TRANSACTIONS

OF THE

PERTHSHIRE SOCIETY OF NATURAL SCIENCE.

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Page 168, line 13 from top, or "1860" read "1861."
Page 176, line 11 from top, insert reference number "6" after "Sir A. Geikie."

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AND

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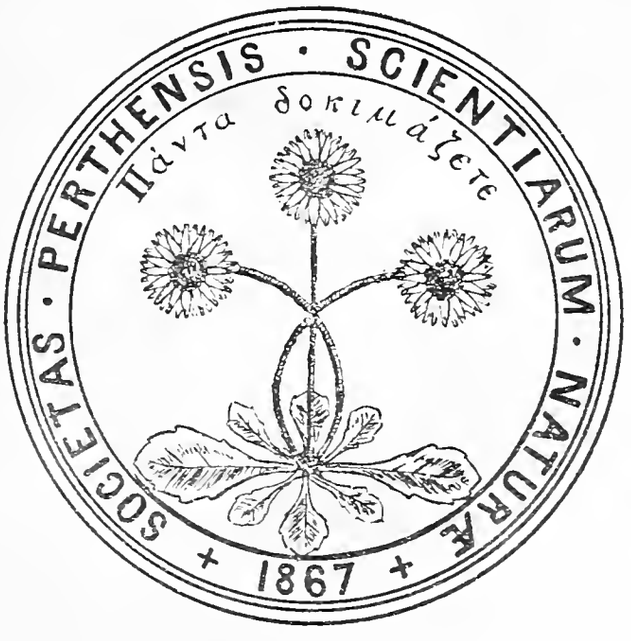

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TRANSACTIONS

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I.—*Outcrop of Diabase at Rossie Priory.* By R. Dow.

(Read 14th December, 1893.)

The Sidlaw Hills throw a flood of light upon the forces of nature at work during the Old Red Sandstone period. Whilst on the one hand that system was being slowly deposited by the action of water, another force came into play to give variety to the monotonous process. Volcanoes seem to have broken out through the sandstone, and to have spread their ejected molten material on the bed of what must have been an inland sea. In the intervals of quiescence between these outbursts the sandstones, grits, and conglomerates were deposited over the volcanic layer, hence that alternation of sandstone and igneous rock so characteristic of the Sidlaw range generally. Out of this mass of volcanic and sedimentary deposits the familiar features of the Sidlaws have been channelled and chiselled by the ordinary forces of nature. These have cut up and carved the range into peak and crag, ravine and den.

This well-known range extends in a north-easterly direction from Kinnoull Hill into Forfarshire, keeping parallel with the strike of the sedimentary deposits of the Old Red Sandstone. From Kinnoull Hill (729 ft.) to the King's Seat (1235 ft.), the highest peak of the range, the distance is nine miles. The range maintains a fairly uniform breadth of three to four miles, but in the vicinity of the border line between the counties of Perthshire and Forfarshire it suddenly contracts in breadth to half these dimensions. The range continues still eastwards, and thins out to its termination towards the centre of Forfarshire. In the great natural recess formed by the thinning down of the range is to be found that small corner of our county which forms the subject of this short paper.

To use a common expression of the tourist guide-book, all who travel from Perth to Dundee by road, rail, or river, cannot fail to be charmed by the varied and beautiful scenic display of the Braes of the Carse, and no fairer spot meets the gazer's eye than Rossie Priory, nestling at the foot of the wood-crowned Rossie Hill.

The Cathedral-looking Priory, from every point of view, is a striking landmark, and a decided attraction to the whole of the eastern portion of the Braes of the Carse. Rossie Hill, so conspicuous a landmark from its isolated position and its wooded slopes, backed by the barer Sidlaws beyond, forms the southern boundary of what might well be termed a basaltic plateau. This plateau, partly on and partly within the confines of our county, is rectangular in general outline, and covers an area, roughly calculated, of nine square miles. From Rossie Hill it extends northwards for some five miles into the parish of Fowlis-Easter.

This basaltic plateau stands quite distinct and apart from the Sidlaws, for it is almost entirely surrounded by the Old Red Sandstone. It is, indeed, an igneous island in the midst of an aqueous deposit. The plateau is cut into two almost equal portions by the stream which has carved out the romantic Den of Balruddery, a spot dear to the local geologist, for it is in this den that many of the fossil fish of the Old Red Sandstone age have been found. A fine collection of these is to be found in Lord Kinnaird's private geological museum at Rossie Priory. The Balruddery Burn has cut quite down through the overlying basalt into the sandstones beneath. The basalt is to be observed at many points resting on the underlying sandstones, thus proving that the overlying plateau must have been laid down after and not during the deposition of the Old Red Sandstone, as in the case of the Sidlaws. If further proof were required to demonstrate that this deposit is younger than the Sidlaws, it could be found in the fact that detached portions of the plateau are to be found in the Sidlaws themselves, and forming detached hillocks, or caps, resting on the underlying porphyrites, as at Littleton Hill and Tinkle Top. Castle Huntly is also situated on another of these isolated caps.

Whilst it can be demonstrated that the rock of Rossie Hill was erupted subsequently to the deposition of the Old Red Sandstone, it is a difficult problem to state when the eruption actually took place. It is highly probable, however, that it took place during the latter part of the Old Red Sandstone age, and it may have been as late as carboniferous times, when our coal beds were being slowly and silently deposited. During the whole of that epoch we have ample evidence of great volcanic activity. A glance at a geological map will at once show that the coalfields of Scotland, and specially of

Fife and the Lothians, are everywhere capped by volcanic rocks; and, whilst there is little to prove, there is as little reason to doubt, that the volcanic hills of this corner of Perthshire may be contemporaneous with the volcanic eruptions of Fife and the Lothians. It is not at all improbable that the plateau once extended over a much wider area—an area, perphaps, which covered a great part of south Forfarshire,—as the same rock forms the basalt outcrops of the Law and Balgay Hills of Dundee and all the more prominent hills for miles around the city. The basalt caps may be only the remnants of what was once one great and universal igneous deposit.

Just behind the wooded hill of Rossie is a romantic little hollow through which the Huntly burn flows. In this hollow, and by the banks of the stream, nestles the sequestered little village of the Knapp. At the upper end of the village there has existed for many years what is known for miles around as the Knapp Quarry. The quarry is situated on the hill slope about 300 yards off, and higher than the burn. It has been worked for a long time for "road metal," so that it is cut well back into the hillside. Stone-crushing works on an extensive scale were erected last summer, an account of which appeared in the *Dundee Advertiser* at the time. The means of transport from the quarry above to the works below is Hodgson's system of wire-rope transport. This consists of boxes suspended on an endless wire rope supported on a series of pulleys resting on posts. At the quarry above a shed has been erected, in which is a large and powerful drum, attached to which are the strong steel wire ropes. Down the hillside, between the quarry and the works below, two lines of rails have been laid, on each of which runs a steel waggon attached to the ropes. The force of the loaded waggon is sufficient to raise the empty one. In the stone-crushing machinery motive power is supplied by water and steam. By means of the waggons and ropes 76 tons or 76 cubic yards of "metal" can be supplied per day.

To the student of field geology a visit to the Knapp Quarry presents geological features, a knowledge of which cannot be acquired from an inspection of hand specimens, any more than the architecture of a building could be told from a few hand specimens of the stone employed in its construction.

In the district which has Perth for its centre the basaltic rock necessary for the maintenance and repair of our highways is worked from no less than 37 quarries. The quarries are, with few exceptions, found in the trap dykes so common in the district. In the Sidlaw district these trap-dyke quarries, which, by the way, are geological ages younger than the Sidlaws themselves or the rock of the Knapp Quarry, are worked at Corsiehill, Muir of Durdie, Pepperknowes,

Balthayock, Pitroddie, Abernyte, Fingask, Kilspindie, Craigneb Evelick, and Dogballo.

An inspection of the Rossie Quarry presents some points of interest which may be noticed. The quarry is situated on an exposed upland, and hence has been subjected to excessive decay in its upper portion. The dark green rock underneath is overlaid by a weathered crust, 30 feet in depth, and in some parts the percolating water has penetrated to still greater depths. The silicates of the rock may on these upper portions be observed in all the stages of decay from the friable earth to the true rock underneath. Now, an inspection of the rock mass of the trap dyke in the Corsiehill Quarry shows the dominant divisional lines which all igneous rocks naturally form when contracting in a horizontal position—that is, at right angles to the cooling planes.

Again, an inspection of the Rossie Quarry will at once show that the rock is differentiated from such eruptive rock as the trap dykes, so common in Perthshire and the Tay valley, by the system of prismatic joints. The position of these joints, by which all volcanic rocks are traversed, is often sufficient to indicate whether a rock is intruded as a dyke or neck or erupted on the surface as a lava flow. These cooling planes, or joints, start from the cooling surface inwards. In an erupted mass they will be perpendicular to its upper and under surface, while in a dyke they will be horizontal when the dyke is vertical. The trap dyke to be seen in Corsiehill Quarry presents these horizontal cooling planes to perfection. The cooling planes of the Rossie Rock are perpendicular, or approximately so. In blasting, the rock mass gives way along these joints, and some parts of the quarry are perpendicular and smooth like the painted wall of some huge building. To designate the face of the quarry as painted is no figure of speech or exaggeration of facts. The basalt is very rich in olivine, and in the course of ages the decomposition products of the whole rock mass, but chiefly of the constituent olivine, have been deposited along these joints, just as the silicates of an agate, or Scotch pebble, are deposited as a decomposition product on the inside of the round steam vesicles of the porphyrites.

As already stated, along the vertical joints, or cracks, water has percolated for ages, carrying with it in solution the mineral constituents of the rock itself. These constituents may be deposited as a segregated mass or left as a crystallized incrustation on the cavity walls. The joints so filled with these segregated minerals serve to fill up what would otherwise be empty veins. The decomposition products serve to bind the rock together with a crystalline cement produced from its own decay, and so prevent the whole rock mass becoming a ruinous heap from earth movements. It is a matter of

daily observation that Nature hastens to cover over and heal up the scars inflicted by the operations of man on her fair face; the same law is applicable to the scars and rents inflicted by the giant hand of Nature on herself.

The decomposition product found so abundantly in the Knapp Quarry consists of a variety of serpentine, a silicate of magnesia derived from the disintegration of the augite, but principally from the olivine present in the basalt. This product is quite soft, and may easily be scratched by the finger nails. It produces a white powder which does not effervesce with acids; on fresh specimens the rock has a peculiar polished surface. It has the same unctuous or oily touch as steatite when rubbed by the hand. The lustrous surface slowly tarnishes on exposure to the air. Talc, soapstone, and meerchaum have a somewhat similar composition, with a difference in the quantity of the various mineral constituents.

When so much internal decomposition has been going on ever since the rock appeared, it must differ considerably from such basalts as we find in the trap dykes where little or no alteration has taken place. To differentiate a basalt such as has been described when the silicates, especially augite and olivine, have undergone a long decomposing process, the name diabase has been applied. As popularly known, a basalt and dolerite have the same constituents. In the case of a basalt the component minerals are too fine grained to be separately determined except by the aid of a microscope; a dolerite is a coarser basalt, in which the minerals can be recognised with the naked eye; a diabase is an altered dolerite. Many of our lavas of early geological times are to a large extent diabase. The greenish serpentine coating sometimes assumes a fibrous structure, forming the mineral picrolite, a fibrous variety of serpentine.

A few veins of calcite fall to be noticed. These are of abnormal thickness in some cases, and of great persistence in the rock mass. In one part of the quarry a series of perpendicular calcite veins extend from the top to the base of the exposed rock. The calcite is removed in solution by permeating water; it may either be a foreign product brought from above or at a distance, or it may be the result of decomposition in the rock itself. In some of the veins the two precipitations of calcite and magnesia are seen to have gone on contemporaneously; in others the chlorite has failed to entirely fill up the vein, but the deposition of calcium carbonate has followed and has completely filled up the entire cavity.

At the base of the quarry the rock consists of a very coarse-grained dolerite, with a macro-crystalline structure; the large elongated pinkish crystals are plagioclase felspar. On fresh unweathered faces the crystals appear as glassy strips or rods, on which may be

detected by the lens, and often by the unaided eye, a fine parallel striation, an unfailing test of this felspar. The rock has a reddish appearance; this is owing to the oxidation of the iron in the rock. It is quite common to find rocks with a reddish tinge on exposed surfaces, as at Salisbury Crags at Edinburgh. The rock, under certain conditions of light, has quite a fiery appearance, although the rock is of the usual steel-grey colour beneath the surface. The rock, however, of the Knapp Quarry has this reddish tinge throughout its entire mass as well as on exposed surfaces, showing that the alteration has penetrated into the rock.

To those members of the Society who are fond of field geology this portion of our county forms a unique field for observation. It is the only locality in the whole of the county where basalt rock is found at the surface as a rock mass on a large scale, and it presents many landscape features which you will fail to detect in the softer rock comprising the Sidlaws proper.

II.—*The Hemiptera-Heteroptera and Hemiptera-Homoptera, together with a list of species occurring in Perthshire.*

By T. M. M'Gregor.

(Read 8th Feb., 1894.)

So little is generally known about these sub-orders of the Hemiptera that it may be well to describe in brief outline the characteristic features peculiar to them, to explain what the respective terms signify, and to glance in passing at their habits and life history.

The term Hemiptera is applied to that order of insects comprising bugs, plant lice, &c., and signifies "half wings," being derived from the Greek *hemi* (half) and *pteron* (a wing). This name was doubtless suggested by the appearance of the front wings, or elytra, of the sub-order Heteroptera, which are coriaceous at the base and membranous at the apex.

The word Heteroptera signifies "diverse wings," from the Greek *heteros* (diverse) and *pteron* (a wing); and it is to the members of this sub-order that the appellation "Bug" is usually applied. They are chiefly characterised by the membranous extremities of the wings, which overlap each other. The neck is more or less distinct, and the head usually prominent, while the rostrum, or beak, arises from the front part of the head. The legs are slender, and sometimes very long, being formed respectively for running, jumping, swimming, &c.

Familiar examples of the Heteroptera are the common water-striders, locally known as "blind fiddlers," &c.

The various kinds of house and field bugs, which all belong to the Heteroptera, are said to give out a strong and disagreeable smell, and many of them such as the *Pentatomidæ*, *Lygæidæ*, *Reduviadæ*, *Nepidæ*, and *Notonectidæ*, live entirely on animal juices, and to obtain their food destroy great numbers of noxious insects.

The name Homoptera (Greek *homos*, same, and *pteron*, a wing) signifies "same wings," the elytra of this genus being uniform throughout, and not membranous at the apex only, as in the Heteroptera.

Some species have the wings coriaceous or beetle-like in texture throughout, whilst others have them entirely membranous, as in the case of the *Cixiidæ*. When these insects are at rest, the wings usually slope roof-like at the sides of the body, and do not overlap as in the Heteroptera. The Homoptera are also characterised by the absence of a neck, while the rostrum arises from the hinder part of the lower side of the head; the legs are formed for jumping, and are clothed with strong spines, which greatly assist them. From their habit of leaping, springing, or jumping, they have undoubtedly derived the name of "frog-hoppers."

The terms Hemiptera-Heteroptera and Hemiptera-Homoptera, then, simply signify "Half-winged diverse wings" and "Half-winged same wings."

The term "bug" is often widely applied to any insect which creeps or crawls. To an entomologist, however, the name is always distinctive of an hemipteron.

The order Hemiptera is a most important one, and includes many insects injurious to vegetation, while some, such as the cochineal, china-wax, and lac insects are distinctly beneficial; these latter, however, belong to the Coccidæ.

The metamorphosis of the Heteroptera and Homoptera is incomplete, that is to say, the larvæ and nymphs are active, and similar in appearance to the mature insect, except that they are devoid of wings, or possess them only in an imperfect form. There are some species, however, which do not possess wings in the adult form. Both the larvæ and the nymphs absorb nourishment in the same way as the perfect insects.

A distinguishing characteristic of all bugs is the possession of a pointed beak or rostrum, of a hard, horny substance, which serves the double purpose of piercing and sucking. This beak consists of four jointed bristles, enclosed in a fleshy, jointed sheath; this sheath is usually four-jointed, and is never composed of more than that number of segments. The beak is also used as a means of offence, and is apparently a most effective weapon, some authorities affirming that a

wound inflicted by our common back-swimmer, *Notonecta glauca*, is much more painful than the sting of a bee or wasp.

Bugs are usually regarded as repulsive creatures, our common house-bug (the *Cimex lectularius* of science) being undoubtedly the cause of this prejudice, for loathsome and repulsive it certainly is; but it must be borne in mind that many bugs are very beautiful indeed, and their life history worthy of patient study.

Our most familiar examples of the Homoptera are perhaps the Cercopidæ, better known as the spittle insects or "froghoppers." The latter appellation has, says Professor Comstock, doubtless grown out of the fact that formerly the froth was called "frog spittle;" and was supposed to have been voided by the tree-frogs from their mouths. The name is not, however, inappropriate, for the broad and depressed form of our more common species is not unlike the form of a frog, while their habit of jumping is very similar.

These insects pass their whole lives on the plants, on the stems of which their eggs are laid in the autumn. The following summer they are hatched, and the young immediately perforate the bark with their beaks and begin to imbibe the juice. Of this they take such quantities that in certain species it oozes out of their bodies continually from different points in the form of little bubbles, which soon completely envelop the insects.

We are indebted to Buckton for a good illustration of this peculiarity of expelling the plant juices at different points of the body, in *Aphrophora spumaria*.

From this habit the name of "cuckoo spits" is often applied to them. The larvæ remain concealed inside these masses of spume until they have completed their final transformation.

When the nymph is about to undergo its change into the perfect insect it ceases to discharge the juice in the form of spume, and then emerges from its concealment.

If we take the trouble to examine one of these frog-spittles, in the centre of the spume will be found a curious looking creature with a head peculiarly like that of a frog. This is the larva of a cicad, and the spume in which it is enveloped is simply the expelled plant juices used as a protection.

"This salivary excretion does not appear to be acrid or injurious "to the plants punctured by them for food, otherwise vegetation "would suffer more from the many thousands of cuckoo spits which "drain our green produce."—*Buckton.*

Most of the British species complete their metamorphosis in a single season, but little has been done in working up their life history, so that there is much need of wide study and patient research.

To the collector of Hemiptera one thing is pre-eminently notice-

able, perhaps more so than to the student of the more elevated branches of entomology, and that is the amazing wealth of hidden life in Nature, a fact which time and again brings us face to face with the problem as to why and wherefore such countless numbers of living creatures are called into being. Under stones and amongst shingles, by streams and rivers, by loch and tarnside, under moss and dead leaves, at roots of grass, amongst dead and decaying vegetation, in almost every conceivable place, we find the same prodigal profusion of life.

Like all Nature's secrets, however, this profusion is only revealed to the patient searcher and ardent collector. It is really very wonderful how easily some insects, and especially Hemiptera, can be overlooked by the novice. Time and again hunting-grounds have been visited without success, when the subsequent discovery of certain habits has revealed the species looked for in large numbers.

The work of preserving such minute creatures is naturally a laborious one, especially if they are to be preserved in the popular way. For this purpose the insects are mounted on small pieces of pure white cardboard, upon which is first put a dab of specially-prepared gum, on which the specimen is placed and allowed to remain a few minutes. The antennæ and legs are then carefully brought into position with a fine camel-hair brush, after which a pin is passed through the card. A small label is then affixed, upon which is written the date and locality, when the specimen is ready for the cabinet.

To prepare these insects for scientific examination is a much easier process, the insect being simply gummed sideways upon the card, in order to allow of all the generic and specific characteristics being seen to the best advantage.

From the long list of species recorded from Perthshire it will be seen that our county is rich in Hemiptera, as indeed we feel confident it is in all other orders, were they only worked up to advantage.

Passing on to the actual list of captures during the past two summers, I find that in 1892 about 100 species of Heteroptera were found, all being collected within a radius of ten miles of Perth. A list of these insects, together with a list of the whole species hitherto recorded as occurring in Perthshire, appeared in the issue of the "Annals of Scottish Natural History" for October, 1893. Amongst the insects collected were many species hitherto recorded only from Rannoch and Pitlochry, while some are new to Perthshire, and others have not been previously recorded from the north. The recurrence of such insects as *Elatophilus nigricornis*, H. S., of which we have only one previous record, by Professor Reuter in 1876, from Moncreiffe

Hill, and *Plesiodema pinetellum*, Zett. (also recorded by Reuter), is of much interest. In addition to these, we are pleased to note the occurrence of an extremely rare bug, *Bothynotus pilosus*, Boh., which is only previously recorded in Scotland in 1865, in which year some specimens were taken by the Rev. T. H. Marshall on the hills between Loch Long and Loch Lomond.

Last year (1893) the list of the previous year's occurrences was supplemented by 15 species of *Heteroptera*, amongst which are many interesting forms, seven being new to Perthshire, while three are new to Scotland.

It is also worthy of note that three additional specimens of *Elatophilus nigricornis*, H. S., were procured, and that *Plesiodema pinetellum*, Zett. (of which only a single specimen was procured in 1892), was found in some numbers.

In regard to the Homoptera, we are not aware that anything has ever been done in Perthshire to this group, although in Buckton we find an occasional obscure note of Perthshire as a district in which certain insects have occurred. This occurs so seldom, however, that we may safely assume our district to be practically unworked.

Probably Mr. Jas. Edwards, in his new work upon the Homoptera, may be able to record some *bona-fide* occurrences.

Fully fifty species of these insects were collected in 1892, and in the summer of 1893 we were able to add four additional species to the list.

The total number of species of both sub-orders which have been collected in Perthshire during the past two seasons is therefore 115 Heteroptera and 55 Homoptera—170 species in all, out of fully 700 British species. Herewith is published a complete list of those insects which have been found in Perthshire up to date of publication.

We are indebted to Mr. Edward Saunders, F.L.S., and Mr. James Edwards, F.E.S., for the naming of these insects.

A LIST OF THE HEMIPTERA-HETEROPTERA AND HEMIPTERA-HOMOPTERA KNOWN TO OCCUR IN PERTHSHIRE.

By T. M. M'Gregor.

[Reprinted from "The Annals of Scottish Natural History," Vol. II., 1893, p. 213, and Vol. III., 1894, p. 99. Revised and brought up to date.—January, 1895.]

HETEROPTERA.

Sehirus biguttatus, Lin.—Pitlochry (Norman); Loch Rannoch (Marshall).

Pentatoma baccarum, Lin.—Kinnoull Hill, in April, on Hesperis and Verbascum (Dr. F. Buchanan White).

Piezodorus lituratus, Fab., Stål.—Perth, on broom and furze, in autumn (Dr. F. Buchanan White).

Tropicoris rufipes, Lin.—Perthshire (Dr. F. Buchanan White).

Picromerus bidens, Lin.—Perthshire (Dr. F. Buchanan White).

Asopus punctatus, Lin.—Kinnoull Hill, in May, upon blaeberry (Dr. F. Buchanan White); Rannoch (Marshall).

Zicrona cœrulea, Lin.—Muir of Durdie (?) (Dr. F. Buchanan White).

Acanthosoma dentatum, De Geer.—Pitlochry (Beaumont), August-September; Ardargie, September, three specimens off birch. *A. interstinctum*, Lin.—Pitlochry (Beaumont), August-September; Ardargie, September. Common on birch.

Berytus Signoreti, Fieb.—Perthshire (Norman).

Nysius thymi, Wolff.—Perthshire (Norman); Stanley, July; one specimen.

Stygnus pedestris, Fall.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September. *S. arenarius*, Hahn.—Banks of Tay below Barnhill (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September.

Peritrechus luniger, Schill.—Moneydie; Forres; Minkie Moss, October, under bark.

Trapezonotus agrestis, Panz.—Bankfoot, August; one specimen off heather by sweeping.

Drymus sylvaticus, Fab.—Kinnoull (Dr. F. Buchanan White); Aldie, by Methven; and Bankfoot. Not common. *D. Brunneus*, Sahlb.—Rannoch (Marshall). Pitlochry (Beaumont), August-September.

Scolopostethus affinis, Schill.—Rannoch (Dr. F. Buchanan White). *S. decoratus*, Hahn.—Fairly common.

Gastrodes abietis, Lin.—Kinnoull and Moncreiffe Hills, in winter, in spruce cones (Dr. F. Buchanan White); Pitlochry (Norman). *G. ferrugineus*, Lin.—Woody Island.

Piesma quadrata, Fieb.—Banks of Tay at Invergowrie, in April, under stones (Dr. F. Buchanan White).

Derephysia foliacea, Fall.—Minkie Moss (Dr. F. Buchanan White).

Monanthia cardui, Lin.—Common on thistles. *M. humuli*, Fab.—At Quarrymill Den (Dr. F. Buchanan White).

Hebrus ruficeps, Thoms.—Minkie Moss, amongst sphagnum (Dr. F. Buchanan White).

Velia currens, Fab.—Very common.

Gerris rufoscutellata, Latr.—Pitlochry (Norman). *G. costæ*, H. S.—Loch Rannoch (Marshall); Pitlochry (Norman); Perthshire (M'Lachlan); Birnam (Dr. F. Buchanan White); Aldie, by Methven, May, one specimen; Hills above Dalguise, several specimens. *G. aspera*, Fieb.—Pitlochry (Norman). *G. lacustris*, Lin.—Almond; four specimens. *G. odontogaster*, Zett.—

Rannoch (Dr. F. Buchanan White). Common on pools at Methven Moss.

Ploiaria vagabunda, Lin.—Pitlochry (Beaumont), August-September; Minkie Moss, September, six specimens off Scots fir.

Nabis flavomarginatus, Scholtz.—Loch Rannoch (Marshall); Pitlochry (Norman); Stanley; Methven Moss. *N. limbatus*, Dahlb.—Rannoch (Dr. F. Buchanan White). Fairly common throughout Perthshire. *N. ferus*, Lin.—Perth (Dr. F. Buchanan White); Bankfoot, August, three specimens. *N. rugosus*, Lin.—Almond, June. Fairly common.

Salda saltatoria, Lin.—Rannoch (Marshall); Pitlochry (Beaumont), August-September; Minkie Moss, October; var. *vestita*.—Linn of Campsie, July; one specimen. *S. C.-album*, Fieb.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September; Almond, May to October. Common. *S. orthochila*, Fieb.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September. *S. riparia*, Fall.—Rannoch (Marshall, Rye). *S. scotica*, Curt.—Rannoch (Dr. F. Buchanan White, Marshall); Birnam (Dr. F. Buchanan White); Perth (Reuter); Pitlochry (Beaumont), August-September. Common. *S. Morio*, Zett.—Shores of Loch Rannoch (Marshall). *S. littoralis*, Lin.—Rannoch (Dr. F. Buchanan White). *S. cincta*, H. S.—Minkie Moss, October. *S. elegantula*, Fall.—Perth, March (Dr. F. Buchanan White).

Ceratocombus coleoptratus, Zett., var. *muscorum*, D. and S.—Minkie Moss, August.

Cryptostemma alienum, H. S.—Tay shingles (Dr. F. Buchanan White); Linn of Campsie, July. Not uncommon.

Cimex lectularius, Lin.—Perth (Dr. F. Buchanan White).

Temnostethus pusillus, H. S.—Widely distributed, and fairly common.

Elatophilus nigricornis, H. S.—Moncreiffe Hill (Reuter). One specimen on *Pinus sylvestris* (1876). Kinnoull; Stanley; Aldie, by Methven; three specimens. Rare.

Anthocoris confusus, Reut.—Common and widely distributed. *A. nemoralis*, Fab.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September; Perth. Common and widely distributed. *A. sarothamni*, D. and S.—Perth (Reuter); Stanley, July; one specimen. *A. sylvestris*, Lin.—Rannoch (Dr. F. Buchanan White); Perth. Common and widely distributed.

Petraphleps vittata, Fieb.—Woody Island, June-July, spruce.

Acompocoris pygmæus, Fall.—Rannoch (Dr. F. Buchanan White); Perth. Common on Scots fir.

Microphysa pselaphiformis, Curt.—Dunkeld, on juniper (Dr. F. Buchanan White); Rannoch (Marshall).

Myrmedobia tenella, Zett.—Minkie Moss, June.

Pithanus mœrkeli, H. S.—Rannoch (Dr. F. Buchanan White); Aldie, Stanley; two specimens; July.

Miris calcaratus, Fall.—Perth. Widely distributed and fairly common. *M. lævigatus*, Lin.—Perthshire (Dr. F. Buchanan White); Ardargie, September; four specimens. *M. holsatus*, Fab.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September; Perth. Widely distributed and fairly common. *M. longicornis*, Fall.—Pitlochry (Norman); Rannoch (Marshall).

Megaloceræa ruficornis, Fourc.—Rannoch (Dr. F. Buchanan White); Perth. Fairly common.

Teratocoris viridis, D. and S.—Rannoch (Marshall); Perthshire (Norman).

Leptoterna ferrugata, Fall.—Rannoch (Dr. F. Buchanan White); Perth. Common and widely distributed. *L. dolobrata*, Lin.—Glenfarg, July; five specimens.

Monalocoris filicis, Lin.—Perthshire (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September.

Bryocoris pteridis, Fall.—Rannoch, on lady-fern (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September.

Phytocoris populi, Lin.— Rannoch, on hazel (Dr. F. Buchanan White); *P. tiliæ*, Fab.—Minkie Moss, September, five specimens; var. *marmoratus*, D. & S.—Pitlochry (Beaumont), August-September. *P. longipennis*, Flor.—Perth (Reuter); Minkie Moss, September; one specimen. *P. dimidiatus*, Kb.—Kinnoull, Almond, Minkie Moss. Fairly common. *P. pini*, Kb.—Pitlochry (Norman); Dunkeld; Minkie Moss (Dr. F. Buchanan White); Bankfoot. Common.

Calocoris striatellus, Fab.—Kinnoull, Minkie Moss, Almond. Not uncommon. *C. sexguttatus*, Fab.—Stanley. Common in Glenfarg in July. *C. bipunctatus*, Fab.—Common and widely distributed. *C. Chenopodii*, Fall.—Almond, July; two specimens. *C. roseomaculatus*, D. T.—Rannoch, on low plants near water (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September; Bankfoot, July; Methven Moss, by sweeping low plants. *C. striatus*, Lin.—Pitlochry (Norman): Rannoch; Perth (Dr. F. Buchanan White); Minkie Moss, July; one specimen off broom by beating.

Dichrooscytus rufipennis, Fall.—Perth. Common on Scots fir.

Plesiocoris rugicollis, Fall.—Pitlochry (Norman): Perth. Fairly common.

Lygus pratensis, Fab.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September; Perth. Common. *L. rubricatus*, Fall.—Bankfoot, August; three specimens. *L. contaminatus*, Fall.—Rannoch (Dr. F. Buchanan White); Perth. Common. *L. lucorum*, Mey.—Perth, July; two specimens. *Var. nigronasutus*.—Perth, July; one specimen. *L. Pabulinus*, Lin.—Perth. Common. *L. cervinus*, H. S.—Rannoch (Dr. F. Buchanan White); Perth. Common and widely distributed.

L. kalmii, Lin.—Pitlochry (Beaumont), August-September; Woody Island, May (Dr. F. Buchanan White); Almond, June; four specimens.

Pœciloscytus Gyllenhallii, Fall.—Pitlochry (Beaumont), August-September; Almond, June, one specimen; Ardargie, September, one specimen. *P. unifasciatus*, Fab.—Pitlochry (Beaumont); Stanley, July; three specimens.

Liocoris tripustulatus, Fab.—Barnhill, February, in hollow stems of Umbelliferæ and Nettles (Dr. F. Buchanan White).

Bothynotus pilosus, Boh.—Pitlochry (Beaumont), one specimen; Bankfoot, July; one specimen. Very rare.

Rhopalotomus ater, Lin.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September.

Strongylocoris leucocephalus, Lin.—Pitlochry (Norman); Rannoch (Dr. F. Buchanan White).

Labops saltator, Hahn.—Rannoch (Dr. F. Buchanan White); Stanley, July; one specimen. *L. mutabilis*, Fall.—Pitlochry (Beaumont). August-September; top of North Inch. Common by sweeping,

Macrolophus nubilus, H. S.—Pitlochry (Norman).

Dicyphus constrictus, Boh.—Perth, on *Symphytum* (Reuter). *D. stachydis*, Reut.—Perth. Common on Foxglove. *D. pallidicornis*, Fieb.—Perth, off Foxglove (Dr. F. Buchanan White). *D. globulifer*, Fall.—Pitlochry (Beaumont), August-September.

Campyloneura virgula, H. S.—Pitlochry (Beaumont), August-Sept.

Cyllocoris histrionicus, Lin.—Pitlochry (Beaumont), August-September: Minkie Moss, Aldie, Kinnoull. Not common.

Ætorhinus angulatus, Fab.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September; Almond; Bankfoot. Not common.

Mecomma ambulans, Fall.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September; Almond; Stanley. Not common.

Orthotylus fuscescens, Kb.—Bankfoot, June. *O. bilineatus*, Fall.—Rannoch, on aspen (Dr. F. Buchanan White); Pitlochry (Norman); *O. flavinervis*, Kb.—Rannoch (Dr. F. Buchanan White). *O. marginalis*, Reut.—Rannoch (Dr. F. Buchanan White); Perth. Common. *O. tennellus*, Fall.—Almond, July; one specimen. *O. nassatus*, Fab.—Rannoch (Marshall). *O. viridinervis*, Kb.—Pitlochry (Norman). *O. concolor*, Kb.—Perth (Reuter). *O. adenocarpi*, Perr.—Perth (Reuter); Almond, July; one specimen. *O. ericetorum*, Fall.—Rannoch (Dr. F. Buchanan White); Methven Moss, August. Common on sallows.

Heterocordylus tibialis, Hahn.—Perthshire (Dr. F. Buchanan White); Aldie; Minkie Moss, July. Common on broom.

Malacocoris chlorizans, Fall.—Rannoch, on hazel and alder (Dr. F. Buchanan White); Minkie Moss, September; one specimen.

Macrocoleus hortulanus, Mey,—Pitlochry (Norman). *M. molliculus*, Fall.—Almond, July; two specimens. *M. tanaceti*, Fall.—Pitlochry (Beaumont), August-September.

Harpocera thoracica, Fall.—Kinnoull; Almond; Minkie Moss, May; three specimens.

Phylus melanocephalus, Lin.—Almond, Kinnoull, Minkie Moss, July and August. Fairly common on oaks. *P. coryli*, Lin.—Rannoch (Dr. F. Buchanan White).

Plesiodema pinetellum, Zett.—Perth (Reuter). Common and generally distributed in 1892.

Psallus ambiguus, Fall.—Rannoch (Dr. F. Buchanan White); Perth. Common. *P. betuleti*, Fall.—Perth, July. Fairly common on birch. *P. obscurellus*, Fall.—Woody Island, June; Perth (Reuter). *P. variabilis*, Fall.—Rannoch (Dr. F. Buchanan White); Perth. Common. *P. quercus*, Kb.—Almond. July; four specimens off oak. *P. lepidus*, Fieb.—Rannoch (Dr. F. Buchanan White); Perth. Fairly common, and well distributed. *P. alnicola*, D. and S.—Pitlochry (Beaumont), August-September. *P. fallenii*, Reut.—Rannoch (Dr. F. Buchanan White); Perth. Not common. *P. varians*, H. S.—Rannoch (Dr. F. Buchanan White); Perth. Common. *P. diminutus*, Kb.—Perth (Reuter). Common and widely distributed. *P. sanguineus*, Fab.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September; Perth. Common.

Plagiognathus viridulus, Fall.—Rannoch (Dr. F. Buchanan White); Perth. Common and widely distributed. *P. arbustorum*, Fab.—Rannoch (Dr. F. Buchanan White); Pitlochry (Beaumont), August-September. Common and widely distributed. *P. pulicarius*, Fall.—Rannoch (Dr. F. Buchanan White). *P. saltitans*, Fall.—Perth (Reuter). *P. Wilkinsonii*, D. and S.—Moncreiffe Hill (Reuter); Minkie Moss, June.

Asciodema obsoletum, D. and S.—Almond, July; two specimens.

Notonecta glauca, Lin.—Common in pools.

Corixa Geoffroyi, Leach.—Almond, August; three specimens. *C. hieroglyphica*, Duf.—Perth, June. *C. Sahlbergi*, Fieb.—Rannoch (Dr. F. Buchanan White); Methven Moss. Common. *C. Linnæi* (var.), Fieb.—Rannoch (Dr. F. Buchanan White). *C. semistriata*, Fieb.—Perth (Reuter); Almond, May, one specimen. *C. venusta*, D. and S.—Almond. Common. *C. striata*, Lin.—Invergowrie (Dr. F. Buchanan White); Almond. Common. *C. distincta*, Fieb.—Perth (Reuter, Dr. F. Buchanan White). *C. mœsta*, Fieb.—Rannoch (Dr. F. Buchanan White); Methven Moss; four specimens. *C. fossarum*, Leach.—Stanley; Almond; six specimens. *C. Scotti*, Fieb.—Rannoch (Dr. F. Buchanan White). *C. Fabricii*, Fieb.—Rannoch; Perth (Dr. F. Buchanan White); Almond, April. *C. præusta*, Fab.—Common at Methven

Moss in August. *C. præusta*, var. *Wollastoni*, D. and S.—Rannoch (Dr. F. Buchanan White); Methven Bog, August; one specimen. *C. concinna*, Fieb.—Perth, May. *C. carinata*, Sahlb.—Dalguise, April. *C. Bonsdorffi*, Sahlb.—Methven Moss, May (Dr. F. Buchanan White).

Sigara minutissima, Lin.—Common at Woody Island.

HOMOPTERA.

Cixius pilosus, Ol.—Almond; Dupplin. Not common. *C. cunicularis*, Lin.—Almond; Glenfarg, July and August. Not common. *C. nervosus*, Lin.—Very common and widely distributed.

Liburnia difficilis, Edw.—Almond, June and July; two specimens. *L. discreta*, Edw.—Almond, July; one specimen. *L. denticauda*, Boh.—Aldie, May; six specimens. *L. limbata*, Fab.—Bankfoot, Minkie Moss, Methven. Not common.

Dicrauotropis hamata, Boh.—Almond, June and July; two specimens.

Stiroma albomarginata, Curt.—Aldie, July; one specimen.

Aphrophora alni, Fall.—Almond, July; two specimens.

Philænus spumarius, Lin.—Very common and widely distributed. *P. exclamationis*, Thunb.—Minkie Moss; common at Bankfoot. *P. lineatus*, Lin.—Common and widely distributed.

Ulopa reticulata, Fab.—Common at Aldie and Bankfoot amongst heather.

Megophthalmus scanicus, Fall.—Minkie Moss, September; one specimen.

Macropsis lanio, Lin.—Common on oak.

Bythoscopus alni, Schr.—Pitlochry (Beaumont), August-September; Stanley, July; five specimens. *B. rufusculus*, Fab.—Fairly common and well distributed. *B. flavicollis*, Lin.—Common on birch, and widely distributed.

Idiocerus confusus, Flor.—Well distributed, and not uncommon on sallows.

Evacanthus interruptus, Lin.—Not uncommon.

Strongylocephalus agrestis, Fall.—Minkie Moss, October.

Acocephalus nervosus, Schr.—Bankfoot and Methven, July and August. Not numerous. *A. bifasciatus*, Lin.—Glenfarg, July; one specimen. *A. albifrons*, Lin.—Minkie Moss, August; two specimens.

Eupelix cuspidata, Fab.—Minkie Moss, August.

Doratura stylata, Boh.—Pitlochry (Buckton); Stanley, July; one specimen.

Athysanus brevipennis, Kbm.—Pitlochry (Buckton); Perth. Fairly common. *A sordidus*, Zett.—Almond, May; one specimen. *A. grisescens*, Zett.—Minkie Moss, June. Fairly common. *A. communis*, Sahl.—Almond; Stanley, June and July; three specimens. *A. obscurellus*, Kbm.—Almond; Bankfoot, August;

two specimens. *A. obsoletus*, Kbm.—Bankfoot, August; two specimens.

Deltocephalus abdominalis, Fab.—Common, and widely distributed. *D. distinguendus*, Flor.—Common, and widely distributed. *D. sabulicola*, Curt.—Stanley, May. *D. striatus*, Lin.—Not common. *D. pulicaris*, Fall.—Bankfoot; Stanley, July and August. Not common.

Allygus mixtus, Fab.—Perth; three specimens.

Thamnotettix prasina, Fall.—Common. *T. subfuscula*, Fall.—Common.

Limmotettix quadrinotata, Fab.—Minkie Moss; Ardargie, August and September. Not common. *L. nigricornis*, J. Sahl.—Bankfoot, June. *L. sulphurella*, Zett.—Almond; Stanley, July; three specimens.

Cicadula sexnotata, Fall.—Aldie; July; two specimens.

Gnathodus punctatus, Thunb.—Stanley, July; one specimen.

Allebra albostriella, Fall.—Common throughout.

Dicraneura variata, Hardy.—Dupplin, September; two specimens.

Kybos smaragdulus, Fall.—Common throughout.

Eupteryx atropunctata, Goeze.—Common throughout. *E. Germari*, Zett.—Kinnoull, July, one specimen; Minkie Moss; common off Scots fir in September. *E. pulchellus*, Fall.—Common in August and September on oak. *E. concinna*, Germ.—Common on oak; August and September.

Typhlocyba sexpunctata, Fall.—Dupplin, September; one specimen.

T. quercus, Fab.—Minkie Moss, September; one specimen.

[NOTE.—*When no authority is given, the insect was taken by myself.*—T. M. M'G.]

III.—*A Mountain Breeding-Haunt of the Raven.*

By Lieut.-Col W. H. M. DUTHIE.

(Read 22nd March, 1894.)

One day in March we left the shore of the loch to which we had driven in the early morning and climbed the hill for the Ravens' Crags. It was one of those ideal days which sometimes follow in the wake of a long wintry storm, a day which combines the sunshine of Italy with the exhilarating air of the Scottish Highlands. There was no cloud in the sky, and no breath of wind was stirred; the ground was hard as iron, and every blade of the crisp grass under foot was incrusted with glittering hoar-frost; the burns and rivulets

were frozen over, and their channels choked with drifted snow, and even the waterfalls were so completely masked by masses of green ice and long icicles that they seemed frozen solid to the rocks, but a soft gurgling sound which came up from under the snow told of water still flowing behind the folds of these icy curtains. In strange contrast to this wintry aspect the sun shone with intense heat, and the grouse sat out on the summits of the knolls rejoicing in its genial warmth.

The first part of our walk was over rough, broken ground, clothed with heather and dotted over with alders and birch trees. The hill then rose abruptly in steep, grassy slopes, with the bare rock protruding through the scanty soil in great perpendicular masses, and in long irregular lines; the summit was crowned by a ridge of precipitous crags, where secure and undisturbed the Ravens have had their abode for untold years. We soon heard the well-known croak of warning, and through our glasses spied one of the birds—a black speck—on a sharp pinnacle of rock near the nest, from which favourite position he had been watching our movements from afar. By the time we had reached the foot of the crags both birds were on the wing, and showed their annoyance at our presence by their constant barking cry, varied sometimes by a deep-toned croak, which was uttered when they alighted on the rocks, and tore up the ground with their strong beaks.

It is a wild place this home of the Ravens, and we clambered with difficulty over the steep ground strewn with huge boulders, and gigantic fragments of rocks lying in chaotic confusion, one upon another, as they have fallen in successive ages from their places in the storm-splintered cliffs which towered above us. A ptarmigan's feather among the stones and the track of a fox on a snow-drift were silent witnesses of its solitude, but all sense of loneliness was dispelled as, with our backs to the crags, we gazed on the glorious and extensive view spread out before us. The snow, which had only powdered the brown, shaggy shoulders of the hills, lay thick on their summits, and far away to the distant horizon peak beyond peak of mountains overlapping one another stood out radiant in their robes of pure glistening white.

Far down below lay the loch, so calm and still, reflecting so exactly every tone and colour, every tree and stone of the mountain above, that it might have escaped notice but for the moving lines of silver, like cracks in a mirror, which the coots and other wild fowl made as they swam on the surface of the water. Shepherds and keepers were burning heather on the moors, and thin columns of smoke rose curling steadily upwards in the still air. There was no sound but the drip of water, the occasional croak of the Ravens, and

sometimes the crash of a large icicle, which, loosened from its hold by the heat of the sun, came tumbling down from the rocks above, and fell in a crystal shower at our feet.

It was a favourable day for observing the strange aërial performances of the Ravens, who seemed to revel in the clearness of the atmosphere, as we did ourselves. We sat and watched their grand and majestic flight as, sweeping in large circles, they soared higher and higher till they became mere specks in the blue of the sky. After gliding for a long distance with wings apparently motionless, they would suddenly drop like falling leaves to a lower level, sometimes turning complete somersaults in their descent; and, continuing their evolutions, they frequently uttered their sharp double note, so like the bark of a dog that the voice of a collie in a distant sheep-farm seemed but the echo of the Raven's cry.

The nest is placed on a ledge within a deep cavity in the face of the precipitous crags, well sheltered from above by its natural overhanging roof. It is a large structure, composed of heather stems and alder branches, some of which are bleached by time and weather. It is repaired every year, and newly lined with fur, wool, and moss, neatly rounded off and smoothened over the rim. This deep warm basin is well adapted to resist the rough weather to which these early breeders are so often exposed, for by the end of February or in early March the eggs are laid. During the period of incubation, which lasts about three weeks, many a bitter blast beats against the Ravens' home, driving the snow and sleet into every crevice of their rocky stronghold, and thick mists settle on the mountains, wrapping them for many days together in a shroud of impenetrable gloom; but the old bird sits on, regardless of cold and storm, impelled by Nature to brood thus early in order that her young may be produced at a time when their food is most abundant.

The young birds remain a long time in the nest before they are able to fly; this may possibly be owing to the fact that the Raven's egg is very small in proportion to the size of the bird. It is a pretty sight to see their first lessons in flight, and to watch the care and anxiety of their parents as they hover near them with steady beat of their wings, sometimes floating below them as if to encourage them in their feeble efforts.

The old birds are very quick to resent any intrusion near their nest, especially after the eggs are hatched. It is no uncommon sight to see the fierce Peregrine driven off by a Raven, and many a boy, when robbing a Raven's nest of its young, has been astonished and alarmed to find how unpleasantly near to his face the infuriated old bird will come in defence of her brood.

No birds are more attached to their breeding haunts than the

Raven. Year after year a pair will return, if permitted, to the tall tree or rocky ledge, and restore the nest which their ancestors have handed down to them; but an ever-widening extent of cultivation and a more rigid preservation of game, which often means the extermination of all animals not included in the game list—these and other causes have of late years tended to drive away the Ravens from many a long-accustomed nesting site. Most of the tree habitations in the British Isles are now tenantless, and only the name as applied to the site—*e.g.*, Ravenswood, Ravensclump, and such like—remains to remind us where once a family of Ravens dwelt. Thus it is that this fine bird is little known and seldom seen in its wild state. Sometimes in the stable-yard of a country inn a poor pinioned creature may be met with, hopping along with its peculiar sidelong gait to peck at a stranger's legs, looking askance with its bright clever eyes as it makes off with a penny to hide in the grass, or perform some trick which it so readily learns; but he who would see the bold flight of the Ravens, and hear in their natural haunts

"the note of death
As through mid air they wing their way,"

must go to our sea cliffs, or to the wild desolate corries of our mountains, where they still hold their own, in spite of much persecution. It is sad that they should be banished altogether from the haunts of men, for, besides being the finest of our crows, they have special claims upon our interest on account of their ancient lineage, the veneration and superstitious awe in which they have been held, and for the rich legendary lore with which their name has been so long associated. From evidence collected from sheep farmers and shepherds they appear to do no harm to the flocks, for, on the very rare occasions when they molest a sheep or lamb, the animal is too far gone to recover.

Even gamekeepers are not unanimous in their verdict of condemnation. There is no doubt that they cannot escape altogether from the charge of sucking eggs—a crime to which all their tribe is addicted, and for which many of them suffer merciless persecution. The carrions and hooded crows are incorrigible offenders, and have no friends. The magpies have paid a heavy penalty, and the jays, those brilliant ornaments of our woodlands, are extinct in some localities where once they were not uncommon. The jackdaws are more fortunate, owing their escape, perhaps, to their inborn impudence. Then, there are the rooks, who do much mischief, every rookery, as is well-known, contributing a small contingent of regular and persistent egg-suckers; but these we preserve. Far be it from me to expose unnecessarily the delinquencies of my bird friends or to favour one at

the expense of another, but I do appeal to the man who likes to hear the cawing of his ancestral rooks to give permission to one pair of Ravens to occupy a tree in his park, should they be inclined to do so.

In the meantime, until some reaction takes place in his favour, the Raven must remain an outlaw. Fortunately, besides being hardy birds, they are shy and crafty, and difficult to trap, and are therefore not likely to be exterminated. Long may they live to give character and interest to our wild corries and misty glens! I have spent many hours in their company, basking in sunshine, or sheltered from storm, among the moss-covered boulders and debris of the hill-side,—

"Alone, when least alone,"—

watching them and other wild creatures who are reared amid the sublime grandeur of our mountain solitudes, where the peregrine, with a mighty rush, dashes across the sky, and the buzzard on broad upturned wings floats among the clouds, and the wild chattering cry of the kestrel is heard as he hovers into sight over the skyline of the crags:—

"I love not man the less, but Nature more,
From these our interviews, in which I steal
From all I may be, or have been before,
To mingle with the Universe, and feel
What I can ne'er express, yet cannot all conceal."

IV.—*The Marine Origin of the Old Red Sandstone.*

By James Reid.

(Read 12th April, 1894.)

The Old Red Sandstone during the last fifty years has been variously regarded by geologists as of marine and of fresh-water origin. Miller, Murchison, and the "old geologists" adhered to the marine view, while Godwin-Austen, Ramsay, and Geikie have favoured the theory of "Inland fresh-water lakes or seas;" and later, Coates and Macnair—in an able paper,* to which we refer—present the latter view in more detail than we have previously met with.

That the geological opinion of the present day is largely in favour of the fresh-water origin of the Old Red Sandstone we are free to admit, yet we have reason to believe that a comparative examination of the Devonian of Europe, the formations of North America, and the Old Red Sandstone of Scotland will reveal the fact that evidence of the strongest kind exists in favour of a "marine origin."

