The flowers, which have five stamens and five petals, are small and inconspicuous. As the stamens expand, the petals, being united at the top, are thrown off in the shape of little caps, the stamens adhering for a time to the hypogynous disk from which they spring. The members of the group are also characterised by the tendrils, or claspers, by which they adhere to the support on which they are grown.

The Grape Vine is found growing wild in the temperate regions of Western Asia, Southern Europe, and parts of Northern Africa, and is generally believed to be a native of that part of Asia Minor which lies to the south of the Caucasus and of the Caspian Sea.

De Candolle, in his "Origin of Cultivated Plants," says:—"Its dissemination by birds and other agencies must have begun very early, perhaps before the existence of man in Europe or even in Asia. Seeds of the Grape Vine have been found in the lake dwellings of Castione, near Parma, which date from the Age of Bronze, and leaves have been found in the Tufa round Montpellier, probably deposited before the historical epoch."

Records of the cultivation of the Grape in Egypt go back to a very remote period. We read in Genesis ix. 20 that "Noah planted a vineyard." In Numbers xiii. 23 we are told, as a proof of the fruitfulness of the Land of Promise, that the spies at the "Brook of Eshcol cut down a branch with one cluster of grapes, and they bare it between two upon a staff." So we see that large bunches of grapes were grown in that land many thousand years ago. The soil and climate of Judea were so well suited to the growth of the vine that grapes were among its principal productions, and particular districts, as Engedi and the Vales of Eshcol and Sorek, were famed for the excellence of their grapes. Sorek signifies the noblest variety of the vine—a white grape, from which the best raisins are made in Persia.

The Phoenicians first introduced the vine into Europe, namely, into Greece and Italy, whence it spread into France and other parts of the Continent.

It is supposed that the Romans introduced the vine into Britain A.D. 70. Tacitus, son-in-law of Agricola, Governor of Britain and teacher of its inhabitants in the "Arts and Luxuries of Civilisation," declared, about A.D. 97, that the moist climate (of Britain) was unfavourable to the vine maturing its fruit; but nevertheless vines continued to be grown. It is said that the Battle of Hastings was fought near a great plantation of vines. "Doomsday Book," a record of a Statistical Survey of England, made by command of William the Conqueror towards the latter part of his reign, contained thirty-eight entries of valuable vineyards, two of them six acres each, one at Ware and one at Essex. In the year 1140 the Barons, as well as the Monks, possessed vineyards. Vines were grown at Godalming, in Surrey, and Canterbury also had its vineyards.

William of Malmsbury states:—"There were more vineyards and better grapes grown in Gloucestershire than any other part of England." That was about the year 1140. In the reign of Edward II. (1307-1327) the Bishop of Rochester sent the King a present of grapes of his own growth. About the year 1560 grapes seem to have become rather scarce, as we read of Grindell, Bishop of London, sending Queen Elizabeth a present of grapes every year from Fulham, grapes being esteemed of great value, and a fruit Queen Elizabeth "stood well affected to." The first Earl of Salisbury planted a vineyard at Hatfield in 1605. Vines were grown on a steep southern slope of a hill at Deepdene, Dorking. Defoe found the vineyards at Deepdene neglected in 1726.

Artificial heat was first employed for the production of grapes in 1718. Lawrence's "Trent Calendar" says:—"Fires were constantly kept up from Lady Day to Michaelmas behind the walls on which the vines were trained" at the Duke of Rutland's gardens at Belvoir Castle. The latest of vineyards is one planted in 1875 at Cardiff Castle by the late Marquis of Bute, who established a vineyard on a somewhat extensive scale, but the experiment is not considered to be very successful.

During the eighteenth century the cultivation of grapes under glass seems to have become pretty general, several examples planted in that century being still in existence, as that of the vine (Black Hamburgh) at Valentine's Ilford, in Essex, which Gilpin, in "Forest Scenery," says was planted in 1785. It is said to be the oldest vine in England, and to be the parent of the still more celebrated vine at Hampton Court, which was planted in 1769, and now covers a space of 1880 square feet. Of more modern vines may be mentioned that at Cumberland Lodge, Windsor, which produces annually about 18 cwt. of grapes. It was found in a cucumber pit in the year 1800, and now occupies a house 138 feet long by 20 feet broad, its stem being nearly 4 feet in circumference. A great vine (Black Hamburgh) exists at Sillwood, Sunninghill. It occupies a house 129 feet long by 12 feet broad, and produces about 1800 bunches of grapes annually. Another great Black Hamburgh vine is grown at Kinnell House, at the west end of Loch Tay, and fills a house 172 feet long by 25 feet wide; it was planted in 1832. The largest of vines in Great Britain, however, is the Black Hamburgh vine at Mauresa House, Roehampton, raised from a cutting by the present gardener, Mr. M. Davis, in 1862; this vine occupies a house 224 feet long.

Under favourable circumstances the vine lives to a great age. Pliny mentions one 600 years old. Vines 100 years old are accounted young in the vineyards of Italy; and Bose states that there are some in Burgundy over 400 years old.

During the last thirty years the cultivation of the grape has increased to a very great extent. In Scotland we have the Clovenfords Vineries and the Kippen Vineries, at both of which tons of grapes are grown. For large vineries, however, we must go to the South of England, where such men as Mr. Ladds and Messrs. Rocheford have glass houses covering acres of ground, each grower sending out from 50 to 100 tons of grapes annually, the usual sort of house for their culture being span-roofed, running from 100 to 500 feet or more in length and 25 feet broad. Vines grown in such houses are cropped heavily, and, whenever the rods show signs of failing vitality, they are pulled up and fresh ones planted.

There are wonderful stories told by ancient writers of bunches of grapes measuring a yard long and having berries as large as pigeons' eggs. This seems rather big, but these sizes have been almost if not quite equalled in this country. Mr. Hunter, of Lambton Castle Gardens, exhibited in 1874 a bunch of Black Hamburgh grapes weighing 21 lbs. 12 oz. Mr. Roberts, Charleville Forest, Ireland, exhibited a bunch of Gros Guillaume grapes in 1877 weighing 23 lbs. 5 oz.; and the late Mr. Dickson, with whom I was well acquainted, and who was gardener to Sir Robert Jardine, at Castle Milk, Dumfriesshire, grew at Arkleton Gardens a bunch of "White Nice" grapes which weighed when cut 26 lbs. 8 oz. It measured 2 feet 3 inches across the shoulders, and was 2 feet 3 inches in length. The berries were full-sized, as the bunch had been properly thinned. This is, so far as I know, the largest bunch on record.

The heaviest bunch, which we have grown at Pitcullen, was an Alicante, weighing 13 lbs. 6 oz., a photograph of which is here and can be seen. Our heaviest bunch this year was 10 lbs. weight, of the same variety. Mr. Goodacre, of Elvaston Castle Gardens, has grown some very fine bunches of Gros Colman grapes, with berries measuring 5 inches in circumference. I may say that the largest berries of that variety grown at Pitcullen Gardens which I have measured were 5¾ inches in circumference. Just to show that Perthshire is not behind in grape culture, I may say that last year there was a great show held at Shrewsbury, open to all, and the greatest prize ever given for grapes was offered for 12 bunches in six varieties, two of each variety. That prize was won, in a keen competition, by Mr. Lunt, Keir Gardens, Dunblane.

The late Mr. Thompson of Clovenfords says:—"The endless variety of Grape Vines in cultivation seems to indicate that the *Vitis vinifera* is not a true species, and this view is confirmed by the circumstance that seed taken from any variety of grape does not reproduce the parent, as it should do if it were an unbroken species, but one widely different, and as a rule very inferior to the parent, except in exceedingly rare instances, when a step in advance may take place. The writer has raised hundreds of vines from seeds taken from the finest grapes in cultivation, the rare exception being a variety equal or superior to the parent, and the rule being the reversion to a very inferior type. It is questionable if any of our high-class grapes are to be found in an uncultivated state in any part of the world. The plant has evidently been developed by the ingenuity of man at some very remote date, of which there is no record, just as our apples, pears, plums, peaches, and many other fruits and vegetables have been; and if man's constant care were withdrawn from their cultivation, they would soon disappear from the earth, leaving it in possession of their wild progenitors."

XV.—*Gulls—the Links of Land and Sea.*

By Lieut.-Colonel W. H. M. Duthie.

(Read 10th January, 1901.)

Late on a summer night in Scotland we are attracted to the river-side, and stand beside one of its deep pools; the sun has set some time ago, but the sky is still luminous, and a faint tinge of gold still lingers on the few clouds which hang over the western hills, for summer days die slowly in the north.

The pool looks black under the dense foliage of the trees, and the movement of the current is scarcely perceptible on its smooth surface, although the stream rippling into it comes down swiftly from above, and flows out again over a long bed of shingle into another pool below, making exquisite melody as it races over the pebbles.

We know every inch of this bit of river, which teems with fishing memories, and many happy hours and exciting moments are recalled as we gaze upon the familiar places where past scenes have been enacted; but there is no fishing now—the river is too low—so we are content to live in the past and look forward to the future as we watch the little rings which are continually forming, expanding, and disappearing on the surface of the water, marking the spots where the smallest of small trout are rising to feed.

Nature is very quiet; song birds are silent; the mavis, which has been pouring out his melody, with only short interludes, from early dawn till the sun went down, is fast asleep under a canopy of leaves; now and again the alarm cry of a peewit comes from the upland fields, or a wakeful blackbird, startled by some creeping thing in the undercovert, gives a warning note, and for a few minutes there is a hubbub of fretful voices in the bushes; then all is quiet again, and only the sound of running water is heard, as the river runs on and on and on with its never-ending song. But, when half the world of Nature sleeps, the other half is wide awake. The swallows have gone to rest, and their places are now taken by crowds of Gulls, which hover over the water, or glide ghostlike among the trees; their graceful movements, in perfect harmony with the quiet and repose of the scene, are noiseless, and no cry escapes them except on rare occasions when two of them, swooping down at the same object, nearly touch.

There has been a drought over the land, and the dry, parched ground is yielding little food for the birds, but, in the damp air over the water, insects evidently abound, for up and down the river, over rapid and stream and pool, the snow-white forms of the Gulls are seen; some are sitting in rows on the rocks along the edge of the stream, and others, in small groups on the grassy slopes above, are resting after their meal, or roosting for the night. They are all of one kind, the Black-headed Gull (*Larus ridibundus*, Linn.), a bird doubly misnamed, for the hood which covers the head is brown, not black, and its harsh, scolding cry is by no means joyous; the term "ridibundus" is much more applicable to the Lesser Black-backed Gull (*Larus fuscus*, Linn.), whose merry voice often sounds like human laughter.

These small Gulls have been familiar objects on the land all the springtime, and we have watched their changing plumage and the gradual development of their dark-coloured hoods as the nesting season approached.

Some of those assembled here to-night belong to a colony which nest at a moorland loch within a few miles of our pool, and we see them winging their way in that direction; others are still unpaired, for Gulls take some time to reach maturity, and do not breed until their third or fourth year.

These so-called "black-heads" nest together in large colonies, generally in wet places; wherever the locality may be, whether in marshes near the sea, beside inland waters, or on the moors, the signs of their presence are always apparent—the same chorus of screaming voices fills the air, and the same white cloud of flashing, interlacing wings drifts over the spots where the birds are nesting; the picture is varied only in its background of yellow sands, of grassy slopes, or of purple hills. The nests are placed close together, and contain an average of three eggs to a nest, all varying in colour and markings in a most remarkable degree. They do no harm either on cultivated or wild lands; the farmer likes them, for they help to clear his ground, and the most bigotted of gamekeepers cannot justly accuse them of sucking eggs. This, however, cannot be said of some of the larger species. The Lesser Black-backed Gulls, for instance, are notorious egg robbers, and are very properly driven away from preserved ground and their nests destroyed; the Herring Gulls, also, which are ever ready to pounce upon the unprotected eggs of Guillemots and other sea fowl, in whose company they are in the habit of nesting, should be watched. But worse offenders than these are the Great Black-backed Gulls, who not only suck eggs, but also devour young birds; in fact, it is said that a sitting grouse is not safe from the keen eyes and sharp beaks of these marauders, and, when providing food for their young, a lamb, and even a sickly ewe, may be attacked to provide food for the family larder.

The Gulls belong to a large genus (*Larus*), comprising nearly fifty species scattered all over the globe, six of which make their home in the British Isles.

The largest of these is the Great Black-backed Gull (*Larus marinus*, Linn.), a magnificent bird, with a breadth of wings from tip to tip of over five feet, and, whether seen standing on the sands foraging for the flotsam and jetsam of the tide, or battling against a gale of wind at sea, he is a great ornament to our coasts. Although nesting sometimes in colonies, they are oftener found in single pairs in wild isolated places. A red-letter day in my field notebook records my first sight of the nesting-place of this fine Gull, and the scene still remains vivid in the memory. We had been exploring that wonderful mass of porphyry columns called the "Scuir," which forms the southern end of the island of Eigg. It was a bright but very windy day in May, and taking advantage of all the shelter we could find in our descent from the summit, we came unobserved upon a small tarn over which the strong wind swept, lashing its surface into sheets of spray. So sudden was our appearance that the immense bird, taken completely by surprise, rose within twenty yards of us, and with a loud scream attracted her mate, who was not far off. The behaviour of the birds, now swooping over our heads, now alighting on the ground with down-stretched legs and upraised wings, uttering angry notes, told its own tale, and we soon found the nest, which was placed in a depression of the ground on a narrow ridge of smooth rock, only a few yards in width, which separates the shore of the tarn from the edge of a steep precipice of 900 feet, forming the western end of the "Scuir," overlooking the Atlantic. It was composed of fine grass, and contained three brown eggs as large as those of eagles; several small bones and the backs and claws of crabs were lying beside it.

It was a typical place for the home of a wild sea-rover, and the outlook was superb. To the north, over a foreground of brown moorland, the Skye hills glistened with newly fallen snow; in the west, the island of Rum, a mighty mass of purple, rose out of the sea, looking stern and grand, with snow showers whirling about among its wild glens and corries; beyond, looming low on the horizon, the islands of South Uist and Barra were just discernible; and southwards, on our left hand, in bold outline, the rugged coast of Ardnamurchan and Mull stretched away into distance.

The Lesser Black-backed Gull (*Larus fuscus*, Linn.) is a smaller copy of the above, and in full plumage, with its dark mantle and snow-white head, is also a fine specimen of the Gull family. They breed in colonies both inland and on the coast, choosing grassy slopes or flat undulating ground for their nesting-places.

The Herring Gulls (*Larus argentatus*, Gmel.), which are about the same size as the last, are easily distinguished by their coats of silvery grey; they love the bold cliffs and rocky precipices with a wide horizon for their home. Always on the alert, their keen eyes detect the slightest sign upon the surface of the sea, a sign which, if seen at all by human eyes, might be taken for the shadow of a cloud. In an instant the large grey wings unfold, and the Gulls are launched into the air, and away they speed in steady flight from the land; the signal is taken up all along the line of coast, and from every cliff and rocky pinnacle and isolated stack the Gulls stream out to sea, and soon there is a swarm of fairylike beings hovering in the air or swimming and splashing in the water intent on their prey. If any fishing boats are near they bear down upon the spot and the men take their share of the harvest of the sea, blessing the Gulls.

The Common Gulls (*Larus canus*, Linn.), which do not breed south of the Scottish border, are by no means the commonest of our British species. Their favourite nesting-places are grassy islands both of sea and inland waters; they are the Gulls of our harbours, bays, and rivers rather than of the deep sea, while the Kittiwakes (*Rissa tridactyla*, Linn.) are the Gulls of the ocean.

On dizzy precipices rising sheer out of the sea, with the restless waves below and the restless wings of innumerable sea-fowl beating the air above and around them, the dove-like Kittiwakes make their home. They build on niches and in quiet corners in the rocky faces of the cliffs, and, when seen snugly brooding on their substantial nests of dry grass and sea-weed, they present a striking contrast to the rabble of comfortless guillemots and razorbills, which sit or stand closely huddled together over their eggs on the ledges beside them.

They are most tame and confiding with man, and the pleasure of a summer evening's fishing is often enhanced by the presence of these gentle creatures swimming round the boat; so close do they approach in their eagerness to secure bits of superfluous bait that they almost dare to take it out of the fisherman's hand.

This excessive tameness has caused their doom, for none of the Gulls have suffered so much persecution at the hands of cruel agents in the iniquitous plume trade as these beautiful Kittiwakes.

Besides our six home Gulls, several others pay periodical and casual visits to our shores during the autumn and winter months, notably the Glaucus, the Iceland, the Ivory, and the Little Gulls.

On the water Gulls are the lightest of birds, and sleeping or awake they float like corks upon the waves; in the air they have a marvellous power of sustaining themselves without apparent effort.

Watch those Herring Gulls now poised above our heads; see how they rise and fall in the air, and float hither and thither with no perceptible movement of wing or feather. The wind freshens, and the gulls seem to be forging ahead against it, and yet even with our glasses we can detect no movement of the wings; then all of a sudden, while we watch and wonder, they swoop downwards with a grand curve to the sea, and with a few strokes of their pinions are out of sight beyond a shoulder of the cliffs.

There has been a good deal of discussion about this soaring flight of birds. The late Professor Gätke, of Heligoland, who devoted fifty years of a long life to the study and observation of birds, felt convinced that "birds are endowed with qualities and capacities by means of which they are enabled, according to their needs, to neutralise and overcome the general laws of gravity without thereby making use of the mechanical powers of their wings or being supported by atmospheric currents." Lord Rayleigh, on the other hand, speaking as a scientist, ridicules this proposition, saying that "the science of mechanics enabled it to be laid down with certainty that a bird could no more maintain itself without motion of the wings in a uniform wind moving horizontally than in air at perfect rest. It was entirely a question of relative motion. If, then, a bird was seen to be maintaining itself without flapping, it was certain the air was not moving horizontally and uniformly. But there might be rising currents of air, upon which it was supported, and these were much more common than was often supposed. In other cases where it was difficult to imagine the existence of such currents, an explanation might be sought in the non-uniformity of the wind, for it is mechanically possible for a bird just at the point of transition between two different *strata* of wind to maintain its position by taking advantage of the different velocities; the albatross probably does so." Whatever the cause of the phenomenon may be, this soaring flight of birds is one of the most beautiful sights in Nature.

Gulls, the friends of the farmer and fisherman, are friends of the sailor too, for many a vessel has been saved from destruction on the rocks in thick weather owing to the timely warning of these useful birds.

Sea Gulls they are properly called, for we always find them by the sea, and yet land birds they are, for we seldom miss them from the land. When the nesting season is over they scatter far and wide; we see them in the meadows when the hay is cut, among the turnips when they are hoed. In dry summer weather they sit on the roofs of houses in town and village, feeding in the streets with the sparrows, and in the poultry yards with the fowls; and in the autumn they follow the plough searching for grubs and worms. When winter comes they go to the estuaries and to the sea to swell the ranks of the vast white-winged hosts of young and immature birds which have never left the coast; but as soon as the frost is out of the ground, and the ploughman is at work again, the landscape is flecked with white, for the Gulls have returned to the land.

Ocean birds only come to the land to breed, and sometimes to die in the crevices of the rocks in which they were born; land birds only trust themselves at sea in their migratory journeys from one continent to another. But the motto of the Gulls is "Ubique," and free as the air in which they live, they roam in blissful independence over earth and ocean alike, claiming both equally as their own.

They are the links of land and sea, and with both we associate them, for whenever we hear the wild musical note of a Gull, and see his clear-cut form sailing across the sky over one of our big inland cities, we are carried away from the ebb and flow of human life to the harbour bar, and to the surf breaking on the sands; and again, as we watch the pack of Gulls following in our wake on the ocean hundreds of miles from land, our thoughts hark back to home, to the cawing of rooks and bleating of lambs, to cowslips in the meadows, to the smell of newly-turned earth, and to a swarm of white glittering specks trailing behind the ploughman's back.

XVI.—*Birds of the Riverside.*

By William Whyte.

(Read 14th Feb., 1901.)

To the student of bird life the riverside offers ample scope for the pursuit of his favourite hobby. The surroundings are so varied, and the conditions so favourable for the breeding haunts of so many different kinds of birds, that it would be impossible to give more than a passing notice of these in a short paper like this. I will therefore confine myself to the mention of those birds which are purely aquatic and of those which are both land and water birds—that is, those which obtain their food either from the river or from the fields adjoining. The part of the river at which these observations have been taken is principally that about Almond mouth.

> There is a pleasure in the pathless woods,
> There is a rapture on the lonely shore,
> There is society where none intrudes,
> By the deep sea, and music in its roar.

But there is also a pleasure by the riverside when the dew glistens in the rays of the morning sun, and the woodland choir are tuning their lays to greet the newly-awakened day, and the lark is singing joyously in his upward flight; or at the close of day, when night is spreading her mantle o'er river, field, and woodland, what a pleasure it is for the lover of Nature to sit quietly by the side of the murmuring river and listen to the voices of the night. You may hear the soft "crook" of the waterhen as she feeds quietly in the shallows, or the whistling flight of the wild duck as it flies rapidly overhead, the harsh scream of the heron, and the loud "tu-whit to-hoo" of the owl; or a shrill squeal which tells of some luckless rabbit which has fallen a victim to its relentless foe the weasel. On a post not far from us sits a tawny owl, solemn and motionless as a statue, when suddenly there is a pounce, one swoop of those noiseless wings, and some hapless mouse has made a sudden expedition into the interior.

The island at the Perth Bridge forms an excellent starting-point, as it is the favourite resort of the gulls which frequent this part of the Tay. These birds may be aptly termed the scavengers of the river, not being very particular as to what their diet consists of. They frequent the sewage outlets, and feed on all sorts of scraps, which are conveyed to the river by these channels. The most numerous, and the smallest, are the Black-headed Gulls, which, when in full feather, are very pretty birds. The head is not black, but a very dark brown, and contrasts strongly with the rest of their plumage, which is bluish white on the back and pure white underneath, every feather fitting so closely and smoothly that there is an entire absence of that scraggy appearance which is so noticeable in some other birds. During the hottest months of summer, when the river is at its lowest level, these birds have great difficulty in procuring a sufficiency of food, and many kind-hearted persons may be observed feeding them on scraps of bread from the railings in Tay Street. Although not a gull may be in sight, yet, as soon as the first scrap of bread is thrown into the water, there is in a moment a perfect cloud of them flying about, now dashing into the water with shrill screams, or, when flying swiftly along, poising themselves suddenly with the assistance of their fan-like tail and capturing the pieces of bread before they reach the water.

There are other three kinds of gulls which frequent this place, the Common Gull, the Grey Gull, and the Lesser Black-back. The two first-named are represented by two or three pairs, but the Lesser Black-back is only an occasional visitor, and may be easily distinguished by the broad black saddle on his back, which forms a striking contrast to his otherwise snowy plumage. None of the gulls nest by the riverside, and when the breeding season comes on they retire to some woodland or moorland loch, and on the little islands which dot the surface, and which are merely accumulations of mud and decayed vegetable matter, their nests may be found so closely placed together that it would be scarcely possible to walk across without injuring some of their eggs.

Of the Wagtails it is hardly necessary to say much, as they are so familiar to us all. There are two kinds which are common on the Tay, the Pied and the Grey. I have never seen the Yellow Wagtail here, but for two years I have observed a pair of them on the River May in the nesting season.

The Dipper, with his sooty-brown plumage and white front, is a common feature of the riverside, although he is more partial to the smaller rivers and burns. He is a lively little bird, and although it is not generally known, has a very pretty song. He is heard at his best on some frosty morning, sitting on a stone in the middle of the burn, singing his love song. He builds his nest under a bridge or close beside some waterfall on a shelf of rock, and in it are deposited some five or six pure white eggs. He is rather an early breeder, commencing his domestic arrangements about the beginning of April, and he is a busy bird until his little brood are able to do for themselves.

The Kingfisher is also an all-year-round resident with us, although he may not be often seen by the casual observer. He is extremely shy, and were it not for his brilliant colour might easily pass unnoticed. He breeds every year on the banks of the Tay or Almond, and his eggs are almost identical with those of the Dipper. His nest, however, is entirely different. Instead of the bulky and comfortable nest of the Dipper, he breeds in a hole in the bank, the lining of his nest being composed of the bones of the small fish which form his food.

The Moorhen, better known as the Waterhen, is of common occurrence on the riverside, and needs very little notice here. It is more of a night feeder, and its soft "crook, crook" may always be heard by those of us who like to take a ramble by the riverside in the evening. It builds its nest on the branch of some tree or bush which overhangs the water, and it lays generally seven eggs.

The Mallards, or Wild Ducks, are exceedingly numerous about Almond mouth, and in the winter months, headed by a large drake of doubtful parentage, may be seen in rapid flight up and down the river, sometimes to the number of fifty or sixty; or, ranged in one long line along the edge of the gravel, they will suddenly, as if by common consent, rise and fly to the top of the Grainhead stream, and alighting on the water with much quacking and splashing, allow themselves to be carried on the breast of the swift, smooth current back to their starting-point. The Wild Duck is a most devoted mother, and exposes herself fearlessly to danger in her endeavours to distract attention from her little charges. Many a guileless youth, coming upon the happy family in some quiet pool in the burn, has been induced by the frantic actions of the apparently disabled mother to give chase after her, filled with hopeful imaginings of stewed duck and green peas, until she has drawn him far enough from the vicinity of her little charges, when, rising strong on the wing with a triumphant quack, she leaves her pursuer standing in hopeless wonderment at her rapid recovery. The little ducklings have meantime disappeared, and the most careful search will fail to discover them, so securely are they hid among the nooks and crannies that abound along the burnside. Others of the duck family visit us in the winter season, but they are so shy that it is not an easy task to get near enough to identify them. The Tufted Duck is a common winter visitor, and is easily recognised by his black and white plumage and his wonderful diving capabilities. This duck nested among the whins at Almond mouth a year or two ago, but the nest with nine eggs was discovered and robbed.

The Heron is a typical riverside bird, and may be seen standing motionless in the water at the edge of the shingle waiting for his evening meal, or flying along the river with slow and seemingly laboured flight to some favourite feeding-place. The Heron is an early breeder, and begins early in March along with the rooks, and like the rooks also breeds in colonies, choosing the top of the highest fir trees for that purpose. There are two such colonies within a few miles of the city, but in different localities. That the Heron does not live entirely on fish may be proved by anyone who may chance to pass under the trees which form their favourite roosting-place, for there, scattered all around, may be seen the bodies of numerous rats and voles in all the different stages of digestion, some of them in fact with but the head and shoulders partly digested and the rest of the body with fur and everything else intact. I am inclined to think, from what I have seen and heard, that these birds have desperate battles with one another, as I have frequently come across their dead bodies in out-of-the-way places; sometimes I have seen two of them together, as if it had been a fight to the death. And when walking by the riverside, when everything is enshrouded in darkness, and no sound breaks the stillness of the night but the rush of the river as it flows swiftly down the Grainhead stream, or the splash of some salmon in the deep pool further down, there suddenly breaks upon the ear a harsh scream, answered after a short interval by another from a point farther down the river, and immediately the night is made hideous with the most fearful din. It is the battle of the Herons. One would imagine from the discordant screams and hoarse barking noises that the fiends of the nether regions were engaged in a civil war on the surface of the silent waters. This continues for some time, and then there is an interval of silence, broken at last by the harsh triumphant scream of the victor, who will now be left in possession of the disputed territory, which is a favourite feeding-place at the mouth of a burn.

The birds already mentioned are residents with us, and may be seen by the riverside at all times of the year, but the group to be dealt with next are only spring and summer visitors. The first to arrive of this group are the Oyster-Catchers or Sea Piets, and the Ringed Plovers. These birds arrive on their breeding-ground every year as early as the 20th of February, and the Oyster-Catcher stays with us until October, although I saw one as late as 29th December of last year, but it must have been a stray bird. We are soon apprised of their arrival by hearing the shrill "cabeek" of the Oyster-Catchers and seeing them skim rapidly up the river. These birds belong to the waders, and feed more on the land than on the riverside. They lay their eggs in a little hollow scraped in the gravel, and deposit therein from three to four eggs on the bare stones; and these resemble so closely the stones among which they are laid that the searcher may pass and repass them without finding them.

The Ringed Plover is, as has been already remarked, also an early visitor to the riverside. It is also a land and water bird, finding its food in the fields as well as at the waterside. There is a peculiarity about the low flute-like note of this bird when it is feeding among stones at the water edge that amounts to ventriloquism, for, though you can hear his voice, you cannot locate the spot which it came from; you may imagine that you are quite close to it and yet, when you discover the bird, it is a considerable distance away. The nesting habits of the Ringed Plover are similar to those of the Oyster-Catcher, and the colouring of the eggs is also the same.

The Tern, I am almost sure, breeds on the shingle, as I have seen a pair of them there for three years at the nesting-time, although I failed to discover their nest. I know that they breed on the gravel banks at Delvine and Guay. Although they resemble the

Gulls when seen in company with them, yet a closer look enables us to notice the lesser size, the narrow tail, and the long graceful sweeps of their swallow-like wings. Although I cannot affirm it with any degree of certainty, I have been assured that this is the Arctic Tern. Their eggs are of a different shape and colour from those of the Common Tern which I have seen. They are almost identical with those of the Ringed Plover but of larger size. It is important to know that, although the three birds last-mentioned belong to different families, yet their eggs are almost identical in colour and markings, so that they may correspond as closely as possible with the surroundings, and thus escape detection by their numerous enemies.

The Sandpiper is another bird whose nesting habits somewhat correspond with those of the last-named birds, although it oftener prefers to build its meagre nest on some sloping bank. The Sandpiper arrives here about the end of April, and soon makes his presence known by his peculiar cry. In the Crieff district this cry has earned for him the name of the Cockie-eelie bird, and it exactly resembles these two words repeated quickly three or four times. In other parts of the district it is named the Sand Laverock, because it hovers very like the Skylark when alighting.

The Sandmartin has strong claims to be classed among the riverside birds as he procures his food from the surface, or rather above it, sometimes dipping into the water as he skims along to secure the floating insect. The Sandmartin is the earliest of the Swallow family to arrive, and I have it in my notes as early as the 8th of April and again on the 12th. Of course it was only single birds that I saw on these dates, the main body not arriving until about ten days later. The riverside also provides this little bird with its nesting-place, and, if you come across some part of the bank where there has been a landslip, you will find it perfectly honeycombed with the nesting-holes of the Sandmartin. It is wonderful how these little creatures, with the limited means at their disposal, can manage to dig holes as long as a man's arm, at the end of which the nest is placed, constructed of a little dry grass and feathers and containing five or six pure white eggs.

The birds already dealt with are the residents and regular visitors to this part of the river, but during severe winters we have some rare visitors. The only time I have seen the Firecrest was by Almondside after a long-continued frost when the river was frozen over; there were about half-a-dozen of them in company with some Goldcrests. The Sisken also comes to the riverside during the hard weather, feeding on the alders which grow along the banks. On the 2nd of January last year I saw a pair of Goldfinches feeding at Almond mouth, and a week later a flock of about twenty was seen about the same place. The Little Auk is also a casual visitor, and two years ago one of these birds dropped into a pool in the Almond, beside which I was standing, and commenced preening its feathers in quite an unconcerned manner. Next day a Little Auk was shot in the Willowgate. A pair of Shags paid us a visit last winter. I saw them come sailing down the Grainhead, and, being puzzled as to their identity, I threw a stone at them, on which they rose and flew up the stream again. They shared the fate of the Auk; one was shot by the keeper at Waulkmill and the other down at Kinfauns. The Swan is a rare visitor to this part of the Tay, but two years ago, after a spate had left the park behind the whins at the top of the Inch covered with water, five of those graceful birds might have been seen swimming about, two adults and three cygnets. They stayed there for three days until the water began to subside, when they disappeared. In concluding this paper I would like to suggest what has often crossed my mind as a most desirable thing, viz., the introduction of the Swan as an ornamental bird on the Tay. The island at Perth Bridge would, I think, be quite suitable as a breeding-place for them, as there is a little bay or inlet which would answer that purpose, and I think every one will admit that to have these stately and beautiful birds on our beautiful river would be an acquisition that would well repay the outlay.

XVII.—*Notes on Ecuador, South America.*

By ALBERT E. PAYNE, A.R.S.M., M.B.A., London.

(Read 11th April, 1901.)

GEOGRAPHY AND PHYSICAL FEATURES.

It would be a mistake to commence the study of the natural history or inhabitants of Ecuador without obtaining some grasp of the chief physical features of the country and an inkling of its political history.

The very name of the country, so significant and appropriate to a land situated on either side of the equinoctial line, or earth's equator, is but a modern one, and was originally used to designate a portion of the great Kingdom of Colombia. In 1830 this "Department of Ecuador" was somewhat extended and formed into an autonomous Republic, under the name of Ecuador.

The coast line of Ecuador we know to be fairly correct, due to the survey work of the British Admiralty; but it is safe to say that there is not one point in the interior of the country that has been determined with astronomical accuracy. Thus no great reliance can be placed on any existing maps, and I will not, therefore, go into the question of frontier lines beyond saying that Colombia lies to the North, Brazil to the East, and Peru to the South, enclosing, with the Pacific Ocean on the West, a claimed area of 286,000 square miles, which is reduced to an actual area of 180,000 square miles, if we leave out the disputed portions of the Eastern province.

I have omitted to mention the Galapagos Islands, which since 1832 have formed an integral part of the country, and whose geographical position is of increasing importance, when the opening of the Panama or Nicaragua Canal will render them of great service as ports of call.

Ecuador is traversed by the great backbone of S. America, the Andes Mountains, which form the great physical feature, and whose great altitude and awe-inspiring character alter the whole tone of both country and inhabitants. It is essential to understand that this great geological phenomenon affects the orographical, hydrographical, climatic, biologic, and even ethnological conditions of the country. We have, in fact, not *one* country but many to deal with, according as we are studying the regions of maximum heat on the coast and at sea level, or whether we soar away to the snow-line and hover about at this altitude, or any point intermediate between these two extremes.

The range of the Andes Mountains is in Ecuador known as the "Cordillera Real," or royal chain. It is composed of two parallel ranges of maximum elevation, running approximately north and south, and enclosing, by means of several transverse ridges from the one range to the other, a number of basins, varying in breadth from 25 miles to a point at Loja, where the two ranges unite and pass south into Peru. The eastern range has a mean elevation of 13,000 feet, at least 1000 feet more than that of the western range. The former, as we should expect, is also the stronger, in that but two rivers break through this chain and find their way into the Atlantic Ocean, against seven or more through the western chain into the Pacific Ocean. The interior basins, as I have called them, but which are generally known as the plateaux—incorrectly, I think, since they are but mountainous and broken-up country between the two ranges—do now and then broaden out into rolling plains, with an average elevation of 8500 feet above sea-level.

It will now be an easy task to grasp the fact that we have three separate divisions—the Western, called cis- or ante-Andean, from the foot of the mountains to the coast; the inter-Andean, or high land, with the higher folds of the mountains; and the trans-Andean, or "Oriente," extending from the lower folds of the range into the Amazon country of Brazil.

Although we have, as we shall see, such a variety of climate, etc., it will always be simplifying matters to revert to these three divisions in treating of any one subject.

The coast region is comprised of four distinct zones—(1) That of the mangroves, subjected to tidal inundations. (2) Savannas and quagmires, which will not admit of agriculture, but which are admirably adapted for the raising of cattle. The whole is inundated in the rainy season. (3) The zone of cultivation, the most important of all, extending from the savannas to the foot of the mountains. It is composed of a slightly sandy though rich soil. Vegetation flourishes profusely, and one finds many wild cocoa woods, as though the soil were predestined for the cultivation of this product. The climate is moist and warm. Inundations are only partial and transitory. (4) The mountain zone comprises the lower folds of the Cordillera. We can extend this to a height of say 3000 feet, up to which the products of a warm clime can be cultivated with profit. This region is sparsely cultivated, with the exception of here and there a stray hacienda. It remains for the most part covered with virgin forest, tropical and majestic vegetation. The rivers become rapid, depositing here and there banks of sand and soil favourable to the cultivation of cocoa, coffee, bananas, tobacco, etc.

In describing the inter-Andean portion of Ecuador it is noticeable that one passes from one continent to another, or, more accurately, from one zone to another. The soil, products, and beauty of the coast districts are of such diverse types and colours that, if the height and impenetrable nature of the ever-flowering woods, the width, number, and majesty of the rivers, the marvellous fertility of the plains startle even truth itself, how great is the contrast for one who, emerging from the labyrinth of forest, enters upon a district of open country, somewhat capriciously decorated with distinct colours, where the snow-peaks seem to lose themselves in the clouds, and contrast so sharply with the darkness and depth of their surrounding chasms; where one finds rushing mountain torrents and placid lakes, bold and bare peaks standing out from green valleys and meadow lands—a truly wonderful panorama.

From the ridge of Azuay certain irregularities in the general course of the Cordillera are apparent, and there is a perceptible widening. This feature is dominant through the rest of the Republic to the frontier of Colombia, and is due to the disruptive element which here enters into the geological constitution of both ranges. From the ridge of Sabanilla to that of Azuay the range bears the simple to almost monotonous outline of the crystalline rocks. From Azuay enters the volcanic element which revolutionises the outline of the mountains. Volcanoes erect their proud but dangerous crests above the ancient rocky base, and masses such as Chimborazo and Carihuairazo completely cover up the primitive form of the mountain chain.

It may serve to impress upon one the importance of the transverse ridges in the physical aspect of the country if I digress for a moment to point out the historical association of some of them. I have already said that the elevation of the enclosed basins is some 8500 feet above sea level, but the elevation of these transverse ridges is much greater, and often above 11,000 feet, with an average thickness, *i.e.*, in a N.S. direction, of more than five miles. Thus the ridge of Sanancajas completely separates the Riobamba basin from that of Ambato. Chimborazo towers up on the left hand, while its eastern slopes join on to those of Igualata, a mountain with an actual elevation of 14,500 feet, and whose eastern slopes again run steeply down into the narrow valley of Chambo, beyond which lies the eastern main range and the famous peaks of Tunguragua, Altar, and Cubillin.

The ridge of Tiocajas is memorable in the history of the country on account of the many decisive battles fought upon it. Here, about the middle of the 15th century, the Inca conqueror, Tupac-Jupanqui, defeated Hualcopo Duchisela, the 14th Shiri of Quito. On the same ground Tupac-Jupanqui's grandson, the Inca Huagna-Capac, defeated Cach-Duchisela, son of Hualcopo, some twenty-five years afterwards. In Tiocajas, Benalcazar, the Spanish conqueror, obtained a decisive victory over Ruminahui in 1534, by which he gained the Kingdom of Quito. And passing to later times, at the Battle of Galtee, the revolutionary party, under Veintemille, overthrew the constitutional Government in 1876.

The ridge of Sonancajas is nearly as famous, for here in quite recent years the present Government have overthrown more than one revolutionary attempt to upset the Liberal party.

It will be seen, therefore, that owing to the prominent elevation of these ridges above the surrounding country they are of strategical importance in maintaining peaceful relations between the several provinces into which the country is divided.

Passing to the last district, though the trans-Andean district has now been traversed by quite a number of explorers, it is still a difficult matter to give a general picture and one characteristic of this country. One thing only it seems safe to deduce, that this region is a boundless expanse of forest, and of much the same composition in all parts. But we know little more than the fringes of the rivers, and it would be dangerous to prophesy great things from an unknown and possibly in parts quite uninhabited country before studying it calmly from a scientific and practical point of view.

HYDROGRAPHY OF ECUADOR.

Despite an abundant rainfall, springs and running waters are rare in the volcanic region of Ecuador. In the loose scoriae and ashes covering much of the surface the moisture disappears as soon as precipitated, and infiltrates to great depths, reappearing at the crater mouths under the form of vapours.

Being fed by no springs about their sources, the rivers developed on the plateaux are of slight volume. Beyond the region of ashes and pumice, the streams flowing in less spongy beds increase rapidly in volume, many assuming the aspect of real rivers before reaching the coast. Such is the Guallabamba, which, after leaving the Plain of Quito, passes into a frightful gorge, 2000 feet deep, at the foot of Moyanda.

A few small coast streams follow southwards as far as the deep inlet, at the head of which debouches the copious Rio Guayas, which gives its name to the port of Guayaquil. The Babahoyo, its chief headstream, rises in the Pacific coast range, and after collecting numerous tributaries on both sides, assumes the proportions of a considerable river below the so-called "bodegas," or "stores," at the landing stage, where travellers start for the ascent of the plateau. The Babahoyo is a large stream, over 2000 feet wide before its junction with the Jaguachi or Chimbo, and expands to over half-a-mile on its junction with the Daule, which latter emerges from an extensive forest region, winding through low-lying plains between "savannas" and "quagmires." The marine inlet now known as the Guayas broadens out to over a mile at Guayaquil.

On the Amazonian slope the copious rains, intercepted by the dense vegetation even along tolerably steep inclines, transform its surface to a veritable sponge, like the turf bogs of the Irish mountains. Here the matted arborescent growths are in some districts replaced by grasses, or, rather, sharp-pointed reeds (*Chusquea aristata*), forming almost impenetrable masses of an average height of about 10 feet. In order to make any progress the wayfarer has to brush them aside with both arms, as in the act of swimming, pressing with the whole weight of his body on these herbaceous waves.

The spongy chusquea savannas peculiar to Ecuador are succeeded by rugged heights, swift streams, and woodlands festooned with the endless coils of lianas, where, to the traveller, dangers, hardships, risk of sickness, and death increase with every step. One reads with astonishment that S. Pizzarro was able to bring back alive even 80 of his followers from his memorable expedition of 1340 to the "Land of Cinnamon," as it was called. On emerging from these wild Andean valleys, the watercourses forming the Napo, Pastaza, Pante, and even the affluents of these Amazonian streams, are already copious rivers difficult to cross.

Of all the rivers on the Atlantic slope of S. America, the Pante, which rises in the Cuenca basin, has its source nearest to the Pacific Ocean. From its farthest headstream to the shores of the Gulf of Guayaquil the distance in a straight line is not more than 34 miles.

CLIMATE OF ECUADOR.

Like Colombia, Ecuador presents a succession of all climates superimposed on the flanks of the highlands. Each of the three physical zones, ante-Andean or cis-Andean, inter-Andean, and the trans-Andean, has its special climatic features, and in each the atmospheric relations are modified by altitude, aspect, and relative proximity to the ocean. Were Ecuador deprived of its uplands, it would be essentially a torrid region, whereas for most of its inhabitants it is a temperate, almost even a cold land, where the snow and glaciers on the mountain summits sparkle beneath the sun at its zenith.

In the projecting headlands of the province of Menabi the climate is cooled by the coast stream. Here the mean temperature of the sea is not more than 73 deg. to 74 deg. F., whereas farther north, in the sheltered waters of Esmeraldas, it rises to 83 deg.

Although protected by the double and triple barrier of the Andes, the Ecuadorean seaboard is subject to the rhythmical succession of tropical seasons. From June to December Guayaquil enjoys a so-called "summer," when the air is drier than during the rest of the year, while the land and sea breezes alternate pleasantly, dispersing both the mosquitos and the marshy exhalations. Then follows the "winter," or rainy season, with its fierce heats during the day, its storms at evening, and at night its downpours, destructive floods, swarms of pestiferous insects, and often its epidemics.

On the inter-Andean uplands the alternation of seasons is half effaced by the effects of the east winds bringing their regular burden of rains and vapours to the eastern slopes of both Cordilleras. Summits like those of Sara-Arcu and Iliniza, which lie near the aerial regions of conflicting clouds, are nearly always shrouded in dense aqueous vapours. The observer may reside months together at their bases without obtaining a single glimpse of their crests.

BOTANICAL DIVISIONS.

One may distinguish five distinct regions or zones :—

(1) The arid coast region, in which the greater part of the trees lose their leaves during the dry season.

(2) The moist region of the lower mountain and littoral, in which the greater part of the trees preserve their leaves throughout the year, even in the dry season.

(3) The forest region, always moist and green, on the outer folds of the Cordillera, ranging from a tropical to sub-tropical flora and the tree limit.

(4) The inter-Andean region of the cereals, whose original sub-Andean and sub-tropical flora has been much altered by the hand of man.

(5) The Andean region of the grassy plains, extending from the tree limit to that of perpetual snow.

FLORA.

The two cis-Andean and trans-Andean forest zones of Ecuador rival those of Brazil itself in richness and variety. In fact, the thickets traversed by the tracks descending to the Napo and the Pastaza valleys are mere extensions of the great Amazonian wood-lands. The Ecuadorean forests have already yielded several valuable species, and hold many others in reserve. It was in the province of Esmeraldas that La Condanine procured from the natives the first samples of caoutchouc gums ever sent to Europe.

The first barks reduced to febrifugal powders by the European chemists were those of cinchona (*Macrocalyx* and *Cinchona pubescens*), which in the 17th century were procured exclusively in the Ecua-dorean forests of Loja and surrounding districts. The efficacy of the bark of cinchona (*Arbol de calenturas*), the "fever tree," was well known to the natives when Juan de Vega ventured to use it in 1638 to cure the chuchu, or endemic ague, contracted by the Countess de Chinchon. Henceforth the *polvos de la condesa* ("Countess's powders"), later called "Jesuit's powders," "Jesuit's bark," or "Peruvian bark" entered into the European pharmacopœia.

The Ratanhia, much used in the case of dysentery and hæmor-rhages, was also a member of the Ecuadorean flora. Another tree growing in the same region produces copal, and the upper Rio Mira basin is the home of the false pepper (*Ichnius molle*), which has become so common round the Mediterranean seaboard. The Quitonians also possess the Guayusa, a kind of "tea," which grows spontaneously in dense thickets on the slopes of Pichincha and other mountains.

Palms occur everywhere, but nearly always solitary or in isolated clumps. Some wax palms shoot up straight and graceful as a reed to a height of 200 feet. The tagua (*Phytelephas macrocarpa*), another variety of palm, has the appearance of a young cocoa-nut tree. Its large fruit or "negro-head," of melon shape, contains numerous grains, too hard for the teeth of the peccary or monkey. This is the "vegetable ivory" of commerce. Another useful variety is the

Carludovica palmata, the ribs of whose fan-shaped leaves are used for making the so-called "Panama hats."

Scarcely less numerous than the palms are the macanas, or tree-ferns, 32 varieties of which were recorded by Lindig in the section of the Andes lying north of the equator. They range in altitude from 650 up to 10,000 feet. The stems are often used as stakes in the "empalisados" (palisaded roads), where, but for these "sleepers," the wayfarer would run the risk of disappearing in the quagmires. The bamboo (*Bambusa guadua*) has even a still higher range.

The befaria, or American "Alpine rose," resembling the European rhododendron, grows to a height of 5 or 6 feet, with a range in altitude of from 9,000 to nearly 11,000 feet.

In the Ecuadorean Andes the upper limit of arborescent vegetation attains an altitude of 11,800 feet above sea level. But many vast spaces comprised within this zone are absolutely treeless despite a superabundant rainfall. Thus the volcanic uplands of the Quito and Riobamba basins have no trees except willows (*capulí*) or wild cherries (*Rhamnus humboldtiana*) fringing the river banks. On the sandy Riobamba plain nothing is seen except agaves, euphorbiæ, Barbary figs, and other cacti, besides a species of reed known by the Quichua name of sigsig (*Arundo nitida*).