* "The Old Red Sandstone of Perthshire," vide *Transactions*, Vol. I., p. 235.

A marked distinction is observable between the rival theories in question. The "lake" theory, on the one hand, implies a new departure—from marine to fresh-water conditions,—and its inadequacy to account for the introduction and geographical distribution of the fauna of the formation is conspicuously apparent. The "marine" view, on the other hand, presents us with a more unbroken continuity—physical and palæontological—between the formations preceding the Old Red Sandstone in geological time and the Carboniferous succeeding it.

We apply the term "marine" in this connection to shallow salt-water conditions—in a word, to "Devonian sea margins,"—for unquestionably the conglomerates and sandstones of the system indicate shore-lines, and shallow water not far from land.

We propose in the following part of our paper, first, to consider the theories advanced in regard to the origin of the Old Red Sandstone, and, second, to review the Palæontological and other evidence bearing upon the "fresh-water" or "marine" origin.

THE OLD RED SANDSTONE: ITS ORIGIN.

The late Sir A. C. Ramsay and Sir A. Geikie refer to the origin of the Old Red Sandstone in the following terms:—"Before the deposition of the Old Red Sandstone, . . . there is reason to believe that a wide and deep valley already existed between the Grampian mountains and the Carrick, Lammermuir, and Moorfoot range, and in this hollow the Old Red Sandstone was deposited." *

"In the west and north-west of Europe the Silurian sea-bed was upraised into land in such a way as to include large inland basins. . . . In the inland basins of the north-west a peculiar type of deposits termed the Old Red Sandstone is believed to have accumulated.† . . . Similar exposures are to be seen here and there round the flanks of the Cumberland mountains, which were not improbably covered over with Old Red Sandstone‡ and carboniferous rocks as the Lammermuir chain of Scotland was." §

Messrs. Coates and Macnair assume the existence during Silurian times of the great faults occurring on each side of the midland valley of Scotland, which, from the "lake theory" point of view, is justifiable. The striking description of the manner in which the conglomerates of the system were laid down shows how thoroughly, step by step, these authors have thought out their subject. Both in its conception and execution the paper in question is one which merits the closest consideration at the hands of geologists.

* Sir A. C. Ramsay, *The Physical Geol. and Geog. of Gt. Britain.* 2nd Ed., 1854. Pages 48, 49.

† Sir A. Geikie, *Textbook of Geology.* 1882. Page 694.

‡ The Old Red Sandstone here referred to is Upper Old Red Sandstone.

§ *Outlines of Geol. Brit. Isles.* 1876. Page 24. (A. Geikie.)

In our view, however, as we shall subsequently show, the evidence points strongly to a "marine" origin. The Laurentian and Cambrian formations are supposed to have formed a northern continental land, abutting upon which the Silurian, and doubtless the Devonian, systems were consecutively laid down. In the British area the Silurian land apparently culminated in the Grampian range, whose southern base was laved by the waves of the Devonian sea. We know that the depth of the Old Red Sandstone of "Lake Caledonia" exceeds 20,000 feet, which was admittedly formed in a sinking area. Now the theory which requires our belief in an *inland* sinking of the land to this extent, with the sea of the period shut out, seems in our view too strained and improbable for acceptance.

In the Old Red Sandstone of the midland valley of Scotland we therefore appear to have a typical lake basin, and in the extracts above referred to a descriptive account of its origin is given. But if we are to infer that the Lammermuir range on the south side of the basin formed land during the greater part of the Old Red Sandstone period, the evidence is unquestionably against it. That the Lammermuir range, on the contrary, was under water during the greater part of the Old Red Sandstone period is made evident by the following estimate, made by an undoubted authority, of the amount of throw of the great fault which stretches across Scotland from Ayrshire to Midlothian, and by the inference which that authority deduces therefrom:—"From the detailed survey of the Old Red Sandstone it is possible to estimate the amount of throw the fault has here, . . . we know the thickness of that formation to be fully 15,000 feet, and the fault must be a dislocation to that amount at least, . . . so vast a thickness of Old Red Sandstone could not have ended originally where the fault now is, but must have swept southwards over the lower Silurian uplands." *

In these 15,000 feet of deposits we have the equivalent in time of at least three-fourths of the Old Red Sandstone period, and in the deposition of this mass of strata the fact is implied that the Lammermuirs during the same period were, not above, but under the sea.

The southern uplands, unlike the central Grampian range, show evidences—if we may so express it—of an "unstable continental margin" during Old Red Sandstone and Carboniferous times. Corroborative proof of this is afforded in "the south-westward extension of the Silurian ridge of the south of Scotland into Ireland, where it sinks beneath the carboniferous rocks of Connaught." †

To the north of the Grampian range a similar occurrence is seen, where, in the mountain chain skirting the southern borders of Caith-

* Explanation of Sheet 15, *Geol. Survey of Scotland.* 1871. Page 37.

† Prof. Young, Introduction to *Cat. W. Scot. Fossils.* 1876.

ness, Morven, its chief summit (2313 feet above the sea level), is capped with Old Red Sandstone conglomerate.

The upper Silurian of the counties of Edinburgh and Lanark—whose deposits range from 3500 to 4000 feet in thickness—overlies the lower member of the system, and graduates upwards conformably into the Old Red Sandstone *(Geikie)*. On the highland side of the valley the upper Silurian is not seen, but we have reason to believe that a depth of strata 4000 feet in extent could not—in a marine formation—occur as a local deposit. It must have extended along the central valley, graduating upwards conformably into the overlying Old Red Sandstone. The latter—probably by an overlap—is to be seen abutting upon the lower series of the Grampians.

From the foregoing it will appear that in the Old Red Sandstone we have no new departure. The conformable deposition of Old Red Sandstone upon the preceding upper Silurian deposits implies a continuation of, not a change from, similar conditions of deposition.

PALÆONTOLOGICAL AND OTHER CONSIDERATIONS.

The fresh-water origin of the Old Red Sandstone is ascribed to "The character of the strata, the absence of unequivocally marine fossils, the presence of land plants, and of numerous ganoid fishes which have their modern representatives in rivers and lakes."* We have, however, to point out that land plants, ganoid fishes, and marine shells occur indifferently in the Old Red Sandstone and Devonian.

The assumption, so frequently met with, that strata of a *red* colour must necessarily be of fresh-water origin does not appear to be well-founded.

In the Devonian of Russia red sandstones and marls containing numerous Old Red Sandstone fishes occur; while Professor Gosselet "cites the case of the Devonian of the basin of the Dinant, where some beds are in one part red and barren of organic remains, and in another part of the same area are of the usual colour and full of marine fossils. But the red colour of the Old Red Sandstone is general (?), and is accompanied with other proofs of isolation in the basins of deposit."†

Sir W. Dawson refers to marine deposits of a red colour in the process of formation on the coast of Nova Scotia which at low tide extend for miles seaward. The red deposits, it is stated, derive their colour from peroxide of iron. "We have here a perfect instance in a modern deposit of phenomena which we will have to notice in the most ancient rocks."‡

* Sir A. Geikie, *Textbook of Geol.* 1882. Page 706. † *Ibid.* Page 711.
‡ *Acadian Geology.* 1855. Pages 28, 31.

We might refer to the red sandstones and conglomerates of the Cambrian of Wales and the north-west of Scotland, as well as to those of the Devonian of New York (6000 feet in thickness), as deposits rivalling, if not exceeding, in extent similar deposits which characterise the Old Red Sandstone of Scotland.

The injurious effects produced by peroxide of iron upon certain organic remains are referred to by Dr. Hunter as follows:—"Peroxide of iron is also unfavourable to the preservation of organic remains, and may in many cases account for their disappearance. Lately, when examining a few cut corals which had been imperfectly cleaned from this substance, . . I found that the smooth surfaces had in the course of a few hours been largely bitten into." *

The plant remains of Turin Hill (Forfar) occur in the form of pseudomorphs of iron, and if we suppose a dissolving agent of this iron to permeate the strata, we can understand the manner in which all traces of the original plants would disappear. Indeed, in localities where peroxide of iron is present, numerous shreds of fossil plants in the last stage of disappearance are not unfrequently met with.

It may therefore be inferred that the presence of peroxide of iron in the waters of the Old Red Sandstone proved a bar to the entrance of the molluscan fauna of the period, and that adventurous mollusks, braving the unhealthy waters by penetrating therein, paid the penalty of their rashness by utter annihilation.

That recent representatives of the ganoids of the Old Red Sandstone inhabit rivers and lakes is by no means a proof of the fresh-water origin of the latter fishes. The immense interval of time implied by the comparison renders its value somewhat problematical. The salmon of our rivers, whose first appearance dates from the chalk of the cretaceous period, is a case in point. Besides, if we consider that *Polypterus*, *Ceratodus*, and *Lepidosiren* are of world-wide distribution, it is difficult to believe that their present *locations* —namely, the Nile and West Coast of Africa, Brazil, and Queensland—could be reached by fresh-water means. The life-history of these obscure representatives of the "age of fishes" would probably show that they preserved their existence in the "struggle for life" by a successful adaptation to new conditions during the change from marine to fresh-water conditions, while their less-favoured contemporaries succumbed.

THE INTRODUCTION AND GEOGRAPHICAL DISTRIBUTION OF THE OLD RED SANDSTONE FISHES.

With regard to the introduction and geological distribution of the fishes of the Old Red Sandstone, the case of the "lake theory" dis-

* *Trans., Geol. Socy. of Glasgow.* Vol. VIII., Part I. 1886. Page 163.

plays conspicuous weakness. The Eurypterids and Cephalaspidians of the Upper Silurian are in evidence, but of the genera of *Osteolepis*, *Dipterus*, *Tristichopterus*, *Holoptychius*, and other fishes of the Old Red Sandstone, no undoubted plates or scales occur in the preceding formation. The question therefore arises, whence came these highly organised fishes of the Old Red Sandstone? More especially, from what fresh-water region did they migrate? Not only so, but as the same genera of fishes occur in the Canadian formation, we have an equal right to know by what fresh-water pathway of distribution they were enabled to migrate 3000 miles between one point and another. Until a more satisfactory reply than we have yet seen is given to these questions, we shall assume that, in so far as the introduction and geological distribution of the fishes of the Old Red Sandstone are concerned, the "lake" theory is utterly inadequate to account for the one or the other. The simultaneous occurrence of ganoid fishes representing the same genera, and even the same species, in the formations of North America and Britain, and in the Devonian of Russia and other parts of Europe, undoubtedly points to a common source of origin and of geographical distribution, which is strikingly met by an adoption of the hypothesis of a boreal centre of origin, and a southward migration. In this way alone can we satisfactorily account for the adventitious appearance of the fishes of the Old Red Sandstone and Devonian.

LAND PLANTS OF THE OLD RED SANDSTONE AND DEVONIAN.

From the fact that land plants of the same genera and species occur in both the Old Red Sandstone and Devonian of Europe and North America, we are inclined to consider "plant evidence" as of but doubtful value. We should be prepared to find, in a marine formation, littoral deposits richer in plant remains than those of a deeper sea, and such appears to have been the order in which plant remains occurred.

The formation of New Brunswick, Canada, is supposed to afford plants in greater number than elsewhere, yet Sir J. W. Dawson regards it as of estuarine origin. We show a specimen from Campbelltown, which, from the character of its matrix, and the contained crustacean remains, points to a marine origin.

Knorria and *Palaeopteris hibernicus* of the Old Red Sandstone of Ireland occur in the Devonian of Cornwall; *Sphenopteris*, *Lepidodendron*, *Gaspianum*, and *P. hibernicus*, are met with in the Devonian of Belgium and the north of France.* We also find in the Devonian of New York, Pennsylvania, and Ohio, numerous plants referable to

* Sir A. Geikie, *Textbook of Geol.* 1882. Pages 700-702.

P. hibernicus, *Psilophyton*, *Lepidodendron*, ferns, and numerous tree ferns; some of which closely resemble *Caulopteris Peachii* of Caithness. The plants of the Old Red Sandstone of Scotland are, in a large measure, but poorly preserved. In illustration of the doubtful character of some of our Scottish plants, we may instance the case of *Arthrostigma*, which, since 1877, had been doubtfully referred to *Psilophyton* and *Arthrostigma*, till, in 1890, Sir J. W. Dawson recognised *Arthrostigma gracile* amongst some fossil plants from Perthshire.*

That traces of sea-weeds have been met with in the Old Red Sandstone of Scotland is a fact which can scarcely be doubted. *Pachytheca* occurs in the sandstones of Murthly, and in Forfarshire, and the late Professor Page has figured an undoubted fucoid from Roxburghshire, while Nicholson says, "the Old Red Sandstone of Scotland contains a good many fragments supposed to belong to sea-weeds." †

In Gaspé, *Nematophyton*, which has been referred by Professor Penhallow and Carruthers to the *algæ*, has been numerously met with.

MARINE SHELLS OF THE OLD RED SANDSTONE.

The singular fact that no marine shells occur in the red sandstones and marls of the Russian Devonian, although these contain Old Red Sandstone fishes, throws light upon the general absence of similar fossil remains in the red sandstones and shales of the Old Red Sandstone of Britain. Yet traces of the occasional presence of mollusks have been met with. *Serpula* and *Conularia* occur in the Welsh area, and *Orthoceras dimidiatum* (of the passage beds of England), *Spirorbis*, and other fossil remains, have been found in Lanarkshire.

The Silurian genera of Eurypterids and Placoderms, which occur in the Old Red Sandstone of Lanarkshire and Ayrshire in the west, and Bridge of Allan, E. Berwick, and Forfarshire in the east of Scotland, undoubtedly point to the presence of a Devonian sea which spread continuously from one side of Scotland to the other. The limestone deposits of Nova Scotia have been referred to by Sir J. W. Dawson, as follows:—"In other words, they belong to groups of the same age as the Devonian of England and the Old Red Sandstone of Scotland. . . . With respect to the fossils, I may remark that they are all marine; that they belong to numerous genera and species." ‡

"Some of the fine beds (Gaspé) hold shells of *Lingula* and *Modiomorpha* of Hall." §

* *Nature*. Apr. 10, 1890. Page 537. † *Manual of Palæontology*. 1872. Page 521.
‡ *Acadian Geology*. 1855. Page 315.
§ *Report Geological Survey of Canada*. 1871. Page 9.

It therefore appears that, even in the red coloured rocks of the Old Red Sandstone of Britain, marine fossils are not absent, and in the Canadian formation marine shells occur in considerable numbers. We mention the interesting fact, that "a large lamellibranch, closely resembling the *Anodonta* of the Old Red Sandstone of Ireland, is met with in the *Devonian* of New York." *

THE KEY TO THE DEVONIAN QUESTION.

In the interbedded limestones and sandstones of the Russian Devonian, containing marine shells and Old Red Sandstone fishes, we find the key to the true position of the Old Red Sandstone and Devonian. Not only so, but as the fish-bearing sandstones contain no marine shells, we can understand the fact of the absence of molluscan remains in the formation of Caithness.

It is highly probable that the sandstones and shales of the Russian Devonian represent the spawning-grounds of the fishes of the formation, and in certain zones of the Caithness flagstones and shales similar conditions are probably met with. We know that in the spawning season numerous dead fishes are seen in our rivers, and the fact may to a great extent account for the greater number of fishes which occur in the sandstones of the Devonian than in its deep-sea deposits.

The exigencies of the "lake" theory require a sudden covering up of the fishes of the Old Red Sandstone to ensure the high state of preservation in which they occur; but an inland fresh-water lake does not seem to afford an adequate medium for the purpose. It is impossible to conceive the manner in which dead fishes could, in fresh water, be preserved entire during the formation of sandstones and shales, of several feet in thickness, *in a tideless inland lake.* A marine formation, however, presents a striking contrast. The antiseptic properties of salt water would prevent decomposition for a time sufficient to allow the diurnal tides, laden with sand and mud, in their ebb and flow, to cover up immense numbers of the fishes in question, and would likewise tend to their preservation for some time afterwards.

Referring to the Old Red Sandstone of the Moray Firth area, Hugh Miller states:—"A bed of pale yellow *saliferous* sandstone, settled, tier over tier, on a bed of stratified clay, and was itself overlaid by another bed of stratified clay in turn, and this upper bed had also its organisms. . . . Some of the sandstones of the system are strongly saliferous." † To one who has seen the large stratum of

* Sir A. Geikie, *Textbook of Geology.* 1882. Page 706.
† *The Old Red Sandstone.* 4th Edit., 1850. Page 285.

yellow *saliferous* sandstone, interbedded with shales containing Old Red Sandstone fishes, which occurs in the precipice of the burn of Eathie, it is difficult to believe that *both the formation and its contained fishes* were not *marine.*

In conclusion, we have seen that the case of the "lake" theory is largely based upon assumptions which may, or may not, admit of being proved. The occurrence of inland fresh-water lakes, the sudden introduction of numerous genera of fresh-water fishes, the unique character of the strata, and the absence of marine fossil remains have been freely assumed, whilst supporting evidence is conspicuous by its absence.

We have adduced in favour of the marine view facts showing an unbroken physical continuity of the Upper Silurian and Old Red Sandstone formations; and we have seen that in the Devonian of Russia, and elsewhere, *the fishes of the Old Red Sandstone are marine*, while in regard to their introduction and geographical distribution the advocates of the "lake" theory are ominously silent.

In other words, subjective theories, on the one hand, have been met by objective facts on the other.

Finally, we believe that the balance of evidence is decidedly in favour of the view that the Old Red Sandstone and Devonian, in their respective littoral and deep-sea deposits, represent *the one Devonian system, which is marine.*

V.—*Perthshire Entomology.* By T. M. M'Gregor.

(Read 12th April, 1894.)

The science of Entomology has always been a popular study, and Coleoptera and Lepidoptera are pre-eminently favourite groups. It is admitted, however, by competent authorities that in the whole range of entomological science there is no group of insects more interesting than another, and no individual life-history, however humble and obscure, less worthy of observation than that of its fellow.

Butterflies and moths have always been favourites, doubtless because of their conspicuous forms, and the fascination of their gorgeous colouring; and because they are our most familiar forms of insect life. In lanes and meadows, by the roadside, in gardens and woodlands, these "children of the sun" are ever to be met with to brighten our path.

Wild bees, too, are associated with the butterflies in our happy memories; and yet, inseparable as they are, and quite as worthy of

our attention, these have never received from entomologists the same degree of patient research and exhaustive study.

And what can be said of those interesting insects the ants, whose economy is so well known. The Scriptural injunction, "Go to the ant, . . . consider her ways, and be wise," deserves more consideration than it receives; and the researches and experiments of Lubbock and others might be profitably imitated and extended by many thinking minds.

Certainly beetles are and always have been popular with entomologists; but the sight of a *live* beetle, however beautiful, usually creates in most people a certain amount of repulsiveness; and even after the specimen has been securely boxed, and its evident beauties pointed out through the glass lid, there is often difficulty in convincing people that the insect is really worth looking at, a process usually gone through at a safe distance.

And so with the Hemiptera—they are despised and their study neglected by reason of popular prejudice, simply because they are "bugs." We have no doubt that if any one would take the trouble to examine our collection of these insects, they would be pleasantly surprised to find that most of them are far from repulsive in appearance, and that many are exceedingly beautiful.

Where, too, can we find a better example of widespread prejudice than that exhibited towards the common earwig, or "forky-tail?" It is universally regarded as a creeping horror by all but an entomologist, to whom, however, it is particularly interesting, having much to commend it, notwithstanding its well-known destructiveness to plants and fruit. The care of a hen for her chickens is proverbial; and here we have a parallel example afforded us by a lowly and despised creature. When the female has laid her eggs, she does not forsake them, as is the habit of most insects, but sits upon them after the manner of a hen until they are hatched. We have repeatedly pushed the female from her eggs, and she has as repeatedly and persistently returned to sit upon them; and when the eggs have been scattered, she has again carefully collected them together. The care of the mother does not cease with the hatching of the eggs; she leads the young ones wherever she moves, and she continues to remain beside and brood over them with affection for many days. If the young ones are disturbed or scattered, or if the parent is removed from them, she will on the first opportunity collect them again and brood over them as carefully as before. Whether or not she provides for her young as a hen provides for her chickens does not appear to be known; but that she does provide nourishment for them till they are capable of taking care of themselves we may be fully assured.

These and like instances show us that God has invested with many redeeming features even the lowliest of His creatures, and teach us that we should never allow popular prejudice to cause us thoughtlessly to despise what the All-Wise has created.

Most people are familiar with the lovely iridescence of the wings of the common house-fly; with the appearance of a dragon-fly, which shoots past us like a dazzling blaze of light as the sunshine strikes its beautiful, sylph-like wings; and with the form of our familiar friend the grasshopper; but how very few have noticed, or taken the trouble to admire, the surpassing beauty of structure—quite apart from colour—which even the humblest of God's creatures presents to us.

Have you ever noticed the delicate tracery of the wings of a lace-wing—that fairy-like creature with the golden eyes,—or paused to look at the burnished gold of the small copper butterfly as it flits lazily to and fro amongst the flowers at "your feet;" or have you ever been fascinated with the striking colour of a blue or scarlet dragon-fly? These and such like are beauties visible to the naked eye; but there are deeper beauties, which are only disclosed through the lens or the microscope:

> "The shapely limb and lubricated joint
> Within the small dimensions of a point;
> Muscle and nerve miraculously spun:
> His mighty work, Who speaks and it is done."

If people would only take the trouble, next time an insect crosses their path—instead of brushing it hastily away or destroying it,—to capture and carefully preserve it, and examine it through a glass—even for the express purpose of finding out wherein it is repulsive,—loathing and repulsion would be turned into admiration; and should they be tempted to go further, and try to learn something of the life-history of certain insects, the outcome of all would be much wonderment at the adaptation of the individual life to its circumstances, and a deep and profound reverence for the marvellous wisdom of their Divine Creator and Sustainer.

We do not here propose to enter upon any discussion as to the utility or non-utility of the study of entomology, but can only say that, did its utility alone lie in its advantages as an elevating source of instruction, or in the health-giving pleasure of collecting, its claims would be sufficient and complete; and although we know that the collection and preservation of insects is by many regarded as a childish and effeminate pastime, we also know that every hard-working entomologist holds a widely-different opinion.

In our own Society the lack of interest in general entomology,

and the more-painfully-evident absence of working entomologists, is matter for regret; and, whilst we are aware that the Perthshire Society of Natural Science is doing much good work, we are afraid our entomological records are not of the best.

Although much has been done for Scottish Entomology by our distinguished ex-President, Dr. F. Buchanan White, a glance at our collections will show how very far behind we are. Of some orders, indeed, we do not possess a single specimen, and this, too, when the very large addition to our Museum is nearing completion. Surely it is high time we were up and doing!

Were the privileges and advantages of its study made evident, we have no doubt whatever but that the students would be forthcoming. The great obstruction has always been the want of appliances for the determination of species; and now that we are to have a laboratory at our disposal, a step in the right direction would be to have the same fully equipped with a complete set of entomological apparatus, including a thoroughly-good entomological microscope.

Few Societies are better supplied with valuable and admirable works on Entomology than our own, and it is much to be regretted that these lie upon our library shelves almost unopened from year's end to year's end. Surely these volumes are worthy of a little more attention from our younger members, and we would most heartily endorse the hope expressed by our esteemed President, in a recent presidential address, that these younger members, and those who heretofore have taken no active interest in the work of our Society, would now decide to come forward and help us.

Probably our Society may at no distant date be induced to arrange for a series of lectures upon structural, economic, and general entomology, a movement which might prove an incentive to the study, for without an increase in the number of working entomologists, we cannot speedily hope for any very complete records of our native insect fauna.

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It is expected that the New Museum Building will be Opened to the Public early next Winter. Until then only those engaged in the arrangement of the Collections will be admitted.

ANY DONATIONS TO THE MUSEUM WILL BE GLADLY ACKNOWLEDGED.

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1895.

BANKS OF THE TAY AT BALLINLUIG.

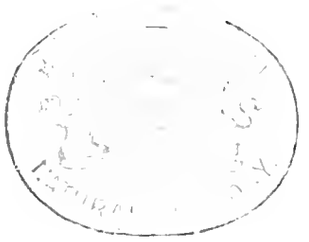
THE

NATURAL HISTORY

OF THE

BANKS OF THE TAY

Being a Series of Papers read before the Perthshire Society of Natural Science.



[*Transactions, Vol. II., Part II.*]

PERTH:
PUBLISHED BY THE SOCIETY,
AT THE PERTHSHIRE NATURAL HISTORY MUSEUM.
1895.

PREFACE.

VARIOUS unforeseen causes have considerably delayed the publication of the following series of papers, which form the Transactions of the Perthshire Society of Natural Science for the Winter Session of 1892-93. They do not, as is usually the case with the Transactions of a Scientific Society, consist of detached papers having little or no connection with each other, but are intended to supplement one another, and, as far as possible, to form a connected whole. Their scope, and the purpose they were designed to fulfil, will be best explained by quoting the remarks of the President, Mr. HENRY COATES, in his Opening Address at the beginning of the Session in which they were read. He said, "They (the Council) have arranged these in the belief that systematic and combined research is likely to give more valuable results than are to be expected from isolated and individual study. It must not be supposed, however, that these papers will be at all final or exhaustive in their nature. It is not possible, and perhaps not desirable, that they should be. In several of the departments they will be merely preliminary reports, laying down the lines upon which future investigation may proceed. It is intended to confine the scope of the papers to the Tay proper, exclusive of its tributaries, from where it leaves Loch Tay at Kenmore to Invergowrie, where it leaves the boundaries of Perthshire. Laterally, the area will embrace the immediate banks, as well as the lowest or most recent river terrace, including, of course, the river itself and its bed."

It is not pretended, therefore, that the present series of papers gives anything like a complete account of the Natural History of the Tay and its banks. Very many blanks remain to be filled up. In the Botany, for example, only the flowering plants have been described; the whole vast field of lower plant life has yet to be entered upon. Not even a beginning has been made in the great subject of Insect life; whilst, in the department of Animal Vertebrates, it is to be lamented that the important section of the Fishes has had to be left out. Much work, therefore, still awaits the members of the Society, but we feel confident that they will face it manfully.

But though they by no means cover the whole field of investigation, the present papers are the result of careful and systematic study, and form a real contribution to our knowledge of the subject. Some of them could only have been written after long years of patient and intelligent observation. It is hoped, therefore, that they will be found to be interesting and helpful by those who take an interest in Natural Science.

WILLIAM BARCLAY,
Editor.

PERTH, *September, 1895.*

VI.—*The Natural History of the Banks of the Tay.*

(Read 8th December, 1892, and 12th January and 9th February, 1893).

1.—PHYSIOGRAPHY.

By Dr. H. R. Mill, F.R.S.E., F.R.G.S., and James Coates.

INTRODUCTORY.

The Tay is the name given to the stream which flows out of the loch known as Loch Tay, and afterwards finds its way past the city of Perth to the sea. But a question naturally arises at the outset whether this may not involve some confusion in nomenclature, and it might be interesting to inquire if the stream at Perth should properly be known by the same name as that which leaves Loch Tay. Suppose an individual to be asked to trace the river from its mouth backwards to its source, what result would probably be obtained? Starting from Dundee in a westerly direction, he would take a northward bend at Perth, and would again turn towards the north-east after passing the mouths of the Almond and the Isla. No doubtful points would occur until he reached Logierait, but here he would find himself at another junction of streams. One of these branches would enter obliquely from the west, while the other branch, of apparently equal size, would come towards him in a straight line with the direction in which he has been proceeding. He would naturally select the latter branch as the main stream, and would follow it to its source, some forty miles or so farther on. It would, however, be found that he had here arrived at the source, not of the Tay, but of the Garry, and to have reached the accepted source, he would have required to follow at Logierait, not the straight, but the oblique branch, until finally he reached the fountainhead on the confines of Argyllshire. Such an error would be a pardonable one, because it is still by no means certain that the name as fixed by local custom and geographers is technically correct, and that it is not really upon the River Garry that our city stands. It is true, that if nomenclature among rivers be a matter depending upon length, and length alone, then the recognised river has the chief claim, its length from source to Logierait being 55 miles, as against 40 for the Garry. On the other hand, if directness of course be of the first importance, then the Garry is not without a claim to carry its name to the ocean. For the purpose of the present survey we must accept the river as prescribed to us by those who have, with or without authority, acted as its sponsors, and we must therefore look upon the streams of the Garry, the Tilt, and the Tummel, however important in their combined volume, as forming merely a tributary of the Tay. In strict physical reasoning we should consider rather the volume than the

length of the constituents of a river system as the most important factor, and the system should be viewed as a whole series of converging channels.

GEOGRAPHICAL.

In a corrie on the side of Ben Lui, nearly midway between Tyndrum and Dalmally, at a point almost exactly 3000 feet above sea-level, the River Tay takes its rise. Impetuosity is the characteristic of its infancy, because before it has travelled a distance of 11 miles, it has descended to an elevation of only 500 feet. Down to this point it has been known as the Fillan Water, and here enters Loch Dochart, a sheet of water about three miles in length. After flowing from this loch for another course of 11 miles, during which its name is changed to the Dochart, it enters Loch Tay below Killin. From the eastern end of Loch Tay $14\frac{1}{2}$ miles distant, the river, issuing from the loch at Kenmore, for the first time assumes the title of the Tay. For the remainder of its existence the Tay pursues a sober and dignified course, gradually augmenting in volume and power, quietly absorbing stream after stream, and sweeping silently along, except when forcibly restrained, as in the case of the barrier of volcanic rock which impedes its progress at Campsie Linn. At length its expanded waters merge into the North Sea eight miles below Dundee, after a total journey of 117 miles from its most distant source. The chief distances may thus be summarised :—

Source to Loch Tay, - - - -	25 miles.
Head of Loch to Kenmore, - - -	$14\frac{1}{2}$,,
Kenmore to junction with Garry, - -	$15\frac{1}{2}$,,
Junction with Garry to Perth Bridge, -	31 ,,
Perth to mouth, - - - - -	31 ,,
	117 miles.

After leaving Loch Dochart the gradient of the river, or its fall in elevation, becomes comparatively slight. The surface of Loch Tay is 350 feet above sea level; at the junction with the Garry, the height is 200 feet; and at a point about a mile above Perth, elevation may be said to disappear, for the Tay has become a tidal river. Twice in its course the Tay changes its direction in a very marked manner, giving rise to three distinct divisions. Starting from the source, its direction is north-easterly until it is joined by the Garry. There it turns almost at right angles, and assumes a direction mainly south-easterly across the vale of Strathmore until it reaches Perth. It there takes another sharp bend and flows nearly east until it reaches the sea. Attentive study of a map may show the causes which

determine these sudden changes of direction. The westward portion of the Perthshire Highlands is trenched by a series of longitudinal valleys running more or less east and west. These are the valleys of the Earn, the Almond, the Bran, the Tay, the Lyon, and the Tummel. These valleys are terminated at their eastern extremities by a great transverse valley, running north-east and south-west, and cutting them off nearly at right angles. Through this valley flows the Garry, and as it passes on it gathers up the waters of each of the longitudinal valleys in turn, carrying them southward in a combined stream. This transverse valley terminates at Dunkeld, where the river emerges from the Highlands, but although it takes advantage of its new-found freedom to assume a more winding track, its main direction continues the same until it reaches Perth. Here, however, it meets with a formidable barrier in the Sidlaw range, and although it has succeeded in forcing a passage for itself between the hills of Kinnoull and Moncreiffe, the achievement has been at the expense of shortening it course, because the effort has effectually bent its direction eastward along the shortest possible route to the sea.

AGRICULTURAL.

But a more important division of the river is the *Agricutural.* Under this aspect it divides itself naturally into two sections—the Highland and the Lowland, and Dunkeld may be considered as the meeting-point of the two. North of Dunkeld the Tay flows through valleys more or less narrow and bound in by lofty hills. Here is the resort of the artist, the tourist, the health and pleasure seeker; and here are situated the mountain reservoirs which feed and support it. But the occupation of the farmer is of secondary importance on account of the steepness of the slopes preventing formation of soil. Crops there are where the valley widens so as to admit of floor space sufficient to collect enough soil for cultivation, but as a whole, the highland part of the Tay basin cannot properly be termed agricultural land. After passing Dunkeld the river enters and traverses the Vale of Strathmore, and again after crossing the Sidlaws, makes its way along the Carse of Gowrie. These two broad level expanses in contrast with the Highlands are devoted almost exclusively to agriculture, and the many thriving farms and orchards dotted about throughout their extent testify to the depth and fertility of the soil which has accumulated. But it is to the river flowing through them that these results are due. The river is necessary now for purposes of irrigation and drainage, but it has in the past served the far more important function of grinding down rocks into soil, bringing it to the low land, and depositing it where it now lies. Age after age the Tay has wandered about from side to side of these two plains, building up its

own banks as it wandered, and spreading out that rich carpet of alluvial detritus which forms the basis of all fertility.

VELOCITY.

The Tay carries more water to the sea than any other river in the United Kingdom, and in velocity it yields only to the Spey. The velocity of the river varies to some extent according as it is in a normal or flooded state. There are very few data regarding the velocity of the Tay, but the following are copied from Stevenson's "Canal and River Engineering" (3rd ed., 1886):—

		PER HOUR.
Velocity of Tay at	Perth, - - -	3·09 miles.
,,	Site of Old Bridge,	3·17 ,,
,,	Willowgate, - -	1·55 ,,
,,	Mugdrum, - -	2 to 2½ ,,

VOLUME.

The variation in the volume of the water is very considerable, as must be evident to any observer who has seen the river at periods both of winter floods and summer droughts. The average discharge for the year at Perth is 207,000 cubic feet per minute, but this may include a variation of from 40,000 to 500,000 cubic feet per minute, so that the river may contain at one time 12½ times more water than it does at another.

RAINFALL.

The Tay in its course from the mountains to the sea passes through a series of regions exhibiting every variation of annual rainfall which is possible within the limits of Scotland. Among the mountains of Argyllshire, in the neighbourhood of which it rises, the rainfall exceeds 80 inches. At Loch Tay the rainfall is reduced to between 60 and 40 inches. At the junction with the Garry 35½ inches are recorded, 27·7 at Perth, and finally 23 inches at Dundee. It will thus be observed that the cultivation of the land in the different regions varies inversely as the rainfall. The same cause which brings the heavy rainfall on the hills—namely, their steep slopes and great elevation—allows of the weathered rock-crust being washed away by the copious showers, so that soil forms only in the valley bottoms. The smaller rainfall in the Carse lands, where the soil is productive, is powerless to wash away the soil firmly spread out on the level land.

UTILITY.

The composition of the water in a river often plays an important part in its destiny, and the Tay affords a very clear illustration of this fact. It is well known that the banks of the Tay have

become the home of the bleaching and dyeing industries, but it may be less generally understood that the quality of the water is specially suited to these purposes. The exact connection between the water and the industries can probably be explained but by few. Without going deeply into chemical details, it may be stated that two outstanding qualities of Tay water are its softness and its purity. Softness is accounted for by freedom from dissolved salts, especially those of lime, and purity is caused by freedom from sediment. Through almost the entirety of its highland course the bed of the river is composed of crystalline schists, which contain only slightly soluble mineral matter, and limestone is absent except for a few narrow bands, such as those on Loch Tay and on the Tummel, which are quickly passed over, and yield but a trifling quantity of material. In fact, the quantity of dissolved salts and lime contained in the water is only 3 to 4 grains to the gallon—an exceptionally small amount. Even the Thames, the water of which cannot be classed as the hardest, contains as much as 20 grains to the gallon. Again, the rocky nature of its bed sufficiently accounts for the small quantity of fine mud brought down by the Tay, for the extent to which it passes over beds of alluvial clay, at least previous to reaching Perth, is comparatively insignificant, and gives little opportunity for gathering the finer sediment which might remain long in suspension. The average quantity of sediment brought down has been computed to be at Newburgh, $6\frac{1}{2}$ tons per minute in a total discharge of 7,500 tons per minute, equal to 1 in 1,100 by weight.

SALINITY.

A new element enters into the composition of all rivers as they approach the sea, viz., the intermingling of the salt water of the ocean itself. The phenomenon of salinity is so gradual in its appearance, and varies so greatly according to circumstances—such as state of tide, volume of current, &c.,—that it is impossible to fix a definite point where its presence can be first detected. In the case of the Tay it has been asserted that salt has been noticed so far up as Kinfauns, but the evidence for this is not reliable, and it seems more probable that the sea water does not penetrate farther up than Newburgh, if so far. Salt was detected in June, 1885, at a highest point only five miles east of Newburgh, but in this department there is still room for careful observation. Travelling seaward, there is found to be off Dundee a mixture of about equal parts of sea and river water. But it is a characteristic of the Tay that the fresh water has a tendency to remain on the surface, and this is found to be the case in St. Andrews Bay, and even beyond the Bell Rock, where the salinity increases with the depth.

TEMPERATURE.

Another department in which observations are still much needed is the important one of temperature. Any observations which have yet been taken, although correct and useful so far as they go, are too meagre, and extend over too short a period to be of service for generalising purposes. Observations were taken at Perth by Messrs. W. Wilson, R. Dow, and A. M. Mechie, from December, 1887, to May, 1888; and at Inver, near Dunkeld, by Messrs. C. and J. Macintosh, from March, 1889, to June, 1890. The results of these investigations are published in the "Fourth Report of the Committee on Seasonal Variation of Temperature in Lakes, Rivers, and Estuaries," drawn up for the British Association Meeting at Cardiff in 1891. In the Perth observations the monthly mean of the temperature of the Tay varied from 35·9 deg. in December to 46·9 in May. At Inver the lowest monthly mean was 37·8 in February, 1890; the highest was 60·7 in July, 1889. The full tabulated results are here reproduced from the Report:—

Monthly Means of Temperature Observations on the Tay at Perth, 9 a.m.

Month	Year	Air	Water	Weather
		°	°	
December . .	1887	32·5	35·9	Some snow and frost.
January . .	1888	40·0	37·8	Some fog and rain.
February . .	,,	36·7	37·5	W. and N.E. winds; some snow.
March . . .	,,	37·9	37·4	W. winds; some snow.
April . . .	,,	45·8	43·6	N. winds; some rain.
May . . .	,,	50·3	46·9	N. and W. winds.

Monthly Means of Temperature Observations on the Tay at Inver, near Dunkeld.

Month	Year	Air	Water	Weather and General Direction of Winds.
		°	°	
March . .	1889	41·2	39·8	N.W. wind; changeable; some thunder.
April . .	,,	42·0	41·3	N.W. wind; stormy; some snow.
May . .	,,	50·8	50·3	E. winds; fine; dull; showers.
June . .	,,	55·7	57·0	N.W. and E. winds.
July . .	,,	56·2	60·7	No remarks.
August . .	,,	53·5	55·5	,,
September .	,,	50·5	53·4	,,
October . .	,,	43·2	46·1	,,
November .	,,	40·7	43·0	,,
December .	,,	37·9	39·5	,,
January . .	1890	36·6	39·5	,,
February .	,,	34·5	37·8	,,
March . .	,,	42·6	39·3	,,
April . .	,,	41·7	43·3	,,
May . .	,,	49·2	50·5	,,
June . .	,,	55·5	53·4	,,

But if temperature data regarding the river proper are scanty, this is by no means the case as regards the estuary, where a series of the most minute and elaborate observations was commenced at the Abertay Lightship in June, 1889, and is still continuing. These results are published in full in the Report of the Fishery Board for Scotland for 1891, and an abstract is given in the Report already referred to. We may here recount some of the more interesting phenomena which they reveal. The Abertay Lightship is anchored at the mouth of the estuary. In summer time, if low tide occurs in the afternoon, the water, as would naturally be expected, has warmed since the morning. But if high tide occurs in the afternoon, the water is found to have cooled since the morning in spite of the heating influence of the sun. In the winter months on the other hand, these conditions are exactly reversed. A low morning tide warms up to a high afternoon tide, but a high morning tide cools down to a low afternoon tide. The explanation of these phenomena may be given in the words of the Report itself:—"It thus appears that the tidal effect on temperature is stronger than the solar. In summer, no matter how hot the day may be, the water at the Abertay lightship cools steadily until the hour of high tide; in winter, no matter how cold the night may have been, the water warms steadily until the hour of high tide. The explanation is simple and sufficient. The temperature of the water of the Tay is always higher in summer and lower in winter than that of the sea, and putting the case generally, the Abertay light-vessel floats in Tay water at low tide, in North Sea water at high tide."

CONCLUSION.

Such a river system as that of the Tay requires for its full study the conjoined labours of many specialists. The present paper attempts to give an idea of the river system as it is to-day, the channel by which the drainage of a large tract of country reaches the sea. From this point of view a river basin is to be regarded as a complex system of sloping surfaces, the lower edges of which meet, one and one, along a sloping line which represents the bed of a stream. These bed-lines and their related slopes are in turn tributary to longer and more gently sloping bed-lines formed by the meeting of wider and less steep valley slopes. At the end where the slope of the bed-line disappears by reaching sea level, the free flow onward of the water is retarded by meeting the sea which already occupies the great hollow beyond the land. The amount of this retardation and the manner of mixing depend on the saltness of the sea-water and the strength of the tides. So far as available data go this paper has tried to describe the Tay with respect to these features. A great agent of

physical change has been outlined with but the scantiest reference to its activity. The following papers will build up the life-history of the river in the past, and show its part in forming and modifying the system of slopes and surfaces, and in preparing the land for the reception of the flora and fauna which now inhabit it, and their reaction upon its water supply and movements.

2.—GEOLOGY.

A.—Stratigraphical.

By H. Coates, F.R.S.E.

The River Tay, during its course from Loch Tay to Invergowrie, passes over two of the geological formations represented in Scotland, exclusive of the recent deposits which overlie these. The first part of its course, from Kenmore to a point two miles below Dunkeld Bridge, comprising about 25 miles, passes over the crystalline and schistose rocks of the Grampian Highlands, recently grouped under the name of Dalradian, but better known as the "Highland Metamorphic Series." The lower part of its course, namely, that from the point two miles below Dunkeld Bridge to Invergowrie, a distance of about 40 miles, passes over the Old Red Sandstone.

Of the former or Highland group, two or three members are met with. From Loch Tay down to Dalguise Station we pass over a pretty uniform stretch of mica-schist. This mica-schist forms part of a well defined band which runs from Glen Clova on the north-east to Glen Falloch on the south-west. Next we come to the band of Grit and Greywacke which forms the south-eastern flank of the Grampians. This band the river traverses from Dalguise to Dunkeld. Lastly, about a mile below Dunkeld, it reaches the curiously narrow strip of clay-slate which crops out along, or near, the south-eastern boundary of the Highland rocks, in a nearly uninterrupted line from Stonehaven to Port Bannatyne, in the island of Bute. This band, where the Tay crosses it below Dunkeld, is only about a quarter of a mile wide.

Passing next to the lower section of the Tay, from Dunkeld to Invergowrie, we find that in these forty miles it passes in turn all the different members of the Old Red Sandstone series which are represented in Perthshire. First in order is the Great Conglomerate, forming the base of the system, which extends from the boundary of the Highland rocks to Caputh Bridge. Here the river enters upon the broad plain of Strathmore, occupied by the sandstone series which is the most extensive member of the Lower Old Red. At Stormont-

field a local outcrop of conglomerate, about 600 yards wide, is crossed, but with this exception the sandstones extend from Caputh Bridge to Perth Bridge. From Perth Bridge to Inchyra, the river crosses the band of volcanic rocks of Old Red Sandstone age which form the Sidlaw range of hills. Lastly, from this point down to Invergowrie, its direction is parallel with the Sidlaws, and it runs between them and the corresponding range of volcanic hills of the same age which runs along the northern portion of Fife. In this latter stretch it crosses the isolated band of Upper Old Red Sandstone which crops out at intervals on both sides of the valley.

There is yet another group of rocks to be met with in the valley of the Tay, the consideration of which has been deferred until now for the sake of simplicity, namely, the trap dykes. Of these there are at least nine which cross the river, and which are exposed either in the bed of the stream or its immediate banks. Taking them in their order, they are as follows :—

1. A small Dyke crosses the river at Birnam, about half-a-mile below Dunkeld Bridge.

2. At Broadgreen, about a mile below Cargill. This Dyke deflects the course of the river for about half-a-mile, the stream being compelled to run parallel with the dyke for that distance before it can effect a passage through it.

3 and 4. Two Dykes, one coming from the north-east and the other from the east, merge into each other and cross the river as one dyke at the Linn of Campsie. The Linn, in fact, is formed by the passage of the water over this dyke.

5. The Thistlebridge Dyke, about a mile below Stanley. This dyke is also a very conspicuous object in the landscape, both in the river where it is exposed at intervals above the surface of the water, and also on both the banks, where it stands out in bold wall-like masses.

6 and 7. Two smaller dykes may be observed in the bed of the river a few hundred yards below Thistlebridge.

8 and 9. Other two dykes cross the river at Stormontfield and Waukmill respectively. These are not so conspicuous in the river itself as those farther up, but they are exposed on both banks not many yards from the river.

The dykes of the Stanley district have been very fully described by Mr. R. Dow in a paper on "Tertiary Dykes of the Lower Tay Valley" (see *Trans.*, Vol. I., p. 226). It will therefore be sufficient to state here that they are all of Miocene or Middle Tertiary age, and form part of the great system of volcanic phenomena exemplified in

the west of Scotland by vast sheets of basalt, and in central Scotland by innumerable Basalt Dykes, all running in an east and west direction.

Such, in briefest outline, are the positions in the geological scale occupied by the rocks which the river Tay passes over in the successive stages of its course from the loch to the sea.

B.—Physical.

By H. Coates.

Under this heading we have to consider, not the age of the rocks, nor their stratigraphical relations, but the positions which they now occupy, and their structure as it affects the configuration of the country.

For the better understanding of this part of the subject, we will now divide the course of the river into sections according as its direction changes. Taking the directions very approximately, we find they are as follows :—

1. From Kenmore to Logierait,—N.E.
2. From Logierait to Cargill,—S.E.
3. From Cargill to Perth,—S.
4. From Perth to Inchyra,—E.S.E.
5. From Inchyra to Invergowrie,—E.N.E.

Taking these in succession, we will endeavour to find a geological cause for each change in the trend of the valley.

1. *From Kenmore to Logierait.*—This section affords an example of a true longitudinal valley, that is, its direction coincides with that of the plication of the rocks. Like the valley of Loch Tay, of which it is the natural continuation, it runs along the axis of an anticlinal arch, the crest of which has been worn away by denudation. This course was probably determined by the fact that the outer or convex region of a bent mass is the region of greatest tension, and therefore of least resistance, so that its particles would be specially liable to be attacked by the eroding agents.

2. *From Logierait to Cargill.*—This portion represents a transverse valley—that is, its direction is at right angles to that of the plication of the rocks. This course seems to be explained by the theory which Mr. Macnair and the present writer ventured to advance in a paper on the Old Red Sandstone of Perthshire, read before the Society in 1892 (see *Trans.*, Vol. I. p. 235). If the views there expressed are correct, then this portion of the valley owes its origin to the drainage from the high lands into the lake which occupied the midland valley of Scotland during Old Red Sandstone times.

3. *From Cargill to Perth.*—This is the section of the river which crosses the area once occupied by the Old Red Sandstone lake, and now forming the flat and open plain of Strathmore. As the surface of this plain falls very little in any direction, a comparatively slight cause would be sufficient to determine the original course of the river. It is probable that, at the close of the Old Red Sandstone period, when the land began to emerge above the receding water, this area would be intersected by a number of sluggish streams, carrying off the drainage by different channels. Gradually these would become concentrated into main channels, as the water found the easiest passage, and thus in time one main channel was worn out.

4. *From Perth to Inchyra.*—This short section of the river's course is the most difficult of any to account for. In trying to solve the problem, the first question which meets us is, why did the river cut a channel for itself between Kinnoull Hill and Moncreiffe Hill, instead of taking the easier course round the latter, which really forms the south-western termination of the Sidlaw range of hills? But if we suppose some initial cause which would tend to develop a channel between these two hills, then the river would naturally adopt such a course, as being the most direct. From the structure of Kinnoull Hill it is evident that the hard beds of porphyrite which form its upper surface must at one time have been continued across the valley of the Tay at this point, and have overlaid the beds of Moncreiffe Hill. But underneath these hard beds occur more friable beds of volcanic conglomerate and tuff. Now, if we suppose that the upper hard beds of porphyrite became fractured during the folding of these rocks into their present anticlinal arch, then an opening would be effected in the barrier of hard strata, and the softer underlying strata would be exposed to the action of erosion. The correctness of such an explanation would, of course, be proved, if we could discover a fault at the point where the river passes between the two hills. So far as I am aware, no fault has been traced just in the course of the river, but the presence of two faults at a short distance on either side—namely, at Cargill Wood and at Lairwell—shows that the cleavage of the rocks in this locality runs in the direction I have supposed.

5. *From Inchyra to Invergowrie.*—This section constitutes what is known as the Carse of Gowrie. The origin of this part of the valley has already been explained in the paper just referred to (see *Trans.*, Vol. I. p. 243). As was there pointed out, the area occupied by the Carse has been sunk down between two faults which run along the flanks of the volcanic hills on either side. The floor of the valley has thus been literally lowered down between two great cleavages in the once continuous strata.

In the foregoing paper I have endeavoured to explain some of the rather complicated problems presented by the valley of the Tay when considered from the point of view of its geological origin. I do not pretend that the explanations I have offered are the only possible solutions of these problems. I rather throw them out as suggestions for the criticism of other investigators.

C.—The Superficial Deposits.

By Rev. F. Smith.

I have been asked to prepare a brief account of what are technically described as the "Superficial Deposits" of the Tay Valley. To give an intelligible epitome of these deposits in brief space is not an easy task; for though they were for many years thought to be so unmeaning as to be almost beneath the notice of the geologist, they are now found to be as full of interest and meaning as any of the groups of rocks in the older geological classification.

The superficial deposits, especially in our northern regions, can be well defined from the more solid crust of the earth, as they had their origin in a period whose phenomena stand out in goological history as distinctly as a mountain range from a flat plain,—namely, the "Glacial Period." The records of this period have come down to us in the form of rounded, scratched, and grooved mountains, and almost mountain masses of broken and ground-up rocks, intermixed with sands and clays. These masses of loose material, taken as one deposit, form what is known as the "Boulder Clay." We shall begin our review of the superficial deposits, therefore, by endeavouring to picture the conditions of the country at the time when the last of the glaciers began to recede from their mountain-holds in Scotland.

The effect of the presence of great ice-masses upon our Scottish mountains was the smoothing down of the rugged outlines of the latter, and the wide distribution over the country of the material thus broken off. All the lateral mountain recesses—that is, all the glens and pre-glacial valleys that opened laterally upon the greater waterways—became filled with the glacial *débris*, and only the greater routes of the glaciers were left as open valleys when the glaciers themselves had finally receded. Even these greater valleys were irregularly obstructed, and often completely blocked, at their lower ends, to a height of several hundreds of feet above the floor of the ancient preglacial river courses. Thus the more ancient configuration of the country became greatly modified, and the older rocks were hidden to a vast extent under what was known to our geological fathers as the "Diluvial Cover." This *Diluvium*, as it is still sometimes called, is known in Scotland as "Till," and, universally, as "Boulder Clay."

We now commence our epitome of the geological history of the true "Alluvial" or recent deposits of the Tay basin, which, with all the manifold changes that have come about since the recession of the glaciers, are all characterised by the presence of a *recent* fauna and flora.

It is quite unnecessary to suppose, as many geologists have done, that the change from glacial conditions to those of our recent epoch was accompanied by any extraordinary or exceptional phenomena. On the contrary, all the evidence seems to point to what we may call natural conditions—to such conditions, indeed, as may be found in some parts of Europe at the present day. The glaciers receded from our country, as they had encroached upon it, by slow and imperceptible degrees. The transition was simply one from flowing rivers to slowly gliding ice, and then from ice to flowing rivers again. We now, therefore, take up the story of the work of the river, begun when the last of the glaciers had gone from the mountains. In considering the geological work of the river it is well to bear in mind that we are dealing with an agency whose operations are familiar enough, but whose power and capacity are too apt to be under-rated by the geologist.

Rivers are not only streams of water flowing down to the sea, but they are, and always have been, the creators of order and beauty on the face of the earth. Where our history of the Tay valley now begins, they were the means of restoring order and beauty to a portion of the country where desolation and chaos had reigned before. The first function of the reinstated rains, streams, and rivers, was that of breaking the shapeless and impeding masses of broken rocks and crushed *débris*, and distributing them far and wide upon the level plains and valley floors. This was, ere long, accomplished, by processes which the proportions of this paper will not allow us to discuss. Thus, hill slopes were shorn of their more rugged masses, the materials of which, finding their way down to the greater valley floors, were re-distributed by the levelling, assorting, and constructive capacity of the river. This being accomplished, the valleys once more became green and beautiful, as they had been in the times preceding the inception of cold conditions.

When this had been achieved, the work of the river may be said to have only begun, for even after the beauty of the valley floor had been restored, every heavy rain would bring down upon it a portion of the superabundant glacial material still remaining on the higher ground. This condition of matters continued for a lengthened period of time, and produced results which have left their mark on the configuration of the Tay valley at the present day. These conditions, which have not hitherto been generally recognised by

geologists, may be summarised as follows:—*the lateral streams conveyed more material, such as clays, sands, and coarse gravels, upon the valley floors than the greater rivers could convey away to yet lower regions.* As a natural consequence of this, the lower area of the river basin continued slowly but steadily to rise, owing to the accumulation of this material. While this was going on, however, the valley plain never ceased to be verdure-clad, for the work of the rain and the river was carried on as orderly and as imperceptibly as at the present day. There is abundant evidence in the upper portion of the Tay valley to show that as this process went on the former position of the river became buried under four, five, or perhaps even six hundred feet of such river-accumulated material. While this was going on, the valley need never have lost its verdure, nor its beautiful and habitable condition. Indeed, if, as I believe there are strong reasons for believing, man were living in the valley at that time, he would no more have been aware of the great changes which the river was then effecting than we are to-day that these same agents are producing equally important geographical and geological changes, though with different results.

This great building-up of material on the valley floors I have elsewhere described as the "Accumulative Period" of post-glacial river work.* This accumulative period came to an end, as a matter of course, by the superabundant supply of glacial *débris* becoming so far exhausted that the lateral streams then only brought down such quantity of material as the river could convey to other regions. Then, for a time, a *stationary* period probably supervened, during which the valley floor maintained a comparatively unchanging level.

In course of time, equally natural conditions followed, which entirely revoked the earlier order of the work of the river, namely, when *less material was supplied to it than it was able to remove.* Thus, there came about the denudatian, or un-building, of the great masses of alluvium which the river had formerly built up; and this change was brought about by the very same functions of the river, acting under altered physical conditions. It was at this time that the floor of the Tay valley began to descend again towards its former and its present level, but, in doing so, it left along its hill slopes scattered memorials of its former condition, in the form of fragments of its ancient high terraces. These fragments we find perched on the valley sides at heights of three or four hundred feet above the present level of the river. In some places, indeed, as at Ballinluig, they may be traced to a height of at least five hundred feet.

This great dispersion of the contents of our northern valleys was largely aided by the great upheaval of land surface which is known to

* Geological Society of Edinburgh, 1878.

have occurred in North-western Europe at this period. In the Tay valley we have evidence of this elevation in the fact that in the lower part of the strath the deposits which once filled up the valley to a great height above the present level of the sea were afterwards denuded to a depth of at least a hundred feet *below* sea level. If this were so, the only inference is that the land must then have stood at least a hundred feet higher than it does now, for the level of the sea itself is, comparatively speaking, a fixed quantity. The probability is, however, that the amount of the elevation considerably exceeded the figure named.

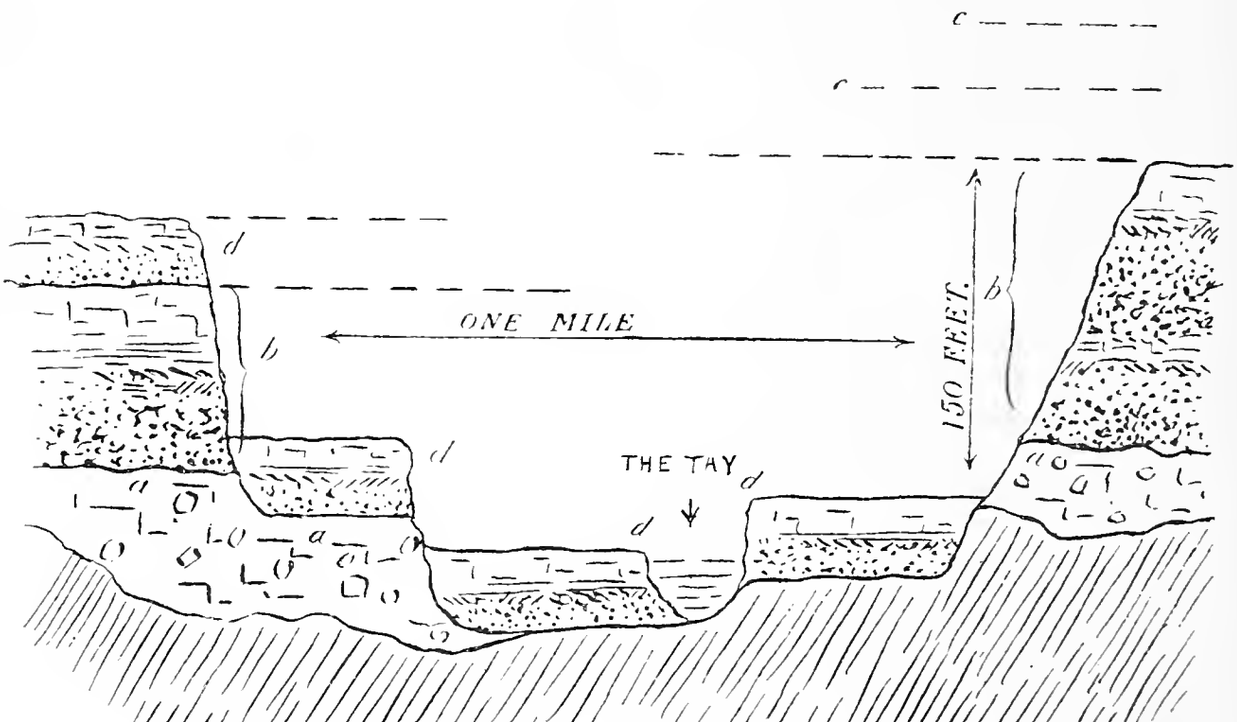
That the sea did not, and could not, have emptied the lower strath of its contents without the aid of such elevation of the land, is shown by the fact that after the upheaval and the denudation of the valley had been effected, a corresponding subsidence took place, which brought the sea once again into this hollowed-out lower valley, and when this took place, the sea, instead of further excavating the lower valley, was the means of filling it up again with estuarine or fluvio-marine deposits. These estuarine deposits, which attain a considerable thickness in the lower Tay valley, and which occupy what must have been a high and dry valley floor during the river-denuding period of the great upheaval, afford strong evidence of the former greater extension of the estuary.

This subsidence, however, does not end the post-glacial alluvial chapter in the geological history of the Tay valley. As we know that all around Perth, in lower Strathearn, and in the Carse of Gowrie, the plough is driven through the old estuarine clays; this is proof that since the subsidence, which allowed the sea to occupy these areas, a minor elevation of the land must have taken place, causing the sea to retire once again. Consequent on this second upheaval, a further modification of the valley floor took place, which brings us at last to the close of this hurried review of the events of which the recent or post-glacial deposits of the Tay basin are records and witnesses. This last modification was a repetition, in a minor degree, of the work which was performed by the river consequent upon the earlier "Great upheaval," when such vast quantities of glacial and other *débris* were carried out to what is now the floor of the German Ocean. When this last minor upheaval took place, the river naturally came down upon the now exposed floor of the estuary, and denuded it in proportion to the height to which it was raised above sea-level. The evidence of this denudation we may see for ourselves in the terraced condition of the land immediately surrounding the city of Perth.

The foregoing is but a glance at the geological history of the Tay basin since the glaciers receded from the Grampians, in the order of

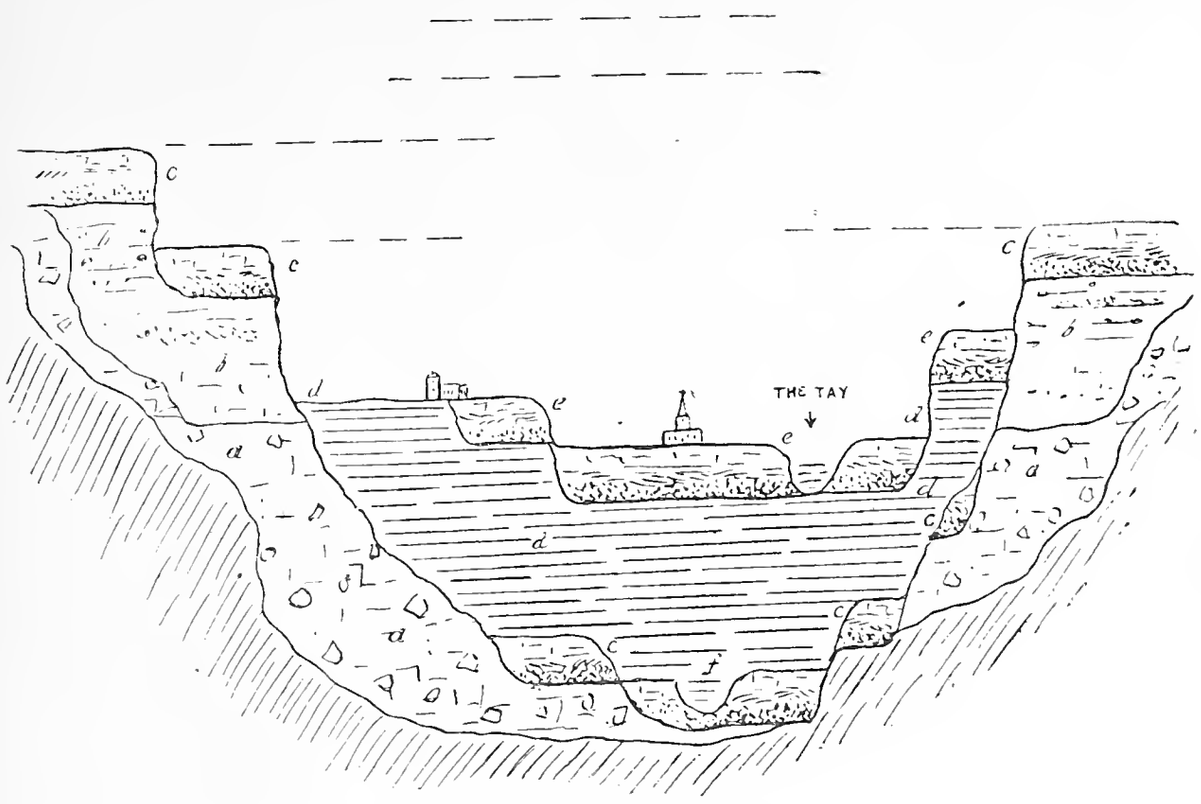
the events which make up that history. Although we stop here, however, we need not fancy that, because the work *seems* finished around us, all is now at rest. On the contrary, the work is still going on, and the history is literally "a story without an end," for the vitality of the world itself is the outcome of constant modification and incessant change.

The following local (diagrammatic) Sections wlll, it is hoped, help the elucidation of the foregoing paper :—



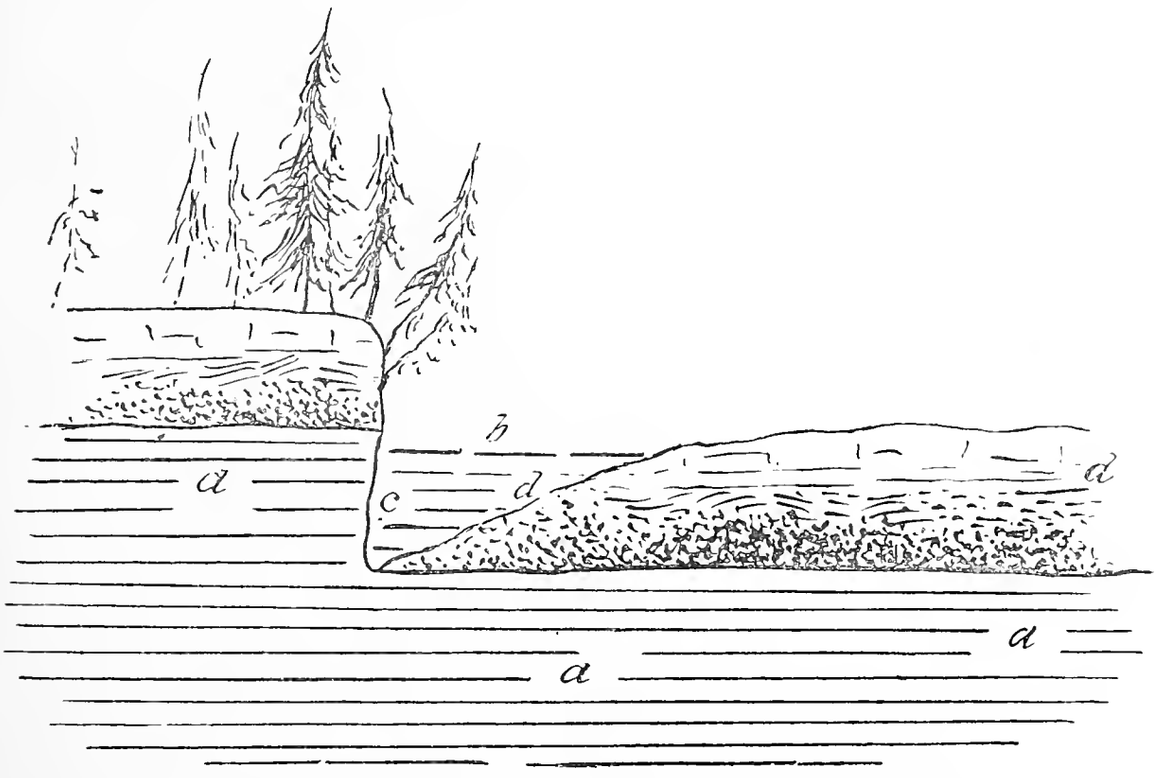
SECTION I.—ACROSS VALLEY OF TAY NEAR GUAY.

a—a are the boulder clay resting upon the primeval rocks ; *b—b*, immediately post-glacial "accumulative" river material, which was built up to much higher levels, as indicated by the broken lines *c*, *c* ; *d—d* are "dispersive" river beds, which were left more or less fragmentary upon the successive valley floors of the denudation during the period of the "great upheaval" and down to present times.



SECTION II.—ACROSS THE TAY VALLEY IN NEIGHBOURHOOD OF PERTH.

a—a, boulder clay; *b—b*, "accumulative" river deposits; *c—c*, "dispersive" river beds of the "great upheaval" valley; *d—d*, the estuarine clays of extended marine conditions; *e—e*, "dispersive" river beds of post-estuarine times; *f*, buried site of ancient river. The building in centre of diagram is in the position of St. John's Kirk; that on the higher terrace indicates the position of St. Ninian's Cathedral.



SECTION III.—ACROSS THE TAY AT "WOODY ISLAND,"

Showing position of the Island upon a higher shelf of the estuarine clays *(a—a)*, while the river *(b)* is denuding the clays at *c*, and depositing coarse gravels and sands upon a lower level at *d—d*.

3.—BOTANY.

The Flowering Plants.

By the late F. Buchanan White, M.D., F.L.S., F.E.S.

The banks of the Tay—restricted for the purposes of this paper to that portion of the river which extends from Loch Tay to the county march at Invergowrie—possess a flora which is not surpassed by any other part of Perthshire in richness and interest.

This very richness makes the subject a somewhat difficult one to handle. It would be easy to give a mere list of the species which have come under observation, but it seems desirable that something more than this should be attempted. We have to discover, if possible, what effect the physiographical, meteorological, and geological conditions have upon the distribution of the flora. That these conditions are potent factors is not to be denied, but in many cases they act in combination, and it is difficult to ascertain which of these several causes, acting together, is the predominant agent.

It will therefore be expedient briefly to inquire into the manner in which the conditions alluded to affect the distribution of plants, and to give a short resumé, from the point of view of a botanist, of the physiography of the Tay.

1.—DIVISION OF THE TAY INTO DISTRICTS.

The course of the river Tay (so far as this paper is concerned) may be divided into three sections or districts.

1. The Highland District where the river runs through comparatively narrow valleys, and where the banks either rise at once into the hills, or have a fringe of low haughlands liable to inundation during floods.

This section extends from Kenmore to 2 miles below Dunkeld, and is about 25 miles in length.

2. The Strathmore District. Here the river forms a great ditch which it has *cut* through the Old Red Sandstone plain of Strathmore. Often the banks are high and rise steeply from the water's edge to the level of the plain above, but, not infrequently, there are low haughlands occupying ground excavated by the river in past ages.

This section extends from 2 miles below Dunkeld to about the mouth of the river Almond, and is about 19 miles in length.

3. The Tidal District. Here also the river is mostly ditch-like, with banks of no great height rising steeply to the plain of the Carse of Gowrie. The equivalent of the low haughlands of the other

districts is, for the most part, marshland lying between the water and the banks.

This section extends from the mouth of the Almond to a little above Newburgh on the one side, and to Invergowrie on the other. The right bank is about 9 miles in length, and the left bank 20 miles.

Some of the characteristics of these districts may be described at greater length.

In the Highland district the river has a generally rapid course (over a pebbly bed) through the valleys of the Silurian hills. The banks vary considerably—in some places rising more or less steeply from the water's edge, in others spreading out into wide cultivated or uncultivated haughlands, sandy, shingly, or marshy in their nature. There are several islands and a few backwaters. The larger affluents are the Lyon, Tummel, and Braan. These have all rapid courses in pebbly or rocky beds through Silurian valleys, and drain a very large area.

In the Strathmore district, the river, after crossing the "Great Fault" in the conglomerate belt, takes its course through the great plain of the Old Red Sandstone formation. The current is generally rapid, and the bed pebbly. The character of the banks varies considerably, in the same way as in the Highland district. Several trap-dykes intersect the course of the stream, and there are several islands and backwaters. There is only one large affluent, the Isla, whose current is not very rapid in its lower course, and whose bed is thus rather muddy.

The Tidal District is—as its name implies—the tidal part of the river, and is also in the Old Red Sandstone formation. For the first $2\frac{1}{2}$ or 3 miles the bed is pebbly, but below Perth it becomes muddy. The current is, on the whole, rather rapid at low water. There are two large affluents, the Almond, a rapid stream, and the Earn, a somewhat muddy and slow running river. There are 7 or 8 islands (3 of which have been converted into peninsulas), and, in the lower part of the district, a number of mud and sand banks, covered at high water. The character of the banks for the first 2 or 3 miles is somewhat like that in the middle district, but below Perth there is a change. The banks (of Carse clay) are often comparatively high and steep, but between them and the river there is, at low water, a fringe, often of considerable width, of marsh—fresh in the upper stretches, salt in the lower—more or less completely flooded at every tide. Stony and pebbly shores are *in*frequent in this district.

Some other things which probably affect the distribution of the plants require to be briefly noticed.

Salinity of the river water.—Statistics regarding that portion of the river which comes within the scope of this paper are non-existent.

The occurrence, however, of certain plants (*e.g.* Fucus) in the lower part of the Tidal district points to a probable considerable salinity.

Temperature.—This is highest on the lower course of the river, and, though the difference between that part and the upper districts is by no means great, it seems to be sufficient to affect the distribution of certain plants.

Rainfall.—This, on the other hand, increases as the river is ascended. It is doubtful, however, whether this difference is sufficiently great to have an appreciable influence on the flora.

Surface Geology.—There is no doubt that this is a factor in the distribution, acting either by the structural character or by the chemical constituents.

II.—THE RIVER IS THE CHIEF FACTOR IN THE PRESENT DISTRIBUTION OF THE FLORA.

In this paper we are not concerned with the origin of the flora in the county as a whole, but merely with the causes of its present distribution on the banks of the river. The chief factor in this distribution is the river itself, and its action is twofold in its nature. In the first place, it is the great medium of transportation, and in the second, it provides suitable habitats for the plants.

It will be remembered that, in describing the characteristics of the sections into which we have divided the river, stress was laid upon the *rapidity of the current* and the *nature of the bed.* By the rapidity of the current, not only are the seeds of plants carried from one part of the river to another, but in times of flood many plants are transported *bodily.*

In estimating the effects of this carrying power we must take into consideration, not only the stretch of the river to which these papers is restricted, but the portion above our upper limit, and also the various affluents. Keeping this in view, it will be seen that the river can draw supplies of plants from a very large area. That area is, however, possibly not altogether co-extensive with the drainage basin of the Tay. The large lochs through which several of the rivers have to pass probably intercept, to a certain extent, the supply of seeds, &c., from the parts beyond them, and, if they do not altogether prove a barrier, at any rate retard the passage. It is perhaps from this cause that a greater number of species of alpine plants do not occur as casuals on the banks of the Tay. The slow-flowing affluents with muddy beds, as the Isla and the Earn, in like manner, are not so prolific in supplying the Tay as the more rapid tributaries.

But the carrying power of the river would not avail much in making a rich flora, unless suitable habitats and sustenance were pro-

vided for the plants. This the river does in various ways. In the upper sections it builds up the low haughlands and *stanners;* in the lower section it creates the rich marshland; in all three it has formed and is forming backwaters. All of them it irrigates and feeds. It is on these younger deposits, far more than on the older banks, that a rich flora occurs. The life history of the low haughlands, and of the stanners or stony islands, is essentially the same. A river, if left to itself, is perpetually, though more or less gradually, making alterations in its channel—eating into one bank, building up the other. Given a rapid current and a pebbly bed, the building up process consists at first in the formation of a mound of shingle, either attached to the bank or surrounded by the water; the foundation in the one case of the future haughland, in the other of the coming stanner.

At first there is nothing but this bank of loose stones, liable to be swept by every flood, but for that very reason tending to increase. Then amongst the stones finer debris—smaller stones and sand, and perhaps a little vegetable matter—gets lodged, and now the place is ready to receive colonists in the shape of seeds and plants brought down by the stream. These obtain a foothold, and though many are doubtless swept away by the high floods of winter, yet a few are likely to remain and assist in retaining more debris. Year by year the plant colonists become more numerous and more permanent, the shingle begins to assume a closer appearance, greater facilities for the retention of loose debris are afforded, and thus a greater height above the water is gradually attained, until only the higher floods inundate the surface. The sediment deposited by these floods, and the annual decay of the leaves and stems of the herbaceous plants, finally make a *humus* which covers up all traces of the shingly foundation, and enables the haughland or stanner to support a luxuriant vegetation, including trees and shrubs, or even to fit it for cultivation. In this condition it may remain for many years, but the chances are that, unless man interferes to protect it, and to keep the river to its bounds, the latter will undo all the work so gradually accomplished, and will remove the materials, but only to make new haughlands and stanners elsewhere.

In Perth itself, and in its immediate vicinity, we have excellent examples of the formation and destruction of haughlands and stanners. The Woody Island is an example of a stanner, which, after attaining a high pitch of perfection, is now in course of destruction. The great shingle bed on the Scone side of the river, opposite the the Woody Island, is a haughland in the earlier stages of its existence. An example of a stanner still nearer at hand is the island at the Bridge. In a map of the date 1774 no trace of this island is shown —of course it may have been omitted, but other details given in the

map make this unlikely. In a plan made about 1834 the island is given, but, so far as can be judged from the details, it was then in its earlier stages and in rather a fragmentary condition. The Bridge was finished in 1771, and, though it has doubtless assisted in the formation of the island, the probable cause was the erection of some river wall or other on the left bank above the Bridge. In 1889 Mr. R. Dow investigated the flora and found that upwards of 130 species of plants occurred on the island. Some of these were quite recent arrivals, as *e.g.* the Blue Lupin (*Lupinus perennis*), which, though long known to abound on islands farther up the river, reached Perth only a very few years ago. At present this island affords material for an interesting study. The portion above the Bridge shows two stages in the formation of a stanner. Part of it is bare loose shingle, and part has a good number of plants, but has not yet quite got to the completely clothed condition. The portion immediately below the Bridge has advanced a step further, and is rapidly becoming covered with plants, although it has not yet attained any great altitude above the water. Finally, the main island which lies immediately south of the second portion is in course of being destroyed, but will probably have its place taken by the advancing second portion, its materials in the meantime going to form new shingles and stanners further down, and some at least of its plants finding elsewhere a new home.

The origin and nature of the backwaters alluded to above must now be considered. A backwater is an old channel through which—either from natural or artificial causes—the river has ceased to flow. Whatever the cause may be, the eventual result is essentially the same. A natural backwater is generally formed in this manner. When a stanner is made it is usually nearer one shore than the other, and from the cause of its origin, there is a tendency for shingle to accumulate at the upper end of the narrower channel and form a bar, which eventually prevents any but flood water passing down. Consequently a quiet lagoon is created, open to the river at its lower end but cut off (unless the river is in spate) at the upper. To this lagoon seeds and roots of water and marsh plants are brought by various agencies, the river itself amongst others, and find a congenial home. To it also the floods bring and deposit fine sediment, the bar preventing the passage of coarser material, which it retains to itself. Thus, in course of time, the bed of the lagoon becomes muddy, a process which is assisted by the natural annual decay of the plants. In the meanwhile the bar has itself become clothed with land plants, and has become an essential part of both the mainland and the stanner. Then the silting up of the lagoon goes on, the lower and formerly open end gets also cut off from the river, the shallower

places become grown up with plants, and pass gradually from marsh into dry land, till at last all trace that remains of the channel through which a stream flowed is a few pools or marshy spots more or less distant from the river, and what was a stanner has become haugh land. But this is not the end. The pools and marshes get filled up by the ever-accumulating vegetable growth and decay, and finally *cereals* may wave where at no distant period the river flowed with rapid current over a pebbly bed. Examples of the more or less completed stage of what we have sketched may be seen at various places—as, *e.g.*, at Delvine and Kinclaven,—while the Woody Island and the top of the Willowgate show initial stages.

The marshlands of the Tay below Perth remain to be briefly noticed. Some of these date from a more or less remote period, more especially those along the lower reaches of the river, where, indeed, some of them have been banked off, and are now under cultivation. But in the part of the river nearer Perth it is probable that these marshes are, to some extent at least, of quite recent origin, and owe their existence to the deepening of the channel (and thus narrowing the bed of the river) under the Perth Navigation Act of 1834. This is the case with the marshes in the artificial backwater at Darry Island, where, before the island was joined by a narrow neck to the mainland, there was a depth of 13 to 16 feet at high-water, and of from 3 to 5 at low-water. On the other hand, the marshes separating Sleepless and Balhepburn Islands from the mainland existed before these islands were made into peninsulas, though they have probably increased considerably since that time. There can be little doubt but that these and other marshes will eventually become dry ground.

Apart from artificial causes (as the conversion of islands into peninsulas), the situation of these marshes, just as the situation of the haughlands and stanners, is determined more or less by the course of the river, and so also it is the river which stocks them with plants and continues to build them up. But, unlike its action in the first two sections, the river in section three brings not only materials and plants from above downwards, but from below upwards. This, of course, is due to the action of the tides, and probably explains the peculiar distribution of a few of the plants.

With deep rich mud, the product of the grinding down of the highland and other rocks, of the washings from many highly-cultivated fields, and of the drainage of the city of Perth, it is not to be wondered at that these marshes support a rank and luxuriant vegetation.

Before proceeding to the next division, let us give a short recapitulation of our argument.

1. The richest part of the flora is that which is situated on the

younger riverine deposits, such as the low haughlands, stanners, backwaters, marshlands, and foreshores.

2. For the formation and stocking with plants of these deposits a rapid current is necessary.

3. Therefore the richness of the flora is determined by the rapidity of the flow of the river.

III.—CHARACTERISTICS OF THE DISTRICT FLORAS.

From what has been already said regarding the physical characters of our three districts it may be readily conjectured that, while there may be differences between the floras of all three, yet the tidal district will present a great divergence from the other two districts than they do from each other. The action of the tides, the proximity to the sea, and the somewhat higher temperature, combine, as has been already suggested, and as we shall try to show, to bring about this result.

The native flora of the tidal district seems capable of being divided into the following groups :—

1. Maritime Plants.
2. Plants whose distribution seems to be governed by the temperature.
3. Plants dependent on the action of the tides.
4. Plants which it has in common with the other two districts. These constitute a majority of the flora.

Group 1—The Maritime Plants.—Of this group there are *apparently* two classes, one containing the plants whose distribution is co-extensive with a certain degree of salinity in the river; the other, those which, while most abundant when the water is salt, yet have an extension of their range to places where there is reported to be no salinity.

Is salt therefore essential to the growth and wellbeing of some of these plants? This question, as regards the majority of our maritime plants, must, we think, be answered in the negative. We have grown some of them (as *Glaux maritima*) in ordinary garden soil, and without any superfluity of moisture, and have found that they did very well. It is clear, therefore, that in this case the presence of salt is not essential, but experiment can alone show whether this holds good with all the species. On the other hand, as the range of some of the plants is co-extensive with the presence of salt, there must be a reason for this connection, and it seems to be this. Many common plants cannot grow in the more or less saline places where the maritime plants flourish. There is, therefore, less competition for room in these places, and less of a struggle for existence, and in the struggle

the plants which can adapt themselves to salt are the more favoured competitors, though under other circumstances they are the weaker. In short, the presence of the maritime plants in the places where they grow, and their absence from others, is simply an illustration of the survival of the fittest.

Of the plants whose range is co-extensive with a distinct salinity the following are good examples :—

Sagina maritima.
Lepigonum salinum.
Glaux maritima.
Plantago coronopus.
Atriplex Babingtonii.
Juncus Gerardi.
Triglochin maritimum.
Glyceria distans.

And, as regards the lower Tay, *Plantago maritima*.

Aster Tripolium has a rather more extensive range, and the following, though most abundant where the water is distinctly salt, yet extend to where there seems to be no salinity :—

Scirpus Tabernæmontani.
„ maritimus.
Glyceria maritima.

Group 2—Plants whose range seems to be governed by temperature.—This group includes two sub-groups—

(a) Species absolutely confined to the district, viz. :—

Trifolium fragiferum.
Œnanthe fistulosa.
Allium Scorodoprasum.
Carex vulpina.
„ acuta.

(b) Species not so restricted, but which are certainly more abundant in the district than elsewhere, viz. :—

Cerastium tetrandrum.
Nasturtium sylvestre.
Epilobium hirsutum.
Œnanthe crocata.
Veronica Anagallis.
Epipactis latifolia.
Allium vineale.

It may be, of course, that there are other causes than temperature which influence the distribution of these plants, but, so far as we can see, temperature seems to be the chief factor.

Group 3—Plants dependent upon the influence of the tides.—In this group we can place with certainty one plant only, namely,

Cerastium triviale, var. *holosteoides*, whose distribution seems to be connected with the tidal part of the river. The type or common form grows in all sorts of places, but this well-marked variety grows only in spots where it can be irrigated by the daily flow of the tide. Its upper limit is at about the top of the North Inch, but it does not descend to the saline parts of the river. This daily irrigation has an evident effect upon other plants, but this is the only one apparently whose range is distinctly affected by it.

Whilst we have endeavoured to show how the flora of the tidal district is differentiated from that of the other two districts by the presence of certain plants, we have yet to see how it is characterised by the less abundance, or even the entire absence, of certain other plants. It must first be premised that there is no hard and first line of demarcation between any of the districts. Unless for the presence of tidal action in the river, the portion of the tidal district which lies above the Friarton has a good claim to be included in the middle, or Strathmore district, and hence some of the distinctive features of the flora of the two upper districts intrude into the lower district, and tend to lessen the differences between them. These differences consist chiefly in the presence of three groups of plants, viz. :—

1. Alpine Plants.
2. Alpine-maritime Plants.
3. Plants which may perhaps be considered upland, or sub-alpine.

Group 1—Alpine Plants.—No part of the Tay is rich in alpine plants, but three species are abundant and well established in the two upper districts and are found also in the uppermost portion of the third, but only in a more or less sporadic fashion. These are *Alchemilla alpina*, *Saxifraga aïzoïdes*, and *Oxyria reniformis*.

Group 2—The Alpine-maritime Plants are *Silene maritima*, *Armeria maritima*, and *Plantago maritima*.—Though we have termed these Alpine-maritime, the term is really erroneous, for, though the plants occur in suitable places on the sea-shore and on the mountains, it is neither the maritime nor the alpine nature of these localities which attracts them, but because it is there that they find less competition for room, and can flourish where some other plants cannot. This same freedom from overcrowding they find on the shingles and younger haughlands, and on such places they abound and form a conspicuous feature of the vegetation in the two upper districts, while from the greater part of the tidal district they are absent.

Group 3—Upland or Sub-alpine Plants.—Whether the species to

be mentioned should be really thus classed is open to question. It may be that they are confined to the upper districts, or are more abundant there, merely because the physical conditions do not suit them in the tidal district. Examples are several species of *Hieracium*, *Vicia sylvatica*, *Meum athamanticum*, and probably others.

In this connection the abundance of *Thalictrum minus* in the upper districts, and its absence in the greater part of the tidal district, must not be overlooked.

Regarding the upper districts it may be at once said that their floras do not differ to any material extent. As might be expected, we find a thinning out of certain weeds of cultivation, such as the poppies and fumitories, as we ascend the river, but most of the other differences in the floras arise either from the inexplicable restrictions in the range of some local plants, or in the physiographical conditions of the banks. The presence of trap dykes, conglomerate beds, and wet sandstone rocks has an effect in localising certain species, but to all intents and purposes the main features of the flora are the same. Still, however, a careful analysis reveals the fact that some plants, which are more or less abundant in the lower part of the Strathmore district, become much rarer, or disappear altogether, in the upper parts of the Highland district. We have not sufficient statistics to enable us to speak very definitely on this point, but are inclined to think that *Hypericum perforatum* and *Knautia arvensis* may be cited as examples, as also *Chærophyllum temulum* and *Caucalis anthriscus*. The cause of this disappearance of certain species is probably connected with the temperature, but a great deal has yet to be learned on this subject.

A brief recapitulation may be useful.

1. The flora of the tidal district shows greater differences from the floras of the two other districts than they do from each other.

2. The characteristics of the flora of the tidal district are the presence of maritime and "temperature" plants, and the absence of alpine and upland species.

3. The differences between the floras of the Strathmore and Highland districts are not marked, and consist chiefly in the less abundance or in the disappearance of certain plants as the river is ascended.

In conclusion, I may say that the number of species of flowering plants and ferns, native or introduced, observed on the ground to which our researches have been limited, amounts to about 486.*

* Further information regarding the flowering plants of the district will be found in the "Flora of Perthshire," by the same author, which is at present in the press.

4.—ZOOLOGY.

A.—The Mollusca.

By H. Coates, F.R.S.E.

The River Tay, being a swift-flowing stream throughout the whole of its course, is not very rich in fresh-water Mollusca. Some of the commoner species, however, are fairly abundant amongst the shingle of the shallower parts, and particularly in the stretch of river below Perth, from Kinfauns to Invergowrie, where the current becomes less strong. The various deadwaters in the upper portion of the valley, from Logierait to Stanley, are fairly productive, and would probably prove to be even more so if systematically examined. In addition to the river itself, and its former channels, certain ponds, ditches, and streams which occur on the haughlands have yielded a good many species. Amongst these may be mentioned the ponds at the top of the North Inch, near Perth, and the Mill Lade which flows past Tulloch. The Old Harbour below Perth has also yielded some interesting forms.

As regards Land Mollusca, the banks of the river will well repay careful examination. Especially is this the case at places where the soil is kept damp by overhanging vegetation, and where there are rocks or loose stones. In such localities some species, such as *zonites cellarius*, are remarkable for the large size which they attain. The following list could have been considerably increased if the higher ground in the immediate neighbourhood of the river had been included, but the area has been limited to that prescribed, namely, the banks and the lower haughlands.

In all cases representatives of the species named will be found in the Perthshire Natural History Museum, where they may be examined by those who wish to confirm the records for themselves.

Sphærium corneum, L.—Common in standing or slow running water.

Unio margaritifer, L. (the Pearl Mussel).—This is by far the most important of the Mollusca of the Tay, both on account of its size and its commercial value. It is found throughout the entire course of the river, and at all depths of the stream. As its favourite habitat is amongst the gravel of swift and mountain-fed streams, it is not surprising that the Tay is one of its principal stations in Britain. The varieties *sinuata* and *Roissyi* both occur, and contorted specimens are not uncommon, caused, probably, by the motion of the stones in the current. Pearls, in all stages of development, are got in considerable numbers by the pearl-fishers in summer, when the water is low. The occupation, however, is not so profitable as it was in former

years. The pearls vary in colour from pure white to deep brown, and are sometimes beautifully iridescent.*

Dreissena polymorpha, Pallas.—This species used to be fairly common at the Old Harbour, where it was supposed to be introduced on teak logs. I am not aware whether it has spread farther up the river.

Valvata piscinalis, Mull.—Occurs sparingly where the current is not strong.

Planorbis albus, Mull., and *P. Contortus*, L.—Common in ponds and ditches.

P. vortex, L.—Has been taken at Errol.

Physa hypnorum, L.—Also taken at Errol, by the late Mr. J. M'Farlane, in 1869.

P. fontinalis.—North Inch Pond.

Limnæa peregra, Mull.—Common throughout the lower part of the course of the river, where the current is not so strong, also in ponds, &c.

L. palustris.—With the last, but not so common. The varieties *decollata* and *elongata* both occur in the Tay near Perth.

Ancylus fluviatilis, Mull.—On stones at the edge of the river in several places.

Of the *Limacidæ* (Slugs), several species must be common on the haughlands, but, as no special search has been made for them in this area, it will be better not to include them in the present list.

Succinea putris, L.—In damp situations overhanging the river in several localities.

Vitrina pellucida, Mull., *Zonites cellarius*, Mull., *Z. alliarius*, Miller, *Z. nitidulus*, Drap., *Z. purus*, Ald., *Z. radiatulus*, Ald., *Z. crystallinus*, Mull., and *Z. fulvus*, Mull.—These all occur amongst moss, loose stones, and long grass in moist and shaded situations on the banks of the river. *Z. cellarius* sometimes attains an exceptional size, as at Stormonfield, on the bank between the river and the lade. Of *Z. purus* the variety *margaritacea* is as common as the type. *Z. radiatulus* is the rarest of the genus, having only been got at one or two stations.

Helix aspersa, Mull.—On rocks at the foot of Kinnoull Hill, not far from the river. This is a rare shell in the county.

H. nemoralis, L., and *H. arbustorum*, L.—Both fairly common and widely distributed, especially the former.

* A detailed account of the Pearl Mussel of the Tay, by the present writer, will be found in the *Proceedings* for 1882, p. 11.

H. concinna, Jeffr., *H. hispida*, L., and *H. rotundata*, Mull.—All common amongst loose stones, &c. The last is perhaps the most abundant species in the county.

Bulimus obscurus, Mull, *Pupa umbilicata*, Drap., and *Clausilia rugosa*, Drap.—All fairly common amongst stones and moss and on rocks. *Clausila rugosa* is frequently found on the trunks of trees, which it climbs to a considerable height.

Carychium minimum, Mull.—Amongst moss and decaying vegetable matter in most situations at several points on the banks of the river.*

B.—Bird-Life within the Banks of the Tay, from Kenmore to Invergowrie.

By Col. H. M. Drummond Hay, C.M.Z.S.

In giving a rough notion of the Bird-Life within the Tay banks, I shall not enter on a description of the banks themselves, though these have in their several sections a strong influence on the distribution and movements of birds on the river. This has been so ably dealt with and gone into in the previous paper on the flora by Dr. Buchanan White, that I feel it would be quite superfluous for me to make further mention of the subject. There are about one hundred species of land and water birds, that obtain their food entirely, partially, or only occasionally within our limits (a classified list of which is subjoined at the end of this paper). These I propose to treat of, and bring before you in a somewhat popular form, as they have been noticed by myself at different times and various seasons of the year, either when boating, or walking along the river-bank, and I will ask you to follow me as if we were now doing the same.

Commencing first with autumn, on the verge of the departure of our summer birds and the arrival of our winter ones, we will take one of our first excursions, a short one, up the water. The nets are off, the last rod fisher has put by his tackle for the season, and the fish have begun to ascend in good earnest to their spawning grounds. The streams are well occupied, and a few of the early fish have begun to deposit their ova. Suddenly our attention is attracted by seeing a plump, short-winged little bird coming down the river at racing speed. Taking a turn he tumbles, as it were, into the water with a splash about mid-stream, and disappears. After a few moments he reappears and hops on to a boulder close by in the stream, his white breast glistening

* For further information regarding the Land and Freshwater Mollusca of the district see paper by the same author in the *Proceedings*, 1882, p. 72.

in the sun, and with sundry jerks of the tail and body he prepares to make another plunge. But suddenly becoming conscious of our presence, he flies back up stream as speedily as he came, and, turning a corner, is lost to view. Such is the Dipper, Water-Ouzel, or Water-Crow, as he is more familiarly called. He is erroneously supposed, when seen on the salmon beds as above described, to be devouring the salmon ova, whereas, as has been proved over and over again, he is then searching for the very creatures that do so—the various ephemera, water-beetles, and other aquatic insects,—and yet he is destroyed.

A few weeks earlier, about the first week of September, we are walking down the river from below the railway bridge at Barnhill, and as we come to some half flooded ditches and water-cuts, left by the tide, we are startled by the sensation of a bright object suddenly passing us and darting up the river with a shrill, piping note, and on recovering ourselves we find we have disturbed a gorgeous Kingfisher in the middle of his repast, while sitting on a solitary branch of an adjoining bush devouring his prey, some minnow perhaps, or small fry. Kingfishers, though not now to be compared in numbers to what they were formerly, are still occasionally seen in autumn on the lower Tay. These may, or may not, be visitors from the continent, which frequently reach us at this season, but we have still a few of these birds of our own, resident and breeding on some of the higher reaches; and where so, a suitable cavity in the river-bank having been selected, six or eight pure white eggs are laid therein, on an accumulation of fish bones and pellets ejected by the birds themselves, the only apology for a nest, not always of the most savoury kind. As we go on, we find the two common species of Water-wagtails, the Pied, and the Grey or Yellow Water-wagtail as it is commonly called, plentiful on the banks by the water's edge, especially the former, much the more common of the two. Both kinds are almost entirely composed of young birds previous to their passage south; and, on watching them, we cannot but admire their graceful motions, their lightness and activity in pursuit of their insect food, as they move along in short, undulating flights, with graceful and buoyant motion of the tail, alighting with cheery chirp, then off again in chase of some passing insect, cleverly taken on the wing.

We now enter our boat and cross the Tay, and on reaching the right or south bank, we find the ground soft and marshy. We have not gone far, when up gets a Snipe, with a loud, unpronounceable note—a sort of half screech—then another and another. These are chiefly home birds that have lately come in, within the last few weeks, from their breeding grounds on the moors; the main flight not having yet arrived. Going deeper into the marsh we come to a lot of debris

of broken reeds and young sprouting water grasses, forming, as the tide rises, a sort of floating island. From the centre of this, a bird much larger than the Common Snipe, and lighter in colour, yet a veritable snipe, suddenly rises at our feet, but quite silently. This is at once recognised to be the rare Solitary or Great Snipe, which is only an occasional autumnal visitant, and which, though common in some parts of Europe, is rarely seen in this country.

Leaving the softer parts we now come to where it is harder and more open, and here we fall in with abundance of the Meadow-Pipit. This often leaves the moors at this season for the marsh, nimbly traversing the ground in pursuit of worms and insects peculiar to marshy spots. Every now and again it rises here and there with a tweet-tweet, and, seeming to hang in the air as it surveys us, retires a short distance, then settling on some sedgy tussock, resumes its occupation. From the persistent note of this bird on the approach of a stranger, it is known in many parts as the Moss-Cheeper. Here we also observe the Common Sky-Lark come down from the adjoining fields to see what food can be gathered in the marsh. Jumping over one of the numerous water-cuts, we disturb a water-hen, which, after sundry flappings along the water's surface, at last gets on wing, and with dangling legs retreats in a hurry to the first thicket of reeds. We see Wood-Pigeons continually flying up the marsh and settling in various spots, not only seeking for food, but often coming to drink. The Newburgh gunner, taking advantage of their abundance at this season, and all the harvest time, sets up his stale-birds on a spot specially cleared for the purpose, and, lying concealed with his gun, often secures a sack load as the reward of a single tide.

Again entering our boat, we proceed slowly down the estuary to the banks properly so called. It is nearly low water, and passing a spit we hear sundry croakings, and observe three or four Carrion-Crows regaling themselves on some savoury repast left by the tide, but long before the boat reaches them, they are off. These birds are not uncommon about the tidal parts of the river all the year round, and are exceedingly useful as scavengers. A little later on in the autumn they are often seen assembled in large parties, which are, more than likely, fresh arrivals from the Continent. As we approach the banks already mentioned, we observe sundry Herons dotted about in the different gulleys intent on their fishing operations. Very interesting it is to watch them with a good binocular, and see the expert way in which a fish is captured, thrown into the air, and dexterously caught again, so as to be swallowed head downwards. As the tide rises, these birds betake themselves to the old stone dykes which jut out into the water, where, if not disturbed, they patiently await events. As we move farther down, the tide begins to make and birds get restless. The

Lapwings, or Pewits, are beginning to call and move up the river in small parties, there to congregate on some spit farther up, and, as the tide gets higher, eventually proceed inland to the turnip fields. The Gulls, also, are now moving up from off the banks which are rapidly getting covered, and are continually passing us. Among these we recognise the Black-headed Gull, as the first to appear, and the most numerous; then small troops of the Common Gull—not so common as the name would imply. We observe also the Herring and lesser Black-backed Gulls, a Kittiwake or two, and a solitary greater Black-backed Gull every now and then. The Kittiwakes are more frequent in the river later on in the season. Presently a dark brown looking bird with a longish tail comes, like a hawk, on the scene. This is the Arctic or Richardson Skua, on the look-out for plunder from some of the over-fed Gulls leaving the banks. Though the Skuas are not often seen, yet the present one is not unfrequent at this season on the higher parts of the estuary about Newburgh. Most of the Gulls, Skuas excepted, are continually to be seen between the bridges at Perth at all seasons, where their graceful motions of flight, as they pick up and scramble for any floating matter on the water's surface, may be there specially well studied. Those seen in the summer months are usually young birds or those not breeding.

Six weeks or so later, or about the third week of October—close on the time we were first up the water and saw the Dipper—we again proceed down the estuary, visiting both sides, and notice many species we had not previously observed, as by this time most of the autumnal birds have arrived. As we get down to Elcho and Balhebron marshes we find the Jack-Snipe now plentiful in the softer parts, having come in from the north during the last week of September, or beginning of October. We have not gone far into the marsh before, through the crisp recently cut salt grass *(Glyceria aquatica)*, something rapidly runs with rat-like motion; this our dog at last, with difficulty, flushes, and we find it is the Little Spotted Craik, usually believed to be exceedingly rare. This belief, however, arises most probably from its extreme shyness, and the difficulty with which it is started out of the dense thickets of water plants which it frequents, so that it may be passed over and over again without being specially noticed. Another bird of the same family that we meet with, and which is pretty frequent at this season, is the Water-Rail. By going cautiously, this may be seen feeding in bare places just outside the line of reeds, into which, on the slightest alarm, it immediately goes into hiding. It is nearly as difficult to get on the wing as the other, and it is as yet an unascertained fact whether these birds may not be both of them residents. As we progress we meet with the Teal and the Wild Duck, the former in twos and threes in some of the water courses, but

occasionally in larger flocks. The Widgeon also is started, but it is not now nearly so commonly seen as formerly. We also come on some Golden-Eyes feeding in one of the said water courses, but more of these hereafter. The Shoveller is also noticed—rather a rare duck, but commoner than formerly, and which is now ascertained to breed in several places higher up.