The agave (*Cabuya Mexica*), so common a feature throughout the country in the hedges and other landmarks, is an interesting and useful plant for the Ecuadoreans. In parts of the country, especially around Riobamba, the leaves are carefully nurtured, lopped at regular intervals and converted by a process of putrefaction under water into a raw hemp, which is afterwards worked up into ropes, sacks, and even cloth, by the most primitive of looms. In addition, the plant has a flower which caps a long straight stalk of 15 to 20 feet, and which, when cooked, very much resembles an artichoke both in appearance and flavour. The stalk, when cut and dried, serves as a rafter in the light houses constructed by these people. Yet another virtue this plant possesses is that the sap, when tapped like the toddy plant in India, yields a very good alcohol. Each leaf is protected by a formidable spine, which is attached to the fibre, and serves the needy wayfarer as needle and thread combined in case of accident to his clothes. Any waste leaves there may be are sun-dried and collected by the poorer natives to serve as fuel.

Even far below the plateau, in the Guallabamba gorge, trees are absent, which is to be attributed, not to the climate, but to the loose volcanic ground, where the rain waters rapidly disappear. But forest growths recover their exuberance and variety in the regions of more tenacious soil, on the eastern slopes of both cordilleras, and farther south in the Loja plateau, where the woodlands of the seaboard are continuous across the cordillera with those of the Amazonian basin. Here botanists have found the condurango, an asclepias formerly supposed to be a specific against cancer, and some rare species of orchids, which, thanks to the temperate climate of the Andes, are more easily acclimatized in European conservatories than the orchids of Brazil. On the seaboard vast spaces, lying to leeward of the mountain ranges, and consequently cut off from the moist trade winds, remain arid and unproductive, despite their naturally fertile soil.

The *Polylepis*, dwarf trees with twisted boughs and roots and birch-like bark, which occur here and there on the slopes, range far higher than the forest growths. In those districts where the shrubs have been fired, they are invariably replaced by various herbaceous plants (*Stipa*, *Andropogon*, *Paspalum*), comprised by the Indians under the general name of "ichu." Farther up nothing is seen except low, vivid green growths, such as the woolly-leafed *Culcituim*, one variety of which (*C. nivale*) flourishes in the very midst of the snows. Certain flowering plants reach the neighbourhood of the snow-line, which is estimated at about 16,000 feet; at an altitude of 18,500 feet Whymper still met patches of a lichen (*Lecanora subfusca*), probably "the greatest elevation at which anything appertaining to the vegetable kingdom has been found in either of the Americas."

FAUNA.

Taken as a whole, the Ecuadorian fauna differs in no respect from those of the conterminous regions of Colombia and Peru. Some species absent from the Northern Andes range as far as Ecuador, although the llama ("camel") of Peru reaches no farther north than Riobamba. In most other districts it has been replaced by the mule as a pack animal. The condor hovers over the Quito plateau, as well as over the Peruvian and Bolivian mountains. But Humboldt was mistaken in supposing that it soars above the loftiest summits of the Andes, and that, by a remarkable power of adaptation to the environment, it finds itself equally at home in the neighbourhood of the sea and in the upper aerial spaces where the atmosphere has already lost half of its weight. If the Chilian condor descends to the coast, its cogener of the Ecuadorean Andes is scarcely seen below 8,850 feet, and even dies if brought in captivity down to the sea.

On the other hand Whymper never saw the condor higher than 15,000 feet. It hovers over the pastures usually at about 1,500 feet from the ground, maintaining itself by nearly imperceptible movements of the wing, and scarcely ever attacking any but young animals or those enfeebled by age—calves, old horses, and the like.

The eastern forests harbour a great variety of birds, which have mostly a very limited range, often depending for their existence on a single species of flower or fruit. Most of the humming birds, even on the uplands, are thus confined to very small areas. An ibis (*Theristicus caudatus*) is the characteristic bird of Antisana, and the "flautero" (flute player), endowed with a marvellously correct musical note, is restricted to the eastern forests.

The habits of various species have also been modified by their different environments. Thus Alfred Simson tells us that the bananas of Baeza, on the Amazonian slope of the Rio Napo, planted at an elevation of 7,880 feet at the foot of cliffs well exposed to the solar heat, suffer much from the ravages of a vampire (*Thyroptera bicolor*) which penetrates into the terminal flower and absorbs its sap. The chief obstacle to the settlement of the Amazonian slope is the multitude of bats (*Phyllostoma spectrum*), which attack both man and beast. Many of the children die of exhaustion from the attacks made on them while asleep by these blood-sucking vampires. In these eastern forests the reptiles are represented by innumerable species of snakes, which, however, are nowhere met higher than 13,000 feet on the plateaux.

The originality of the local fauna appears especially in the lower organisms, notably the insects, most of which are also confined to very narrow ranges, several being found only on certain mountains. Whymper discovered on Pichincha no less than 21 new species of beetles, 8 of which have been met nowhere else. Ecuador has altogether as many as 8,000 known species of coleoptera. The *Colias alticola* butterfly flits upwards to the neighbourhood of the snow line, although never seen on the lower slopes of the mountains.

On the plateaux the streams and meres at the great altitude of 14,600 feet present only a single species of fish—the preñadilla (*Pimelodes*, or *Cyclopium cyclopum*). The natives no doubt speak of others inhabiting the upland basin, but naturalists have hitherto failed to discover them.

The seas, especially about the estuaries along the north coast near Colombia, abound in animal life. One species, large shoals of which frequent Pailon Bay and the Sardines Archipelago, is the famous "musical fish," first described by Onffroy de Thoron. It is distinguished from the grondin and all other singing-fishes by a peculiar note "well sustained, prolonged and harmonious." The same waters are infested by the manta, another curious marine animal, much dreaded by sailors. According to De Thoron's description it has no fins, but two arms, with elbows of almost human shape, and seizes with its "palmed hands" the floating seaweeds on which it feeds.

As I have said, the fauna is specially distinguished for the amazing variety of animal forms, birds and insects. Like North America, this region had also its gigantic mammals, whose numerous remains are found—bones of megatheriums, glyptodons, taxodons and fossil horses. According to some naturalists the mastodons would appear to have survived till recent times on the elevated plateaux.

The present mammals,—such as apes, bats and vampires; pumas, jaguars, and other felines; bears, sloths and ant-eaters; tapirs and peccaries,—all belong to the same species as those of Venezuela and Central America, as do also most of the birds. Nevertheless certain species have a very limited range, conditioned by the presence of certain trees and flowers. Hence any slight disturbance—a fire, a clearance, erosions, or landslips—will at times suffice to cause their disappearance.

The monkeys of the tropical forests never ascend to the cold regions; above 6,000 feet the traveller is safe from the fangs of venomous snakes; and fleas and many other parasites, as well as birds and butterflies, are similarly limited in vertical range.

INHABITANTS.

In Ecuador proper the aborigines have disappeared, or have been merged in the conquering races of pre-Colombian times, and afterwards slightly modified by crossings with the Spaniards. The Caras, Cañars and Quitus, formerly dominant on the plateaux and western slopes, had originally come from the south. In Ecuador they intermingled with the indigenous peoples, who perhaps belonged to the same ethnical stock, as may be inferred from the generally current Quito language, a dialect of the Peruvian Quichua. According to a native chronicler, quoted by Spanish historians, all the subjects of the Incas were required to speak the language of the conquerors, and this injunction was everywhere complied with. But such conformity, even if it were possible, would of itself imply a certain affinity between all these forms of speech.

ABORIGINAL POPULATION OF AMERICA.

Professor Wilson, in his "Prehistoric Man," rejects the idea of ethnical unity between the Mexicans and Peruvians, and considers the indications as pointing to two, or possibly three, great divisions of race, with as many distinct lines of immigration. He conceives "the earliest current of population" from "a supposed Asiatic cradle land" "to have spread through the islands of the Pacific, and to have reached the South American continent long before an excess of Asiatic population had diffused itself into its own inhospitable northern steppes. By an Atlantic Ocean migration, another wave of population occupied the Canaries, Madeira, and the Azores, and so passed to the Antilles, Central America, and probably by the Cape Verdes, or, guided by the more southern equatorial current, to Brazil. Latest of all, Behring Straits and the North Pacific Islands may have become the highway for a northern migration by which certain striking diversities of nations of the northern continent, including the conquerors of the Mexican plateau, are most easily accounted for." "The north and south tropics were the centres of two distinct and seemingly independent manifestations of native development," but with "clear indications of an overlapping of two or more distinct migratory trails leading from opposite points."

It is to be remarked that the novelty of this theory consists, not in any new suggestion to account for the original settlement of America, but in the adoption and symmetrical blending of various conjectures, and the application of them to explain the differences of physical characteristics, customs, developments, etc., between the savage and civilised or semi-civilised nations scattered over the continent. The evidence offered in its support does not admit of being summarised here. Elaborate as it is, it will scarcely be considered sufficient to establish the certainty of the general conclusions deduced. On the other hand, arguments in disproof of a supposed craniological uniformity of type among the American aborigines appear to be irresistible, and to justify the statement that "the form of the human skull is just as little constant among different tribes or races of the New World as of the Old."

Quichua tradition spoke of a race of "giants," who inhabited the forests of the sea-boards, and whose remains, probably those of mastodons, are still to be met with. The term "giant" given to these aborigines may perhaps be explained by the stout resistance they offered to the Quichua invaders.

Under the Spanish rule the Cara tribes of the coast-lands all became merged in the general population except a few Colorado families of the Upper Rio Toachi, and about 2,000 Cañars, who still keep to the forests on the banks of the Rio Cayapa, holding carefully aloof both from the whites and the negroes. Wolf has collected a vocabulary of their language, which has also remained unaffected by Quichua or Spanish influences. In the inter-Andean districts all the aborigines have been similarly merged in the half-caste population of Quichua speech; a few Cañar families alone survive near Zaraguro.

But whilst most of the Indians have lost the memory of their origin, numerous huacas or tolas ("graves or barrows") have been discovered, and unfortunately eagerly rifled of their contents by treasure-seekers. Even the "Castles of the Incas," which had been erected in various parts of Ecuador, have been systematically destroyed by the inhabitants of the neighbouring towns in the hope of finding gold, and used afterwards as convenient quarries. I have myself seen some of these graves that have been broken open by intelligent people, and especially in one case by a man, educated in Europe, who, quite regardless of some specimens of pottery, and other household treasures found in the grave, ordered his peons to dig on to find the gold, to the inevitable destruction and loss of what was perhaps more interesting and valuable to mankind in general. In several places archæologists have re-discovered sections of the highways laid down by the Incas, but they are not built with the same care as those of Peru itself.

In the eastern regions, on the Amazonian slopes, the uncivilised tribes are still reckoned by the dozen. Their nomenclature is interminable, but despite this fact they are but thinly scattered. They form two social and political groups, "salt-eating" Indians, and others who make no use of salt.

Most famous of these rude tribes are the Jivaros, who were formerly grouped about the mission stations in the south-east of Ecuador, but who, towards the close of the 16th century, rose up and massacred all the whites, sparing women alone. Since then, driven east, they have roamed the forests of the Pastaza gorges and the Pongo de Manseriche. Their speech is absolutely distinct from the Quichua, and they have been affiliated by the anthropologists to the great Guarani family. They are a fine race, living on the produce of the chase, of fishing, and their swine. They are of industrious habits, attending both to agriculture and to the manufacture of diverse useful objects. The warriors shew remarkable skill in preserving the skin of the enemy's head, which is shrunk by a drying process without undergoing any modification of form. The traffic in these heads is of course forbidden by the Ecuadorian government, but nevertheless they do still find their way into the market. Every bone in the head is of course extracted before reduction, and the finished article, about the size of a man's fist, with long and often beautifully silken hair, is not altogether a pleasant object to adorn one's sitting-room with.

The mestizoes, who, however, have but a slight strain of Spanish blood, and who constitute the bulk of the inhabitants of Ecuador, appear to have preserved the character, habits and genius of their Quichua ancestry. Accustomed to dread the violence and oppression of their Inca and Spanish rulers, they still cringe before the white man, mistrusting even those who treat them with kindness. They never decline service, and are always full of promises, and seek by a thousand subterfuges to shirk work and deceive their masters. Their courtesy is genuine, being in fact inspired by fear. Those Spanish-speaking natives never pass the traveller without raising their hats and a "good day," whilst those who still converse in their own Quichua dialect have been taught to address the wayfarer with "may the blessed sacrament be praised," to which the appropriate reply is expected, "may it ever be praised." This timidity of character so common amongst the Ecuadoreans may perhaps be explained by the frequency and destructive force of the earthquakes. The frightful shocks, swallowing up whole cities, seem to them divine punishments for their sins. Hence they live in a state of perpetual terror, even imploring the priests, saints and angels to plead for them.

In this fervent piety they worship the Catholic saints with the same faith as that with which they worshipped their former idols. As in Spain and as among the ancient Quichuas, the solemn processions have their masks, mimes and dances; they have also their voluntary martyrs, who lacerate themselves like the mediæval flagellants and the fakirs of India.

Except during these days of frenzy and ecstasy, the Ecuadoreans are a sad and sullen people. Their features, especially those of the women, seem haggard with care and abiding misery. Some of their customs are repulsive to the European, and uncleanly habits prevail in this land of dust. Yet, despite their sordid surroundings, the Quitonians appear to possess the sentiment of form and colour in the highest degree. It is noticeable that neither his extreme poverty, nor the dull existence to which he is condemned, has prevented the Ecuadorean from distinguishing himself by the elegant cut and harmoniously-blended colours of his clothes. Silk hats and frock coats are *de rigueur* amongst Quitonians, whilst the ladies, I am told, order most of their gowns from Paris. The convents provide for them excellent drawn work, lace and embroidery, whilst the practice of their religion occupies most of their time. Notwithstanding the rigid hieratic formulas and conventionalities to which the priests have enslaved them, many of the mestizoes, and even of the full-blood Indians, succeed in executing really remarkable religious paintings, as well as sculptures of Christs and Madonnas, works greatly admired in Peru and other South American countries, to which they are regularly exported. But the natives have lost one artistic industry—inlaid work in costly woods.

Of all the Hispan-American republics, Ecuador has been the least modified under the influence of European customs and ideas. On the elevated plateaux, always difficult of access, the Quichua, Cañar and Puruha natives have scarcely changed their social habits in the presence of a handful of whites, themselves almost cut off from all intercourse with their fellow-countrymen elsewhere. The first collision had been terrible and decisive, and the surviving Indians had been fain to adapt themselves to a new political system.

The later political movements had their origin, not in the lower strata of society, but exclusively in Quito and the other cities, when the creoles of Spanish descent felt themselves outraged in a thousand ways by the privileges and arrogance of the fresh arrivals from the peninsula. Lawyers ousted from their lucrative positions by young Spanish favourites were the instigators of the first rising, which took place in 1809 in Quito, "in the name of the legitimate Sovereign, Ferdinand VII., and of the holy Roman Catholic Church." Then ensued the War of Independence, and the result was the constitution of an autonomous republic in Ecuador. Certain changes in the social position of the people followed, such as the attraction of the rural classes to towns by the development of trade, and, in a less measure, by the awakened thirst for knowledge.

Racial crossings, more developed in the urban than in the rural districts, tend to blend the ethnical elements in which Indian blood predominates, and at the same time to diffuse European political and social sentiments. The inter-Andean region, where have sprung up all the towns, properly so called, except Guayaquil, may be regarded as practically constituting the whole of Ecuador, viewed from the stand-point of wealth and culture.

The movement of immigration remains insignificant, and many of the towns have not one single foreign resident. I myself, if I may except a Jewish watchmaker who claimed to have come from London, was the only Englishman in Quito, though my friend the British Consul, Mr. Söderström, a Swede, was in every respect an English gentleman.

Ecuador, a country of old Spanish and aristocratic traditions, is also a country of vast landed estates. The result is that the bulk of the population are serfs, almost slaves, still burdened with debt, an oppressed generation whose woeful condition is disguised under the name of concertados, by contraction conciertos, as if their wretched plight were the effect of "free contract."

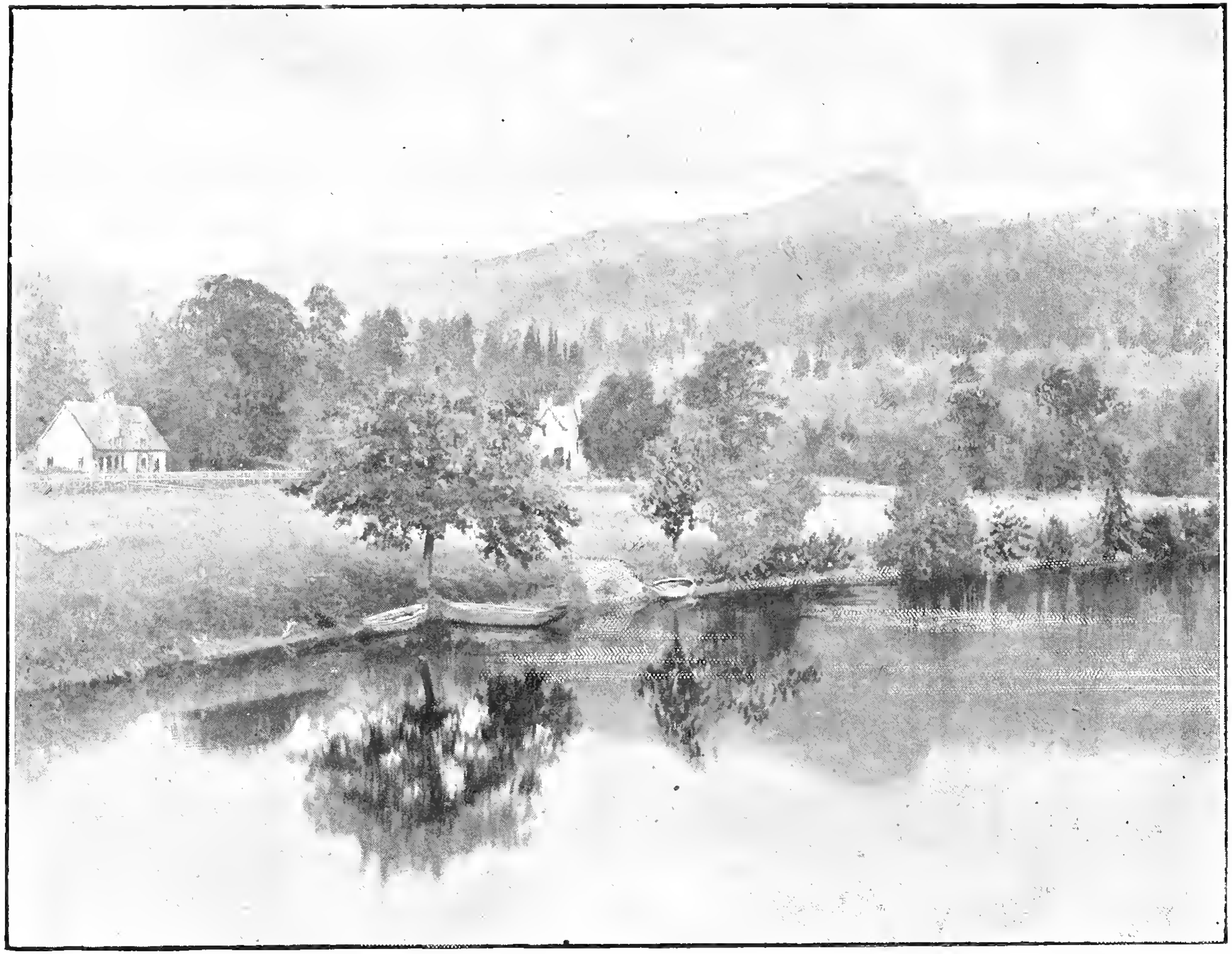
Stock breeding and sheep are the chief industries of the plateaux. Midway up the mountains, and in many of the lower valleys in the interior, coffee plantations flourish, replaced lower down by sugar and cacao.

GOVERNMENT.

Although the Republic of Ecuador is theoretically founded on the "sovereignty of the people," the suffrage is far from being universal. The privilege of voting is in fact restricted to Roman Catholics. The electors may even be excluded from the voting roll for misconduct, of which the administration is judge, which rather reminds one of the Transvaal's proposed franchise restrictions.

EXPLANATION OF PLATE.

THE photograph has been taken from Lochy Bridge, Killin. Behind the cottage to the left numerous fine exposures of the Loch Tay limestone with its associated epidiorites and hornblende schists may be seen. The river here flows across the outcrop of the Loch Tay limestone, which runs up to the base of Creag-na-Caillich. The first ridge of the mountain covered with fir trees consists of garnetiferous quartz and mica schists. The summit of the mountain seen beyond consists of the phyllites, quartz-ites, and greywackes, in which the annelid tubes are found, and which strike westwards across Meall Dhùin Croisg, whose rugged outline is seen to the left of the picture. Creag-na-Caillich is a classic mountain in the history of Perthshire botany, the summit being composed of the same schists as cap Ben Lawers, and whose influence in the distribution of our Alpine flora has already been discussed by the author—see Vol. II., Part VI.



R. Bulloch]   **Creag-na-Caillich, from Lochy Bridge.**   [*Photographer.*

The legislative power has been entrusted to a Congress of two houses—a Senate composed of two members for each province, elected for four years, and a Chamber of Deputies elected for two years on the basis of one deputy for every 30,000 inhabitants. One half of the Senate retires every two years.

Both President and Vice-President are elected by direct popular suffrage for four years, but the latter is nominated two years after the President, so that he remains in office two years after him, and is thus a member of two administrations. During his term of office, the President is aided by a ministry of four members, charged with the conduct of home and foreign affairs, finance, war, religion and public instruction. The President chooses the judges of the higher courts from a list of three candidates presented by the Supreme Court of Justice.

This tribunal consists in its turn of judges named by Congress for ten years and re-eligible. Their power is thus less exposed to political vicissitudes than that of any other functionaries.

The present so-called Liberal form of government has separated Church from State, and has thus struck a blow at what was formerly a peculiarity of the Ecuadorian constitution, whereby Ecuador proclaimed itself explicitly "Catholic, Apostolic and Roman," to the exclusion of all other creeds, and was then the only government which had a really and thoroughly Catholic character.

XVIII.—*On the Occurrence of a Zone of Annelid Burrows across the Southern Highlands of Scotland.*

By Peter Macnair, of the Glasgow Museums, Assistant Secretary Glasgow Geological Society.

(Read 11th April, 1901.)

The Geological Survey of the Highlands of Scotland being now considerably advanced, it can at last be said that geologists are beginning to know something at least of the structure of that complicated and difficult region. In a paper which I contributed to the *Geological Magazine** in the year 1896, I gave a short description of the stratigraphy and structure of the southern highlands, dividing the clastic rocks of that region into six well-marked zones. Since that time the detailed researches of the Geological Survey, as published in their memoir upon the geology of Cowal, and in the annual reports, have, so far as I can see, tended to confirm the views set forth

* *Geol. Mag.*, 1896, Dec. IV., Vol. III., pp. 167 and 211.

in my paper. These six zones are found to exhibit along the southern highlands six well-marked outcrops, whose features it is impossible to mistake.

Further, the detailed work of the survey has enabled them to subdivide these zones into well-marked sub-zones or horizons, having a general north-east and south-west strike across the highlands from sea to sea. In my former papers I had hinted at the possibility of still further sub-dividing the main zones in this manner, though I had not then obtained sufficient data to successfully determine these stratigraphical details.

Perhaps one of the most striking examples of these sub-divisions marked out by the Geological Survey is the boulder-bed in the upper arenaceous zone. This bed has been found at various points along a line stretching from Aberdeenshire on the east to Islay on the west, and tends to show that the schists of the highlands belong to one great group.* Another exceedingly interesting and well-marked horizon is a group of fine, often calcareous, sericite schists, found in the upper argillaceous zone, and locally known as the Ardrishaig, Ben Lawers, and Caenlochan schists; it is to this group of rocks that I propose to revert more particularly in this paper. In the upper argillaceous zone I have noticed at least four other types of rock, as well as these calcareous sericite schists, namely, quartzites, greywackes, dark graphitic mica-schists, and beds of black slate. In the quartzites, greywackes, and even the beds of mica-schist, as had been pointed out by the late Duke of Argyll, certain peculiar bodies have been found, which I venture to think cannot be explained on any other view than that of their annelid origin.

Before passing, however, to the discussion of these worm-tubes—the more immediate subject of my paper—I may here briefly revert to the cyclic character of these highland rocks, a feature not without interest even in the interpretation of the worm-burrows. It has been pointed out by certain geologists that the great formations of the earth show evidence that they represent a series of physical changes corresponding with the gradual sinking of the land to a maximum, followed by its gradual upheaval, the successive stages in this cycle being represented roughly by an arenaceous, argillaceous, and calcareous group of rocks respectively. Thus, when the land began to sink, and estuarine and littoral conditions prevailed, the arenaceous rocks were deposited, and were represented by conglomerates, grits, and sandstones. A further sinking produced a more argillaceous type of

*This bed was first noted by Macculloch, *Western Islands*, Vol. II., page 249, 1819; afterwards by James Thomson, *Transactions Geological Society of Glasgow*, Vol. V., page 210, 1875. The survey has also differentiated out a group of schists known as the green beds, which appear to overlie the Ben Ledi grits.

deposits, in the shape of shales, etc.; while the maximum stage in the lowering of the land is shown in the presence of limestones and similar calcareous deposits; these three stages being again repeated in a reversed succession upon the upheaval of the land. The British carboniferous deposits may be taken as a striking example of this cycle of deposition. Now, it seems to us that in the altered clastic rocks of the highlands we have evidence of similar cycles of deposit. We have, in the slates and limestones of the highland border, evidence of deepish water conditions. Then the land begins to rise, and the quartzites, grits, and greywackes of the succeeding arenaceous zone take the place of the underlying argillaceous deposits. A sinking again takes place, and reaches its maximum in the thick beds of the Loch Tay limestone. Again this upheaval is followed by a lowering of the sea floor, and the upper argillaceous series is thrown down, this being finally succeeded by a re-emergence of the land, during which period our upper arenaceous series was deposited, represented by the quartzites and grits of Schiehallion and Ben-y-Ghloe, etc. The metamorphism of these sediments, if it has obscured the original structures of the rocks, has tended to perpetuate and emphasise their larger characteristics, so that one can still trace with a strongly-marked distinction the argillaceous, arenaceous, and calcareous deposits succeeding each other in what might be called a cycle of succession. As already hinted, even in the worm-burrows a marked distinction between the more arenaceous walls and the argillaceous contents of the burrow can often be traced, as was pointed out by the Duke of Argyll.*

The occurrence of the burrows and castings of errant annelids in the Cambrian quartzites of the north-west of Scotland has now been known for close upon a century, and for nearly the same period of time the zonal value of these worm-tubes has been recognised. The researches of the Geological Survey amongst these rocks have shown that the quartzites with annelid burrows—the so-called pipe-rock—is capable of a still further zonal sub-division, according to the size of the tubes. Thus, three sub-zones are identified by the different sizes of the annelid burrows which they contain, the diameters of the tubes being respectively an eighth, a half, and from three to four inches. Again, the fucoid beds, which are now recognised to be of annelid origin, form a well-marked horizon, co-extensive with the pipe-rock just mentioned, these beds of quartzite, with their characteristic annelid burrows, having been traced from the shores of Loch Erribol through Assynt, by Ullapool, to the western shores of Ross and Inverness. From the evidence derived from this particular instance, then, we can at once see the great

* *Proceedings*, *Royal Soc.*, *Edinburgh*, Vol. XVI., p. 39. 1888-9.

possible value of these annelid burrows in identifying zones amongst the highly-altered rocks of the highlands; in fact, they are the only trace which has been retained of an organism amongst these highly-altered rocks.

From the very beginning of my study of the southern highlands, though recognising the highly-altered character of its rocks, I had hoped to be able to find somewhere among its more arenaceous members traces of worm-burrows similar to those found in the north-west of Sutherlandshire; but though I had diligently searched the grits, greywackes, and quartzites of the highland border, as well as the central highland quartzites, the search was about to be abandoned as futile when, by pure accident, I at last found what seemed to be the object of my long and hitherto fruitless search amongst the wild, wind-swept corries of Creag-na-Caillich, a mountain rising to an altitude of 2990 feet above sea level, at the western end of Loch Tay, and forming a point in a picturesquely rugged ridge culminating to the east in Ben Lawers (3984 feet).

The first thing to attract attention was the nature of the rock, which forms a bold escarpment facing the east, upon the summit of Creag-na-Caillich, and which seemed at some points to be composed of a finely-banded quartzose rock broken up by weathering into large slab-like masses. The first indication of the presence of annelid burrows in this rock was a slab covered all over with small pit-like markings having a diameter of about $\frac{1}{4}$ inch. The striking similarity of the specimen to the pipe-rock of the north-west was apparent, and I at once concluded that these markings could only be of annelid origin.*

In the beginning of the year 1889 the Duke of Argyll read a paper before the Royal Society of Edinburgh † upon certain bodies, apparently of organic origin, from a quartzite bed near Inveraray. In this paper he described the occurrence of certain peculiar ovate-shaped bodies which he had found in the immediate neighbourhood of the castle, and upon the shores of Loch Fyne. They were described as occurring in thin bands of quartzite, inter-bedded with finely-foliated mica schists. The bodies were best seen in the pure white quartzite, from the matrix of which they were sharply defined. The interior of the ovate bodies was generally seen

* Some time after their discovery I showed the specimens to Mr. James S. Grant-Wilson, who was then surveying the district for the Geological Survey. Shortly after this a notice appeared in Sir A. Geikie's "Geology and Scenery of Scotland" in the shape of a footnote to the following effect:—"Mr. B. N. Peach and Mr. J. S. Grant-Wilson have recognised the occurrence of annelid tubes like those so abundant in the so-called piped-quartzite of the north-west among the quartzites of Perthshire."

† *Proceedings*, *Royal Soc.*, *Edinburgh*, Vol. XVI., p. 39. 1888-9.

to consist of a more highly argillaceous material than the surrounding matrix. In many cases the ovate was so extremely drawn out that, seen in section, it was only represented by a thin streak or line; while in the surface of the quartzite it presented a lenticular ribbon-like shape. These the Duke believed to be nothing more nor less than worm-burrows, which had been deformed and drawn out during the extreme plications to which these rocks had been subjected. His Grace based his conclusions upon a carefully-made study of the living annelids inhabiting our foreshores at the present day; and, so far as I am able to judge, the Duke of Argyll's interpretation of these bodies seen in the quartzites of Inveraray appears to be the correct one.

Upon reading the notice of the Duke's paper, I at once recognised that his specimens were identical in their general features with those collected by myself, and I had the pleasure of submitting to the Duke specimens from the Creag-na-Caillich beds, along with a section showing their stratigraphical position at that point. These His Grace acknowledged to be similar in every essential characteristic to his own, though perhaps rather more finely marked than the Inveraray specimens.

Since that time I had recognised the possibility that these annelid burrows might correspond in a similar manner with those of the north-west, and mark a definite line or horizon along the southern highlands. On several occasions, in correspondence with His Grace, I had drawn attention to this important aspect of the question; and, from the descriptions which he sent me of the nature and relationships of the beds seen along the shores of Loch Fyne, I came to the conclusion that, apart even from the occurrence of the annelid burrows in them, they seemed to occupy the same stratigraphical position as the beds of Creag-na-Caillich.

In the year 1892 a geological map of Scotland was published by Sir A. Geikie, embodying the most recent results of the Geological Survey in the differentiation of the altered rocks of the highlands. Here these beds in which the annelid tubes occur were given under one colour as the Ardrishaig, Ben Lawers, and Caenlochan schists, from which I concluded that the Survey had at least recognised the identity of the rocks, if they had not admitted the annelid origin of the bodies they contained.

It may here be stated that Sir A. Geikie had previously objected to the organic origin of these bodies, except in the footnote already referred to in his work upon "The Geology and Scenery of Scotland." At a meeting of the Royal Society of Edinburgh Messrs. Geikie and Peach had put forward the view that these so-called annelid burrows were merely clay-ball concretions which had been formed along the seashore, and which had subsequently been drawn out into their present ovate and lenticular shapes. At a meeting of the Edinburgh Geological Society in 1889 I read a paper in defence of the annelid origin of these bodies, and of their probable zonal value, though I cannot find that any notice was taken of this paper in the *Transactions* of the Society, and my views were not then accepted.

Previous to this, however, I had given a short notice of the discovery and nature of these bodies before the Perthshire Society of Natural Science. This paper was afterwards published in the *Transactions* of the Society for the year 1889. I also at that time presented a large suite of specimens to the Museum of the above Society, which were labelled by me as sheared annelid tubes.

It may be as well to remember here that Maculloch had, at the beginning of the century, discovered annelid tubes in the quartzites of Islay, a discovery which has recently been confirmed by the Geological Survey.*

In the Memoir upon the Geology of Cowal we find a reference † made to the Duke of Argyll's discovery among the Loch Fyne quartzites. The organic origin of these bodies is, however, denied, and their occurrence is ascribed to the drawing out of crystals of iron-pyrites, which are "not uncommon in the quartzites." The occurrence of a bed is, however, cited near St. Catherine's, in which these peculiar bodies are also found, and in which no trace of pyrites can be seen, the conclusions being evidently qualified by the occurrence of this bed, for it is stated that in most, if not in all instances, these structures can be traced to the drawing out of iron-pyrites.

During the course of last summer I had an opportunity of examining the beds in which these annelid burrows occur at various points along the shores of Loch Fyne, and, by the kindness of the Duke of Argyll, of inspecting the localities originally described by him in that district. I also examined certain sections near Tyndrum, where an outcrop takes place of the same beds as those at Loch Fyne in Argyllshire and Creag-na-Caillich in Perthshire, namely, a group of finely-foliated sericite schists, with thin beds of quartzite, and found in the quartzite beds exactly the same structures as those described by the Duke of Argyll from Loch Fyne. It seemed that here there was confirmatory evidence of the organic nature of these bodies and of their zonal value.

The object of this paper, then, is to re-state the arguments in favour of the annelid origin of these bodies, and also to show that they have evidently a well-marked horizon among the highly-altered

* (1) *Quarterly Journal, Geological Society*, Vol. XVII., p. 211. 1861. (2) *Scenery of Scotland*, Sir A. Geikie. Third ed., p. 137. 1901.

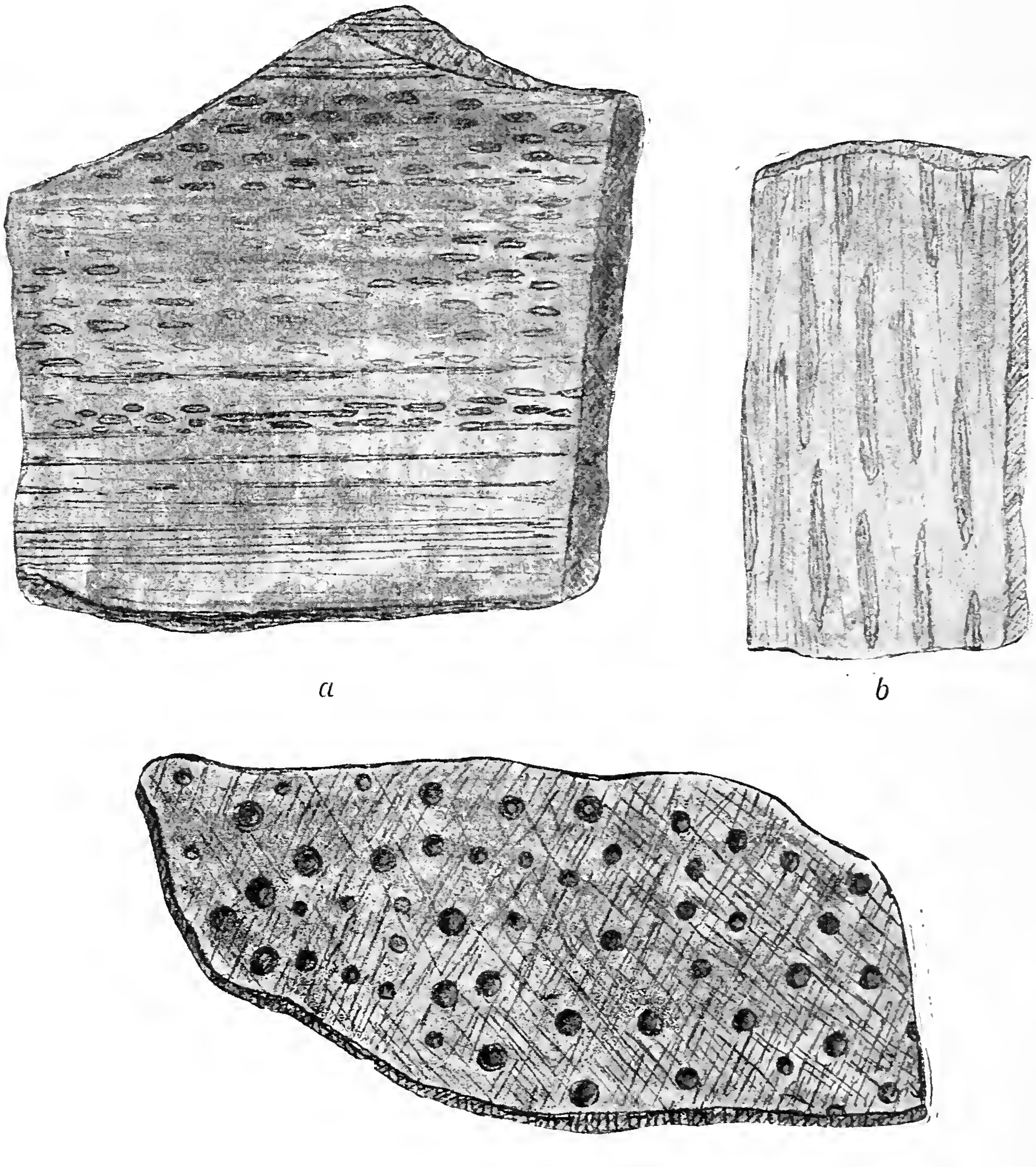
† *Geology of Cowal*, p. 56, 57. 1897.

clastic rocks of the southern highlands. Objections have been raised on all hands to the views advanced by the Duke of Argyll and by myself. This, however, is not to be wondered at, when one considers the exceeding obscurity of the specimens. I have submitted what I consider to be some of the most conclusive specimens in my collection to several of the leading experts in the study of these rocks, and there seems to be a growing belief in their organic origin. When the Duke of Argyll discovered his specimens he submitted them to Mr. Robert Etheridge, F.R.S., one of the ablest and most experienced of living palæontologists, who had no hesitation whatever in ascribing to them an annelid origin. Some time after I also had the privilege of submitting to Mr. Etheridge several exceedingly clearly marked specimens from the Creag-na-Caillich section, which he recognised at once as annelid burrows, and said they left not a shadow of doubt in his mind as to their being the work of annelids. Since my former paper was written I have returned again and again to examine the splendid section seen at Creag-na-Caillich, on Loch Tay, and have obtained from it specimens whose annelid origin seems to me so plainly evident as scarcely to admit of a doubt.

Passing now to a description of these bodies, and to a consideration of the evidence linking their origin with the burrowing of annelids, let me in the first place describe the specimens found on Creag-na-Caillich, Killin. The rock in which the annelid burrows have been found on this mountain is of a dark grey colour and of exceedingly fine texture. It is associated with dark graphitic mica schists, fine-grained quartzites with planes of secondary mica, and beds of calcareous sericite schists finely foliated and extremely contorted. The greywackes in which the annelid burrows are most conspicuously seen often exhibit finely-banded structures of lighter and darker shades of grey and of pure white quartzose bands. The rock is so exceedingly fine that at first sight, and in hand specimens, it might easily be mistaken for an igneous rock; but, when seen in the field, the finely-banded structures and general aspect of the rock at once indicate its clastic origin. With a magnification of 200 diameters the clastic origin of the rock is clearly brought out, it being seen to be made up of well-rounded grains of felspar and quartz, and also to contain numerous specks of pyrites, often considerably weathered. Scattered through this fine felspathic-quartzose ground mass may be detected numerous long prism-shaped crystals, evidently andalusite,* which appear to have been developed in the ground mass by contact-metamorphism. The cause of this meta-

* Crystals of Horneblende are also not uncommon, occurring disseminated through the greywacke, and also in peculiar nest-like arrangements.

morphism may be found in an intrusive boss of diorite, which is seen to penetrate the surrounding schists and quartzites at this point. It is not my intention to enter into a detailed examination of these rocks. This boss of diorite may have been intruded into the schistose rocks at a period prior to their regional metamorphism, as sections of the diorite show the felspars to be in a finely granular condition, from which I infer that the boss had been crushed along with the clastic rocks during the earth-movements which have so



a *b* *c*

Fig. 1.—Annelid Tubes in Greywacke.—Creag-na-Caillich, Perthshire.

profoundly affected the rocks of the highlands. It also seems that these bosses of diorite may be in some way connected with the sills of epidiorite and hornblende schists which form such well-marked horizons in the neighbourhood of the Loch Tay limestone.

Returning now to the annelid burrows, it may be noted that it is only upon the weathered surfaces of the rock that the burrows can be detected. In massive beds of the rock, though the same structures are often undoubtedly present, nothing can be seen. On weathered surfaces, taken along the line of bedding, the annelid burrows are observed to stand out either in little rounded knobs, like the nails on a labourer's boot, or the material which originally filled the burrows has become weathered out, and they then form little circular pits in the greywacke, as seen in Figure 1 *c*. In this respect they present to the eye exactly the same appearance as the well-known pipe-rock of the north-west. I have not been enabled to exactly determine the cause of this, but it is probably owing to the comparative hardness of the material within the tube of the burrow. Another striking feature which links these bodies at once with those of the north-west is the fact that the material within the burrow is generally of a lighter colour than the surrounding matrix. This is often very beautifully brought out when a piece of the greywacke has been cut and polished in transverse section. The average size of these pits and knobs may be taken at about an inch, but from this they may vary down to about the size of a pin's head. It might at first seem that this great discrepancy in size was an objection to their organic origin, but a consideration of Fig. 1 *a* will at once remove this difficulty, for in this sketch, which represents a slab of the burrows seen in transverse section, it will at once be noted that the burrows, unlike those of the north-west, do not run into the greywacke in vertical cylinders, but have a distinctly ovate shape. Now it will at once be evident that the size of the pit or knob upon the bedding-surface must be dependent upon the extent to which the weathering agents have eaten into the burrow. If the surface of weathering only touches the top of the ovate or burrow it will only present a very small pit or knob, but as the weathering proceeds this will be gradually enlarged till it reaches the maximum represented by the longer diameter of the ovate.

Another common feature presented by these burrows, and seen upon the planes of bedding, is that seen in Fig. 1 *b*. Here the material of the burrow presents a long lenticular form. It is evident that this form represents those cases in which the worm-burrow has been drawn out to the merest line, as seen in section. Here, as in the less-sheared specimens, the material within the burrows is usually of a lighter colour than the matrix in which they are set. Occasionally a slab may be seen covered with hundreds of these lenticular forms, when they present quite a striking effect.

Another feature in these ovates or burrows, and one which immediately catches the eye, is the presence in some of them of a wall-like structure, which can be seen both in section and along the planes of bedding. Where this wall-like structure is present in specimens which have been highly weathered, it causes the edges of the ovate to stand up in a crater-like form, having a well-marked rim. The nature of this wall we shall discuss later on, when we give a general explanation of the origin and deformation of the burrows. Still another characteristic feature is the presence within the tube of iron pyrites, but that this is entirely independent of the tube itself, and not the cause of the tube or burrow, as has been suggested by the Survey, can at once be seen from specimens obtained both at Loch Fyne and Creag-na-Caillich, in which the deformed burrow is seen to be quite distinct from the pyrites. In many cases the burrows are beautifully marked when no trace of pyrites can be found within the burrows at all.

Such, then, is a short description of these bodies as found in the greywackes of the Creag-na-Caillich section, and they will be found to be exactly similar, in all their essential features, to those found in the Inveraray quartzites. When seen in section along the planes of shearing in the quartzites, the Inveraray specimens present the same circular and lenticular forms as those described from Creag-na-Caillich. When seen in sections at right angles to the planes of shearing they may either be distinctly ovate in shape or they may be drawn out to a mere line. To my mind there can be no doubt as to the identity of the bodies found at these two widely-different points. As we shall presently see, I have also found them at a third place, namely, in several stream sections near Tyndrum. Here they are in the quartzites, and, being thus formed and preserved under similar conditions to those from Inveraray and Loch Fyne, they present exactly the same appearances as those described by the Duke of Argyll.

I received from His Grace a series of specimens from a burn near the Castle at Inveraray, but in this case the tubes were preserved in the phyllites,—this being the first instance in which I have seen them in so highly schistose a rock. As would naturally be expected, they seem in this case to have been drawn out or stretched to their utmost limits. When we come to consider the stratigraphy of the rocks in which these tubes have been found, we shall see that the argillaceous rocks have been subjected to a much more severe plication and disturbance than the more arenaceous beds. This accounts for the extreme deformation to which the burrows in the phyllites have been subjected, as compared with those found in the quartzites, the burrows as seen along the foliation planes being similar in appearance to those from Creag-na-Caillich shown in Fig. 1 *b*.

Let us now glance at the methods adopted by living annelids in the formation of their burrows, and see what light they can throw upon the bodies found in the highland quartzites and greywackes. Along our sea-shores, between tide marks and in shallow waters, numerous annelids are to be found, which have the power of burrowing rapidly through soft sand. In this burrowing process they pass large quantities of the sand through the alimentary canal, for the purpose of obtaining from it any minute organisms which it may contain, and upon which they subsist. In doing this they display a certain selective power, choosing only the smaller grains of sand and casting the larger ones aside, the smaller grains which they pass through their bodies being generally voided into the burrow behind. One of the finest and most instructive examples of this burrowing and selective power of annelids is to be found in a quarry at Giffnock, near Glasgow, in a carboniferous sandstone, to which we may turn for a moment, as it exhibits this particular feature better than can be found in the living annelids. A reference to Fig. 2 will make the description clearer. In it the dark beds *a* represent thin layers of shale, not thicker than an inch, and often as thin as the edge of a

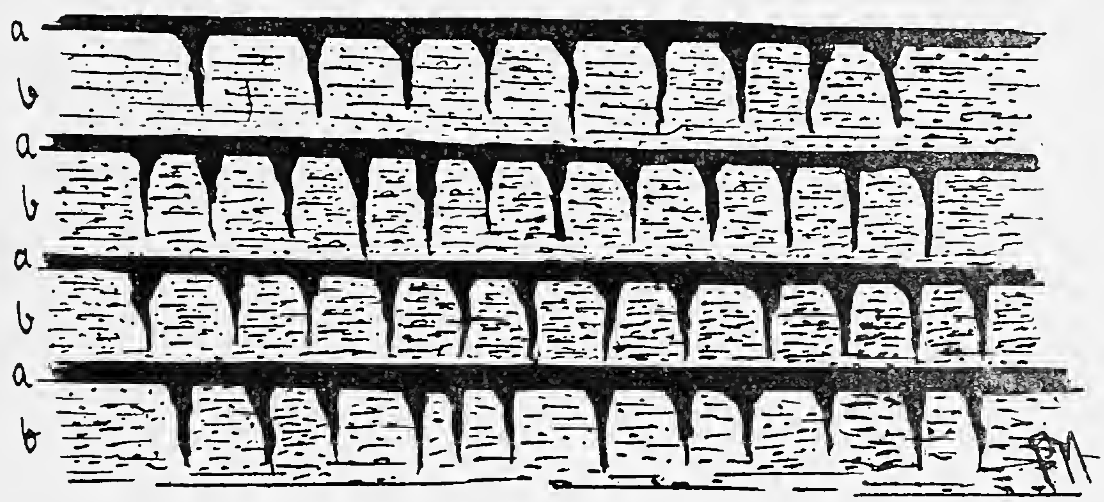


Fig. 2.—Annelid Burrows in Carboniferous Sandstones and Shales, Giffnock Quarries, near Glasgow.

sheet of paper. Between these layers of black shale occur a series of beds of sandstone of irregular thickness, some not thicker than two inches and others exceeding a foot. Now, from each layer of shale, and projecting vertically downwards into the sandstone, occur numberless annelid burrows; in fact, the sandstones are literally riddled with them. Upwards towards the shale each burrow opens with a trumpet-shaped mouth; while downwards it gradually dies out into the sandstone. Now it is quite clear, we think, that these annelids could only have lived during the periods represented by the thin beds of shale which they passed through their bodies in search for food, and afterwards voided into the burrow behind, this being a most striking example in the selective power of the worm, choosing only the finer material and rejecting the more arenaceous grains. Now it will be found that the same process is still carried on by living worms, and it is this differentiating out of the finer particles and their subsequent voidance into the burrows which becomes one of the principal distinguishing features whereby we are enabled to trace the past existence of annelids in sandstones, long after the latter have become consolidated, and even metamorphosed into quartzites.

Another feature in connection with the burrowing of living annelids is the power which they have, in common with other organic substances, of decomposing iron ores into red oxides. Hence it is not uncommon to find the walls of the burrow and the castings of living annelids stained with peroxide of iron. The Duke of Argyll has pointed out, in his interesting examination of the burrows of living annelids, that the walls of the tube are often found to be stained for some distance on each side by oxide of iron, the extent of the staining corresponding to the quantity of iron in the sand or the length of time during which the annelids have been in contact with the surrounding material.

Prof. Macintosh has also shown that living annelids have the power of secreting from their skins a slimy substance, the tendency of which is to give the walls of the burrow a greater coherence than the loose sand forming the surrounding matrix. From this we can better understand the process of the infilling of the burrow by the castings and finer materials which have been passed through the annelid's body. Referring to Fig. 2, it seems difficult to understand how the loose grains of sand could have kept their position long enough, preserving the walls of the burrow intact, to allow the latter to be filled with the finer argillaceous material; still, it is evident that they must have done so. Again, in the quartzites of the north-west of Sutherlandshire, the annelid tubes are often found to run into the quartzites for over a foot, the contents of the tube preserving their distinctive character. Thus it is probable that these ancient annelids, like their living representatives, had the power of cementing together the walls of their burrows.

Another characteristic of living annelids, and one which we cannot here pass over, as it is of considerable significance in the interpretation of the bodies found in the highland quartzites and greywackes, is the power which they have of bleaching the materials which they pass through their bodies, this process being probably connected with the reduction of the iron ores usually contained in the surrounding sand. It is generally found that the materials forming the interior of the burrow are of a lighter colour than those of the surrounding matrix, this being, as we shall see, a prominent feature in the bodies whose annelid origin we are attempting to prove.

Let us now turn to those bodies found in the quartzites, greywackes, and mica schists of the southern highlands, and see to what extent they present the characteristics of the burrows of living annelids. And in the first place let us remark that they invariably show the materials contained within their walls to be of a finer texture than that of the rock in which they occur. This is very markedly shown in the burrows from the Creag-na-Caillich quartzites, when seen under the microscope, and also in the burrows found in the Inveraray quartzites. In the latter case, the material within the burrow being of a more argillaceous character than the quartzite in which they occur, it follows that in the shearing of the quartzites the burrows have been drawn out, and are now represented by ovate and long lenticular areas of lustrous, pale, silvery mica schists, or, as the Duke of Argyll puts it :—"As in all the surrounding country the siliceous strata are in general sharply distinguished from the argillaceous beds, and as these last have been generally metamorphosed into mica slates, with pure mica very highly developed in most of them, we should expect to find, as a necessity of the case, a corresponding development of mica and of micaceous particles in the inside of the worn tubes or along the lines of alteration and deformation to which these may have been exposed by crushing or slipping movements in the rock."

The existence of a distinctly-marked wall in certain of the specimens is also a feature which helps to link these bodies with the burrows of living annelids. In the Creag-na-Caillich specimens, as we have already shown, this wall-like structure is often present to a striking degree, presenting a well-marked feature both in transverse and longitudinal sections. In such a specimen as that seen in Fig. 3 *e*, in which the burrows are seen along a sheared surface, we not infrequently find well-marked traces of this wall structure. As a rule, the material filling the burrow has been entirely removed by weathering, and nothing whatever is left of the substance which originally filled it, so that the matrix of greywacke is to be found weathered out into a series of little pits or holes. At other times, however, this pit or hole is found to be lined all through with a highly micaceous wall, having a thickness of about $\frac{1}{12}$ of an inch. In other specimens, when seen longitudinally, this wall presents a somewhat different aspect. Thus we have, first of all, the matrix of dark greywacke; then a fine wall of pure white quartz-like material; and, lastly, the interior of the ovate filled with the same material as that forming the matrix outside the wall.

In the specimens from the Inveraray quartzites, this wall, as noticed by the Duke of Argyll, is generally represented by a deeper stain of red oxide of iron than that found within the interior of the burrow. On other occasions, however, as in certain specimens which I have found at Strachur Bay, the staining of the red oxide of iron may be entirely confined to the wall, the grains of quartz within the tube being of even a purer white than those forming the matrix. Nothing can be more certain than the existence of this wall-like structure within these bodies, while the different appearances which it often presents, as seen in different specimens, often from widely-different localities and in widely-different rocks, seem to us entirely to exclude any theory which would account for these bodies on the assumption that they are merely the dragging and drawing out of iron pyrites along lines of shear. To us they seem to point to some original difference in the wall of the burrow, such as that already referred to as found in the burrows of living annelids, giving it a greater coherency in some cases, and in other cases staining it with the red oxide,—features which have evidently

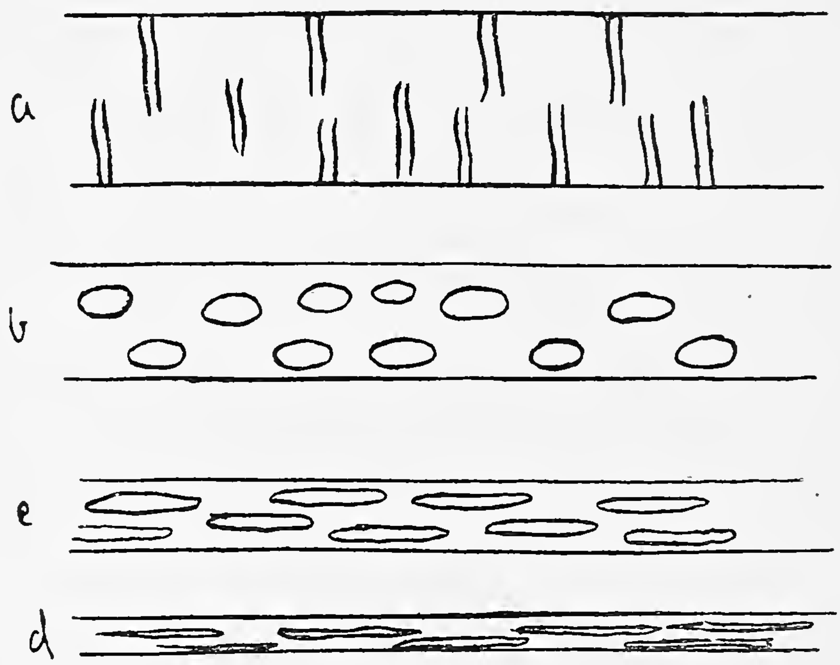


Fig. 3.—Diagram showing the manner in which the Annelid Tubes have been drawn out by the shearing of the rocks.

not been destroyed, but rather perpetuated, by the subsequent metamorphism to which they have been subjected.

Still another feature which helps to link these bodies with the burrows of living annelids and with other fossil forms is the bleaching of the material found within the burrow. In the Cambrian quartzites of the north-west highlands, the tubes are often seen to be of a purer white than the matrix in which they are enclosed. Fine specimens illustrating this condition of preservation are to be found amongst the Creag-na-Caillich greywackes, in which the matrix is of its usual dark greyish colour, while the material filling the interior of the tube is of pure white quartz.

We have often found a good deal of misconception to arise as to the nature of these bodies, owing to its not being clearly understood what their original form probably was, and its relationship to those found in these highly-altered rocks. To make the subject clearer, we have given Fig. 3, which shows the manner in which the original cylindrical tubes have been drawn out into their present forms by the subsequent shearing and stretching of the rocks in which they occur. At *a* we have the original more or less perfectly cylindrical burrow entering the rock at right angles to the planes of bedding; while at *b* they have been subjected to a slight amount of pressure, which has drawn the walls of the tube asunder, giving them an approximately ovate form, perhaps the most characteristic form occurring amongst the quartzites and greywackes. At *c* we have still a further deformation of the burrow, and at *e* the tube has been drawn out to its greatest length, representing the lenticular form, as figured in Fig. 1 *b*, a form which is most characteristic of the phyllites and more argillaceous rocks, which have given way more readily to the shearing and stretching forces.

From the evidence just adduced there can, we think, be no doubt as to the annelid origin of these bodies. All of these points were dealt with in greater detail by the Duke of Argyll, in his paper read before the Royal Society of Edinburgh, and we gladly admit here our great indebtedness to His Grace for first showing the way in the interpretation of these obscure bodies, and also for much personal assistance which we received at his hands during our long study of them, and in the preparation of this paper.

Let us now consider the important question as to whether these annelid burrows can be said to occupy a definite horizon among the rocks of the southern highlands. And, in the first place, let us consider the section seen near the summit of Creag-na-Caillich, a mountain rising above the village of Killin, at the western end of Loch Tay, Perthshire. At the base of this mountain, and in the woods of Finlarig, there are some very fine exposures of the Loch Tay limestone,* which here dips towards the north-west at an angle of about 45 degrees, marked *d* in Fig. 4. Many of the sections also show the associated sills of sheared basic rocks which are found so commonly to follow the line of the Loch Tay limestone, these being marked *e* in Fig. 4. Above the Loch Tay limestone comes a thick series of garnetiferous mica-schists, which extend from the Loch Tay limestone up the mountain side nearly to the 1500 feet contour line, and form the upper division of what we have termed the middle arenaceous zone. These apparently lie quite conformably above the

* An exceedingly interesting exposure of this Loch Tay limestone is seen by the roadside at Druim-na-Lairig. The limestone has been extremely folded, the axes of the fold shading towards the north-west, and the overfolding being consequently towards the south-east. The under limbs of the folds are distinctly thinned, and the whole evidence shows that the thrust has been from the north-west.

Loch Tay limestone. On approaching the foot of the Creag-na-Caillich escarpment, and at a height of over 2000 feet, the quartz-schists and mica-shists, with garnets, are replaced by a group of finely-foliated calcareous sericite schists, or phyllites, with thin beds of quartzite, which are well exposed in the beds of the streams descending from the higher grounds. In Fig. 4, these quartzites and phyllites are marked *a* and *b* respectively. The extreme contortions to which these beds have been subjected may be inferred from the

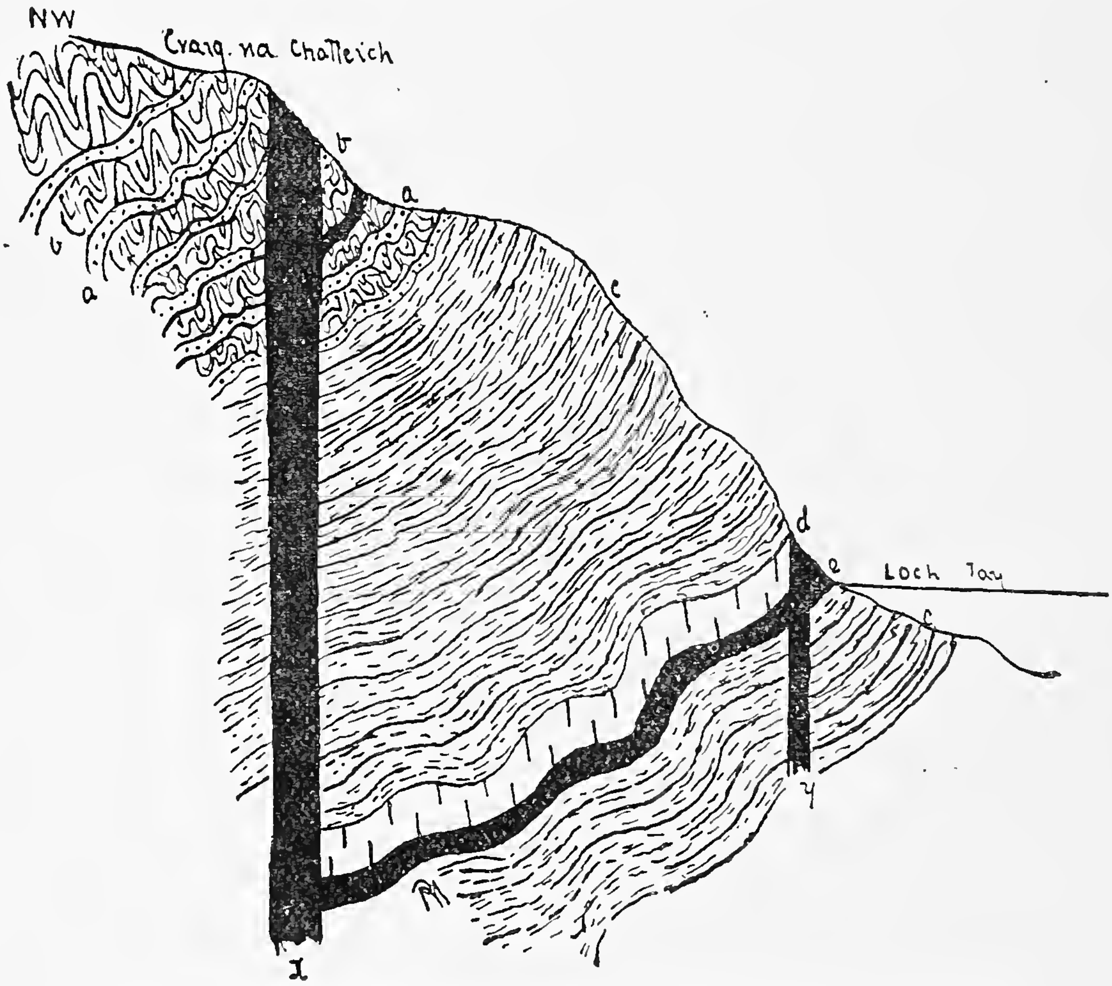


Fig. 4.—Diagrammatic Section across Creag-na-Caillich, Perthshire.

rapidity with which the dip changes through all angles in the course of the stream. Leaving the stream, and ascending the south-eastern face of the escarpment, where huge blocks of the greywacke may be seen dislodged from the precipice above, we can trace all round the base of the precipice the beds of greywacke, containing finely-marked examples of the annelid burrows.

From the base of the mountain, then, to the summit, we have the following ascending succession of beds :—

1. Altered basic rocks (Hornblende-schists).
2. Loch Tay limestone, with beds of calcareous mica-schists.
3. A thick group of garnetiferous quartz-schists and mica-schists.
4. Quartzites, greywackes, phyllites, and dark graphitic mica-schists ; the quartzites and greywackes containing the annelid burrows.

The extreme contortions to which the phyllites have been subjected serve to indicate the amount of shearing which must have taken place, not only in the phyllites themselves, but also in the quartzites and greywackes with which they are interbedded, as we have shown in Fig. 4. The finer argillaceous rocks have evidently been driven between the harder and more arenaceous bands of quartzite. An extremely finely-foliated structure has been superinduced upon the argillaceous rocks, the acute foldings of the planes of foliation being seen to be cut by numerous and finely-developed strain-slips. The thin beds of quartzite which are associated with the phyllites, and which contain the annelid burrows, seem to have offered a greater resistance to the cleaving forces than the more argillaceous members, and can easily be distinguished in the stream sections upon the hill, as their superior hardness causes them to stand out from the interbedded and more friable phyllites. Nevertheless, they have also participated to some extent in the changes produced by the great crust-creeps which plicated the highland rocks. Thus the quartzites break along planes which are generally glistening with a secondary mica, and the deformation to which the annelid burrows have been subjected also gives us an idea of the great amount of rolling-out which these beds of quartzite must have undergone.

The exact position of the annelid beds, as seen at Killin, is thus pretty clear. We have grouped these rocks together under one zone, namely, the upper argillaceous zone, and it forms a well-marked outcrop all along the ridge on the north side of Loch Tay. These same beds, forming the very summit of Ben Lawers, exhibit much the same features as those already described as seen on Creag-na-Caillich; but we have not yet seen any very good specimens of annelid tubes from Ben Lawers, those which we have seen being too small and fragmentary to be satisfactorily determined. Traced westwards, these beds of phyllites and greywackes are seen to cross the River Lochay a short distance above the falls, where fine sections showing the extreme contortions to which the phyllites have been subjected may be seen; but we have not found at any of these points the burrows of the annelids. Whether this be owing to their original absence from the beds, or whether they have been subsequently squeezed out of all recognition, is a question that would be difficult to answer; but it is quite possible that, if these beds were carefully searched, traces might yet be found of annelid tubes.

The next section we select, for the purpose of showing the exact stratigraphical position of the annelid burrows, is about fifteen miles to the west of that just described, and extends from a point to the north of Tyndrum down Strath-Fillan to a little beyond Crianlarich. Beginning at the south-east end of the section, we find the Loch Tay limestone exposed in a quarry on the roadway between Crianlarich and Tyndrum, a little over a mile beyond the former village. At this point the dip of the limestone is seen to be towards the north-west, as at *d* (Fig. 5). Above this, and still dipping towards the north-west, we have the same group of garnetiferous quartz-schists and mica-schists, as already described in the Creag-na-Caillich section, marked *c* in Fig. 5. At this point there seems to be a synclinal trough occupied by the phyllites and quartzites, constituting our upper argillaceous zone, and in which the annelid tubes occur. Near Tyndrum these phyllites and quartzites are seen to dip to the south-east, and must consequently form the northern limb of the synclinal fold. At this point the great Tyndrum fault throws the central highland quartzites against the phyllites and quartzites of the upper argillaceous zone. The quartzites, however, still dip in the same direction as the mica-schists.

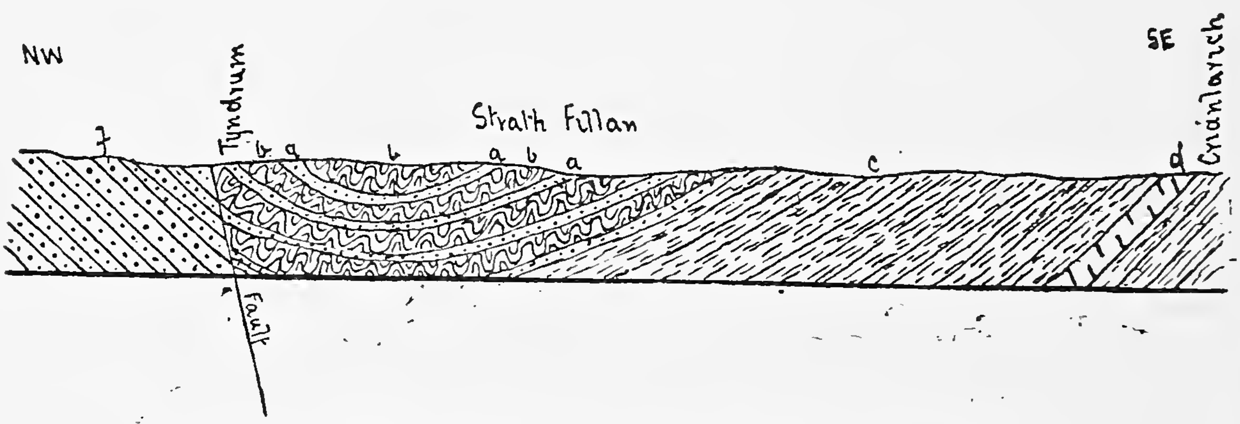


Fig. 5.—Diagrammatic Section from Tyndrum to Crianlarich.

A very fine section, showing the relationships between the central highland quartzites and the phyllites, with thin beds of quartzite containing annelid burrows, may be seen in a section exposed along the course of the Alt-nan-Sae, a stream flowing down the slope of the Meall Odhar towards the Coninish water. Near the summit of Meall Odhar, the central highland quartzites are exposed in the stream section, dipping towards the south-east. We have examined these quartzites on several occasions for annelid tubes, but have never met with anything that could be identified as organic. Proceeding down the burn, and near a series of waterfalls, we find that the great Tyndrum fault has brought down these upper quartzites of the central highlands against the phyllites and thin beds of quartzite belonging to our upper argillaceous zone. In the remaining part of the stream section, to where it enters the Coninish water, we have a series of phyllites and quartzites dipping towards the south-east, and forming the northern limb of the synclinal trough seen in Fig. 5. When we first examined this section some years ago, we concluded that the quartzites seen on the west side of the fault belonged to a horizon lower than the schists, owing to the hade of the fault, as seen in the gorge near the mines, being under the schists. It was always a difficulty with us, however, to correlate such a massive group of quartzites with any that we knew to be below the schists or phyllites. The conclusion which we have now arrived at is that the quartzites lying to the west side of the fault belong to the main body of our upper arenaceous zone (the central highland quartzites), and the fact that this fault hades on the upthrow side leads us to the conclusion that at this point at least it must be a reversed fault. From the point where the Alt-nan-Sae crosses the great Tyndrum fault to where it enters the Coninish water, it has exposed a group of beds having exactly the same lithological features as those in which the annelid tubes were found on Creag-na-Caillich. Moreover, in the thin beds of quartzite belonging to this group, and exposed in the Alt-nan-Sae, are to be found bodies similar to those from Creag-na-Caillich, described as annelid burrows. Let it be remembered, however, that we have not found in this section the same beds of

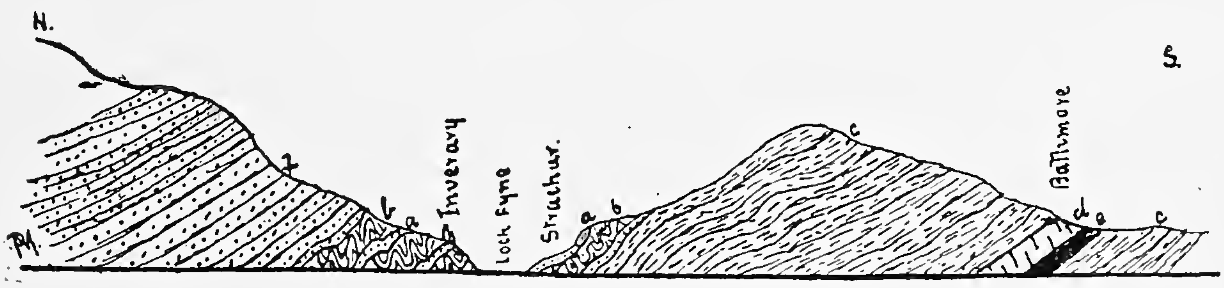


Fig. 6.—Diagrammatic Section from Ballimore through Loch Fyne to a point to the north of Inveraray.

greywacke as exist on Creag-na-Caillich; and as the burrows found in the greywacke are generally more finely marked than those from the quartzites, it follows that the burrows obtained at this point are somewhat obscure. There can, however, be no doubt as to their essential similarity to those already described both from Creag-na-Caillich and Loch Fyne.

Turning now to the last section which we shall describe, and which lies about fifteen miles to the south-west of the Tyndrum section, we begin again with the Loch Tay limestone as a base from which to determine the exact position of the annelid beds. The section is taken from Ballimore, near Strachur, in Argyllshire, and runs across Loch Fyne to the north of Inveraray. Beginning at the south end of the section, we have the Loch Tay limestone, marked *d* in Fig. 6, dipping towards the north at a low angle. As in the two former sections, the Loch Tay limestone is overlaid by a group of quartz-schists and mica-schists, with garnets, this group being well seen in the lower reaches of the Eas Dubh.

Above these garnetiferous schists, and well seen along both the eastern and western shores of Loch Fyne, we have an outcrop of our upper argillaceous zone, consisting here, as in the Tyndrum and Creag-na-Caillich sections, of a group of finely-foliated sericite schists or phyllites, accompanied by thin beds of quartzite and dark graphitic mica-schists, which are in their turn overlaid by the quartzites of our upper arenaceous zone, the argillaceous zone being marked *a* and *b* in Fig. 5 and the upper arenaceous zone *f*. It was in these thin beds of quartzite (*a*, Fig. 5) that the Duke of Argyll first detected the annelid tubes, and, as we have already said, he found some remarkably plain specimens, though highly sheared, in the phyllites accompanying the quartzites.

It is clearly evident, then, that we have here exactly the same bodies, occurring in exactly the same kinds of rock, and occupying the same stratigraphical position, as those already described from Creag-na-Caillich and Tyndrum; and it seems to us that these sections clearly prove the zonal value of these bodies.

NOTE.—Since the above paper was read the following reference to the occurrence of annelid tubes in the Southern Highlands appears in a paper contributed by Mr. J. Horne, F.R.S., to the *British Association Handbook* to the Fauna, Flora, and Geology of the Clyde Area, Glasgow, 1901, page 402 :—

"Annelid tubes have been detected in the quartzites of Jura and Islay. Similar structures were detected by the late Duke of Argyll in quartzose schists near Inveraray, and Mr. Macnair of the Glasgow Geological Society has detected what he believes to be worm-casts in certain schists apparently above the Loch Tay limestone."

XIX.—*A Preliminary List of Perthshire Collembola and Thysanura.*

By WILLIAM EVANS, F.R.S.E.

(Read 11th April, 1901.)*

On several occasions during the last five or six years, when collecting in Perthshire, I carefully secured or noted any Spring-tails and Bristle-tails that came under my observation, and, from the slight data thus obtained, the following series of records has been drawn up as a contribution towards a list of the Collembola and Thysanura of the county.

No group of insects has been more neglected in this country than the Aptera, with the result that, apart from the incompleteness of the

* Revised up to 10th October, 1901.

British list, very little is known from actual observation of the distribution of even the commonest forms in these islands. In the summer of 1876, Prof. O. M. Reuter, of Helsingfors, visited Scotland, and sent to the *Scottish Naturalist* three years later (Vol. V., pp. 204-208) a list of Collembola and Thysanura collected during his tour. Of the twenty-two species there recorded, the most interesting is *Anurida crassicornis*, a form new to science, found under stones in the Tay near Perth, and not since met with anywhere. The type specimens having been lost, its rediscovery is much to be desired. A few years ago my own attention was turned to the Aptera of the Edinburgh district, where a collection of sixty species of Collembola —many of them additions to the British list—and five of Thysanura has rewarded my efforts (see list by G. H. Carpenter, B.Sc., and myself in the *Proceedings* of the Royal Physical Society of Edinburgh for Session 1899-1900). The present list contains only thirty-seven Collembola and three Thysanura, so there is a fruitful field of research still open here to any resident naturalist who will earnestly take up the subject.

In the matter of nomenclature and arrangement I have followed the Edinburgh list above referred to.

My best thanks are due to my friend Mr. G. H. Carpenter, of the Dublin Museum, who has kindly checked my determinations.

COLLEMBOLA.

Fam.: Sminthuridæ.

Sminthurus fuscus (Linn.)—Aberfoyle, September, 1897, half-a-dozen specimens among withered oak leaves. This does not seem to be a common species in Scotland.

Sminthurus viridis (Linn.)—Blair-Atholl, September, 1898; Glen Farg, September, 1899; Luncarty, June, 1900; Muthill.

Sminthurus novemlineatus, Tullb., var. *insignis*, Reut.—Loch Moraig, near Blair-Atholl, September; damp spots on the Ochils west of Glen Farg, September; pond near Muthill; common on sedges.

Sminthurus bilineatus, Bourl.—Damp spots on the Ochils west of Glen Farg, a few off sedges and other herbage, September, 1899.

Sminthurus hortensis, Fitch.—Glen Farg, September, 1899, a few specimens obtained on a garden walk.

Sminthurus luteus, Lubb.—Fenderbridge, near Blair-Atholl, and in several spots in the Glen Farg district; common on grassy banks.

Sminthurus quadrilineatus, Tullb., var. *ochropus*, Reut.—Blair-Atholl, September, 1898, on chips of wood where trees had been felled; seven specimens secured.

Sminthurus aquaticus, Bourl.—Abundant at Methven Bog in September, 1899; also at Drummond and Balloch Lochs.

Papirius cursor, Lubb.—Fairly common on wood chips about Blair-Atholl, September; Bridge of Allan, February, 1898; Muthill.

Papirius ornatus (Nic.), Lubb.—Common on dead branches, etc., lying on the ground in woods: Blair-Atholl, Comrie, Glen Farg, Aberfoyle, Bridge of Allan, Callander.

Papirius minutus (O. Fabr.)—Blair-Atholl, September, 1898, a good many; Aberfoyle, September, 1896, a few; Muthill.

Fam.: ENTOMOBRYIDÆ.

Tomocerus niger, Bourl.—Muthill, September, 1901.

Tomocerus tridentiferus (Tullb.)—Abundant everywhere: Methven, Blair-Atholl, Comrie, Bridge of Earn, Glen Farg, Bridge of Allan, Callander, Aberfoyle, etc.

Lepidocyrtus lanuginosus (Gmel.), Tullb.—Generally distributed and abundant: Methven, Luncarty, Blair-Atholl, Comrie, Bridge of Earn, Glen Farg, Bridge of Allan, Callander, Aberfoyle, etc.

Lepidocyrtus cyaneus, Tullb.—Blair-Atholl, Glen Farg (under flower-pots, October, 1899), Callander, April, 1900.

Entomobrya albocincta (Templ.)—Blair-Atholl, Comrie, Glen Farg, Callander; Muthill; not uncommon under bark.

Entomobrya nivalis (Linn.)—Widespread and common: Blair-Atholl, Comrie, Methven, Glen Farg, Callander, Aberfoyle.

Entomobrya muscorum (Nic.)—Also widespread and common: Blair-Atholl, Methven, Glen Farg, Callander, Muthill.

Entomobrya multifasciata (Tullb.)—Bridge of Allan, about green-houses; Muthill, in gardens.

Orchesella cincta (Linn.)—Comrie, April, 1899; Bridge of Earn, September, 1899; Glenfarg, Callander, Aberfoyle, Muthill.

Orchesella villosa (Geoff.)—Bridge of Allan, January, 1894, a few specimens obtained; apparently an uncommon species in Scotland.

Templetonia nitida (Templ.)—Comrie, Glen Farg, Callander, Muthill.

Isotoma viridis, Bourl.—Generally distributed and abundant: Methven, Comrie, Blair-Atholl, Glen Farg, Callander, Aberfoyle, etc.

Isotoma palustris (Müll.)—Widespread and common: Near Blair-Atholl, Methven Bog, Callander, Drummond Pond; var. *maculata* (Schäff.), Muthill.

Isotoma grisescens, Schäff.—Blair-Atholl, September, 1898, a few; Callander, April, 1900, a few.

Isotoma sensibilis, Tullb.—Bridge of Allan, February, 1898, a good many; Glenfarg, September, 1899, a few under bark on rotten tree trunk; Muthill, September, 1901.

Isotoma cinerea (Nic.)—Comrie, 30th April, 1899, plentiful under bark on dead spruce.

Isotoma fimetaria (Linn.), Tullb.—Dron, near Bridge of Earn, September, 1899, one under a board.

Isotoma schötti, Dalla Torre.—Common along the edge of Methven Bog in September, 1899. The locality, being an inland one, is interesting, as the species is usually found on the sea-shore.

Fam.: Poduridæ.

Achorutes armatus (Nic.)—Common: Blair-Atholl, Glen Farg, Bridge of Allan.

Achorutes viaticus (Linn.), Tullb.—Muthill, October, 1891.

Achorutes purpurascens, Lubb.—Bridge of Allan, February, 1898, one specimen; Callander, April, 1900, two; Muthill, September, 1901.

Anurophorus laricis, Nic.—Aberfoyle, April, 1896, a good many under bark on a dead tree.

Lipura armata, Tullb.—Glen Farg, Comrie, Muthill, Callander; common under stones, bark, etc.

Lipura ambulans (Linn.), Tullb.—Examples of this form were taken at Bridge of Allan in February, 1898.

Anurida crassicornis, Reut.—This form was described by Prof. O. M. Reuter, of Helsingfors, in the *Scottish Naturalist* for 1879 (Vol. V., p. 208), from specimens found by him in June, 1876, "under stones in the River Tay, near Perth." It is otherwise unknown; and, as the types have been lost, its rediscovery is much to be desired. I looked for it in June last on the Tay shingles above Perth, but without success.

Anura muscorum (Templ.)—Common in wooded districts: Blair-Atholl, Comrie, Glen Farg, Callander, Aberfoyle, Muthill.

THYSANURA.

Fam.: Campodeidæ.

Campodea staphylinus, Westw.—Not uncommon among earth and under stones: Bridge of Allan, Glen Farg, Muthill.

Fam.: Lepismidæ.

Lepisma saccharina, Linn.—The "silver fish" is, I am informed, not uncommon in Perth. Mr. S. T. Ellison had specimens from a greenhouse brought to him last year.

Fam.: Machilidæ.

Machilis polypoda (Linn.)—I have taken this species sparingly in the following localities: Aberfoyle, April, 1896; Bridge of Allan, February, 1898; and Glen Farg, September, 1899.

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XX.—*The Geology of Creag-na-Caillich and the District round Killin.*

By Peter Macnair, of the Glasgow Museums, Assistant Secretary Glasgow Geological Society.

(Read 9th January, 1902.)

The mountain, whose geological structure and mineral wealth form the subject of this brief notice, stands at the western end of Loch Tay immediately to the north of the village of Killin. It has long been famous in the annals of both Perthshire botany and geology. Botanically it emerges into history about the end of the eighteenth century, being often mentioned in Lightfoot's "Flora Scotica," and it is probably the locality where Stuart, the minister of Killin, first gathered the Alpine plants of Scotland. Geologically we first hear of it from that pioneer in the study of our Scottish mountains, John Macculloch, who in the year 1814 contributed a paper to the *Transactions of the Geological Society of London* in which he gives a short description of the geological features of Creag-na-Caillich. In referring to the rocks of Creag-na-Caillich he says, "The predominant rock of this ridge is a very well characterised chlorite slate." Evidently he here refers to the phyllites which cap the summit of the mountain, and regarding which we shall have more to say presently. He notes the presence in the schists of very large cubical crystals of pyrites. The existence of colloidal quartz is also referred to as occurring in the mica schist, the dark varieties known as cairngorm having in his day already attained to a certain notoriety amongst lapidaries. The occurrence of the mineral chlorite is also mentioned, Macculloch remarking that the chlorite appears in abundance, and is generally interposed between the chlorite slate and a quartz nodule. Macculloch says that the chief reason for which he has noticed this mountain is the occurrence on it of rutile, a mineral as yet of sufficient rarity to deserve a record of all its habitats. It is found in the larger as well as in the smaller quartz nodules, and exhibits many of its well-known varieties. The crystals generally penetrate the quartz, and often appear to have their bases fixed in the investing chlorite. It is worthy of remark that though they most commonly penetrate the quartz as if crystallised at perfect liberty, yet they are frequently bent so as to accommodate themselves to its occasional elevations and depressions. Such is, so far as I know, the first notice of the geology of Creag-na-Caillich, and also the first record of the occurrence of rutile on this mountain. Since that time its occurrence on this mountain has been copied into all text books of mineralogy, and Creag-na-Caillich has become a world-renowned locality for the occurrence of rutile.

Proceeding now to an investigation of the geological structure of the mountain, we propose in the first place to make an examination of the rocks forming the low grounds around Killin, and then, having finished the lower ground at the base of Creag-na-Caillich, we shall ascend the mountain by way of the stream which, draining it almost from its summit, enters the Lochy near the Bridge of Lochy Inn. As you are probably aware, the best method of studying the geological structure of our Scottish mountains is by examining the sections laid bare in the streams which flow down their sides, choosing in preference those streams which appear to cut the strike of the rocks most nearly at right angles. The stream section which we now propose to examine in our ascent of Creag-na-Caillich fairly well fulfils this condition, as its course is almost at right angles to the strike of the foliation in the schistose rocks.

In the first place, then, turning to an examination of the rocks forming the low grounds in the neighbourhood of Killin, I would direct your attention to a section seen in the bed of the River Dochart about a mile above the falls. Here the bed of the river is somewhat rocky, the river flowing over a group of limestone rocks whose foliation planes evidently dip towards the north-west. The limestone is the well-known Loch Tay limestone, and an examination of it shows that it is in a thoroughly crystalline condition, the calcite crystals showing cleavage faces varying from a small mustard seed up to half an inch in diameter. At places where the rock shows evidence of having been crushed the crystals are generally much smaller, giving the rock a compact mico-crystalline appearance. The colour of the calcite crystals varies from pure white through different shades of grey to a jet black. At times it appears as if the black crystals were set in a matrix of finer calcareous material, the larger dark crystals also showing evidence of having been drawn out along the planes of foliation. Mr. Clough has suggested that this structure may be accounted for on the supposition that the white parts may have been formed by a crushing and recrystallisation of the darker parts.

The presence of small flakes of pale-coloured mica in the limestone is not uncommon, the quantity increasing at times to such an extent as to make the limestone pass into a calcareous mica-schist. In many cases the rock presents a distinctly banded appearance owing to the alternation of micaceous and calcareous laminæ. Whether this may represent an original structure in the rock, or whether it has been brought about by subsequent deformation, is a subject which we cannot at present discuss. Whatever may have been the original cause of this structure, it certainly at first strikes one as evidence of the original bedding; but a little reflection upon this matter will, I think, tend to throw considerable doubt upon that explanation. It seems to us that there is no evidence that these are other than secondary planes of foliation. It is almost impossible to examine the Loch Tay limestone without being struck with the remarkable manner in which it has been folded, evidence of this folding being of course best seen where the banded structures to which we have just referred occur.

Turning now to a consideration of the nature of the outcrop of the limestone zone in the neighbourhood of Killin, let us see if it throws any light upon the structural relationship of the limestone to the other schists with which it is apparently intercalated. At the point where we have just examined the limestone in the bed of the Dochart it has, as we have already remarked, an apparent dip towards the north-west. From the bed of the river the limestone appears to ascend the side of Sron Clachan to near the precipice known as Cnoc a Mhanaich. Traced eastwards round Sron Clachan, the limestone evidently covers the whole of the ground between the main street of the village and the 1000 feet contour line, and may be seen at various points as above the manse and at Maragowan. From this point the limestone stretches along the side of Loch Tay, forming the base of Creag-na-Caillich and evidently dipping at a considerable angle below that mountain. Numerous fine sections may be observed along the road which leads to Kenmore, for instance on the road about half a mile beyond the inn and immediately on this side of the keeper's house, probably the Drum-na-Larig of the inch Ordnance Survey map. At this point the main body of the limestone is seen to be dipping towards the north-west at an angle of about 45°, and an examination of it shows that it is banded in a similar manner to that already described, namely, by alternations of micaceous and pure limestone bands. The rock has been thrown into a number of folds, which are very clearly shown owing to the banded structure. The longer axes of the folds are seen to distinctly hade with the main body of the limestone, namely, towards the north-west, the overfolding being consequently towards the south-east, while the under limbs of the folds are those which are most thinned. From this it would appear that the direction from which the thrust has been applied has been the north-west, and that it has transmitted towards the south-east; and we will find that, as a rule, this seems to be the general law of folding observed in this part of the Highlands.

It would seem, then, that this band of limestone must pass below and underlie the main mass of the mountain. In the neighbourhood of the village it apparently dips below Sron Clachan. According to the lately published survey map the outcrop of the limestone has been shifted westwards, by a fault passing through Sron Clachan. Crossing the River Lochy between the pier road bridge and the

Lochy Inn the limestone apparently underlies the mountain, whose geological structure is the more immediate subject of this paper.

Associated with the band of limestone there is a remarkable group of altered basic rocks which are known to accompany the Loch Tay limestone from shore to shore across the whole of the southern highlands. In the neighbourhood of Killin they may invariably be seen accompanying the Loch Tay limestone, being of the character of epidiorites and hornblende schists. In appearance these rocks are generally of a dark grey or almost black colour, and, being generally harder than the limestone with which they are associated, they are often seen to present bolder outcrops than the latter rock. So far as we have observed they never shew any evidence of a scoriaceous or vesicular structure, and at certain places, as near Finlarig, they give evidence of contact metamorphism. At places we also think they appear to transgress the clastic schists with which they are associated, but upon this point we should not like to speak with any degree of assurance. The whole aspect of these rocks has led us to the conclusion that they are of the nature of sills of basic igneous rock which have been intruded along lines of junction between the clastic schists. So completely, however, has the subsequent metamorphism rolled out and welded these rocks into one another that it becomes exceedingly difficult, if not impossible, to determine what their original relationships might have been.

An examination of the rock microscopically shows it to be made up of long prism-shaped crystals of hornblende and granular water clear felspar, and quartz, with garnet, epidote, pyrites and magnetite as accessories. Where the rock has been rendered thoroughly schistose, the hornblende prisms are seen to be arranged with the longer axes of the prisms parallel to the general schistosity of the mass. Like the limestones which they accompany, their foliation planes are often seen to be folded, obeying the same laws as those described as regulating the former rocks, and even at times a rough *ausweichung* structure may be seen to cross the folds parallel to the axes of the folds. As regards the positions of the beds of epidiorite and hornblende schists relative to the Loch Tay limestone it would be difficult at present to give any decision; thus in the section at the Dochart a sill appears interbedded with the limestone, another sill appears to run parallel with the pier road having limestone both above and below it. Apparently above this sill runs a second sill which outcrops behind Finlarig farmhouse, while, still higher up the mountain side, what appears to be a third sill marks the line of junction between the limestone and garnetiferous schists above. The extent to which these different outcrops may represent separate and different intrusions is a matter which it would as yet be premature to discuss, until we had reached some data as to the extent to which these rocks have been folded. That they have been folded and that to a considerable extent may be assumed as without any doubt, and it is highly probable that, if we could determine the extent of this folding, we should be able to identify several beds which now appear to be distinct intrusions. On the other hand, if we keep in mind that these rocks were originally intruded as sills, it ought not to surprise us that in examining sections along the strike of the beds it should be found that they should vary considerably both in number and in size. We would naturally expect one bed to die out and be replaced by a clastic schist, while another sill would appear upon a horizon slightly higher or lower than the one last traced.

The amount of shearing, to which these altered basic rocks have been subjected, is more or less variable; thus in some parts they will appear quite massive, in other parts a rough foliation may be distinguished, the foliation planes not being closer than about every inch, while in yet a third locality they are as finely schistose as a typical clastic schist. As a rule we generally find that the outside edges of any sill where it comes in contact with the clastic schists (and this may often be a very well defined line) are more schistose than the interior of the sill, which is a phenomenon that we would naturally expect in the shearing of a petrological complex in which rocks of variable resisting powers were present.

An interesting and exceedingly clear section showing the actual junction line between the hornblende schist and the limestone is to be seen in the pier road about a quarter of a mile east of Finlarig farmhouse. The limestone in contact with the hornblende schist is very hard, and contains a large quantity of siliceous matter effervescing but slowly with acid. The limestone at this point shows evidence of having been baked to a distance of about two feet beyond the line of contact, and the original colour banding in the limestone comes out much stronger in those parts which have been affected by contact metamorphism.

Having thus examined the rocks forming the low ground in the neighbourhood of Killin, and having in that way obtained some knowledge of the structure of the base of the mountain, we are now prepared to begin our ascent and make an examination of those rocks higher up its side. But before proceeding to an examination of the schists we may just remark that, in this region, as all over this part of Scotland, quite a number of basalt dykes may be seen, several being exposed in the Dochart below the bridge, while one, which has been quarried, runs along the base of Creag-na-Caillich. Immediately above Tirurthur the character of these dykes is so well known that it would be entirely superfluous for us to enter into a description of it here.

Immediately above the Loch Tay limestone I have noticed at various points in this region a massive bed of grit with somewhat large pebbles of opalescent quartz, the first locality in which I had observed this particular bed being on the hillside to the east of Lochearnhead and in Glen Ogle. Thinking that a careful examination of the stream section above the outcrop of the limestone at the base of Creag-na-Caillich might reveal a similar bed, during last summer I went over the ground in some detail and found what appears to me to be exactly the same bed in a similar relative position to the Loch Tay limestone as that seen at Glen Ogle and Lochearnhead. It contains large pebbles of quartz and felspar, which have been drawn out along the general direction of foliation in the schists, and it makes a rocky barrier in the course of the burn owing to its being harder and more massive than the schists with which it is intercalated.

Above the Loch Tay limestone comes a group of mica and quartz schists, which are generally characterised by the quantity of garnets which they contain. Now it might be rash to assume that these garnetiferous schists mark a definite stratigraphical horizon, yet it is a somewhat singular thing that in tracing these beds across the Highlands it is quite evident that the beds which apparently overlie the Loch Tay limestones are more highly charged with garnets than the schist horizons evidently underlying the Loch Tay limestone, and than certain horizons apparently above the garnetiferous zone. Whether this has been owing to some original difference in the composition of the schists, or whether it merely indicates a more intense metamorphism along certain horizons, is a problem upon which we cannot at present throw any light.* One thing is certain that immediately above the Loch Tay limestone there occurs a group of garnetiferous schists which can be traced from shore to shore across the southern Highlands.

Upon an examination of these schists it will be seen that there is an almost endless variation in the rock, according to the predominance of one or other of the two essential minerals, quartz and mica. In certain places the bulk of the rock may appear to be composed of mica, while in others the mica dwindles rapidly down, and the rock

*One would naturally look for an increasing metamorphism towards the core of the great geanticlinal where the beds could not be jammed any closer, and where arrested motion would generate heat. As a matter of fact, there is evidence of an increasing metamorphism proceeding inwards from the Highland frontier, it becoming more and more difficult to trace the original clastic structures in the sedimentary schists as we approach the great axial line of folding.

puts on the appearance of a schistose quartzite. The mica is generally of a pale species, being arranged in folia parallel to the general schistosity of the mass, bending and flowing round the larger segregations of quartz and the other accessory minerals which are to be found in the schist.

The garnets, which form the principal accessory mineral, often make up a large bulk of the rock. They are of a port wine colour, and vary in size from the merest speck, which requires the aid of the microscope to be detected, up to nearly half-an-inch in diameter. In an interesting section seen on the mountain side near the top of the wood, the schist appears to be almost wholly composed of garnet, or, to be more exact, certain bands in the rock exhibit this appearance, these alternating with other bands which appear to be almost destitute of garnet. At various places on the hillside, handfuls of garnets may be gathered from the bottom of the streams. They have been weathered out of some of the highly micaceous or more easily friable mica schists. It is also worthy of notice that, in certain parts of Loch Tay, a pale red sand may be gathered, which is wholly composed of fragments of garnet that have been washed out from the schists.

A careful examination of the schists will often reveal that the garnets have been subjected to a certain amount of distortion, and they are often seen to be surrounded with a rim of chlorite. Again, the garnets may not infrequently be found to have their crystalline faces rounded off, or to be cracked in several places, and to have the cracks filled with granulitic quartz, facts which seem to point clearly to a certain amount of movement in the schists after the garnet had been crystallized out, and this seems borne out by other phenomena which we shall discuss later on and which seem to point to there having been a succession of movements, the first producing certain schistose structures which have been more or less destroyed by a later series which have set up new structures.