Passing downwards, the mouth of the Earn is reached. Here rather a rare bird, the Green Sand-Piper, is noticed. This is more commonly found about inland waters, than near the sea, and it is an autumn and spring visitant only. At this point, crossing over to the opposite shore or left bank, we see a largish-looking Sand-Piper with shining white breast on a mud spit. This is the Greenshank, once not by any means uncommon at this season, but now exceedingly rare in its old autumn haunts; it breeds on the higher hills, coming down to the lower Tay and coast on its way south. We land, and at the side of the marsh another bird of the Sand-Piper race, of about the same size, but darker in colour, shows itself—the Ruff, or Reeve, by which name the female is known. Though rare with us, it is not unusual on the Tay during the autumn passage. The Ruff was a well-known bird in the old Lincolnshire Fen days, when many of these birds, the males only, were trapped and netted for the London market in the spring, the poulterers' shops being then full of them. The Ruff is so called from the extraordinary elongation during the breeding season of the neck feathers, which form a ruff of every shade of colour in different individuals, but which they soon lose; this stage of plumage is unknown with us. As the bird is polygamous this great destruction of the males at that season did not perceptibly aid in its decrease, but the drainage of the Fens eventually drove them out of the country as a breeding bird. Another of the rarer Sand-Pipers we meet with on the same ground is the Curlew Sand-Piper, or Pigmy Curlew, as it is often called, from the length and curve of the bill, but it is only to be seen with us either in the winter or grey plumage, or just on the change from the reddish plumage of summer, assumed during the breeding season.

Keeping down the river, we find the reed beds teeming with Blue-Tits, and most interesting it is to watch the way they ascend and descend the reed stalks, peering and prying into every leaf joint in busy hunt for insects; while others again cling to the pendant seed tufts in search of the grain therein contained. It may be worthy of remark that the Blue-Tit is the only one of the tribe we have ever noticed visiting the reeds, and this we find they do regularly on the Tay every season during the autumn months.

Here also we find the Reed Bunting or Reed Sparrow in small groups, clinging in the same way to the pensile tufts of the tallest

reeds, busily extracting the seeds, and all the time uttering a somewhat feeble monotonous chirp to keep the little party together. So intent are they that they heed us not, but, if by chance disturbed, they immediately fly off and settle a little farther on. Among the land birds frequently inhabiting the reeds and marshy ground is the Pheasant, which I here mention, though, being an introduction, it is not enumerated in the list; but I do so to illustrate how strangely the wild habits of a bird have been retained after generations of semi-domestication. In Macedonia, where the Pheasant is truly wild, having originally spread over from Asia Minor, I invariably found them on the margins of the large rivers, among reeds and osier beds, also in the marshy woods and reedy thickets in the vicinity, never on the high grounds or in dry woods; and so with us, the Pheasant still shows itself to be a true bird of the reeds wherever it can get at them. The Partridge also sometimes comes down and settles in some warm corner of the drier grassy spots, not that he prefers marshy ground, like the Pheasant, but either he comes for protection, or for the rich supply of various aquatic seeds he well knows are to be found there. Here, also, we see, though in broad daylight, an Owl hunting the marsh. This is the Short-eared Owl, occasionally seen with us during autumn within the river banks, his home and habit being very different from those of other Owls, and though, as we see him, he is only on the look-out for water beetles, or any small fry he may pick up, yet he is a veritable mouse-hunter and should be encouraged instead of being shot at, as he too often is. I must add another good word in his favour. During the great mouse or vole plague, which occurred so lately in the Border counties, every device was tried to stay it, but without effect. But when these same Owls arrived afterwards in considerable numbers, and, being unmolested, remained to breed, feeding their young entirely on voles, the numbers consumed proved to be so enormous that soon the voles began perceptibly to decrease.

But to proceed; entering our boat again, and keeping the left bank, we pass Errol and meet with various birds on our way. As we glide past, the Hooded Crow is to be seen pretty abundantly on various points along the water's edge, searching for dead fish and other savoury morsels. Though occasionally seen at other seasons, the Hooded Crow is not nearly so frequent as its congener, the Carrion, but at this time they are always more abundant than at other times. The plumage, also, is much clearer and brighter, suggesting these to be foreigners which have recently come, and which will take their departure a little later on. As we near Seaside, Wild Geese are seen on the outer banks. These have only lately arrived, the first week of October being about the time of their first appear-

ance. There are, or rather were formerly, four species common to the Tay—the Grey Lag, the Pink-footed, the White-fronted, and Bean Goose. Of the four the two first are still pretty numerous, more especially the Pink-footed; the two latter are seldom or never now seen. At certain stages of the tide Geese quit the river, and may then be seen high up in **V**-shaped flight, making for the fields in the broad Carse, many of them also going over to the Fife side, but all returning at stated times.

As we approach the mud flats near Invergowrie we notice various Waders. Feeding at the water's edge are Curlews, Redshanks, and a Bar-tailed Godwit or two, now very rare, also the Knot. This last was once very abundant, but it is now seldom seen. Dotted about on the mud are a few Golden Plover, recognised by their plaintive whistle. Not so very many years ago these might be seen, as the tide rose, settling in large flocks on the adjoining fields. Here, also, are small flocks of Dunlins; these breed on the higher hills, as well as on Tentsmuir, congregating on the estuary and along the coast in autumn, and with them we notice the little Ox-eye, or Ring Plover, whose after-acquaintance we will make.

As we take the flow on our return we approach Newburgh, and, coasting along the north side of Mugdrum Island till near the centre, we ensconce ourselves behind one of the big stone dykes already mentioned, and there, like the herons, await events. It was not far from this spot, but on the opposite (or Fife) side, that a specimen of the Bittern was obtained some few years ago. Though now only a casual, the time has been when the Bittern was doubtless not an uncommon bird on the Tay. We have not been long here before some Dunlins, already mentioned, pass within a short distance. Then, with outstretched neck and rapid flight, comes a Cormorant, with the prospect of fishing a little higher up. These birds are not uncommon in the fresh water as well as salt, and have been got as far up as Loch Tay. Shortly afterwards, the tide rising quickly, there comes racing up with it, and with a chirring kind of croak, a considerable flock of Sheldrake; these go floating past, but not higher than the head of the island, and return with the ebb. The Sheldrake, the very handsomest of our Ducks, is resident on the Tay, breeding in rabbit burrows, both at the mouth and on the banks above, as also sometimes on the braes of the Carse.

The day is now on the wane, and most interesting it is to watch the numerous parties of Starlings as they come flocking in from every direction before going to roost in the large reed-brake at the head of the island—the great resort and roosting-place of seemingly every Starling in the district. These, as they come in, unite, and at last form one

gigantic body of many thousands, which, after wheeling about in every variety of evolution, sometimes in separate columns, sometimes united, suddenly, as it were by given signal, precipitate themselves in one vast mass, and are at once buried out of sight in the dense growth of reeds; but we are still conscious of their presence from the one universal chatter and confusion of voices, which after a while subsides, and all are settled for the night. At early dawn, separating again into small parties, they make their way back to their several homes; and so it goes on, night after night, every autumn after the breeding season is over, until the cutting of the reeds a month or two later. The Starlings, along with their cousins the Rook and the Jackdaw, are all riverside feeders as the season advances, and there is a difficulty in obtaining food elsewhere.

To the winter season I would now draw your attention, but, not to detain you too long, I will merely take a cursory view of the birds at that time as we again visit the tidal waters. Many of our small birds come down now to scrape up a subsistence. The alder bushes overhanging the water are visited by numbers of Siskins, busily feeding on the catkins, the Lesser Redpoll now and then accompanying them, but always on the ground picking up any small seeds he can find. Sometimes the Bullfinch may be seen on the dockweeds and other seed-covered plants, or we may meet with an occasional Greenfinch and Chaffinch, all seed-feeding birds, but generally on the ground. The Hedge-Sparrow and the little House-Wren move about among the tangled roots and debris left by the tide, about which also the Blackbird may be seen routing and grubbing, while out on the broader marsh, strange to say, the Robin often takes up his abode even among the stranded ice, and seems quite to understand what he is about. Here, also, occasionally a Thrush may be seen, but only a straggler, the main body having left long ago for the sea-coast and other warm places. The Woodcock is often down on the softer spots at night, but off again before morning. Of our web-footed birds, perhaps one of the handsomest and most deserving of notice is the Goosander, which, like the Cormorant, is a most expert diver, feeding entirely on fish. Though not very abundant, it is to be seen spread over most parts of the Tay, both above and below, till late on in the spring; very detrimental to the salmon-fry, no doubt. Some even remain to breed on the higher lochs.

While severe weather lasts, and many of the lochs are frozen over, we find several strangers on the open waters of the lower Tay that we do not meet with at other times. Of these may be mentioned the Swan, of which we have three species—the Mute, the Hooper or Wild Swan, and the lesser or Bewick's Swan; the latter very rare.

We have also the Egyptian and the Canadian Goose, both casuals, or perhaps escapes. The former bird, however, has been long known to the Tay. The Brent Goose, the smallest of our Geese, is occasionally to be seen on the higher tidal parts, having come up from the salt water lower down, where it is more usually to be found. The Scaup Duck also comes up at times from the salt water below; and we now occasionally fall in with the Tufted Duck, as also the Red-headed Pochard. The former is a rather handsome black-and-white-looking Duck, with purplish shining metallic crest. Though not common, both these birds are now known to remain and breed on some of our inland waters. But perhaps the rarest of the winter Ducks on the lower Tay is the Gadwall, another of our fresh-water Ducks. This bird does not remain, and is only occasionally met with.

Others of our rare visitors are the Red-breasted Merganser and the Smew, both closely allied to the Goosander already mentioned, and, like it, both fish-eaters and the most expert of divers. Specially expert is the Smew, swimming, or rather flying, under water, the wings being used as well as the feet, with so great a velocity that a fish has little chance of escape, especially as the saw-toothed bill never loses its grip. I may here mention that a Smew was shot on the Stormontfield breeding ponds a few winters ago with four salmon-parr in its stomach and the remains of several others, as noticed by Mr. Marshall, of the Stanley Stores. Besides these, we have the Black-throated and Red-throated Divers, mostly in immature or winter plumage. All these are fish-eaters, but the supply of fish food, such as that of sperlings, garvies, eels, etc., is so ample on the lower water at this season, at which time the young of the salmon and sea-trout are not there, that any amount of fish-eating birds can do little or no harm. It is only in those parts of the Tay above tide flow that any real mischief can happen. Of the Grebes there are the Crested, the Red-necked, and the Sclavonian, all expert divers, but not injurious like the others. These are also rare, especially the two latter. The Little Grebe, along with the Coot, both common on the pools and backwaters in the upper districts, now visit the estuary. By the estuary I mean that part of it from the Mouth of the Earn to Invergowrie Burn.

In addition to those mentioned, we have several sea-birds that come up to the fresh water. Some may be driven in by gales, but, at times some are seen when the weather has been particularly mild. At such a time the Guillemot has been found up above Darry Island. The bird had been evidently fishing higher up, and was coming down rapidly with the tide at the time. It has also been known to frequent the pools about Stanley, together with the Razor Bill, which

last has been seen as far up the fresh water as the Tummel, beyond Pitlochry, and both of them have even been got on Loch Tay. Possibly, however, in that locality they may have been driven over by severe westerly gales. All are expert divers, living entirely on fish. The Puffin has been got above the Bridge of Perth, and several Little Auks, true oceanic birds, also made their appearance in the severe winter of 1879 a little below Perth, where they remained for some days. Examples of all these sea-birds obtained in fresh water from time to time are now in the Society's Museum.

It may not be here out of place also to note the occurrence of two alien species, stragglers to Europe, that have been got on the Tay. These are the Green-backed Gallinule *(Porphyrio smaragdonotus)*, which was got in the thick reeds below Errol, and the Black-throated Thrush *(Turdus atrigularis)*, which was obtained on a marshy spit below the Friarton, Perth. The former is a S.E. African species that has occasionally wandered to Europe; the latter is a native of Siberia, and of it two examples were seen in company, one of which is now in the Museum. Another casual, but of the Arctic Regions, which has been observed as high up as Perth, though it has not been obtained, is the Ivory Gull.

This brings our list of winter visitants on the Tay to an end. We will now picture to ourselves the arrival of spring, and thence on to early summer. The month of March has arrived, and I will ask you to come down with me a short way below Perth. It is towards the end of the month, and, thanks to the Wild-bird Act, the report of a gun has not been heard for some two or three weeks, and birds are beginning to gain confidence. Notwithstanding that the nets are on, the fishermen busy, and the river everywhere full of life, yet the Wild Duck now comes up with his mate at night and returns in early morning, in safety and without fear. It is now nearly low water, and as we go along the shore we hear the shrill but pleasant piping notes of numerous Redshanks, and see them tripping along the mud in quiet corners of the tide-left watercourses, their home for a week or two before separating for their breeding-grounds on the moors. Though we noticed a few down below in the autumn, this is their first appearance up here since last spring. On parts of the river where the nets are not plying, but not far from where they are being shot, a flock of Golden-eye Ducks are fishing, seemingly quite unconcerned. Let us watch and we shall see that, all the same, they take very good care to keep a sharp look-out. There may be seven to fifteen birds or more, but, while most have dived and are out of sight, two or three are always afloat, and as one comes up another goes down, till all the sentries have been relieved. These Ducks are the last winter ones to leave, it being sometimes near the end of April before they

do so. A few years ago they could not have remained so long, as every bird would have been driven off the water long before from the incessant shooting which was going on. It did not matter what the mark was, so long as it was a bird—Gull or Water-hen, it was all the same. All that is now changed, and it shows what a little quiet and rest will do; and perhaps there is no greater result of this than what may be seen any day within the precincts of the Fair City itself—*i.e.*, the wonderful confidence attained by Gulls and others in these happy hunting-grounds, where a gun is never fired, and long may this be so. Many of the citizens may recollect how one of these very birds, the Golden-eye, whether disabled or not is best known to himself, took up his quarters between the bridges for nearly three years, becoming quite tame, and we may hope when he disappeared it was not by violent means, but that he was wiled away by some of his friends to take a trip to the north; be that as it may, he never returned. But enough of this digression.

As we resume our walk we hear the trilling note of the Curlew, or Whaup as he is often called, in pairs or in small parties, steadily following the course of the river, but high up in the air. These are all on their way to their breeding-grounds on some of the higher moors; it may be those on Loch Tay side. By and by our ears catch the shrill piping notes of four or five birds which pass us in rapid flight near the water, conspicuous in black and white and orange bill. These are Oystercatchers, whose acquaintance we have not yet made, also off to their breeding-grounds—not the moors, as is the case with the Redshank and Curlew, but to the Stanners (a local name), high shingly banks covered with sparse herbage, as explained in the paper on the Flora already alluded to. Over these the Oystercatchers are distributed all the way up by fresh arrivals from the coast, from the head of the tide-way at Almond Mouth to Kenmore, where we will follow them and work our way down. As we get up the river above Dunkeld and into Strathtay we find that our friends the Oystercatchers, instead of regaling themselves on their usual fare of clams and limpets—not here to be got,—are now quietly following the plough on the low haughs like so many rooks, busily picking up worms and grubs as they appear above ground. By the middle or end of April they are chiefly down on the Stanners, where we will now go, and on reaching them we observe several pairs quietly sneaking away and taking wing. They return again a little lower down, running along the shingle in an opposite direction, so as to mislead the stranger.

On the high parts we find numerous attempts, as it were, at formations of nests among the stones, tussocks of campion, sorrel, and other riverside plants. These seeming nests are cavities in the shingle, the larger stones being scraped away and neatly arranged

with smaller ones inside, and commonly with a single stone about the size and colour of an egg in the centre. These sham, or deserted nests, as they are sometimes thought to be, are peculiar to the Oystercatcher, and appear to us to be intended more as a blind to the real nest, which we find further on, with much difficulty, the eggs so exactly resembling in size and colour the surrounding stones. Moving a little further down, we notice the Ox-eye, or Ringed Plover, in pairs, whose acquaintance we made last autumn. Some still remain at the sea coast, but many now come up to their summer quarters and breeding stations in the highlands. Its former companion, the Dunlin, though we see him not, is not far away, being on the moorland adjoining. We have seen nothing of him on his journey, and therefore surmise that he must have travelled by night.

The month of May has come, and we are gladdened by the cheery pipe of the Common Sandpiper, or Summer Snipe, which has just arrived. This is a summer migrant only, and is dispersed pretty generally up and down the Tay and other streams, where it seeks some desirable grassy or gravelly bank not far from the water in which to build its simple nest. These, together with many other summer migrants, are now before us as we descend.

On the willows at the waterside we see abundance of the little Willow-Wren in busy search for insects among the branches. In the thickets on the banks and islands we hear the querulous chatter of the White-throat, and with difficulty start him from his hiding place. Reaching the more open and scrubby parts, we notice the Whinchat, and in a reedy backwater we start the Reed Warbler, a rare and rather unknown bird on the Tay. Further on, in the sedgy thickets, we hear the loud scolding notes of the Sedge Warbler, who every now and then shows himself for an instant, and then, buried again in the coarse water herbage, he is lost to view, but the perpetual babbling, scolding notes still go on, and are often to be heard through the whole summer night.

The various Hirundines are now skimming over the water in all directions in insect-hunt, and, though taking an occasional sweep beyond the banks, may well be considered as birds of the Tay, as we frequently see them tip the water, dexterously seizing an insect from off its surface as they rapidly pass over it. These are the Common Swallow, the House-Martin, and Sand-Martin, the latter nesting in considerable numbers on the steep gravelly bank close by. We notice a small colony of Terns, or, as they are often called, Sea Swallows, breeding on the broad shingly parts as we go down, but comparatively scarce now to what they were formerly, when it was common to see them on all our inland waters in summer. The Swift is rampaging about over the water, sometimes high up in the

air, sometimes lower down, and as we near Perth Bridge we find him nesting underneath, while others are screaming and screeching in every direction, both there and further down the river, in search of insect food.

Besides all those mentioned, we see also at this season on our way down many of our autumn friends to which I have already drawn your attention—the Little Grebe, Coot, and Water-hen, nesting on the backwaters; the Grey or Yellow Water-Wagtail, now in full summer plumage, balancing himself on some boulder in the stream, his mate on her nest near by; an occasional Kingfisher, the Dipper, a Lapwing or two, and several others.

Such is bird life, or was till very lately, on the Tay, but I fear that the birds are getting scarcer every year. The water-birds, properly so called, have greatly diminished from many causes on which I will not now enter, but will merely say that one of the greatest is the wholesale destruction of eggs, not only by professional egg-lifters, but by every boy or lad in the vicinity of their breeding-grounds. I am glad to find that a move is now being made in the right direction to bring eggs, as well as the birds themselves, under the Wild Bird Protection Act. This is a measure which it is to be hoped every Natural History Society throughout the country will support with their utmost strength.

Among the land section of those birds I have mentioned there has been only a partial decrease. The Skylark and the Bullfinch have grown scarcer, and perhaps one or two others—the Swallow and House-Martin for instance,—but this has been brought about entirely by the Sparrow, which robs them of their nests. On the other hand, there has been a most marvellous increase in the case of the Starling, perhaps the greatest egg-stealer of any. It was only in the middle of the third decade of this century that the Starling made its first appearance in Perthshire, and, I believe, in this part of Scotland; yet now they are spread far and wide, and in hundreds of thousands. The cause of this wonderful change is difficult to explain. An ornithological friend, on discussing with me the general decrease of our birds, once made the remark, "The day will come when not a single bird will be left but the Sparrow and the Starling, and the Starling will have the dominion." In conclusion, I will only say—though we are seemingly tending to it—may that day be still very far from us.

NOTE.—Since the above was written the Rev. Biot Edmonston of Kincardine, in the South-east part of Perthshire, in the Forth District, informs the writer that the Starling did not appear in that part of the country until many years subsequent to the time stated.

LIST OF BIRDS THAT OBTAIN THEIR FOOD ON THE TAY AT ONE SEASON OR ANOTHER WITHIN THE LIMITS MENTIONED IN THE FOREGOING PAPER.

NOTE.—An asterisk (*) denotes those which are of irregular as well as those of abnormal visitation.

Turdidæ.

Song-Thrush.
Turdus musicus, Linn.
Blackbird.
Turdus merula, Linn.

Cinclidæ.

Common Dipper.
Cinclus aquaticus, Bechst.

Sylviidæ.

Whin-Chat.
Pratincola rubetra, Linn.
Redbreast.
Erithacus rubecula, Linn.
Whitethroat.
Sylvia rufa, Bodd.
Willow-Wren.
Phylloscopus trochilus, Linn.
Reed-Warbler.
Acrocephalus streperus, Vieill.
Sedge-Warbler.
Acrocephalus schœnobœnus, L.
Hedge-Sparrow.
Accentor modularis, Linn.

Paridæ.

Blue Titmouse.
Parus cœruleus, Linn.

Troglodytidæ.

Common Wren.
Troglodytes parvulus, Koch.

Motacillidæ.

Pied Wagtail.
Motacilla lugubris, Temm.
Grey Wagtail.
Motacilla melanope, Pall.
Meadow-Pipit.
Anthus pratensis, Linn.

Hirundinidæ.

Swallow.
Hirundo rustica, Linn.
Martin.
Chelidon urbica, Linn.
Sand-Martin.
Cotile riparia, Linn.

Tringillidæ.

Siskin.
Chrysomitris spinus, Linn.
Greenfinch.
Ligurinus chloris, Linn.
Chaffinch.
Fringilla cœlebs, Linn.
Lesser Redpoll.
Linota rufescens, Vieill.
Common Bullfinch.
Pyrrhula europœa, Vieill.

Emberizidæ.

Reed-Bunting.
Emberiza schœniclus, Linn.

Alaudidæ.

Sky-Lark.
Alauda arvensis, Linn.

Sturnidæ.

Common Starling.
Sturnus vulgaris, Linn.

Corvidæ.

Jackdaw.
Corvus monedula, Linn.
Carrion Crow.
Corvus corone, Linn.
Hooded Crow.
Corvus cornix, Linn.
Rook.
Corvus frugilegus, Linn.

Cypselidæ.

Common Swift.
Cypselus apus, Linn.

Alcedinidæ.

Common Kingfisher.
Alcedo ispida, Linn.

Strigidæ.

*Short-Eared Owl.
Asio accipitrinus, Pall.

Pelecanidæ.

Common Cormorant.
Phalacrocorax carbo, Linn.

Ardeidæ.

Common Heron.
Ardea cinerea, Linn.
*Bittern.
Botaurus stellaris, Linn.

Anatidæ.

Grey-Lag Goose.
Anser cinereus, Meyer.
*Bean-Goose.
Anser segetum, Gmel.
Pink-Footed Goose.
Anser brachyrhynchus, Baill.
*White-Fronted Goose.
Anser albifrons, Scop.
*Egyptian Goose.
Chenalopex ægyptiaca, Linn.
*Canada Goose.
Bernicla canadensis, Linn.
*Brent Goose.
Bernicla brenta, Pall.
Mute Swan.
Cygnus olor, Gmel.
Whooper Swan.
Cygnus musicus, Bechst.
*Bewick's Swan.
Cygnus Bewicki, Yarr.
Common Sheldrake.
Tadorna cornuta, Gmel.
†*Ruddy Sheldrake.
Tadorna casarca, Linn.
Wild Duck.
Anas boscas, Linn.
*Gadwall.
Chaulelasmus streperus, Linn.
Shoveller.
Spatula clypeata, Linn.
Widgeon.
Mareca penelope, Linn.
Pochard.
Fuligula ferina. Linn.
Scaup.
Fuligula marila, Linn.
Tufted Duck.
Fuligula cristata, Leach.
Goldeneye.
Clangula glaucion, Linn.
Goosander.
Mergus merganser, Linn.
Red-Breasted Merganser.
Mergus serrator, Linn.
*Smew.
Mergus albellus, Linn.

Columbidæ.

Ring-dove.
Columba palumbus, Linn.

Phasianidæ.

‡Pheasant.
Phasianus colchicus, Linn.
Partridge.
Perdix cinerea, Lath.

Rallidæ.

Water-Rail.
Rallus aquaticus, Linn.
Spotted Crake.
Porzana maruetta, Leach.
Water Hen.
Gallinula chloropus, Linn.

† Although this bird has long been known to occur at the mouth of the Tay, it was not till very lately that it was observed above Invergowrie (Sept., 1894), and it is therefore not noticed in the body of the paper.

‡ Introduction.

Common Coot.
Fulica atra, Linn.

Charadriidæ.

Golden Plover.
Charadrius pluvialis, Linn.
Ringed Plover.
Ægialitis hiaticula, Linn.
Lapwing.
Vanellus vulgaris, Bechst.
Oystercatcher.
Hæmatopus ostralegus, Linn.

Scolopacidæ.

Woodcock.
Scolopax rusticola, Linn.
*Solitary or Great Snipe.
Gallinago major, Gmel.
Common Snipe.
Gallinago cœlestis, Frenzel.
Jack Snipe.
Gallinago gallinula, Linn.
Dunlin.
Tringa alpina, Linn.
Pygmy Curlew.
Tringa subarquata, Güld.
Knot.
Tringa canutus, Linn.
Ruff.
Machetes pugnax, Linn.
Common Sandpiper.
Totanus hypoleucus, Linn.
*Green Sandpiper.
Totanus ochropus, Linn.
Common Redshank.
Totanus calidris, Linn.
Greenshank.
Totanus canescens, Gmel.
Bar-Tailed Godwit.
Limosa lapponica, Linn.
Common Curlew.
Numenius arquata, Linn.

Laridæ.

Common Tern.
Sterna fluviatilis, Naum.
Black-Headed Gull.
Larus ridibundus, Linn.
Common Gull.
Larus canus, Linn.
Herring-Gull.
Larus argentatus, Gmel.
Lesser Black-Backed Gull.
Larus fuscus, Linn.
Greater Black-Backed Gull.
Larus marinus, Linn.
Kittiwake.
Rissa tridactyla, Linn.
*Richardson's Skua.
Stercorarius crepidatus, Banks.

Alcidæ.

*Razorbill.
Alca torda, Linn.
*Common Guillemot.
Lomvia troile, Linn.
*Little Auk.
Mergulus alle, Linn.
*Puffin.
Fratercula arctica, Linn.

Colymbidæ.

Black-Throated Diver.
Colymbus arcticus, Linn.
Red-Throated Diver.
Colymbus septentrionalis, Linn.

Podicipedidæ.

*Red-Necked Grebe.
Podiceps griseigena, Bodd.
Sclavonian Grebe.
Podiceps auritus, Linn.
Little Grebe.
Podiceps fluviatilis, Tunstall.

The following are aliens which have occurred once, as mentioned in the paper, viz. :—

Black-Throated Thrush.
Turdus atrigularis, Temm.
Green-Backed Gallinule.
Porphyrio smaragdonotus, Temm.

C.—The Mammalia.

By the late F. Buchanan White, M.D., F.L.S., F.E.S.

Whilst it may be taken as a certainty that all, or almost all, the Perthshire Mammals, if not permanent residents on the banks of the Tay, or in its waters, pay at least occasional visits thereto, there is a lamentable absence of records regarding the distribution of species throughout that part of the river to which these papers are restricted. The reasons for this are various. Many of our Mammals are either nocturnal in their habits or live a life of concealment, and, unless they interfere with the interests of the game preserver or the agriculturist, their very existence is ignored. There are, moreover, but few naturalists who pay much, or any, attention to British Mammalia, and thus a few people only are able to distinguish between the closely allied species. With this in view, and considering the long stretch of river to be dealt with, it is not greatly to be wondered at that records are few and far between, and that the evidence for such as do exist requires to be carefully sifted. The object of this paper, therefore, is quite as much to indicate what information is required, as to show what has already been obtained. From this lack of records it will not be possible to point out the distribution of the mammals in the same way as the distribution of the plants has been shown.

The great factors which determine the distribution are, first, the possibility of obtaining a suitable habitat, and second, the presence or absence of a sufficient supply of the proper kind of food. For example, an arboreal animal, such as the squirrel, might be able to obtain sufficient food, but will not be a permanent resident in places where trees are absent. Neither will an amphibious creature, like the otter, dwell in a locality where the banks do not offer facilities for hiding, even though there be abundance of fish.

Given, therefore, a sufficient supply of food and a suitable environment, there is no reason, except human interference, why most of our mammals should not have a wide distribution on the banks of the river.

Long-Eared Bat (*Plecotus auritus*, L).

Common Bat (*Vesperugo pipistrellus*, Schreb.).

Both of these bats are more or less common from the Carse of Gowrie to Loch Tay. We are rather poorly off for specimens in the Museum, and should be glad to get more.

It is by no means improbable that Daubenton's Bat (*Vespertilio Daubentoni*, Leisl.) also occurs. It has the peculiar habit of flying close to the surface of rivers and ponds, and, as it is not easily seen,

may be abundant in a locality where its occurrence is not even suspected. We have yet to learn much about the bats of Perthshire.

Hedgehog (*Erinaceus europæus*, L.).

Mole (*Talpa europæa*, L.).

Common Shrew (*Sorex tetragonurus*, Herm.).

All of common occurrence. The Lesser Shrew (*Sorex minutus*, L.) should possibly be included in the list, but we have as yet no evidence of its occurrence in Perthshire.

Water Shrew (*Crossopus fodiens*, Pall.).—No record for the banks of the Tay, but, as it has been found at no great distance, it is almost certain to occur.

Wild Cat (*Felis catus*, L.).—Since comparatively recent specimens have been got from the banks, it is very probable that, in days when the species was not uncommon in Perthshire, an occasional wanderer may have entered our district.

Fox (*Canis vulpes*, L.).—Again no record, but there can be no doubt of its occurrence as it is a common species. The foxes in the Museum are all Highland ones. We need a characteristic Lowland specimen.

Polecat (*Mustela putorius*, L.).—A now very rare Perthshire Mammal of which the Museum does not yet possess a specimen. As it has been killed near Stormontfield Ponds about 40 years ago (*fide* Mr. T. Marshall), and used to inhabit Strathtay, it may perhaps be included in this list.

Weasel (*M. vulgaris*, Erxl.).

Stoat (*M. erminea*, L.).

Both common.

Badger (*Meles taxus*, Schreb.).—Though less common than in the western half of Perthshire, the Badger has occurred at various places in the valley of the Tay from below Perth upwards. Near the water side, at Pitfour, there are some old "earths," which Sir James S. Richardson tells me are still occasionally inhabited.

Otter (*Lutra vulgaris*, Erxl.).—Common in various parts of the Tay, though not often seen by casual visitors.

Common Seal (*Phoca vitulina*, L.).—Though Perthshire is practically an inland county, and has no proper sea board, yet, as we have seen in treating of the flora, the Tay affords facilities for the growth of some plants which are usually considered to be maritime. In like manner the waters of the Tay, even within the limits of the district to which these papers are restricted, are not destitute of some animals whose proper and more usual home is rather salt than fresh water. Amongst mammals, the most important of these is the Common Seal, and regarding its distribution and habits in the Tay I have endeavoured to get some information, for which I am indebted

to Colonel Drummond Hay, and through him to Mr. George Pitcaithly, Mr. A. Lumsden, and Mr. T. Marshall.

As may be supposed, Seals are most common in the lower stretches of the river, as between the Tay Bridge and Flisk Point, or Newburgh. On some of the banks (places uncovered at low water), especially opposite Invergowrie, Mr. Lumsden has seen form 30 to 40 at a time, and here they seem to be resident. [In this connection I would ask if the large bank just above Invergowrie, named on the ordnance map the "Dog Bank," gets its title from being frequented by Sea-Dogs, another name for Seals?] Above this they are much less numerous, and occur chiefly as single individuals, who follow the salmon up the river as far (Mr. Marshall tells me) as the Linn of Campsie, where they have been seen from time to time. Whether they go higher than this is not known.

Mr. Pitcaithly believes that Seals are very destructive to salmon. "I infer this" (he writes) "from the number of salmon which we get scarred and torn. It is quite a common thing to see one out of every three or four big fish torn. The late Charles Powrie watched a Seal at Orchard Neuk one Sunday in May, and in the course of an hour and a half he saw it kill three salmon. The late Jas. Miller, Errol, was also confident of one large Seal killing nine salmon during the time (four or five hours) he was fishing on a bank out from Errol. I think the salmon falls a very easy prey to the Seal. On the fish we get scratched, the mark of their claws is always down to the belly and backwards. I have tried a salmon upon a dead Seal, and could not get the scratches to correspond with the claws of the Seal unless the Seal had been on its back when it caught the fish. If that is the case, the fish have little chance of escape. My belief as to this was confirmed when watching the Seals in the ponds of the London Zoological Gardens. When the Seals were swimming with their heads above water, they turned on their backs whenever they went below water. The Seals are very numerous between Dundee and Newburgh, but their place of resting seems to be nearly opposite Invergowrie. There are one or two high banks thereabouts, on which they go to rest as soon as the banks become dry. I have seen them there like a flock of young cattle, but could not get nearer than five or six hundred yards. The only step taken to destroy them was by a man of the name of Melville. Knowing the latter well, I consulted with him, and approved of his plan, which was this—He got long planks of wood sunk on the face of the bank at low water, and a great number of big hooks or 'cleeks' nailed to them. When the tide was out he came on the Seals and hurried them down on the cleeks, but many of the cleeks being too weak straightened out, and a number of Seals escaped. He got, I think, however, four or five,

which he brought to Perth." Mr. Pitcaithly adds that the "Seals are nearly all black, with a few grey ones—the latter I consider the old ones. I think dynamite would be the best method of destroying them."

I would emphasise the fact that we are much in need of specimens of Seals in the Museum. Another species, the Gray Seal, locally known as the Black Seal (*Halichœrus gryphus*, Fah.), occurs in the Firth of Tay, but I have no evidence that it ascends the river to our district. Possibly the Grey Seals mentioned by Mr. Pitcaithly may belong to this species.

Porpoise (*Phocœna communis*, F. Cuv.)—Another marine mammal which ascends the river, occasionally as far as Perth Bridge, in pursuit of salmon.

Two of the cetaceans should be included in the list, but, as the species were not identified at the time that the specimens were killed, it is now impossible to say what they were. One was a species of Dolphin, which was caught in a salmon net near Seggieden. The evidence for the other species rests on a tradition that seven Bottle-Nosed Whales attempted to ascend the Lade where it enters the Old Harbour, and that the largest one, which was leading, was unable to turn, and was killed by a carpenter from a neighbouring shipyard. The name Bottle-Nose is applied to several of the smaller cetaceans. Possibly the species, if it was not the Common Porpoise, may have been the Pilot Whale (*Globicephalus melas*, Trail).

Red Deer (*Cervus elaphus*, L.)—Common near Taymouth, and stragglers probably occasionally visit the banks of the Tay, as they have been seen near it in the low grounds of the district. From the bones that are now and then found, Red Deer were probably common in the Carse of Gowrie in prehistoric times. The Fallow Deer (*Cervus dama*, L.), which is not a native, is semi-wild on the banks of the river near Dunkeld and Taymouth.

Roe Deer (*Capreolus capræa*, Gray).—Common in wooded parts of the district.

Squirrel (*Sciurus vulgaris*, L.)—It is now abundant, as it was also probably in past ages. At one time, however, it seems to have become rare, if not altogether extinct, but it was re-introduced by the Duke of Atholl at Dunkeld in 1776, and became common in a few years.

Brown Rat (*Mus decumanus*, Pall.)—Though not an inhabitant of Britain before about the middle of last century, and possibly not of Perthshire till near the end, it is now too well known.

House Mouse (*Mus musculus*, L.)

Long-Tailed Field Mouse (*M. sylvaticus*, L.)

Common Field Vole (*Arvicola agrestis*, De Selys).—All common.

Red Field Vole (*Arvicola glareolus*, Schreb.)—Not improbably common, but the only locality I know of on the banks of the river is Eastwood, near Dunkeld, where Mr. Athole M'Gregor found them destructive to bulbs in his garden.

Water Vole (*A. amphibius*, L.)—Common, as is the Black variety.

Common Hare (*Lepus europæus*, Pall.)—Common.

Mountain Hare (*L. variabilis*, Pall.)—As this species abounds on the hills, it is extremely probable that individuals occasionally visit the banks of the river, especially in winter, since they have been seen in the low grounds not far off.

Rabbit (*L. cuniculus*, L.)—Common, though a comparatively recent introduction in some parts of the Highlands, as at Taymouth, to which they were brought in 1820.

4.—CHEMISTRY OF THE TAY WATER.

By Dr. Andrew Thomson, M.A., F.C.S., F.R.S.E., F.I.C.

(Read 11th January, 1894).

When the first paper on the physiography of the Tay Valley was given last session, the President and Sir Robert Pullar both suggested that in order to complete these papers I should give one on the water of the Tay. This I hesitated to do, not from any lack of interest in the subject, but simply on account of the fact that my time is so fully occupied that it is extremely difficult to find the necessary leisure from professional duties to perform the careful and frequent analyses which must be made in order to get anything like an adequate idea of the exact composition, and natural and artificial impurities present in the Tay Water, and how these impurities make it fit or otherwise for the purposes for which it is chiefly used. Mr. D. Ferrier, F.C.S., one of my colleagues in the Chemical Department, kindly consented, however, to assist me, and the report I present is based chiefly on our own analyses, though in regard to the sanitary view of the subject I have been at the trouble and expense of getting three independent analyses from outside to establish and confirm our own report. The samples used on these occasions were drawn independently by two gentlemen, sealed up, and one handed over to us, the other being sent to a special analyst in a place far removed from Perth, so that we have the utmost confidence in the results presented to the Society, and in the deductions we draw from these results.

The Tay proper, receiving its water from Loch Tay, which is fed

at Killin by the Dochart and Lochay, starts at Kenmore, and receives, a few miles farther down on its left bank, the waters of the Lyon from Loch Lyon. After passing Aberfeldy it is joined on the left bank, near Ballinluig Station, by the Tummel from the Moor of Rannoch. The Tummel drains Loch Lydoch, Loch Ericht, Loch Rannoch, and Loch Tummel, and also brings with it the waters of the Garry from Loch Garry. Up to this point the Tay has been flowing east by north-east, but now it turns southward, and the open valley of Strathtay contracts into a glen which is terminated by the Pass of Birnam about two miles south of Dunkeld. A little above Dunkeld the river again turns, now in a south-easterly direction, receiving on its right bank the Braan, which drains Loch Freuchie. From the Pass of Birnam the direction is almost due east to Delvine, when it turns north, then east, and then south-east to Kinclaven Castle, where on the left bank it receives the Isla, bringing with it the Shee, the Ardle, and the Ericht. From here the direction is south-west to Stanley. From Stanley the direction is more or less due south to the Friarton. A few miles above Perth it receives on its right bank the Almond, which rises to the south of Loch Tay and joins the main stream opposite Scone Palace. At the Friarton it abruptly turns east, then south-east to Newburgh, where the Earn, the last tributary of any importance, is received on its right bank. The time at our disposal has not been sufficient to enable us to make a separate analysis of each of these tributaries, but from the analyses made we are quite satisfied that, so far as *natural impurities* are concerned, there is nothing to fear in the river water. The Tay, in its *natural condition*, is admirably adapted for domestic, dietetic, and general manufacturing purposes. For the brewer and aerated water manufacturer the water is too soft, but doubtless these know how to increase the hardness by the addition of lime, or possibly find a supply elsewhere more suitable for their purposes.

Besides the tributaries named and marked on the map we have, however, a large number of unmarked tributaries, which are undoubtedly the sources of the objectionable impurities found in our river; impurities which, though small in comparison with the large volume of water in the Tay, are yet sufficient, under certain conditions, and in certain states of the river, to prove hurtful to those using the unfiltered water for other than manufacturing purposes. Very little sewage enters at Kenmore, but in an account of a recent meeting of our County Council we have a paragraph, entitled the "Pollution of the Tay," in which it is shown that the crude sewage of Aberfeldy is run into the River Tay, and this action was even defended in a report signed by the Provost and Medical Officer of Health for that burgh, notwithstanding the fact that cases of typhoid or enteric fever were distinctly traceable to the use of Tay water below Aberfeldy. All

along the river and its tributaries examples might be cited of the same kind of thing, in some cases the sewage being partly purified, and in other cases run in in its crude state as at Aberfeldy. Reports got from gentlemen in several districts we do not feel at liberty to make public, and the grosser forms of pollution are being found out and stopped by the vigilance of our Medical Officers and Sanitary Inspectors; but I have said enough, I think, to bring home the fact that sewage—in some cases at least, crude and undiluted sewage,—enters the Tay, and we shall ask a little later, are the natural and artificial means at our disposal sufficient to effectually purify our water supply from the contaminations which undoubtedly it contains.

Let us now examine the results of the two sets of analyses of the River Tay, and from these we shall get a general impression of the kind of water we have to deal with. The first set of samples were drawn from the river at the different points mentioned on January 31st, when the river was in spate and slightly muddy. In each case we filtered off the suspended impurities, and then determined the dissolved impurities, dividing them into volatile substances, or those driven off by heat, which are chiefly organic matters and ammonia salts, and saline substances or those not driven off by heat. These two added together give us the total solids dissolved in the water. We also determined the chlorine, the hardness, and the temperature both of the water when drawn from the river and of the air at the same time.

TABLE I.—ANALYSES OF TAY WATER, DRAWN JAN. 31st, 1893.

(RIVER IN SPATE.)

	I. Above Aberfeldy.	II. At Logierait.	III. At Delvine.	IV. At Campsie.	V. At Perth. Low Water.	VII. Perth Water Supply.	VIII. At Inchyra. Low Water.	IX. At Inchyra. High Water.
Solids in suspension, -	·6	1·7	4·6	2·4	1·6	—	1·2	1·6
,, in solution, Volatile, -	2·8	2·6	2·0	2·4	3·2	2·8	3·0	2·7
,, in solution, Saline, -	1·3	1·0	1·0	1·2	1·4	2·4	1·4	1·8
,, in solution, Total, -	4·1	3·6	3·0	3·6	4·6	5·2	4·4	4·5
Chlorine, - - -	·60	·60	·53	·60	·55	·90	·60	·60
Hardness, Temporary, -	·5	·5	·2	·3	·5	·4	·5	·4
,, Permanent, -	2·0	2·0	2·2	2·3	2·2	3·0	2·5	2·4
Total, - -	2·5	2·5	2·4	2·6	2·7	3·4	3·0	2·8
Temperature of Air (degs. C.)	8	7	6	10	5	9	8	9
,, Water (degs. C.)	4	6	5	6	2	5	5	7
Time of Day, - - -	10 a.m.	5.30 p.m.	5.15 p.m.	1.30 p.m.	11.15 a.m.	3.43 p.m.	9.45 a.m.	3.20 p.m.

These figures represent parts of the substance in every 100,000 parts of the water. The chief points to note here are :—

1. When the river is in full flood, as here, due to the melting of snow among the hills, the composition of the water is practically the same throughout, as is shown by the solids, the hardness, and the chlorine.

2. The sample No. 7 in the table was drawn at the same time as the others, but from the town supply. The flood came down between the Monday and Tuesday, the water being low before, and we have here an increase in total solids in solution, also in the chlorine, and in the hardness, showing that the spate water had not had time to pass through the service pipes before the sample was drawn.

3. The temperature of the air is in all cases higher than that of the water, which is what one would expect, as a large volume of the water is got from melted snow. In addition, it is interesting to note that the general difference in temperature is greater in the early part of the day and gradually decreases during the afternoon.

4. The amount of solids in suspension shows, we think, that in flood the Tummel must contribute a large quota of the muddy matter, and that this is carried in large quantity through the Pass of Birnam and down the length of Delvine. At Campsie the river has been joined by the Isla, and is flowing at a much slower rate, so that the heavier matters in suspension have settled down, and amount to little more than half of what we found in suspension at Delvine. This diminution goes on all the way to Inchyra, and is interesting geologically as showing the action of water as a denuding agent, and its further action as the agent by which river islands, deltas, and alluvial soils have been deposited.

Let us next examine the second set of analyses, which are more valuable in the way of giving us a general impression of the water in the Tay under normal conditions. These samples were drawn from the different points mentioned, on May 2nd when the river was low, and the water clear, and free of suspended impurities except in the samples drawn at Inchyra and Newburgh, where the mud found was evidently stirred up from the bottom of the river.

TABLE II.—ANALYSES OF WATER TAKEN FROM THE TAY ON MAY 2nd, 1893. (RIVER LOW AND CLEAR.)

	I. Above Aberfeldy.	II. Logierait.	III. Delvine.	IV. Campsie.	V. Perth. Low Water.	VI. Perth. High Water.	VII. Perth Water Supply.	VIII. Inchyra. Low Water.	IX. Inchyra. High Water.	X. Newburgh Low Water.	XI. Newburgh High Water.
Solids—Suspended,	0	0	0	0	0	0	0	4·98	5·80	9·00	—
,, in solution, Volatile,	3·0	3·0	2·2	2·8	4·0	3·3	3·2	3·8	15·6	7·4	64·0
,, Saline,	1·2	2·8	2·8	3·2	2·2	4·0	4·2	2·4	41·0	17·8	517·0
,, Total,	4·2	5·8	5·0	6·0	6·2	7·3	7·4	6·2	56·6	25·2	581·0
Chlorine,	·61	·70	·70	·70	·80	·90	1·10	·77	28·35	9·10	317·0
Ammonia—Free,	·005	·008	·008	·007	·006	·004	·003				
,, Albumenoid,	·003	·006	·008	·009	·011	·015	·003				
,, Total,	·008	·014	·016	·016	·017	·019	·006				
Hardness—Temporary,	·3	·2	·3	·3	·5	·5	·4	·25	1·0	·9	1·5
,, Permanent,	2·2	2·3	2·2	3·2	3·5	3·5	4·0	3·5	11·5	6·1	22·5
,, Total,	2·5	2·5	2·5	3·5	4·0	4·0	4·4	3·75	12·5	7·0	24·0
Temperature, Air (degs. C.)	9	7	8	9	9	8	10	11	9	11	12
,, Water	8	9	9	11	10	10	10	11	11	11	11
Time at which drawn,	2·30 P.M.	3·10 P.M.	6·30 P.M.	1·0 P.M.	9·30 A.M.	4·30 P.M.	9·45 A.M.	9·45 A.M.	4·27 P.M.	9·45 A.M.	5·0 P.M.

As in the first table, the analyses give parts of the different substances in every 100,000 parts of the Tay water. For comparison, the numbers on the top of this table have been made to correspond with the numbers on the top of the former table.

1. We have here not only the disappearance of suspended impurities till after we pass Perth, but a considerable increase in the total amount of both volatile and saline matter. We wish you specially to note that the total solid matter in the samples taken at *high water* at Perth, and from the town supply, is about 15 per cent. greater than in the sample either above or immediately below Perth.

2. In regard to the chlorine. Above Aberfeldy it is almost exactly the same as in the first set of analyses, but it gradually increases, and is considerably greater in analyses No. 6 and No. 7 than it is above Perth, or at Inchyra at low water. These facts, taken with others I shall note in a little, point clearly to the conclusion that in the summer time at least the tidal water passes above the filter beds and finds its way into our water supply, accounting in great measure at least for the high percentage of chlorine, which Perth water undoubtedly has.

3. The ammonias in the first 7 samples were also carefully determined by Wanklyn's process, and these afford valuable criteria as to the purity of the water, organically considered. "The free ammonia is that which can be removed by simple distillation of the water" after adding a little sodium carbonate, which must first be carefully tested and freed from any trace of ammonia. The albumenoid ammonia does not pre-exist as ammonia in water, but is produced from the nitrogenous albumenoid substances present, by boiling the water, after removing the free ammonia, with a strongly alkaline solution of potassium permanganate. The ammonia got in this way is called albumenoid ammonia, and is proportional to the quantity of nitrogenous or albumenoid substances present in the water. In the sample drawn above Aberfeldy the free and albumenoid ammonias are both small, but after getting down the length of Logierait, both are very much increased. The free is increased 60 per cent., and the albumenoid is just doubled, and this is without doubt, we think, due to the introduction of sewage at Aberfeldy. The albumenoid ammonia goes on increasing all the way down to Perth, but the free ammonia decreases slowly from Delvine downwards to the filter-beds. This decrease is undoubtedly due to the fermentation or oxidation of the free ammonia into nitrous and nitric acid. In No. 5 the nitrogen present as nitrates and nitrites was ·005 per 100,000 parts of the water, and though, owing to an accident to our nitrometer, we were unable to determine the nitrogen as nitrates and nitrites in the other samples, we have no doubt but that the explanation given is the true one.

In No. 7 there is still a diminution in the free ammonia, and a most decided drop in the albumenoid ammonia, showing the highly beneficial results of filtration. At the same time allow me to most strongly emphasise the fact that the presence of the amount ·015 of albumenoid ammonia in every 100,000 parts of the water just before filtration, taken along with the free ammonia found farther up the river, and the nitrogen as nitrates and nitrites just before filtration, is a distinct proof of contamination.

Professor Wanklyn says that "if the amount of albumenoid ammonia amounts to ·002 parts per 100,000 then the water belongs to a class of very pure water. When the albumenoid ammonia amounts to ·005 parts per 100,000 then the proportion of free ammonia becomes an element in the calculation." When the free ammonia exceeds ·008 parts per 100,000 it is often due to the fermentation of urea into carbonate of ammonia, and shows the presence of sewage contamination. And he says—"I should be inclined to look with suspicion on a water yielding a considerable quantity of free ammonia along with more than ·005 parts of albumenoid ammonia per 100,000 parts. Free ammonia, however, being absent, or very small, a water should not be condemned unless the albumenoid ammonia reaches something like ·01 parts per 100,000. Albumenoid ammonia above this begins to be a very suspicious sign, and over ·015 parts per 100,000 ought to condemn a water absolutely. The absence of chlorine, or an amount of it which does not exceed 1·4 parts per 100,000, is a sign that the organic impurity is of vegetable *rather than* of animal origin; but it would be a mistake to allow water highly contaminated with vegetable matter to be taken for domestic use." Now, from this table you will, we think, clearly understand that the water of the river at Perth before filtration is contaminated, and decidedly objectionable for drinking purposes, and hence the absolute necessity for careful filtration, and you will also be led to inquire whether filtration renders the water sufficiently pure *at all times* to be called a perfectly innocuous water for domestic and dietetic purposes.

4. The amount of lime giving rise to the hardness in the water is very small all the way down to Perth, and this, along with the absence of an excessive quantity of organic matter, shows the water to be admirably adapted for the important industries of dyeing and bleaching, for which Perth and its vicinity have long been famous. The water is also most suitable for washing purposes, and for use in steam boilers. This is well shown by comparison with the London water supply, which has about 25 degrees of hardness, and is most unsuitable for dyeing or bleaching purposes.