Apparently interbedded with the garnetiferous schists and outcropping near the 1500 feet contour line (immediately above a considerable fall in the bed of the stream) there is exposed a sill of hornblende schist which exhibits a finely banded structure of alternating basic and acid material, the more acid portions being mainly composed of granular felspar without any hornblende, while the ultrabasic bands are almost entirely composed of hornblende. It would be very difficult to say whether we have here an original structure in the basic rock; such banded structures are not uncommon in lava flows, and it is quite probable that the hornblende schist may have originally had some such distribution of its component minerals. On the other hand we could easily conceive how such banded structures might have been set up by the subsequent shearing of a rock. In a paper contributed to the *Transactions* in the year 1897, Mr. Henry Coates and the author have discussed the probable origin of a similarly banded hornblende schist from the Pass of Killiecrankie, the views advanced by Mr. Harris Teall being then adopted to account for the phenomena under notice. The sill seen in Creag-na-Caillich differs in many respects from that described as occurring in the Pass of Killiecrankie; thus, while the latter exhibits a rough pegmatitic structure, the former is much more finely banded, and we would be inclined to think that it represents an original flow structure in the rock. We have not been able to trace it for any great distance along the hillside, but it is well seen in the bed of the stream and for a few yards on each side, and it is probable that it is only a lenticular sill.

Above the garnetiferous schist zone just described there occurs a group of schists which we have named the Upper Argillaceous Zone, because of the predominance in it of rocks of an argillaceous type. This well-marked zone, like the others just described, has been traced across the southern highlands from shore to shore. The principal rock of this zone is a phyllite, or calcareous serecite schist, of a dark grey or greenish colour. The rock is generally exceedingly soft, but with it are intercalated beds of quartz schist and schistose greywacke, the latter of which was described in some detail in communication last year, as it is in it that we find the peculiar bodies which we suppose to be of annelid origin. It would be impossible, we think, to draw an exact line of demarcation between these phyllites and the underlying garnetiferous schists, the one gradually passing over into the other; but after we have reached an altitude of about 1700 feet above sea level, or near the point where the burn splits into two separate streams, we find that the garnets have entirely disappeared from the schists, while the phyllites are quite easily distinguished from the mica and quartz schists of the mountain foot. On Creag-na-Caillich these phyllites with their associated quartz and greywacke schist occupy the whole summit of the hill, but, in passing eastwards beyond Loch-na-Lairig, the phyllites are seen to pass into a group of dark graphitic schists which were at one time quarried on the north-west shoulder of Ben Lawers, a still higher group of gritty quartzite being also seen on the same slope.

That these phyllites have originally been of the nature of clay slates seems undoubted, though all trace of their original structure has now been destroyed. We have failed to find any trace of the original bedding in the phyllites unless the lines of junction between the quartzites and greywackes with which they are apparently interbedded be taken as such; if so, the value of this evidence is unmistakable, as they often protrude in the stream sections above the softer phyllites, thus indicating at a glance the direction of the dip. We have examined the latter beds carefully for any evidence which would show which was the top side and which was the bottom side of the quartzite, but hitherto we have entirely failed to satisfy ourselves upon this point.

Numerous divisional planes are of course to be seen in the phyllites, but they all appear to us to be of secondary origin, having been caused by movement in the rocks. Numerous fine examples of the structure known as *ausweichung*, or strain slip, may also be observed, and as the nature of this structure is not generally known we might here examine it a little more carefully.

Upon a cursory examination of these rocks one might be led to suppose that all the structures which he sees in them have been produced at the same time and by the one operation, but a more detailed examination will show that this view is quite untenable. Thus the folding of the bedding in these rocks and the principal foliation has evidently taken place at the same time, but the folding of the main foliation already referred to must evidently have taken place at a later period. We have here at least clear evidence of two distinct periods of disturbance and folding in these phyllites. In the case of the greywackes and schistose quartzites with which they have evidently been originally interstratified, the former have not been folded to nearly the same extent as the latter, and it seems quite evident that the phyllites have been subjected to a series of successive movements between the more massive beds.

Turning now to a more detailed consideration of the manner in which the phenomenon known as *ausweichung*, or strain slip, has been developed in the phyllites, we notice that, wherever these phyllites have been sharply folded, a series of fine lines indicating distinct divisional planes may be observed running parallel with the axis of the fold and cutting the early foliation in much the same manner as we may often see foliation planes cutting the original bedding planes in schistose rocks. These secondary foliation planes are known as *ausweichung cleavage*, or double foliation; as a rule this secondary foliation or strain slip is seen to cut the earlier foliation, or rather the folds in the earlier foliation, parallel to the axes of these folds.

The same rule holds good regarding the facility with which the secondary foliation planes have been produced as that which governs the first foliation; thus we find that in the space of an inch the phyllites may have become so completely foliated as to make it impossible to count the number of divisional planes, whereas the foliation planes occurring in the schistose quartzites and greywackes are very much apart. Where the phyllites and quartzites have been folded together, as not infrequently happens, a finely developed *ausweichung* cleavage may be seen to pass through the phyllites, while the quartzites remain comparatively untouched, or, if any evidence can be seen, it is only in the shape of faint cracks at considerable distances. A remarkably fine example of the phenomenon can be seen in the great landslip on the south side of Meall Dhuin Croisg, and numerous fine examples may also be seen in the bed of the stream descending from the summit of Creag-na-Caillich.

Another character which is evidently connected with this structure, and which is also prominently exhibited in the phyllites when the specimen has been broken along the line of the earlier foliation, is the minute puckering which the specimen displays. This is accounted for by the peculiar manner in which the secondary foliation has bent the early foliation into a series of sigmoidal curves.

When seen in micro-section, where the structure has been well developed, the nature of the secondary foliation can at once be perceived. In a hand specimen the *ausweichung* structure can be traced as a series of secondary planes, there being as many as eight or nine to the inch, and often more. The mica flakes can be seen to be bent into a series of sigmoidal curves somewhat like a straggling S. Now this seems to me to show clearly that this secondary foliation has been produced by a differential movement, set up in the rock by the dragging forward and the production of lines of strain slip, or drag, parallel to the axis of the fold.

We pass now to a consideration of a specimen in which actual rupture has evidently taken place along the line of strain. Here the beautiful flowing sigmoidal lines have been destroyed, and the mica flakes of the secondary foliation have been arranged along the original lines of strain and at right angles to those of the earlier foliation, or, perhaps, to be more exact, if not exactly all at right angles, at varying angles, showing that a certain amount of crushing had actually taken place along the line of strain.

The question arises would it be possible for this secondary foliation to proceed so far as entirely to obliterate the earlier one. On this point, Mr. Harker remarks, a rock mass cannot present two foliations in the same place, the second will destroy the first as a direction of true schistosity. He further says, "I have examined numerous examples of the local phenomenon styled double cleavage, in the Ardennes, and in all cases resolved the second set of structural planes into a false or ausweichungs cleavage, consisting in a set of minute folds."

It has been observed, however, that in certain places in the Scottish Highlands these secondary strain slip planes run so close to one another—there being something like 40 in the space of an inch—that the earlier foliation is entirely obliterated, and its existence is only made evident in the more massive beds. As an illustration of this we may cite the occurrence in the lower argillaceous zone near Dunoon, on the Firth of Clyde, of a secondary foliation, cutting the principal foliation at an angle of about 80°, and with a nearly vertical hade. This secondary foliation is accompanied by slight throws and contortions, but, as the planes are not so close as those of the early foliation, the preference of the phyllites is to split along the earlier planes.

It is also not uncommon to find in tracks, which have been subjected to a series of earth movements, structures indicating that strain slip foliations have themselves been folded—and that oftener than once—and these early strain slips crossed by strain slipping of still later age. Numerous examples have been described in the Cowal Memoir by the Survey as occurring in the specially contorted belt, which, according to their views, forms the core of a great anticlinal arch in the foliation. I have also noticed some very fine examples of folded strain slip amongst the phyllites of Creag-na-Caillich, while a number of specially clear and conclusive examples may also be observed in the numerous blocks of schist which mark the position of the landslip on Meall Dhuin Croisg.

As we have already observed, there is a bed of black graphitic schist lying immediately over the phyllites just described, but this horizon does not seem to be reached on Creag-na-Caillich, the highest rock seen on that mountain belonging to the phyllite series. We have taken this bed of dark graphitic schist as marking the upper limit of the Upper Argillaceous Zone. Above and evidently conformable to the Argillaceous Zone comes the Upper Arenaceous Zone, the chief member of which is the central highland quartzite. Further east, and on the northern slope of Ben Lawers, the black schists and grits have evidently been preserved in a deep isoclinal fold of the phyllites.

A number of minerals are to be found in the schists just described; at several places on the hillside garnets have been weathered out of the surrounding schists, and may be gathered in handfuls in the beds of the streams as large as half an inch in diameter, and crystallised in their usual forms as rhombic dodecahedrons. In the phyllites of the Upper Argillaceous Zone, large cubical crystals of pyrites are not uncommon, the side of the cube being sometimes as long as three inches; at one time the schists were mined for the pyrites. Veins of pure white quartz are also numerous in the phyllites, having been segregated out from the surrounding matrix. In many cases these veins have been folded along with the phyllites, thus showing that they had been segregated out before the final movements in the schists had taken place. Occasionally the quartz is transparent and of a brownish colour, forming the well-known cairngorms of Creag-na-Caillich. Long acicular crystals of rutile penetrating the quartz are not uncommon; as MacCulloch has noted, they are not unfrequently seen to be bent round the quartz, from which we would infer that they had been crystallised contemporaneously with the quartz veins and had subsequently been folded along with them. Long prism-shaped crystals of hornblende occur in the beds of greywacke near the top of the hill, being usually oriented along the foliation planes. Curious nest-like arrangements of hornblende are also to be found in the greywackes.

A boss of diorite has penetrated the schists near the base of the great escarpment on the summit of the hill, and we have traced it along the strike of the schists for about two miles. We have not been able to satisfy ourselves as to whether this boss of diorite has been intruded into the schists previous to or after their metamorphism. So far as we have observed, it gives no evidence of having been sheared. The rock is composed of hornblende and felspar, both of which show evidence of having been considerably altered.

Turning now to a consideration of the physical structure of the mountain under notice, it will be necessary for us to take in a somewhat wider field than the mountain itself, so that we may be able to discuss the relationship of the schists seen in the mountain to the general structure of this part of the Highlands. Taking the Loch Tay limestone, which is perhaps the most distinctive of all the highland schists, as a sort of datum line, let us see what light the position of its different outcrops throws upon the structure of the ground. We have already pointed out that where the limestone is seen in the bed of the Dochart, near Acharn, it has an apparent dip towards the north-west at an angle about of 45° and seems to underlie the schists which cap the summit of Sron Clachan, and which belong to the garnetiferous series, from whence the outcrop can be traced eastwards round the foot of Sron Clachan, crossing the mouth of Glen Lochay and running along the north side of Loch Tay, where it also appears to underlie the garnetiferous schists, dipping north-west at an angle of about 45°. Returning to the exposure in Glen Dochart, the limestones are well exposed in the bed of the stream which, flowing from Lochan-Lairig-Eala, joins the River Dochart near Easter Lix. Ascending the stream, a somewhat extensive outcrop of the limestone is passed over, still apparently dipping north-west, but getting gradually flatter as we ascend the stream. A similar section is seen in the Ardchyle Burn between the village and the ford. Near the village the dip is distinctly north-west, but, in ascending the burn, the dip becomes gradually flatter and flatter till it eventually rolls over and appears to dip south-east and under Creag MacRanaich. At Glen Ogle head an exposure of the limestone is seen by the roadway near the station; here the limestone has been considerably folded and appears to dip towards the south-east. Outcrops of the epidiorite are also seen in the neighbourhood. From the head of Glen Ogle the limestone may be traced more or less continuously along the northern side of Beinn Leathan; and though it is much covered with drift, excellent sections of it may be seen in the beds of the Alt-nan-Sliab and the Alt-ant-Socaich at a point a little higher up the hillside than where they unite. From this the limestone can be traced along the hillside to the north of Creag Charbh, where it is thrown out by the powerful fault which runs across Loch Tay to the east of Ardeonaig. On descending Glen Ogle the limestone which was seen at its head disappears for the space of about two miles, but again appears about half-way down the glen, in the bed of the stream, accompanied by beds of epidiorite, the dip of the schists being now almost flat or slightly to the north-west. From the foot of Glen Ogle the limestone may be traced in a large horse-shoe curve up Gleann Ceann Droma, then bending round the foot of Meall-ant-Seallaidh, its beds sweep round the Kirkton Glen, and back into the main valley of the Dochart. At the head of Loch Earn, the limestones, as we have already noted, seem to undulate gently towards the south-east, plunging below the garnetiferous schists of Meall-nan-Uamh to the east of Lochearnhead Station and abutting against the great Glen Ample fault, which is a continuation of that already noticed as crossing Loch Tay. From the northern shores of Loch Earn, near Dalveich, the limestone may be traced up Glen Beich on the west side of this great fault for nearly three miles.

In the latter half of the last century the investigations of Murchison, Geikie, and others tended to show that the crystalline schists of the Highlands were arranged in a series of great anticlinal and synclinal folds lying roughly parallel with one another, and stretching across the Highlands in a north-east and south-west direction, and though their theory of the age and succession of these rocks was wrong, and further, as we shall presently attempt to show, the structure is not quite of the simple character then believed, yet we must admit that a great step in advance was made by these geologists, inasmuch as they for the first time recognised the existence of some definite order and structure in these highly metamorphosed rocks.

Perhaps the most striking example of this supposed anticlinal and synclinal arrangement of the schists, and that partly because of the prominence given to it in the "Scenery and Geology of Scotland," is that of the great anticlinal ridge of schists which is supposed to have coincided with Loch Tay and the corresponding synclinal trough to the north which coincided with the high ground between the valley of Loch Tay and Glenlyon, it being argued that Ben Lawers had been cut out of a great trough or hollow in the schists, while Loch Tay had been cut out of an upward curve or fold. Of course the primary lesson which it was intended to convey was the fact that an enormous denudation had cut deep into the core of the anticlinal fold, while the syncline had comparatively resisted the denuding agents, and it may yet be taken as a very striking monument of the work of sub-aerial denudation.

It is now a considerable number of years since we first examined this area, and though at first we looked upon the high ground to the north of Loch Tay as a simple trough of the limestones and the schists lying between it and Glenlyon to the north, yet within more recent years it has been gradually forced upon us that we are dealing not with a single trough in a great series of parallel folds, but that we have here the backbone or core of the great geanticlinal along which the crystalline schists of the Highlands were first piled. Little now remains of the superstructure of this great central core; it has been razed to its very foundations. Still it seems to us that the structure of the schists as exposed on the Ben Lawers ridge undoubtedly points to this having been the position of the main axis of upheaval of the mountain chain.

Further west the position of this great backbone of schists may be traced through the ridge to the north of Glen Dochart and in the district of Loch Awe. To the east it has been recognised by Mr. Cunningham Craig, of the Geological Survey, who refers to it incidentally as follows: "This ground lies to the south-eastward of the great central axis of folding of the Perthshire and Aberdeenshire highlands, so that only a part of one side of the fächer or fan structure is represented." It seems to us, however, that no better ground could be found for the study of this highly interesting structure than the ridge north of Loch Tay.

Let us now glance at some of the details of the structure and see if we can throw any light upon the manner of its development. By reference to the accompanying sketch map, and from what has already been said, it will be found that all the dips seen in the descent of Creag-na-Caillich are towards the west. Magnificent sections are exposed in the beds of the streams, and everywhere the same general dip towards the north-west holds good, there being an apparent upward succession through limestones, garnetiferous schists, phyllites and quartzites to the summit. Now as the dips are often considerable, say at an average of 45° near the base and increasing towards the summit till they reach the vertical, this would give an enormous thickness of schists, probably many thousands of feet, and certainly

Folded Limestone: Roadside, Drum-na-Larig.

far too much to be granted without careful examination, and at least some evidence to justify it.

One can hardly examine any considerable section in the Loch Tay limestone without being struck with the evidence which it gives of having undergone extensive folding, none of the other schists being so conspicuously folded as the limestone. One can in fact scarcely examine the limestone at any point without noticing this; thus the section already referred to as seen by the roadside at Drum-na-Larig, and of which we reproduce a photograph, shows very clearly the manner in which it has been folded. Perhaps, however, the finest example seen in this district of the extreme folding to which the limestone has been subjected is that on the south side of Loch Earn below the falls at Edinample. At this point the Loch Tay limestone abuts against the Glen Ample fault at a low angle, and it is seen to be plicated into innumerable folds. Besides these smaller folds, however, one can scarcely examine what appears to be a comparatively unfolded bed without having his suspicions aroused that the simplicity is more apparent than real. For instance, we cannot examine any considerable section of the Loch Tay limestone without noticing the presence of cores around which the limestone has evidently been folded. A similar view has been adopted by the officers of the Geological Survey, who consider that the Loch Tay limestone is of no great thickness, and that the great width of its outcrop is of course dependent upon the amount of folding to which it has been subjected.

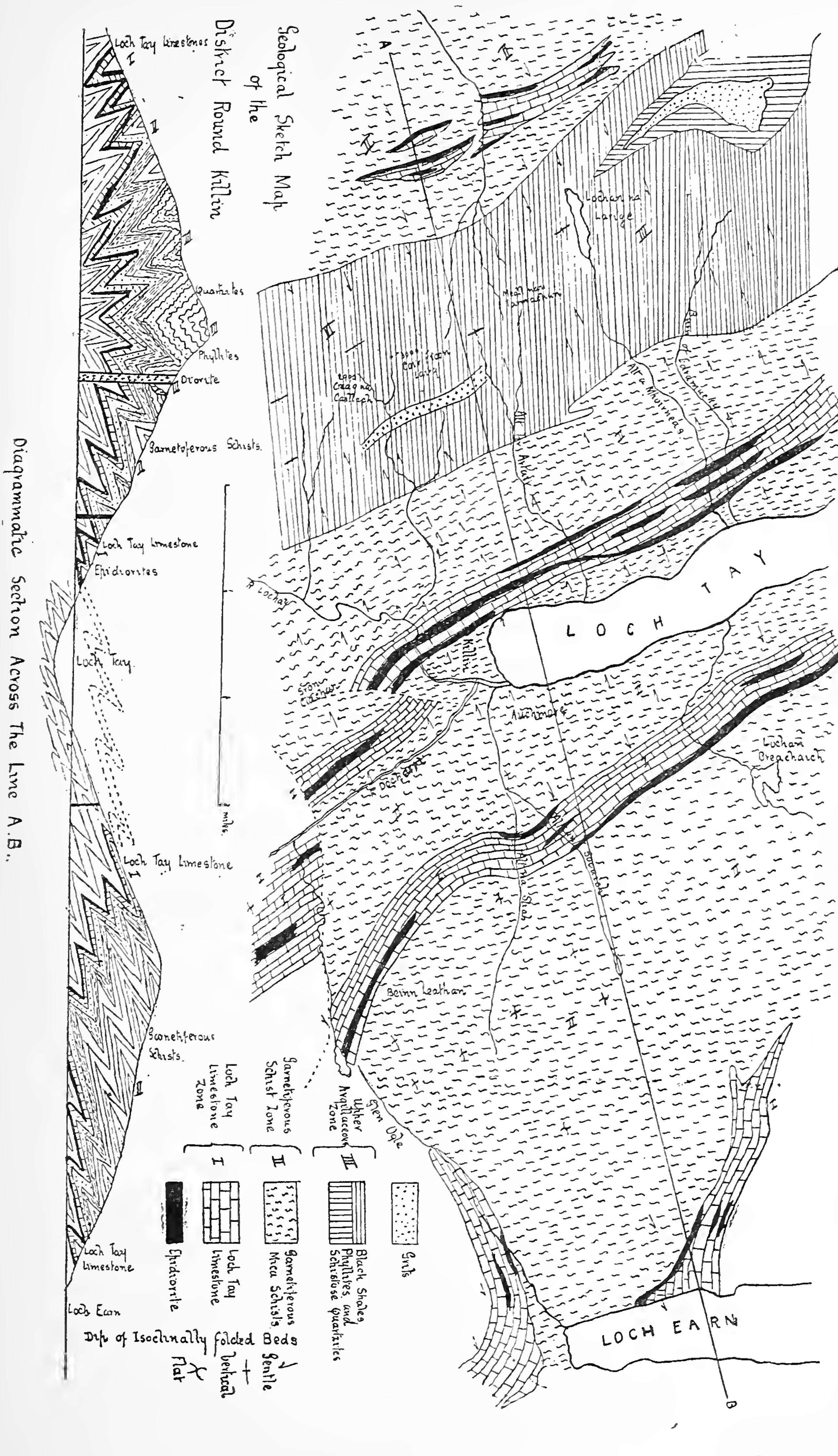
Now while it must be frankly admitted that we have no clear evidence as to the exact thickness of the limestone, and consequently cannot speak with any assurance as to the amount of times it has been duplicated in any given section, yet it seems to be fairly clear that the bed is a comparatively thin one which has been folded over and over again upon itself.

It should be noted here that in the recently published map of of this district, sheet 46, an outcrop of limestone is given as occurring high up the side of the mountain, and well within the main mass of the garnetiferous schists. I have not seen this outcrop, and cannot say whether it may simply be the Loch Tay limestone brought in again by folding or whether it represents another and higher bed. The upper boundary line of the Loch Tay limestone can be pretty accurately traced, and, as a rule, there are no exposures to be found above a definite line. From this one would assume that the folding of the limestone has been pretty equable across large areas.

Turning now to the garnetiferous schists which apparently overlie the limestone, let us see what light they bring to bear upon the subject; and here the ground is even more difficult. After having ascended the hill to near the 800 feet contour line, the limestone disappears, and massive beds of garnetiferous mica schists come on. Like the limestones beneath, they have the same steady north-west dip. No data seem available, however, for the differentiation of these schists into separate well-marked beds. Once you cross the upper limits of the limestone no definite horizons can be found till the phyllites of the upper argillaceous zone are reached. Now the question again arises whether we have here a continuous succession of schists, representing a great thickness of rock, or whether, on the other hand, the beds have been repeatedly folded upon one another. I am afraid that we have not yet got sufficient data to definitely solve this problem. Above the garnetiferous schists, and lying conformably upon them, we have a group of rocks known as the Upper Argillaceous Zone, which consists of thin beds of schistose quartzites alternating with phyllites and greywackes. This group gives evidence of intense folding, the character of the folding being well shown in the escarpment which crowns the summit of the hill, and in which the schists are clearly seen to be plicated into a series of isoclinal folds with their axes hading towards the north-west.

A consideration of the section accompanying the map and taken across the line A B, will give a better notion of what we regard the structure of the ground to be like. From an inspection of the section it will be seen that the rocks forming the ridge to the north of Loch Tay have been plicated into a fan-shaped structure, in which the folds on the south side of the ridge have their axes hading towards the north-west, while those on the north side hade towards the south-east, those in the centre being in a vertical position. From this one would infer that we have here a great axis of plication from which the pushing forces have extended themselves outwards in a north-easterly and south-westerly direction. We may now trace the section towards the south-east, and note the general effect of the plicating forces in that direction. Near the summit of the ridge, as we have already observed, the schistose phyllites and quartzites are seen to be plicated into a series of isoclinal folds, whose axes are in a vertical position. Proceeding down the hill and towards the south-east the axes of the folds become more and more inclined towards the north-west. When about half-way down, the garnetiferous schist zone comes out from beneath the upper argillaceous zone, the beds being folded in a similar manner, and with the axes of the folds dipping towards the north-west at an angle of about 45°. From beneath the garnetiferous schists, and near the foot of the mountain, comes the Loch Tay limestone, in which the character of the folding is more clearly seen.

From below the limestones there outcrops a group of flaggy schists well exposed in the bed of the Dochart, at the falls, and in the lower


Geological Sketch Map
of the
District Round Killin
Diagrammatic Section Across The Line A.B.
Loch Tay Limestones
Quartzites
Phyllites
Diorite
Garnetoferous Schists.
Loch Tay Limestone
Epidiorites
Loch Tay
Loch Tay Limestone
Garnetiferous Schists.
Loch Tay Limestone
Loch Earn
miles
LOCH TAY
LOCH EARN
Lochan na Lairige
Creag na Caillich
Killin
Auchmore
Lochan Breachaich
Beinn Leathan
Glen Ogle
R. Lochay
Upper Argillaceous Zone
Garnetiferous Schist Zone
Loch Tay Limestone Zone
Grits
Black Shales Phyllites and Schistose Quartzites
Garnetiferous Mica Schists
Loch Tay Limestone
Epidiorite
Dip of Isoclinally Folded Beds
Gentle
Vertical
Flat
A
B

reaches of the Alt-an-Sliab, behind Achmore. They probably belong to a horizon lower than the limestone, and occupy the whole of the bed of the Alt-an-Sliab from its junction with the loch up to near the 1000 feet contour line. Unlike the schists lying immediately above the limestone, they contain very few garnets, or are almost destitute of them. In the lower reaches of the Alt-an-Sliab they dip north-west, and probably continue across the loch; traced up the stream the dip gradually lessens till they become quite flat. About half-a-mile above the junction of the Alt-an-Sliab and the Alt-ant-Socaich, the Loch Tay limestone again comes on, and we have drawn it as conformably overlying the schists just described, and as underlying the garnetiferous schists which form the main bulk of Ben Leathan and Eildreach at higher levels. The garnetiferous schists have also been drawn as plicated into a series of isoclinal folds with axes in an almost horizontal position. When we first examined this ground we considered that we had here a great thickness of schists, but for reasons already given we have also drawn this part of the section as having been extensively folded. At Dalveich, on the northern shore of Loch Earn, where the section terminates, the Loch Tay limestone was formerly quarried where it outcrops along with the epidiorite.

For the sake of comparison, a section about six miles to the east of that just described may be given. It is taken from Ben Lawers across Loch Tay, at Ardeonaig, and terminates on Meall-na-Creag. In the bed of the Alt Gleann Da-Eig, north of Lochan-na-Lairig, exposures may be seen of the Loch Tay limestone and epidiorites with the axes of the folds hading towards the south-east. Ascending Ben Lawers by the east side of Meall Corranaich above the limestones there come the garnetiferous schists and then the phyllites and schistose quartzites, all dipping towards the south-east. At a higher level, a group of black shales and grits may be seen in the stream section, which evidently occupy a higher horizon than the phyllites. As we have already observed, they are not exposed on the summits further to the west, being preserved on the north side of Ben Lawers owing to the folding being deeper at this point. On the summit of Ben Lawers the phyllites and quartzites may be seen in an almost vertical position. Descending the south side of the mountain, the hade of the axes of the isoclinal folds become reversed, being now towards the north-west, numerous fine sections showing the garnetiferous schists. The Loch Tay limestone and the epidiorites, as also the schists underlying the limestone, are to be seen in the Lawers Burn, the Alt-an-Tuim Bhric, and other streams descending the south side of the Ben. Crossing Loch Tay, the limestone is again exposed at Margmore, where it has been quarried, and where it abuts against the Glen Ample and Glen Beich fault which enters the loch at this point. Ascending the Alt Mheine, we cross a series of flaggy schists which evidently belong to a horizon lower than the Loch Tay limestone, as, at the top of the stream and on the summit of Meall-na-Creag, an outlier of the limestone is found capping that mountain. The structural identity of the northern part of this section with that of Creag-na-Caillich is evident; that part of it lying to the south of Loch Tay and to the west of the great fault presents a somewhat different character from that of Ben Leathan and Eildreach, this being caused by the fault having a considerable downthrow to the west, which brings in the lower schists on the west against the Loch Tay limestone and garnetiferous schists on the east. In the meantime, we class all the schists that appear to be below the Loch Tay limestone as belonging to our Lower Arenaceous Zone. To what extent these flaggy schists are the equivalents of the grits and greywackes, which further to the south retain their original clastic structures comparatively unaltered, we cannot at present say. It is just possible that the grits and greywackes of Ben Ledi and Ben Voirlich may have originally passed northwards into finer sediments, while the increasing metamorphism in that direction would also tend to destroy the original clastic structures.

The next section which we describe is taken about two miles to the west of the Creag-na-Caillich section and stretches from Meall-Ghaordaidh in the north, across Creag Mhor on the dividing ridge between Glen Lochay and Glen Dochart, thence across Glen Dochart at Ardchyle and over the summit of Creag Mac Ranaich, terminating near Lochearnhead. The summit of Meall Ghoardaidh is capped by an outlier of the phyllites from beneath which come the garnetiferous schists with a dip towards the south-east; at Tullich, the Loch Tay limestone is exposed, also dipping towards the south-east; crossing the River Lochay at Corrycharamaig, the garnetiferous schists are again seen to pass below the phyllites of Creag Mhor, to the east of which passes a powerful N.N.E. and S.S.W. fault. The effect of this fault has been to shift the beds on the west side further south, thus bringing the Loch Tay limestone against the phyllites. As these faults are later than the plication of the schists, they must tend to break up and destroy the original tectonic arrangement of the schists. In this case beds which were originally on the north side of the great axial line of folding have been brought into line with those on the south side. Crossing the Mid hill we again meet with the garnetiferous schists coming out from beneath the phyllites and now dipping towards the north-west. Descending to the level of the Dochart we find the Loch Tay limestone coming out from beneath the garnetiferous schists of the Mid hill, from which point they can be traced up the stream to the west of Ardchyle (Glen Dubh). In ascending the stream the limestones get flatter and flatter till they eventually roll over, and the garnetiferous schists again come in. These can be traced up Glen Dubh to the summit of Creag Mac Ranaich and Cam Chreag, where they appear to be about horizontal. Tracing the garnetiferous schists northwards down the Gleann Ceann Droma they are seen to have a gentle dip towards the north-west, and the Loch Tay limestone again appears a little to the south of the ford. From beneath the limestone come the lower schists forming the core of an anticlinal axis, the limestones again appearing to the east of Lochearnhead Station, where they dip towards the Glen Ample fault, being covered by the garnetiferous schists which are seen in Meall nan Uamh and Meall nan Oighreag.

The structural identity of the section with the two just described is, I think, apparent when allowance is made for the effect of the great N.N.E. and S.S.W. fault, which, as we have already said, tends to destroy the continuity of the great axial line of folding. The beds lying to the north-west of the line of fault, the axes of whose folds dip towards the south-east, evidently belong to the north side of the geanticlinal of the Grampians. After crossing the line of fault we pass on to the phyllites near what would be the apex of the fan; from this point to where the section terminates at the Glen Ample fault the beds are entirely on the south side of the axial line, and the axes of the isoclinal folds hade towards the north-west at a gradually decreasing angle as we proceed south.

From a consideration of these three sections, our view of the general tectonic arrangement of the rocks will be made clear. We have in this area a great geanticlinal or fan-shaped structure from which the rocks are thrown off towards the north-east and south-west in a series of isoclinal folds. Near the apex of the fan the isoclines are vertical, on each side the axes of the folds dip inwards towards the north-east and south-west respectively. Traced towards the south-east the axes of the folds become flatter and flatter till they are almost horizontal. On approaching the Highland frontier the axes of the folds again begin to rise till they dip towards the north-east at a high angle. In following the sections from the apex of the fan towards the south-east, lower and still lower beds rise to the surface. On the apex of the fan we have the Upper Argillaceous Zone, further south the Garnetiferous Schist Zone, then the Loch Tay Limestone Zone followed by the Lower Arenaceous Zone and the Lower Argillaceous Zone along the Highland frontier. On the north-west side of this axial line the arrangement of the schist zones is somewhat different, as the members of the Lower Arenaceous Zone and Lower Argillaceous Zone seen along the Highland frontier do not appear to come to the surface, being everywhere covered by members of the Upper Argillaceous Zone and schists higher in the series.

We suppose that in the development of the fan-shaped structure the rocks along the line of what is now the Highland frontier met with some obstacle, probably the piling up of the massive beds of grit in the Lower Arenaceous Zone, which tended to ridge up the isoclines into a vertical position. Further west and to the south of Ben Lomond the vertical position is actually reached. In Cowal and along the shores of the Firth of Clyde the isoclines have become inverted, the axes of the folds now hading toward the south-east.

The scope of this paper precludes our entering into any further details regarding the structure of the southern Highlands and its manner of development; that is reserved for a future paper. From what has been said it will however be seen that the structure of this part of the Scottish Highlands is not quite so simple as geologists up to comparatively recent times have supposed it to be, and that, instead of being arranged in a series of simple anticlines and synclines, the tectonic arrangement of the schists is more likely to be something like what has been advanced in this paper.

XXI.—*Notes on certain Perthshire Fungi.*

By JAMES MENZIES.

(Read 13th February, 1902.)

Perhaps no class of plants has received so little popular attention as the fungi. The stately forest trees, the shrubs, herbs, and flowering plants, the grasses, ferns, and even the lowly mosses, have all been admired and prized for their beauty, elegance, or fragrant properties. With the fungi it has been quite otherwise; despised and looked on with disgust and suspicion, as poisonous and monstrous growths, begotten of death and putrefaction, they have formed a race of vegetable pariahs. In spite of this, fungi are highly-interesting plants—not, indeed, possessing those manifold special adaptations of means to ends which lend such a charm to the study of the flowering plants, but, nevertheless, possessing many curious and remarkable eatures.

Fungi exhibit very different phases of life from those plants containing green colouring matter—chlorophyll. The absence of this substance in the economy of the fungi constitutes a well-marked physiological difference between them and even their nearest allies, the algæ, which resemble them a great deal in their methods of reproduction. Being devoid of chlorophyll, fungi are unable to decompose carbon-dioxide after the manner of green-leaved plants, and so they are obliged to take up their carbonaceous food in the form of organic compounds; and their mode of living bears a distinct relation to this circumstance, fungi being always found on organic remains or soil rich in humus, or living as parasites on other plants or on animals.

As might be supposed from their mode of life, light is of little consequence to the growth and development of fungi. Mushrooms can be cultivated to perfection in disused tunnels and cellars, and, as everyone knows, a mildew or mould will develop in a situation where not a ray of light enters.

Fungi comprise a great number and variety of organisms, some of which are very simple in their structure, and consist only of a single cell; others attain a great size and considerable complexity of structure; but however large a fungus may be, it consists entirely of cellular tissue.

On the importance of fungi in the economy of nature I will quote Sachs:—"One may well say that if there were no fungi the entire surface of the earth would be covered with dense layers of the bodies of plants and animals, which had accumulated for thousands of years; since it is essentially the fungi, and particularly the minute forms of very simple structure, which have year by year, in the course of geological time, decomposed the dead plants and animals, and again resolved them into carbon-dioxide, water and ammonia. Fungi not only absorb the materials necessary for their nutrition, which would result in effects only extremely insignificant, but destroy, in addition, the substances which they do not take up."

Amongst the more highly organised fungi, the Agaricini are by far the best known. They belong to the Hymenomycetes, or naked-spored fungi. The family is a large one,—1000 species are said to be found in Britain alone, and amongst these many beautiful and elegant forms occur. The name Agaric is generally believed to be derived from a district of Sarmatia, called Agaria, whence the Romans obtained a particular fungus called Agaricum, which they used for medicinal purposes. Linnæus eventually conferred the name Agaricini on the gilled fungi, but they are much better known in this country as toad-stools and mushrooms,—the latter being popularly supposed to be entirely different in their nature from their despised relatives.

Here one might ask, "What's in a name?" Perhaps nothing has contributed so much to the contempt and dislike with which these plants are regarded as this unfortunate association with an animal which, in more credulous ages, was looked on with grave suspicion. Even Edmund Spenser, the poet, wrote:—

> "The grieslie todestoole growne there mought I see,
> And loathed paddocks lording on the same."

One need hardly say that this was merely a flight of poetic fancy. According to M. C. Cooke, the name toad-stool is clearly derived from the German "tod" and "stuhl," meaning death-stool, in reference to the poisonous nature of some of these stalked fungi.

Though perhaps not altogether absent at any season of the year, it is during the autumn months that fungi are most abundant. The still warm earth, with the copious rains and humid conditions then generally prevalent, being highly favourable to their growth and development, they may then be found almost everywhere:—in deciduous woods, growing in lines or rings on the last year's leaves; here rising solitary or in groups from the humus of the soil; there clustering on mouldering stumps with their relations, the cup-lichens; in heathy pine woods, luxuriating on the fallen needles, or investing the twigs blown from the trees by the gales of winter; here rising above the carpet of hair-mosses, there nestling under the tangled shoots of the heather or blaeberry; forming imbricated masses on some decayed tree, or decking the woodland path with their varied growths; on sheltered banks and in old pastures; by the borders of fields and under hedges; in bogs amongst sphagnum, and ascending our loftiest mountains almost to their summits.

Though found in such different habitats, the fungus-hunter soon discovers that, like other plants, certain species affect certain situations. Many will be found delighting in the shade of one particular species of tree. A few, like the fly-agaric—*Agaricus muscarius*, L.—will be found haunting the vicinity of the birch. A great variety affect the shelter of the beech, where the rich mould formed by the decaying leaves, and the absence of any very vigorous competing vegetation, create conditions highly favourable to fungi. *Agaricus virgatus*, Fr., *Russula fellea*, Fr., and *Lactarius blennius*, Fr., are almost invariably found under beeches. Many are found frequenting conifers: amongst these are the spotted caps of *Agaricus maculatus*, A. & S., the liver-coloured *Lactarius rufus*, Fr., and *Cantharellus aurantiacus*, Fr.; the false chantarelle is common, while *Agaricus conigenus*, Pers., devotes its attention entirely to the fallen cones.

Amongst those occurring on wood, some, like *Agaricus fascicularis*, Huds., seem indifferent to the kind on which they grow, while others are more restricted in their choice. *Agaricus sapineus*, Fr., is confined to pine-wood; *Agaricus mucidus*, Schrad., to beech;

and *Agaricus velutipes*, Curt., shows a marked partiality for the decaying stems of the broom and whin. Grassy glades and borders of woods are much frequented by various species of *Russula*, while the genus *Hygrophorus* is always well represented in old pastures. The genus *Coprinus* is especially attracted by dung and rank soil, and the species of one genus are parasitic on the dead species of another.

The Agaricini are recognised by the stem or stipes, surmounted by the cap or pileus, on the underside of which are arranged a close series of plates or gills, the spore-bearing surface, technically called the hymenium. This is usually looked upon as the whole plant, and, indeed, is the only part of the plant by which its specific identity can be established, but in reality it is the shoot, reduced to a fructification.

At the base of the stem will generally be found a number of slender fibres assuming the appearance of roots, and which functionally perform the office of these organs to the fungus. This is the mycelium, the product of a germinating spore, and the individual threads are known as the hyphæ or hyphal threads. In those agarics which grow in a loose debris, such as fallen leaves or twigs, the mycelium can be easily seen. Sometimes it presents the appearance of a mass of white felt, while sometimes it has a silky, shining appearance, and is almost as fine as a spider's web.

When examined under the microscope, these hyphal threads are found to be cylindrical in form, consisting of single rows of cells. The growth of these hyphæ is always apical, but they branch freely, and where they come in contact coalescence may take place, not only between the branches of the same hyphæ, but also between such as are growing together, but were originally distinct, being the product of distinct germ-cells.

The filamentous mycelium is the form which comes most frequently under observation, but different forms occur. In some species the hyphal threads unite and form strands, which in their appearance and mode of branching bear a strong resemblance to the roots of the higher plants.

The mycelium, better known as the spawn, of *Agaricus campestris*, L., the mushroom, has its hyphæ united into strands. In *Agaricus præcox*, P., common in gardens in summer, the mycelium is similar, but in *Agaricus melleus*, Vahl., this strand formation is said to attain its highest development. This agaric is sometimes a parasite on members of the pine family, in which it produces a disease known as resin-flux. The mycelial strands creep in the soil from tree to tree, and, penetrating the cortex of the roots, spread into the wood, sometimes doing great damage. These creeping strands were formerly known under the name of "Rhizomorpha," and believed to be an independent fungus until *Agaricus melleus* was discovered to be its fructification.

In a few species there is produced from the mycelium a secondary formation called a sclerotium. This results from the firm union of hyphæ into the form of a ball or tuber, which when mature becomes detached from the mycelium, and may remain in this condition for a considerable time, thus presenting a resting-stage.

The mushroom or toad-stool is always developed from one or other of these mycelial growths, and is woven entirely of hyphal threads. The internal structure of the fungus gives the impression of very numerous hyphæ, each one of which, strictly speaking, leads an independent existence, having become united into a colony, the single individuals of which—that is, the hyphæ—are subordinate, however, to a common plan of configuration. The texture of the structure varies not only with the species, but also with the different parts of the individual plant. In the stem the hyphal threads are fairly long and uniform; dense, even cartilaginous, in the outer or cortical part, looser, sometimes spongy or woolly, in the interior.

In the pileus the hyphæ are much branched and interwoven, growing downwards and forming a fine fibrillation in the gills, and ending determinately in the formation of the hymenium. In addition to this close union and interweaving of the hyphæ, these threads in many fungi are bound together by an intercellular substance which softens in water.

In some of the Agaricini the fructification is developed until maturity in a membranaceous sac, termed the universal veil, within which the stage-carpentry of the toad-stool drama is carried on. In others only the gills are enclosed, when the investing membrane becomes the partial veil, while in a large number no investing membrane is present.

In spite of these diversities, the mode of growth is essentially the same in most species. If *Agaricus campestris* be taken as a type, the mushroom will be found to begin its growth from the mycelium as a small globose body. After growing vertically for a short time it loses its globose form and becomes elongated. At this stage a longitudinal section shows the formation of a narrow, annular cavity; this is the position of the future gills. The membrane or outer skin, which is the universal veil, is continuous over the whole fungus.

The subsequent growth of the pileus is by the elongation of the hyphæ and the introduction of new branches in the direction of the margin. The enlargement of the annular cavity keeps pace with the growth of the pileus. A longitudinal section at this stage shows that the gills are being developed, growing downwards from the layers of hyphæ forming the underside of the cap. With the completion of the gills there is an elongation of the stem and an expansion of the cap, when the veil, now stretched to its utmost, parts round the margin of the pileus and hangs loosely on the stem, becoming the annulus or ring.

The elongation of the stem and expansion of the pileus are often accomplished with great rapidity, and it is from this that the fallacious idea has arisen that a mushroom grows up in a night, while the fact is that this abrupt extension is only the last phase in the growth of a structure which has been developing for some time.

A little examination of the gills will show how the same distance apart is preserved between these plates. It must be apparent that, radiating outwards from the stem, their distance apart will always increase with the circumference of the cap. This is obviated by the introduction of a second, a third, and sometimes a fourth series, each shorter than the other, which extend from the margin of the cap inwards between the full-length gills, so that a uniform distance apart is maintained throughout.

The central portion of the gills, technically the trama, is composed of long-celled, slender hyphæ, which diverge right and left, and terminate in a layer of round cells, the sub-hymenial layer. The hymenial layer covers the entire surface of the gill, and consists of closely-packed, club-shaped cells, the basidia. From these basidia arise four tiny branches, the sterigmata, each bearing a spore at its apex. The basidia contain a granular liquid charged with little drops of oil. This liquid passes upwards through the sterigmata, which are hollow, and communicate with the spores.

It is believed by some authorities that a succession of spores is developed from the sterigmata, but of this there is no positive proof. Accompanying the basidia as part of the hymenial surface are a number of smaller club-shaped bodies, the paraphyses, which are usually regarded as sterile basidia.

In the Agaricini nothing of the nature of a sexual process has ever been discovered. Their life-history is therefore very simple. From the germinating spore arises the mycelium, which in its turn produces the fructification. The spores consist of single cells, and are produced in the most extraordinary abundance. In size and shape they exhibit a wide diversity, in this respect reminding one forcibly of pollen grains, to which they often bear a strong resemblance.

The colours of the spores are very varied: though a great many are white, some are pink, some brown, some purple, and others black, and many species have their own particular tint of these colours. Both shape and colour of the spores are of great importance in the determination of species.

If the stem is removed from one of the Agaricini, and the cap placed gills downwards for a few hours on a sheet of paper, the spores will be found lying in lines corresponding to the gills, when the colour can be ascertained, but further examination can only be carried on by the aid of the microscope. Here I should say that the colour of the gills is no safe guide to the colour of the spores.

The spores, especially if white, may often be noticed powdering the grass or ground for some little distance beyond the circumference of the cap. From this circumstance it is believed that the spores are abjected from the sterigmata with some slight force. Their wider dispersion is probably due in a great measure to animals. Flies have been suggested as likely agents in this work, and in some fungi, such as the stink-horn, this is probable; but I do not believe the Agaricini are affected by flies until in a state of putrefaction, and consequently past the spore-bearing stage. On the other hand, they are devoured to an enormous extent by snails and slugs, so much so that in moist weather it is hardly possible to find a whole specimen; even the deadly fly-agaric is no exception.

Squirrels eat largely of fungi. Instances of this have come under my own observation, and the fact has been corroborated by all gamekeepers and foresters whom I have questioned on the subject. These animals must inevitably carry away spores clinging to their bodies.

The spore retains its vitality only for a short time, and little is known as to the conditions under which it germinates naturally. The spores of some species have been cultivated artificially, and in this way their method of germination has been observed, but all attempts to propagate fungi by sowing the spores have ended in failure. It is even said to be impossible to raise the mushroom from spores; it is necessary to plant the mycelium or "spawn" in suitable conditions. The spawn is obtained from dry horse-manure. From this circumstance it is inferred that the spores are conveyed to the stomach of the horse in its food, and in the bowels of the animal find the necessary conditions for germination.

The mycelium is long-lived, and an extra wet August, by which fungi are very favourably affected, will show the humus of our woods and pastures to have been teeming with mycelial growths awaiting suitable conditions.

I do not think that the life of the mycelium ends with the development of the fructification, as one finds the same species appearing year after year on the same spot with a regularity which seems to preclude the possibility of their being developed annually from spores.

The ring-like formations of fungi, common in woods and pastures, seem to be due to the perennial nature of the mycelium. These rings may arise from a single vegetating spore, which, as the soil becomes exhausted, pushes outwards all round, producing every year a fresh crop; the circle continually widening, ultimately attaining large dimensions. The rings formed in pastures by the fairy-ring mushroom, *Marasmius oreades*, Fr., which is parasitic on the roots of grasses, are particularly noticeable from the dark hue of the vegetation growing within the circle. The fungus kills the grass, and then in turn dies, its remains leaving the soil richer for succeeding vegetation.

These "fairy rings" have given rise to many curious beliefs. In the west of England they are known as "Hags' tracks." In Sweden they are said to be enchanted circles made by the fairies, and the belief prevails in some parts of that country that anyone treading within the magic circles loses consciousness and cannot retrace his steps. Many curious theories were propounded by the learned as to the cause of these circles before they were discovered to be produced by fungi.

I have already said that in this country the Agaricini are popularly divided into mushrooms and toad-stools,—the former good to eat, the latter poisonous. But on the Continent many species of the latter are highly esteemed as food, and are eaten not only while fresh, but dried and used for seasoning, the very varied flavours of fungi allowing ample scope to suit all palates. Many possess an agreeable mealy taste, and amongst these are some of the best edible species; but this cannot be relied on as a distinguishing feature between the edible and the poisonous, as a number having a mealy taste and odour are known to be dangerous. A few have the flavour of the mushroom, others of garlic; some are bitter, some acrid, so much so that the throat burns after tasting the smallest morsel—I can speak feelingly on this!

Fungi have always possessed a bad reputation for their odour, and certainly some are far from agreeable; but no agaric taints the air in the manner of the stink-horn, which I think Tennyson must have had in his mind when he described Lynette's behaviour towards Gareth, the supposed kitchen-knave:—

"She thereat, as one
That smells a foul-flesh'd agaric in the holt,
And deems it carrion of some woodland thing,
Or shrew, or weasel, nipt her slender nose
With petulant thumb and finger, shrilling, 'Hence!'"

Some of the Agaricini are very fragrant. *Agaricus odorus*, Bull., *Agaricus fragrans*, Sow., and *Lentinus cochleatus*, Fr., smell of anise, but many are less pleasant. Some have the odour of radishes, one of prussic acid, another of tar; some have a soapy or alkaline odour, others a nitrous odour, while many are either odourless or only possess that peculiar mouldy odour which is perhaps best described as fungoid.

In colour, too, the Agaracini have a wide range: scarlet, reds, purples, amethyst, blues, violets, green, yellow, and through all shades of brown to almost black.

Many species have the cap furnished with hairs, which produce a downy appearance, as in *Agaricus terreus*, Schæff. In others the stem may be clothed with hairs, giving the appearance of velvet, as in *Paxillus atro-tomentosus*, Fr., and *Agaricus velutipes*, Curt.

In *Coprinus micaceus*, Fr., some of the exterior cells of the pileus are filled with a clear liquid, which sends out luminous rays, giving the cap the appearance of being sprinkled with the familiar mica scales which invest the roots of floral specimens from Ben Lawers.

In many of the Agaricini the pileus has a superficial layer of slimy, gelatinous tissue, which is the seat of the distinctive colouring matter. This is often washed off in rainy weather. *Ag. muscarius*, Linn., and *Ag. æruginosus*, Curt., then present a very different appearance, the former losing its brilliant scarlet and becoming orange, the latter from a dark green becoming straw-coloured.

The genus *Coprinus*, in which the spores are black, is remarkable for its deliquescent habit. In decay the gills dissolve into a black fluid.

In the genus *Lactarius* the species possess a system of lactiferous cells, which ramify throughout the whole fungus, but are most abundant in the gills. A slight pressure ruptures the cells, when the milk oozes in drops, which in some species change in colour on exposure.

The order Agaricini is divided into 20 genera, of which 18 are represented in Britain. The largest, and what may be called the central genus, is *Agaricus*, which is divided into five series, according to the colour of the spores, and each of these series contains a number of sub-genera, in which the structure of the fungus is taken into consideration; the presence or absence of the universal and partial veils; the relation between the stem and pileus; whether the stem is cartilaginous or fibrous; whether the gills are free or attached, and, if attached, their mode of attachment. The other 19 genera differ from *Agaricus* in the possession of certain characteristics peculiar to each genus.

I will now try, by the aid of lantern slides, to illustrate some of the genera and sub-genera :—

Ag. (Amanita) rubescens, Pers.
„ „ vaginatus, Bull.
„ (Lepiota) rachodes, Vitt.
„ „ cepæstipes, Sow. (in hothouses).
„ (Armillaria) melleus, Fl. Dan.
„ (Tricholoma) resplendens, Fr.
„ „ virgatus, Fr.
„ „ acerbus, Bull.
„ (Clytocybe) nebularis, Batsch.
„ „ maximus, Fl. Wett.
„ „ laccatus var. amethystinus, Bolt.
„ (Collybia) confluens, Pers.
„ „ dryophilus, Bull.
„ (Mycena) polygrammus, Bull.
„ „ epipterygius, Scop.
„ (Pluteus) cervinus, Schæff.
„ (Clitopilus) prunulus, Scop.
„ (Pholiota) squarrosus, Müll.
„ (Inocybe) geophyllus, Sow.
Ag. (Hebeloma) crustuliniformis, Bull.
„ (Hypholoma) sublateritius, Fr.
„ (Panæolus) separatus, L.
Coprinus comatus, Fr.
Cortinarius (Phlegmacium) purpurascens, Fr.
Cortinarius (Dermocybe) sanguineus, Fr.
Cortinarius (Telamonia) armillatus, Fr.
Paxillus involutus, Fr.
Hygrophorus coccineus, Fr.
„ olivaceo-albus, Fr.
Lactarius torminosus, Fr.
„ deliciosus, L.
Russula nigricans, Fr.
Cantharellus cibarius, Fr.
„ tubæformis, Fr.
Marasmius peronatus, Fr.
Panus torulosus, Fr.

These were all gathered in our immediate neighbourhood by myself or Miss Miles, and Miss Jamieson and Mr. Rodger kindly photographed them. The originals are preserved in the Museum.

XXII.—*History and Culture of the Grape Vine.*

By J. Leslie.

Part II.—Culture. (Read 13th February, 1902.)

There is no fruit-bearing plant grown under glass that gives a better and more certain return for careful cultivation than does the Grape Vine (*Vitis vinifera*). To have good grapes in this country there are at least four things needed. First, a glass house well built, with plenty of provision for putting on air; second, a well drained border of good soil; third, proper appliances for heating; and fourth, constant attention to all the vine's requirements, or, in other words, good culture.

The vine is a plant of easy propagation. It can be raised from

Plate 1—A. rubescens, Pers.—In this species the remains of the universal veil may be seen as warts on the pileus, while the partial veil forms a loose ring on the stem.

Plate 2—A. rachodes, Vitt.—The concentric scales on the pileus are formed by the breaking up of the universal veil.

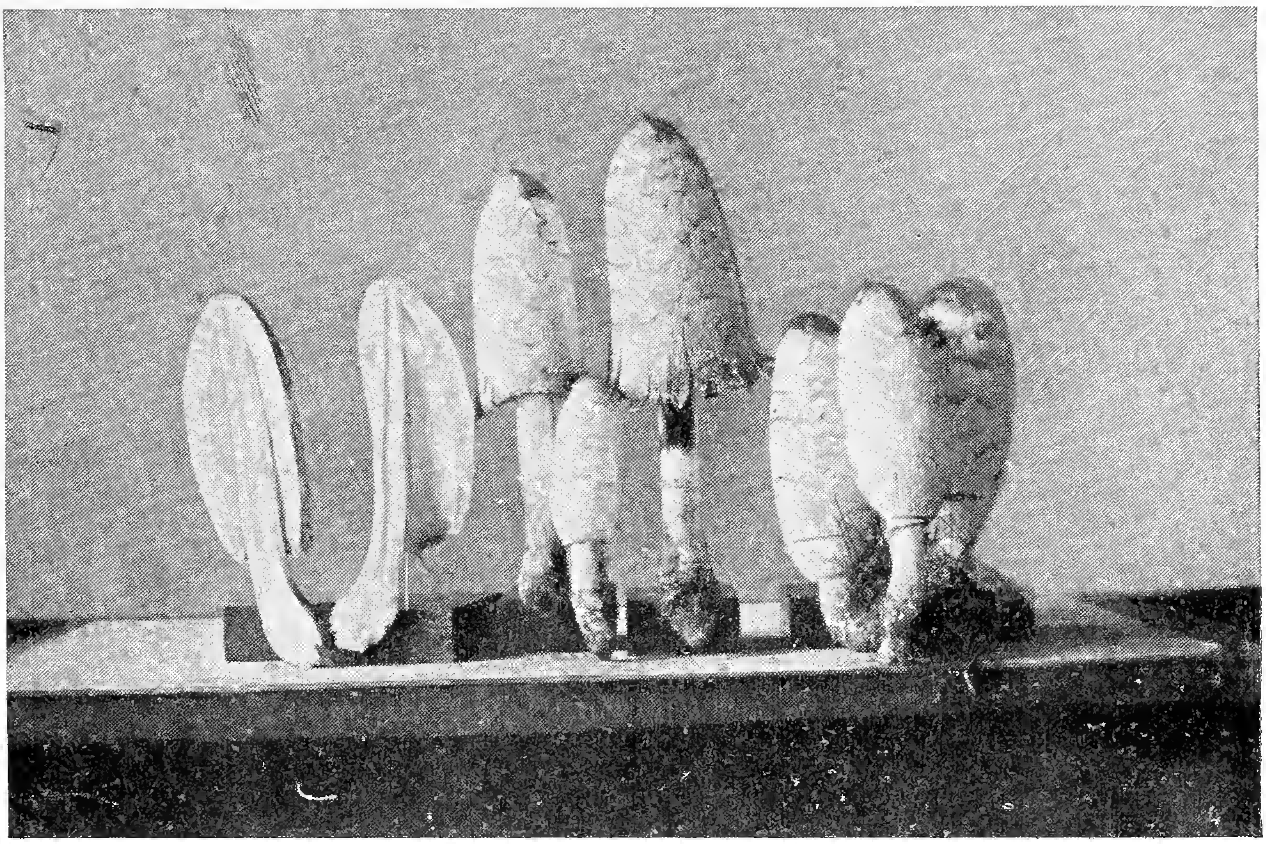


Plate 3—Coprinus comatus, Fr.—Very common on dung or rank soil, is rapid in growth and equally rapid in decay, deliquescing into a black fluid.

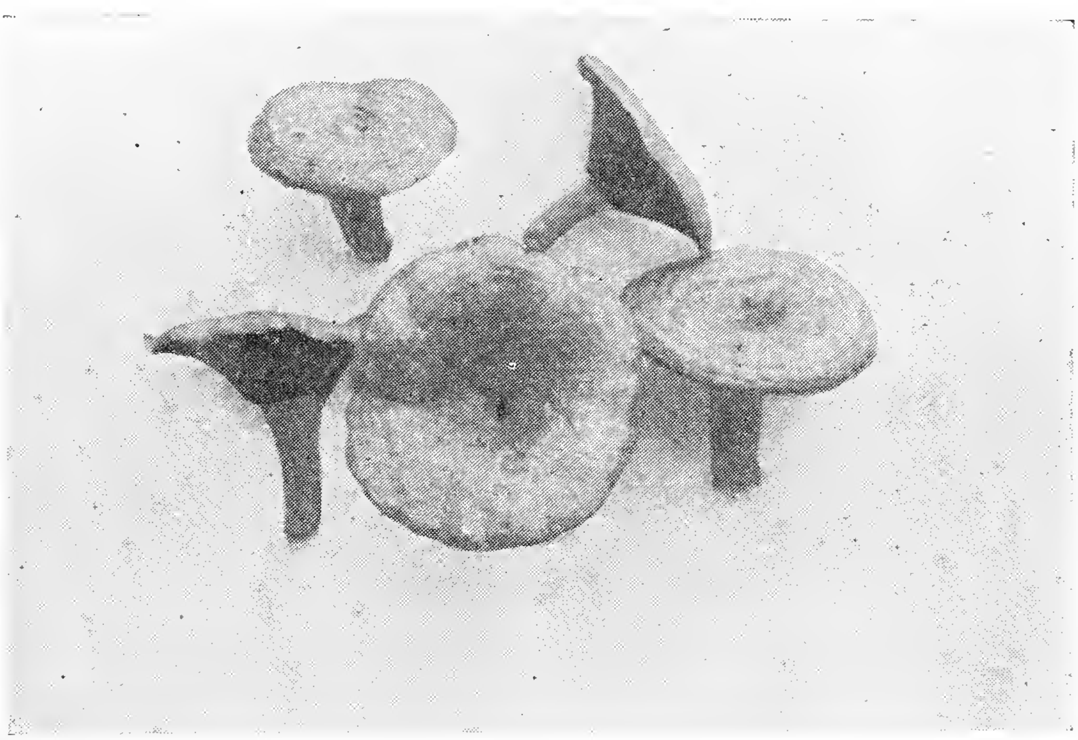


Plate 4—Lactarius deliciosus, L.—A highly esteemed edible species, common in fir woods The milk is of a bright orange colour, but on exposure becomes green.

seeds, cuttings, buds or eyes, and layers, also by grafting and inarching. Propagation from seed is seldom resorted to except by persons wishing to raise new varieties. Propagation by cuttings is the method most common in the Continental vineyards. The cuttings are prepared and planted much in the same way as we make and plant cuttings of the gooseberry bush.

Propagation by buds or eyes is the method most commonly adopted in this country by those wishing to raise young vines. The bud, or as it is mostly called the "vine eye," is cut off the young wood of last season's growth, leaving about three-quarters of an inch of wood below the bud and half an inch above it. A little of the wood on the underside of the bud is sometimes pared off, but this is not necessary. Three-inch pots, with a few pieces of broken pot in the bottom to secure drainage, are filled with soil composed of turfy loam two parts, leaf soil one part, and one part sand. Before inserting the bud a little sand is put in the centre of the pot; into this the eye is placed and the soil made fairly firm, leaving the top of the eye on a level with the surface of the soil. The buds are then placed in a propagating bed with a temperature of 75° to 80°, and watered with water about 80°. When the young vines have grown six to seven inches high they may be re-potted into flower-pots five or six inches in diameter, using soil composed of turfy loam two parts, with one quarter part sand or more if the turf is of a clayey nature, a quarter part spent mushroom bed manure and a five-inch potful of quarter-inch bones, mixing all thoroughly and potting moderately firm. In a few weeks they will be ready for moving on into eight or nine-inch pots, using soil same as last, adding a five-inch potful of some artificial manure and the same of charcoal. In these pots the vines will continue to grow rapidly, and may be trained up the trellis of the roof or to some kind of support; by the end of the season they will probably have made rods about twenty feet long.

Propagation by layering is generally practised where a branch or young rod can be easily laid down to the ground and pegged in; the stem is sometimes cut much in the same way as the stem of a carnation and layered like it. Roots are soon formed, and when the time for pruning comes round it may be severed from the parent stem.

Propagation by inarching is done by bringing two young growths of green wood together after cutting a slice out of each half way through the stem and about two and a half inches long; bring the parts together and bandage them with raffia so as to exclude air. The variety that is being put on is then allowed to grow, and the stock is stopped at the second or third leaf. This method of inarching the vine is preferred by some to that of grafting, but I consider propagation by grafting a much simpler and easier method.

Grafting like inarching is resorted to for the sake of having a weak growing kind of vine placed on to a stronger, or for the sake of having a number of varieties.

Grafting the vine can be done in three or more ways. I have practised three—whip, wedge, and bud—and must say that I prefer bud grafting to the other forms. The principal thing to be observed in grafting the vine is the proper time at which the operation should be done, and that time is after the stock to be grafted has young growths on it three or four inches long. If done before the young leaves appear the vine will bleed so profusely that no union can be formed between the stock and scion. Of course the bud to be grafted must be very little more than dormant. I generally bring the buds I intend to graft into the vinery about three days before grafting. The young wood that is pruned off the vine rod at pruning time, and is wanted for grafting, is taken and heeled into the ground outside and remains there all winter, frost not doing the buds any harm. Many gardeners consider the grafting of the vine a difficult operation, but if done at the right time there is really no difficulty about it: it is just as easy and as certain of success as the grafting of an apple tree.

There are three forms of vinery buildings which are common, and may be called the "lean-to," "half-span," and "span-roofed"; but a vinery may be of any form or shape providing it is built facing S., S.W., or S.E. I prefer the S.W. aspect as I consider we get much more benefit from the afternoon than we do from the morning sun. The trellis of wire on which the vines are trained should be fixed not less than sixteen inches from the glass.

It seldom happens that a vinery can be built where the natural soil is so good that it is capable of growing vines and sustaining them in vigour for a number of years, therefore what is termed a vine border has to be made. To do this procure good turfy loam, cut three inches thick from an old pasture. It may be stacked up for a few months, or it may be used fresh. Chop the turf well up, and add to every twelve cartloads one cartload of lime rubbish from an old building, three cwt. of half-inch bones, two cwt. of vine manure, and one cwt. of charcoal; if the turf is of a clayey nature add one load of sharp river sand. The whole should be turned over five or six times, mixing it thoroughly. Drain the border properly by laying down tiles or drain pipes six feet apart across the bottom of the border (which should not be more than three feet deep), and a row of drain pipes along the front into which each cross drain is placed. Over the bottom of the whole of the border lay a quantity of rough stones, broken bricks, or danders from the furnace, about nine inches deep, on this place the compost to the depth of two feet six inches;

this will allow the soil three inches to settle, leaving a border of soil two feet three inches deep, which is quite sufficient.

As few gardeners have proper accommodation for the rearing of young vines, they are generally bought from some nurseryman. The vines may be bought at any time from the end of December to early in March. I consider that good strong one-year-old canes are best. When they come to hand they will be from six to nine feet long. Do not prune back, but keep them in a cool house till the buds begin to show signs of growing. They should then be taken out of their pots, and the roots disentangled and spread out evenly over the soil, not deeper than six inches below the surface (less would do) leaving the neck of the plant at the surface of the border. Allow four feet between each vine. Each cane must be tied up loosely through its whole length, and care taken that no heat is allowed that would tend to force the growth. "Slow and steady" must be the motto at this stage, for, if a strong heat is put on before root action sets in, there will be a quick growth till the young buds have pushed shoots five or six inches in length, then, having used the stored up sap in the vine, the leaves will begin to flag and the whole plant show signs of distress. In some cases the vine just dwindles on all summer; in others there is after a while a response from the roots and growth starts again, but it is never robust.

When the young rod begins to grow, it must not be cut back because it would bleed, but the buds must be rubbed off just as they come into leaf, beginning with the top one and leaving off at a bud, it may be two feet from the ground or it may be six inches; if at two feet do not rub off the buds below the one that is left to form the leading shoot, but let them grow, and pinch out the growing points after they have made five or six leaves. The leading shoot must not be pinched. Care must always be taken in watering young vines never to use water under a temperature of 75°; this will help to keep the border in which the roots are working as warm as the atmosphere in which the vines are growing.

As the young vine grows, it will throw out what are termed lateral growths on each side of the leading shoot. These should be pinched at the sixth leaf, but let the leader grow till it reaches the top of the roof.

The syringe or garden engine should be used daily for the whole of the first season, for there is no better or cheaper insecticide than plenty of water.

After the leaves are fallen the vines may be pruned back to within four feet of the ground.

The border will now have a good many roots in it, and must not suffer even during winter for want of water. At the end of the second season's growth the vines should be pruned back, leaving.

according to the strength of the rod, from four to seven feet of that season's growth, thus leaving the vines from eight to eleven feet long, and each of these will be able to carry and finish well from five to six bunches the following season. The branches or side shoots should be not less than eighteen inches apart. This allows room for the leaves to develop.

As to cropping, though a shoot or branch will often show as many as three bunches, it should never be allowed to carry more than one. A vine rod, that has grown the full length of the house and is ready for cropping to that extent, will have sufficient grapes to carry, if every other shoot on both sides of the rod is cropped with one bunch of say two and a half pounds weight.

Bunches generally appear about the fourth leaf from the base of the shoot, then, if stopped two leaves beyond the bunch, that, with lateral leaves, will give twelve leaves to the fruit-bearing branch. Those branches which are not allowed to carry a bunch should grow not less than the same number of leaves.

After the shoots are pinched, growths will start at the base of each leaf. These growths are termed laterals, and may be permitted to grow one leaf and then pinched if the vine is in robust health. Another growth called a sub-lateral will start at the base of that leaf; this and all subsequent growths should be nipped off, thus leaving the side branches or shoots, with twelve or fourteen leaves, which will be sufficient to cover the roof. There should never be more foliage in a vinery than what there is ample room and light for.

Thinning the bunches is an operation which should be done as soon as the berries are set; if possible, never allow them to be larger than small peas before having the shears at them. Begin thinning at the point of the bunch, using a cleft stick like a lead pencil, with the letter V cut out of one end, with which to steady the bunch. Take care not to handle the berries, as doing so will spoil the bloom.

No definite rule can be laid down as to the number of berries that may be cut off for every one left on, as so much depends on the variety of grape which is being thinned, but we can form some idea of the space each berry that is left should occupy, when we take into consideration the diameter that we expect the berry to have when it has attained its full size. Black Hamburghs may be thinned to about three-quarters of an inch apart; the berries ought to grow more than that in diameter, but if the thinning is done early, as suggested, the berries will be a little further apart as the bunch lengthens and thus give room for each berry to develop to its full size. If the variety be Muscat or Madresfield Court, and they are properly fertilised, thin to an inch apart. Gros Colman and Gros Maroc need to be well thinned; an inch and quarter is not too much for each berry to be left apart. In thinning, all the centre berries should be well cut out, but the shoulders on the top may be left a little thicker, as this will leave the bunch, when ripe, with berries right up to the stem. The aim in thinning a bunch of grapes should be to let every berry have room for its full development, so that, when laid on the table or exhibition board, the bunch will keep its shape, with not the stalk of a single berry to be seen.

Some varieties of grapes set their berries freely and without much trouble. Of these I may mention Alicante, Appley Towers, Black Hamburghs, Foster Seedling, Gros Colman and Gros Maroc, but Alnwick Seedling, Duke of Buccleuch, Mrs. Pince and Muscats are all grapes that are the better for being artificially fertilised. The temperature for these latter varieties when in bloom should never be below 70° at night, and all the better if it can be kept to 75°, running up to 85° through the day and 90° by sun heat. I find it helps the setting of Muscats, if the hand is drawn very gently down the bunch in the forenoon about 10 o'clock, and again about 12 o'clock of each day, from the time they commence to bloom till they are set. The setting of Alnwick Seedling and Duke of Buccleuch is much helped by getting the pollen of free setting sorts; shake this off on to a sheet of paper, then hold the paper containing the pollen under the bunch you want to set and blow the pollen on to the bunch, going carefully round it.

Syringing should be done twice a day from the time of starting till the vines come into bloom. After that there should be no more syringing until the grapes are all cut.

There are three ways of pruning the vine, viz., the spur, the long spur, and the long rod. The spur, or, as it is sometimes called, the close spur, is the pruning back of the summer's growth to the bud nearest to the main stem of the vine. The long spur is the method of pruning back to the best bud that may be within an inch or two of the stem of the vine. The long rod is the system of taking up one rod of young wood to replace next year that which has been fruiting the same season.

At Pitcullen we practise the long spur mode of vine-pruning. We do so because we find by experience that we secure better bunches and larger berries than we could expect by very close pruning.

As regards airing the vinery, the ventilators should be opened to prevent the temperature from rising too quickly, and shut down to prevent it from falling too suddenly. During the whole season of the vine's growth there should always be as much air admitted as can possibly be allowed, consistent with the keeping up of the desired temperature.

At the time when it is wished to start the vine into growth, the night temperature should be 50° to 55°, and 60° to 65° through the day, till the buds begin to grow, when the heat may be 55° to 60° at night and 65° to 70° during the day, the temperature being gradually raised till the time the vines are in flower, when they may be kept at the temperature before stated.

After the grapes are set and thinned, the temperature may be lowered a little, by about 5°, both night and day, until the grapes are ripe, when the temperature may be kept somewhere about what it was at starting time. So long as the grapes hang on the vines, keep always a little heat in the pipes to prevent moisture condensing on the berries.

With regard to watering inside vine borders, my practice is to give a good watering about once a month, but, as so much depends upon the weather, no fixed rule can be laid down; but I believe in letting the inside border have as much water during the twelve months as will be equal to the average yearly rainfall, always bearing in mind to let the water be as warm as the atmosphere of the house.

The vine has many enemies in the shape of diseases and insect pests. The diseases that have come under my own observation are Mildew, Scalding, Shanking, Spot, and Rust. Of insect pests I mention a few, namely, Greenfly, Mealy Bug, Red Spider, Scale, Thrips, Vine Weevil, Wasps, Wire-Worm, or larva of the Click Beetle, and last, and most terrible and most destructive of all, *Phylloxera vastatrix*. Happily this foe does not trouble us much in this country, but it has cost the French growers many thousands of pounds.

Report of Field Lecture on Inchtuthill, given to the Members of the Perthshire Society of Natural Science, on 19th May, 1902.

By Sir ALEXANDER MUIR MACKENZIE, Bart.

MY report of the lecture delivered on the occasion of the very pleasant visit of the Society of Natural Science to Inchtuthill, or Delvine, naturally divides itself, as Gaul was divided by Cæsar, into three parts, "In tres partes divisa est."

First,—The possible occupation of the south-west promontory, or "horn," of the Island of Inchtuthill, called "Tuline," by the Picts or Caledonians.

Second.—The evidence of a possible occupation of another portion of the Inch,* by Agricola, 84 A.D.

Third,—The relation of the entrenchments thus thrown up to the battle of Mons Grampius, possibly fought in the neighbourhood.

The existence of Roman occupation north of the Tay has been

* Inch or Innsh may mean "Pasture" or "Island."

mostly denied by the antiquaries of modern times, so that the recent excavations made on Inchtuthill by the Society of Antiquaries for Scotland came as an agreeable surprise. But under the "whup" of modern criticism only what can be *seen* was allowed, and any pre-occupation or relation to the battle was dismissed with ignominy. Nevertheless, I boldly advance what evidence seems to me to throw light on the byegone history, with the object of eliciting a more careful study of the vestiges at our feet and before our eyes.

"What mean ye by these stones?"

is capable of many translations since the time of Joshua.

First—"Tuline."—The five lines of entrenchments defending the "oppidum" or "citie," described by Hector Boece, are still in full evidence, and I can see no reason for doubting that the original inhabitants had a "citie," town, or kraal—what you will—on such an undeniably favourable situation.

I further conceive that the broad dyke that ran across the "Inch," from north to south, about 500 yards from the "oppidum," was to confine their flocks and herds. In Wiltshire, Hampshire, and Somerset, notably at *Worlebery*, similar entrenchments, forming a similar encampment, are found, and surely it may be assumed that "things which are equal to the same things, are equal to one another." Accordingly, if Britons constructed encampments on lines thus indicated in the south, may not a people in the north, having already so much in common—language, dress, and religion—have built and laid out their "camps" on identical lines?

That the original inhabitants returned, after the departure of the Romans from Caledonia, and made use of the old camps is highly probable. Roy further suggests that the Danes, in their campaign up the Tay, made use of, and probably modified, the entrenchments at Tuline. The spot was known as "Tullen" to the end of the nineteenth century.

Second—The encampment of 500 yards square was shown in Roy's and Mazel's maps (1750), and was investigated by the Society of Antiquaries for Scotland in 1900. The traces of the encampment are still clearly visible on three sides, and are clearly traceable to Roman origin. The fourth side, towards the north-east, follows the line of the sloping bank, and was probably never completed. Whether this side was the "front" of the camp, or whether the Porta Pretoria faced the Grampians to the north-west, is a debatable point. The redoubt at the south-east corner may have been constructed to defend the Porta Decumana, as well as the "trajetus" or ford immediately below. The remains of the Via Principalis "were traced right through the camp and as far as the sloping bank on that side" (north-west). The most important, as well as the most interesting of the Society's explorations, was, however, at the south-west corner of the camp. Besides two large "ovens," thought by some to have been intended as "hypo-causts," the walls of a building were laid bare. These, to the height of about three feet, clearly established the fact of a villa, or a bath-house, having been erected, showing clearly the intention of the Romans to have constructed on Inchtuthill a permanent camp—a Castra Stativa.

The hypocausts with their brick pillars still *in situ*, the cold bath with its lead pipe, the tiled floors, and the cemented, coloured walls, all speak of the undoubted presence of the conquering Romans nineteen centuries ago. The recall of Agricola, about 85 A.D., probably prevented the carrying out of the intention to make Inchtuthill a permanent (Castra Stativa), and not a temporary camp (Castra Æstiva).

Third—The possible relation of these camps to the Battle of Mons Grampius. It may be recalled to the memory of students that there are in Perthshire at least *three* sites claimed by different writers as those of the great battle.

Gordon claims Dalginross, near Comrie, and "proves" it in a long dissertation.

Playfair selects Meikleour for a camp of Agricola, and finds the site of the battle on the slopes of Gormack and Ballied.

Sir James Ramsay, supported by his learned brother, Sir George Ramsay, however, offers to settle the matter by making Agricola and his legionaries to have encamped on this very ground at Delvine, while the battle, in accordance with the description of it by Tacitus, was fought around the slopes of *Redgole*, or *Gourdie.*

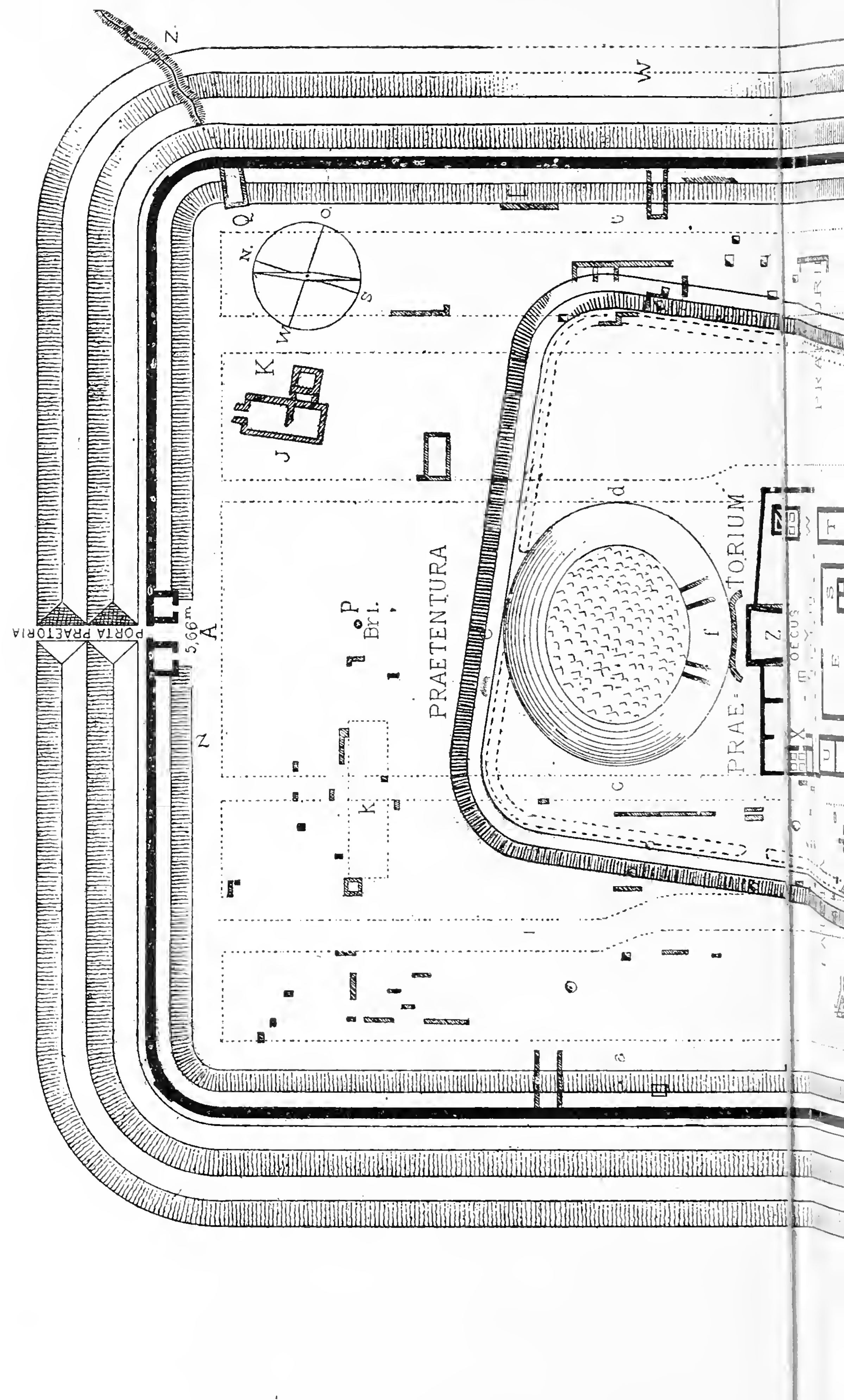
As Sir James Ramsay remarks, the battle, wherever it was fought, took place *in front* of an entrenched camp, "and this limits us to a choice of sites," among which he gives Delvine or Inchtuthill the first place. (The heights of Gormack and the line of the Cleaven Dyke at Meikleour are to be seen from the commanding position at Inchtuthill.) (See "Delvine and the Romans," 1902.)

The whole subject has been ably treated by the Hon. John Abercromby and Mr. Thomas Ross, Architect, in their exhaustive report to the Society of Antiquaries, to which the student is referred. A *resumé* of these operations is further given in a small book "Delvine and the Romans," 1902.*

A collection of various articles found at Inchtuthill is to be viewed at the museum of the Society in Queen Street, Edinburgh, and also at Ruffell House, near Spittalfield.

* By Sir Alexander Muir Mackenzie.

[This Part, pp. 155–192, published 1st November, 1902.]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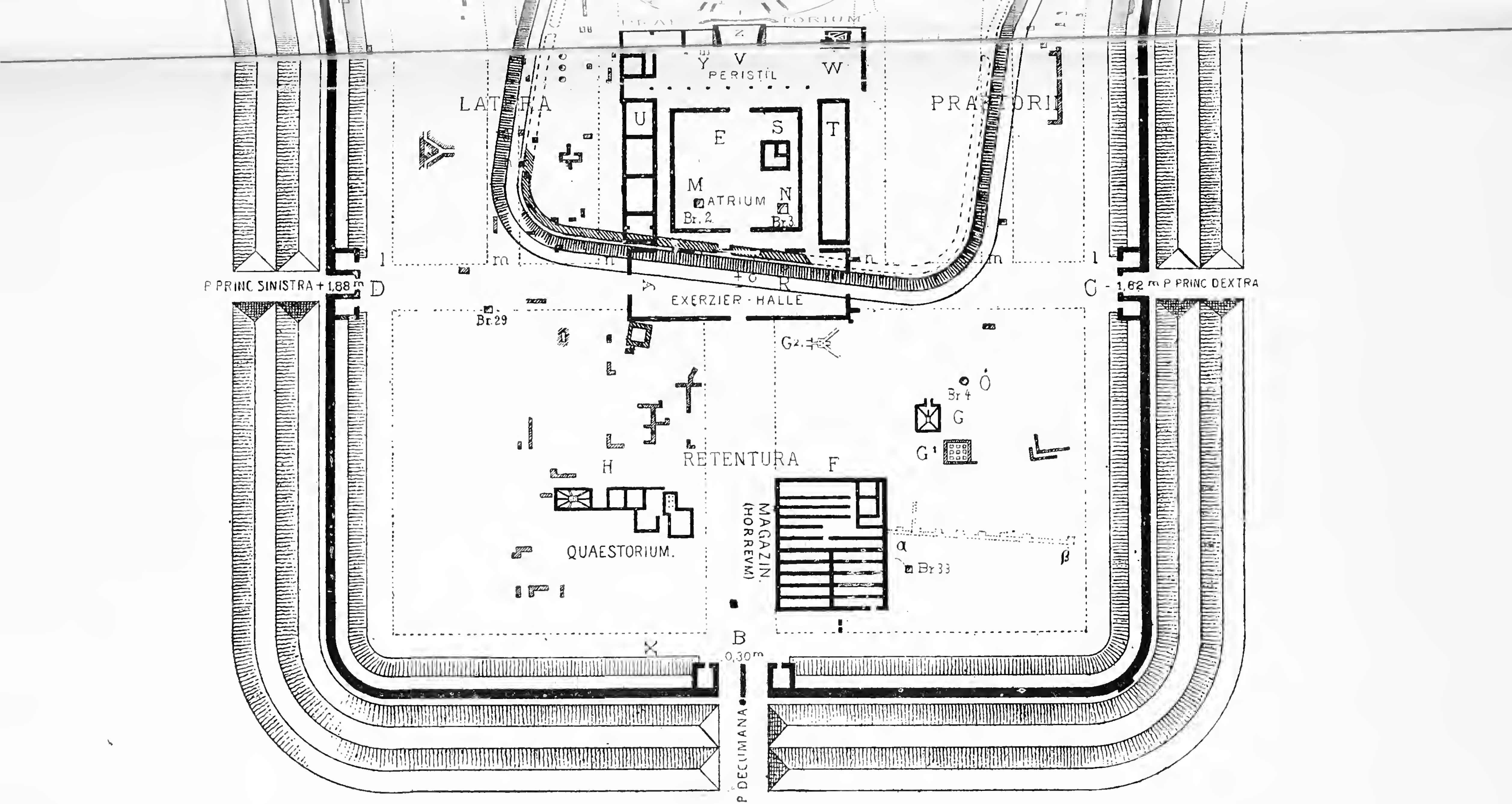
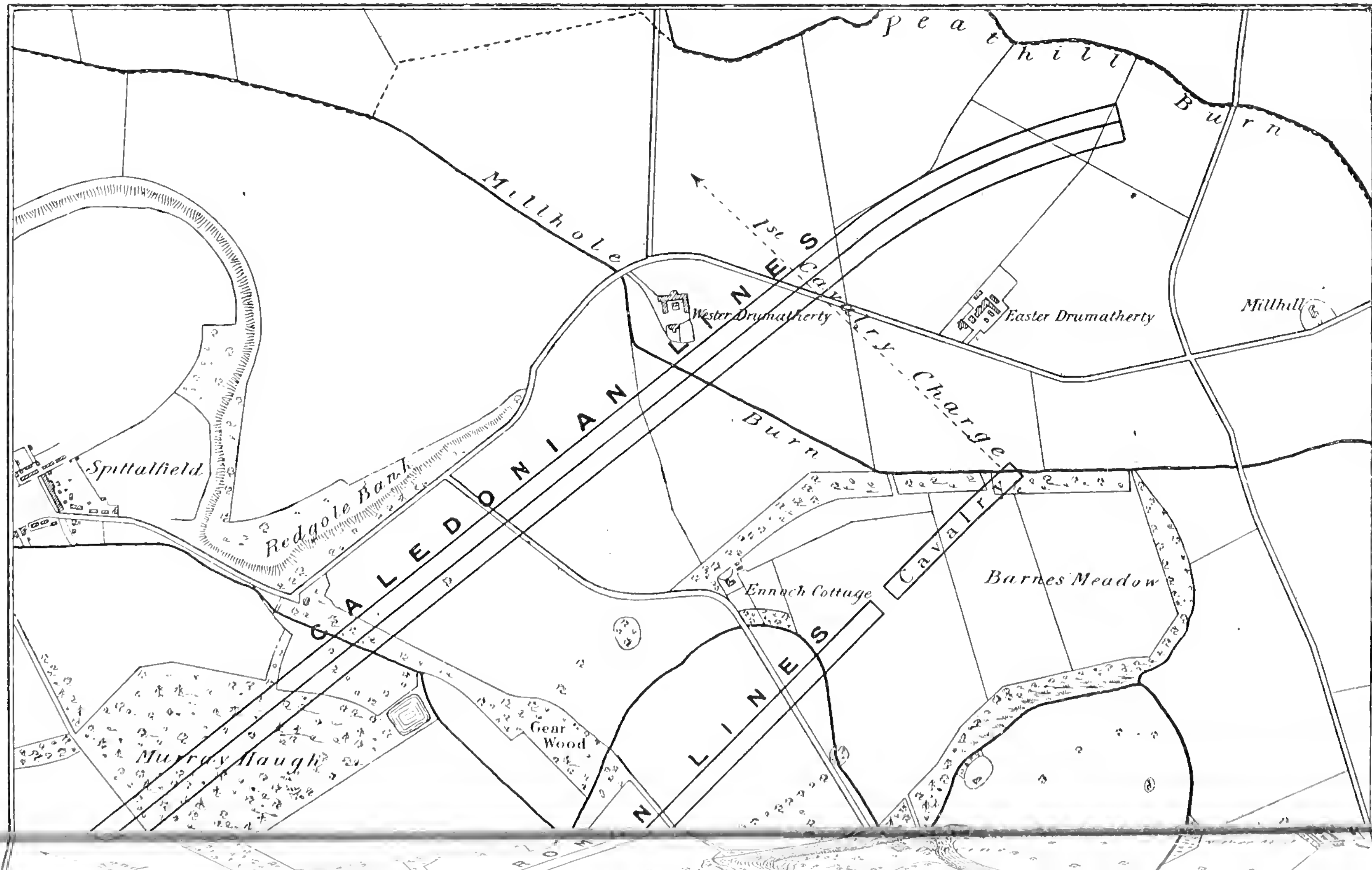


Plan of Excavations.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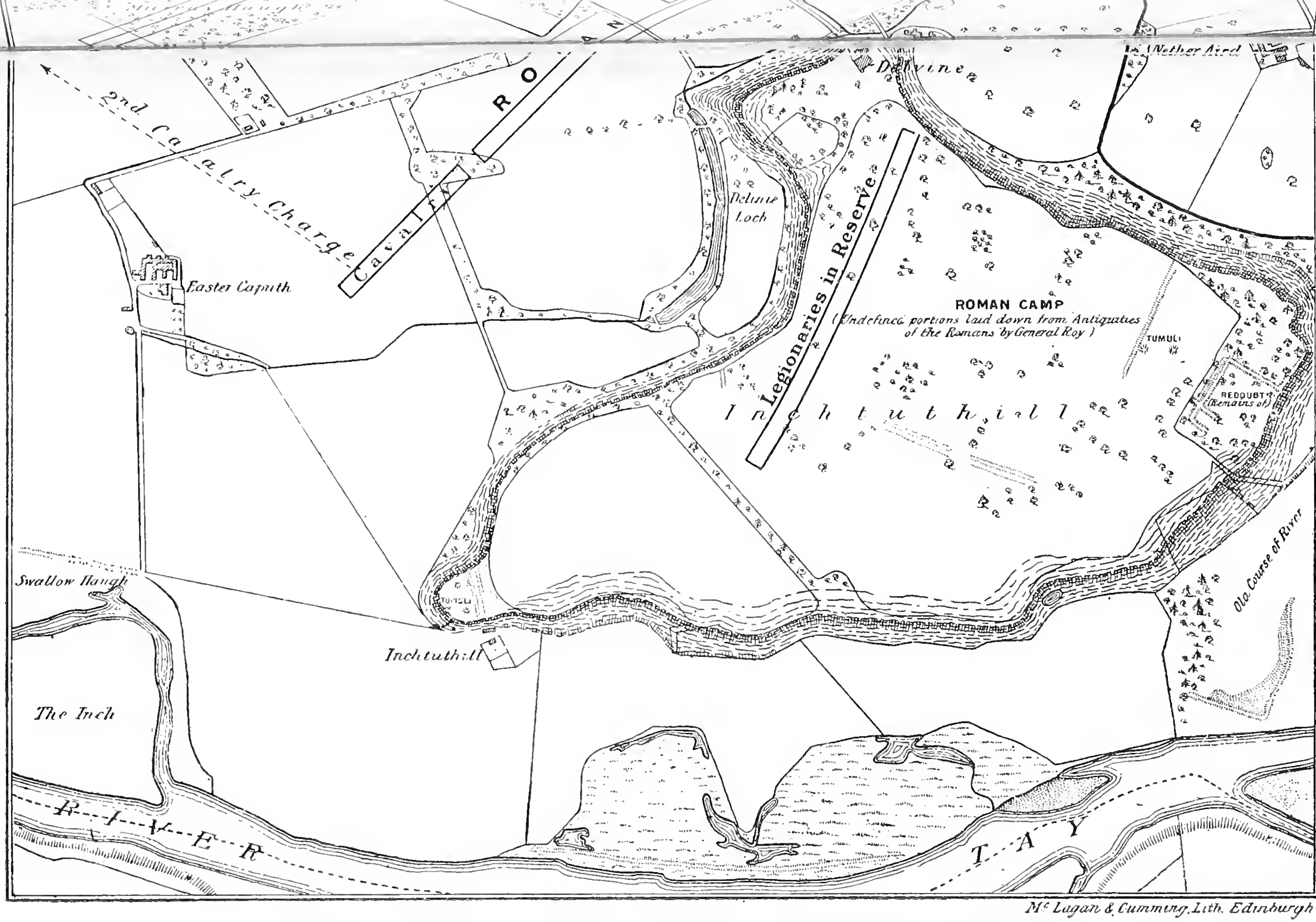
Spittalfield
Redgole Bank
Gear Wood
Murray Haugh



Map of the whole "Island," and site of the Battle of Mons Grampius.

Women's Knowe or Burial Place.

View of Pictish Excavations—Remains of House.

View of Villa or Bath House.

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1903.

XXIII.—*A Visit to the Outer Hebrides in search of Mollusca.*

By the Rev. G. A. Frank Knight, M.A., F.R.S.E., Auchterarder.

(Read November 13th, 1902).

If you take a map of Scotland, you will notice, far to the west, a long chain of islands, which seem to act as a kind of barrier reef, shutting off from the mainland the incoming billows of the Atlantic. They are known as the Outer Hebrides. They consist of Lewis and Harris to the north (together called the "Long Island"); and then towards the south, the islands of North Uist, Benbecula, South Uist, and Barra. Besides these main islands, there is an infinity of smaller islands, rocks, and skerries, some near at hand, such as the Monach Isles, Pabbay, Berneray, &c.; and some far out, exposed to the full fury of the Atlantic, such as St. Kilda, and the Flannan Isles or the Seven Hunters.

Often had I studied on maps the wonderfully indented coastline of that storm-beaten shore, and ever as I studied a deeper longing sprang up in my heart to visit these far off islands. Comparatively few naturalists have penetrated to the Outer Hebrides, and information regarding most of the islands from a zoological point of view may virtually be said to be summed up in a single volume—"Harvie-Brown and Buckley's '*Vertebrate Fauna of the Outer Hebrides.*'"

It may perhaps be going a little too far to say what I read the other day in a review of a new book on these islands by Miss Goodrich Freer, but the statement embodies a certain amount of truth—"It is no exaggeration to say that any man of average intelligence in this country will be found, as a rule, to know more about the natives of Uganda and the Soudan, or about the tribes of Bechuanaland, or the Valley of the Niger, than he does of the inhabitants of the outlying points around our own shores. And no shame to him. The average man has, as a rule, no more time to spare for a visit to Eriskay and Benbecula than he has to take a trip up the Congo, and so it comes about that the real *terra incognita* of the English-speaking race lies about a day's sail from Oban."

Accordingly when my holidays came round, I determined to go to this island, and see for myself what was to be seen. But as the journey thither from my home in Auchterarder was so interesting, and as I enjoyed *en route* the privilege of seeing so many objects of scientific importance, I feel inclined, with your permission, to take you along the whole line of travel, and point out with more or less detail the things which arrested my attention.

All the way from Auchterarder to Dunblane, across the watershed of the country at Blackford, and down Strathallan by Greenloaning and Kinbuck, you have on your left the great green slopes of the Ochils, a range composed of volcanic matter, which has burst up from the wide stretch of Lower Old Red Sandstone, of which nearly the whole of the Midland Valley of Scotland consists. The Ochil Hills, now so planed and smoothed by the overflowing ice of the Glacial Period, are standing memorials of that wonderful time in the remote past, when the Old Red Sandstone was rent asunder by the upwelling of plutonic matter, which, in a broad anticlinal fold, ultimately produced the formation which now margins the southern side of the great plateau.

Leaving Dunblane, the train proceeds westwards up the valley of the Teith to Doune and Callander. All the way, more or less, and especially on the right hand, may be observed the curious geological phenomenon known as "Kames," or "Eskers." Long rampart-like ridges of gravel and sand, the mystery of their origin has for many a day baffled the mind of man. Many have been the theories brought forward to account for their strange appearance, but of all that I have read, the most convincing seems to me to be that advocated by Dr. Wright in his work, "The Ice Age in North America." Briefly his theory is, that these ridges of gravel and stones are the remains of the *débris* dropped through crevices in the caverns of glaciers that were melting overhead. At the time when the Glacial Period was disappearing, and a more genial climate was supervening, the glaciers became worn away underneath by the rush of streams formed from the melted ice. Numerous caverns were formed by these streams, and into these caverns there fell morainic matter from crevices above, and thus long lines of rubbish were deposited, which only came to light when the superincumbent ice had finally disappeared. Kames, therefore, are to be carefully distinguished from moraines, whether terminal or lateral.