5. The only other thing to note here is that in our second table, the temperature of the air and water is very nearly alike; but, as a

rule, the water has the higher temperature, which is the reverse of what we found in our analyses of the water during the month of January.

There is still a third table, showing the composition of the water supply for the city; but, before examining it, we wish to state our reasons for coming to the conclusion that the Tay tidal water, or sea water, passes in larger or smaller quantity to a point at least 100 yards above the lower filter-bed:—

1. In the first table the sample from Perth water supply (No. 7 in table I.) gives total solids 5·2 and chlorine ·9 parts per 100,000. The river was very low before Tuesday, 31st January, and it was nearly full moon, giving us high tides. The water drawn from the service pipe on Tuesday must have passed in on the Sunday or Monday afternoon when we were having very high tide. In table II. the same thing occurs with samples VI. and VII.

2. Six samples were drawn from the Tay on two different days at full tide, one sample being taken from the top or surface water, and the other from the bottom, and it was found on each occasion that the amount of chlorine in the surface water was ·75 per 100,000; and in the bottom water ·85 per 100,000. These six samples were drawn on 23rd and 24th November, full moon, and therefore high tide being on 23rd about 3 P.M. This gives 1·22 parts of common salt in the surface water to 1·40 parts in the bottom water per 100,000 of the water, or an increase in the bottom water of about 15% of common salt. This proves what was suggested in the first paper on the physiography of the Tay, viz., that the heavier water remains at the bottom, and contains a perceptible amount of sea water.

3. The action of Perth water upon the inside of the iron pipes of the service supply also indicates the presence of sea water. This action will be shown and explained, we understand, by Mr. John Young, civil engineer, and is, we expect, due to the presence of chlorine or chloride of sodium in the water. It is found more or less in all pipes, and the amount of it indicates the amount of chlorides present. From the immense deposit in the Perth pipes, we are warranted, we think, in saying that more chloride must pass through these pipes than the chlorides found in the Tay water above Perth, and, further, that this excess of chlorides is got from the tidal water.

Let us now examine this third table, which gives a number of analyses by at least four different analysts of the Tay water after filtration as supplied to the city. We forbear to give names, but everything has been done to ensure accuracy and to endeavour to get at the truth concerning our water supply. Some of these samples were drawn and sealed up by two independent gentlemen, one sample, as

has been said, being handed to us, and the other sent to the outside analyst from a place a long way from Perth.

TABLE III.—ANALYSES OF TAY WATER AS SUPPLIED TO THE CITY OF PERTH.

		Jany.	1893					
	1881	1892	Feb.	May	June	Sept.	Oct.	Dec.	Dec.
Solids, Volatile, - -	1·40	1·40	2·8	3·2	*·22	*·97	1·60	*·60	2·00
,, Saline, - -	5·60	6·60	2·4	4·2	4·48	3·40	5·04	5·41	4·00
,, Total, - -	7·00	8·00	5·20	7·40	4·70	4·37	6·64	6·01	6·00
Chlorine, - - -	1·30	1·30	·90	1·10		·97	·94	·70	·75
Ammonia, Free, - -	·003	·004	·001	·003	·003	·003	·003	·010	·008
,, Albumenoid,	·005	·009	·009	·003	·007	·002	·005	·007	·005
,, Total, -	·008	·013	·010	·006	·010	·005	·008	·017	·013
Hardness, Temporary,	—	·6	·4	·4	2·40	—	·42	—	—
,, Permanent,	—	3·6	3·0	4·0	1·48	—	3·07	—	—
,, Total, - -	—	4·2	3·4	4·4	3·88	—	3·49	3·21	3·10

In samples marked so * the upper column gives the organic matter only, and not the whole volatile matter.

Of these analyses four or five are very satisfactory. Three of these, January, 1892, and the two in December, 1893, are not sufficiently bad to condemn the water, but at these times the water could not be looked upon as a water of first-class quality. These three analyses are done independently of each other; the latter two were drawn in the manner indicated, and are samples of the same water, the last being our own analysis, and the second last that of an outside specialist. These two, and also the one in January, 1892, all bring out the fact that, during the winter time, when the river is often flooded, when the natural purifying agents are not so active, and the purification by filtration is not so effective as in the summer time when the river is low, we are undoubtedly much more liable to suffer from impurities than during summer. In fact, in the winter time we are not in a position to say that the water is of first-class purity, although at the same time we, from chemical analyses alone, are not in a position to condemn the water for domestic and dietetic purposes. We are distinctly of opinion, however, that there ought to be, especially for some time after flooding, a thorough bacteriological investigation of the water supply in addition to the chemical analyses. The water for both examinations should be drawn independently from the water supply of the city. The Medical Officers and our Sanitary Inspectors deserve all praise for their efforts to lessen the danger arising from contamination of the Tay by sewage, but we dare not shut our eyes to the fact that sewage in considerable quantity is run into the river, and that in certain states of the river the purifying agents are less active, and there is at least a danger of the filter-beds being insufficient to remove dissolved impurities got from sewage contamination.

We shall now devote the rest of this paper to an examination of the purifying agents which we know to be at work, and endeavour to account for the fact that our water is less pure in winter, and especially after the early flooding in autumn.

PURIFYING AGENTS IN THE RIVER.

1. The action of light as a purifying agent. The water in any river is swarming with bacteria, and when sewage is passed into a river we are certainly apt to find a larger number of pathogenic bacteria present. The excreta from patients suffering from cholera and typhoid or enteric fever are especially dangerous, and anything which in any way helps to remove or destroy these is most important.

The bacterial purification of a river has recently been set down to "a process of sedimentation which the micro-organisms in the water undergo," but Buchner in investigations made little more than a year ago—see Ueber den Einfluss des Lichtes auf Bakterien in Centralblatt für Bakteriologie, vol. II., 1892—clearly proved that the most important factor in the destruction of bacteria in water was the action of light. In his experiments he took water highly charged with typhoid bacilli, and after exposure to light it was found that these were all destroyed. In carrying out his experiments one water was charged and exposed to light, and a companion experiment was conducted under exactly the same conditions, with the exception that the glass was entirely covered with black paper, so that all light was excluded. For example, in one water at the commencement there were 100,000 germs of the typhoid bacilli in each cubic centimetre of the water, and after one hour's exposure to direct sunlight, not one bacillus could be found, while in the control flask a slight increase over the 100,000 to start with was got. The experiments with diffused daylight were equally satisfactory, only the bactericidal effect of the diffused light was less than that of direct sunlight. After Buchner's experiments we have a number of experiments conducted by Professor Marshall Ward, F.R.S., of Cooper's Hill, and communicated to the Royal Society. He conclusively proved that "the light of a winter's sun, and also that of the electric arc, rapidly destroy the life of the spores of the anthrax bacillus, and showed that the bactericidal action is really direct, and not due to elevation of temperature, or to any indirect poisoning or starving process incident on changes in the food materials." The evidence goes to prove that the effect is chiefly due to the rays of higher refrangibility towards the violet end of the spectrum—in fact due to the same rays as are most active chemically.

We thus see that one of the most important factors in the purification of the Tay from pathogenic bacteria is the action of light, and

that at the period of the year when the temperature tends to help the development of these bacteria the light is very much stronger, and therefore able to keep in check the stronger foe with which it has to contend.

2. Another most important purifying agent is the action of the oxygen from the air *dissolved* in the water. The water is only able to dissolve a small quantity of air, so that we get its oxygen soon used up. There is little doubt, we think, that the oxidation of organic matter in water is partly, at least, a process of fermentation or nitrification, whereby the nitrogen of the ammonia is first converted into nitrous acid and then into nitric acid, and the presence of nitrites and nitrates in water is a proof of ammonia having been previously present. In fact, the presence of nitrites and nitrates generally indicates previous sewage contamination, but at such a period before the sample is drawn as to give time for the nitrifying organism to convert the nitrogen of the ammonia of the sewage into nitrous and nitric acids. Below a certain temperature this nitrifying organism ceases to perform its function and this is undoubtedly one of the reasons why the amount of ammonia is greater in the winter-time, and also for the absence of nitric acid which was not found in the December analyses.

3. Possibly the most important agent of purification we have to discuss, however, is filtration. The scheme in use was devised in 1834 by Dr. Adam Anderson, whose report to the Water Commissioners we have carefully perused, and as a natural means of filtration, we think, it was ingeniously planned and carefully and successfully carried out. There is, however, so far as we have been able to ascertain, no means of regulating the rate of filtration which has been recently proved to be a most important factor in efficient filtration; also during winter, when there is severe frost for a time, and the river low, a large part of the filter-beds is certain to freeze. Then when the thaw comes, and a large volume of water descends, the extra pressure on the limited filtering area forces the water through the filter-beds at a rate which prohibits efficient filtration. Those of you who cross the bridge regularly, and watch the upper filter-bed when there is high tide, and see the immense rate—as shown by the large volume of air bursting up through the water right above the top of the tunnel—at which the water enters the tunnel and forces out the air when the extra pressure is on, will readily understand what we mean.

The effective action, where due precautions are used, of a sand and gravel filter for purifying highly contaminated water was very well demonstrated in the case of Hamburg and Altona during the recent cholera epidemic, and is fully and carefully set forth in papers by Koch, of which a translation was published in the *Scotsman* of August

21st and 28th of last year. The water supply of Hamburg was drawn from the Elbe in an unfiltered state at a point above the city, while Altona received its water supply after filtration through sand and gravel from a point below Hamburg. Hamburg, as is well known, suffered terribly from cholera during the summer, while Altona was almost free of it. Yet in these two cities the soil, the buildings, the sewage arrangements, and the population are exactly analogous, the only important difference being the water supply. On investigation it was found, that one street on the frontier between the two towns had the houses on one side supplied with Hamburg water, while the houses on the other side were supplied with filtered water from the Altona supply. The latter side of the street escaped, while the former was attacked by cholera. "Here, then," Professor Koch says, "we have to do with a kind of experiment which performed itself on more than 100,000 human beings, but which, despite its vast dimension, fulfilled all the conditions one requires in an exact and absolutely conclusive laboratory experiment. In two large groups of population all the factors are the same except one—namely the water supply. The group supplied with unfiltered Elbe water suffered severely from cholera, that supplied with filtered water very slightly." In this connection the fact that before filtration the Altona water was much worse than the Hamburg emphasises the great value of sand and gravel filtration as a means of purifying water. There are certain precautions, however, absolutely necessary if sand filtration is to be thoroughly effective. Koch clearly shows this in his second paper referred to above. Periodic outbreaks of enteric fever had occurred at Altona from 1886 onwards, and an attack of cholera occurred during January and February last, and after very careful bacteriological examination of the water, two or three of the filter-beds were found to be acting improperly, due to over pressure of water or freezing of the surface of the filter-beds.

A second case of the same kind of thing in our own country brings the thing nearer home, and is possibly even more to the point. In the twenty-first annual report of the Local Government Board, published in 1893, there is a most valuable and full report on "Enteric fever in the Tees Valley," by Dr. Barry. There are two periods of six weeks each dealt with in the end of 1890 and beginning of 1891, and the chief towns investigated were Stockton, Middlesborough, and Darlington. The water is pumped from the Tees, and, after a process of sand and gravel filtration, distributed either through the works of the Darlington Corporation, or by those of the Stockton and Middlesborough Water Board.

Before filtration the water is, as in the case of the Tay, polluted by sewage run in higher up the stream, especially from Barnard

Castle. The one part of the population of these three towns, numbering 219,435 got this filtered water pumped up from the Tees, whereas the rest of the population numbering 204,181 received their water from other sources than the Tees. Those receiving filtered Tees water were in the first six weeks attacked at the rate of 33 per 10,000, while those receiving other water were attacked at the rate of 3 per 10,000; in the second six weeks' period the Tees water gives 28 per 10,000, as against 1 per 10,000 in the other case. Had the epidemic been one of Asiatic cholera in place of enteric fever, Darlington, Stockton, and Middlesborough, would have undoubtedly suffered quite as badly as Hamburg, and here note that the water was carefully filtered, and also that these epidemic outbursts occurred soon after sudden floods, which washed masses of filth from the banks down the stream, and doubtless also hastened the rate of filtration through the sand and gravel to such an extent that the water was not sufficiently filtered.

From pages 119 to 124 of this report we have a record of chemical analyses during the periods of the outbursts. These analyses are by

(1) The County Analyst for Darlington.

(2) Mr. Alfred Allen, Public Analyst, Sheffield.

(3) Dr. E. Frankland, London.

In all cases the chemical analyses will compare favourably with those of our Perth water. Dr. Frankland reports concerning the water drawn during the first six weeks' period that "The water is free from every trace of previous sewage or animal contamination, and the microscope reveals nothing of a deleterious character. It is a wholesome water of moderate hardness, and, with the exception of a peaty taste, is in all respects of excellent quality for dietetic and all other domestic uses."

There are at least five analyses of the filtered water supplied to these towns. These analyses extend over a period of three months, and in no case was anything discovered to throw any doubt on the quality of the water, and yet during these *same months* the *same water* was carrying disease and death all over the area in which it was being used.

To those interested in this matter, and, I suppose, we all must be more or less so, I would most strongly recommend a most careful and unbiassed study of Dr. Barry's report. It proves the fact which I have all along contended for in regard to the Perth water supply, that water once contaminated with animal excreta is at best a doubtful water for domestic and dietetic purposes, whatever results chemical analyses may give. Filtering through sand and gravel removes, if carefully done, many of the impurities, and may make contaminated water as at Altona and Middlesborough, Stockton, and Darlington,

sufficiently pure for all purposes, and even at its worst sufficiently pure to pass a chemical analysis respectably, but Koch's second paper and Dr. Barry's report conclusively prove that after flooding, frost, or any other derangement of the filters, such water is apt to be more or less contaminated and in a condition such as to induce or carry disease all over the area in which it is used. The last table of analyses goes to prove that Perth water at least deteriorates during the winter months, and we are strongly of opinion that at such times especially, a strict bacteriological examination is also indispensable along with the chemical analysis. In water once contaminated with sewage, chemical analysis alone is undoubtedly not sufficiently refined to detect pathogenic bacteria, or to prove the water innocuous. This is shown beyond doubt in the case of the Tees water, which from chemical analyses, was reported by such experts as Dr. Frankland and Mr. Allen to be "free from every trace of previous sewage or animal contamination."

Boiling, of course, destroys these pathogenic bacteria, and for nearly two years we have used none of the Perth water for drinking purposes without first boiling it, and the result has been such as to give us confidence in recommending the same course to others.

A few days after the above paper was read to the Society a gentleman who had been actively connected with the Perth Water Supply wrote suggesting that the increase of impurity in the winter months was due to the new supply from above the Bridge, and in order to test that we obtained, through the kindness of the Lord Provost and the Water Commissioners, samples from the old and new filters separately at the water-house. One of these samples was sent to the City Analyst from Blairgowrie, and the others were analysed in our own Laboratory, the result being as follows :—

TABLE IV.—ANALYSES OF PERTH WATER SUPPLY, JAN. 16th, 1894.
(RIVER IN FLOOD.)

	I. Old Supply.	II. New Supply.	III. From Service Pipe.	IV. Confirmatory Analysis of I.
Solids, Organic Matter, -	·7	·7	·5	·5
,, Volatile ,, -	2·1	1·8	2·4	4·3
,, Saline ,, -	3·2	2·4	3·0	
,, Total ,, -	6·0	4·9	5·9	4·8
Chlorine, - - - -	1·0	·8	·9	(not given)
Ammonia, Free, - -	·002	·002	·002	·0043
,, Albumenoid, -	·0075	·007	·007	·0071
,, Total, - -	·0095	·009	·009	·0114
Hardness, Temporary, -	·35	·3	·3	·57
,, Permanent, -	2·90	2·7	2·9	2.86
,, Total, - -	3·25	3·0	3·2	3·43

These analyses, as formerly, give parts per 100,000 of the water, and show that the water supplied by the new filter is, as already stated, slightly purer than that supplied by the old filter. The excessively high free ammonia of December—see Table III.—has disappeared, and this bears out Koch and Barr's contention that the greatest danger to a water supply, such as ours, occurs in the early stages of flooding, and disappears as the banks of the streams and river get washed free of their impurities, and, as the fine filtering deposit on the surface of our filter beds, which is stirred up at the early stages of flooding, gets settled down again. The albumenoid ammonia is quite as high in these analyses as in the December analyses, and certainly much higher than in the mean summer analyses.

We cannot here too strongly emphasise the fact that our work has been done quite independently as scientists—not as partisans for or against the Perth water supply—for the scientific society to which it was communicated, and at the request, publicly made, of some of the leading members of that society. As both our summer and winter analyses are entirely confirmed by an outside analyst of undoubted repute, we can guarantee their accuracy, and in no case is the filtered water condemned. The analyses do prove that the water changes, in regard to the amount of ammonia present, more than a natural water should, and our whole contention is that water with fresh sewage matter run in immediately before filtration cannot possibly be acquitted by chemical analyses alone,—see Dr. Barr's Government Report of the Tees Water, already referred to. In the summer-time, when the river is low and the purifying agents most active, we feel there is little to fear; but immediately after heavy flooding there is certainly need for caution, and this is the conclusion which will, we feel sure, be reached by every one able to understand the points at issue.

Our thanks are here gratefully tendered to Mr. Wm. Ellison for making boxes for the Winchesters used in collecting the samples, and also for assistance with the collection of samples; to Mr. Jardine for making a duplicate analysis for chlorine and hardness in a number of the samples of the second table; to Mr. Pullar and the teachers attending the Saturday Classes, for assistance in collecting samples; and also to Mr. Young, civil engineer, and to Mr. Mackay, chief sanitary inspector of the county, for copies of reports.

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The Society's MUSEUM in Tay Street contains representative collections of the Fauna, Flora, and Petrology of Perthshire, as well as an Index Collection of general Natural Science, the latter section being kept entirely distinct from the former.

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ANY DONATIONS TO THE MUSEUM WILL BE GLADLY ACKNOWLEDGED.

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VII.—*The Marsh Tit in Scotland.**

By J. A. HARVIE-BROWN, F.R.S.E., F.Z.S.

(Read 8th Nov., 1894.)

Out of a very large series of notes received from all parts of Scotland we have been able, we believe, to locate, with fair exactitude, the nesting distribution of the Marsh Tit, and thereby to arrive at a certain class of conclusions which are not altogether without interest from distributional and migrational points of view.

Our friend, Mr. Wm. Evans, has before given us his experiences in connection with his discovering the Marsh Tit nesting in Upper Strathspey in a most interesting paper in the Annals of Scottish Natural History. We were inclined at first to think when the Marsh Tit was found in Strathspey that the individuals observed would probably prove to be migrants from Scandinavia. This belief, of course, Mr. Evans promptly put *out of court* by his afterwards finding the nests in May. We still, however, adhere to the belief that this species is as yet of quite local distribution, although it will no doubt increase in the course of time. Its very local distribution, *as at present known*, in Scotland tends to strengthen our belief. We have known it ourselves as long ago as 1859 or 1860 as a winter visitor to the neighbourhood of Edinburgh, and we knew of its nesting at an even earlier date from MacGillivray, on the authority of Mr. Weir. But we think, considering that so much attention has been given to our British and Scottish birds since those days, that the distribution of the Marsh Tit, *as known* at present, cannot be very far removed from the facts. We also consider that *distribution* is such a moving quantity from year to year that what we do know is scarcely equal to keeping pace with it in the cases of many species. Want of observation, so often pleaded as the cause of want of knowledge, will not, we consider, serve as an excuse in this case however, even though it be granted that the species is of retiring habits and inconspicuous. However that may be, we have been at some pains to collect data, which, whether negative or positive, have been carefully sifted.

Mr. Evans has epitomised the distribution, which we may give again. St. John for Moray, *in winter (Natural History and Sport in Moray*, Ed. 1882, p. 16). A. G. More, quoting MacGillivray for Fife (on the Distribution of Birds in Great Britain in the Nesting Season, *Ibis*, 1865), Perthshire, and Aberdeenshire, and, on the authority of Mr. Wm. Dunbar, "as far north as Inverness." Then

* This paper is confessedly incomplete, but is offered in the hope that the more exact distribution may be worked out north of Forth and Clyde.

Mr. Wm. Evans obtained a nest and fresh eggs upon Dunipace property (Forth), when informed of the site by us, and again found them nesting on Strathspey, as related above. We have long been aware of its very general distribution in Forth, and know many localities in the County of Stirling, both southward and westward; but by far the greater part of our information from Tay and north-eastward from Stirling is decidedly negative to date, though many most suitable localities are perfectly known to us, A. G. More's information notwithstanding.

By the late Mr. A. G. More's paper and accompanying map *(loc. cit.)* it would appear to the ordinary reader that the distribution of the Marsh Tit is continuous through Perth, Forfar, and Aberdeen, and even to Inverness; but the information afforded to our author for (part only) Perth, and for Aberdeen and Inverness, appears to us to have been exceedingly fragmentary and incomplete, nor have any subsequent data come to hand to warrant such a general and sweeping statement of the bird's distribution. The blank specially deserving of attention extends between the valley of the Forth northward to the Spey, and thence north-eastwards through all the north-east districts of Dee and Moray, and northwards, north of the Great Glen.

Our negative information consists of the following:—Mr. Marshall, the Store, Stanley, a gentleman who possesses a very good collection of local birds, assures us he has not seen nor heard of the Marsh Tit being obtained in his district, and the Perth Naturalists appear to be unanimous in their opinion that they cannot include it as a Tay Valley bird. It does, we believe, occur in the County of Perth, but not in any portion of it that can belong to the valley or watershed of Tay. Yet we can feel very certain of its breeding up the Forth Valley as far as Kippen, ten miles west of Stirling, and possibly even further in that direction.

Mr. Geo. Sim, who (as is well known) is our first authority for Dee area, has only one single record of the Marsh Tit in Dee, and that only an October one.

In Moray our negatives far exceed our positives. Our friend, Mr. John Young, of the War Office—an excellent observer—"never met with the Marsh Tit in the Spey Valley, but has met with the four species of Tits (four southern species)" passing south. Some authorities say "Tits do not migrate," but we have Gäthe's authority that they do, past Heligoland.

Mr. Geo. Muirhead, author of the "Birds of Berwickshire," adds his testimony to Mr. Sim's, but, of course, with less local experience except during the past few years, and omits it from lists from Haddo, Aberdeenshire. Keepers in Strathspey do not recognise the species

from drawings—certainly not in summer; and in autumn and winter and even late summer, they may be certainly too much occupied on the moors preparing for the eventful "Twelfth" to have much opportunity. But the Crested Tit is well known to them all the year round.

In autumn and winter the Marsh Tit is abundant in Forth, but not a conspicuous species, nor necessarily seen every day. On Dec. 24th, 1891, I found my note—"Marsh Tit common. 'Tzee, tzee' all around us in a bank of 40 to 50 year old oak." Col. Duthie writes from Doune district of Forth (county of Perth)—"I have been on their trail for the last three years without success, but Buchanan Hamilton, of Lenny, mentions it in his list from the Callander district."

Writing from the parish of Ardclach (Moray), on the Findhorn, Mr. R. Thomson cannot recal a single instance of the Marsh Tit within his parish, regarding the Natural History of which he must be considered our first authority. He feels sure that it could not have escaped his observation, and he is perfectly acquainted with the other species of Titmice. He certainly never met with its nest in all his bird-nesting experiences. We may add, at this opportunity, that Mr. R. Thomson was initiated and encouraged in his Natural History Studies by the Rev. Geo. Gordon, who has always considered him a specially careful observer and recorder. His knowledge of the district Botanically, Entomologically, and Ornithologically is probably unexcelled.

In a list of birds sent us by Mr. Chas. H. Alston, who resided in Upper Badenoch, he mentions Blue and Cole Tits, Great and Long-tailed Tits, as observed there in mixed migratory (or vagratory) flocks, but says nothing of the Marsh Tit, a species also well known to him.

Now, all the above negative evidence proves, to my view, *only* the general local nature of the Marsh Tit's distribution. It redounds all the more to Mr. W. Evans' credit that he discovered an "oasis" —as I still believe it to be—where the Marsh Tit breeds. All we still desire to contend for is that the distribution of this interesting species is still *local* in Scotland; that it is most common and more general in Forth and South of Scotland than elsewhere (of Clyde we cannot speak); that on Tay it is still extremely rare, if present at all; that in Moray it is still local, if not indeed very restricted; that in Moray, north of the Caledonian Canal, it is probably entirely absent (A.D. 1894). Also, that because it is absent *now*, or extremely local, it is impossible to say that it will remain so, or that it will not within a few years become more general. And we contend that it is not absence of observation in the southern districts of the Moray Basin or Tay that is sufficient to account for its extremely locally recorded dispersal. With innumerable instances of the dispersal of many other species, which can hardly be controverted

or laid aside, we cannot see that our argument is inadmissible. We have only to instance the rapid increase, beyond the shadow of a doubt, of so many other species that it is not even necessary to name them. Yet we do so—the Starling, the Stock Dove, the Tufted Duck, the Crossbill, the Redstart, the Missel Thrush; and the distribution of many others could be written out.*

The whole or principal interest associated with such an inquiry as the above seems to us to rest in the far wider one of whence came the first colonists of an increasing species. The fact that the habits of the two allied forms—*i.e.*, in Scandinavia and Great Britain—differ, is, to our mind very unimportant. We allude to the difference in their nest-building materials as evidence of specific differentiation. Numerous other instances could be given where habits change with geographical or physical circumstances; even the very bird-voices of certain species are known to change.

The present isolated characters of localities occupied by several species—amongst which the Marsh Tit is one—can hardly be the direct influence of migratory or "vagratory" hosts coming from south to north, or why should so many good intermediate localities be left neglected? Is it possible, rather, that occupations of sporadical nature such as these, may arise from a direct east to west, and return journey west to east dispersal, along certain *old lines of migration?* † At least, we do not think such a hypothesis is less worthy of consideration than the other. The subsequent rate of increase of any species must be in large measure dependent upon richness of food-supplies in an area, consequent fecundity of the species, and pressure upon the centres of over-population. Some species lay few eggs, others many. This alone, we believe, is one of the first proofs of physical energy, and natural increase. We have chosen this species as only one of many which appear to us to prove several simple laws of Nature.

* May I be allowed to suggest to brother-ornithologists of Tay that inquiries made into the life-history, decrease or increase, and steps of advance of many other species during the past ten or twenty or more years, would be likely to yield useful material for future work. I may mention especially the subject of the present notice, also the present and past distribution of the following:—The Redstart, the Wood Warbler, the Grasshopper Warbler, the Chiff Chaff, the Crossbill, the Greenshank, the Capercaillie (since the issue of our volume on that species), the Jay, the Titmice generally, the House Martin, the Short-Eared Owl, the Birds of Prey, the Shoveller, Pochard, Widgeon, Tufted Duck, Goosander and Merganser, &c., among Anatidæ; the Stock Dove (all minutiæ), Quail, Woodcock (especially as regards its *past*), and any others which may occur to you. Each species should be worked out separately for *Tay* area. I would be pleased to receive and report on such if sent to me.

† This expression is tentative—a convenience merely of speech.

VIII.—*The Distribution of Birds included in the Avi-Fauna of Perthshire.*

By Lieut.-Colonel Campbell.

(Read 13th Dec., 1894.)

When I was first asked by our late friend Dr. Buchanan White to write a paper on Ornithology for the Perthshire Society of Natural Science, I thought I might be able to say something about Cosmopolitan Birds; as, however, there are very few species distributed over the whole surface of the globe, I decided to make the subject of my paper the Distribution of Birds included in the Avi-Fauna of Perthshire. Since it was written it has been revised by Colonel Drummond Hay, to whom I am much indebted for the valuable notes which he has been good enough to add, and which I have incorporated in it.

With regard to the general distribution of Birds, I would bring to your notice the fact, that in these small islands of ours, situated as they are on the western extremity of that immense extent of country comprising Asia and Europe, we have an Avi-Fauna of which a large proportion may be said to be typical of the birds which are found throughout the length and breadth of these two vast continents. As an instance of the north and south meeting on the banks of the Tay, I may mention the fact that our climate permits the Glaucous Gull to pay us an occasional visit in winter, and even the Little Auk is sometimes driven to our shores; whilst of visitors from the south I believe we have a specimen of that beautiful and most interesting bird, the Hoopoe, an inhabitant of India, Egypt, and the south of Europe, which was procured not twenty miles from the Fair City.

Under such climatic conditions it is no wonder that the Avi-Fauna of Great Britain and Ireland should be so rich; and, as we in Perthshire are determined to be to the front in Ornithology as well as in all other branches of Natural Science, I think you will find, when Colonel Drummond Hay has arranged the specimens in our new hall, that we are not behind any other local Museum in having a collection of birds which may be said to be not only representative of this country, but of Mid and Northern Europe and Asia, as well as of many species from Southern Europe, Persia, Afghanistan, India, China, and even Japan.

Many years ago, when I was a newly joined subaltern, I made the acquaintance of one who has done more to enlighten us on the Ornithology of India than any one who had ever gone before him—I mean Dr. Jerdon; and it is chiefly from the notes which I made in his book "The Birds of India," that I have got the information which I hope to lay before you this evening. Indeed, this book was

a veritable *vade-mecum* and accompanied me in all my wanderings. However light was the marching order in which I was frequently obliged to travel, it invariably formed part of my kit, and was second in importance only to my rifle, my gun, and ammunition. In the forests of the Dhoon, in the Valley of Cashmere, over the Himalayas to Ladakh and Thibet, on the plains of the Punjaub, and in the Bamboo jungles of Central India, it was my constant companion. When the day's work was over I used to sit by the camp-fire and consult its pages, making notes of any rare species I had come across; and I can assure you nothing ever gave me greater pleasure than recording the occurrence of some well-known home bird.

I have also been indebted to "Yarrell's British Birds" for much valuable information.

MERULIDÆ.—Of the Merulidæ or Thrushes our well known Song Thrush (*Turdus musicus*), the Missel Thrush (*T. viscivorus*), the Redwing (*T. iliacus*), the Fieldfare (*T. pilaris*), the Blackbird (*T. merula*), and the Ring Ousel (*T. torquatus*), are more or less migratory, and are generally distributed throughout the whole of Europe and Central Asia. Large numbers are snared all over the Continent, and I have seen all the above species hanging up in the poulterers' shops in the towns throughout France, Italy, Belgium, and Spain. The Common Dipper (*Cinclus aquaticus*) is, as is well known, found on all our streams, and on most of the fast running rivers of Europe; in the Northern Countries, migrating when they become frozen. On one occasion I found a nest of young Dippers on the banks of the Avon, near Hamilton, and wishing to try their swimming powers, I put them in a pool of water which had been left by the river after a spate. Though these birds' flying powers in the air were so limited that I could easily catch them, they flew under water with the greatest rapidity, moving their wings as if they were flying, and, whilst quite submerged, cleaving their way through the water like an expert diver.

Before leaving the Thrushes I would refer to a bird not quoted in the Catalogue, viz., the Black Throated Thrush (*T. atrigularis*), a specimen of which we have in the Museum. Colonel Drummond Hay informs me that it was shot in February, 1879, and "was one of a pair feeding on the banks of the Tay near Friarton;" but how they got there, or where they wandered from, is a mystery. Jerdon mentions it as from the Himalayas, and Colonel Drummond Hay suggests "these are doubtless strays from Siberia."

INSESSORES—SAXICOLINÆ.—The Common Wheatear (*S. œnanthe*), the Whin Chat (*Pratincola rubetra*), and the Stone Chat (*P. rubicola*), have a wide European range, and, whilst the Stone Chat has been reported as far east as Japan, the Wheatear is included in the fauna

of Greenland, and has been seen in Bermuda by Colonel Drummond Hay.

SYLVIADÆ.—The Red Start (*Ruticilla phœnicurus*), a not uncommon bird in our woods, is distributed throughout Europe. I remember seeing one near Stromness so late as the month of November.

The Red-breast or Robin (*Erithacus rubecula*) is, I need hardly say, a common bird in Perthshire. I may mention that on one occasion a pair of Robins selected the pulpit in the chapel at the General Prison as a building place, and successfully brought up their brood. I wish all Prison birds were as confiding and innocent as that family of Robins.

The White Throat (*S. rufa*), the Lesser White Throat (*S. curruca*), the Black Cap (*S. atricapilla*), and the Garden Warbler (*S. salicaria*) are spread over Europe and Central Asia. I myself have not observed either the Black Cap or Garden Warbler in Perthshire; but Colonel Drummond Hay sends me the following note:—"The Black Cap and Garden Warbler are by no means uncommon in Perthshire, though the Lesser White Throat is, I may say, almost accidental. The White Throat is very abundant." Dr. Jerdon describes all the above in his "Birds of India."

The Golden-crested Wren (*Regulus cristatus*) so common in our fir woods, and the allied species, the Fire-crested Regulus (*R. ignicapillus*) so extremely rare with us, extend in suitable localities to the pine covered slopes of the Himalayas.

The same may be recorded of the Chiff-Chaff (*Phylloscopus collybita*), the Willow Wren (*Ph. trochilus*), the Wood Wren (*Ph. sibilatrix*), the Reed Warbler (*Acrocephalus streperus*), the Sedge Warbler (*A. schœnobœnus*), the Grasshopper Warbler (*Locustella nœvia*), the latter a very rare bird with us, and the Hedge Sparrow (*Accentor modularis*), as common as the other is rare. All these birds are migratory to the Northern Countries of Europe, though, as is well known, the latter remains with us throughout the year.

PARIDÆ.—The Great Tit (*Parus major*), the Blue Tit (*P. cæruleus*), the Long-tailed Tit (*Acredula rosea*), and the English Cole Tit (*P. britannicus*), a form of *P. ater*, are common all over the country in the wooded districts, and only last week, I saw the whole four species in one of the large woods at Stobhall. All these Tits are found throughout Europe and extend to Central Asia as well, although Colonel Drummond Hay considers the two latter species to be distinct from the European birds. He also informs me that "two specimens of the Crested Tit (*Lophophanes cristatus*) were shot at Blairdrummond by the late Dr. Saxby, in April, 1858,—quite entitling them to a place in the Perthshire list."

CERTHIADÆ.—The Common Creeper (*Certhia familiaris*), so common in our Perthshire woods, has an extensive range throughout Europe, and it has also the distinction of being included in the fauna of N. America. Our Common Wren (*Troglodytes parvulus*), one of the smallest of British birds, is, according to Yarrell, distributed over Europe, Asia, Africa, and America. Jerdon makes out the Himalayan bird to be distinct, but those I have seen in Cashmere had the same appearance, habits, and note—that harsh "churr" which sounds so loud when emitted by so small a bird—as our own species.

MOTACILLINÆ.—Of the Wagtails, the Pied (*Motacilla lugubris*) and the Grey (*M. melanope*), so common with us, extend eastward as far as India, where they are as common during the winter months as they are in Perthshire in summer. I have a note of the Pied species being found in the Dhoon Valley in May, and of the Grey one at Lahore in September. The Yellow or Ray's Wagtail (*M. Raii*) has not hitherto been found in Perthshire, though it has been got in the Tay district in Fife.

ANTHIDÆ.—Of the Pipits there are specimens of the Tree Pipit (*Anthus trivialis*) in the Museum, and I have frequently seen and shot it in India. The Meadow Pipit (*A. pratensis*) is one of our commonest moorland birds, and the Cuckoo selects its nest more than that of any other species in which to lay her egg. It is also found in the N.W. Provinces of India. I have seen the Rock Pipit (*A. obscurus*) on the sea-shore at Tentsmuir, and have got its nest and eggs there.

LANIIDÆ.—We are most fortunate in having specimens of the Grey Shrike (*Lanius excubitor*) in the Museum, as this is one of the rarest of our Scottish birds, although I have seen an Orkney-killed one and have also come across the bird itself in Southern Spain.

AMPELIDÆ.—The Waxwing (*Ampelis garrulus*) is a northern bird frequenting the pine forests of Norway, Sweden, and Russia. I have seen caged specimens for sale in the St. Petersburg market. It is a very occasional and erratic visitor to this country, but we have a specimen in the Museum, and there are others at Seggieden and Megginch. Yarrell tells us its range extends to Japan, and it is also found in North America.

MUSCICAPIDÆ.—Of the Flycatchers, the Spotted (*Muscicapa grisola*) is as common in Perthshire as the Pied species (*M. atricapilla*) is rare, and we have not a specimen of the latter in the Museum, though it is said to have been shot at Moncreiffe. It is, however, a regular summer visitor to Norway and Sweden, is common in Southern Europe, and its range extends as far as South Africa.

HIRUNDINIDÆ.—Of the Swallows, the Common Swallow (*Hirundo rusticus*) is, I need not say, one of our most welcome summer

visitors, and I made the following notes regarding its occurrence in India :—"Very common in the N.W. Provinces and Punjab in the cold weather. I found it breeding in Cashmere in May. I also saw it a long way north of Leh, in Ladakh, in June, 1865. It arrives in the Peshawur Valley about the beginning of July. Seen in Nowshera, 6th July, 1866." I can assure you that no arrival gave me greater pleasure, when living in the sweltering plains of India, than did that of the first swallow, a sure sign of the approaching cold weather, just as here we look forward to its coming as the harbinger of summer. In 1893 I saw my first swallow in Rome on 14th February, this year I came across him at Toledo, in Spain, on 11th March, but did not see my friend in Perth till 23rd April, and this, I think, is about the usual date of arrival here. The 11th October is the latest date on which I have seen the Swallow in Perth.

The Martin (*Chelidon urbica*) is, according to Jerdon, very rare in India, but there is a species, called by him *Ch. cashmiriensis*, which is, I believe, identical, or nearly so. I remember when crossing the Pir Punjab—the range of hills which separates the plains of the Punjab from the Cashmere Valley—on the 25th April, 1864, coming across a colony of these birds building their nests in the window corners of an old caravanserai or rest-house, though how they got the mud to construct them was a mystery, as we were 11,000 feet above sea-level, the whole surrounding country was covered with snow, and it was freezing hard !

Our Common Sand Martin (*Cotile riparia*) is found skimming over the surface of the Ganges, at Cawnpore, in much the same way as we see it on the Tay or Earn, but it does not breed in India, though it does in Afghanistan and over the whole of Northern Europe and Asia.

FRINGILLIDÆ.—That beautiful bird, the Gold Finch (*Carduelis elegans*) is, I am sorry to say, one of our rarest birds. I have never seen it in Perthshire, and only once in Scotland—near Nairn, in August, 1891. In the south and west of Ireland, where thistles, its favourite food, are allowed to grow abundantly, it is very common, and I do not think I ever saw so many as in and about Tipperary, nearly every cottage having a caged Gold Finch at its door.

The Siskin (*Chrysomitris spinus*) is a regular resident in the Highlands, breeding there in tall Scotch firs where the nest is very difficult to find, but there are large accessions to their numbers in autumn and winter, numerous flocks coming over from Norway and Sweden.

The Green Finch (*Ligurinus chloris*), one of our commonest birds, has a very wide distribution throughout Europe, and, Yarrell tells us, it is found in the island of Bonin, 500 miles east of Japan.

Two specimens of the Hawfinch (*Coccothraustes vulgaris*) were killed in 1861 in the garden at Annat Lodge. It is not so uncommon in the southern counties of England, and is also found throughout Europe and Asia, as far south as Malta, and eastwards to China and Japan.

The Tree Sparrow (*Passer montanus*) has not yet been observed in Perthshire, though found in various parts of Scotland, and Colonel Drummond Hay says it takes the place of the Common Sparrow in Bulgaria. Its near relative the House Sparrow (*Passer domesticus*) is, like the ubiquitous Scotsman, found almost everywhere. I have seen it nesting in the rigging of a ship at Calcutta, and I have no doubt, when the ship sailed, the sparrows accompanied her, and started a new colony in, to them, some unknown land, though, I believe, when they got ashore, some of their own species would be there to welcome them! The hot weather in India takes it out of them, however, and it is pitiable to see them during the heat of the day, crowding to the shady side of the verandah, with wings outspread and beaks wide open, gasping for air. Colonel Drummond Hay informs me that in the Mediterranean the Spanish and Italian species predominate.

The Chaffinch (*Fringilla cœlebs*) is perhaps one of our best known birds in Perthshire. We all know its beautifully constructed nest, but the birds which stay to breed with us are nothing to the myriads which flock to our shores from the north in October and November, and which leave us in spring.

The Brambling (*Fringilla montifringilla*) is a winter visitor; but though I am told it is common with us, I have never found it so; indeed, the only specimen I have seen was one I found lying under a beech tree on Drummond Hill, Kenmore, in the winter of 1890. I have, however, the following note in my book as showing the range of this bird. "Shot at a height of 18,000 feet, while crossing a pass into Thibet, May, 1865."

The Linnet (*Linota cannabina*) has also a wide geographical range, extending as far as Japan, and the same may be said of the Mealy Red Poll (*Linota linaria*) and the Lesser Red Poll (*Linota rufescens*) which is found from Spitzbergen in the Arctic Circle in summer, to the south of Europe in winter.

The Mountain Linnet (*Linota flavirostris*) is one of our commonest birds throughout the moorland districts of the country, and has, according to Yarrell, a wide distribution over Europe and Asia.

The Common Bullfinch (*Pyrrhula europæa*) is one of the best-known birds of the country though somewhat local in its habits, and I have generally found it in young fir and larch plantations. It

occurs all over Europe, and, as with us, is a favourite cage bird in Germany and Russia.

The Common Crossbill (*Loxia curvirostra*) is generally distributed throughout the pine woods of the country. I have seen it or heard of its occurrence at Moncreiffe, Stobhall, Glenalmond, Kenmore, and other districts, and have no doubt it may be found wherever fir seed, its favourite food, is obtainable. It is common all over Mid and Northern Europe as far as Lapland, and I have seen it as a cage bird in Russia.

EMBERIZIDÆ.—The Common Bunting (*Emberiza miliaria*) is very local in its distribution—common in some districts, whilst in others, apparently equally suitable, it is seldom if ever seen.

The Yellow Bunting (*Emberiza citrinella*), on the other hand, is one of our commonest birds, and may be seen with distended throat emitting its plaintive song on the top of every hedgerow in the country.

The Reed Bunting (*Emberiza schœniculus*) is found among the thatching grass along the lower reaches of the Tay, and I have seen it in the marshlands of Holland and Belgium. The above three species have a wide European and Asiatic range.

The Snow Bunting (*Plectrophanes nivalis*) comes to us from Lapland and other northern countries in autumn, and departs in spring. It is also found throughout Siberia, and, Col. Drummond Hay informs me, it extends from North America to the Bermudas, "where it arrives most winters in small parties, but does not remain long."

ALAUDINÆ.—Of the Larks, our only resident species is the Sky Lark (*Alauda arvensis*), which delights us every spring with its beautiful song. Much has been written of late years regarding the diminution and possible extinction of this species. It is, however, still well known all over Europe; and, I am sorry to say, delights the gourmets on account of the delicacy of its plump little body, as much as it does the lover of nature by its song. Thousands are killed every year all over the Continent, and I fear this country is not behind others in the work of destruction.

STURNIDÆ.—The Common Starling (*Sturnus vulgaris*) is met with everywhere all over the country, as well as in this county, and over almost the whole of the Old World, even to the Canary Islands, the Azores, and the Cape. I have seen it breeding in Cashmere, and, to come nearer home, a colony have established themselves in the Old Watch Tower at the back of the General Prison, where they nest every spring, and use it as a roosting-place summer and winter. About sunset every evening the surrounding trees are covered with the birds, and, shortly after, they commence flying in,

by twos and threes, to their night's quarters in the ivy. There is a good deal of squabbling and chattering at first, but they soon settle down. I am sure there are hundreds, and how they all manage to find accommodation is a mystery.

The Rose-coloured Starling (*Pastor roseus*) is, I am sure, only a very occasional visitor to Perthshire, but to illustrate its extensive geographical distribution, I may mention that I have constantly seen it in India, in the month of April, previous to its northern migration, and also in the month of July, on its way to the south.

CORVIDÆ.—That handsome bird, the Jay (*Garrulus glandarius*), is still comparatively common in the large pine woods of Perthshire, but the Magpie (*Pica rustica*), is almost extinct, though I have met with it once or twice. Both are common throughout Europe.

The two allied species, the Carrion Crow (*Corvus corone*) and the Hooded Crow (*Corvus cornix*), which are now known to interbreed, extend throughout the whole of Europe and Asia, and I have met with them in India during the cold weather. There are far too many of them in Perthshire, in spite of the persecution they undergo, and they are well known as arrant poachers of any and every kind of egg which their sharp eyes may light upon.

I have the following Indian note regarding our Common Rook (*Corvus frugilegus*):—"Very common at Peshawur in the cold weather. It leaves about 20th April. I saw young Rooks which could scarcely fly, near Iskardo, in Balthistan, in July; they did not appear to be breeding in rookeries as they do at home."

The Raven (*Corvus corax*) is, I believe, found over all, or nearly all, the known world, both old and new, consequently I need hardly say it is included in the fauna of Perthshire. Col. Duthie gave us an interesting account of a breeding place in the southern part of the county, and I know of several in the mountainous district of Glen Lyon, as well as in Glen Etive and Glencoe. It is common in North India, Cashmere, Ladakh, and Thibet, and I have the following note regarding it:—"One of the few birds I saw on the Chang Chenmoo Pass, June, 1865." This pass is 18,000 feet above sea level. These birds were quite at home, and did not seem to feel the rarified air which inconveniently affected some of my men.

The Jackdaw (*Corvus monedula*), which every spring causes me so much trouble by wrenching the wire-nettings off the openings of the cell ventilators in the Prison, and blocking them up with his unwieldy nest, is the same pert little gentleman whose appearance I used to hail with pleasure in the Peshawur Valley (North-West India) thirty years ago. They are very common about the Prison, and fight with the Sparrows and Starlings for possession of the nooks and crannies of the water tower.

CYPSELINÆ.—The Common Swift (*Cypselus apus*) is common throughout Europe and Asia. I have seen it in Belgium, France, Denmark, Sweden, and Russia, screaming round the towers of the Kremlin at Moscow, in much the same fashion as it does round the steeple of St. John's Church here. I have also seen it in Cashmere and Ladakh in the months of May and June, so I have no doubt it breeds in those countries. The Swift arrives with us about the 5th of May, and leaves about the 12th of August; but I have on one occasion seen it in the south of England, between Dover and Deal, so late as 5th September.

CAPRIMULGIDÆ.—The Common Nightjar (*Caprimulgus europæus*) is a summer visitor, and is found throughout the county in fir woods and beds of bracken. It is well known over Europe and Asia, but is replaced in Northern India by an allied species.

PICIDÆ.—There are Perthshire specimens of the Great Spotted Woodpecker (*Picus major*), the Green Woodpecker (*Gecinus viridis*), and the Wryneck (*Yunx torquilla*) in the Museum. Col. Drummond Hay informs me he has frequently heard the note of the latter in the Ballathie and Faskally woods. They are all, however, very rare in Scotland, though distributed in suitable localities over the whole of Europe.

ALCEDINÆ.—The Common Kingfisher (*Alcedo ispida*)—I wish it were more common in Perthshire—is found throughout Europe, migrating from the more northern countries when the streams become frozen, and being resident in France and Spain, where I have seen it.

UPUPIDÆ.—I have already mentioned that a specimen of the Hoopoe (*Upupa epops*) is to be found in the Museum, and Sir Robert Moncreiffe has another specimen, but its proper habitat is the south of Europe, Egypt, Persia, and India, where it is very common. I have seen it breeding in Cashmere.

CUCULIDÆ.—The Cuckoo (*Cuculus canorus*), whose note is so commonly heard in all the wooded districts of the county, is widely distributed over the whole of Europe and Asia, from the extreme north—Lapland and Siberia—to the south of India. I once picked up a dried and dessicated specimen on the high table-land of Thibet, and I have seen specimens in St. Petersburg collected by Russian convicts on the island of Saghalien on the north-east coast of Asia.

STRIGIDÆ.—The Barn Owl (*Strix flammea*) was once common in Perthshire but has been nearly exterminated. I have seen it in Orkney and also at Dover, and I had a specimen sent me from Lewis. I shot specimens of a bird which Jerdon calls *Strix javanica* in different parts of the Punjab, which exactly agreed with Bewick's description of *Strix flammea*, and I believe the Indian bird to be identical with the European one.

I have not seen either the Long-Eared Owl (*Asio otus*) nor the Tawny Owl (*Syrnium Aluco*) in Perthshire, but I have shot the former in the Himalayan pine forests, and they are both found throughout the forests of Europe and Central Asia.

With regard to the remaining Perthshire species, the Short-Eared Owl (*Asio Accipitrinus*) is as common in the grass jungles of the north-west provinces of India as it is here in the woods of Perthshire. I have seen it constantly out in India, and I find the following note regarding it:—"Very common at Meerut, I found it during the day roosting in thick acacia bushes in long jungle grass." As Colonel Drummond Hay remarks, "It is a true cosmopolitan."

FALCONIDÆ.—I have noted the Marsh Harrier (*Circus æruginosus*) and the Hen-harrier (*Circus cyaneus*) as "common" in India, which, I am sorry to say, they are not in Perthshire.

The Common Buzzard (*Buteo vulgaris*) is not a common bird with us though we have six specimens in the Museum. It has an immense geographical range, which extends from the fur countries of North America to the south of Europe, North Africa, and the Azores, whilst Jerdon mentions it in his "Birds of India."

We have also four specimens of the Rough-legged Buzzard (*Archibuteo lagopus*), which has even a wider recorded range than the last species. It is said to be common in the United States, and is also found in Africa as far south as the Cape.

The Golden Eagle (*Aquila chrysaëtus*) appears to be equally at home on the snowy slopes of the Himalayas, the Alps, and the rugged Sierras of Spain, as in the wilds of Appin, Glencoe, and the Black Mount. I am glad to say that during late years the Eagles have been preserved by Lord Breadalbane, so it is hoped that at any rate in the Black Mount they may not become extinct.

The Sea Eagle (*Haliaëtus albicilla*) has as wide a distribution as the last, and I have frequently seen it in India. I saw a splendid specimen of this bird a few years ago at the Black Corries. It flew past Mr. Gilmour and myself as we were sitting in the heather having our lunch, and as it was not more than forty yards off we had an ample opportunity of admiring it.

The Sparrowhawk (*Accipiter nisus*) is not uncommon in Perthshire, and specimens, in a more or less advanced state of decay, are generally to be seen on the gamekeeper's board. I have shot it in North India, where it is migratory. The Kite (*Milvus ictinus*) is a very rare bird with us, and, owing to its persecution by gamekeepers, is almost extinct, not only in Perthshire, but over the whole country. On the continent it is included in the fauna of all the countries of Europe, of Siberia, and also of Algeria and Egypt.

The Honey Buzzard (*Pernis apivorus*) is even rarer than the last

named, and we are particularly fortunate in possessing a Perthshire specimen, which was acquired through the generosity of Sir Reginald Ogilvy. We have also a specimen of the Gyr or Jer Falcon (*Falco gyrfalco*), another extremely rare bird in Great Britain; an Arctic bird found in Russia, Siberia, and North America.

The Peregrine Falcon (*Falco peregrinus*), the finest of all our hawks, is common in all the wild mountainous parts of the country, and I have frequently seen it in the Glencoe districts on the borders of Argyllshire. I met with it frequently in North India, and found it breeding in Cashmere. It may be casually remarked that it is nearly, if not quite, cosmopolitan. The Peregrine is a bird for which I have always had an intense admiration, and when last I heard its shrill bell-like notes echoing among the rocks of Loch-na-Larige it reminded me of a similar scene many years before, when, stalking Ibex in the rocky ravines of the Scindé Valley in Cashmere, I unwittingly invaded the sanctuary of *Falco peregrinus*.

The Hobby (*Falco subbuteo*) is a miniature Peregrine, and consequently a very handsome bird. I saw one last August chasing a Meadow Pipit, and stooping to it several times, but always missing it, as the little bird invariably gave a turn or double—which reminded me of a hare being coursed by greyhounds,—and finally saved its little life by gaining the friendly shelter of a young fir plantation. It has a wide distribution over the whole of Europe, and is also found in North India.

The Merlin (*Falco æsalon*) is very rare in the north-west provinces of India, where, like our own bird, it is migratory.

Of the Kestril (*Falco tinnunculus*), one of our commonest hawks, I have the following note:—"Common in the Punjab in cold weather. I found it breeding in Cashmere in May." I have seen it in Belgium—one accompanied our steamer from Ostend to Dover a few weeks ago,—also in France, Italy, and Spain.

The Osprey (*Pandion haliaëtus*) is almost extinct, but our Museum possesses a specimen shot at Finlarig, Loch Tay, in 1866. It is still comparatively common throughout Europe, and when out shooting in India I used constantly to see it hovering over the surface of the lakes and rivers or plunging into their depths.

PELECANIDÆ.—The Cormorant (*Phalacrocorax carbo*) and the Gannet (*Sula bassana*) are, Col. Drummond Hay informs me, quite common at the mouth of the Tay, and he has been so fortunate as to procure an albino specimen of the former species, which he has presented to the Museum. I have seen the Gannet in the Mediterranean and the Bay of Biscay.

The Shag (*Ph. graculus*) is, on the other hand, a very rare bird in our part of the country.

ARDEIDÆ.—The Common Heron (*Ardea cinerea*) is generally distributed over our district, and I have found it nesting in various parts of the county. This spring I was informed of a fact which I never knew before—viz., that the Heron is almost entirely nocturnal in its habits. Yarrell alludes to its feeding late in the evening and early in the morning; but the keeper at Earlshall told me that the Herons, which had their nests in some old Scotch fir trees, never commenced to feed their young until after sunset, and that, till sunrise, they constantly flew to and from the sea, conveying sand eels to them. It is, according to Jerdon, "found throughout all Europe, Asia, and Africa," and is very common in India. The Bittern (*Botaurus stellaris*) is a rare bird with us, but common in India; and I seldom went out for a day's snipe shooting without killing one or two. They are excellent eating.

ANSERIDÆ—The Greylag Goose (*Anser cinereus*) is common in winter and spring in the Carse, and extends across the whole northern coasts of Europe and Asia where it breeds, to Spain and other southern countries where it spends the winter. The other species—the Bean Goose (*A. segetum*), the Pink-footed Goose (*A. brachyrhynchus*)—which I have shot on Tentsmuir,—that rare bird, the White-fronted Goose (*A. albifrons*), and the Brent Goose (*Bernicla brenta*), have, I believe, all been procured within our boundaries, and, like the last, are widely distributed throughout Europe, Asia, and America.

CYGNIDÆ.—Of the Swans, the Mute Swan (*Cygnus olor*) is found in a semi-domesticated state on the lochs and rivers of Perthshire. I was much astonished by once seeing a pair flying across the Black Mount deer forest in the month of October, and the man who was with me told me they had frequented the district for years.

Colonel Drummond Hay makes the following note regarding the Whooper (*C. musicus*):—"The Whooper was common enough in Perthshire every winter; but now there is such wholesale destruction of them on their breeding grounds in the north, by the natives, during the time they lose their feathers, that they have become few and far between, and will possibly very soon become extinct altogether." I have never seen it myself in Perthshire; but shot one at Hythe, in Kent, during the severe winter of 1860-1.

I once saw a flock of seven Swans flying in an easterly direction towards the Tay, over the prison, in the month of January, 1890; but as they were distinctly smaller than the Whooper I think they must have been Bewick's Swan (*C. Bewicki*). The above Swans are found over the whole of Northern Europe and Asia, where they breed, and migrate to the south in winter.

The Common Sheldrake (*Tadorna cornuta*) is common along the tidal waters of the Tay, and breeds, I believe, in the hilly ground of

the Carse, quite a considerable distance from the water. It is very common on Tentsmuir, where I have found it breeding in rabbit burrows. It is also included in the Indian Fauna.

ANATIDÆ—Of the Anatidæ or Ducks found within our limits, I have shot the following species in Northern India :—The Shoveller (*Spatula clypeata*) at Nowshera, 21st April, 1866, The Wild Duck (*Anas boschas*) in Cashmere, 19th April, 1865, the Gadwell (*Chaulelasmus streperus*) at Nowshera, 21st April, 1866, the Pintail (*Dafila acuta*) at Nowshera, 16th April, 1866, the Widgeon (*Mareca penelope*) at Nowshera, 16th April, 1866, the Common Teal (*Querquedula crecca*) at Nowshera, 23rd April, 1866, the Pochard (*Fuligula ferina*) and the Tufted Duck (*F. cristata*), 9th March, 1866. The Scaup (*F. marila*) is reported from Nepaul. I have shot it in the Orkneys and off Tentsmuir, where I have also shot the Golden-Eye (*Clangula glaucion*), one of which, a few years ago, frequented the Tay, at Perth Bridge.

The Long-tailed Duck (*Harelda glacialis*) comes to us from the far north in winter and is essentially a maritime species. There is a specimen in the Museum, procured at the mouth of the Tay in May. Colonel Drummond Hay tells me he has killed them in summer plumage in Nova Scotia as early as April. The Eider Duck (*Somateria mollissima*) breeds on Tentsmuir, but is a northern bird, its southern breeding limit being the Farne Islands on the Northumbrian coast. I have never seen that rare bird the King Eider (*Somateria spectabilis*), but the next species on our list, the Velvet Scoter (*Œdemia fusca*), is very common at the mouth of the Tay, and sometimes remains, Colonel Drummond Hay informs me, as late as the month of July, before migrating north. The Common Scoter (*Œdemia nigra*) is comparatively rare with us. I believe Mr. Millais has shot it off the mouth of the Eden in Fife. All the above-named species have a wide European and Asiatic range.

MERGIDÆ.—The Goosander (*Mergus merganser*) is found on the rivers and lakes throughout the county. I have shot it on the Ericht at Craighall, and seen it on Loch Tay, where it breeds in holes of old trees on the margin of the lake.

The Red-breasted Merganser (*M. serrator*) is also found on the Tay. I have seen it at Stobhall, and it breeds in the Black Mount.

The Smew (*M. albellus*) is very rare. I have only seen it once. During a hard winter, when I was trying to circumvent a flock of Mallards off Tentsmuir, a pair of them flew past me. One was killed at Seggieden in December, 1890, and, thanks to Mr. Kelsall, another specimen in beautiful adult plumage, which was shot in the Crieff district, has lately been added to our collection.

COLUMBIDÆ.—We next come to the order of *Rasores*, and com-

mence with the family of *Columbidæ*, or Pigeons, of which the Ring-dove (*Columba palumbus*) is one of the commonest species. It is well known throughout the wooded districts of the country, and also over the whole of Europe from north to south. The Cashmere variety has a clay-coloured patch on the neck, but is otherwise identical with our bird.

The Stock-dove (C. *œnas*) has during the last few years been procured in this district, and is one of the marked instances of the unaccountable appearance of certain species hitherto unknown.

The Turtle-dove (*Turtur risorius*) has, Col. Drummond Hay informs me, "been shot at least twice in the district some few years ago, and on more than one occasion has been noticed by myself in the Carse of Gowrie." It is common in all the southern countries of Europe, North Africa, and Southern Asia as far as India.

PERDICIDÆ.—Our Common Partridge (*Perdix cinerea*) has a wide European range, and Colonel Drummond Hay says it is abundant in Macedonia.

The Common Quail (*Coturnix communis*), which extends its migrations over almost the whole of Europe, Asia, and Africa, may also be claimed as a Perthshire bird, a specimen having been shot by Duncan Dewar at Remoney on Loch Tay side.

The Ptarmigan (*Lagopus mutus*) is found on all the higher Perthshire mountains, and members of the Society have had ample opportunities of seeing it on Ben Lawers, Ben Voirlich, and Ben More. It is also found on the Swiss Alps and Sierra Nevada in Spain, but its proper habitat is the north—Scandinavia, Russia, and Siberia, right round the Arctic circle to Greenland and Iceland.

Our next species, the Red Grouse (*Lagopus scoticus*), essentially a British bird—is the only one peculiar to our islands, but so dour in his nature is he, that, though he consents to live as far as Derbyshire, south of that county he will not go, and all attempts to acclimatize him have failed, although the moorlands of Devonshire and Cornwall are, apparently, as well suited to his tastes as the heather of Scotland.

The Capercailzie (*Tetrao urogallus*) is a good example of, not exactly acclimatization, but of what we may call re-introduction. Last century, mainly owing to the burning of the pine woods, it became extinct; but, thanks to the efforts of a Perthshire laird, the then Marquis of Breadalbane, it was re-introduced some fifty years ago—birds having been brought from Norway to Taymouth—and now it is spreading all over the country.

I wish I could say the same of the Black Grouse (*Tetrao tetrix*) which, for some unaccountable reason, is steadily decreasing in most parts, not only of Perthshire, but of Scotland. It ranges throughout

all Mid and Northern Europe, and I have seen both it and the Capercailzie in St. Petersburg.

Before closing my notes on the *Rasores* I would mention a bird, specimens of which we are fortunate enough to possess, though it must be called, not only an occasional, but a very rare visitor—I mean the Sand Grouse (*Syrraptes paradoxus*). This bird, whose home is on the parched stony plains of India, Persia, Arabia, Egypt, Algeria, and Morocco, has at various times visited this country, and in 1888 considerable flocks suddenly appeared, both in England and Scotland, and made themselves so much at home that it was confidently thought they might be induced to stop and breed with us. An act for their preservation was actually passed through Parliament, but our erratic visitors evidently objected to being legislated on, and took themselves off, disappearing in the same mysterious manner in which they had come.

RALLIDÆ.—Of the Rallidæ, the Water Rail (*Rallus aquaticus*) is very common in the marshy grounds along the banks of the Tay and Earn, whilst the Land Rail (*Crex pratensis*) is generally distributed over the agricultural districts. They are found all over Europe, and the former is reported from Smyrna, whilst Colonel Drummond Hay says the latter occurs in Bermuda and the Azores.

The Spotted Rail (*Porzana maruetta*), so rare a bird in Perthshire, is found over the greater part of the continent of Europe either as a summer or winter migrant, and is one of the commonest of the cold weather visitors to India.

The Moor Hen (*Gallinula chloropus*) and the Coot (*Fulica atra*) are very common on our rivers and lochs, where they breed, and I have seen thousands of the latter bird off the mouth of the Tay in winter. They extend throughout Europe and are common in India.

CHARADRIADÆ.—Our Common Golden Plover (*Charadrius pluvialis*), so well known on our moors during summer and our coasts in winter, has an almost world-wide distribution, varieties, if not the same bird, being found in Europe, Asia, America, and Australia.

The Grey Plover (*Squatarola helvetica*), which is nowhere so common as the last species, has, however, a wide range, extending, according to Jerdon, to Southern India and Australia.

The Ringed Plover (*Ægialitis hiaticula*), so common on Tentsmuir and the adjoining shores at all seasons, is found throughout Europe and Asia. Yarrell mentions it in the fauna of West Greenland, and I have seen specimens from Saghalien, so I have no doubt it extends round the whole of the North Temperate and Arctic Zones.

The Dotterel (*Eudromias morinellus*) is very locally distributed through the higher districts, and specimens have been procured in

Breadalbane and Rannoch. It also has a wide European and Central Asiatic range.

The Lapwing (*Vanellus vulgaris*), besides being common from the extreme north to the south of the British Islands, extends to the east as far as Northern India, where I have shot it.

The Turnstone (*Strepsilas interpres*), which visits Tentsmuir in autumn, is found also on the coast of Madras in Southern India, whilst its occurrence has also been recorded as far north as Nova Zembla. Not only in Europe and North America has it been seen, but Yarrell reports it from the Cape, the Straits of Magellan, Molucca, and New Guinea. From this I conjecture that our friend the Turnstone must have some Scotch blood in his veins!

The Oyster Catcher (*Hæmatopus ostralegus*) is a common bird with us, breeding on the gravelly beds of our rivers, and collecting in large flocks at the mouth of the Tay in winter. Its foreign range is extensive—from the coasts of Southern India to North Asia.

Those two extremely rare species, the Red-necked and Grey Phalarope (*Phalaropus hyperborea*) and (*P. fulicarius*) are to be found in our Museum. The far north is their proper habitat, though they are actually included in the birds of India. The late Mr. Dunn told me he knew of breeding-places of the Red-necked species in Orkney, and he had specimens of the birds and eggs in his collection.

The Woodcock (*Scolopax rusticola*) is nearly as common in the Sub-Himalayan ranges, and even in the hilly country of Southern India, during the cold weather as it is with us during autumn and winter. I have observed in Cashmere, where it breeds, the same habit of flying about in the evening uttering its low whistling call.

The Double Snipe (*Gallinago major*) is a rare bird in Perthshire, and I have only seen it once, in some long thatching grass on the banks of the Tay above Mugdrum, in November, 1887. I have shot specimens of this bird in Northern India, where, however, it is not common.

The Common Snipe (*Gallinago cœlestis*) and the Jack Snipe (*G. gallinula*) are commom with us in winter, and the former breeds on our moors and marshes. I have seen young birds unable to fly so late as 12th August. All over India both species are common in the cold weather.

The Dunlin (*Tringa alpina*) has a wide range, and has been found well within the Arctic circle to the north, whilst to the south it has been recorded from Sicily, Malta, Tangiers, and Vera Cruz, in Mexico. I found it breeding on Tentsmuir in the month of May.

I have never seen the little Stint (*Tringa minuta*), that very rare bird the Pygmy Curlew (*Tringa subarquata*), the Knot (*Tringa canutus*), the Ruff (*Machetes pugnax*), or the Sanderling (*Calidris*

arenaria) in Perthshire, though I have no doubt some of them at least are to be found within our marshes on that ornithological paradise, the sands of Tentsmuir. Like most of the birds of this family, all the above have a wide range over Europe and Asia, as well as America.

The Common Sandpiper (*Totanus hypoleucus*) and the Redshank (*Totanus calidris*), common Perthshire birds—the former breeding on the gravelly banks of our rivers and the latter on our moors and marshes,—are found, according to the season, from the shores of the Arctic circle in summer to the coasts of North Africa and India in winter.

The Greenshank (*Totanus canescens*) is a rare bird in Perthshire, as it is, generally, in our islands, where it is most frequently met with during its spring or autumn migrations. It also wanders from the Arctic circle to the Straits of Sunda, and from the extreme north of America to Florida.

The Bar-tailed Godwit (*Limosa lapponica*) is a regular winter visitor to the mouth of the Tay, and Yarrell records it from the shores of the Caspian Sea, India, and Java.

The Whimbrel (*Numenius phæopus*) has been seen by Col. Drummond Hay in large flocks on Tentsmuir, but it is nowhere so common as the Curlew (*N. arquatus*), which breeds on all our moorlands, and is a shy and wary bird. I have shot both the Whimbrel and Curlew on the banks of the Ganges at Cawnpore.

STERNIDÆ.—Of the Terns, we have specimens of the Common Tern (*Sterna fluviatilis*), the Little Tern (*S. minuta*), the Sandwich Tern (*S. cantiaca*), and the Black Tern (*Hydrochelidon nigra*) in the Museum. The two former are common at the mouth of the Tay, where they breed, and are, I am glad to say, protected by the proprietor, Mr. Mackenzie of Earlshall; but the latter are rare, and occasional visitors to our shores. All the above species have an extensive range throughout Europe, Asia (including India), and Africa, and the Common and Lesser Tern are also included in the American fauna.

LARIDÆ.—The Black-headed Gull (*Larus ridibundus*), the commonest and at the same time one of the most interesting birds on the Tay, where it may be seen at all seasons of the year, breeds on many of our reedy lochs, and also on the river, forming, when unmolested, large colonies, such as may be seen at Methven and Dupplin. It also breeds in Sweden, Russia, and Siberia, and is recorded as far south as Sicily in winter.

The Common Gull (*L. canus*) and the Herring Gull (*L. argentatus*) are also common on the Tay, as far at least as Perth Bridge, and may also be seen, in the early mornings of autumn, hunting for

worms on the South Inch. The former breeds on islands on several of our lochs, but the Herring Gull, so far as I know, always nests on maritime cliffs.

The Lesser (*L. fuscus*) and the Greater Black-backed Gull (*L. marinus*) are much more maritime in their habits, though they, especially the former, may frequently be seen in winter as far up the river as Perth. The Lesser Black-back breeds on some of our inland lochs; but I have never heard of any breeding place of the Greater in our district. They range from the Arctic Ocean to the Mediterranean in Europe, whilst the former species extends as far as the Cape, and the latter through North America to Bermuda.

The Glaucous Gull (*L. glaucus*) is essentially a northern species, and breeds in all the countries included in the Arctic zone, the rigours of winter sending it occasionally to our shores. I have shot it in Orkney, and it has been recorded so far south as Devonshire, and once in France.

The Kittiwake (*Rissa tridactyla*) is, like the last, an essentially maritime species, and is a migrant, coming to breed on our rocky coasts in summer, and seeking more genial climes in winter; being found, according to the season, as far north as Nova Zembla, and as far south as the Caspian and the Mediterranean.

The Pomatorhine Skua (*Stercorarius pomatorhinus*), Richardson's Skua (*St. crepidatus*), and Buffon's Skua (*St. parasiticus*), are all represented in the Museum, having been procured at the mouth of the Tay. They are arctic birds, which seldom stray so far south, though Richardson's Skua breeds in Orkney.

Procellaridæ.—The Storm Petrel (*Procellaria pelagica*) is most frequently met with in mid ocean, and I have seen it in the Bay of Biscay, the North and South Atlantic, and, I believe, in the Indian Ocean. They breed on some of the rocky islands off our coasts

Leach's Petrel (*P. Leucorrhoa*) is, like all the others, entirely pelagic in its habits, and is never found inland unless driven by the force of gales from its wild home among the storm-tossed waves of the Atlantic or German Ocean.

The Fulmar *Fulmarus glacialis*) is a northern bird; but though, strange to say, St. Kilda is one of its breeding places, it is more at home among the icebergs of Spitzbergen than in the more genial climate of the Tay.

Alcadæ.—The Razor Bill (*Alca torda*), the Common Guillemot (*Lomvia troile*), the Black Guillemot (*Uria Grylle*), and the Puffin (*Fratercula arctica*), are all common birds on our coasts, and never found inland except when driven in by stress of weather. They are all arctic birds though they also breed with us. Large accessions to our home-bred birds visit and remain with us in winter, with the ex-

ception of the Puffin, which migrates south at that season. I have seen it in the Bay of Biscay in November.

The Little Auk (*Mergulus alle*) is essentially a northern bird, and is common in all the countries within the radius of the arctic circle, in Europe, Asia, and America, revelling among the ice, and never coming to our shores except when driven to them by northern gales. Their visits to us are very uncertain, though, since I wrote this paper, we have, during the severe winter of 1894-5, had an unprecedented flight of these most interesting little birds, which were found dead or exhausted all over our islands. Several were procured in the neighbourhood of Perth, and one which was found in the garden of the Prison, will, I hope, soon be exhibited as a skeleton in the Museum.

COLYMBIDÆ.—The Great Northern Diver (*Colymbus glacialis*), the Red-throated Diver (*C. septentrionalis*), and the Black-throated Diver (*C. arcticus*) are all found in the estuary of the Tay in autumn and winter. The former never remains to breed in Scotland, but the Red-throated breeds in Sutherlandshire and Orkney, whilst I have found the nest of the Black-throated species in Perthshire.

The Great-crested Grebe (*Podiceps cristatus*) is found on the lower reaches of the Tay, and I know of more than one of its nesting-places in the county, It extends from the reedy lakes of Russia and Siberia to South Africa and India, and is also included in the fauna of North America.

The Red-necked Grebe (*P. griseigena*) and the Sclavonian Grebe (*P. auritus*) are both rare visitors to the estuary of the Tay, their habitats being in the far north. I have shot the latter species in winter plumage at Stromness.

The Little Grebe (*P. fluviatilis*) is, on the other hand, one of our commonest birds, being found on most of the reedy lochs and ponds in the district, where it remains all the year round. It is included in the birds of Sweden, and ranges through Holland, Belgium, and France, to Italy, Sicily, and Malta, to which, however, it is only a winter visitor. It is also common in India in the cold weather.

I have now exhausted the list of our local birds, and I think it will be seen from the above enumeration that the ornithologists of Perthshire are particularly fortunate in possessing so rich and varied an Avi-fauna.

IX.—*The Home of the Dipper.*

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

(Read 10th January, 1895.)

The burn comes rushing down the glen, leaping over the stones and dancing on the shallows, and falls foaming into a deep rocky basin, where the water rests for a while, gathering strength for its onward course down to the valley below. The water-spiders slide about on the smooth surface of the water, and a trout darts under cover of a stone as we look down into the dark depths of the pool.

It is April, and the dead leaves of the young oaks still cling to the branches, and the buds of a great ash tree, which spreads its boughs overhead, are hard and black, but there is ample compensation for the lack of foliage above in the wealth of fresh verdure which clothes the ground. The rocks are covered with moss, and woodland rush, and golden saxifrage, and the stalks of young ferns are pushing their curled heads through the rusty wreckage of last year's growth; the exposed roots of the overhanging trees twine in and out among the herbage, and from the top of a high bank, ivy and honeysuckle fall in long tresses to the water's edge; primroses and wild anemones are in full flower, and the deep orange petals of the marsh marigolds are reflected in the mirror of the pool—all this verdant growth is kept fresh by constant moisture, for the water, ever trickling down the rocks, soaks into the spongy mosses, where it is held in reserve, to fall down, drop by drop, from the ends of every tiny leaf and stem. A ceaseless sound of running waters fills the air—the murmur of distant waterfalls, the rush of swiftly racing rapids, and the splash of the near cascade are all blended together into one melodious strain of natural music which the Dippers love, and it is in places such as this, that these birds choose to make their home and build their nests.

> "There to the brooding bird, her mate
> Warbles in fits his low clear song,
> And by the busy streamlet, both
> Are sung to all day long."

Their beautifully constructed domed nest is built firmly against a rock, or among the roots of a tree, or in any suitable place in the bank of a stream, sometimes so close to a waterfall that its roof is constantly wet with spray. It is of the same character as that of the Wren, but is larger in size, and more oval in form. It is composed of moss and grass, and these materials are so tightly and closely woven and knitted together that its walls, two or three inches in thickness, are like felt, rendering the snug little abode quite impervious to cold and damp. It harmonizes well with its natural surroundings and is not

easily found unless one happens to see one of the birds in the act of leaving or returning home. The pure white eggs, generally five in number, are laid on a layer of grass or dead leaves. The Dippers are early breeders, incubation commencing in the month of March, when the bank is often white with frost and icicles hang round the nest. The eggs are hatched in about fifteen days, and both birds are then most assiduous in collecting food for their brood, flying hither and thither in their busy cheery way. The young birds begin their amphibious life at a very early stage of their existence, for, from the position of the nest, they often tumble into the water when using their wings for the first time, and have to struggle to land as best they can.

The family haunt the neighbourhood of their home till the summer days begin to shorten, they then become independent and scatter far and wide, and by the autumn they may be found on any part of their native stream, from its very source on the moorlands, in all its wanderings as a tiny rill under the overshadowing heather, where it leaps and falls from pool to pool on the mountain side, or ripples through the woodlands in the valley; on the broad reaches of the full river, and even as far as the brackish waters of the estuary, when the white Gulls swoop over the shining sands, and the smoke of ocean steamers is seen trailing in long lines over the dark blue horizon.

Every angler is familiar with the dark, little white-chested bird—the Water Ouzel, as he is often called, who keeps him company on many a day's fishing. He sees him now bobbing and curtseying on a stone, now diving into the water in search of food, steadying himself with his wings, as he half flutters, half walks on the gravelly bed some feet below the surface. Sometimes, when crossing a pool, he suddenly stops in his flight and drops with a splash into the water, vanishing from sight; after a few minutes he reappears, floating like a cork down the current, and either sinks again or rises on rapid wing to disappear round the next bend of the river.

The ordinary note of the Dipper is a sort of chirp, which he almost invariably utters when flying. He has besides this a real song, and a very sweet one it is, which may be heard during most months of the year; but in summer it is seldom noticed, being drowned in the chorus of other birds. He is heard at his best, and is all the more welcome, in the depths of winter, when, sitting on a piece of ice on the rim of the black water, he pours out his music to the bitter east wind, with the snowflakes falling thickly round him, when even the Redbreast is silent in the holly tree close by.

The Dippers suffered a good deal of persecution at one time from keepers and others, under the impression that they fed upon the ova of salmon and trout. This fallacy has been dispelled, and

dissection of many specimens has proved that their food largely consists of beetles and larvæ of water insects, some of which are themselves the great enemies and destroyers of spawn, so that the Dipper is rather beneficial to fisheries than otherwise. When one of them is seen diving into the water, and feeding close to a spawning salmon there certainly seems to be a case against him, but on investigation it has been discovered that the fish, in burrowing in the gravel and sand of the river bed, has exposed the embryo insect food of the Dipper, who is attracted by instinct to the spot. There is no doubt that occasionally he may eat a fish's egg, but it is exceptional, just as the Kestrel, whose normal food consists of mice, beetles, and moths, is known sometimes to snatch a chicken from the poultry-yard or a young pheasant from the covert side; and the Owls, when hunting round the hedgerows in the gloaming, do not always resist temptation. Gamekeepers, however, allow no exceptions to their inexorable rules, and ruthlessly destroy these and other useful birds, notwithstanding that the amount of general good they do, far outweighs the evil results of a paltry act of poaching which they may from time to time commit.

Independently of any aggressive action on our part, we must often, in the course of our progress, interfere with the laws of Nature, and necessarily alter the conditions under which wild animals and plants exist, and thus gradually, and almost imperceptibly, the whole fauna and flora of the civilized world is shifting and changing under the irresistible influence of man; new species are attracted to places where before they were unknown, and others disappear and become extinct, while in some localities there is a crowding together which tends to an undue predominance of the strong over the weak, and the balance of Nature is disturbed.

In order to restore the lost equilibrium, a certain amount of readjustment may from time to time be needed, but should never be attempted except with the greatest care and discrimination— a little pruning here, and a little extra protection afforded there, may sometimes have the desired effect, but all harsh and severe measures, which generally proceed from ignorance, are to be deprecated, for outraged Nature sooner or later takes her revenge. In the study of birds alone, experience has taught us much. We know, for instance, that the wholesale destruction of Owls in a district is often followed by a plague of rats and voles, and that in countries where soft-billed birds have been annihilated, cornfields and orchards are devastated by caterpillars, locusts, and other insect pests.

This problem of readjustment is a most complicated one, and it is rendered all the more difficult owing to the fact that, through want of sympathy and lack of general knowledge, there can be no com-

bined action, and thus the efforts for good in one locality are often frustrated by ill-advised action in another. Legislation emanating from practical knowledge based on experience is the only remedy. The Wild Bird Preservation Act of 1880 has already done much good, and the amending Act of 1894, which deals specially with the eggs of wild birds, is on its trial.

The successful operation of these Acts will depend largely upon the spirit in which they are received and understood by the public at large, and there is no doubt that our local Natural History Societies throughout the country have much scope for usefulness, both in disseminating accurate information, and also in assisting, if need be, the County Councils, upon whom now rests the responsibility of setting the law in motion. Our aim should be to repair any mischief which we may have done in the past, and to restore to Nature what we can of that beautiful order and perfect harmony which belongs to the original design, always bearing in mind that the smallest and most insignificant representative of animal or vegetable life, equally with the largest, has its part to play in the great economy of Nature, and that we can no more decide the limit within which the influence of any particular particle of the universe is restrained, than we can measure the latent energy which exists in the tiniest ripple of an ocean wave, or calculate the result of the storm which we hear gathering in the first rustle of the forest leaves.

The Dipper has shared with other birds the benefit of the above-mentioned Acts, and is now allowed to live unmolested. Although of a solitary disposition, he is always cheery, and sometimes in the air, sometimes in the water, now appearing, now disappearing from sight, he lends a mysterious charm to our mountain streams; and wherever the current runs swift and strong, and when the rainbow flashes in the spray of the waterfall, the notes of his sweet song may be heard amid the roar of the cataract or mingling with the music of the hurrying waves.

X.—*The Vegetable Origin of* Parka decipiens.

By James Reid.

(Read 14th February, 1895.)

It requires but a cursory glance at the subject of Geology to be convinced of the fact that the science has little or no claim to rank as an "exact science." Yet year by year a progress in the main in the latter direction is unquestionably apparent. Much of this advance is doubtless due to microscopic and allied methods of research,

which reveal to us, not alone the constituents of which the rocks forming the crust of the earth are composed, but also their microscopic fossil contents, the presence of which had been previously unsuspected.

The discovery of *Radiolaria* in the Ordovician is a case in point. The rocks of the Lower Silurian of Ayrshire and the Grampian range, as well as those of West Cornwall, have yielded to the microscope *Radiolaria*, whose recent representative the naturalists of the "Challenger Expedition" in the South Pacific Ocean have met with at depths exceeding five miles (4575 fathoms).

These discoveries would seem to indicate that pelagic conditions obtained in the early Palæozoic not dissimilar to those occurring at the present day, and we have reason to believe that further discoveries may be looked for in the not distant future.

In following out a similar line of research Sir William Dawson and Professor Penhallow have recently placed the subject of our paper upon a more scientific basis than it has previously occupied, and one such as no unsupported scientific opinion is at all likely to overturn. The *Parka* question, in a word, having emerged from the region of opinion and passed into that of well ascertained fact, falls to be dealt with upon scientific grounds alone.

THE HISTORY OF PARKA DECIPIENS.

In 1831 Dr. Fleming compared this interesting fossil to the seed of *Juncus* and *Sparganium*.* Hugh Miller expressed a similar view, while Page regarded *Parka* and certain associated seed-bodies as of respectively vegetable, molluscan, and crustacean origin. Lyell, Powrie, Woodward, and Geikie, on the other hand, believed *Parka* to represent the egg-packets of crustaceans, and latterly geologists have apparently settled down into the belief that in the clusters of of *Parka decipiens* we find the spawn of *Pterygotus*.

That these varying opinions, more especially the latter, are but plausible conjectures is evident from the fact that in the Upper Silurian *Pterygotus* and allied crustaceans are equally prevalent, whilst in the Old Red Sandstone of the counties of Lanark (East), Berwick, and Caithness *Pterygotus* occurs. Yet in neither the former nor the latter do we find a trace of *Parka decipiens*.

THE DISCOVERY OF THE VEGETABLE ORIGIN OF PARKA DECIPIENS.

The papers on *Parka* by Dawson† and Penhallow‡ were based upon material obtained by the writer from the Old Red Sandstone of

* Cheek's Edinburgh Journal.

† Trans. Roy. Soc. Canada, 1891. ‡ Canada Rec. Science, 1892

Myreton, and by Mr. Wm. Graham, from Turin Hill, near Forfar, and also upon specimens kindly presented by Mr. P. Macnair of Glasgow (all of which in essential particulars were the same). Some of the material from the shales of Myreton apparently indicated a high state of preservation, and from this the microscopic examination by Sir Wm. Dawson was made, which resulted in the discovery that *Parka decipiens* was a plant (allied to *Pilularia*) possessing a creeping rugose stem, linear leaves, and sporocarp, with contained spores and prothalli. The process by which this result was arrived at may be described as follows :—The rounded flattened discs of *Parka*, when stripped from the matrix and examined under the microscope as opaque objects, in some of the best specimens, showed a hexagonal cellular areolation identical with the structure of extinct *Protosalvinia*. Some of the discs, on being boiled in nitric acid to remove the opaque outer coat, presented an inner transparent structure. This, upon being broken up in water, disclosed a *mass of amber-coloured spores* of two kinds, namely, macrospores and microspores. Prothalli in various stages of development were more sparingly obtained.* In this connection we quote an extract from the letter of a friend—"In the latter part of 1892 we had the pleasure of being present at an examination of some discs of *Parka decipiens*. In one case—which was placed for a *short time* in nitric acid—we found under the microscope a beautiful semi-transparent body, showing perfect hexagonal structure (extending from margin to margin of the disc) identical with the structure of the sporangia of recent *Salvinia natans*."

(Signed) G. Soutar.
J. Richardson.

We may state that, in addition to *Parka decipiens*, *Psilophyton*, *Zosterophyllum*, *Pachytheca*, and certain seed-bodies occur in the Lower Old Red Sandstone of Forfarshire. These, however, do not come within the scope of the present paper.

STEMS, LEAVES, AND SPORES OF PARKA DECIPIENS.

In a recent review of Dawson and Penhallow's† papers on *Parka*, Mr. Kidston remarks :—"But in the absence of any knowledge of their organic union . . . . we have no evidence placed beyond reasonable doubt that the stems and leaves (?) with which *Parka* is associated are really referable to it." ‡

We find, however, *in the paper under review*, a *stalked fruit cluster of Parka* figured. And in Miller's Old Red Sandstone a stalked fruit

* Trans. Roy. Soc. Canada, 1891, pp. 6, 7, 15. † Trans. Roy. Soc. Canada, 1891.
‡ The Annls. Scot. N. History, 1893, p. 254.

is figured, from a specimen in the collection of the late Lord Kinnaird, while Sir William Dawson refers to cases of the same kind. But the fact remains, that, if in determining fossil plants, this dictum in regard to organic union of stem, branch, and fruit, were to be acted upon, but few plants of the Old Red Sandstone, or of any other formation, would prove eligible.

We are painfully familiar with the fragmentary condition in which the plants of the Old Red Sandstone occur, and cases of organic union are undoubtedly but few and far between. The palæobotanist, therefore, in dealing with the imperfect material at his command, more frequently finds it necessary to *break the "rules"* than to observe them. An example of this occurs in a paper by Mr. Kidston "On Arthrostigma,"* which states, "That the Perthshire specimens must be identified as *Arthrostigma gracile* (Dawson)," though the evidence upon which this opinion is based is comprised in a few fragments of somewhat obscure stems, devoid of branches or fruit. Again, we find an interesting paper by this author "On the occurrence of the genus *Equisetum* in the Yorkshire Coal Measures,"† in which a representative cone 1 inch in length by $\frac{6}{10}$ inch in breadth is figured, and "Beyond evidence gained from an examination of the surface of the fossil (cone) there is none." No stems, branches, or seed occur.

We may therefore search in vain for evidence of "organic union" in this case, none such occurring in the Carboniferous formation of England.

The paper is an able one, and we are far from questioning the conclusion arrived at. Yet it will be generally conceded that had a few fragments of branches or stems of *Equisetum* been discovered in association with this cone (or cones), the case would have been materially strengthened.

Parka decipiens, on the other hand, occupies a much stronger position. Perhaps *Parka*—possessing sporocarp, and sporangia of rhizocarpian structure—could better afford to dispense with stems and leaves than even *Equisetum*. The rhizocarpian form, however, of these, and their invariable presence in the same beds in which the fruit-clusters of *Parka* occur, irresistibly point to the same origin.

In conclusion, the excellent work accomplished by Dawson and Penhallow has undoubtedly advanced the *Parka* question beyond the reach of conjectural opinion. And we are in no small measure indebted to the veteran geologist, who has so ably solved the problem of *Parka decipiens*, the "deceiving" nature of which has proved (for so many years) a stumbling-block in the way of leading geologists of our time.

* Trans. Roy. P. Soc. Edinburgh, 1893.

† The Annls. and Mag. N. History, 1892, pp. 140, 141.

If there is one thing more strongly brought out than another in the recent *Parka* inquiry, it is the fact that the origin is not a crustacean origin. There remain the stems, rachis, *sporocarp*, and *spores*, whose rhizocarpian origin, we venture to think, few will be disposed to question.

XI.—*Botanical Notes from Murthly.*

By Prof. J. W. H. Traill, M.A., M.D., F.R.S., F.L.S.

(Read 11th April, 1895.)

The following notes are the result of spending the month of August, 1894, in the district of Murthly. It may be remembered that the weather was very broken during the greater part of the month—indeed, during the first three weeks not one day was absolutely free of rain, while most days were decidedly wet. This, along with other causes, very greatly hindered botanical work; but I met with a few plants, galls, and other specimens that may afford materials for a short paper. I am not sufficiently familiar with the distribution of the plants of Perthshire to know in how far the records are new to the district in all cases; but I have reason to believe that some, at least, are so; and I trust you will excuse the repetition of such as are already on record for this part of Perthshire.

The Phanerogams will be noticed first, then a few Cryptogams, and lastly a few Galls. In each group only those of more special interest from any cause will be enumerated.

Phanerogams.

Thalictrum minus, L., var. *montanum*, Wallr., is not uncommon along the banks of the Tay. In Aberdeenshire we have only the var. *maritimum*, Syme, of this species.

Ranunculus Lingua, L., was observed in flower in a marsh near the Tay a little way below Delvine. Dr. White told me of this locality having been previously known.

Radiola linoides, Roth, (*R. millegrana*, Sm.), was found in abundance in several places along the Great Avenue in Murthly Castle Grounds, on a road at Gutterhole east of the King's Myre, and in a damp hollow on a low hill north-east of Stenton, in Caputh. In each locality it was associated with *Centunculus minimus*, an association that I have observed elsewhere. It is somewhat curious in view of the decidedly local distribution of both species.

Ononis repens, L., occurred with white flowers on the bank of the Tay, about a quarter of a mile below the Bridge of Caputh. The abundance of this species in the southern and midland counties of Scotland is in marked contrast to its scarcity near Aberdeen.

Medicago sativa, L.—One or two plants observed in fields in Caputh were doubtless introductions, probably unintentional.

Trifolium glomeratum, L.—One example was found on the side of the road near Strathord Station.

T. agrarium, L. (observed twice or thrice in Caputh, near Braecock, a little way below the Bridge), is also introduced, but it seems to be likely to become naturalised in many parts of Scotland.

Ornithopus perpusillus, L., is plentiful in certain fields near Braecock, and along the bank of the Tay near that farm. It appears to be undoubtedly native in that locality.

Spiræa Filipendula, L., was plentiful in fruit on the embankment on the right bank of the Tay, about a quarter of a mile above Kinclaven Church. Dr. White told me that the form growing there has single flowers, and he was strongly of opinion that it is native in this habitat, though its being confined to the embankment suggests doubts.

Agrimonia odorata, Miller.—Several plants were found by the side of the Perth and Dunkeld road, not far north of Strathord.

Saxifraga aizoides, L.—This species grows in abundance in a marshy hollow between fields on the farm of Brownmuir, near Murthly Asylum, at about 200 feet above the sea-level. It occurs here and there along rivers that rise among our higher mountains down to even lower levels, but at Brownmuir its occurrence cannot be accounted for as due to seeds carried down by the Tay. I have not elsewhere met with it as a permanent resident at this elevation.

Peplis Portula, L., was found on damp spots on a woodland road near the King's Myre, and also on the muddy slopes of a mill-dam near Murthly.

Galium uliginosum, L., in one or two localities (roadside near Auchtergaven, etc.), showed much greater luxuriance than I have observed in the north-east of Scotland. Some stems were nearly eighteen inches in height and branched freely, bearing many flowers.

Scabiosa Succisa, L., in extreme profusion in one or two pastures.

S. arvensis, L., in abundance, markedly contrasted with its rarity in Aberdeenshire.

Gnaphalium sylvaticum, L.—A specimen found near Murthly showed a curious departure from the usual form. Instead of the simple interrupted spike of small heads, it bore twelve branches and a short terminal spike, each of which repeated the structure of the ordinary inflorescence, though on a somewhat reduced scale. The

branches were from five to three inches long, the basal two or three inches of each being slender.

Centunculus minimus, L., has already been noted in connection with *Radiola*.

Solanum Dulcamara, L., was noticed in a good many hedges about Strathord and elsewhere. Its presence catches the eye of one accustomed to botanise in a part of Scotland in which it is rare.

Bartsia Odontites, Huds.—This is another of the plants whose abundance in Perthshire is in very marked contrast to their local distribution or scarcity in the district around Aberdeen. Its prevalence in Perthshire must be hurtful to the pastures.

Polygonum Hydropiper, L., and *P. lapathifolium*, L., as common weeds of cultivated fields attracted my attention, since they are both of rare occurrence in the north-east of Scotland. Indeed, *P. Hydropiper* is scarcely ever seen as a field-weed there, and *P. lapathifolium* seems to be more a casual introduction than a resident weed with us. I gladly took advantage of the opportunity of carrying on careful observations on the variations of structure in the flowers of both species, in connection with similar observations on the flowers of other species of the genus. I find the structure to be extraordinarily variable in some, and fairly constant in other, species of Polygonum.

Rumex conspersus, Hartm.—Of this dock I met with examples near Murthly, and also near the Lake of Menteith.

Rumex obtusifolius, L.—In the mill-dam already referred to, situated in a shady spot surrounded with trees, on the Burn of Gelly, near Murthly Station, I found plants of unknown aspect growing under water, though the dam was then at a very low level. The leaves were from fifteen to eighteen inches in length; with the blade narrowly lanceolate, from six to nine inches long by little more than one half-inch in width, and of delicate texture. I was a good deal at a loss at first to identify the plants, but an inspection of the bottom of the dam and of its sides afforded a series of examples that showed the submerged forms to belong to some species of Rumex. It was more difficult to ascertain the species, as the most careful search failed to secure examples in a satisfactory condition, the most developed bearing only small flowers. *R. crispus*, L., and *R. obtusifolius*, L., grew round the dam, and I also found a single example of *R. conspersus*. Comparison of the aquatic form with these species led me to the conclusion that it is most probably to be referred to *R. obtusifolius*, though the condition of the reproductive organs and the changes due to the environment prevent full certainty. I am not aware of any similar observation having been put on record of the effect of aquatic environments on any of the above species of Rumex. Additional observations from this locality are desirable.

Carex vesicaria, L., also grew in the dam. It appears to be very local in the north-east of Scotland.

Molinia coerulea, Moench, was noteworthy on account of the extreme range of variation that it presented, from examples of not more than four inches in height, with a few dark spikelets, on the more barren spots on heaths and waste places, to others growing in luxuriant clumps in the shade of woods. The flowering stems of the latter reached a height of three feet occasionally, and bore many spreading branches with pale greenish spikelets.

Cryptogams.

Riccia fluitans, L.—This grew in plenty in the dam, both floating in small masses in the water, and creeping on the damp mud on those parts of the bottom and of the sloping sides that were above water.

Fungi.—Of this group of plants I picked up a few species, but shall mention here only certain parasites on flowering plants.

Peronospora violacea, Berk., was found near Murthly on the flowers of *Scabiosa arvensis*, causing them to become enlarged and dull in hue, and to remain sterile. This fungus has not previously been recorded from Scotland.

P. densa, Rabh., on *Rhinanthus Crista-galli*, *P. Alsinearum*, Casp., on *Stellaria media*, *P. obovata*, Bon., on *Spergula arvensis*, and *P. alta*, Fckl., on *Plantago major*, are all new records for the basin of the Tay, so far as I am aware, though already known as Scotch.

Ustilago Scabiosæ, Sowerby, was not scarce in the anthers of *Scabiosa arvensis*. It has not, I think, been recorded from Perthshire. The allied *U. flosculorum*, D.C., recorded by Dr. White from Rannoch, was also not rare, infesting the anthers of *S. Succisa*.

Taphrina cœrulescens, M. and D., was found on Oak leaves, causing spots, discoloured and prominent above, concave and at first pale below, where the asci are formed after a time. This obscure parasite, though not previously recorded from Scotland, is not rare in various districts from Perth to Aberdeen.

Galls.

Of these the only forms that call for special mention, with one exception, are the work of the microscopic Gall-mites (*Phytoptidæ*), since the few other galls met with have all been already recorded by me from Perthshire. For convenience the galls are enumerated in the order of the plants on which they occur.

Ornithopus perpusillus.—In a field of grass, allowed to have relapsed almost into its natural condition, in Caputh, this plant was very plentiful, but almost every specimen was more or less altered

by the attacks of mites. The upper leaves and the flowers were rendered abortive, or distorted and twisted, often into tubular form.

Trifolium minus.—A pretty large patch by the side of a road near the farm of Muirlands, in Murthly, showed great alterations of the flower-heads, many of which were much branched and had the flowers "virescent," their parts being more or less like ill-developed leaves. Though I did not succeed in actually detecting mites in the specimens, the condition was so essentially similar to that produced by mites on other plants that I do not think there can be doubt as to their agency in this case.

Ribes nigrum.—The swollen buds, characteristic of the too-well-known Currant Mite (*Phytoptus Ribis*, Westw.), showed themselves in numbers on two bushes in a garden in Caputh in spring; but burning the infested bushes put an end to the attack, none of the other bushes in the garden showing infection.

Galium palustre and *G. uliginosum* both showed leaves rolled into tubes and distorted by the action of mites. (*Cecidophyes Galii*, Karp.).

Achillea ptarmica.—A few dwarf plants on the Moor of Murthly bore leaves rolled into narrow tubes, in the manner so characteristic of the action of gall-mites. Owing to its inconspicuous nature this gall is very easily overlooked. I had not previously met with it.

Veronica officinalis.—The flower-buds of numerous plants in the slate quarries on Birnam Hill were galled by a *Cecidomyia*, or gall-midge, becoming fleshy or much swollen, as described by me in "Scottish Naturalist," 1888, p. 326.

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XII.—*The Boys' Brigade Field Club at Ballinluig.*

By T. M. M'Gregor, F.E.S.

(Read 12th December, 1895.)

Through the kindness of our esteemed President and the Officers of the Boys' Brigade, I was invited to join the camp-out at Ballinluig during the past summer, the primary object being to interest the boys in Natural Science studies. As the ground was new to me, and there was the probability of some good records, the invitation was at once accepted.

With excellent foresight, detachments of boys from the various companies were deputed to accompany me upon my daily outings; and certainly it was evident to all present in camp that a week was all too brief in which to take out in rotation all the willing candidates who were so enthusiastically anxious to accompany us, so we had to soothe the wounded feelings of the unsuccessful by glowing promises for the future.

From an entomological point of view, the week's work was highly successful, from the fact that, amongst other interesting records, we obtained six specimens of *Salda Muelleri*, Gmelin., a bug which is exceedingly rare in Britain, together with some specimens of *Salda Cocksii*, a bug not previously recorded in Perthshire, but which appeared to be common in this locality.

*"Salda Muelleri in Perthshire.—The six specimens of *Salda Muelleri*, Gmelin., have been very kindly identified by Mr. Edward Saunders, F.E.S., who at first informed me that the insect was new to the British List; but he now tells me that, 'as a matter of fact, *Muelleri* has been previously found, but has been hitherto wrongly identified as *S. Morio*, Zetterstedt. It has been taken at Aviemore by G. C. Champion; Scarborough by Wilkinson; Horning by G. C. Champion. Apparently I [E. Saunders] am the only one who has met with the true *Morio* in this country, which I took at Buxton, on the moors, but only a very few males; and in my *British Hemiptera* I described the male *Morio* and female *Muelleri* as one species, under the name *Morio*. The two species may be known apart thus: *Morio* is more shining, almost burnished, and the elytra are so smooth as to show no definite puncturation; whereas in *Muelleri* there is a distinct though irregular puncturation on their disc. The eyes in *Morio* male are smaller than in *Muelleri* male, each being narrower than the intervening space between them. Dr. Reuter has recently published a work on the *Saldæ* of the

* The part within quotation marks appeared in the *Annals of Scottish Natural History* for Oct., 1895, page 254.

Palæarctic region, and it is from his book that I have gleaned the characters which distinguish the two species.'

Subsequently I paid a flying visit to Ballinluig in search of more specimens. I was again successful in obtaining four males of *Muelleri* and a damaged female. In the sunlight the insect is of a bright bronze blue colour, and is sluggish in habit, making no attempt to leap or fly like our *S. Scotica* and many other species of Saldæ, which are so difficult to capture. The specimens seemed to avoid open places, and were only found by careful searching at the roots of the grass."

We shall now proceed to give a brief *resumé* of the week's work.

Thursday, 4th July.—Visited the Dead Water, Guay, in company with Col.-Sergt. Leslie and Sergt. Mitchell, 3rd Coy.

Insects were scarce, except the common forms of butterflies, such as blues and meadow browns. Searched for dragon-flies amongst reeds of Dead Water, but only succeeded in obtaining one small crimson specimen, *Pyrrhosoma mnium.* Here we found a new bug, *Salda littoralis*, amongst the mud, and succeeded in boxing a good many specimens for future determination. On the way home we obtained one blue sand wasp, *Pompilus niger.* The common shingle bugs, *S. Scotica*, were numerous at the water's edge, but we did not trouble them. After tea a sweep-net was taken with us down the river-side, and by it we obtained some specimens of a beautiful rose-coloured bug, *Calocoris roseomaculatus*, and some more of a different species, *Nysius thymi*, which we had not previously met. Many fine forms of lady-birds, *Coccinellæ*, were boxed during the day.