In the relative position of Callander below and Loch Lubnaig above, we have an instance of what is very frequent in Scotland. The valley at Callander is wide and fairly level, but contracts very greatly as the Pass of Leny is reached, while Ben Ledi towers on the left. But no sooner has the Pass been ascended than the valley again expands, and contains a lake basin. Many examples of this formation are to be found in Scotland—a lake basin above, a narrow neck or pass down which a river runs as the outfall from the lake, and a broad flat valley beneath. Loch Lubnaig is remarkable in this respect, that it lies in the bed of a transverse valley. As it stretches across the strike of the rocks, the truncated ends of the strata which it traverses are seen in rugged massive grandeur, and add greatly to its beauty and romantic appearance. The difference between a loch of this kind, lying transversely to the strata, and a loch which lies in a basin, which is in the line of geological structure, is very marked. Loch Earn, on the other hand, which is the next loch encountered, is a lake which, strictly speaking, is neither longitudinal nor transverse. It lies in a valley which has been hollowed out by drainage, independent of the geological formation of the land.

The savage Glen Ogle, which the line now ascends, is thickly strewn with boulders which have fallen from the overhanging crags. And all through this Glen, and along Glen Dochart and Strathfillan, for mile after mile, the railway line cuts through an interminable succession of morainic mounds and scattered heaps of boulders. The Ice Age has emphatically left its traces upon this wild region. The great glen which stretches across Scotland from Loch Tay to Loch Awe is flanked by numerous side glens, which must each have contributed their share of ice and glacial *débris*. No wonder, then, that the main glen is marked by countless mounds of gravel and sand, and strewn with boulders and stones. Whenever one passes the mouth of one of these collateral valleys, the piles of rubbish are seen in bewildering confusion. Between Crianlarich and Tyndrum the stream sometimes seems to be choked up, and at Tyndrum itself there is a vast congeries of moraine heaps, which came originally from the distant slopes of Ben Laoigh.

After traversing the weird pass, with its solitary dark tarn Lochan Bé, the line descends the valley of the Lochy amid a succession of morainic mounds and alluvial terraces. Beyond Dalmally it crosses the wide delta of the Orchy, which in winter time is often entirely under water, while Kilchurn Castle stands far out in the lake, surrounded with dashing waves. Now the train is sweeping along the shores of Loch Awe, with Ben Cruachan towering overhead. And as you descend the dark Pass of Brander, with its tremendous crags and awe-inspiring black depths of water, your sense of the majesty of the scene is not diminished, but rather increased, if you remember the extraordinary geological history of the gorge. That dark outlet for the waters of the lake, by the sombre Pass of Brander, is not the ancient channel. The giant cleft between Ben Cruachan, on the one hand, and Craig-an-Uni, on the other, is a fissure of comparatively recent formation. Far back in the history of Loch Awe the outflow of its abundant waters was at the extreme south end—by Ford and Kilmartin, on to the Sound of Jura. But while the loch, swelled by a thousand burns, found an outlet thus far in the south, two little streams were doing their unerring work at the spot now marked by the Pass of Brander. There was in old time a neck of land joining Ben Cruachan to Craig-an-Uni, and across this neck two burns sawed their way in opposite directions. Lower and lower fell the watershed, and the summit of the neck of land steadily approached the level of the loch. Then came the Glacial Period, with its mighty rivers of ice. The neck of land was finally sawn through, and henceforth the lake forced its waters down this western channel, and deserted the ancient passage to the sea *via* the southern end. One's awe is, therefore, greatly deepened as one goes down this mighty cañon, when one reflects that the great chasm is not an ancient piece of of earth sculpture, but one that has been effected since the close of the Glacial Period in Scotland.[1]

Emerging from the Pass, and descending to Taynuilt and the shores of the sea at Loch Etive, there is now a marked change in the character of the rocks. The schists and granites are left behind, and the volcanic deposits of the Old Red Sandstone Period are entered upon. Terraced rocks, the result of successive eruptions of plutonic matter, take the place of

> "Crags, knolls, and mounds, confusedly hurled,
> The fragments of an earlier world"

in the geological history of the land.

All along the shores of Loch Etive excellent examples of raised beaches are to be seen. It is not the common 25 feet raised beach which is so frequently met with in other parts of Scotland, but the 50 feet beach. It skirts the shore in many places on both sides of the loch, and is very conspicuous at Achnacloich, on the southern side, and Ardchattan, on the northern side. Remains of ancient canoes have been found embedded in the peats of these now elevated shore margins, suggesting by the positions in which they were discovered the enormous changes that have taken place in the configuration of Scotland since our rude forefathers disturbed the calm waters of the loch with their primitive paddles. The sea at that time must have been at least 50 feet higher than it is to-day.

At Connel Ferry there are the famous Falls of Lora. The reason for their existence is most interesting. Let us remember that the majority of our western sea lochs were formed by the submergence beneath the waters of the sea of what were formerly glens clothed with heather and carpeted with turf and bracken. These glens have suffered submergence in different degrees. Some have gone down very far indeed, and the waters of the ocean have penetrated far up the ancient glen, *e.g.*, Loch Fyne, which at its mouth has the tremendous depth of 624 feet. On the other hand, in the case of other glens, the downward movement has been arrested in the very nick of time to obviate this total submergence. Such are the glens wherein now lie the fresh-water lochs—Loch Maree and Loch Morar.

[1] See Sir Archibald Geikie, "The Scenery of Scotland viewed in connection with its Physical Geology," p. 238.

But a third set of glens have gone so little under the sea that the water at their outer end is very shallow indeed. Of this class Loch Etive is the best example we have. Standing on the shore at low tide you see the mass of water which forms the great loch in its upper reaches striving here to force itself out to sea by a narrow channel. There is a reef of rocks from side to side, only about six feet below the surface, and over these rocks the volume of ebbing water rushes with a fury and turmoil which sounds like an angry roar. For a brief period twice a day there is "a veritable cataract of sea-water," which has earned the name of the "Falls of Lora." If Loch Etive were to be raised even a few feet at the mouth it would cease to be a sea loch, and would be converted into a long, winding, fresh-water lake.[1]

Into the vexed question of the geology of Oban I will not be tempted to plunge, even for a single moment. Macculloch, Hugh Miller, Prof. Nicol, Sir Archibald Geikie, and Prof. Judd have all tried their best,[2] and, where these giants have failed to reach any settled conclusion, ordinary mortals may be forgiven for declining to express an opinion! But everyone can admire the wondrous beauty of Oban, and enjoy the famous view of the town, and bay, and surrounding landscape from the Pulpit Hill.

The steamer "Flowerdale" leaves Oban at 6 a.m., and a splendid fresh morning I had for the start. Passing under Dunolly Castle, seated on its grand crag of what the majority of geologists call the Old Red Conglomerate, the vessel rounds the northern end of the island of Kerrera with its singularly formed terraces of volcanic rocks resting on slates, and steers for the Sound of Mull. On the first bold promontory of Mull stands Castle Duart, famed in Scott's "Lord of the Isles," and right up the Sound are numerous other castles which make the locality one of the most romantic in Scotland. Ardtornish Castle lies beautifully guarding the entrance to Loch Aline. The Sound of Mull on a fine day is one of the loveliest stretches of water that could be conceived, with the wooded shores and the gently sloping mountains on either hand. Approaching Salen there is a striking instance of how scenery is affected by geological structure. Mull is seen here under two aspects. The northern half of the island is made up of plateaux basalts, lying more or less flat; the centre and southern half is composed chiefly of granites, and the mountains assume a conical appearance. Tobermory is touched at, and now the steamer rounds the great headland of Ardnamurchan,

[1] See Geikie, "Scenery of Scotland," p. 184; Sir A. C. Ramsay, "The Physical Geology and Geography of Great Britain," 6th edit., p. 273.

[2] See "Notes on the Geology of Oban," by Dugald Bell, Geol. Soc., Glasgow Trans., p. 116.

with its giant trap dykes and "remarkable veins of dark basalt and gabbro which have been injected into the light-coloured Secondary sandstones and limestones."[1] Even the most unscientific observer is struck with the singular aspect of this great promontory, the most westerly point in Scotland, against which even on the calmest days the surge of the Atlantic beats with a sullen roar. "In olden times an imaginary line from this point divided the Hebrides into two sovereignties, those to the north being Nordereys, the others Sudereys. When the land was divided into episcopates the latter were assigned to the Bishop of Man; hence the well-known title of 'Sodor and Man.'"[2] The "Flowerdale" steamed past the lonely island of Muck—"the isle of the wild sow," whose name frequently appears in Scotland in such connections as Ben-Muick-Dhui, Glen Muick, Muckairn. It is an island which owes its origin to eruptive forces. The lava has been belched forth from the interior of the earth, and has cooled down in the form of successive sheets, which to-day appear as terraced plateaux. In 1773 the inhabitants of Muck numbered 140, but in 1828 they all emigrated to America. To-day, but for a couple of herdsmen, the island is unoccupied by a single human being.

I was singularly fortunate in finding on board the steamer a scientist, whose recent untimely death has cast a gloom over many a friend, and has been a great loss to this Perthshire Society. The Rev. H. A. Macpherson of Pitlochry, the renowned ornithologist, whose father had owned the Island of Eigg, was on his way to Glendale, his estate in Skye. A more delightful companion I could not have had. Not a bird skimming the calm blue waters escaped his observation, not an object of natural interest but he had something of importance to say about it. We passed a most delightful day together, and parted with regret at Loch Pooltiel.

Eigg is one of the most extraordinary islands in the world. It is a demonstration of the colossal denudation which has taken place in the Inner Hebrides since the close of the volcanic eruptive period. The Scuir of Eigg rises abruptly for 400 ft. above the hill on which it stands, and its total height is 1289 ft. above the sea. Its sides are so vertical, that, looking over the edge one has a clean drop of 400 ft. But at the back the Scuir is seen to be only the end of a long narrow ridge. The Scuir consists of that curious glassy rock known as pitchstone, which is generally in a columnar form. But the pitchstone rests upon a hollow, eroded out of the underlying sheets of basalt and filled with compacted shingle. Search amongst this shingle on which the great mountain rests, and you will find

[1] Geikie, *Ibid.*, p. 465.

[2] Miss C. F. Gordon Cumming, "In the Hebrides," p. 113.

coniferous wood, branches, and charred chips! Mr. Macpherson informed me that often when a boy he had gone to the Scuir and pulled out the charred wood which underlies the mass of rock overhead. The story which the mountain tells is almost incredible. That hollow where are the shingle stones and the branches is the channel of an ancient river which had cut its way through the plateau basalts. At the time when this stream was flowing, the island of Eigg must have been joined to some higher land, probably to the west or north-west. Where now is the shingle at the base of the Scuir there was then a river strong enough to carry with it great blocks of stone, which can only have come from the opposite island of Rum. Subsequently there occurred this great explosion of volcanic matter. A stream of molten rock in the form of pitchstone rolled down that river channel and covered it more than 400 ft. deep. Since that time enormous denudation has taken place. The land that united Eigg to other islands has been washed away. Eigg has become an island. The island itself has been worn down to a shadow of its former size. The valley with shingle and wood chips has been protected from weathering by the hardness of the pitchstone above it, and the result to-day is that the ancient pitchstone, which once flowed down the river valley, now rears itself aloft like a pillar which has withstood the disintegration of the elements; and the ancient water-course which once was the lowest level is now seen at a height of 800 ft. up the basaltic slope! Well may Sir Archibald Geikie, who describes the scene so vividly ("Scenery of Scotland," p. 150), remark, "The Scuir of Eigg stands out as one of the most striking monuments of denudation in the British Isles."

The Island of Rum, with its three great peaks—Haskeval, Haleval, and Scuir-na-Gillean—is of singular beauty: and then comes Canna, with that strange elevation—Compass Hill—on the north-east end, containing so much magnetic iron ore as to affect the compasses of passing vessels. Between Canna and Loch Bracadale, in Skye, the wind rose and we had for an hour a wild sea, but were recompensed by a splendid view of the Coolin Hills of Skye. The Coolins afford fine examples of the striking outline which gabbro assumes under weathering, its dark, hard masses rising into black crests and serrated ridges and towering peaks.

From Loch Bracadale along the coast to the north, the traveller will see some of the grandest cliff scenery to be met with in the world. The dominant hills at this place are Macleod's Tables, rising to a height of 1600 feet, "built up of horizontal lava beds, which once spread away out into the Atlantic on one side, and over the hills of Skye and Rum and Eigg on the other." Fragments of these lava beds, piled up in masses one above another, are to be seen in the so-called "Macleod's Maidens." But between Loch Pooltiel and Dunvegan Bay the steamer hugs the cliffs at the base of the great wall. High overhead tower the stupendous crags, tier upon tier of many-coloured basalt, until the eye is wearied with looking up the face of the rock, which rises sheer 1025 feet. This is the characteristic of the coastline, right on past Dunvegan, with its inlet marked by its picturesque castle, to the northernmost point of the island, near Duntulm Castle. I have sailed under the giant crags of St. Helena, but I felt my Scottish pride rising when I found that cliff scenery so magnificent could be seen much nearer home, in our own beloved land.

As the steamer approaches Lochmaddy, in North Uist, two great rocks are observed at the mouth, as if guarding the entrance. They are called "Maddies," or watch-dogs, and give the name to the loch and township. Standing out of the sea to the height of 100 to 150 feet, they at once attract attention, and when it is noticed that the rock of which they are composed is black basalt, quite different from that of the main island, interest is still further excited. Prof. Heddle maintains that these "Maddies" are the vents up which the basaltic matter poured, which led to the formation of the great dykes which intersect the long island from end to end. After a night spent at the Lochmaddy Hotel, I proceeded next day to cross by boat to the other side of the loch, to get a view of the island.

In North Uist, there are only two hills of any magnitude, the North Lee and the South Lee, 824 and 920 feet respectively, forming one range; and Eaval, 1138 feet high. I climbed the North Lee, and the island lay at my feet. A more extraordinary view I never got. It was formerly the custom to say that the Outer Hebrides were of the same geological age as the Laurentian, in Canada, the oldest rocks known to exist on the face of the earth. But this has now been departed from. The evidence goes to show that the Outer Hebrides are vastly older than the Laurentian, in fact that they are actually the most ancient rocks to be found throughout the world. The rock is known as "Hebridean gneiss." To the western horizon stretched the level country, dotted with innumerable lochs. Indeed, such was the maze and network of lochs and lochans as far as the eye could reach that it was impossible to trace their outline, or count the innumerable islands which studded their surface. There is no other district in Scotland to be compared with it, except a few portions of Sutherlandshire. Arms of the sea, such as Loch Eport, stretch from the east coast right across the island, and only a few yards of land separate them from the Atlantic on the western side. Lochmaddy itself is really a vast number of lochs and harbours combined; for, though it covers only about 10 square miles, were one to follow closely its numerous windings, its countless fiords, its deep channels, which run inland sometimes for 9 miles, one would have to traverse a distance of over 300 miles ! Seen from the hill-top, North Uist appears to be made up more of lochs and sheets of water than of solid land, and the view is unlike anything else to be seen in Scotland.

Away to the north, the sands of Harris, and Berneray, and Pabbay were gleaming, but Lochmaddy itself was destitute of sand, the shores being entirely rocky, stony, and thickly covered with weed. Further to the east were the Shiant Islands, looking like a giant indented wall, islands very rarely visited and difficult of access. Across the Little Minch—15 miles—were the splendid peaks of Skye; further to the south the grand masses of Rum and Canna and South Uist. Sitting on the lonely crest of the North Lee, overlooking the wide plain, it was strange at that height, in the stillness of the air, to hear the tide roaring and chafing along the margin of the loch at my feet. Sometimes the sound reached me like the roar of a cannon, or the crash of blasting, and then it would die away again as it was carried seawards on the gentle zephyr. The sense of utter loneliness was increased by a weird song which suddenly was wafted to me. For a time I could not divine whence the notes came, but at last a boat made its appearance round a far-off promontory of one of the windings of Lochmaddy, and I saw that the song came from a solitary fisherman in it, who was crooning to himself a strange wild lament. The utter silence of the neighbourhood was only enhanced by the mysterious refrain which reached me on the mountain top.

With Lochmaddy itself I was in no way impressed. I diligently counted every house in the township, and I could not get the total to exceed 27. Yet Lochmaddy is the principal town of interest on the eastern side, and is the residence of a Sheriff-Substitute.

Recrossing the loch in the boat, I was followed by quite a number of seals, which are very common in the quiet waters here. The silent reaches and deserted channels which thread the land in every direction are the home of every kind of man-fearing creatures. The rocks are dotted with seals at low tide, and the sea-birds build their nests here in incredible abundance.

The drive across North Uist was under the worst auspices. The gloomiest skies overhead, the wettest of Scotch mists, the dreariest of landscapes ever crossed by man. The road wound its way round innumerable lochs, and occasionally crossed them on rough embankments to save detours. The largest of the fresh-water lochs is Loch Scadavay, which has 365 islands; but the scenery is so featureless that a feeling of melancholy and intolerable loneliness oppresses one. Not a human being was to be seen, not even a thatched cabin, only utter solitude, and mile after mile of gloomy lochs and dark heather and peat bog. At last I reached Clachan, a township on the western sea coast, and for a week made this my headquarters, in the hospitable manse of my old college friend, the Rev. Ewen Gillies. The scenery here is extremely uninteresting—not a tree in sight: nothing but loch and island. One of the industries of the township is kelp-making, and in all directions, along the rough paths, rude carts, drawn by diminutive horses or oxen, could be seen conveying the precious seaweed to the factory. The kelp industry has fallen on evil days, but is not altogether dead yet. I visited the kelp factory on Loch Eport, and was very much interested in what I saw. Only the stems of the tangle now are burned; the fronds are discarded as not being worth the trouble. The decay of this industry is perhaps not altogether to be regretted. In former times thousands of pounds were obtained, and the natives, finding that this was much more remunerative than working on the land, sadly neglected their crofts. Since the kelp industry has so far declined, there has been an immense increase in careful attention to the land, and there is now fully five times as much grazing and arable country as was to be found in the old days. A family formerly made £15 to £20 in three months, and then idled the rest of the year away; now constant work all the year round on their crofts is the rule. Some of the kelp gatherers inhabit the most wretched of cabins.

Across from Clachan stretches a long island called Baleshare, which is well worthy of a visit. The tide recedes altogether at low water, and it is possible to cross to the island dry-shod. I walked along the Atlantic shore of Baleshare for some miles, but was disappointed in the nature of the coast so far as mollusca were concerned. The breakers were coming in with unrestricted force from America, and thundering with majesty on the beach. But the shore was of shingle mostly—the very worst for my purpose. Still I succeeded in securing specimens of the following:—

Mytilus edulis, Linné.
Volsella modiolus (Linné).
Cyprina islandica, Lamarck.
Tellina crassa (Gmelin).
Macoma balthica (Linné).
Donax vittatus (da Costa).
Spisula subtruncata v. striata, Brown.
Lutraria elliptica, Lamarck.
Dosinia exoleta (Linné).
Tapes virgineus (Linné).
Tapes pullastra (Montagu).
Cardium edule, Linné.
Solecurtus antiquatus (Pulteney).
Ensis siliqua (Linné).
Thracia fragilis, Pennant.
Thracia pubescens (Pulteney).
Patella vulgata, Linné.
Helcion pellucidum v. lævis, Pennant.
Gibbula magus (Linné).
Gibbula cineraria (Linné).

Calliostoma zizyphinus (Linné).
" " var. lyonsi, Leach.
Littorina obtusata (Linné).
" rudis (Maton).
Buccinum undatum, Linné.
Neptunea antiqua, Linné.
Purpura lapillus, Linné.
Nassa reticulata (Linné).

There were evidences of recent land elevation along the shore of the island, for I discovered a raised beach from 10 to 15 feet above high-water mark, in the strata of which were imbedded large numbers of

Cardium edule, Linné.
Littorina obtusata (Linné).
Littorina littorea (Linné).
Purpura lapillus, Linné.

Near the centre of Baleshare Island are the remains of an ancient temple, which is called Teampul Chriosd, or the Temple of Christ. Very little of it now exists, and I was able to glean almost nothing as to its history in the days long gone. But it was a place where one could easily fall into a reverie. Far on every hand stretched the flat green island, with hardly a human being in sight, with no fence to break the level of the plain; and in the heart of this wide expanse were a dozen mouldering stones, held together by the hardest lime, and with many shells embedded—stones which no doubt could have revealed many a tale, had speech been theirs. Far out on the Atlantic the sun was setting, and where I sat at the ruined temple the sullen roar of the ceaseless surf reached me in fitful risings and fallings.

The islands along the west coast of North Uist support a large population, or rather the islands form splendid grazing ground for their cattle, while the natives have their crofts and huts on the mainland. The islands are growing in fertility every year through the spreading of "a kind of wiry bent grass, which extends its long clinging roots and makes such a mat as binds the sand and keeps it in its place. After a while a thin crust of soil forms over these roots, and eventually finer grasses find a livelihood on these *machars*, as this sandy soil is called." The machar land forms the sweetest grass for cattle, and the crofters are finding it to be for their highest interest to extend the area on which this grass grows.

On the way back I called at the house of a crofter, and was interested in observing how much the good man was indebted to the sea and to Nature for the supply of his wants. The walls were of great stones of granite piled one on another; the crevices were filled up with lime. A barrel of lime obtained from the shells on the shore can be had for sixpence; the sand is to be had free for the carting. The floor was of earth, and at the side was a great ingleneuk. There was no chimney, the smoke escaped by the low door; hens and calves shared the single apartment with the rest of the family. The roof was of heather, free for the gathering, held down by ropes and great stones, for the wind from the Atlantic sweeps over these level islands with the fury sometimes of a hurricane. And yet inside were many beautiful ornaments and foreign curiosities, rare woods carved into elegant shapes, and other things, all washed ashore by the warm waters of the Gulf Stream. To-day those islands are indebted to the ocean for every scrap of wood they possess. Every crofter has a long iron rod with his initials at the end. When he finds any drift-wood on the shore he stamps the log, and marks it with his initials as discoverer; then he writes to the Receiver of Wrecks, tells him where the wood is, gives the dimensions, and he is thereafter legally entitled to one-half of what is found.

On another day I went northwards to the extreme west point of North Uist, a distance of about 10 miles from Clachan. The district was densely populated, and since the passing of the Crofters Act the people seem prosperous and contented to a degree they never were before. Their crofts were certainly small enough, and the method of agriculture primitive. The inside of these crofters' houses was very snug, and in quite a number was the spinning wheel, with which the natives spun the wool to be made into tweed.

All the way the views out to sea were most interesting. Ten or twelve miles away were the low and grassy Monach Isles—the isles of the monks—consisting of two fair-sized islands and a multitude of smaller rocks and skerries. They are all very flat, and on their sandy soil quite a number of families reside. The lighthouse, which is very conspicuous from the mainland, is 165 ft. in height; but, notwithstanding its help, wrecks on the islands are by no means infrequent.

Further to the north was the extraordinary group of islands known as the Haskeir Rocks. A full description of them will be found in Mr. Harvie-Brown's "*Vertebrate Fauna of the Outer Hebrides*," p. lxiv. But what was remarkable was the way in which they seemed to alter their shape and size and number under the influence of a slight sea fog which drifted past them. In reality there are just two main islands. The one is large, one mile in circumference, and rising into two hills each about 120 feet high. "The other, called Haskeir Aag, is composed of five bare rocks, with deep water channels between, without a blade of grass or fresh water, and capable of being approached only in fine weather." The highest pinnacle is 83 ft. above the sea. More lonely storm-beaten stacks o rocks it would be impossible to imagine, standing out into the Atlantic, and meeting the full brunt of the waves which roll in from

2000 miles of ocean. These waves have already hollowed out of the rock two fine natural arches through which the seas hurl themselves. And away beyond the Haskeirs was the towering mass of Liassic volcanic rocks known as St. Kilda—that Ultima Thule of western Scotland. The peaks of the island were lifted up against the westering sun, and I longed that my time would permit of a visit to their shores. The west side facing the Atlantic is shattered with awful chasms, and no wonder, considering the stupendous force of the billows. The bird life on St. Kilda has long been famous, and the gannets make their home here in incredible numbers.

At Tighary, the extreme west point of North Uist, there is a remarkable cave, which is thus described in the "*New Statistical Account of Scotland*," vol. xiv., p. 161. "It is hollowed, a considerable space in the rock, by the action of the waves, which beat with violence against the point where it is formed. The outer or external side of the cave is naturally, yet regularly, arched through the solid rock. Within this arch, from the superincumbent surface, is an opening 12 ft. in diameter. The immense volume of flood poured into the cave, too copious at once to recede, rises during and after a storm, as if from the bowels of the earth, in splendid magnificence to the height of upwards of 200 ft. It is called Sloch-a-chorry, or cave of the kettle."

Descending to the shore here, I wandered over the strange promontory and peninsula known as Cloughcohen. It is a great piece of rough heathery ground jutting out into the sea, and surrounded by the ocean, except for a narrow neck of land. At the highest point there is an enormous block of granite, which is said to mark the burial-place of Macalpine, the great bard of North Uist. The entire peninsula was accordingly thereafter given over to the purposes of sepulture, and lonely in the extreme are the graves. Cloughcohen is called after the same saint whose name appears in Kilchoan in Ardnamurchan and elsewhere. Round this central stone monument the graves are arranged in innumerable circles; no headstones, no lettering, no inscriptions, but little heaps of stones marking each the resting-place of some ancient clansman. It was a place of weird fascination, as I gazed on the hundreds and hundreds of little heaps of stones surrounding the great central boulder on which I sat. All around was the moorland of heather, at my feet thundered the Atlantic against the cliffs, and far out to sea were the sandy Monach Isles, the serrated peaks of St. Kilda, and the desolate stacks of the Haskeirs.

There were evidences near Tighary that the shore had been elevated even higher than at Baleshare Island. I found a raised beach fully 30 feet above high-water mark, and in the closely-packed sand were multitudes of *Gibbula cineraria* (L.) and *Littorina obtusata* (L.).

I then walked nine miles along the shore, following the indentations of the coast-line, and carefully scrutinizing all that met my eye. The following shells were observed from Tighary to Paible :—

Mytilus edulis, Linné.
Macoma balthica (Linné).
Spisula solida (Linné).
Venus fasciata (da Costa).
Tapes virgineus (Linné).
,, pullastra (Montagu).
Cardium edule, Linné.
Ensis siliqua (Linné).
,, ,, var. arcuata, Jeffreys.
Patella vulgata, Linné.
Helcion pellucidum (Linné).
,, ,, var. lævis, Pennant.
Gibbula cineraria (Linné).
Calliostoma zizyphinus (Linné).
,, ,, var. lyonsi, Leach.
Littorina obtusata (Linné).
,, rudis (Maton).
,, littorea (Linné).
Trivia europæa (Montagu).
Buccinum undatum, Linné.
Neptunea antiqua (Linné).
Purpura lapillus (Linné).
Nassa incrassata (Ström).

During my long walk I was noticed by many of the crofters at work on their fields. Next day I heard that my movements had given rise to endless controversy. Who was this stranger who thus in solitude walked along their sands, turned over stones, searched seaweeds, and visited all the wreckage? At first they maintained I was an Excise officer; then next, opinion veered round that I was an inspector of wrecks; and lastly, one old woman gave it as her decided conviction that I was a Boer spy searching the shore with a view to discover the best landing-places for a Boer naval invasion!

Of the other islands I visited I have not time to say much. Grimsay is a large island lying between North Uist and Benbecula, and Stromay is a small island between the latter and Baleshare. On Stromay there were simply myriads of the shells of *Buccinum undatum* lying on the upper portion of the islet, which was evidently a raised beach. The eastern side of the island was gravel, the western side big stones. To my list of the mollusca of North Uist the island added *Lucina borealis*, Linné, and *Cardium fasciatum*, Montagu.

There are some archaeological remains in North Uist which I visited, and which I found of the highest interest. Near Clachan there are "two immense heaps of stones, some of them of large size. They are called *barps*, a word evidently not of Celtic origin." They are huge piles, surmounting the tops of two hills, but whether they were ancient barrows, or cairns, or signal stations, has never yet been ascertained. In South Uist and other islands they are frequent, and certainly they give a singular appearance to the landscape. In Loch Caravat, a large fresh-water loch, there is an island. The island contains ancient remains of what were said to be Danish fortifications, but I had no opportunity of examining them close at hand. All that the field-glass revealed was a walled structure which at one time must have protected the island from attack. There were indications that when the loch was low a causeway out to the island might be fordable. On the banks of the loch I found a rope made of heather—a rare curiosity now, as the art of making such ropes is almost forgotten.

On Ben-na-Coille, 224 feet, the hill which overlooks the loch, there were two remarkable mounds. The entire hillside was a wilderness of peat-moss and heather, but standing out conspicuously on the hill slope were two circular mounds on which only grew green grass and rushes. The mounds were flanked by great stones, and at the foot of each were indications of an ancient fosse; and I have no doubt that further examination would reveal much that is of interest regarding their history. They certainly seemed to be the tumuli of great chiefs of the forgotten past.

Near Carinish, again, there are the massive ruins of Teampul-na-Trianaide, or Trinity Temple. Tradition asserts it to have been built in the 14th century by the daughter of Lorn when she was separated from the Lord of the Isles. I examined this ancient sanctuary with great care. The interior was filled almost breast high with huge nettles, and everywhere one trampled upon the shells of myriads of *Helix aspersa*. I found that the temple faced due east, and was in direct line with the highest mountain on the island, viz., Eaval, 1138 feet. On the north side of the nave was a beautifully moulded window, and, looking through it, another conspicuous eminence was found to be in direct line, viz., Unival, 458 feet, in the north of the island. There must have been a corresponding window in the south of the nave, and I found that its orientation was directly towards the highest point of Benbecula—Rueval, 409 feet. Here, then, were a Trinity of Peaks as seen from the three main windows, and the church itself was dedicated to the Holy Trinity. On the north side was a small chapel connected with the main building by an arched passage. Behind the temple was a mound shaped like a circular platform. It was impossible to say for what purpose it had been erected. Perhaps it was a place, as tradition asserts, where criminals were made to walk, in full view of all, before being executed. Perhaps it was merely a spot for threshing corn, an open, windy threshing-floor, where the chaff would readily be blown away.

North Uist is united to Benbecula at low water by what is called the North Ford, a stretch of sand and rock extending to almost 4 miles.

Innumerable are the stories connected with this dreaded passage, and the question of the tides enters most curiously into ordinary conversation. Neighbours, when they meet, do not talk of the weather, but of the tides. Every man has to calculate in his mind the hours of high tide and low tide, spring tide and neap, or the results may be fatal. The first time I crossed was in the forenoon of a dreary day; for the first half-mile the horse trotted over firm sand, then came a deep channel which reached to the axle-tree of the dog-cart, then away for 2 miles or so stretched a long line of weed-covered stones, which had been placed in position many years ago to guide the solitary traveller over this dangerous place. But the evil is that the safe path is constantly changing; one week the sand may be firm, the next it may be a treacherous quicksand. Every passenger across makes it a question of life and death to ask of the last person who passed that way what new quicksand must be avoided. A sad fatality was related to me. A whole family was crossing in a cart, and, while passing a shallow pool, the father dropped his whip and asked his boy to jump down and run back to get it. The boy did so and recovered the whip, and was coming back apparently by the same track, but, for a moment, he must have swerved from the only line of safety. In an instant, he disappeared from his parents' eyes, and the gurgling waters and sand closed over their boy's head. Another time, the Sheriff of Lochmaddy and a party were driving in a waggonette to Benbecula, when down went the two horses, and the waggonette was saved from following only by a miracle. The occupants were thrown out, but managed to scramble on to the rocks and gain firm footing. They saved the law books, but the horses were drowned.

This is what happened one bleak December night to the postman who has charge of the distribution of H.M. mails in these perilous regions. About half-a-mile out from North Uist, I have said there is a deepish channel: then there are several miles of sand and rock and sea-weed, and an intricate pathway more or less marked by stones, which in many cases have disappeared; but, nearing Benbecula, there is another deep channel, and then beyond that is safety. One dark evening the postman trotted his horse out from North Uist, and as he crossed the first channel noticed its unusual depth. In the gathering darkness he tried to hasten over the succeeding miles, but the path was often so obscured that speed was not attainable. When he reached the second channel, he found it unfordable. It was a night of wild storm, there had been a very small ebb-tide, the Atlantic was coming in, and he could not cross to Benbecula. Back he drove for his life to see if he would be in time to cross the deep channel over into North Uist, but, on his arrival there, there were great waves rolling in, and he was thus enclosed in a trap. He remembered that it was a time of neap tide, fortunately for him. Driving out to the highest rock, he jammed his dog-cart into crevices with stones, unhitched the horse and let it swim all night while he held its head with the bridle. He himself stood upright in his cart, and, though the waves at times dashed over his head, the tide did not rise higher than his waist. All night was spent in this terrible position, but when the grey morning broke he was safe.

The second time I crossed was at night, with a fitful moon overhead, and a more dreary melancholy scene it is impossible to imagine. The wet sands, the dark masses of slimy rock, the gleaming of treacherous pools, the weird cries of unseen sea fowl, the distant moaning of the Atlantic seeking once more to come in and pour its strong current through the islands to the Minch—all these have contributed to make the North Ford one of the most eerie and desolate pictures in my mind.

Benbecula is an island, extremely flat, with only one elevation in it, viz., Rueval, 409 feet high; for the most part it is a wilderness of peat-moss and morass, interspersed with hundreds of lochans. I commenced my inspection of its coast at Balivanich Schoolhouse, and walked round the entire western shore on one of the wettest, stormiest days I have ever seen in the Highlands. As a result of my walk I have to report the following shells from its tempest-swept sands:—

Anomia ephippium, Linné.
Glycymeris glycymeris (Linné).
Mytilus edulis, Linné.
Volsella modiolus (Linné).
Ostrea edulis, Linné.
Pecten pusio (Linné).
Lucina borealis (Linné).
Tellina tenuis, da Costa.
Macoma balthica (Linné).
Donax vittatus (da Costa).
Máctra stultorum, Linné.
Spisula subtruncata (da Costa).
,, ,, var. striata, Brown.
Dosinia lupina (Linné).
Tapes virgineus (Linné).
,, pullastra (Montagu).
Cardium edule, Linné.
,, norvegicum (Spengler).
Mya truncata, Linné.
Ensis siliqua (Linné).
,, ,, var. arcuata, Jeffreys.
Patella vulgata, Linné.
Helcion pellucidum, var. lævis, Pennant.
Acmæa virginea (Müller).
Gibbula cineraria (Linné).
,, umbilicata (Montagu).
Calliostoma zizyphinus (Linné).
Littorina obtusata (Linné).
,, rudis (Maton).
,, littorea (Linné).
Rissoa parva, var. interrupta, Adams.
Trivia europæa (Montagu).
Buccinum undatum Linné.
Neptunea antiqua (Linné).
Purpura lapillus (Linné).
Nassa reticulata (Linné).

Between Benbecula and South Uist, there is another ford known as the South Ford, but it is not so dangerous nor so wide as the dreaded North Ford, being only 1 mile across. I did not, however, visit South Uist by this route, but returned to North Uist and sailed by the evening steamer from Lochmaddy. Wild was the night of tossing out in the black Minch, and we seemed never to be able to get past Ushinish Light House, situated on the great promontory jutting out from South Uist; but, in the small hours of the morning, Lochboisdale was reached in safety.

South Uist is much more mountainous than Benbecula or North Uist, and there are some great masses overtopping Lochboisdale. I climbed to the highest point and got a very fine view of the islands from Hecla in the north to Barra in the south. South Uist is redolent with memories of Prince Charlie, and of Flora Macdonald. The creek where Prince Charlie landed in 1745 is still visited, and Prince Charlie's Cave, where he took refuge in 1746, is a spot still held in reverence. Flora Macdonald, again, has given imperishable fame to South Uist by her womanly devotion. Her birthplace is about a mile from the sea, on the Atlantic side, at a weird lonely spot, amid desolate swamps and peat-moss, but she sleeps far away from her home over the sea in Skye.

The scenery of South Uist, on the east side, is all mountainous and very grand; at the back of these mountains is a strip of bog-land and heather-covered slopes, and the western shore is all low-lying, sandy, and machar land. But what strikes a visitor to this beautiful island is the deep poverty and misery of the people. Formerly the land belonged to the Clan Ranald, whose ancient castle stands forth to-day as a memorial of departed greatness. Since 1841 it has passed to strangers, and the lot of the people is not much improved. Some even inhabit underground caves in order to evade the crushing rents and other burdens which the factor lays on them. The people earn a precarious livelihood by crofting, kelp collecting, and fishing. Nowhere have evictions been carried out with such cruelty and recklessness as in South Uist. It is a mournful isle, teeming with tales of former cruelty, wrong, oppression, and callous indifference to the rights of man. There is but one road from north to south, and it is built upon a narrow stone causeway, which is carried in a straight line for miles over moor and moss, bog and loch. Most pathetic is the old burying-ground on the top of a grassy knoll overlooking the sea. "The centre is marked by a cross of worm-eaten driftwood, round about are clustered the dead of many centuries. The people of the island are for the most part Roman Catholics, and for them the central ground is reserved. Protestants are buried in the outer circle, while in a third circle are laid all strangers and all the unknown dead who are cast up by the sea" (Miss G. Cumming). The fuel of the islanders is entirely peat, of which there is fortunately abundance. Any wood used in the erection of buildings on the island must come from the mainland by importation, or from the sea as driftwood. In former times the islands must have been thickly wooded, for "in digging peats, branches of trees with hazel nuts are to be found, and in some places at low water, in great spring tides, trunks of trees are seen in moss in the sea on the west side among rocks and sand" (*Statistical Account of Scotland*, page 191). This vegetation probably grew during the epoch when the shore, as far as the 100 fathoms line, was elevated, and when a broad continental plateau gave a chance for trees to survive the fierce salt winds which must always have swept in from the Atlantic.

But to-day the ocean sends many a gift of timber. Not only wrecks—which are still looked on as a godsend—but great logs of hardwood and felled trees from the West Indian and Mexican forests, as well as chance branches and spars, are washed ashore, drifting along with the warm Gulf Stream. "Bales of cotton, bags of coffee, Molucca beans, and all manner of quaint treasures," says Miss G. Cumming, in her interesting book on the Hebrides, "are among the spoil which rewards the patient seekers. Sometimes they find foreign shells, sometimes such bamboos and fragments of carved wood as encouraged Columbus to seek for an unknown world far away to the west, and sometimes, most precious prize, some drowned lady's raiment, which will set the fashion, no matter of what country, for many a long day." "Portuguese men-of-war" or, scientifically speaking, the wonderful cœlenterate *Physalia utriculus*, are sometimes stranded, as well as live tortoises—not much the worse for their long voyage. The beans I exhibit were thus washed ashore; the one is *Entada scandens*, the Sea Bean, and the other *Mucuna virens*, the Ass's Eye. From Lochboisdale Post Office, I was allowed to carry away this advertisement announcing sales of wreckage, on particular dates, in certain localities. Here are the items to be sold in the course of *one week*:—25 logs, 989 deals, 23 poles, 21 casks of oil, 10 spars, 2 casks of varnish, 1 cask of turpentine! Multiply this harvest of the sea by the 52 weeks in the year, and it will be seen how much the islanders owe to the ocean for such comfort and prosperity as they possess.

The western sands were singularly destitute of molluscs, and the high winds blew the sand over those which had been cast up. I therefore can report only the following from South Uist:—

Mytilus edulis, Linné.	Lucina borealis (Linné).
Volsella modiolus (Linné).	Diplodonta rotundata, Montagu.
Pecten varius (Linné).	Lutraria elliptica, Lamarck.

Dosinia exoleta (Linné).
Venus fasciata (da Costa).
„ „ var. radiata, Jeff.
„ gallina, Linné.
Tapes pullastra (Montagu).
Cardium edule, Linné.
„ norvegicum (Spengler).
Mya truncata, Linné.
Ensis siliqua var. arcuata, Jeffreys.
Patella vulgata, Linné.
Helcion pellucidum var. lævis, Pennant.
Gibbula cineraria (Linné).
Littorina obtusata (Linné).
„ littorea (Linné).
Rissoa parva var. interrupta, Adams.
Trivia europæa (Montagu).
Buccinum undatum, Linné.
Purpura lapillus (Linné).
Nassa reticulata (Linné).

Of these the most interesting is the discovery of *Diplodonta rotundata*, Montagu. Regarding this find, Mr. J. T. Marshall, of Torquay, has favoured me with the following remarks:—"Some years ago I got a valve from off Rum in 33 faths., but was so sceptical of its origin and depth that I did not record it in my papers. Since then, however, I have had another fresh valve from Benbecula Sound, 10 faths., and a remarkable thing is that associated with it were *Cerithiopsis concatenata*, *Lepton sulcatulum*, and on the shore *Littorina obtusata* var. *ornata*, all exclusively southern forms." Jeffreys says regarding *D. rotundata*:—"It is not uncommon on the southern coast of England and in the Channel Isles, and also in the South and West of Ireland in 12-20 faths., sandy mud." The only West of Scotland record previously to my find, was that of Mr. Frank Coulson, who took two valves off Horse Island, Ardrossan, in 5-12 fathoms.

On the machar land, facing the Atlantic, I obtained a considerable number of specimens of *Helix hortensis*, Müller, *H. itala*, Linné, *H. itala*, var. *maritima*, and *H. acuta*, Müller.

On the lonely shore of Loch Eynort there stands a stone monument similar to those at Stennis, in Orkney, and Tormore, in Arran; a monolith of great size, whose impressiveness is increased by the solemn, weird scene in which it rears itself aloft.

In the exquisite freshness of an early summer morning I sailed from Lochboisdale to visit the last large island of the Outer Hebrides, namely, Barra. Away to the south, past the beautiful islands of Eriskay, Gighay, and Hellisay the steamer sped, and before long was rounding Muldonich Island into Castlebay, in Barra. Without hesitation I will say that Barra is the gem of the Outer Hebrides. Its splendid harbour, crowded with many hundreds of fishing craft, is the greatest centre for the fishing industry in this part of the world. The shores are lined with curing yards, and there is a cheery bustle and activity, on which great Heaval looks down serenely. I wish I could say as much of the character of the people. Never have I beheld such scenes of drunkenness as on Saturday night, when the fleet of fishing boats was in. It was one pandemonium of screams, oaths, and yells. The ecclesiastical condition of the Outer Hebrides is very remarkable. Lewis and Harris are entirely Protestant. North Uist, with a population of 5000, has one Roman Catholic family; Benbecula, with a population of 1800, has 50 per cent. Roman Catholic; South Uist has 70 per cent. Roman Catholic; and Barra has 90 per cent. Roman Catholic. Beyond Barra to Bernera, the last island, there are no Protestants at all. At the Reformation the people followed the religion of their chiefs, and Clan Ranald and the M'Neills still clung to the Church of Rome. To-day Barra is practically Catholic, and the priest rules the people with iron hand. There are only 45 Protestant families in the whole island, and these are the object of sullen hate on the part of the Catholics. There is a most remarkable difference between the lands tenanted by the two parties—the same difference as is observed between the Romanist and the Protestant cantons of Switzerland. The Catholics are unprogressive and lazy; the Protestants are industrious and active. Cross the machar land from the farm of a Catholic to that of a Protestant, and the difference is most striking. The slightest hole in the turf is apt to get larger by the action of the wind, and soon the sand dunes are rent asunder, and much pasture land is destroyed. Every week the Protestant rides over his land, and stops up every incipient hole; the Catholic neglects his, and consequently there are acres of blown sand to-day where formerly there were productive crops. The largest proprietor on the island is Mr. William Macgillivray, a nephew of the celebrated Professor Macgillivray, of ornithological fame. The nephew himself has a great genius for natural history, and his beautiful home at Eoligarry, which I had the pleasure of visiting, is stocked with a remarkable number of curiosities. He owns the islands of Fuday and Hellisay, and half of Barra, and his domain is a perfect paradise for beauty of scenery.

The road from Castlebay to Eoligarry is, I think, one of the most beautiful I have ever driven along. In parts it is as fine as portions of the Corniche Road along the Riviera. First of all it climbs out of Castlebay, and over the shoulder of the hill, through the miserable Catholic village of Kentangaval, where the natives have a wretched hangdog look, and, as you pass, children come out and curse in Gaelic, and throw stones. Then it descends to the other side of the island to Borve Bay, where the most conspicuous object is the white church of the priest. Beyond that the road follows the windings of the coast, along lovely sandy bays, up the steep face of cliffs, through exquisite little dells, and at the base of frowning crags, while always to the west is the magnificent blue expanse of the Atlantic Ocean.

In the fresh water Loch Mor, near Borve, with its ruined castle on an island, and among the neighbouring mounds, I gathered the following mollusca :—

Hyalinia pura (Alder).
Helix aspersa, Müller.
,, hortensis, Müller.
,, itala, Linné.
,, ,, var. maritima.
,, acuta, Müller.
Helix elata.
Cochlicopa lubrica (Müller).
Succinea elegans, Risso.
Limnaea peregra, Müller.
,, ,, var. lacustris (Leach).

But in Borve Bay itself, and on the West Coast, I discovered that there were many conchological treasures, which made me long for my dredge that I might explore the hidden depths beyond. The list is as follows :—

Modiolaria discors (Linné).
Crenella decussata (Montagu).
Pecten varius, var. nivea, Macgillivray.
Lima subauriculata (Montagu).
Turtonia minuta (Fabricius).
Lucina borealis (Linné).
Montacuta bidentata (Montagu).
Kellia suborbicularis (Montagu).
Cardium fasciatum, Montagu.
,, minimum, Philippi.
Gari tellinella, Lamarck.
Helcion pellucidum (Linné).
,, ,, var. laevis, Pennant.
Acmaea virginea, Müller.
Eumargarita helicina (Fabricius).
Phasianella pullus (Linné).
Lacuna divaricata (Fabricius).
,, pallidula (da Costa).
Rissoa parva (da Costa).
,, ,, var. interrupta, Adams.
Onoba striata, var. candida, Brown.
Skenea planorbis (Fabricius).
Capulus hungaricus (Linné).
Velutina laevigata (Pennant).
Purpura lapillus (Linné).
Bela turricula (Montagu).
Scaphander lignarius (Linné).

It was strange to find *Phasianella pullus* in great abundance on the shore, and with it the variety *candida* of *Onoba striata*. From what I saw of Borve Bay, I should say that further research would amply repay the conchologist.

In Castlebay is that strangely picturesque castle, Kiessimull, situated on a rocky islet. It was for long the seat of the M'Neills of Barra. Anciently it had a well in the centre of its area, but that has now been choked up by stones. When Martin visited it 200 years ago, he states that the castle was then 500 years old, and that it had its regular officers and guards. To-day it is merely a most picturesque ruin.