Friday, 5th July.—Visited hill opposite camp, in company with Private R. Douglas and Corporal D. Brown of 3rd Coy.

This proved to be the most successful day of the week. Many beautiful butterflies were captured, including the fritillaries (three kinds), large and small heaths, blues, etc.; two fine specimens of the burying beetle were procured; some pretty crimson (*Pyrrhosoma mnium*) and blue (*Agrion cyathigerum* and *Ischnura elegans*) dragon-flies were observed amongst the rushes on the margin of a mountain loch on the hill top, and many good specimens secured. On the sides of a mountain burn, farther east, we obtained, after patient searching, six specimens of a rare bug, which eventually proved to be *Salda Muelleri*, Gmelin., already spoken of. Throughout the day many caterpillars were got amongst the heather, such as those of the emperor moth, oak eggar moth, and tussock moth. From the hill top a glorious view of the surrounding country was obtained, the hills being aflame with the purple bell heather.

Saturday, 6th July.—Visited hill between Tay and Tummel, in

company with Captain Mitchell, of the Belfast Battalion, and Lance-Corporal Stirton, 3rd Coy., and Private D. Coltart, 11th Coy.

Many fine butterflies were again on the wing, and a few of the large dark-green fritillary were boxed, as also three exceptionally fine large dragon-flies, *Cordulegaster annulatus*, about three inches long, which were captured on the edge of a mountain stream. Returning by way of the Tayside, the river was forded three times, but nothing of unusual interest was noted, although an occasional kitten-moth *(Furcula)* larva was picked up. *Salda Scotica* was seen to be very numerous amongst the shingles. Large flocks of oyster-catchers awoke the surrounding echoes with their shrill piping when disturbed.

Monday, 8th July.—Visited Killiecrankie and Ben-y-Vrackie, in company with Captain Mitchell and Col.-Sergeant Munro, 8th Coy., and Lance-Corporal Stewart, 3rd Coy.

After visiting the Queen's View and Soldier's Leap, walked through Pass of Killiecrankie on to Pitlochrie, and from thence to Ben-y-Vrackie. The weather being dull, with a strong wind blowing, specimens were very scarce, only two crimson dragon-flies, *Pyrrhosoma minium*, being captured at a mountain tarn, where a pupa skin of a large dragon-fly, *Libellula*, was found. After reaching the topmost point of Ben-y-Vrackie, and enjoying the splendid view therefrom, the descent to the lower ground was commenced, and many specimens of the emperor moth larva were found among the heather. Nothing, however, of any special interest was found, and the party walked back to camp about five o'clock, rather disappointed with the day's work.

Tuesday, 9th July.—Visited a hillside on the right bank of the Tay, where we had previously met with the large dragon-flies, *Cordulegaster annulatus*. On this occasion we were accompanied by Privates John and Jas. Henderson, 1st Coy., and Privates M'Currach and Glass of the 12th Coy.

The weather was dull and threatening, with occasional heavy showers, which in the afternoon turned to a persistent and heavy rain. Searched patiently for specimens, but got none until well on our return journey, when we came upon a pond. Word was then given to spread out and search carefully, with the result that many fine dragon-flies were found at rest, while numerous specimens of a beautiful beetle were found upon the flowers of a water plant. Some of these were splendidly coloured in crimson, green, blue, and gold. On the west side of the pond we came across a large nest of the wood ant, *Formica rufa*, from which we secured many specimens for our Museum, it being the first occasion on which we had met with

the species. Altogether a very successful day, notwithstanding the unfavourable weather.

One thing especially noticeable to the entomologists during the week was the scarcity of humble bees. Only one specimen of a mountain form *(Bombus cognatus)* was obtained.

Whether or not the boys learned anything of entomology during this brief holiday I do not presume to say; certain it is that their humble teacher learned something about the natural history of boys, not the least noticeable characteristic being the delightful fact that boys are certainly not specialists. No living thing escaped their notice—rabbits, squirrels, birds, fishes, frogs, &c., received a fair share of their enthusiastic attentions, every creature they could lay hands on being promptly captured and presented for identification and explanation. Forky-tails and cockroaches from the tents and cook's kitchen (and even specimens rescued from the soup itself!) were objects of unremitting attention.

The enthusiasm of the boys knew no bounds, not even the ordinary one of sleep, and here let me hint to my esteemed friend, Mr. S. T. Ellison, that, whenever he decides to make the camp of the 'Boys' Brigade his headquarters for sugaring, a willing staff of workers awaits his call to action.

There can be no doubt that intense love of nature is dominant in every boy, and it is much to be desired that something be done to extend and encourage the interest in nature manifested by the boys of the Brigade, by forming a field-club, and recognising such as a permanent feature of the camp-out of the Brigade; and in this connection I would here like to quote an extract from the *Atlantic Monthly*, entitled

TEACHING BOYS THE LOVE OF NATURE.

"One of the surest ways of acquiring an influence over rough boys is to instil into their hearts a love of nature, or rather to develop that love which is dormant in most of us. But is it not better, along with such an education, to give also lessons in self-control; to teach them to find nests, study them, and even examine the eggs, without touching them; to gather for botanical purposes only as many flowers as are really necessary, leaving some to beautify the earth and to multiply their kind; to study trees without girdling the trunks; and to hunt for frog spawn without stoning the frogs? A genuine love of nature means such sympathy with all nature's children, animal and vegetable, that the lover learns to exercise a jealous care lest they suffer at his hands. With this proviso, let the street boys go into the fields and woods; the more of them the better."

Where could we wish for a better opportunity of studying mother nature than in her own temple—the country itself?

I would humbly suggest that—if funds can be obtained—prizes be given to the boys for, say, the best collection of insects, for the best preserved insects, and so forth.

The same suggestion might be applied to other branches of Natural Science, and who knows but that the ranks of the votaries of Natural Science might be largely recruited from the Boys' Brigade? Perhaps the suggestion is worthy consideration.

The boys deserve credit for their exemplary conduct throughout. It was all that could be desired, and cruelty to the creatures themselves was only conspicuous by its absence.

XIII.—*Notes on the Nesting of British Birds.*

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

(Read 16th January, 1896.)

[The following Paper was read in order to introduce and explain a series of Lime-light Views of the Nests of Scottish Birds, photographed from Nature by Mr. G. Burn Murdoch and Mr. H. C. Munro, which were shown by Mr. R. Kidston, F.R.S.E., Stirling.—*Ed.*]

The Nesting of our Birds, although nominally belonging to the spring-tide, really begins before the winter is over, and it extends far into the summer months.

In February, when the snow is still lying deep in the Highland glens, the Ravens are seen hovering round their old homes, making estimates for repairs, while some of their race, who breed in the chalk cliffs of our southern coasts, have already laid their eggs. The Crossbill in the fir woods of the north is busy building, and the Long-eared Owl has selected an old Crow's nest or the roof of a Squirrel's draw on which to rear her young. The coveys of Partridges are dispersed, and although the birds still roost together on the ground at night, they are flushed in pairs during the day time. If, by chance, these quiet indications of the nesting season escape our notice, our near neighbours, the Rooks, always take care to remind us of its advent.

After many a grave consultation on the bare branches of their favourite trees, active operations usually take place by the first week in March, when the Rookery is a scene of great bustle and animation, and there is a business-like ring in the cawing of the birds as they fly hither and thither, carrying sticks and twigs, to repair old nests, or begin new ones.

During this month a decided movement among our home birds is observable; crowds of Lapwings come up from the sea shores and

estuaries, and scatter over the upland fields, where they pair, and make scratchings in the ground: several of these are often made before the actual site is fixed upon, and lined with a few straws for the reception of the eggs. Large flocks of Gulls also come inland and follow the plough, filling the newly turned furrow, to feed upon the worms and grubs exposed to view, and there is a continual circling of glistening wings as each bird presses forward in turn, to take the foremost place, in the long white line behind the ploughman's back. A party of Rooks is often present to share the rich banquet so opportunely provided at this time of the year, their glossy black coats contrasting strongly with the pure white and gray plumage of the Gulls. There is a marked difference in the behaviour of the two species of birds—the Gulls, especially the Black-headed variety *(Larus ridibundus)*, are very noisy, squalling and scolding each other in the air, while the Rooks feed quietly, as they walk deliberately along the furrow, without uttering a sound.

High overhead we hear the cry of the Curlews, as they fly onward to the moors, from the ooze and mud-flats of the sea-shore, where they have spent the winter, and perhaps a small flock of Oystercatchers or a pair of Redshanks hail in as they hurry past to their breeding grounds. Many birds are now choosing their mates, and terrible battles are often fought before this matter of all importance is settled.

By the end of March a few young Thrushes and Blackbirds are out of their shells, nests of Redbreasts, Hedge-Sparrows, and Wrens are finished; Ringdoves are sitting on their platforms of dead twigs, and Dippers in their domed nests in the river bank, while woodland, copse, and fields, are ringing with the musical notes of the birds.

Foreign migrants are now on the wing, and delicate birds from the palm-groves of Africa and the orange-gardens of Southern Europe are continually dropping into our woods and shrubberies, some perhaps returning to the very bush where their last year's nest is hanging in tatters on the branches.

Filled with an intense and longing desire which they can neither resist nor control, myriads of these feathered pilgrims gather together at this time of the year in southern climes, and watch and wait till at a change of the wind, at the rising of the moon, or at some sign of which we know nothing, they suddenly rise in great swarms into the air and start with outstretched necks and swiftly-beating pinions to compass a flight of thousands of miles over desert and ocean, through light and darkness and storm, to their nesting haunts. Flock after flock rush on in rapid succession, and all through April and part of May there is a continuous stream of aërial travellers steering their way with unerring precision to their several goals: some choose the haunts of men, where they are more or less known and observed, others

prefer more secluded spots, and occupy the waste places of the earth: others again, pushing farther forward, disappear into the mystery of the north, beyond the tread of human foot, and are not seen in their nesting haunts; the eggs of the Curlew-Sandpiper have never yet been found.

As the various Ocean Steamboat Companies of the world have each their recognised highways from port to port, across the vast expanse of waters, invisible to the eye, but well known to navigators; so the birds on well defined lines of their own, wing their way twice a year to and fro, eastward, westward, northward, and southward through the illimitable air.

They fly generally at a great height, far beyond the range of human vision, but sometimes in favoured spots and under favourable circumstances they are observed like grains of finest dust on the blue of the sky, and occasionally under certain atmospheric conditions they approach within earshot of the earth, and strange mysterious chatterings and faint rustlings of wings are heard as some vast aërial host is passing overhead. These sights and sounds, however, are of rare occurrence, for the great movements of the birds are, for the most part, conducted in silence and solitude, and only the results are revealed to us. A few Swallows, the first of the season, seen some morning skimming over the meadow grass, or the first note of the Chiff-chaff recorded in the naturalist's diary, is all that is known of a great wave of migration which broke upon our shores during the previous night—thus smoothly and quietly, Nature carries out her resistless laws.

"Who ever saw the earliest rose
First open her sweet breast?
Or, when the summer sun goes down
The first soft star in evening's crown
Light up her gleaming crest?"

Our home songsters, who have been singing merrily for some time, are now reinforced by the foreign minstrels, and a great chorus goes up from the woods and fields and from the willows by the river-side. The Sky-Larks floating under the great blue dome of the heavens join in the strain, and when other birds are silent, the Nightingales carry on the concert during the stilly night,

"With skirmishes and capricious passagings,
And murmurs musical, and swift jug-jug,
And one low piping sound more sweet than all,
Stirring the air with such a harmony,
That, should you close your eyes, you might almost
Forget it was not day!"

On the moorland also, the air is filled with minstrelsy of another

and wilder sort; the rippling cry of the Curlews, the musical voice of the Redshank, the calls of Golden Plover and Dunlin, and perhaps the clamour of innumerable Gulls, the drumming of Snipe, the defiant note of the cock Grouse, and the soft song of the Cuckoo; all tell the same tale, that the ground has been apportioned out and that nesting is in full force, and so the month of May passes.

If we now shift our quarters to the sea shore in the sunny days of June, we there find a different set of birds only commencing the work of incubation, which the others are bringing to completion.

The Terns are laying their eggs among the sand and shingle among the wrack and dead sea-weed washed up by the tide, and the cliffs and rocky islets, deserted all the winter, are now densely populated by sea-birds of many kinds, that drift along the dizzy precipices like a snowstorm as we pass. July is a busy month with the sea-birds, and the supply of fish and other food required to satisfy the appetites of these innumerable hosts must be prodigious. By the end of July the nesting season is practically over; it is true that some birds, which rear more than one brood in a year, continue to lay during the autumn, as for instance, fresh eggs of Wood-pigeons may be found in October, the same pair having laid in March, but these need not be taken into account. On the 1st August, the close time expires, birds are again collecting into flocks, and on the 12th the reports of guns on the moors wake up the echoes of the hills.

If we now examine the ground over which the different breeding birds distribute themselves during the spring and summer months, we cannot fail to observe that the nesting haunt of each is made dependent upon the facility of obtaining food supply for the birds themselves and for their young. Thus, Eagles and the larger Hawks generally build on ledges among rocks on mountain sides, whence an extensive view is obtained of the country over which they forage. Our woods, shrubberies, and gardens are the natural nesting resorts of Finches, Warblers, and other seed or insect-feeding birds.

The rocky coasts and sandy shores are chosen by various sea-birds and waders, which feed on fish, marine insects, and worms; while the moorland is resorted to by Grouse, Plovers, and certain Gulls. Margins of sedgy pools and river sides are the breeding places of Grebes, Moorhens, and Coots. Kingfishers build in a bank close to their fishing haunts, and Woodpeckers and Tits in holes of trees in the bark of which their insect food is found.

Birds of the Swallow tribe always take care to have easy access to their nests, from the air in which they obtain their living, and so on with the nesting haunts of all the birds, the same rule is found to apply.

As upon the food supply depends the site of the nest, so again

this nesting site must to a certain extent determine the sort of structure which is best adapted to the surroundings and most suitable to contain the eggs and shelter the young birds.

Note the light frame of dry grass suspended in the nettles, the home of the Whitethroat, and compare it with the finely-made felted nest of the Hedge-Sparrow; the one is the work of a summer visitor, the other that of a hardy resident and early breeder. See, again, that exceptionally deep cup of grass and wool woven into the stalks of the tall reeds; the wind may blow and the reeds may bend to the water's edge, but the nest of the Reed-Warbler will not upset the eggs nor overturn the young brood. The Sedge-Warbler, building on a firmer foundation, constructs a shallower nest. The Dabchick, on a floating raft of rush leaves and water plants, moored to the bank, sits on her eggs regardless of the river's rise or fall, and the Rooks, swinging aloft in their bulky nests laced into the pliant branches of the great elms, defy the stormy winds of March. That arch egg-stealer, the Magpie, probably judging others by herself, protects her own eggs with a screen of twigs and thorns, and thus all the bird architects, according to their various crafts, design their homes and modify them, if necessary, to suit their several needs.

A certain similarity may be traced in the design and construction of nests built by birds of the same species, yet all differ in a greater or less degree in their details. Nests of all the Thrush family are composed principally of grass, moss, and mud; the Song Thrush moulds the mud separately, forming a smooth cup, as a lining to the nest; while the Blackbird and others mix the mud promiscuously with the other materials and line with fine grass.

The clay-houses of the Swallow and Martin differ in exterior construction, but the warm lining of grass and feathers is common to both, and also to the little Sand Martin, who places her soft couch at the end of a long tunnel in a bank. The outward appearance of the domed nests of the Willow Wren and Wood Warbler is much the same, but the former is invariably lined with feathers, the latter with leaves.

It is curious that birds building in similar situations and exposed to the same circumstances are so different in their tastes and habits. For instance, Eagles, Buzzards, and Ravens make nests of sticks, and line them with warm materials, while Peregrine Falcons and Kestrels found breeding in the same rocks lay their eggs on the bare soil. The Wren requires a roof for her home, while the Linnet and Goldcrest, brooding in the same bush at the same time, are content with open nests.

Some birds take no care to conceal their nests, others take infinite pains to do so. The Swallows build under the eaves of our houses;

and, long before the leaves are out to hide it, the nest of the Missel Thrush is placed in the fork of a tree, close to the public road; while the unmistakable signs of the House Sparrows' homes are seen in the untidy tufts of hay hanging from the ivy wall.

On the other hand, the Willow Wren weaves her bower of dry grass close to the ground, deep down among the herbage and ferns and wildflowers, defying the eyes of all but the keenest observer to detect it; and the Chaffinch, by imitating natural surroundings, matches the exterior of her lovely nest with the lichen, moss, and bark of the tree in which it is placed. Grebes and Wild Ducks on leaving their nests cover their eggs, the former with leaves, the latter with some of the down which composes the nest-lining.

Nature seems to afford special protection to birds that breed on the ground, giving them eggs which harmonise in colour and markings with their surroundings. How beautifully concealed are the little brown eggs of the Skylark as they lie in their cup of fine grass in a hollow of the fallow field! And how difficult it is to distinguish the eggs and young of some of the Plovers and Terns from the sand and shingle on which they are placed!—there is no nest, but merely a scratching in the ground. The eggs of Sandpipers and Curlews, which are found in depressions of turf or moss, have the appearance of being laid in the same casual manner, but these birds are in reality most careful nest-builders. After selecting the site, the herbage is systematically scratched away till the bare soil is exposed, the spot is then drained and prepared before the nest-lining of perfectly matched material is introduced, and some days elapse before the nest is considered ready for the eggs; as incubation proceeds the surrounding vegetation quickly springs up, and the growing grass bends over and shelters the sitting bird.

The foregoing notes only touch the fringe of a very engrossing subject, embracing, as it does, the most important period of the life-history of birds—their movements and distribution in the springtide, the choice of nesting sites, the construction of their nests, and the rearing of their young.

In the study of this, as in that of all other branches of Natural History, we are constantly impressed with the wonderful vigour and freshness of Nature, and realize that while her changeless and irresistible laws go on continuously, yet her action is always new, and the eternal purpose is again and again revived, and is implanted afresh in every individual of created life. Thus, we find young birds with no previous knowledge building elaborate nests, corresponding in every detail to the exact patterns of that in which they themselves were brought up, and in accordance with a design handed down through the long ages.

We know also that the young of many of our foreign visitors leave our shores before their parents, and find their own way to winter quarters. What is the magic force which impels them; what the power which sustains and guides them on their first journey, through infinite space, to lands to them unknown? We may call it "instinct," or describe it by any other name we choose, but it still remains one of the great mysteries as yet unsolved by man.

XIV.—*Museum Notes: On the Nesting Birds of Perthshire and the Basin of the Tay.*

By the late Col. H. M. Drummond Hay, C.M.Z.S.

(Communicated by the President, 9th April, 1896.)

[Note.—This paper, which was the last piece of work Col. Drummond Hay undertook, has been transcribed from rough jottings, put down, apparently from time to time, in a note-book. Had he lived, the material would no doubt have been put together in more consecutive form, but it has been thought best to print it pretty much as he left it, with only such verbal alterations as were necessary to make a connected narrative. His object in preparing the paper, as explained by him to the President not many weeks before his death, was to place on record how the collection of nests in the Museum had been brought together, and also how the nests had been prepared and mounted. He was particularly anxious to guard against the possibility of any one supposing that the "surroundings" had been selected in an artificial or unscientific manner. As a matter of fact, he took infinite pains to ensure that these surroundings were in all cases scientifically accurate. —*Ed.*]

Bird Architecture is now, I am glad to find, receiving more attention than has hitherto been the case. This subject brings before us some of the greatest wonders in nature, which are only equalled in insect life. In the case of insect architecture, however, it must be borne in mind that the insect artificers are provided with special tools for the construction of their dwellings. The eggs, from the beauty and variety of their colour, have always proved to be a source of attraction, especially to our youth. How often do we see a nest ruthlessly torn down and cast aside, after its treasures have been robbed; no thought is bestowed on the time, labour, and skill of the architects, no consideration given to the love and devotion displayed in the many days of incessant toil and labour expended in anticipation for the progeny to come. If, however, the nest be carefully examined, we at once see its beauty and the wonders of its construction. It is, in fact, a perfect work of art, which cannot but call forth our extreme admiration. Consider, for instance, the great variety of nests in respect of form and the materials of which they are constructed, and

their adaptation to circumstances, whether it be for concealment or deception. All seems to have been fully considered, and the nest is so cunningly disguised that it seems a part of the tree trunk or mass of rock on which it is placed, and thus deceives the passer-by. We have only to examine the nest of the Chaffinch or that of the Golden-crested Wren to see how beautifully they are constructed of moss, wool, and various other materials, all interwoven and felted together with cobwebs, and interspersed with lichens. Take again the nest of the Long-tailed Tit, or that of the Willow Wren—both of which are domed, and equally beautifully made,—and see how artfully the entrance is concealed by a feather or a stray leaf.

Turning now to nests of a different type of construction, let us examine the nests of these veritable house masons, the Swallow and House-Martin. See how cleverly and artistically they attach their buildings to ours, seizing on some slight projection of the wall or beam for a foundation; and as the plasterer works up his plaster with hair, so do the Martin and Swallow mix the mud for their nest with fine grass and other material. The whole is then firmly cemented together with a glutinous secretion which the bird emits, care being taken that each layer is sufficiently dry before the next is added. Look again at that prince of miners, the little Sand-Martin, with what marvellous skill and dexterity it excavates the perpendicular face of a sand or gravel bank in which its future nest is to be. Mining operations are commenced by first forming a small hole, the bird clinging to the steep face, sometimes head downwards, and pegging away at the opening with closed bill, which its muscular neck enables it to do with great effect. In this way it loosens the material much in the same way as the collier does with his pick, and the loosened sand and gravel fall down below. The excavation proceeds at a slightly upward incline, which facilitates both digging operations and drainage. Should a stone or other hard substance intervene in the course of the tunnel, the passage is diverted to right or left, and thus the tunnels are not always in straight lines. Sometimes a large boulder is met with, and the work has to be begun afresh. When a sufficient depth has been attained, the hole is widened to a diameter of five or six inches. The flooring on which the scanty nest of grass and feathers is placed is kept flat, and on this six white eggs are placed.

Some birds make no nest at all, but a mere depression in the sand in which the eggs are laid, as in the case of the Ring Plover and others. Some lay in the hollow of a tree, the decomposed wood forming the nest. Others, again, such as the Horned Owl, and some of the Hawks, use a deserted nest, such as that of the Raven or Hooded Crow. The Peregrine Falcon also frequently does the same, while others of the same family, such as the Kite, Osprey, Eagle,

etc., make a large and elaborate nest. The Hobby generally chooses the deserted nest of a Crow or Magpie. Most of these are now represented in the Museum.

It was in order to bring these facts regarding the nesting habits of our native birds prominently before the student and visitor that our late lamented President, Dr. Buchanan White, soon after the opening of the original building, in 1881, conceived the idea of forming a complete series of nests in addition to the collection of birds. At that date our knowledge of the Perthshire-breeding birds was much more imperfect than it is at present. But such as it was a printed list was drawn up and sent out, craving the help of the county proprietors and their gamekeepers. In response to this appeal many nests were sent in, the first being that of a Blackbird, with five eggs, from Dr. Buchanan White. In the year 1882 sixteen nests in all were received, which formed the nucleus of the present collection. It may be of interest to record what these were, namely:—Blackbird, Chaffinch, White-Throat, Hedge-Sparrow, Garden Warbler, Bullfinch, Willow-Wren, Yellow-Hammer, House-Sparrow, Corncraik, Wren, Water Hen, Sand-Martin, Coot, Greenfinch, and Lapwing. The following year was not so productive, but in 1884 and 1885, when intimation was made as to what was required, large additions were made to the collection, and special thanks are due to Sir Robert Menzies, whose keeper, Mr. John Macdonald, from his extensive knowledge of birds and their nesting places, proved of the greatest value in collecting both birds and nests. Several of the latter were obtained through him for the first time in Perthshire, as, for example, the Greenhawk, the Goosander, the Widgeon, and the Black-throated Diver. Our Thrushes were due to Colonel Smythe of Methven, at whose hands we have received nests of the Tufted Duck and the Pochard, both of which were new to Perthshire, although their occurrence had been suspected. During these two years we were also greatly indebted to three local collectors, namely, Mr. R. H. Meldrum of Cherrybank and Messrs. S. and G. Alexander, from whom we obtained many of our rarest ground nests. I must not forget to mention also Mr. Herd of Scoonieburn and Mr. James Keay, head keeper at Murthly, both of whom have collected for us from the very beginning, and still continue to do so. The first named carried on the work under the sanction of the late and present proprietors of Moncreiffe, namely, the late Sir Thomas Moncreiffe, Bart., and Sir Robert Moncreiffe, Bart.; while Mr. Keay has worked under the sanction of the proprietors of Murthly, the late Sir Douglas Stewart, Bart., and Mr. Stewart Fotheringham. To these two collectors we are indebted for some of our best and rarest specimens, including the nests of the Night Jar and the Red-breasted Merganser, the latter

being got on the high water-shed of the Tummel. It is exceedingly rare to find this bird nesting so far inland. Another nest of the same bird was taken in Argyleshire, but still within the Tay District, by Lieut-Col. Campbell, to whom the Society is indebted for many rare and interesting nests. To the Dowager Duchess of Atholl we are indebted for the nest and eggs of the Osprey, probably the last that will ever be got in Perthshire. Our thanks are due to Mr. Atholl Macgregor of Eastwood for his exertions in securing this nest, and also for other acquisitions got in the neighbourhood of Dunkeld. I may here mention in passing that the Osprey's nest is of so great a size—being four feet in diameter—that it was found impossible to place it in the regular nest cases. Room will, however, be found for it in a case by itself in the Index Museum, while a blank label is placed where it ought to occur in the series.

As nests continued to accumulate after the first few years, it was found undesirable to stop them until such time as a good representative collection was formed. These had to be arranged temporarily in the cases in the old Museum pretty much according to size, until proper accommodation could be provided for them. When the new building was erected a great amount of care and thought were bestowed on the designing and construction of the nest cases, in order that the late Dr. Buchanan White's original idea might be properly and systematically carried out.

It was found from experience that many of the nests sent in with moss, turf, and other surroundings, soon dried up and lost their distinctive characters. When this happened it was apt to give a false impression that these dried-up surroundings formed part of the structure of the nest itself. Therefore, previous to the rearrangement of the collection, it was necessary to devise some plan whereby the natural appearance and individuality of each would be preserved. The solution of the difficulty was suggested to me by the arrangement of an Oystercatcher's nest composed of stones, set down with cement in its natural form, and enclosed in an open square box, which had been sent to the Museum some years previously by Mr. Atholl Macgregor. The idea struck me that if each nest were contained in a similar box or tray, constructed of some light wood, and concealed with the earth from the turf, so as to give it the appearance of the turf itself, the surroundings softened and spread out, and, when required, made up with a little additional moss, etc., the object might be attained. This was tried, great care being taken to use only the materials of which the surroundings were composed, the nest itself being left entirely untouched, as found, so that the whole might be as nearly as possible a copy of nature.

Having from boyhood been well acquainted with our native nests,

most of which I myself have found at one time or another, I felt quite equal to carry this out, and am glad the result has met with your approval. In some cases, such as in that of the Sheldrake inside a rabbit's burrow, the Herring Gull on the wall of the Round Tower at Loch Rannoch, the Sand-Martin, and some others, special means had to be devised to represent the natural characters of the locality and position of the nest. So also with the floating nests, which are preserved just as they were, with merely the addition of the water being represented. The nests of the Water Hen and Coot, though sometimes resting on a raft of moss or reeds, are generally to be seen floating on the water. That of the Little Grebe always occurs either among water weeds or attached, as shown in the case, to a clump of reeds. Naturally the eggs should be covered with water weeds, but as this could not be accomplished without hiding the eggs it was thought better to leave them exposed, as is sometimes the case when the bird has been suddenly disturbed, and has not had time to cover them.

The variety of bird architecture is great. Even in the same family the differences are wide. For example, the Chaffinch and the Lesser Redpole build beautiful and highly-finished nests, while that of the House Sparrow is usually clumsily constructed of straw, hay, pieces of string, worsted, or any other material he can pick up, and is lined with feathers, but these things are coarsely and carelessly put together. When he chooses a tree to build in, it is still of the same character—one of the most untidy of nests. Similar differences of character are seen among the nests of the Sylviadæ.

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XV.—*The British Abode of the Crested Titmouse.*

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

(Read 10th December, 1896.)

The bright, active family of Paridæ is represented in the British Islands by six kinds which live and breed with us: four of these are common, and probably well known to the least observant of bird observers. They are the Great Titmouse or Oxeye *(Parus major)*, a handsome bold bird, whose harsh monotonous voice, like the rasping noise of a file, is one of the signs of the coming spring; the smaller and more sombre Cole Titmouse *(Parus Britannicus)*; the brightly-tinted Blue Tit or Blue Bonnet *(Parus cæruleus)*; and the Long-tailed Titmouse *(Parus rosea)*, the vagrant of the tribe, which is periodically met with in companies of ten or a dozen, foraging along the hedgerows, or wandering through the woodlands, kept together by a shrill call-note, which is uttered by one or other of the party, as they thread their way in graceful flight through the mazy intricacies of the trees. Then there is the Marsh Titmouse *(Parus palustris)*, which is not so common, being more local in its habitat than the four above-mentioned birds; and lastly the Crested Titmouse *(Parus cristatus)*, which is more local still, its British abode being confined to one locality in Scotland, a bit of country in the valley of the Spey, where remnants of old primeval forests are still in existence; here it is by no means uncommon, but the extent of ground suited to its taste is so limited, that it may fairly be classed among our rare British Birds. The hope of seeing its nesting haunt, and at the same time visiting a district so full of interest to the naturalist as that in which the Crested Tits make their home, was a double attraction to us, and one afternoon at the end of April, we found ourselves journeying along on the Highland Railway, past wooded straths and grey misty mountains, across wide wastes of desolate, treeless moorland, and down to woods again to the quarters which we had chosen for our base of operations, a small village on the edge of a forest tract. The next morning we were early a-foot on a road which follows the course of a mountain stream, where, along both banks, white cottages with neatly fenced gardens extended in straggling lines, or nestled in groups under the shelter of pine woods.

The mark of spring was impressed on everything around us; it was seen in the blossom of the cherry trees, in the newly-burst buds of the birches, and in the wayside flowers, it was heard in the wild chorus of song-birds, and in the humming of bees, and the river, rushing down in heavy spate, brought a message from the hills that the snow was melting, and that another winter had passed away.

At the end of the village is a large sawmill, with a yard well filled with stacks of newly cut timber, and many huge logs were lying about, waiting their turn to be converted into planks.

The sandy road leading to the forest which we now entered, was deeply furrowed by the wheels of heavy timber wagons, and the sharp ring of the axe, the sound of voices, and now and then the crash of a falling tree told us that the foresters were at work, and the air was laden with the sweet perfume of bruised pine branches. With the exception of a few birch trees, rowans, and alders near the village, or fringing the streams, the forest is entirely composed of the Scotch Fir, a tree so stiff and formal in its youth, but so grand in its maturity. When fully grown its strong and graceful form makes it a pleasing contrast in any landscape, but perhaps it is seen to best advantage when standing alone, or in groups on the fringe of a moor against a background of purple hills, and when in addition the rays of a low western sun strike the upper branches and set them aglow as if with fire, a lovely picture is complete.

The trees which first met our gaze to-day were comparatively young, but they have sprung from an ancient stock, and stand upon ground which has been wild since the earliest ages—they are the representatives, through a long line of ancestors, of that great *Silva Caledonia* which once covered the greater part of Scotland.

Many records of its past glory are stored up under the turf of the highest hills, and the streams which cut their way through the peat mosses in the valleys are every day revealing roots and trunks of oaks, firs, and birches which flourished a thousand years ago. The sight of these relics gives zest to the imagination, already fired by strange tales and legends of wild men and wild beasts, the former denizens of this old wood. Through its glades once roamed the wild oxen of snowy whiteness, with manes like lions, as described by Boethius, wild boars crunched acorns under its giant oaks, and in its fastnesses the last British wolf was slain.

Vicissitudes of many kinds have passed over it: it has been swept down by storm and tempest, devastated by fires, laid low by axe and saw, and for a while everything tended to destroy it, and nothing was done in reparation till about the end of the last century, when a reaction set in and the work of restoration was begun. Millions of young trees have now been planted, existing trees preserved and cared for, and the forest bids fair to regain some of its former grandeur and to be a source of profit instead of waste.

It is seen to-day as a restored ruin, with its trees in all stages of growth, from the small seedling, struggling for light through a tangle of heather, to the hoary stump which, discarded by the axeman, and spared by the storm, is slowly crumbling into dust.

Continuing our walk, we leave the beaten track and push our way through the screen of young firs crowded together by the roadside, and, walking knee-deep through the undercovert of heather, juniper, and whortleberry, we reach an open glade, where some real monarchs of the forest are standing. These are old veterans, with trunks deeply furrowed and seamed, the survivors in the struggle for life, which now, with ample room and space, stretch out their arms freely and unrestrained in all directions, holding out their clusters of dark tufty foliage to the sky, while their lower limbs gracefully feather to the ground.

Further on, is a part of the forest which has been left undisturbed for many years. Here, thousands of well-grown trees, pruned by Nature's own devices, rise tall and symmetrical for fifty or sixty feet without a branch. In solemn majesty they stand, these numberless grey columns, with vistas between their long lines like the aisles of a great cathedral; the sunshine streaming here and there through openings in the dark-foliaged roof relieves the deep shade and illuminates the rich tones of red, orange, and purple of the boughs which arch overhead. The tread of our footsteps falls noiselessly on the thick carpet of fir needles, and beast and bird are silent, as if awed in the presence of some mysterious spirit. The great stillness is only broken by the wind in the fir branches, singing the same song of long ago, which has gone on since the world began—the song of eternity. It is always heard where the pine trees are, their sensitive needle-pointed leaves being ever ready to respond to the faintest breath of air which floats along, and so the old, old song is never quite hushed.

On emerging from the shade into the open again, we find animal life abundant; a roe-deer springs from her couch in the heather and in a few bounds vanishes from view, some blackcocks rise from a tangle of briars on the skirts of the wood, and a tree pipit trills sweetly as he falls hovering in the air before alighting on the topmost twig of a high tree.

The features of the landscape are now completely changed; we have entered a region where the forest has been cleared, and a wide expanse of moorland stretches out before us, interspersed with solitary fir trees and little groups of birches in tender green. We push on to a keeper's house which stands on the side of a hill, facing a range of mountains where the snow is still lying deep in the corries which look to the north. Here we get a magnificent view across a broad valley. The deep blue of the distant fir trees and the reddish brown of the heather make a glorious purple, and, on this April day, there are rainbows marking the course of passing showers on the hills. The whole country over which we look is one of great diver-

sity of feature—mountain, moorland, and forest, river, swamp, and tarn, are disclosed in all their natural wildness. The few houses to be seen, besides the now deserted shooting-lodge, are those of foresters, stalkers, and keepers, who for nine months of the year are almost the sole representatives of the human race in this solitude, where innumerable wild creatures, from the red-deer to the mouse, and from the eagle to the wren, find sanctuaries on the ground which is most suitable to each. We experience a delicious sensation of freedom as we stand here, far away from the hurry and bustle of life, alone with Nature, drinking in the fresh Highland air and watching the pure white clouds as they drift over us straight from the North Sea. The keeper points out from his door the position of a Golden Eagle's eyrie over in those grey hills, where the red-deer live in company with the ptarmigan, the mountain hare, and the fox; and not far off, thanks to the protection and watchful care afforded to them by the proprietor of a neighbouring forest, a pair of Ospreys yearly bring up a brood.

In this wild forest there is plenty of wreckage: numbers of old decayed trees are seen in all directions; of some nothing but the stump remains, while others retain enough of their main limbs and branches to show their noble proportions. These weird skeletons, ghosts of their former grandeur, stand out conspicuous against the dark foliage of the living trees. White and honeycombed with age, they are still so tough and hard of fibre that the only effect the wind has upon them is to blow off some crumbling dust from their barkless trunks. In holes and cavities in these old trees, owls and kestrels rear their young, and in one of them we found the eggs of a Goosander lying in a bed of soft white down. This is the abode of the Crested Tits: they build in these old decayed stumps, boring holes for themselves or adapting ready-made ones, and sometimes fitting their nests into a crevice between the bark and stem.

The first nest we found was in the latter position, and in attempting to examine it we accidentally broke away a piece of the friable bark and exposed the sitting bird to full view; she was, however, quite undaunted, and refused to move, till she was actually lifted off her eggs. She then flew to the branch of a neighbouring tree, where she was joined by her mate, and they both fluttered about within a few yards of us, scolding us well, and giving us a rare opportunity of inspecting them.

Their general plumage is of a sober hue of brown and grey; there is a well-defined black ring on a white ground round the eyes which gives them a smart appearance, further enhanced by the distinguishing feature, the speckled crest on the head, composed of

black and white feathers. Their call-note, when once learnt, is a sure sign of recognition.

The nest is a pad of the softest materials, composed almost entirely of rabbit or other fur and a few feathers, with a little moss as a foundation. We found other nests during our stay in the forest in similar kinds of stumps, the nesting hole being generally within a few feet of the ground; the birds were sitting hard, looking at us with fierce little eyes, but we had no need to disturb them, and left them to bring up their brood in peace. The eggs are of the regular Titmouse type, white with small red spots.

The Crested Tits are of a hardy nature, like all their tribe. We have found them in Switzerland in the month of March at a height of 3000 feet above the sea, when the ground was held tight in the icy grip of winter, and the boughs of the spruce firs, which attain such noble proportions in those regions, were bending under their weight of snow. They are fairly distributed over the continent of Europe, being equally at home in the pine forests of Norway and Sweden, as in the oak woods and cork groves of Spain and Southern France, and it seems strange that the little colony established in Scotland does not spread beyond the very limited area which it at present occupies. Cultivation, artificial draining, and reclamation of waste lands have driven away many birds, such as the Bustard, the Bittern, and the Black Tern, which were formerly habitual breeders in our Islands, into more and more isolated districts, until, their last abiding place being intruded upon, extermination has ensued. Other species are now passing through the same process; the Kentish Plover is almost extinct as a British nesting bird, and the Bearded Titmouse (*Panurus biarmicus*), a bird which belongs to a different family from the subject of this paper, is probably now behind his last entrenchment in the reeds of the Norfolk broads. The causes which have led to the banishment of these birds do not apply in the case of the Crested Tits, for the destruction of old forests, which perhaps at one time caused a shrinkage in their area of distribution, has been arrested, and in their present quarters they are practically unmolested, and should be increasing; why, then, do they not enlarge their sphere? There is plenty of well timbered land outside their isolated domain; their food is much the same as that taken by such cosmopolitans as the Cole Titmouse, Goldcrest and Tree Creeper, with which they associate in mutual foraging expeditions; they do not restrict themselves to pine trees, nor are they dependent on old decayed stumps for their nesting sites, one nest having been found in an iron post, and it is well known that the deserted nests of Crows, Magpies, and Squirrels are sometimes used by the Crested Tits for breeding purposes. It is possible that the old British stock may be dying out for want of new blood, but whatever

the cause may be for their exclusiveness, the fact remains that they confine themselves solely to one locality in our Islands; stray vagrants have been occasionally observed and recorded in other parts of the country, but the true home of the British Crested Titmouse is in the old primeval forest district on Speyside, with its murmuring pines and rippling streams, where the air of the mountains is scented with sweetgale, and with the resinous odour of fir branches. In this secluded region, well suited to their reserved habits, they find plenty of food all the year round, and, possessing constitutions capable of resisting any changes of temperature likely to occur in Scotland, they are independent of the causes which influence the migration of birds in general.

XVI.—*On a Banded Hornblende Schist at Balhoulan Quarry, Pitlochry.*

By Henry Coates, F.R.S.E., and Peter Macnair.

(Read 14th January, 1897.)

Amongst all the sections of hornblende schist we have examined in the southern Grampians, that in Balhoulan Quarry, near Pitlochry, is one of the most interesting. The quarry is situated about half-a-mile north-west of the village, to the east of the Highland Railway, and has evidently been worked for a considerable period, as some of the faces are old and weathered, while others are quite fresh, showing evidence of more recent working. The stone is principally used for macadamising the roads.

The study of these hornblende schists, or sheared basic rocks, has engaged considerable attention ever since the publication of Mr. Harris Teall's paper on the Scourie Dyke.* That an originally crystalline igneous rock may be made to assume the appearance of a foliated or schistose structure is now placed beyond dispute. It is to another set of phenomena presented by these sheared basic rocks we now revert, believing that the sections at Balhoulan Quarry present some tangible data for the solution of some of the problems connected therewith. We refer to the peculiarly banded structure presented by so many of these hornblende schists, this structure being particularly well seen in Balhoulan Quarry. We had previously on several occasions noted a banded structure amongst the hornblende schists of Loch Tay and Killin. Usually they presented a finely banded appearance, the bands varying from a mere line to a quarter of an

**Quart. Jour. Geol. Soc.*, Vol. XLI., p. 133 (1885).

Plate I.—General view of Balhoulan Quarry, showing Band of Sheared Grit.


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inch in thickness, and sometimes corrugated into a series of fine foldings. Mineralogically, these bands were composed of alternating layers of granular quartz and felspar, and we thought they might have been in some way referable to the crushing of the original constituents of the rock. Of course it would be difficult to conceive how such a banded structure could have been developed, by shearing, out of a homogeneous crystalline rock, and in a paper read before the Glasgow Geological Society, on the altered Basic Rocks of the Southern Highlands as exemplified by the sill of hornblende schist underlying the Loch Tay limestone,* one of the authors has sought an explanation of the problem on the supposition that such bandings might be accounted for by supposing them to represent the ultimate deformation of such porphyritic hornblende schists as are found more or less commonly amongst these rocks. That this may be the case in some instances is highly probable, but the phenomena seen at Balhoulan Quarry open up another line of inquiry which may be of some value in illustrating the theory advanced by Mr. Teall to account for the banded structures in sheared igneous rocks by supposing them to be developed out of a heterogeneous mass of crystalline igneous rock during the process of shearing and metamorphism.

It is particularly in the district of the Lizard in Cornwall that such altered igneous rocks as hornblende schist have to any extent been studied. We believe that the phenomena seen there are somewhat similar to those presented by the hornblende schists of the Scottish Highlands, and we therefore propose to cite briefly the various theories that have been advanced to account for these banded hornblende schists as seen at the Lizard.

In his original papers, and up to that published by himself and Major-General M'Mahon in 1891,† Professor Bonney maintained that the banding, and more particularly the current bedding which he described as occurring in these rocks, were only to be accounted for on the supposition that the rocks were of stratified origin, though they were probably of volcanic nature, being ejected as tuffs from a volcanic vent. In his later papers,—namely, that on the "Hornblende-schists, Gneisses, and other Crystalline Rocks of Sark"‡ and the "Serpentine, Gneissoid, and Hornblende Rocks of the Lizard District,"§—Professor Bonney withdraws from his original position in which he believed these rocks to be of pyro-clastic origin, and, while still opposing the dynamo-metamorphic theory, he advances the idea that the banding may have been caused by fluxional movement in the yet unconsolidated magma of basic igneous material.

* *Trans. Geol. Soc. of Glasgow*, Vol. X., p. 302.
† For these papers see *Quart. Jour. Geol. Soc.*
‡ *Quart. Jour. Geol. Soc.*, Vol. XLVIII., page 137.
§ *Quart. Jour. Geol. Soc.*, Vol. LII., page 21.

In a paper contributed to the *Geological Magazine* for the year 1877* by Mr. J. J. Harris Teall, on the origin of certain banded gneisses, the author advances a hypothesis to show how, under certain conditions, a crystalline igneous rock may eventually, by the ordinary processes of dynamic metamorphism, assume a perfectly banded structure. In the course of his paper he shows the *a priori* probability of his theory by an experimental illustration with coloured clays; showing that if clays of two colours be intimately mixed and then drawn out to represent the shearing process they will eventually assume much of the appearance presented by the banded hornblende schists of the Lizard. He next goes on to observe (1) that banded gneisses are on the whole identical with plutonic rocks in composition; (2) that masses of plutonic rocks are often heterogeneous; and (3) that heterogeneous masses, if such exist, may be deformed in the manner required to produce banded structures. He then discusses the igneous rocks of the Lizard and their sheared representatives. In conclusion, and with reference to the granular structure of these rocks, he says:—"It is undoubtedly true, as Professor Bonney has pointed out, that many of the rocks are largely composed of broken crystals, and may be said therefore to possess a clastic structure, if we use the term clastic in its etymological sense. But this is no proof that the fragments have been deposited as such. The original minerals may have been broken during the deformation of the rock masses. This, I believe, is what has actually taken place. The structures are of the kind for which Professor Kjerulf has proposed the term 'cataclastic'."

In a paper read before the Geological Society of London,† Major-General C. A. M'Mahon gives an account of the Hornblende schists of the Lizard district, and advances a theory to explain their origin. He also criticises the theory advanced by Mr. Teall as already cited, and opposes the view that such rocks as the banded hornblende schists of the Lizard could be produced by shearing movements. He maintains that, granted the volcanic origin of the schists, he has not been able to find any evidence showing that dynamic metamorphism has at all effected these schists, nor can he see how their banded structure could be produced by such movements. He says that not only would the regular succession and alternation of these thin bands present a serious objection to the acceptance of this explanation, but it is obvious that the shearing of a solid rock into such extremely thin layers would have developed heat sufficient to fuse the whole mass, in which case it would have lost its banded structure and assumed that of a hornblende granite. The stripes are so sharply defined and thin that several of them can

* *Geological Magazine*, 1877, p. 484.
† *Quar. Jour. Geol. Soc.*, Vol. XLV., 1889., p. 519.

Plate II.—Banded and Folded Hornblende Schist, Balhoulan Quarry.

be seen in a slice mounted on an ordinary microscopic slide. The supposition that these bands were originally thick and were drawn out into streaks of thread-like thinness by stretching is not supported by the microscopic evidence, and fails to explain how the hornblende segregated into a series of parallel zones. He further asks the question, in advancing his own theory, How has this segregation of the hornblende been produced? Accepting, to begin with, the original volcanic ash-bed origin of these rocks, he proceeds to show how, by the percolation of heated water through these ash-beds, not only the ordinary types, but the banded hornblende schists might be produced. We cannot now enter into the details of this theory, but shall only quote the conclusion he arrives at. He says :—"I suppose, then, to conclude my remarks on this branch of the subject, that the banding of the hornblende schists was produced by the capillary flow or percolation of heated water through the rocks in two ways, namely, by the leeching out of unstable minerals (such as pyroxene) from the spaces between the planes of lamination, and by the formation of comparatively stable minerals (such as hornblende) along those planes."

In a paper published in the *Quarterly Journal* for 1893, Messrs. Fox and Teall* deal with certain sections of the Lizard rocks. They there come to the conclusion that the serpentine and hornblende schists of the Lizard are part of the same igneous complex, and that the latter rocks, like the former, are undoubtedly of truly igneous origin. They do not deal with the problem of their banding, but simply state that the banding had taken place prior to their folding and corrugation.

In the neighbourhood of Pitlochry, numerous sills of hornblende schist occur, though it is in Balhoulan Quarry alone that we have been able to see the phenomena about to be described. Numerous sills of hornblende schist are also exposed along the sides of Ben Vrackie, and are seen here and there on the road leading across the hills from Pitlochry to Kirkmichael, dipping at high angles to the north-west. In the wild and romantic Pass of Killiecrankie and in the bed of the river Garry similar sills of hornblende schist also occur. Several striking examples may be seen in the bed of the river Tummel below Clunie Bridge, about half-a-mile above Pitlochry. In certain instances these hornblende schists show traces of an originally porphyritic structure, and numerous boulders of these are found in the bed of the Garry. Professor T. G. Bonney thus describes one of these in a paper on "Some Schistose Greenstones and allied Hornblende Schists from the Pennine Alps, as illustrative of the effects of Pressure Metamorphism."† In a foot-note referring to the Scottish example, he says, "Since the above paper was written I have obtained

* *Quar. Jour. Geol. Soc.*, Vol. XLIX., p. 199.
† *Quart. Jour. Geol. Soc.*, Vol. XLIX.

additional evidence from Scotland. In the Pass of Killiecrankie dioritic dykes more or less schistose are frequent, some of which present interesting resemblances to certain of these Alpine hornblende schists. The rocks can be examined *in situ* close to the Garry and occur as boulders in its channel. They are more or less foliated, evidently sometimes containing biotite, and not unfrequently red-garnet. Occasionally the former presence of a porphyritic felspar is indicated by white spots. In other parts of the same mass garnets are abundant (I have long suspected that most eclogites are diorites in which garnet has taken the place of felspar). I have examined microscopically one of the less foliated examples from a dyke above the bridge in the village and the most foliated one from a boulder. Both, especially the latter, strikingly correspond with some of the rocks described in this paper, the hornblende occurring in dark green prisms with enclosures evidently of a later date than that of the principal crushing—the biotite being newer than the hornblende and sometimes suggesting pseudomorphic replacement, and the garnets being anterior to the crushing."

We have here cited this foot-note of Professor Bonney's for the purpose of calling attention to his opinion that these rocks were originally intruded amongst the clastic rocks in the form of dykes. The great difficulty in exactly determining the true relationships of these rocks to those into which they have been intruded is owing to the amount of subsequent shearing and rolling out to which they have been subjected, so that the original relationships of the intrusive rock has been more or less obscured. Supposing they had been intruded as dykes, it is not difficult to conceive how they could be so stretched and rolled out along the line of shear as to become apparently almost included between the lines of bedding or foliation of the clastic schists. In the bed of the Garry the extreme tenuity of the masses of these hornblende schists would, we think, rather tend to favour their fissure or dyke origin. This view might well be held when we compare the size of these masses in the Garry with such an undoubted sill as that which underlies the Loch Tay limestone, and which has been estimated at five hundred feet in thickness.

The geological structure of the surrounding country is somewhat monotonous, presenting extensive zones of mica schist, quartz schist, and dark graphitic sericite-schist, the whole dipping at high angles towards the north-west. In the Pass of Killiecrankie the rocks become more arenaceous, and dip at high angles. The black graphitic schist of Ben Vrackie may probably belong to our upper argillaceous zone, and in that case it is the equivalent of similar rocks seen at Easdale, Oban, Ben Lawers, and Glenshee.*

* *Geological Magazine*, 1896, p. 167.