Taking a boat, I rowed across the 2½ miles to Vatersay Island. In the fishing season this is alive with boats, but I found the island deserted. The shore of one of the little bays was literally composed of the dead shells of *Littorina obtusata*. There they lay in myriads and myriads, and the effect of their colouring was very remarkable. The island is most singularly shaped, and has an extensive harbour. I proceeded straight to the outer bay, facing the Atlantic, in the expectation of getting some treasures there. But never did I see a shore more destitute of shells. It was absolutely bare: a dreary expanse of coarse gravel and mud. High up lay stranded an immense iron cabin, evidently the framework of the deckhouse of some vessel which had been wrecked. This bay has an evil reputation. It was here that in 1852 a great vessel was wrecked. Many of the crew and passengers managed to reach the shore in safety. The natives of Castlebay swarmed across to Vatersay, and murdered them all in cold blood: a great mound near the solitary farmhouse marks the spot where hundreds were buried. When all proof of their guilt was thus removed, they set to plundering the wreck, which was laden with rich stuffs and goods. But the news of the atrocity leaked out, and soon the name of a Barra fisherman stank in the nostrils of all sailors. For years after that, for a seaman on board a vessel to confess that he came from Barra was almost to sign his own death warrant, so intensely were sailors incensed against the islanders. I conversed with a man who had been taken when a boy by his father to see the bodies laid out, and he pointed out to me old men who had had their share in the awful deed. The Catholic population of Barra is still not too scrupulous about bloodshed, and the Protestants have just cause to live in fear of their lives from their growing hate and ferocity.

I was agreeably surprised to find that the land-locked Vatersay Bay had a better molluscan record to give than the seaward bay. In addition to what I had found on the more northerly islands, I now discovered:—

Pecten maximus (Linné).
,, pusio (Linné).
,, opercularis (Linné).
Tellimya ferruginosa (Montagu).
Syndosmya alba (Wood).
Tellina fabula, Gronovius.
Mactra stultorum, Linné.
Saxicava rugosa (Linné).
Thracia fragilis, var. villosiuscula, Macgillivray.

The most interesting of these was *Mactra stultorum*. I had already taken a valve on the shore of Benbecula, and here was another. This Mactra is extremely common on the coast of Aberdeenshire, but its west coast distribution is very scanty. Until this find of mine, the only western Scottish records were Oban Bay and Islay, by Mr. A. Somerville; Ardrossan, and between Saltcoats and Irvine, by Mr. Frank Coulson. Further research would doubtless yield more specimens.

Heaval is the highest peak in the Island of Barra, and is 1260 feet high. I found there was no need for the erection of a cairn on the summit, for the summit itself was shaped like a cairn and was sufficiently conspicuous. But what struck me as very curious was that the great stone had ribs on its surface, and projections and promontories, which corresponded to the various projections and promontories of the Island of Barra itself. One point of the stone projected towards the north of the island, where the great cape of Eoligarry was, another towards the west to Doirlinn Head, and a third to the east. The outline of the natural rock cairn, in fact, was an epitome of the outline of the island itself. The resemblance was most striking. Mr. Whymper has stated that the rock at the very summit of the Matterhorn is an exact epitome of the Matterhorn itself in configuration and outline. There may be fancy in this, or there may be here the utterance of a great scientific law. From Heaval I saw far to the south, to where the islands ceased. First Vatersay, then Sandray, then Pabbay, then Mingulay, and last Berneray. The great light-house on Berneray, situated 700 feet high, on Barra Head, is renowned. It is the last outpost of human existence till America is reached. Some of the cliffs of Mingulay, which are almost perpendicular, are 1400 feet in height, and the Outer Hebrides terminate in scenery of the most savage grandeur. Here is the home of the cormorants, on the myriad ledges of the rocks; and then comes the last great cliff, and beyond that, there is the illimitable ocean.

The list of marine mollusca collected comprises 71 species and 9 varieties, making a total of 80. The nomenclature followed is that in the "List of British Marine Mollusca and Brachiopoda, prepared by a Committee of the Conchological Society of Great Britain and Ireland, 1901."

The following books and papers, to some of which I am indebted for several facts, will be found useful to anyone entering upon the study of the Outer and Inner Hebrides :—

Martin (M.)—"A Description of the Western Isles of Scotland." 1703 and 1716.
Pennant (T.)—"A Tour in Scotland and Voyage to the Hebrides." 1769-1774.
M'Culloch (Dr.)—"Description of the Western Islands of Scotland." 2 v., 1819.
Macgillivray (J.)—"Account of the Series of Islands denominated the Outer Hebrides" (Edinb. Journ. Nat. Hist. and Geog. Sci., Vols. I. and II., pp. 161 and 321). 1829-30.

"The New Statistical Account of Scotland." 1841-44.
Miller (Hugh).—"The Cruise of the 'Betsey.'" 1858.
Gray (R.)—"The Birds of the West of Scotland, including the Outer Hebrides." 1871.
Feilden (Capt. H. W.)—"Journal of a Tour through the Outer Hebrides in 1870" (Nat. Hist. Soc., Glasg., Trans., Vol. II., p. 58). 1876.
Cumming (Miss C. F. Gordon).—"In the Hebrides." 1883.
Harvie-Brown (J. A.)—"The Islands and Rocks of Haskeir, off North Uist, and their Bird Life" (Nat. Hist. Soc., Glasg., Trans., Vol. V., p. 181). 1884.
Harvie-Brown and Buckley (T. E.)—"A Vertebrate Fauna of the Outer Hebrides: with a Geological Sketch by Prof. Heddle."
Hoyle (W. E.)—"Report on the Biological Investigations on the Sea to the West of Lewis" (Scott. Fishery Board Rep., 1888, Part III., p. 215).
Smith (W. Anderson).—"Lewsiana: or, Life in the Outer Hebrides." 1886.
Geikie (Sir Archibald).—"The Scenery of Scotland Viewed in connection with its Physical Geology," 2nd Edit. 1887.
Geikie (Sir Archibald).—"The History of Volcanic Action during the Tertiary Period in the British Isles" (Royal Soc., Edin., Trans., Vol. XXXV. Part 2). 1888.
Somerville (A.)—"Notes on the Flora of the Island of Barra" (Nat. Hist. Soc., Glasg., Trans., Vol. II. (N.S.), p. 183). 1890.
Somerville (A.)—"Notes on the Flora of Barra and South Uist" (Ibid. Vol. III. (N.S.), p. 31). 1892.
Ramsay (Sir A. C.)—"Physical Geology and Geography of Gt. Britain," 6th Edit. 1894.
Goodrich-Freer (Miss)—"The Outer Hebrides." 1902.
Mackenzie (W. C.)—"History of the Outer Hebrides, with Chapters on the Geological Structure and the Fauna and Flora of the Group," by Rev. W. Morrison, Carr-Bridge. 1903.

XXIV.—*A Ramble on the Moor at Blair-Atholl.*

By Mary L. Miles, L.L.A.

(Read 11th December, 1902.)

The warm sunshine of the previous day had not prepared us to look out on a white world at 7.30 a.m. The sheep in the field opposite the Tilt Hotel were hardly distinguishable from their surroundings. Although no later in the year than the 4th of October, there had been $12\frac{1}{2}$ degrees of frost during the night. But by eight o'clock the sun had attained such power that from the sound one could have imagined rain to be falling, so rapidly was the frost thawing and dropping from the roof. Gradually the earth lost its mantle of whiteness, and before noon we had forgotten all about frost when starting out for the moor with a glorious blue sky overhead, the only break in which was caused by tiny flecks of gauzy white clouds.

Crossing the Garry by the wooden foot-bridge at Blair-Atholl, we begin at once to ascend the Tuloch. At this part it is thickly covered with *Calluna vulgaris*, Salisb., ling, or Scotch heather, of very luxuriant growth, interspersed at rare intervals with plants of *Erica cinerea*, L., the bell-heather. As we ascend the hill, at every step we are reluctantly forced to break the gossamer threads of the spider, which are interwoven with the *Calluna*. The steepness of the hill is here so pronounced that we are glad to use the narrow zig-zag paths worn by the sheep. These paths give ease to the ascent, though they lengthen the distance. About half-way up we pause, and look down on Blair-Atholl at our feet, seemingly a tiny cluster of small houses. To the right, on higher ground, and commanding an extensive view, stands Lude House, while to the left is Blair Castle, easily distinguishable at long distances by its white exterior. From our position on the Tuloch, the fine avenue of trees which leads from Blair-Atholl to the Castle is seen to advantage. Directly opposite to us lies Glen Tilt, up which we can see for a distance of about five miles. Beyond this, east of Glen Tilt, stands out boldly the shoulder of Ben-y-Gloe. Above Lude House, and to the right of it, towers Ben Vrackie. Again turning our faces to the ascent, we are attracted by what at first seem to be oval stones amongst the heather. We look at them for some minutes, an odd contrast to the purple *Calluna*. Presently one of the apparent stones raises its head—it is a sheep! While feeding in the depths of the heather, with their legs and heads buried amongst the herbage, the rounded backs of the sheep look curiously like grey stones. At last we are on the open moor, more than 1000 feet above Blair-Atholl.

Our walk so far has been on singularly dry ground, considering the hard frost of the early morning. But now we have to pick our path, for the moor, though somewhat level, is very boggy in places. We avoid green and mossy spots, and at last, at 1.30 p.m., with Glen Tilt on our left, and distant mountains in front of us, we seat ourselves on a knoll to enjoy a well-earned lunch. This knoll soon becomes a centre of interest. Hardly a yard distant a great boss of *Sphagnum* closely wreathes the lower stems of the *Calluna*, and in the sunlight we can see that its soft pink tufts are thickly ornamented with fruits of a deep red. To examine this moss more closely we secure a handful. It does not leave its habitat so easily as usual, and we soon discover why. Although the sun is now very powerful, the bases of the *Sphagnum* are still encrusted with icicles, so severe has the frost been on the open moor. The moss proves to be a variety of that most variable species of all the *Sphagna*, *Sphagnum acutifolium*, Ehrh. *Sphagnum*, or peat-moss, as it is more commonly called, differs so widely in structure from the rest of the mosses that many authorities do not consider it a moss, in the strict sense of the word. The thread-like stem only maintains its erect position by the crowded condition of the plants, which are usually found in dense masses or cushions. The structure of the cell-tissue of peat-moss renders it peculiarly adapted to the absorption and conduction of water. If a plant, or a tuft of *Sphagnum*, is placed in water, the water is rapidly soaked up and distributed over the whole plant, from the surface of which it can easily pass by evaporation and transpiration. It is owing to this peculiarity in the structure of *Sphagnum* that extensive tracts of watery country have been drained of their moisture, while at the same time the surface of the country has been raised by the mode of growth of the stem. A secondary stem being formed each year below the apex of the stem of the previous year, the constantly accumulating *debris* of decayed tissue at the base of the plants forms a dense mass of vegetable detritus, which, when compressed by the weight of growth above it, is often changed into peat. On further examination we discover that all our specimens have lost the *calyptra*, and the capsules appear like tiny red claret-cups on tall pale green stems. Just at our feet the ground is covered with lichens, the soil here being very scant and poor. *Cladonia rangiferina*, Hffm., the reindeer lichen, predominates, but there are also undersized specimens of *Cladonia bellidiflora*, Schœr., with its scarlet fruits, and *Cladonia pyxidata*, Fr., the cup-lichen; and growing through a patch of the reindeer lichen are a few stunted shoots of *Vaccinium Vitis-Idæa*, L., the cowberry—its glossy green coriaceous leaves forming a marked contrast to the grey of the lichen.

But time is passing, and we must resume our ramble. The moor becomes still more boggy, and *Myrica Gale*, L., the bog-myrtle, is very abundant, emitting a spicy odour in the warm sunshine. Here and there we find single plants of *Polygala vulgaris*, L., the milkwort, but always the blue-flowered variety, and the hue is intensely deep. At intervals we come across *Nardus stricta*, L., the mat-weed, still bearing its erect, though now withered spikes. The harsh foliage of this grass protects it from the grazing sheep. We also find occasionally the panicles of *Holcus mollis*, L., *Deschampsia cæspitosa*, Beauv., *Deschampsia flexuosa*, Trin., and *Agrostis vulgaris*, With. On a rock is a large patch of *Rhacomitrium fasciculare*, Brid. The specific name of this moss is derived from its fasciculate branches. Near it is a large cushion of *Rhacomitrium lanuginosum*, Brid., its long hyaline hair-points giving this moss the appearance of being covered with wool; and an olive-green tuft of *Bryum inclinatum*, Bland, bearing numerous long red dish-brown setæ, from which most of the capsules have fallen. Beside a stony streamlet are some good specimens of *Saxifraga aizoides*, L., its golden yellow flowers, dotted with red, standing out plainly from the background of bright green leaves; and close at hand are numerous plants of *Pinguicula vulgaris*, L., the butterwort. Its flowering season is past, but its rosette of pale green leaves, with involute margins, is still conspicuous against the darker-hued vegetation. This little plant is chiefly interesting from its insectivorous habit. In the water, on a boulder, *Blindia acuta*, B. & S., is growing. Our specimen is of an olive-green colour, and the stems are about an inch high. One must look closely to discover the capsules, for, though exserted, they are almost hidden by the leaves of the innovations. A little farther on we came across *Hypnum scorpioides*, L. It is of a deep reddish colour. The leaves are closely imbricated on the stem, and strongly *falcato-secund.* The tips of some of the branches are of a bright yellowish-green. This moss rarely fruits, and although we look closely, not a single capsule appears on our specimen. *Philonotis fontana*, Brid., is also growing here in tall wide tufts. It is of a glaucous green, and the stems are closely interwoven below with tomentum. Its dark brown capsules are now somewhat shrivelled, for this moss fruits in summer, but the numerous red setæ still remaining show that the fruit has been abundant. Presently we notice another variety of *Sphagnum acutifolium*, forming large cushions of a pale green colour. This specimen bears no fruit. *Bryum pallens*, Sw., also occurs here, with stems nearly three inches high, and so abundant is the fruit that the long setæ, with their sub-pendulous capsules, almost conceal the slender stems with their minute leaves. Near at hand a few tufts of the cotton-grass, *Eriophorum augustifolium*, Roth., are waving gently, the spikes of silky-white fruits drooping gracefully on their slender peduncles. Another well-known insectivorous plant now becomes somewhat frequent, *Drosera rotundifolia*, L., the sundew. It still bears its dead scape in the centre of the rosette of apparently red leaves, not really red, but appearing so from their thick covering of red filaments, bearing the glands which secrete the digestive juice. The poetical name sun-dew is derived from the viscid drops surrounding each of the glands, glistening in the sunlight. Helping to show up the redness of the sundew are large patches of *Hypnum falcatum*, Brid., and *Hypnum intermedium*, Lindb., growing together. *Hypnum intermedium* is a rare moss, and we are not surprised that it bears no fruit, as it is usually barren, but neither is there any fruit on *Hypnum falcatum*, which is a more robust plant, of an orange-brown colour. Here, too, we find *Aulacomnium palustre*, Schwgr., with loosely tufted stems, nearly five inches high, closely covered with brown tomentum almost to the apex. The tips of the branches are of a pale green.

Now there appears directly in front of us a young fir-wood, enclosed by a low stone dyke, which we can easily scale; but before doing so, our attention is attracted by the frozen state of the moss-covered ground overshadowed by the fir-trees. It is now 2.30 p.m., yet we take up tufts of *Hypnum Schreberi*, Willd., *Hylocomium splendens*, B. & S., and *Hylocomium squarrosum*, B. & S., still rigid with the frost. Within the fir-wood the character of the vegetation is entirely dissimilar to that of the moor. It is well-known that fir-woods are good hunting-grounds for fungi, and almost as soon as we cross the dyke we are arrested by some good specimens of *Cortinarius (Dermoc.) cinnamomeus*, Fr., the cinnamon Cortinarius. As its name indicates, this agaric is of a cinnamon-brown colour. A few steps more bring us to several good specimens of *A. (Lep.) carcharias*, Pers. The pink pileus is mealy, with innate granules, and its margin fringed with the remains of the universal veil. Next we come to a spot where there has recently been a fire, yet, in spite of this, here we find three of the *Clavariei; Clavaria rugosa*, Bull, the wrinkled Clavaria, *Calocera viscosa*, Fr., a bright egg-yellow fungus, growing on a fir-stump, and *Calocera cornea*, Fr., thrusting its curious little orange-yellow, subulate clubs, through the bark of a prostrate branch; and on the ground beside them, the foliaceous lichen, *Peltigera canina*, L., is abundant. In the heart of the fir-wood is a sheet of water of oblong shape, seeming to be partly natural and partly artificial. The end at which we first arrive is banked up by roughly broken fragments of rock, as if to prevent the water from overflowing. Yet at one point, in spite of this artificial barrier, it does succeed in escaping bounds, as a large still pool at a much lower level than the path which surrounds the loch, bears evidence. *Potamogeton natans*, L., grows so profusely in the loch that periodically large quantities of it are dragged out of the water, and left to rot in heaps just within the wood. On one of these heaps rank specimens of *A. (Trich.) personatus*, Fr., are growing in a densely imbricated mass. We take up one of the largest, which measures $8\frac{1}{2}$ inches across the fawn-coloured pileus. The gills and stem of this fungus are of a beautiful violet colour, and the stalk is clothed with violaceous down. The ground here gradually slopes down into the pool already mentioned. Floating on the surface is the body of a dragon-fly, upheld even in death by its four rainbow-hued wings. The bottom of the pool is green with *Chara fragilis*, Desv., and the water teems with animal life. We dip unsuccessfully for a beetle, but succeed in catching a lively young frog, about $1\frac{1}{2}$ inches in length, and having secured enough *Chara* for our small aquarium, we again take the path round the loch. Here another *Potamogeton* is growing at a considerable depth. As we have no dredging-hook, it is only with difficulty that we secure a specimen.

It is *Potamogeton prælongus*, Wulfen., in which all the leaves are submerged. At the western side of the loch there is a considerable stretch of grassy ground between the water's edge and the fir-trees, and here we find *Achillea Millefolium*, L., the milfoil; *Galium verum*, L., the Lady's bedstraw; *Scabiosa succisa*, L., the Devil's-bit scabious; *Brunella vulgaris*, L., the self-heal; and *Cnicus lanceolatus*, Hoffm., the spear-thistle; all in flower. In the fir-wood beyond, *A. (Clito.) fragrans*, Sow.; *Hygrophorus hypothejus*, Fr., the fir-wood hygrophorus; *A. (Clito.) pithyophilus*, Fr., the fir-wood Clitocybe; and *A. (Col.) butyraceus*, Bull, the Buttery Collybia, are frequent. We also find *A. (Trich.) vaccinus*, P., the scaly Tricholoma, and *A. (Phol.) flammans*, Fr., the yellow scaly Pholiota. On the grassy ground at the southern end of the loch *Potentilla Tormentilla*, Scop., the cinquefoil; *Ranunculus Flammula*, L., the lesser spear-wort; *Leontodon autumnalis*, L., the hawkbit; *Linum Catharticum*, L., the purging flax; and *Cerastium glomeratum*, Thuill., the mouse-ear chickweed, are growing; the two last in fruit. Some fungi occurred amongst these plants; *A. (Nauc.) melinoides*, Fr., *A. (Lep.) granulosus*, Batsch.; both the yellow and white varieties; *A. (Pan.) campanulatus*, L.; *A. (Stroph.) æruginosus*, Curt., the livid green Stropharia; and *Lycoperdon gemmatum*, Fr., the warted puff-ball. At the water's edge, *Juncus effusus*, L., the rush, and its variety, *Juncus conglomeratus*, L., grow together. *Usnea barbata*, L., the beard lichen, clothes the stems of many of the trees at this part of the wood, and we feel we are again close to the open moor from the strong wind which is blowing on this higher ground. Crossing the wire fence which here is the only barrier between us and the moor, we find, under the shade of the fir-trees, single dwarfish specimens of *A. (Amanita) rubescens*, P., and *Lactarius deliciosus*, Fr., and several specimens of *A. (Trich.) imbricatus* growing gregariously. From this position our outlook is towards distant mountains. The ground is covered with closely-nibbled grass, bedecked in places with Burns' "Wee, modest, crimson-tippit floo'er," *Bellis perennis*, L., the daisy. Two species of fungi common in pastures are growing near—*Hygrophorus virgineus*, Fr., the satin-white Hygrophorus, and *Hygrophorus conicus*, Fr., with pitch-black pilei. *Hygrophorus conicus* is the only species in this genus which turns black in old age. In its earlier stages the conical pileus is brilliant orange and scarlet.

Returning to the wood, we begin our journey homewards. On the east side of the loch the fir-trees reach quite to the margin, and most of the way we keep to the path which is thickly covered with pine-needles. Here *A. (Clit.) laccatus*, Scop., the waxy Clitocybe, and *A. (Clit.) bellus*, Fr., the pretty Clitocybe, but possessing a fœtid odour, grow near each other. Towards the north end of the loch is a large patch of *Molinia cœrulea*, Moench., the moor-grass, growing quite at the water's edge. It looks very graceful, with its numerous tall panicles of blue-purple spikelets, for owing to the lateness of the present season it is still in flower. On another heap of decaying potamogeton, *A. (Clito) ditopus*, Fr., is growing abundantly, and in the wood *Dicranum scoparium*, Hedw., and a form of *Ceratodon purpureus*, Brid., are common.

Leaving the fir-wood at the same place as we entered it, we retrace our steps to Blair-Atholl. The sun has gone down, and the numerous mountain peaks on our right present a curious phenomenon. The morning sky was almost cloudless, but now a long line of clouds seems to be resting on all the distant summits, giving the mountains the appearance of possessing similar altitudes. Having crossed the boggy region, we follow a path slightly to the west of that by which we ascended. Near the foot of the hill we stop by the side of a burn to add a little water to the chara in the vessel containing our frog, when the latter seizes the opportunity to free itself from captivity, and we are left with only the chara for our aquarium! As we turn away from the scene of our loss, we notice a fine specimen of *Lomaria Spicant*, Desv., the hard fern, growing in a sheltered nook on the bank. Just before leaving the region of *Calluna*, a covey of partridges rises up in front of us, the only birds we have seen or heard during our ramble! From the time that we crossed the brawling Garry in the morning, we have been impressed with the loneliness and silence of the moor. Besides sheep, with the exception of a few stray rabbits and the partridges, no other animals have attracted our attention. There has not been the sound of a gunshot, nor was a keeper with his dog to be seen in any direction.

XXV.—*The Bacteria, or Schizomycetes, and their place in the Natural System.*

By John Lyell, M.D.

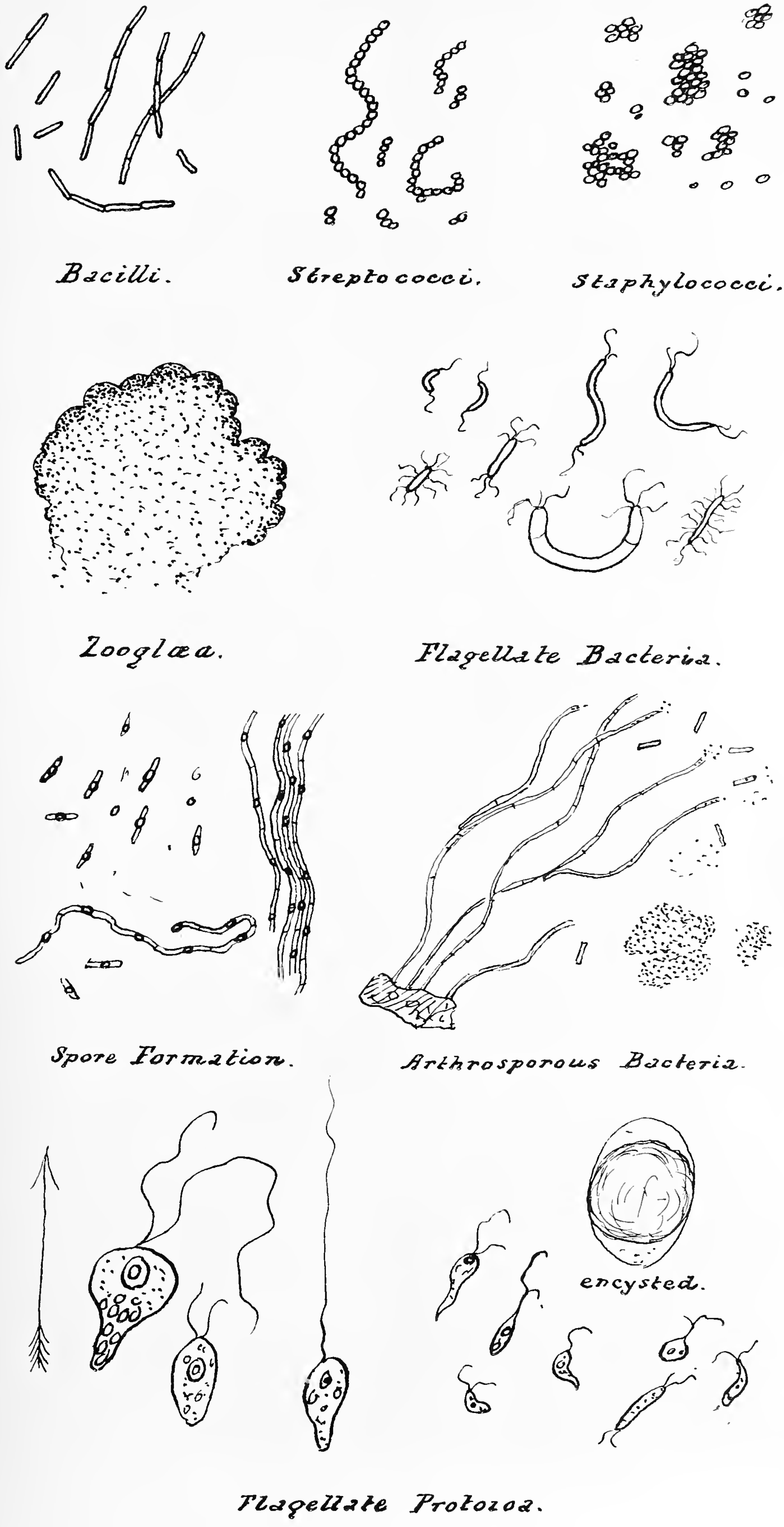
(Read 11th Dec., 1902.)

The Bacteria, or Schizomycetes, were discovered more than 200 years ago by the Dutch scientist, Antony von Leeuwenhoek, who demonstrated the presence of minute moving organisms in the saliva by means of a globule of glass mounted between two pieces of metal. This simple instrument was the prototype of the modern compound microscope. As improvements in optical appliances were gradually introduced our acquaintance with the minuter forms of life has increased to an enormous extent; but it was not till the middle of the nineteenth century that anything like a Science of Bacteriology could be said to exist. At the present day, when the compound microscope has been brought to a high state of perfection, the most accurate study of the Bacteria is possible. The *rôle* which these organisms play in the world is now seen to be one of vast significance; but it must be confessed that, notwithstanding the amount of research which has been devoted to the subject, there are many points in reference to the natural history of the Bacteria which are still somewhat obscure. Their real nature and exact place amongst other organisms have long been much disputed, and scientific opinion has gone through many phases in regard to these important points. The object of this paper is to trace as briefly as possible the progress of our knowledge regarding the problems referred to, and to show how far their solution has, up to the present, been attained. Before doing so, however, it will be necessary to give a short sketch of the main features of the Bacteria, as a class of micro-organisms of the lowest possible type.

I.

The Bacteria are the smallest known forms of living matter, and are absolutely invisible except under the highest powers of the microscope. Their minuteness may be judged of by the fact that, in one direction at least, they do not usually measure more than $\frac{1}{25000}$ part of an inch. In shape the individual Bacteria vary, and the different forms have been compared to a billiard ball, a lead pencil, and a corkscrew,—being known respectively by the names of Cocci, Bacilli, and Spirilla. Sometimes they are arranged in beautiful chains, like a necklace of beads (*Streptococci*); or they may be gathered together in clumps (*Staphylococci*), or in a felted mass (*Zooglœa*). They have, as a rule, no colour, being distinguished from surrounding objects by their peculiar refractive properties. There is a delicate gelatinous envelope encircling each individual germ, enabling it to adhere to its fellows; and in certain species this may constitute a distinct capsule. Bacteria are often found in a state of active movement. This may either be what is known as Brownian motion, a dancing or circling in delicate eddies, and not different in its nature from the movement of minute particles of non-living matter as seen under the microscope. In other cases the Bacterium is provided with little whip-shaped processes called flagella, by means of which it can propel itself in a fluid medium. The remarkable property which all Bacteria possess of taking up the aniline colours has been of immense service in their study. They are thus rendered visible amongst surrounding bodies which would otherwise completely obscure them. A great deal of the practical part of the Science of Bacteriology consists in the skilful use of various staining reagents, and Medicine

PLATE I.


Bacilli.
Streptococci.
Staphylococci.
Zooglæa.
Flagellate Bacteria.
Spore Formation.
Arthrosporous Bacteria.
encysted.
Flagellate Protozoa.

especially has been greatly indebted to the researches of such brilliant investigators as Koch, Löffler, Ehrlich, and others in this direction. The discovery of the Tubercle Bacillus, for instance, which has had such a profound influence upon the theory of disease, was only possible after prolonged experiments in differential staining, which took years to bring to perfection.

The conditions of life and growth of the Bacteria are of great interest. Their function in Nature is to break up dead organic matter into its simpler constituents. They are thus our greatest benefactors, for without their unwearying activity the world would long ere this have become a huge sepulchre. The processes of putrefaction and decomposition are essential for the restoration of the great balance of Nature. Green plants feed upon air, water, and dissolved salts; animals feed upon plants; and, again, dead animals and plants are devoured by Bacteria, which, in so doing, set free simple gases into the air and salts into the soil, to form anew the sustenance of the plant world. Thus the great wheel of life rolls on, and the humble Bacteria are seen to have an all-important place in the economy of Nature and the service of man.

The power of the Bacteria lies in their universal distribution and their extraordinary capacities for growth. They are found everywhere—in the air, in the earth, and in the water we drink; in our clothes, on our skins, in the dust of the street and the room; in our food, in our mouths and digestive tract. The moment that they come in contact with suitable matter on which to feed they begin to flourish and to multiply. They are subject, however, to various checks, both natural and artificial. The exhaustion of food-supply at once inhibits their increase. Bright sunlight kills them. Cold and lack of moisture soon reduce their activity and render their functions inert. By the use of strong acids and spirits, chloride ot lime, and the whole host of modern antiseptics they can be completely destroyed. They cannot withstand prolonged boiling, or dry heat over 170° Centigrade.

It is fortunate that we have the means of thus entering into warfare with these ubiquitous organisms, for although their place in the universe is to an overwhelming extent a salutary one, yet they can be at times our deadliest enemies. In the popular estimation the microbe has come into very evil repute. And it is doubtless true that a number of our commonest ailments are due directly to their secret action in our blood and our tissues. Yet it must be remembered that only a limited number of Bacteria give rise to disease; and there is even room for believing that in certain cases where this occurs it is only an accidental event, and that the microbe is really out of its true place in Nature when it invades our bodies and leads to their destruction. Still the fact remains that most of us are, after all, killed by Bacteria. However easily we can destroy them in the outside world, once they gain a firm foothold within us we are at their mercy. Nevertheless, much has been achieved of late in the way of carrying war into the very camp of the enemy. Some of our deadliest diseases are now open to direct attack upon their microbic cause, and every day the battle is being waged the fiercer, because we believe that we are upon the winning side.

II.

We come now to the consideration of the important question as to what is the real nature of the Bacteria. For many years opinion was divided as to whether they belonged to the animal or the vegetable kingdom. This was partly due to their extreme minuteness, which precluded exact study of their structure and habits of life. It was also due to a certain confusion which formerly existed as to the proper delimitation of the two great kingdoms of the organic world. Increasing research has, however, furnished much clearer views upon the differentiation of the lowest forms of animals and plants, and it is now possible, with a considerable degree of confidence, to allocate the Bacteria to their proper place in the Natural System. The grounds upon which their classification amongst other organisms is at present based are of much interest, and we shall now proceed to examine them in greater detail.

We are accustomed to form a very clear conception of the difference between plants and animals, because we have constantly before us examples of the higher representatives of these two classes of living creatures. It is only when we come to the examination of the lowlier forms of life that the exceeding difficulty of the problem is seen. Amongst these all the conventional distinctions fail, and we are compelled to look below the surface for the true elements of contrast. These are to be found in the great processes of nutrition upon which all organisms depend for the maintenance of their existence. Living Protoplasm, in whatever form we see it, is subject to a constant waste and repair, and it therefore stands in a very peculiar relation to all other matter. It has to find for itself the elements necessary to supply the place of those which it has used up. The difference between plant and animal largely consists, after all, in the means which each employs in achieving this end,—in short, it is a question of where and how each *feeds*. While the plant, by means of its green colouring matter, called chlorophyll, can go direct to inorganic nature for its nutriment, the animal is compelled to rely upon second-hand sources. The plant, on the one hand, derives its carbon, hydrogen, oxygen, and nitrogen from simple inorganic salts and gases; while the animal, on the other hand, takes up these elements in the form of complex organic products, such as sugar, starch, fat, and other albuminoid bodies, which have first of all been elaborated in the tissues of plants or of other animals. It is thus the possession of chlorophyll, above everything else, which marks off the plant from the animal, and gives a clue to the difficult question at issue.

We have, however, so far only got the length of what may be called an "average distinction." It is found that amongst the lower forms of organic life the presence or absence of green colouring matter has little value as a basis of classification. Certain of the Protozoa, for instance, possess it, while there is a huge order of true plants, viz., the Fungi, numbering about 40,000 species, absolutely devoid of it. The vegetable nature of the latter is, of course, undoubted, yet their mode of life is quite different from that of the other members of the plant world, as they derive their nourishment from decaying organic matter, or from the juices and tissues of other living plants, and do not rely upon the atmosphere at all for their carbon.

With regard to the Bacteria a similar difficulty arises. They also possess no chlorophyll wherewith to utilise the carbon of the atmosphere, and the nature of their occurrence shows that they feed on the products of decomposition of plants and animals, physiologically speaking, very much as animals do. Their nutriment is of a very complex nature, consisting of the albuminous and other substances which form the bodies of plants or animals, or which are excreted from them. These they break up into simple salts and gases, which become diffused into the soil and into the atmosphere, as we have already seen. Their function is therefore chiefly an analytic one. Yet it has been recently shown by Winogradsky and others that certain Bacteria are capable of the opposite action, namely, of building up out of simple chemical compounds others which are more complex. On the roots of all Leguminous plants are found little tubercles, which contain colonies of Bacteria; and one function of these is to take up free nitrogen from the air and out of it to form salts, which these plants can utilise as food. This, however, must only be considered as an exceptional phenomenon. The general fact remains that the Bacteria resemble animals in their mode of nutrition, and for that matter they might well be classed amongst the lowest forms of these, were it not that they possess other important characteristics which are found to point strongly to an affinity with the vegetable kingdom. In order to understand the grounds for this conclusion, it will be necessary to look more closely at certain of these characteristics, which are both of a morphological and physiological nature, and have been the subject of much recent investigation.

III.

Besides the nutrition of the individual organism, there are two other important functions which every living plant or animal must exercise. These are the multiplication of the species, and its distribution in space. Amongst the higher orders, we find much intricacy of mechanism devoted to these ends, and as we descend the scale the variety and beauty of the reproductive processes are no less apparent. Their importance indeed seems to increase with every reduction in the general complexity of the type. In the lowest orders of all these processes are found to hold a predominant place, and to form the real secret of those extraordinary powers of growth, which seem out of all proportion to the seeming feebleness and insignificance of the organism.

The Bacteria, as we have seen, possess this capacity for reproduction in a remarkable degree. Being unicellular organisms, their mode of increase is of the simplest possible description. It consists in the division of the individual Bacterium into two daughter cells, each of which grows into a new Bacterium, similar to the parent cell. The process is known as multiplication by fission, and usually occupies about twenty minutes to half an hour, when circumstances are favourable. The new Bacteria go on multiplying in the same manner through an unlimited number of generations. It has been calculated that in twenty-four hours a single individual could thus reproduce itself seventeen million times; but it is seldom that this tremendous rate of increase can proceed long without interruption. The limitations of space, and especially the accumulation of waste products in the culture fluid, cause a rapid check to multiplication; and, indeed, were it not for another function which the Bacteria possess, they would quickly kill one another by sheer overcrowding. Those Bacteria, however, which can no longer find suitable food, do not necessarily die off. Instead of doing so, they have the power of entering into a kind of dormant condition, in which they can remain until more favourable conditions for growth arise. But as this is an all-important phase of their life-history, it will be necessary to explain t more in detail.

If we examine a clump of Bacilli, such as the common Hay Bacilli, taken from a culture which has reached its highest point of development, we find that many of the individual rods contain a minute highly refractive granule. This is always shorter than the Bacterium itself, but often broader, and therefore may project a little beyond its edges. In other parts of the field some of these granules may be seen lying separate, the Bacterial cell having fallen away as an empty tube. The function of these bodies is a very interesting and important one. It is apparent, in the first place, that they contain the whole of the protoplasm of the Bacterial cell, there being nothing left of the original organism but a mere shell, which quickly breaks up and disappears. They have also something to do with the preservation of the species, because it is found that, on fresh nutriment being added, they have the power of growing again into new Bacterial cells similar to those from which they originated. Their most important function, however, is to facilitate the distribution of the species, and its preservation during adverse circumstances. This they are enabled to do in virtue of their extraordinary powers of endurance, which far transcend those of the simple Bacterial cell. These granular bodies, indeed, are far and away the most resistant living particles known. They can be dried, blown about, or boiled, without losing their vitality; and even after long periods of the roughest usage, they can germinate quite readily on finding themselves in favourable surroundings. It is thus seen how admirably these lowly organisms are provided with the means of surviving in the great struggle for existence. Against all ordinary agencies they are practically impregnable. It is in fact only by the employment of the most powerful artificial measures that their complete destruction can be accomplished, and in many cases all that can be done is to restrict their development within reasonable limitations.

The process which we have just described is known as spore formation. When the granular resisting body arises *within* the Bacterial cell it is termed an Endospore. There are certain other Bacteria, however, in which the process is somewhat different. These show a rather higher development, which consists in the differentiation of the filament into two ends, one of which is attached to some fixed object, while the other is devoted to reproductive purposes. Amongst the cells forming the filament or chain, "certain individuals are found to separate from their connection with the others, and under certain conditions these become the initial members of new combinations" (De Bary). From the fact that no new formation occurs within the protoplasm, but that it is the whole of the latter which participates in the change, these Bacteria are called Arthrosporous in contrast to the Endosporous forms. The Arthrosporous Bacteria appear under the microscope as fine transparent fibres, often branched, and in many cases the individual rod-like cells of which they are composed are not visible without special staining. Certain species are very common, growing upon Algae in stagnant water, and are found also in water pipes, where they form a slimy deposit. These Bacteria have also another method of propagation besides ordinary fission. When their nutrient conditions become unfavourable the filaments break up into a number of minute cocci, which become aggregated into zooglœae, or remain free and acquire motility. These afterwards develop into rods and filaments similar to the original forms. There has been much discussion with reference to the Arthrosporous Bacteria, and their life history and morphology are in many cases far from clear. Whether the term "spore" is really applicable to the separating cells which have been described, and whether these have any analogy to the spores of Endosporous Bacteria, are still points of discussion. The Arthrosporous Bacteria, however, have a special interest with respect to the classification of the whole group of Bacteria; though their real affinity with the Endosporous forms is still considered an open question. But these points will be taken up later on.

IV.

Having now got some conception of the general morphology and life history of the Bacteria as a class, it will be possible to enter more particularly into their relationship with other organisms, and to fix in some degree their classification amongst these. It may be said at the outset, that the task is far more difficult than it would seem from the comparative simplicity of the various types which are concerned. There is no doubt, however, that the Bacteria possess well-marked features, which have great interest from a comparative point of view, at least; and if their exact place in the Natural System be somewhat dubious, a provisional classification amongst other primordial organisms is by no means impossible.

The chief points, then, upon which a classification of the Bacteria is based are somewhat as follows:—

1. The unicellular nature of the individual Bacterial organism.
2. The absence of chlorophyll in the Bacterial cell.
3. The peculiar mode of nutrition of the Bacteria consequent thereon.
4. Their movement by means of flagella.
5. Their mode of propagation by simple fission.
6. Their peculiar mode of forming spores, and the special function of these.

V.

Lying at the very bottom of the scale of creation we have two large groups of organisms, known as the Protozoa, or primitive animals, and the Protophyta, or primitive plants. These are distinguished from all others by the fact that they are essentially unicellular in their structure. They are of the most minute size, being to a large extent invisible to the naked eye. Most of them live in water, or at least require moisture for their growth and development. They propagate by division of the cell into two or more new individuals. In their nutrition they follow the general kingdom to which they belong—the Protozoa feeding like animals, and the Protophyta, which contain chlorophyll, like the higher plants.

It is amongst these primitive organisms that the Bacteria naturally find a place, in virtue of their unicellular structure, their mode of propagation, and certain characteristics which link them to one or other of the two groups. Our task therefore resolves itself into that of comparing the Bacteria with the leading types of Protozoa and Protophyta, in order to determine in what direction their special affinities lie, and thus to show how their proper classification may be attempted in so far as that is possible with our present knowledge of these lower forms of life.

VI.

Let us, first of all, glance at the Protozoa. To these the Bacteria bear a strong resemblance in their mode of nutrition, which is, as we have seen, distinctly animal-like in its nature. Amongst the numerous divisions of this great order, the Flagellata concern us chiefly here. They are so named from their possessing two or more whip-like organs, or flagella, by means of which they can swim about with great rapidity. They are subject to a well-marked process of encystment and spore-formation—sometimes even preceded by conjugation. This encystment is twofold in its object—first, protective; and second, reproductive. The organism can thus preserve itself during periods when the environment has become unfavourable for activity, and is further enabled to break up into fragments or spores, each of which, in turn, can lead an independent life, and grow into a new organism.

The chief analogies between the Bacteria and the Flagellata consist in the possession of flagella, and in their mode of encystment and spore-formation. The Bacteria, as we have seen, are in many cases provided with motile whip-like organs. Sometimes these occur in pairs at one extremity, but in other cases they proceed in large numbers from the whole body of the cell. Bacterial movement may be very active. The organisms can be clearly seen swimming about either singly or in short chains, with a wriggling action; but the flagella are so delicate that they can only be seen after the Bacteria have been killed and stained up by a very elaborate method. As regards spore-formation, the Bacteria, like the Flagellata, enter into a stage of encystment, but the spore when formed has a different function in the two organisms. The Bacterial spore, unlike the Flagellate spore, is in no sense a generative body. It is never formed by conjugation, and it never breaks up into new individuals, but simply reproduces the unit from which it was derived. It is really not a spore, in the strict sense of the term, being simply a resting stage in the life of the Bacterium—a condition of passive endurance (Dauerzustande) into which the organism falls, a mere protective device of Nature to enable it to survive adverse circumstances. The multiplication of the Bacteria is therefore carried on solely by fission, as we have seen, and never by means of spores. This is a very important point to keep in mind.

The main distinction, on the other hand, between the Bacteria and the whole group of the Protozoa consists in the much higher development of the Protozoan cell. It has a well-defined structure, with a nucleus and contracting vacuole, both of these latter being absent in the Bacteria. When we add that the Bacterial spore is essentially different, as we have seen, from that of the Protozoon, the morphological differentiation of the two types is sufficiently clear. There is, in fact, no vital affinity between them, and all that can be said is that they possess certain resemblances in life history and structure.

VII.

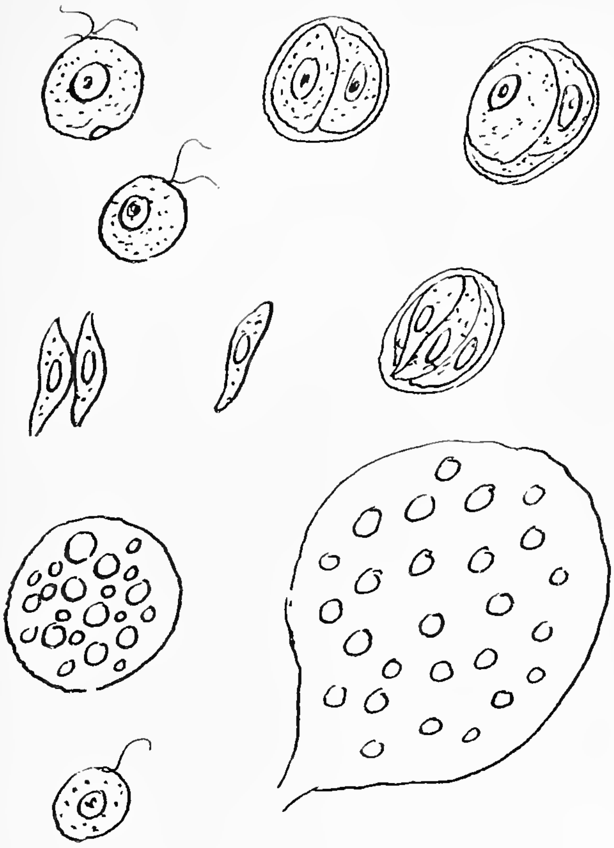
Coming now to the Protophyta, or primitive plants, we have a large class, containing a variety of elementary organisms, and characterised, as a rule, by the presence of chlorophyll. They are, on this account, generally looked on as the lowest division of the Algae, and they have certainly many important affinities with that great group. They are usually divided into two orders*—the Schizophyceae, or fission Algae, and the Schizomycetes, or fission fungi—in other words, the Bacteria. The latter name of Schizomycetes, as will shortly be shown, is an unfortunate one, being a relic of a time when the real nature of the Bacteria was misunderstood. We have in the meantime, however, to consider the Schizophyceae, or fission Algae, and the relation of the Bacteria to these.

The fission Algae are divided into three groups—viz., the Protococcaceae, the Diatomaceae, and the Cyanophyceae, all being unicellular organisms of the simplest possible structure, containing chlorophyll, and devoid of all sexual processes. Reproduction by fission is a universal characteristic, and spore-formation is part of the vegetative life of the individual, and not a sexual phenomenon.

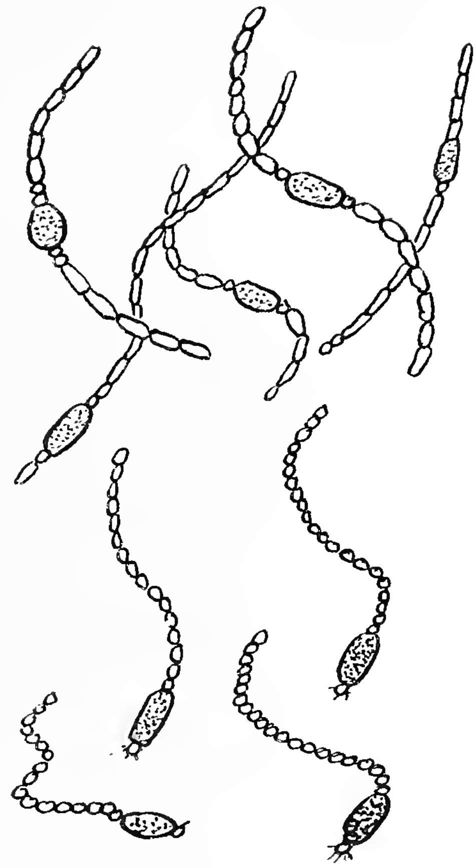
Time will not permit of a detailed examination of the numerous types included in this large order. The Protococcaceae consist of minute green cells, occurring as a deposit on damp walls and tree trunks, or on the surface of pools of water, where they are endowed with powers of rapid movement. They are subject to encystment, the dried-up cells being capable of renewed vitality on meeting again

* Bennett and Murray's classification is here adopted.

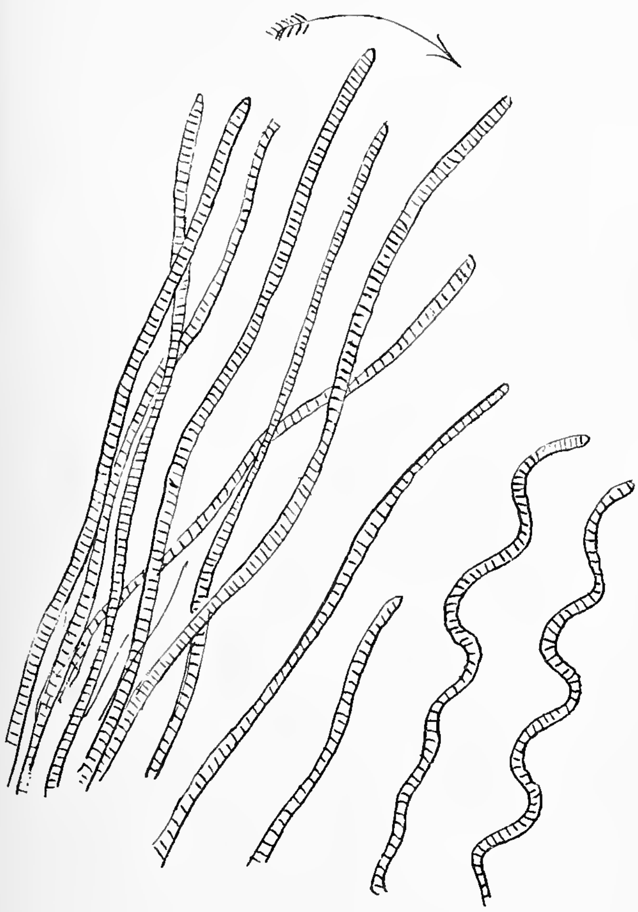
PLATE, II.



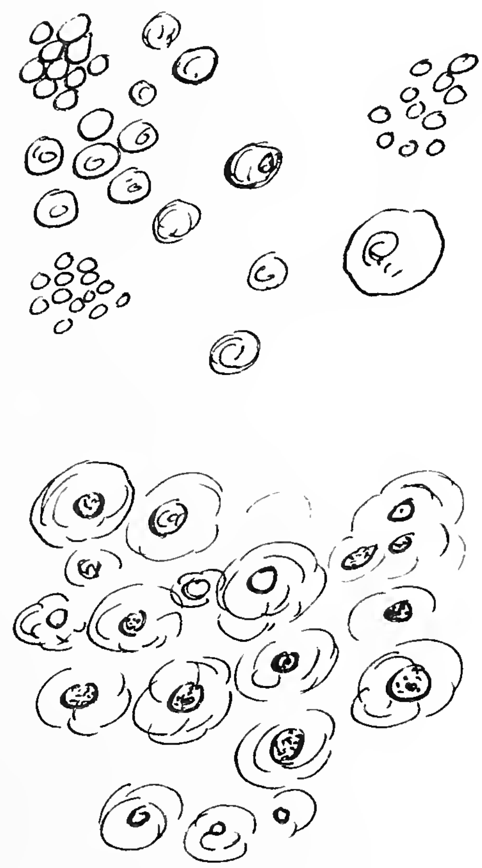
PROTOCOCCUS.



NOSTOC.



OSCILLARIA.



CHROOCOCCUS.

with moisture. The Diatoms are among the commonest and most widely distributed unicellular plants, wherever there is free standing water. They are remarkable for the beautiful symmetry of their forms and for the silicious shells which they leave behind them. They have a peculiar slow movement, the real cause of which has been the subject of much discussion. The spores are produced apparently as part of the process of cell division, and sometimes after conjugation; and they do not serve the purpose of multiplication, but simply grow into new individuals like the parent cells.

The Cyanophyceae require a more minute description. Here the bright green of the chlorophyll is masked by a blue-green colouring matter. Perhaps the best known examples of this class are the Oscillariaceae and the Nostocs, both being very common organisms in our ponds and ditches. They are very simple in their life history, and rank amongst the lowest members of the vegetable kingdom.

The Nostocs are found on damp rocks or soil as a dark green jelly, containing an immense number of tiny threads of cells. Here and there in the filaments are certain clear cells, called heterocysts, and others of a larger size, which are the spores. The organism multiplies in three ways—first, by the spores, which break off and grow into new threads; second, by the separation of portions of the filament, called hormogonia; and third, by ordinary cell division. The Oscillariaceae are still more primitive in their life history. Here the threads have a peculiar slow, oscillating movement, from which the name is derived. They are not known to produce spores, being propagated solely by division and by the separation of hormogonia, like the Nostocs.

Lastly, we have the Chroococcaceae, consisting of isolated cells, often capsulated, but never forming filaments. These organisms are so minute and elementary that very little is known as to their mode of life. Apparently they have no other mode of propagation except cell division. Doubts, indeed, still exist as to whether they are really independent organisms at all, and not merely stages in the life history of certain higher Protophyta, or even Algae. They approach, however, very near to the Micrococci, and hence their interest for us in the present inquiry.

VIII.

When we come to trace the relationship of the Bacteria to the groups which have been described, we are met by the initial difficulty that the Bacteria really constitute a heterogeneous assemblage of organisms, showing a diversity of types, and having apparent affinities in various directions, and also very striking diversities amongst themselves. It may be said, however, that the Bacteria are considered on the whole to bear the closest resemblance to the last-named group, viz., the Cyanophyceae. With regard to the Protococci and the Diatoms, it cannot be said that the Bacteria approach them at all in morphology, both these types being clearly on a much higher plane of structure. The Cyanophyceae share with the Bacteria the distinction of possessing the most elementary life history and cell-formation known amongst living organisms. Propagation by fission and the lack of all sexual processes are characteristics common to both, while the arrangement of cells in filaments and the absence of nuclei are important resemblances. The Arthrosporous Bacteria, according to De Bary, are simply Nostocaceae which possess no chlorophyll, and Cohn has pointed out that they correspond to the Oscillariaceae in their normal form. With regard to the Endosporous Bacteria, all that can be said is that, while they certainly deviate from the Arthrosporous forms in the very important point indicated by their names, yet they come nearest to one another in all the other points of morphological significance, and are the same in their mode of nutrition. There are distinct resemblances, besides, between the Micrococci and the minuter forms of the Chroococcaceae, the presence of a capsule even being a well-known phenomenon in certain Bacteria. The spiral forms of Bacteria (Spirillum or Vibrio) have also a strong likeness to certain twisted Oscillariaceae of common occurrence (Cohn). It must be remembered, however, that mere resemblance, as De Bary has pointed out, may not imply actual affinity; and the Endosporous Bacteria, at any rate, may after all be more closely allied to the flagellate Protozoa. The formation of Endospores finds its analogue nowhere so distinctly as in the spores or cysts which certain members of the latter group develop within their protoplasm; and the power of movement by means of flagella, which both possess in common, is also an important point of resemblance, as we have seen.* The Arthrosporous Bacteria even,

* Professor Fischer of Basel, whose observations on the phenomenon of osmosis in the lowest organisms have thrown much light upon various obscure points of morphology, has recently called attention to the resemblance between the Bacteria and a certain minute flagellate animalcule occurring in dirty water called *Polytoma uvella*. This organism was formerly considered to belong to the Flagellata, but is now found to differ from them in the possession of a distinct protoplasmic membrane, separable by plasmolysis from the contents of the cell. It is therefore related to the Volvox group, and thus affords another link between the Bacteria and the Algae. The motile Bacteria, however, according to Fischer, are not to be considered as derivatives but rather as precursors of the Polytoma species. The non-motile Bacteria, on the other hand, are to be looked upon as progenitors of the flagellated forms, the latter having gained a step in advance through the acquirement of an appliance by which they can compete more successfully in the

with their alternate mode of propagation by swarming cocci, may be said to have an unmistakable likeness to the simpler forms of the varied group of the Flagellata. It will thus be seen how difficult it is to fix definitely the exact place of the Bacteria amongst these primitive organisms, and the problem is complicated by a further relationship which they are supposed to possess to another great class of the vegetable kingdom—namely, the Fungi. This we will now proceed to consider briefly.

The relationship referred to is implied in the name Schizomycetes, or fission Fungi, which was given to the Bacteria by Nägeli at a time when the exact morphology of the Fungi was only imperfectly worked out; and it has since been much disputed. Cohn, as far back as 1853, protested that to say the Bacteria are offshoots from the Fungi is to contradict all trustworthy observations; and De Bary considers that in structure and development the two classes of organisms are as little related as bats are to birds. The word "fungus," however, may be used in several ways. Loosely speaking, it may be applied to all those lowly flowerless plants which are devoid of chlorophyll, and therefore condemned to a parasitic or saphrophytic mode of nutrition. The Bacteria might in this sense be included in the group, in the same way as we might classify bats and birds together as flying animals. But in the more exact nomenclature of systematic descriptive Botany the name fungus signifies an organism with the characteristic form of a mould or a mushroom, and exhibiting peculiarities of structure and development which mark it out from all other types. The members of the fungus group are, of course, all devoid of chlorophyll, but this qualification no more constitutes any given organism a fungus than the possession of a flying apparatus renders an animal a bird. There are certain orchids and other flowering plants, for example, which have no chlorophyll, and consequently lead a strictly parasitic life,* but these could never be looked upon

struggle for nutriment. Fischer further looks upon the Bacteria as "the first and simplest of primitive organisms which by the formation of a membranous encasement have raised themselves above the Amœbae and such like, whose naked protoplasm is exposed to every form of internal pressure or external injury." He adds the warning that the Bacteria ought not too rashly to be placed in the very lowest position of the organic world, merely on account of their extreme simplicity of structure and the absence of a nucleus. They are distinctly on a higher plane than the skinless Amœbae and Rhizopods, and are perhaps the real progenitors of the vegetable kingdom, through their relation to the Volvocaceae and the Algae. With those who will not accept the intermediate group of Protista (see footnote, p. 236) he is, however, quite willing to agree in the prevalent idea that the Bacteria belong to the Protophyta or primitive plants. ("Vorlesungen über Bakterien," 2te Auflage, 1903.)

* *e.g.*, Neottia and Coralliorrhiza (Orchidaceae) and the Monotropeae, &c (Strasburgher).

as fungi. And, on the other hand, there are a few true Bacteria which actually contain green colouring matter, and others which, as we have seen, though devoid of chlorophyll, yet possess the power, like true plants, of building up their structure from inorganic material. Some recent authorities have suggested a similarity between the formation of endospores in the Bacteria and of ascospores among the Ascomycetes* and the Yeasts, two divisions of the Fungi; but these resemblances are not strong enough to constitute a true organic relationship. The absence in the Bacteria of any arrangement of the cells into hyphae or a mycelium, and the general simplicity of their development and reproduction, mark them off too strongly from the Fungi for the admission of any affinity between the two groups; and we are therefore forced to exclude the Bacteria from any place among the latter, notwithstanding their important resemblances in mode of life and nutrition.

IX.

In conclusion, therefore, the Bacteria are to be considered as an independent group, showing relationships in different degrees to various types of primitive organisms. Their nearest morphological affinity is undoubtedly to the Algae, through the connection of the Arthrosporous forms with the Nostocs and the Oscillariaceae, these being really lower-grade Algae; while the whole group is certainly analogous to the Fungi in its physiological aspects, but further than this it has no organic bond of union with the latter group. This is all that can be said in the present state of our knowledge. Some of the most recent authorities,† indeed, will not even go the length of admitting any of the affinities which have hitherto been suggested, but consider the Bacteria to deviate in so many essential characteristics from all other forms of life that a near relationship with any one of these forms is hardly to be postulated.‡ They are thus looked upon by such writers as an isolated group of micro-organisms, lying at the very bottom of the scale of life, and, as far as can be seen,

* *e.g.*, Meyer, cited by Fischer.

† *e.g.*, Schmidt and Weis.

‡ Haekel, for instance, has attempted to cut the Gordian knot by placing them, along with all similar doubtful organisms, in a special group called the Protista, or the "very first." To this group he relegates "all those organisms which show in their external form, in their inner structure, and in all their vital phenomena, such a remarkable mixture of animal and vegetable properties that they cannot with perfect justice be assigned either to the animal or vegetable kingdom." The various members of this group, which include the Monera, Amœbae, Flagellata, Diatoms, Myxomycetes, and Rhizopoda, he further considers "to baffle at present every attempt distinctly to make out their blood relationships with one another, or with the lowest animals on the one hand, and with the lowest plants on the other hand." ("History of Creation," Vol. II.)

showing no indication of having been derived from any other group, or of having given rise to any higher forms in the evolutionary process.

Here, therefore, we must leave the whole question of the classification of the Bacteria in the Natural System until further research may have elucidated new points in their structure and development, and in the morphology of the two great groups of the Protozoa and Protophyta, which will allow of greater exactitude in the comparison of the various types concerned. There is still room for increased investigation into such points as the relation of the two classes of Bacteria to one another, the life history of the Arthrosporous forms, and the possible affinity of the whole group to certain of the lower Fungi. Various details in the habits of the Nostocs and Oscillariaceae also require further elaboration, and there are still doubts which require to be cleared up regarding the true nature of the Chroococcaceae and other unicellular Algae. In the meantime we must be content with the provisional classification of the Bacteria which I have endeavoured to indicate, awaiting the results of further discoveries. Athough present day bacteriological research may apparently be chiefly directed to the medical and industrial aspects of the subject, yet the more special points of morphology which have a bearing on classification are not being neglected. The trend of the most recent opinion, as I have pointed out, is certainly rather towards the reduction of the supposed affinities of the Bacteria to other groups than to the narrowing of the gap between them and their nearest neighbours. It would therefore look as if they were finally to be left in comparative isolation, any affinities which they may seem to possess being shown to be accidental rather than vital. It is more likely, however, that this is a passing phase of opinion. The goal to be arrived at, in the interests of true science, is not their isolation, but the discovery of their true place in the evolutionary scale and their exact relationships to other organisms. That this end will be eventually attained there is no reason to doubt.

BIBLIOGRAPHY.

Flügge—"Die Mikroorganismen," 1896 (various articles by Frosch, Gotschlich, Kruse, &c.)

Fischer—"Vorlesungen über Bakterien," 1903.

Schmidt und Weis—"Die Bakterien; Naturhistor. Grundlage f. d. bakter. Studium," 1902.

De Bary und Migula—"Vorlesungen über Bakterien," 1900.

Cohn—"Untersuchungen über Bakterien," 1875.

De Bary—"Comparative Morphology and Biology of Fungi, Mycetozoa, and Bacteria," 1887.

Muir and Ritchie—"Manual of Bacteriology."
Newman—"Bacteria," 1899 (Progressive Science Series).
Frankland—"Our Secret Friends and Foes," 1897.
Thomson—"Outlines of Zoology," 1900.
Strasburgher—"Text-Book of Botany," 1898.
Bennett and Murray—"Handbook of Cryptogamic Botany."
Massee—"Evolution of Plant Life; Lower Forms," 1891.
Cooke—"British Fresh-water Algae."
Bayley Balfour—"Address in Botany," British Association, Glasgow, 1901.

Huxley and Dyer—	"Encyclopædia Britannica,"	9th Edition.	Article,	Biology.
Ray Lancaster—	,,	,,	,,	Protozoa.
Phillips—	,,	10th Edition.	,,	Algae.
Muir and Ward—	,,	,,	,,	Bacteriology.

XXVI.—*Our Smallest Birds and their Habits.*

By W. Whyte.

(Read 9th April, 1903).

The smallest of our British birds, by reason of their habits, come but rarely under the notice of casual observers, and for this reason I have thought that it might be interesting to give some account of the life history of these delicate and beautiful little creatures. As this paper has no pretensions to be of a scientific nature, but is more a record of personal observations, I purpose dealing with one or two birds, which, although of common occurrence in this district, are, as I have already said, but rarely seen on account of their habits; which is the less to be wondered at as they are the smallest of our British, or in fact of European birds.

The smallest of these is the little Goldcrest. Some authorities would like to class it with the Tits on account of its habits. Others, and with more reason I think, would class it with the Warblers; and in general appearance it much resembles the gentle little Willow Warbler, although it is of a more dumpy or compact build. The Goldcrest has a very wide distribution, being found throughout the whole of Europe, in North-Western Africa, and as far east as Japan. In the British Isles it is of common occurrence wherever there are fir woods. It is what may be termed a partial migrant; and although we may not see any lessening of its numbers in the woods, still during the usual migratory seasons large flocks may be seen leaving and arriving on our coasts. At some of their arrival stations they have been picked up by the hand off the bushes, which they literally covered, so numerous were they; and little wonder they were exhausted when we consider what little resistance their tiny bodies could offer to the rude buffeting of the wind in their long and arduous journey across the Channel, and how many of them must have succumbed while in obedience to that mysterious force which impels them once again to visit our shores and guides them with unerring certainty to the spot where they first saw the light to take their part in the propagation of their species. The Goldcrest is a most sociable little bird in his woodland haunts, and is nearly always found in flocks or parties; nor does he confine his sociability to his own kind, for Goldcrests are generally seen in company with a number of Coal Tits and Tree Creepers. Whether they derive mutual benefit from this association it would be hard to say, but when danger threatens, or it is desirable to shift to some other feeding ground, you hear the shrill "Treen Treen" of the Goldcrest, when the whole company take flight and commence operations about twenty yards farther away. Spending most of their time among the higher branches of the spruce and Scotch fir trees, their presence may be entirely unknown to those who are unacquainted with their call notes, as the thick foliage of the firs entirely conceals their little forms, and even if seen for an instant it is difficult to identify them, so quick are their movements. Theirs may be said to be lives of incessant motion, and if closely watched they may be seen twisting, hanging, climbing, in every conceivable position in search of their insect prey. The domestic arrangements of the Goldcrest are carried on in some fir plantation. The site for the nest is at or near the extremity of some drooping branch of a fir or yew tree, and always under the branch. It works in some of the twigs, which provide for it a safe anchorage as it is wafted about by the passing breeze. The foliage of the upper branch forms a complete covering for the nest, protecting it from the rain and concealing it from its enemies, of whom like every other animal it has some. The nest is cup-shaped, and is composed outwardly of green moss, with sometimes a few lichens, closely felted together with spiders' webs and warmly lined with feathers. The eggs are from six to as many as twelve in number, and are of a whiteish ground closely spotted all over with yellowish brown. The female sits very close while hatching her eggs, and if disturbed displays little fear but hops about in close proximity to the intruder. When the young are ready to leave the nest they do not quit their parents, but form a family group which may keep together till early spring. Sometimes a number of their nests may be found at no great distance from one another, and when we consider the number of mouths they have to fill, and the minute size of the insects on which they feed, we may readily imagine that they will choose some favoured spot where their food is most abundant, so that their journeys to and from the nest may be as short as possible, and that they may the more easily still the clamour of their infant brood. One of the greatest enemies of the Goldcrest is the squirrel. This sprightly little animal has endeared himself to many of us by his frisky and amusing antics, but he is a rascal for all that, and he commits an amount of damage to the shoots of the young fir trees which no amount of friskiness can atone for; and not only that, but like his detested relation the brown rat, he has well-developed carnivorous tastes, and is often caught in traps baited with meat which have been set for cats and weasels. He is also a notorious egg thief, and is by no means averse to a nice fat fledgling. One gentleman observes that one spring a squirrel appeared in his garden and nearly all the small birds' eggs about the place were sucked. Another observer says he found a blackbird's nest in a tree. A squirrel was sitting on the edge of it with its head down in the interior, while the parent bird was scolding and screaming in the most approved Billingsgate fashion. The thief speedily decamped on his approach, and on climbing to the nest he found one fresh egg with two small holes in it and the fragments of some more in the bottom of the nest. On another occasion, while searching a fir plantation, he found fourteen nests of the Goldcrest in about an hour. Only one of these contained eggs, the others had the lining pulled over one side of the nest and contained fragments of shells. This also was the work of the squirrel. This is but a specimen of the evidence against this destructive little rodent, but it will, I think, be sufficient to show him up in his true colours; and when we know that his habitat is the same as the Goldcrest we can imagine the destruction he must cause among these, the smallest of our woodland birds.

The Firecrest is closely allied to the Goldcrest, and is exactly like it in general appearance. Its range of distribution is, however, much more restricted. In the British Isles it is by no means of common occurrence, although in England it has come into notice more frequently than in our more northern land. In a former paper which I read before this Society I mentioned that on one occasion I had seen the Firecrest on Almondside, and, although the pronouncement was received with some doubt, I still maintain that it was the Firecrest, as I am sufficiently well acquainted with the Goldcrest to be able to distinguish the difference at a couple of yards distance and on a level with my face. It was during a prolonged storm about ten years ago, which lasted for several weeks, when the most intense frost prevailed and lochs and rivers were bound in an iron grip, that I saw a small flock of Goldcrests leave the strip of firs which stretches for some distance up the side of the Almond above the bridge and alight on a hawthorn bush which grows in the open. Drawing nearer to watch their movements I could see the pale lemon-coloured crests of the females and the deeper orange-tinted crests of the males; but among them were three or four whose crests were of a brilliant orange red, and calling the attention of my companion we watched them for some time as they busied themselves searching along the smaller branches, now on top, now hanging back downwards until they reached the extremity of the branch, when they hung from the very point, their little wings beating with the rapidity of lightning and their beautiful crests throwing off shafts of golden light in the frosty sunshine. That these birds were Firecrests I am convinced, but science will not accept anything less than the bird itself, and, as I had no means to procure one of them as a specimen, I had to flatter myself that I was understudying Emerson and learning to know the birds without a gun. The habits of the Firecrest are similar to those of the Goldcrest, and for that reason need no further notice here.

The Tits belong to the genus *Parus* and are a rather numerous family, embracing some forms with which we are quite familiar, some which are not so familiar, and others which rarely if ever visit the district. The two best known are the Great and the Blue Tits. The Great Tit, as his name implies, is the largest of the family, and is easily recognised by his strongly-marked colouring. The crown, forehead, and sides of the neck are of a rich glossy black, the back is of a blue gray colour, whilst the underparts are of a yellowish green, with a broad black stripe from the throat to the vent. This bird has, I think, the greatest variety of call notes of any that I know, and will often confuse an expert as to its identity. The nest is generally built in holes in trees, and the materials are dry grass, feathers, and some rabbit's fur. But it is sometimes constructed in the deserted nest of the Crow or Magpie, and then it is a well-built dome-shaped structure. A nest of this kind was got last year in the Woody Island. The eggs have the usual Tit markings, and number from six to ten.

The Blue Tit is so well known that it is hardly needful to give him much notice here. His bright plumage and fearless character bring him under constant notice, and in winter he will come into the centre of the town in search of crumbs which he knows are placed on the window sills for hungry birds, and a piece of fat or a bone is a special tit-bit for him. For a nesting site he shows a partiality for holes in dykes or walls, or in the crevices about stone bridges.

The Coal Tit is not so common as the last-mentioned bird, and as its habitat is in the fir plantations, which skirt the bleak moorlands, it comes less frequently under notice. It is more subdued in colour than the others, except for the black head and the white patch on the nape of the neck, but is even more active in its habits. Dixon thus writes of the Coal Tits—"Perhaps their actions, though somewhat resembling those of the Titmice in general, are more rapid than the other members of the family. You sometimes see them dart through the foliage with great rapidity, apparently in sportive glee. There is scarcely a tree or a bush that the Coal Tit does not visit; now hanging from the long pendant branches of the graceful birch, now searching the thorny sprays of the hawthorn, now on the topmost branches of the oak or ash, then onwards to the drooping elm, now on the lowly branches of the hazel or elderbush, then the evergreens are visited in turn, and even the ivy on the ground is frequently explored. A favourite place to see the Coal Tit is on the spreading branches of the fir-tree, notably those which are studded with cones. There you see him dexterously ejecting the tiny seeds from their scaly bed, the bird very often clinging to the extremity of a slender twig, and its active motions causing the branch and its living burden to sway backwards and forwards, like the steady beat of a pendulum. A merry little party of wanderers they are, and busy themselves with their own affairs alone." When the sun nears the western horizon, the Coal Tit, if it be winter time, repairs from the verdant branches of the evergreens to roost or seek shelter in the warm side of a haystack, always choosing the side opposite to the direction from which the wind is blowing. The principal food of the Coal Tit is insects, but it also feeds freely on seeds. It is partially migratory, and during the usual seasons numbers of them are seen leaving and arriving on our shores. In its nesting habits it has the usual preference of the Titmice for holes in trees, but does not confine itself to these, and may often be found at the roots of the hedges, at the foot of a decayed post, or in a hole in the ground, just like a mouse. The nest, like those of the other Tits, is loosely put together, and of the same materials. The eggs are from six to eight in number, and of the usual Titmouse colouring.

The Long-tailed Tit is, I think, the most interesting member of this family. It is fairly numerous in this district, and has the usual clinging habits of the other Tits, but differs much from them in general appearance. Its plumage is more varied in colouring, and it is more mouselike in appearance, even to the length of the tail, than any of the other Tits. What useful purpose this long appendage performs in the general economy of the birds it would be difficult to say; but to watch them while in search of their food one is apt to think that it is more of an encumbrance than of any practical use to a bird of such active habits. Like the rest of their family, they are incessantly in motion, and though gregarious in their habits, they confine this trait to their own sphere, and generally to their own family party. They may thus be observed in the winter working their way along the hedgerows, a happy little family, minutely inspecting each nook or crevice that might conceal the insects on which they feed, or twittering among the branches of the tallest trees; they go through most amusing antics while ever moving on, until one flies to another tree, and the others follow, resembling nothing so much with their long tails and undulating flight as a party of pigmy Wagtails. In early spring these family parties become broken up, the units which composed them are scattered, each seeking to form relations of a more tender nature with some member of another family of their own species. In short, the lovemaking season is approaching, and each one is apprised that he or she will have to look out for a little mate, and take part in those domestic arrangements which form such an interesting part of their lives. The nesting habits of this little bird are of special interest. The nest itself is one of the most exquisitely beautiful of any bird. It is a rather bulky structure, and has secured for the bird the local name of Bottle Tit and Oven Builder from its oval shape. It is composed of green moss, felted together with spiders' webs, and beautifully studded all over with silvery lichens. It is most profusely lined with feathers. One authority states that he has counted no less than two thousand feathers in the lining of one nest, and I have seen one that had been pulled to bits, with feathers so numerous, that, if they had been put loosely into an ordinary felt hat, they would almost have filled it; and yet the building of this wonderful structure is done by the female bird alone. But one may ask, what in the meantime is the partner of her joys and sorrows doing while she is planning, carrying the materials, and building what is to be the home of their prospective offspring? Is he bringing food to her while she is carrying on the building operations, or does he assist her in any way? I have watched this interesting function, which takes fully a fortnight to complete, and I can safely say that he always seemed to be doing nothing, and he did it exceedingly well—I mean that I never saw him do any useful work, although to all appearance he was as busy as his partner. Every journey she takes for fresh material he was in close attendance, returning with her, and cheering and chittering, and passing about as if he were inspector of works instead of a partner in the business, and as if he was encouraging her by voice and gesture, and telling her that she was getting on nicely, and if she hurried up that she would soon be finished. Which seems very selfish of him, no doubt; but we need not judge him harshly, for he was performing the part which had been allotted to him by nature. The nesting site is generally in the fork of a bush or small tree, and so nicely is the nest fitted in, and so closely does it resemble the lichen-covered branches, that they appear to separate at the top instead of at the bottom of the nest, which looks like a continuation of the main branch. The entrance to the nest is on the side, but near the top, and is nearly always decorated with a number of gaudy-coloured feathers, which protrude from the hole. This arrangement, which seems to have received but little notice from ornithologists, must serve some useful purpose; and as we know that the long tail of the sitting bird, which cannot be disposed of in the usual way, is carried along her back, and the end protruding from the entrance, this may be a device of the bird to hide this portion of her anatomy from the vulgar gaze. The eggs of the Long-tailed Tit number from six to eight, sometimes even ten, and are invariably pure white, with sometimes a spot of red here and there. When the young leave the nest they take to the surrounding branches, and may be seen sitting all in a row expectant little balls of feathers, while their parents flit backwards and forwards, conveying a crumb of comfort to each waiting little mouth. The bird, like many others, is exceedingly local in its selection of a nesting site, and I have known a pair to build for three successive years in the same tree. The third year the nest was destroyed when almost completed, when the bird began again to build on the same tree, but on a different branch. This nest also was destroyed before the eggs were laid, and not until then did the pair leave this favourite spot; and although the building of this beautiful structure cost such an infinite amount of labour, I have no doubt that they persisted in their efforts, and let us hope successfully, in fulfilling their destiny, and reared their little brood in safety, where the prying eyes of the schoolboy failed to find it.

We cannot omit the Common Wren from this list of our smallest birds, although his habits are pretty well known. He is such a quaint little customer with his upright tail and his perky inquisitive habits that one cannot help liking him. The Wren is seldom seen in the open; his habitat is among the dense undergrowth of ferns and brambles, or among the gnarled and twisted roots under the overhanging banks. He is like a little ball of feathered energy; never for an instant at rest, he flits along with quick jerky movements among the brambles or brackens picking up his insect food as he goes, sometimes resting on the topmost spray to trill out his shrill, joyous, vibrating song, often leaving his perch and finishing it during his short rapid flight. The Wren is the most cosmopolitan of any bird in his selection of a nesting site. Any place that suits his fancy will do; an old boot, a flower pot, the pocket of an old coat, a crevice in the wall, under the bank on the ground, among the ferns, and sometimes in a haystack, and almost in every case the outside material corresponds with its surroundings. If it is in the bank it is embedded in it and not easily detected; if it is in a beech hedge it is like a ball of decayed leaves; if in a haystack the outside is of hay. The nest is built by the female, but the male assists in carrying the material for its construction. The eggs are from six to eight in number, and are white with an occasional red spot. When the young leave the nest they accompany their parents and quickly adapt themselves to their business. When alarmed the mother draws her family together and they disappear under the bank, but if you watch quietly a little head pops out and, as if satisfied that there is no immediate danger, she will slip along one of the root strands and fly away "churring" all the time. Then one by one her quaint little family appear from the friendly shelter, and sitting all in a row, a comical little group, they hear their mother calling from the adjoining cover, where they speedily rejoin her.

The birds dealt with here remain with us all the year, and if anyone wishes to gain an intimate acquaintance with these little creatures he must learn their different call-notes, as the thick foliage of the trees among which they live conceals their little forms, and one might be among a flock of them and not know of it unless acquainted with their calls.

XXVII.—*The Horizon from Corsiehill.*

By JOHN RITCHIE, LL.B.

(Read 11th April, 1903; revised to 15th October, 1903.)

LIKE many others, the writer was for a long time deeply interested in the fine view of mountain summits which is to be seen from almost any part of the high ground near Perth, and he did his best to identify the hills which are visible. At last, after many hill excursions and much scrutiny by the aid of maps and field-glass, it became possible to make out practically all the peaks which were to be seen from a selected view-point, viz., Corsiehill, and as it seemed desirable to record the results obtained, and to give others the benefit of them, it was decided to make a sketch of the horizon visible from Corsiehill, and to have it erected on a stand there. The writer made a rough sketch of the hill outline—a great number of points were marked in this sketch, and their position accurately determined by the use of the theodolite. A corrected sketch was then made, and after many efforts to obtain as exact an outline as possible, a final drawing was prepared, and set up at Corsiehill on 7th July last. The writer is very much indebted to a friend who assisted him by taking the measurements by the theodolite, and by making the final drawings. He is deeply conscious of the imperfections in his own attempt to accurately represent many of the hill outlines; but on the small scale which it was necessary to adopt, it was found almost impossible to copy the shapes of the mountains as they appear to the eye.

The printed matter accompanying the Chart gives most of the information required for the view from Corsiehill; but it has been suggested that it would be of some interest to members of the Society to have a record of the hills seen from *(a)* Perth Bridge; *(b)* a point further to the east—*e.g.*, Murrayshall Hill; and *(c)* a point to the west—*e.g.*, Craigie Knowes. The following notes are accordingly submitted as to the range of view from these points, and while the variation in the appearance of the hills from these several positions is considerable, there will be no difficulty in making out the various summits by the aid of the Chart.

(*a*) Perth Bridge.

The range of hills seen from the Bridge extends from Carn Chois, in the south-west, to Ben Bhuirich, in the north-west. The highest mountain visible is Beinn a' Ghlo (Carn nan Gabhar), 3671 feet; the most distant is Beinn Dearg, 38 miles. From a position about the middle of the Bridge (at the protection railings), the following guide lines will indicate the situation of a number of the hills and glens:—

Carn Chois—Over Atholl Street.

Beinn Chaonaidh—Over corner of Rose Terrace and Atholl Street. Very little of this mountain is seen, and it is difficult to identify it, except when it is marked out from the ridge in front by the snow on its summit.

Sma' Glen—Over Perth Academy.

Meall Reamhar and *Meall nan Caorach*—Over Barossa Place, beyond Craiglea Slate Quarries.

Little Glen Shee—Over Balhousie Castle.

Beinn Dearg—In the extreme distance, between Birnam Hill and Ben Vrackie. Best seen when covered with snow in early summer.

Carn Liath (*Beinn a' Ghlo*)—Over Fishers' Lodge. This summit has the appearance of being completely separated from the remaining three peaks of the same mountain on account of its being seen over the shoulder of Ben Vrackie. The other peaks are easily identified, as is Ben Bhuirich.

A hill is seen to the right of Ben Bhuirich, and over Springland, but it is in a nearer range, and is of no great height.

(*b*) Murrayshall Hill.

This hill is only 918 feet in height, but the view from the top on a clear day is extremely fine. There are few Scottish hills of the same altitude from which a more extensive view can be had. The Chart will be found of service in identifying the mountains which can be seen, but the following summits may be noted, as they are not visible from Corsiehill:—

**Meall nan Tarmachan* (3421 feet) near Killin—Sharp peak, seen through Sma' Glen opening.

Ben Lawers (3984)—Highest point shows over centre of village of Scone, almost over Craiglea Slate Quarries.

Meall Garbh—Is seen to the right, almost over Meall nan Caorach.

Cairn Mairg (3419) and the other hills at the entrance of Glen Lyon—Over Little Glen Shee and the shoulder of Meall Dearg.

Schiehallion (3547) is easily recognised by its towering cone. It is an interesting object on the walk to Murrayshall from Perth. It is first seen about the sharp turn to the east, just before we come to Bonhard, and from the entrance to Balcraig it is seen over Bonhard House.

**Ben Alder* (3757)—May be seen on a very clear day just to the right of Schiehallion. Distance nearly 50 miles.

Ben Chuallaich (2925)—North of Kinloch-Rannoch. Round conical top, a little to the right of Tullybeagles Shooting Lodge (Glengar).

Meall Tarruin Chon (2559)—Jagged ridge, to left of Farragon.

Farragon (2559)—This striking mountain is easily recognised by its rounded summit. Like Schiehallion, it is a prominent object on the horizon during the walk to Murrayshall from Perth. It is first seen (through the Glengar opening) as we leave the footpath through the Gannochy fields, and pass into the main road.

Craig Lochie (1700)—Over Birnam Hill.

Cairntoul (4241)—Between Ben Bhuirich and Carn an Righ. Monadh Mor and Ben Bhrottain are, it is thought, seen to the left of Cairntoul.

Tolmount (3145)—At the head of Glen Callater, and about nine miles from Braemar, is seen to rignt of Cairn na Glasha.

Lochnagar (3786)—Another high shoulder of this mountain is now seen to the left of that visible from Corsiehill.

Mount Battock (2555)—On the east side of Glen Esk,—almost over Bandirran House, and through the dip to the left of Dunsinane.

Kinpurney Hill (1134)—At Newtyle. Seen through dip to right of Black Hill.

We catch a glimpse of the North Sea at the mouth of the Tay, and, a little further south, in St. Andrews Bay.

* The writer is not quite certain as to these points, and would be glad to have confirmation from any member of the Society.

Norman's Law (936)—On the south shore of the Tay, a little to the east of Newburgh.

The Mount, with Hopetoun Monument, and *Largo Law* (948), are visible between Norman's Law and Newburgh.

The *East* and *West Lomonds* are too well known to call for any remark.

Ben Cleuch (2363), the highest point in the Ochils, is seen over the summit of Kinnoull Hill.

Ben Lomond (3192)—Peak just showing on the horizon, down Strathearn. This mountain is the most distant point seen from Murrayshall Hill. It is about 50 miles off.

(*c*) Craigie Knowes.

The view extends from Craig Gibbon to the Black Hill. The following guide-lines may be of assistance :—

Craig Gibbon—Over Pitheavlis Castle, on left side of entrance to Glen Gar.

Obney Hill—On right side of Glen Gar.

Carn nan Gabhar—Right of chimney stalk, Tulloch Works.

Glas Tulachan—Over west end of Poorhouse.

Beinn Earb—Peaked hill, over centre of Poorhouse.

Carn Bhinnein—Peaked hill, over east end of Poorhouse.

Carn Geoidh—Seen over left shoulder of Beinn Gulabin.

The Cairnwell—Over west end of Craigie School of Refuge.

Glas Maol—Over St. Stephen's Church.

Cairn na Glasha—Over left shoulder of Mount Blair.

Lochnagar—Over west end of Craigie Public School.

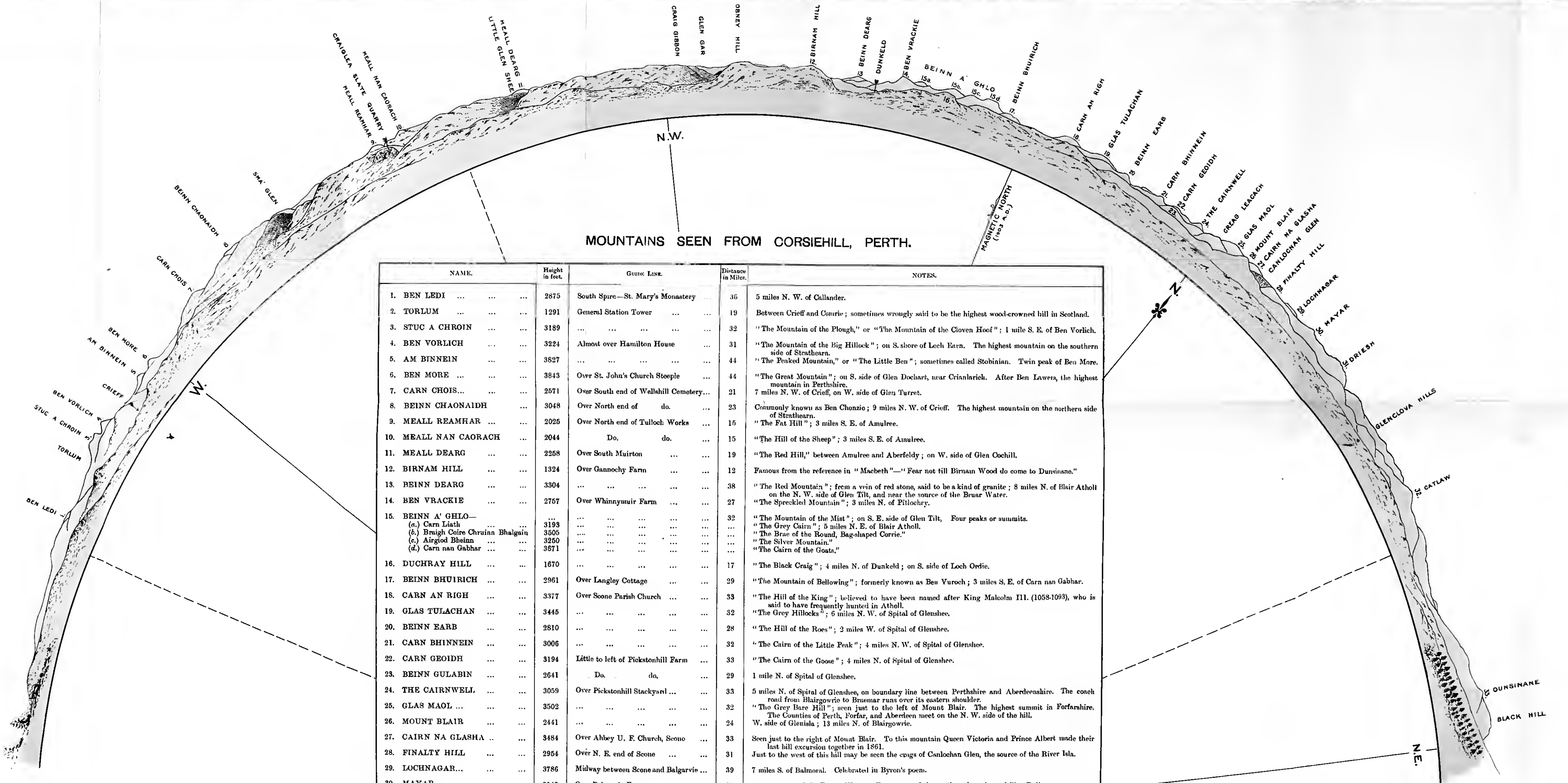
Driesh—Over Caledonian Road School.

Catlaw—Over General Post Office.

Dunsinane—In front of Black Hill.

Black Hill—Over chimney stalk at Water Works.

[This Part, pp. 193–248, published 1st November, 1903.]



MOUNTAINS SEEN FROM CORSIEHILL, PERTH.

NAME.	Height in feet.	Guide Line.	Distance in Miles.	NOTES.
1. BEN LEDI	2875	South Spire—St. Mary's Monastery ...	36	5 miles N. W. of Callander.
2. TORLUM	1291	General Station Tower	19	Between Crieff and Comrie; sometimes wrongly said to be the highest wood-crowned hill in Scotland.
3. STUC A CHROIN	3189	... ...	32	"The Mountain of the Plough," or "The Mountain of the Cloven Hoof"; 1 mile S. E. of Ben Vorlich.
4. BEN VORLICH	3224	Almost over Hamilton House ...	31	"The Mountain of the Big Hillock"; on S. shore of Loch Earn. The highest mountain on the southern side of Strathearn.
5. AM BINNEIN	3827	... ...	44	"The Peaked Mountain," or "The Little Ben"; sometimes called Stobinian. Twin peak of Ben More.
6. BEN MORE	3843	Over St. John's Church Steeple ...	44	"The Great Mountain"; on S. side of Glen Dochart, near Crianlarich. After Ben Lawers, the highest mountain in Perthshire.
7. CARN CHOIS...	2571	Over South end of Wellshill Cemetery...	21	7 miles N. W. of Crieff, on W. side of Glen Turret.
8. BEINN CHAONAIDH ...	3048	Over North end of do. ...	23	Commonly known as Ben Chonzie; 9 miles N. W. of Crieff. The highest mountain on the northern side of Strathearn.
9. MEALL REAMHAR	2025	Over North end of Tulloch Works ...	15	"The Fat Hill"; 3 miles S. E. of Amulree.
10. MEALL NAN CAORACH ...	2044	Do. do. ...	15	"The Hill of the Sheep"; 3 miles S. E. of Amulree.
11. MEALL DEARG	2258	Over South Muirton	19	"The Red Hill," between Amulree and Aberfeldy; on W. side of Glen Cochill.
12. BIRNAM HILL	1324	Over Gannochy Farm	12	Famous from the reference in "Macbeth"—"Fear not till Birnam Wood do come to Dunsinane."
13. BEINN DEARG	3304	... ...	38	"The Red Mountain"; from a vein of red stone, said to be a kind of granite; 8 miles N. of Blair Atholl on the N. W. side of Glen Tilt, and near the source of the Bruar Water.
14. BEN VRACKIE	2757	Over Whinnymuir Farm	27	"The Spreckled Mountain"; 3 miles N. of Pitlochry.
15. BEINN A' GHLO—	...	... ...	32	"The Mountain of the Mist"; on S. E. side of Glen Tilt, Four peaks or summits.
(a.) Carn Liath	3193	... ...	...	"The Grey Cairn"; 5 miles N. E. of Blair Atholl.
(b.) Braigh Coire Chruinn Bhalgain	3505	... ...	...	"The Brae of the Round, Bag-shaped Corrie."
(c.) Airgiod Bheinn	3250	... ...	...	"The Silver Mountain."
(d.) Carn nan Gabhar	3671	... ...	...	"The Cairn of the Goats."
16. DUCHRAY HILL	1670	... ...	17	"The Black Craig"; 4 miles N. of Dunkeld; on S. side of Loch Ordie.
17. BEINN BHUIRICH	2961	Over Langley Cottage	29	"The Mountain of Bellowing"; formerly known as Ben Vuroch; 3 miles S. E. of Carn nan Gabhar.
18. CARN AN RIGH	3377	Over Scone Parish Church	33	"The Hill of the King"; believed to have been named after King Malcolm III. (1058-1093), who is said to have frequently hunted in Atholl.
19. GLAS TULACHAN	3445	... ...	32	"The Grey Hillocks"; 6 miles N. W. of Spital of Glenshee.
20. BEINN EARB	2810	... ...	28	"The Hill of the Roes"; 2 miles W. of Spital of Glenshee.
21. CARN BHINNEIN	3006	... ...	32	"The Cairn of the Little Peak"; 4 miles N. W. of Spital of Glenshee.
22. CARN GEOIDH	3194	Little to left of Pickstonhill Farm ...	33	"The Cairn of the Goose"; 4 miles N. of Spital of Glenshee.
23. BEINN GULABIN	2641	Do. do. ...	29	1 mile N. of Spital of Glenshee.
24. THE CAIRNWELL	3059	Over Pickstonhill Stackyard	33	5 miles N. of Spital of Glenshee, on boundary line between Perthshire and Aberdeenshire. The coach road from Blairgowrie to Braemar runs over its eastern shoulder.
25. GLAS MAOL	3502	... ...	32	"The Grey Bare Hill"; seen just to the left of Mount Blair. The highest summit in Forfarshire. The Counties of Perth, Forfar, and Aberdeen meet on the N. W. side of the hill.
26. MOUNT BLAIR	2441	... ...	24	W. side of Glenisla; 13 miles N. of Blairgowrie.
27. CAIRN NA GLASHA	3484	Over Abbey U. F. Church, Scone ...	33	Seen just to the right of Mount Blair. To this mountain Queen Victoria and Prince Albert made their last hill excursion together in 1861.
28. FINALTY HILL	2954	Over N. E. end of Scone	31	Just to the west of this hill may be seen the crags of Canlochan Glen, the source of the River Isla.
29. LOCHNAGAR...	3786	Midway between Scone and Balgarvie ...	39	7 miles S. of Balmoral. Celebrated in Byron's poem.
30. MAYAR	3043	Over Balgarvie Farm	31	At the source of the Prosen Water. Forms part of the southern boundary of Glen Doll.
31. DRIESH	3105	... ...	31	"The Hill of the Blackthorns"; west side of Glen Clova, and part of southern boundary of Glen Doll.
32. CATLAW	2196	Left of Muirhall Farm	25	6 miles N. W. of Kirriemuir.
33. DUNSINANE...	1012	... ...	7	Site of Macbeth's Castle. See No. 12 above.

Note.—From the road leading uphill past the Inwickers' Ourling Pond and Deuchny Quarry, the following mountains may also be seen:—Ben Lawers (3984), over north end of North Inch; Schiehallion (3547), to right of Meall Dearg (No. 11 above), and Little Glenshee; Farragon (2559), over Glengar; Cairntoul (4241), to left of Carn an Righ. Some of these may be seen from the top of Kinnoull Hill—point north of Stone Table.

J. HENDERSON LITHO PERTH