At Balhoulan Quarry the clastic rocks had, prior to their metamorphism, been invaded by a sill of basic lava, which had subsequently been altered in the general shearing of the rocks into a true hornblende schist. Seen in hand specimens, and in the face of the quarry, the rock is of the usual dark greyish colour, dipping at an angle of 30 deg. to the north-west. The most striking peculiarity of the rock is the presence in it of numerous bands and lenticular masses, showing to the naked eye a distinctly granular clastic structure. They vary in size from a mere line to a couple of feet in thickness, and lie more or less parallel with the shearing planes of the hornblende schist. In one instance a large lenticular mass, nearly a yard in diameter at the widest part and tapering down to a few inches near the edges, may be seen, while the more striking examples might be more strictly called bands rather than lenticular masses. They run across the face of the quarry, having an average thickness of five or six inches, and extending to about fifteen yards in length. As already remarked, in hand specimens from the larger bands and lenticular masses the original clastic structure of the enclosed rock masses in the hornblende schist can be distinctly recognised. It seems to have been a grit, or fine conglomerate, all the pebbles of which have been crushed and elongated along the line of shear. It will, of course, be understood that these conglomerate or grit masses and bands have undergone a double metamorphism,—first, that consequent upon their inclusion in the molten rock, the effect of which would probably be simply an induration of the pebbles and grains in the rock; and, secondly, the shearing or drawing out process which they would have to undergo along with the schists.

The fragmental structure is also well shown on the surface of the bands, where they come in contact with the hornblende schists, the larger pebbles standing out all over the surface in knobs. This may be accounted for by supposing that the fragments of grit and conglomerate torn from the clastic rock while the sill was being injected into it would be somewhat coarsely granular, or pebbly, on the surface, and that their enclosure in the molten lava would help to retain this character even after the period of the second metamorphism.*

In Fig. I. we have given a sketch of a hand specimen of the banded hornblende schist from Balhoulan Quarry. It will be seen that the bandings consist of lighter and darker portions of the rock alternating with one another and of bands composed of almost pure quartz and felspar. The former, marked *b* in the sketch, and measuring about ·125 in. in width, are probably referable to the

* In comparing the grit bands occurring in these hornblende schists with some of the highly mineralised grits of Dunoon, the identity of their origin is, we think, at once apparent.

shearing and segregation of the original felspar and hornblende crystals of the rock, and are characterised by the predominance of some of these two minerals, the increase of felspar causing the lighter bandings, and that of hornblende the darker ones. The pure white bands marked *a* in the sketch, and measuring from ·0625 in. to ·25 in. in width, are the finely drawn out or sheared representatives of parts of the fragmental rock caught up while the hornblende schists were in a molten state. That this is so was clearly borne out by their behaviour when being prepared for microscopic slides, for in the process of being rubbed down they separated out into large grains, just

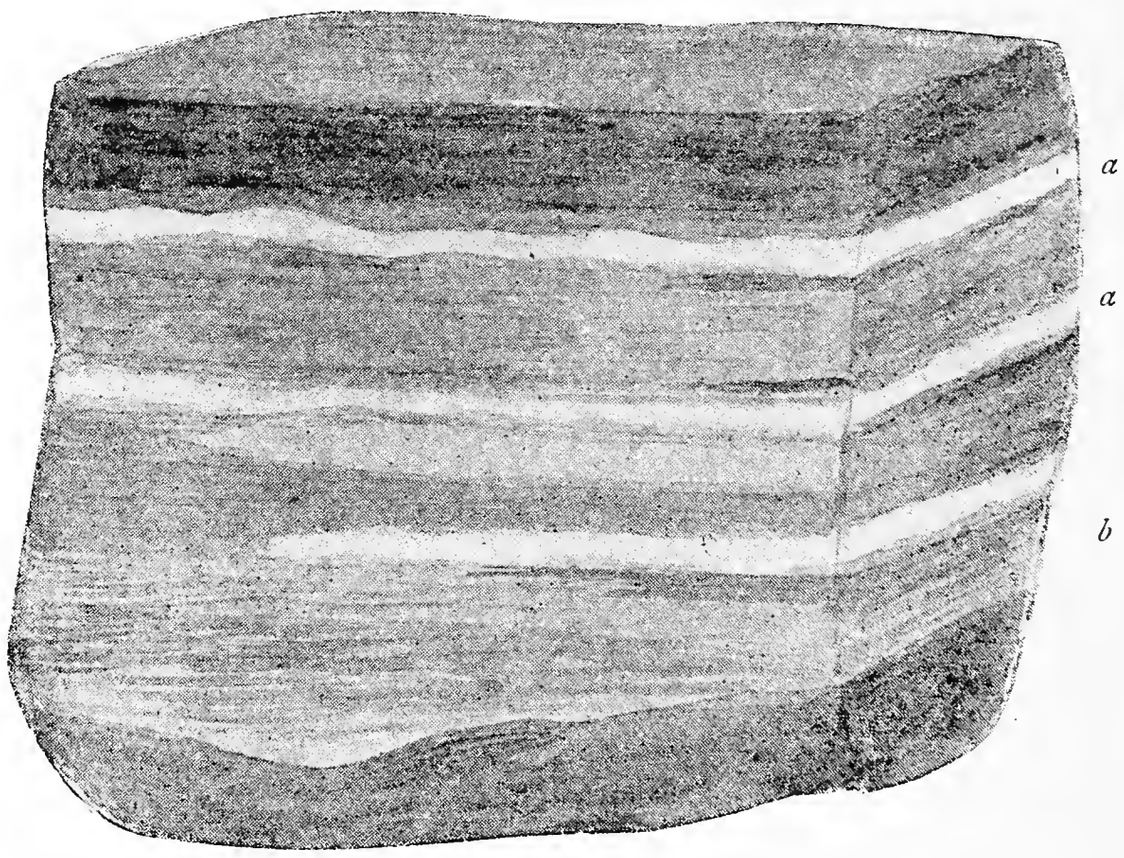

Fig. I. Hand specimen of Banded Hornblende Schist from Balhoulan Quarry.

like a clastic rock. These bands vary through all widths up to the large ones seven inches wide, shown in Plate I., and through that into large lenticular masses. These bands may often be seen to terminate suddenly, which fact also points to their original existence as inclusions in the rock mass.

We may here note in passing the peculiar phenomenon of the association of these sills of hornblende schist with bands of limestone. One of the authors has already described a striking illustration of this in the valleys of Loch Tay and Loch Earn,* and it is also common in the extensive area occupied by these hornblende schists in Argyll-

* *Trans. Geol. Soc. of Glasgow*, Vol. X., p. 302.

shire. At Balhoulan Quarry, in contact and along the sill, bands of limestone appear, and we have also detected bands of calcite in the hornblende schists occurring in a similar manner to the bands of grit and conglomerate just described. What the reason of this constant association of these two rocks may be we cannot say, nor do we believe that the data at Balhoulan Quarry are sufficient to determine it. Sir Archibald Geikie also notices this fact in his Presidential Address to the Geological Society of London for the year 1891.* Numerous foldings of the rock are to be seen in the quarry. One very large and striking example is over two feet in depth, the lines of schistosity being bent back upon each other to that extent (see Plate II.). It seems to us that the occurrence of these folds indicates that the process of shearing and metamorphism must have been the consequence of a series of intermittent forces rather than of a continuous

Fig. II. Microscopic Section of Banded Hornblende Schist from Balhoulan Quarry. X 50 Diameters.

strain, for it is difficult to conceive how the puckering and banding could both have been produced at the same time, as the banding or drawing out of the included fragmental portions of the sill must first have taken place, and the plication of these bands into folds been the result of a second application of the shearing and straining forces.

In Fig. II. we have given a drawing of the banded hornblende schist as seen under the microscope. The section has been cut at right angles to the plane of schistosity. The rock consists essentially of long prism-shaped crystals and grains of hornblende, thickly scattered through a ground mass of felspar and quartz. The latter minerals also occur in the granular form so common amongst these altered basic rocks, and which so closely simulates the frag-

* *Quar. Jour. Geol. Soc.*, Vol. XLVII., p. 76.

mental structure of an ordinary clastic rock. The accessory minerals are garnets and iron ores, the former being often so numerous as to form a large proportion of the bulk of the rock. They seem to be more numerous along the bands of felspar and quartz than along those of hornblnde, which would favour the idea that the felspar in the process of shearing may have ultimately passed into garnet. The prisms of hornblende are seen to lie with their longer axes in the direction of the shearing force, and parallel to the bandings of the rock. Where they encounter the garnets they are often seen to bend and flow round them, thus seeming to indicate that the garnets had crystallised out first.

In describing the macroscopic appearance of these rocks, we referred to two kinds of banding, one in which the grains of quartz and felspar were largely intermixed with grains and long prism-shaped crystals of hornblende, and another which seemed to be composed of fine granular quartz and felspar, without any indications of hornblende. The former type of banding we are inclined to think may simply be owing to the segregation of the hornblende along certain zones of the rock, leaving the original quartz and felspar of the rock comparatively free from hornblende. Of course, *vice versa*, the quartz and felspar would also have a tendency to segregate together into bands or zones. On the other hand, the bands which represent the fragments of the original clastic rock which were enclosed in the hornblende rock during its intrusion as a molten lava can easily be recognised by the absence of hornblende, and also by the distinctly granular or fragmental structure of these bands, both in hand and microscopic specimens.*

In Fig. II. one of these bands is shown. It is composed mainly of quartz, with a pale green secondary mica, and runs parallel to the general schistosity of the rock. Unlike the other bandings just described, it is sharply defined from the surrounding hornblende schist. The junction of the banding with the normal rock is exceedingly irregular, being similar to the larger bands previously described in the macroscopic appearance of the rock, but on a much smaller scale.

The section shown in Fig. III. is cut from one of the larger bands of grit included in the hornblende schist. The white eye-like or lenticular parts represent the original grains of quartz and felspar

* It might be supposed that all these bands were merely the result of segregation, but we are inclined to think that many of the so-called bands or veins of segregation found in the clastic schists of the Highlands are really the original quartz pebbles and boulders drawn out into long linear streaks and bands, of which we have seen several striking examples on the hillsides near the foot of Loch Eck and at Dalveich on Loch Earn.

drawn out into these forms during the second or mechanical metamorphism and shearing process to which they were subjected. The first or contact metamorphism would not probably have much influence in altering the shape of the granular constituents of the grit, but would simply indurate or fuse them together, as we see in more recent contact metamorphism, thus tending to obliterate the individuality of each grain and pebble. The difference between a grit which has undergone this double metamorphism and one which has simply been acted upon by shear and strain is easily recognisable by its more altered or mineralised condition. The dark sinuous lines seen in the drawing represent a secondary development of pale green mica around the grains and pebbles in the grit, and may probably be referred to the action of the shearing forces causing the finer argillaceous matter of the grits to pass into mica along the gliding planes of the larger grains and pebbles.

Fig. III. Microscopic Section of Grit Band in Hornblende Schist from Balhoulan Quarry. X 50 Diameters.

Let us now consider how far the theories cited at the beginning of this paper to account for the hornblende schists of the Lizard are applicable to the phenomena seen at Balhoulan Quarry. At the outset, we must put aside any theory based on the supposition that the hornblende schists of the southern Grampians (at least so far as we have seen them) were originally stratified ashbeds, thrown down in water. Such a supposition is not borne out by the phenomena presented by these rocks. Admittedly they present strong resemblances to the ordinary and undoubted clastic schists, in so far as they are curved and contorted in a similar manner, while the foliæ of felspar and hornblende might be compared with those of mica and quartz in the mica schists. Further, the felspars often show a granular structure, which might easily be taken for that of a truly clastic rock, while, to complete the deception, the foliæ and general lie of the beds

of these rocks are always more or less coincident with the main lines of plication in the Highlands. Thus on a cursory view the hypothesis advanced originally by De la Beche and Jukes, and latterly by Bonney, M'Mahon and others, that these hornblende schists were the metamorphosed equivalents of volcanic ashbeds, and that the banding and similar structures were referable to deposition in water, might seem not to be without some support. But we believe that when the whole evidence is considered it will be found to be in favour of the view that most of the hornblende schists found in the southern Grampians are of igneous origin, and it is from this standpoint we would seek to explain all the phenomena seen at Balhoulan Quarry.

Though at Balhoulan we have not been able to trace the hornblende schists to any distance beyond the quarry, yet we believe from the general appearance of the rock that, like similar sills seen in the neighbourhood of Loch Tay and Loch Earn, could it be traced for any distance it would be seen to transgress the clastic rocks, breaking across from one horizon to another. The fact that the division planes of the rock are lines of shear makes it exceedingly difficult to trace the above phenomena in a limited section such as that exposed in Balhoulan Quarry, the hornblende schists appearing deceptively to be intercalated between the bedding planes of the clastic schists.

Again, the more highly mineralised condition of the clastic rocks along the line of contact with the hornblende schists points most conclusively to the intrusive origin of the latter. Along the lines of contact at Balhoulan, between the clastic rocks and the hornblende schists, an enlarged metamorphism of the former can be distinctly traced, the bands of limestone and grit being much harder and more mineralised in comparison with those that have only suffered from regional metamorphism. The occurrence of masses of fragmental rocks included in the hornblende schists of Balhoulan Quarry is in itself sufficient to place their igneous origin beyond dispute. We think the evidence we have adduced for the fragmental origin of the banding in these rocks is conclusive, and directly points to the fact that the hornblende schist must have originally been intruded into these rocks in a molten state.

Let us now consider, in conclusion, the manner in which the banded structures in these schists have been produced. As we have already seen, the mode of occurrence and mineral structure of these hornblende schists entirely precludes the possibility of their aqueo-volcanic origin, and is strongly in favour of their intrusive igneous nature, so that the original theories of Bonney and M'Mahon regarding the banding of the Lizard schists cannot be applied to the hornblende schists of the southern Grampians, nor to the section seen at Balhoulan Quarry.

Let us now see how far the theory advanced by Mr. Teall to account for the banded structure in the gneisses of the Lizard district is applicable to the phenomena seen at Balhoulan. In the first place, he shows that gneisses are on the whole identical with plutonic rocks in composition. The same position may, as we have seen, be taken with regard to the hornblende schists of Balhoulan, as they show strong affinities to many of the basic igneous rocks. It is to Mr. Teall's second point we would, however, draw more particular attention, namely, that plutonic rocks are often heterogeneous in structure, —that is, a great intrusion of plutonic rocks may often be seen to be composed of two or more distinctly different rocks. Typical examples of these "plutonic complexes," as they have been called, may be seen in our Perthshire Highlands, as at Tomnadashan, on the south side of Loch Tay, where a mica trap and a granite are involved, and in Glen Lednock, where a granite and a diorite are also seen intimately connected. Now, though at Balhoulan we have only one igneous rock in the form of a sill, yet the heterogeneous condition is supplied, as we have seen, by the existence of large masses of the clastic rocks which had been caught up and enveloped in the lava when it was intruded into the latter in a molten state. These would be of all sizes, varying from the merest fragment up to large masses, and would, we think, be of the same value as a plutonic complex as regards supplying a heterogeneous mass for the deforming forces to operate upon. In the third place Mr. Teall, in his paper, proceeds to show how, given a heterogeneous plutonic mass, this mass may be deformed into a foliated and banded rock by the ordinary processes of regional metamorphism. Taking for granted that the two kinds of rock (the grit and the lava) were more or less thoroughly mixed when the great series of straining and shearing forces connected with the regional metamorphism of the Highlands first commenced, it would not be difficult to understand how the smaller fragments of grit would eventually be drawn out into the fine bands, while the more massive fragments would be represented by the thicker lenticular bands and masses of grit we have described. When the whole evidence is considered, we think it is only upon such an hypothesis that the section seen at Balhoulan Quarry can be explained, and we hope that in bringing the section before the notice of the Society we have contributed a not unimportant illustration of Mr. Teall's theory, and a striking example of the manner in which an originally crystalline igneous rock may be made to assume all the appearances of a clastic schist. We have also here one of those remarkable facts which are ever arising to confirm the great generalisation made by Hutton and Lyell many years ago, namely, that the forces at present operating upon the surface of the earth are sufficient to account for all the

phenomena seen in the rocks. Of all the crystalline rocks found in the Highlands, the hornblende schists seemed to most fully confirm the theory that these rocks had been precipitated from the waters of some thermal ocean during the earlier ages of the world's history. But the facts we have just brought to light tend to show that we have nowhere evidence for assuming that any of these rocks are part of the primitive crust of the earth or that they have been formed under conditions different from those with which we are acquainted.

The following is a summary of the various stages through which the hornblende schist must have passed before assuming its present appearance :—

(1) The hornblende schist must have been originally intruded into the clastic schists as a dyke or sill of basic igneous rock, at a period prior to the metamorphism of either rock.

(2) During this intrusion it caught up and enveloped large and small masses of the clastic rocks, the intrusive sill being thus converted into a heterogeneous mass.

(3) During the great period of regional metamorphism which subsequently affected the rocks, while the clastic rocks were metamorphosed into schists, the basic igneous rock was metamorphosed into a true hornblende schist, the rock undergoing the following profound chemical and structural changes :—*(a)* Chemically, the felspars passed into sausurite, while the augite became changed into hornblende. *(b)* Structurally, the original crystals of felspar became broken up into granular masses, resembling those of a clastic rock, while the crystals of augite passed into long needle-shaped prisms of hornblende. *(c)* The masses of grit and other clastic rocks included in the basic igneous rock were drawn out into bands of varying thickness, depending upon the original size of the included masses, thus giving the hornblende schist a perfectly banded structure.

XVII.—*Recent Advances in the Study of the Rocks of Highland Perthshire.*

By Peter Macnair.

(Read 8th April, 1897.)

The remarkable confirmation which the famous researches of James Nicol on the structure of the north-west Highlands received at the hands of Professor Lapworth and the officers of the Geological Survey has now become a matter of history.

Nicol's paper was originally read on 5th December, 1860, and

subsequently published in the *Quarterly Journal* of the Geological Society of London. We all know how the far-reaching conclusions which it involved were set aside by the great weight of such names as Murchison, Harkness, Ramsay, and Geikie, who opposed it in favour of a certain hypothetical succession, and how in this opposition Scottish Geology received a blow from which it was destined not to recover for a space of nearly twenty years. Professor Lapworth reawakened an interest in the study of the Highland problem, with the result we have just mentioned. This was followed by the detailed mapping by the officers of the Geological Survey, the consequence of the whole being that a new impetus was given to the study of the Highland rocks, which has continued since that time. It must be confessed, however, that little advance has been made upon the general principles laid down by Nicol both for the north-west and southern Highlands, although the unravelling of the minute details of these regions has tended in a remarkable way to confirm the broader generalisations of that famous stratigrapher, and has brought us face to face once more with many interesting problems in the structure, succession, and metamorphism of these Highland rocks, which for so long a period had been entirely neglected.

In the first part of this paper we propose to glance at those memoirs which were published by Murchison and Geikie, Harkness, Jamieson and Nicol, on the geological structure of the southern Grampians, about the years 1860-63, and to show that Nicol had already grasped the main features of the geological structure of that region, and that he maintained his views against the opposition of all the leading geologists of the day. We shall then proceed to a review of some of the more recent investigations into these rocks, which will bring us up to the present time and show us the remarkable confirmation which Nicol's work has received, alike for the southern Highlands as for the north-west. We also propose to discuss shortly the more recent advances which have been made in the study of those altered igneous rocks which, during the plication and folding of the Highland rocks, have become deformed into epidorites and hornblende schists. It will be remembered that the first important contribution to the elucidation of the origin of these rocks was made in 1885 by Mr. J. J. Harris Teall in his valuable paper "On the Metamorphosis of Dolerite into Hornblende Schist as displayed in a Dyke near Scourie in Sutherlandshire," and we propose to see how far these principles may be applied to the altered basic igneous rocks of Highland Perthshire. Lastly, we intend to give an account of the more recent researches which have been made into those igneous complexes distributed here and there through the southern Grampians, and the peculiar metamorphic phenomena seen in the neighbourhood

of these great intrusions. It will be seen that here also many of the more recent views regarding the structure and origin of these plutonic rocks had already been anticipated in some form or other, and more especially that which now regards the two extreme types of acid and basic rocks found so intimately associated with one another as having been differentiated out from the same magma. It will be unnecessary for us to refer to any of the material written on the structure of the Perthshire Highlands during the period preceding the publication of Murchison, Geikie, Harkness, and Nicol's papers of 1860-63, for with the contributions of these authors the real study of the Highland problem, as we now know it, may be said to have commenced.

In their papers on the altered rocks of the Islands and north-west and central Highlands of Scotland, published 1860, Murchison and Geikie[1] describe certain sections along the margin of the southern Grampians, with reference to the supposed succession of the rocks in the north-west. Briefly put, it was believed that the southern and central Highlands were overlaid by a great series of quartzites, limestones, and schists, the representatives of those found in the north-west of Sutherlandshire, and that they always occupied the same relative positions to one another—namely, the quartzites at the base, these followed by the limestones, and the whole overlaid by the schists. Let us now glance at the manner in which these authors read this supposed succession into the rocks of Highland Perthshire. In their description of the area between Tyndrum and the head of Loch Tay, Murchison and Geikie refer the higher reaches of Glen Dochart to the so-called upper schistose group, while the quartzose group is ushered in near the bottom of the Glen along with the limestones. A similar structure was supposed to exist in the case of Loch Tay and Ben Lawers, the limestone exposed along the base of the latter mountain and both sides of Loch Tay marking the division line between the upper schistose series and the lower quartzose group. From the following sentences we would infer that the authors did not look upon the Loch Earn and Loch Tay limestone as being upon the same horizon, and it also appears that they did not quite understand the relationship of the limestone band towards the south. "We are not aware," they say, "how far the limestones stretch towards the south-west. Those of Lochearnhead appear to belong to another arch. Towards the north-east of Loch Tay they are soon lost, but reappear in the valley of the Tummel at Pitlochry."

In their description of a cross section from Loch Tay to Loch Rannoch, a succession similar to the foregoing was there supposed to be traceable, the schistose rocks around Kenmore being referable to their upper group, while the quartzites of Schiehallion were

supposed to underlie these schists, and, with its limestones, to represent their lower group. Passing now to their next traverse, namely, that from Dalnacardoch to Blair-Atholl, a great series of quartz rocks in an ascending order is described, terminating in the superposition of a very thick limestone series, two miles and a half from Blair. We quote the authors' own words in description of the Blair-Atholl region:—"In examining the south-western flanks of the Grampian chain near Blair-Atholl it was indeed quite manifest, judging even from the flaggy and schistose characters of the rocks, that we were already among strata superior at all events to the lower quartz rock and limestones of the north-west Glossy Shillat, while micaceous schists, resting upon granular quartz rocks and limestones, and even alternating with them, presented to the eye a mineral development unknown in the lower members of the altered silurian rocks of the north-west, and wholly unlike anything in the Cambrian rocks and fundamental gneiss of the outer Hebrides and the west coast of Sutherland."

In concluding our review of these authors' sections describing the relationship of the schists and quartzites of the southern Grampians, we would here notice their description of a traverse from the Spittal of Glenshee to Blairgowrie and from Blair-Atholl to Dunkeld. In the former of these we pass across a complete series of the rocks forming the southern Grampians, and as Nicol subsequently described the same section, it will be of some value to compare Murchison and Geikie's work with that of Nicol. It is not very clear in Geikie and Murchison's paper what they consider to be the exact relationships of the black schists of the Spittal of Glenshee and the quartzites of Ben-y-Ghloe to the mica-schists, quartz-schists, clay-slates, and greywackes along the margin of the Grampians, as seen to the north of Blairgowrie. But it is likely that they looked upon the Ben-y-Ghloe quartzite as underlying these other rocks in a similar way to the quartzite of Schiehallion and the region north of Blair-Atholl.

The same remarks may be made regarding their description of the ground between Blair-Atholl and Dunkeld. It is here again difficult to discover what Murchison and Geikie exactly refer to their lower quartzose group, and what to their upper schistose group. The rocks around Dunkeld, consisting principally of schists, grits, and clay-slates, are referred to their upper schistose series, and thus the whole problem of these marginal rocks seems to have been evaded.

It is unnecessary that we should enter into any further description of these sections, for what we have already given is sufficient to show that the main contention of these authors was that in the Southern Grampians we have a great series of quartzites overlaid by limestones

and schists. How thoroughly the true structure of the southern Grampians escaped their notice, and how much they were under the influence of this preconceived succession, will be better understood when we come to consider Nicol's paper, which was published shortly afterwards. Mention may here simply be made of the paper by Harkness[2] on the structure of the Southern Highlands, as it follows much the same lines as that of Murchison and Geikie, adopting as he did their theory of succession. In all his sections, including those from Callander to Loch Earn, from Loch Earn to Loch Tay, from Loch Tay to Glenlyon, and from Dunkeld to Blair-Atholl and Ben-y-Ghloe, he recognises the same succession of quartzites and limestones, overlaid by a great series of schists.

We now proceed to examine the famous paper of James Nicol,[3] published in 1863, on the Geological Structure of the Southern Grampians. Geikie, Murchison, and Harkness, as we have already seen, had published their papers, which were based on a hypothetical succession supposed to have been discovered in the north-west of Sutherlandshire. Nicol, however, was free and untrammelled by any such theory, if we except, perhaps, a tendency towards the Wernerian doctrine of the succession of the crystalline rocks. At the outset of his paper, he states the object of it, which was to examine the relations to each other of each of the three great formations,—the clay-slate, the mica-slate, and the gneiss,—which, with some subordinate groups, such as quartz-rock and the chlorite series of Macculloch, had hitherto been regarded as composing the chief stratified masses in the Scottish Highlands. Nicol's method was to begin at the south-west end of the Grampians, and, proceeding towards the north-east, he made a series of sections at different points across the Highlands from the verge where they abut against the Old Red Sandstone, explaining their principal mineral and stratigraphical features, and comparing with one another the results arrived at in the various sections. He first of all notes the position of the clay-slates in the Island of Bute, showing that they dip towards the south-east at angles varying from 20 deg. to 60 deg., and appear to be overlaid by the mica-schists of the interior. In his next section, that of Loch Long and the Gareloch, he notes a similar dip of the clay-slates towards the south-east at Roseneath at an angle of 40 deg., these in their turn being conformably overlaid by the mica-schists and greywackes.

Passing now still further towards the east, the next locality which he describes is that from Ben Lomond to Balloch. In this section he again notes the occurrence of the clay-slates, greywackes, and mica-schists, the whole series being apparently conformable, and dipping at high angles towards the south-east. He makes the following

remarks upon this group:—"In this section, though the beds dip at much higher angles, the relation of the formations is still the same as on the Gareloch. The mica-slates dipping south are covered by an upper group of blue and green clay-slates and greywackes. The two formations also appear to be conformable, and the direction of the beds varies little from east and west by compass."

The next section is in Perthshire, namely at Callander and the Pass of Leny. Here again a similar series of rocks to that seen in the Ben Lomond section is described, but with this important difference, that they are now seen all to dip inwards upon the mountain chain. A detailed account is given in his paper, with exceedingly accurate measurements of the dip, of the beds of clay-slate, grits, greywackes, limestones and mica-schists of Callander, the Pass of Leny, and Ben Ledi, and they are all shown to dip towards the north-west at greatly varying angles. With regard to this reversal of the dip he makes the following remarks:—"The first general impression is that there is here a continuous series of beds dipping regularly to the north, the one below the other; in that case the greywackes to the south would be the lowest and oldest deposit, followed by clay-slate, and this by mica-slate, as the upper and newest formation. This is, of course, exactly the opposite order from that noted in the former sections, and cannot therefore be adopted without some consideration."

The next localities with which Nicol deals are those of Comrie, Strathearn, Loch Earn, Loch Tay, Dunkeld, and Blairgowrie. It is entirely unnecessary that we should here enter into a detailed account of his description of these sections. It will be sufficient for our purpose merely to indicate their larger features, and to show how this influenced his conclusion regarding the structure of the southern Grampians. At Comrie he notes the occurrence of greywackes and clay-slates exposed in the gorge of the Lednock, and gives their dip as averaging about 70 deg. north, 10 deg. west. He, however, afterwards refers these divisional planes to foliation, and not to planes of deposition, and he also believed that there is an uncomformity between the clay-slates and mica-schists at this point. At Dunkeld and Blairgowrie he shows that the clay-slates and greywackes dip towards the north-west, and thus apparently under the main mass of the Grampians, which dip they retain onwards through the eastern Grampians to Stonehaven.

Passing now to a consideration of the general relationship of the clay-slates and mica-schists along the margin of the Highlands, as seen in these sections just described, he shows that in Bute and the Gareloch both the clay-slates and mica-schists dip to the south-east and are evidently perfectly conformable. At Loch Lomond he shows

that both formations are nearly vertical, but have still a southerly dip. At Callander a reversal of the dip is noted, and now both formations dip to the north, which would make the mica-schists overlie the clay-slates. At Comrie he says they are unconformable, while at Dunkeld, Blairgowrie, and onwards towards the east, they are seen to dip inwards upon the mountain chain. Thus, in the eastern part of the mountain chain the clay-slates, grits, greywackes and mica-slates seem all to dip towards the north, so that the mica-slates are upon the higher horizon, while at the western end of the chain all these rocks, which show every evidence of being physically the same series, dip outwards from the mountain chain and towards the south, the consequence being that the clay-slates must be looked upon as occupying the higher horizon. The following is in his own words the conclusion which he arrives at:—"The analogy of other localities leads us to believe that the clay-slate is the higher and newer formation, and the lower inclination and more regular dip of the beds in Bute and on the Gareloch confirm the view that the strata are there in their normal position. The reversed position, therefore, seen at Callander and other points to the north-east, must be abnormal." He then proceeds to show how this reversal of the beds has been accomplished, but this we will pass over in the meantime.

We now come to a consideration of those sections which deal with the relationships of the central gneiss and quartzites to the mica-schists. Nicol mentions that as far back as the Leeds meeting of the British Association in 1858 he held that the great central formation of gneiss, quartzite, and limestone of the southern Grampians must overlie and be younger than the mica-schists. In a footnote he refers to the recently-published map of Murchison and Geikie, as also showing that the gneiss, quartzites, and limestones of Glen Lyon, Blair-Atholl, Schiehallion, and Ben-y-Ghloe belong to a lower horizon.

The first section with which he deals is that of Tyndrum and the Blackmount, in which, tracing the schists from the head of Loch Tay to Crianlarich, he shows that they dip at low angles towards the north-west. After passing Crianlarich the dip is reversed, and he says that at this point there is probably a syncline. Proceeding farther up the Glen towards Tyndrum, the mica-schists and limestone are seen to dip towards the south-east. From this point, along the road leading to Kingshouse and Glencoe, the schists are seen to roll over and pass upwards into the quartzites and gneiss of the Blackmount. He further says:—"This section left no doubt on my mind that the gneiss forming the great central region of the Blackmount overlies the mica-slate of Tyndrum and Loch Tay," and thus, as stated, is a newer formation.

The next section in which he traces the relationship of the gneiss and quartzites to the mica-schist is that of Glenshee and Braemar, also partly in Perthshire. We may here note, however, in passing, that he believed the same relationship to exist in the Valley of the Tay and its tributaries, though he had not been able to examine them for some time. The greater part of Glenshee, he states, lies in the mica-slates, these beds showing a general inclination to the north. North of the Spittal of Glenshee he indicates a band of black carbonaceous shale dipping towards the north-west, and therefore conformable upon the mica-schists of the lower part of the valley, and compares it with the shales of Easdale and Oban. He also appeals to this bed as indicating the true position of these shales above the mica-schists. Proceeding up Glenbeg to the foot of the Cairnwell he indicates the existence of a bed of limestone still dipping to the north-west and overlaid by beds of gneiss and quartzite, and in his remarks upon this section says:—"There is no doubt that the great formation of gneiss, limestone, and quartzite rests on the mica-slate of the southern Grampians, and is thus a newer formation. I have also no doubt that it is a continuous portion of the same great gneiss and quartzite formation which we have seen in the Breadalbane Highlands overlying the mica-slate of Loch Tay and Glen Dochart."

We need not follow the remaining part of this able paper, relating to the sections in the western Highlands. Enough has been given to enable us to perceive Nicol's general views upon the structure of the southern Grampians. *First*, that along the margin of the Grampians we have a series of grits, greywackes, and clay-slates lying in their normal position on the south-western part of the chain, but evidently being infraposed by faulting and a reversal of the beds along the north-eastern part of the chain; the clay-slates thus appearing to dip under the mica-schists as seen along the margin of the Perthshire Highlands. And *second*, that these mica-schists were overlaid by the quartzites, limestones and gneisses of the central Highlands.

Let us now compare the conclusions arrived at by Murchison and Geikie with those of Nicol. As we have pointed out, the main contention of Murchison and Geikie was that the schistose rocks of the southern Grampians were always superinduced upon the limestone, quartzite, and gneiss. We have shown that Nicol, in his paper, maintained that the quartzites of Ben-y-Ghloe, Glen Lyon, and Blair-Atholl actually occupied a higher horizon than the mica-schists. We have already noted how thoroughly the structure of the marginal parts of the southern Grampians escaped the notice of Murchison and Geikie, and in the following part of this paper we propose to show how the more recent researches upon the structure and succession of the rocks of this region have tended to confirm the views of Nicol.

Who can but admire the scientific skill displayed by Nicol in his attempt to solve the structure of the southern Grampians? First, in the method he adopted in choosing his sections; second, in the faithful descriptions which he gave of these sections; and lastly, in the masterly manner in which he compared them together and arrived at his conclusions as to their true structure.

We have dealt somewhat in detail with the contemporaneous work of Murchison, Geikie, and Nicol, and we have done so chiefly in order that justice may be done to the latter observer from the platform of this Society, which has for one of its ends the unravelling of this complicated problem of the structure of the Perthshire Highlands.

Undoubtedly Nicol's work in Perthshire was overshadowed by the magnificence of his discoveries in the north-west; but it would ill become us, even though now so late in the day, to allow it to be passed over in silence. None but those who have wandered amongst those lonely mountains, despairing of ever being able to wring from them the deeper secrets of their age and history, can realise the full depth and meaning of the words which Nicol used in reference to the opposition which his work received. In the preface to his Geology and Scenery of the North of Scotland, for example, he says:—"I would gladly have abstained introducing any controversial matter into these lectures, and been content with stating simply my own views, leaving time and the unchanging mountains to confirm or refute them." Again, when speaking of the supposed succession in the north-west, he says:—"Again and again proofs of conformable upward succession have been adduced. Again, and yet again I have traversed these wild mountains, and one and all have vanished on closer inspection." I have often thought that there is a close parallel between this man Nicol's life-work and that of the old grammarian celebrated in Browning's immortal poem. With what peculiar fitness might such a funeral as was his, have been that of Nicol, and with what force of truth might these lines have been written for his epitaph—

"Here—here's his place, where meteors shoot, clouds form,
"Lightnings are loosened,
"Stars come and go; let joy break with the storm,
"Peace let the dew send:
"Lofty designs must close in like effects.
"Loftily lying,
"Leave him still loftier than the world suspects,
"Living and dying."

We now proceed to a consideration of some of the more recent advances which have been made in the study of the structure and

succession of the altered clastic rocks of the Highlands. In a summary of the Rocks of Highland Perthshire, read by Mr. H. Coates and myself[4] before this Society in January, 1891, we gave an account of what we supposed to be the order and succession of these rocks as seen in Perthshire. In that paper we placed at the top the great arenaceous series of Schiehallion, Blair-Atholl, and Ben-y-Ghloe; then the mica-schists and quartz-schists of Ben Lawers and Loch Tay, with their limestones, and, below these, the arenaceous and argillaceous groups of the marginal Highlands. Subsequently, but in the same year (1891), in his Presidential Address to the Geological Society of London, Sir Archibald Geikie,[5] as the result of the work of the Geological Survey, arranged the altered rocks of Highland Perthshire in the following descending order :—

17. Dark schist, calcareous schist, and limestone (Blair-Atholl).
16. Quartzite (Ben-y-Ghloe, Schiehallion).
15. Graphite schist.
14. Calcareous sericite schist.
13. Sericite schist with bands of quartzite (Canlochan, Glen Isla).
12. Garnetiferous mica-schist and schistose pebbly grits.
11. Limestone (Loch Tay).
10. Garnetiferous mica-schist and schistose grits.
9. Upper group of "green schists."
8. Garnetiferous mica-schists and schistose grits with pebbly bands.
7. Lower group of "green schists."
6. Thick group of massive grits, often abundantly pebbly, with partings of mica-schist phyllite (Trossachs, Ben Ledi, Ben Vorlich, etc.).
5. Schists and shales, with occasional bands of pebbly grit (Loch Achray).
4. Band of conglomerate, with pebbles as large as a pigeon's egg (ridge between Lochs Achray and Ard).
3. Pale green, grey, and blue slates, with purple and red shales and bands of sandy flags (Aberfoyle).
2. Pebbly rusty-coloured greywacke and grit (Pass of Leny).
1. Black shales and flags, with lenticular bands of limestone seen against the great fault at Callander.

The above is supposed to be a perfectly conformable series, the highest member, the dark calcareous schists of Blair-Atholl, being placed at the top, while the black shales and limestones of Kilmahog,

in the Pass of Leny, are placed at the exposed base of the whole series. With reference to the structure of the ground Sir A. Geikie remarks:—"Over many square miles the angles of inclination are low and the successive bands may be traced from hill to hill, across strath and glen, forming escarpments along the slopes and outlines on the summits, precisely as gently undulating beds of sandstone and limestone may be seen to do in the dales of Yorkshire." In this address he proposes the term Dalradian for these rocks, to include the whole region lying to the south-east of the great glen, and the north of Ireland.

In his Geological Map of Scotland, published 1892, Sir A. Geikie gives some of the results of the differentiation of these rocks by the officers of the Geological Survey, the principal additions in the map being the bands of graphite schist and sericite schist seen along the higher ridges of Loch Tay, and extending from Loch Fyne, in the west, into the eastern Highlands. The occurrence of two large faults is also marked; the one extending from Aberfoyle through Loch Lubnaig and Loch Tay and onwards through the higher reaches of Glen Tilt; the other running in a parallel direction from Luib, in the valley of Glen Dochart, through Glen Lochay, above the falls, and onwards into the eastern Highlands. This map serves to illustrate the succession given in the Presidential Address of 1891, the lower grits and greywackes being succeeded to the north by the mica-schists and limestones of Loch Tay, and these again in their turn being overlaid by the sericite and graphite schist bands of Tyndrum, Craig-na-Challeich, Ben Lawers, and Ben Vrackie, while the whole is overlaid by the quartzites and grits of Glen Lyon, Schiehallion, Blair-Atholl, etc.

The next reference to these rocks which we have to note is that of Sir A. Geikie[7] in the last edition of his Text Book of Geology, published in 1893, where he says:—"It is deserving of remark that the rocks along the southern margin of the Highlands are for the most part so little affected as closely to resemble portions of the unaltered Silurian series of the south of Scotland, and that they dip towards the mountains, becoming more foliated as they recede from the lowlands." He also here mentions the discovery by Mr. Peach of *radiolaria* in the cherts found associated with the graphite schist of the southern margin of the Highlands.

In a paper by myself,[8] published in the *Geological Magazine* for last year, I have arranged the clastic rocks of the southern Grampians in the following zones, according to their larger lithological features:—

TABLE OF THE ALTERED CLASTIC ROCKS OF THE SOUTHERN HIGHLANDS OF SCOTLAND.

ZONE.	ROCKS.	LOCALITIES.
Upper Arenaceous Zone.	Limestones. Quartzites.	Glen Tilt, Blair-Atholl. Glenlyon, Schiehallion, Ben-y-Ghloe.
Upper Argillaceous Zone.	Graphite Schist. Sericite Schist. Quartzites and Greywackes, with Annelid Tubes.	Ben Lawers, Glenshee. Loch Fyne, Ridge north of Loch Tay. Craig na Chailleich, Ben Lawers, Killin.
Middle Arenaceous Zone.	Garnetiferous Quartz-schists and Mica-schists, with bands of Grit and Conglomerate.	Loch Tay, Loch Earn, Glen Dochart, Balquhidder.
Loch Tay Limestone Zone.	Pure Limestone and Micaceous Limestone.	Loch Tay, Loch Earn, Glen Dochart, Ashintully.
Middle Arenaceous Zone.	Garnetiferous Quartz-schists and Mica-schists with bands of Grit and Conglomerate.	Loch Tay, Loch Earn, Glen Dochart, Balquhidder.
Lower Arenaceous Zone.	Massive Grits and Conglomerates. Grits, Greywackes, and Quartzites.	Ben Ledi, Ben Vorlich. Pass of Leny, Glen Lednock, Forneth.
Lower Argillaceous Zone.	Clay-slates and Phyllites. Limestone. Graphite Shale, Red and Purple Shale.	Aberfoyle, Loch Lubnaig, Pass of Kilmahog, Pass of Leny. [Leny. Kilmahog, Pass of Leny.

In the paper just referred to, the principal lithological features and the geographical distribution of each zone are first given, and then a series of sections illustrating the structure and succession of these rocks as seen in Highland Perthshire. I may here mention that, at the time the paper was written, I was under the impression that Mr. Peach's discovery of *radiolaria* amongst the cherts of the southern Grampians in association with black graphitic shales referred to my upper argillaceous group, and I concluded that there might be a succession from the quartzites with annelid tubes (possibly on the same horizon as those of the north-west of Scotland) up into those black schists and shales of Arenig age. Since then I have learned that this bed was found in my lower argillaceous series, namely, in the lower reaches of the valley of the Esk, and consequently such a succession has to be abandoned, unless the theory to be afterwards given should prove to be correct.

It will be recollected that at the outset of this paper, when dealing with Nicol's theory of the structure of the southern Grampians and the relationship of the clay-slates to the mica-schists, we showed that Nicol believed that along the margin of Highland Perthshire the clay-slates occupied an abnormal position. His theory was that they did not really underlie the mica-schists, but that the latter are the older rocks, which have been pushed and faulted over the clay-slates. Now we find Sir A. Geikie, in his later Government Reports,[9] reverting to this old theory of Nicol's, and receding in part from the position taken up in his Presidential Address of 1891, and the succession there published. We quote from his Report of last year (1896):—"In my Report for 1893 reference was made to a belt of rock, not improbably of Lower Silurian age, interposed along the Highland border between the schists on the one hand and the fault that brings down the Old Red Sandstone on the other. Mr. Clough was instructed to resume the examination of this belt between Aberfoyle and Loch Lomond. Notwithstanding his detailed mapping, to which reference has already been made, we are still unable to form a definite conclusion as to the structure of this difficult piece of ground. Mr. Clough is on the whole inclined to believe that between the black shales and cherts, which may be Lower Silurian, and Aberfoyle grits which lie immediately to the north of them, and form apparently a continuous portion of the Highland rocks, there are indications of a discordance or stratigraphical break." It is, however, admitted in this Report that a great difficulty arises in the attempt to fix any line of demarcation between these supposed younger rocks and the grits and phyllites presumably belonging to the Highland rocks. It is also admitted that these grits are no more altered than the shales and cherts of the supposed younger rocks; while, further, it is often observed that the shales, phyllites, cherts, and grits are so much interbedded as to point to the conclusion that they form one stratigraphical group. Again, to quote from the Report:—"The obscurity of this boundary line has suggested the inquiry whether the Aberfoyle grits should not be grouped with the black shales and cherts as probably also of Lower Silurian age. But this explanation would only shift the difficulty farther north, for we would still have to find somewhere a southern line of demarcation for the schistose rocks of the Highlands. Certainly, so far as detailed investigation has yet gone, no such line is to be found between the Trossachs and Aberfoyle." It seems to us that these views are nothing more than a resuscitation of the old theory advanced by Nicol many years ago to account for the position of these less altered rocks along the margin of the Grampians.

In the Government Report for 1897 Sir A. Geikie states that Mr. Barrow has been enabled to distinguish a series of unaltered rocks

along the marginal Highlands of Kincardineshire by a microscopic examination of their micas. In the slates and phyllites belonging to the crystalline rocks of the Highlands the micas show evidence of re-crystallisation, while in the unaltered band of supposed Silurian age they still retain their original clastic appearance. Referring in the same Report to the work of Mr. Clough at Callander, Sir A. Geikie says they are still unable to come to any conclusion which will enable them to separate out the presumably Lower Silurian rocks from the phyllites and grits of the marginal Highlands, for similar reasons to those which we have already cited in our extracts from last year's Report.

Last summer we had an opportunity of re-examining these rocks at the following localities,—Bridge of Cally, Dunkeld, Callander, Aberfoyle, and Dunoon,—for the purpose of seeing how far these later views of the Survey could be maintained. We think that there can be no doubt that the whole of this marginal belt of grits, greywackes, and slates, extending from Stonehaven on the north-east to the Firth of Clyde on the south-west, belongs to the same group of rocks. The dominant north-east and south-west strike of the rocks forming the southern Grampians is one of their most characteristic features. Local variations in the strike undoubtedly occur, but, when we consider the extreme plication and twisting to which these rocks have been subjected, this is not to be wondered at. A comparison of the lithological characters of the rocks at different localities along the margin of the Highlands also points to their all belonging to the same group or horizon, though at some points they show evidence of more extreme metamorphism than at others. Thus at Bridge of Cally, Dunkeld, and Callander they appear to be less altered than at Dunoon and elsewhere on the Firth of Clyde, where the slates pass into true phyllites and the grits become more mineralised. We also think there can be no doubt, from what we have seen, that the grits, slates, and phyllites are conformably interstratified with each other, and belong to one stratigraphical group. At Dunkeld and Birnam, in the quarries, this interbedding of the arenaceous and argillaceous types is well seen. To the north they pass upwards into the arenaceous group, as seen to the north of the Loch of the Lows, while to the south, as at Forneth, this areno-argillaceous zone passes downwards into beds of pure grit. Again, at Callander and Aberfoyle a similar lithological succession may be seen, namely, shales with bands of grit passing both upwards and downwards into pure grits.

We now pass on to consider briefly the structure of this marginal belt of grits, greywackes, and phyllites, and the problem of their relationship to the more crystalline rocks. In Perthshire and the

north-eastern Grampians, as was long ago pointed out by Nicol, these rocks have a dominant north-west dip, and seem to pass under the mica-schists, quartz-schists, and limestones of Loch Tay, which again pass upwards into the quartzites of Schiehallion and Glen Lyon. Sir A Geikie, in his Presidential Address to the Geological Society for 1891, already cited, notes the remarkable lowness of the dips in this region and also adopts the view that these slates, phyllites, and grits pass under and are older than the more crystalline rocks lying farther to the north. So far as we have been enabled to observe, there is no evidence of any stratigraphical break or overthrust between the quartz-schists and mica-schists of Loch Tay on the one hand, and the grits, shales, and phyllites of Callander, the Pass of Leny, Crieff, Comrie, and Dunkeld on the other. On tracing these rocks, however, towards the south-west, as was also shown by Nicol, the dips become gradually higher and higher towards the extreme south-western boundary of Perthshire, as at Aberfoyle. They have still, however, a north-westerly dip at this point, evidently passing under the limestones and schists of Glen Dochart, and thus bearing the same relationship to these schists as was seen to hold good in the last locality. On reaching Loch Lomond they become vertical, and from this point, along the shores of the Firth of Clyde, the dip is reversed, it now being towards the south-east, as at Dunoon and along the shores of Cowal, and thus they now, apparently, overlie the rocks forming the interior of the Highlands. The relationship of this marginal belt of grits, greywackes, and phyllites to the main mass of the Grampians, and its structure, may be seen in the section from Kirn to the head of Loch Eck. Along the shores of Cowal these rocks are seen to dip, at angles varying from 40 to 70 degrees, to the south-east. Near Kirn pier, a series of beds of phyllites, greywackes, and black slates are seen interbedded with bands of limestone. Continuing the section up the Holy Loch, a great series of beds of lustrous phyllites, still dipping towards the south-east, may be observed. Near the head of the Holy Loch, they pass upwards into a more arenaceous group of grits and greywackes, having at this point a dip of 55 deg. to the south-east. Proceeding up Loch Eck some fine sections of these arenaceous rocks may be seen, evidently greatly disturbed, but still dipping towards the south-east.

We have already shown how Nicol was confronted with the problem of the relationships of these rocks, and how he decided in favour of the slates and phyllites being the younger rocks. He also believed that they were in their normal position, relative to the mica-schists of the interior, along the Firth of Clyde, while in the north-east, as in Perthshire, they had been faulted against these schists and

were there made to appear as if they were older than the schists of the interior. Taking this marginal group of arenaceous and argillaceous rocks as a whole we are still inclined to think that in Perthshire we find these rocks in their normal position, and that there is there a perfectly conformable upward succession as shown in the tables already referred to, prepared by Sir A. Geikie and ourselves. Towards the north-east of the mountain chain, as in Perthshire, the north-west dip of the beds of phyllites, slates, grits, and greywackes indicates that these rocks form the southern limb of a deep synclinal trough. Traced inwards towards the north-west, they are seen to pass upwards into the quartz and mica-schists and limestones of Loch Tay and Ben Lawers, which rise to form the northern limb of the syncline. From a comparison of the dips it seems that the southern limb of the syncline formed by the phyllites and grits abutting against the great fault is much steeper than the northern limb, and, so far as we can see at present, it seems to us that in tracing this southern limb from north-east to south-west across the mountain chain it gradually becomes steeper and steeper till it folds over and eventually, in the Firth of Clyde and Cowal district, is made to appear as if it overlay the higher group of quartz-schists and limestones which it really underlies, as seen in Perthshire.

Within this zone of phyllites and grits whose relationships we have just been discussing occur certain beds showing a much less altered appearance than others. As we have already seen, Sir A. Geikie, in his Government Reports, mentions their occurrence at Aberfoyle, Callander, and in the river Esk, Kincardineshire. The beds in the latter locality containing *radiolaria* have a general appearance which seems to link them with the Arenig rocks of the Southern Uplands. From this he concludes that amongst this belt of grits and phyllites, which evidently belong to the crystalline rocks of the Highlands, there has been interposed a group of younger rocks, probably of Lower Silurian age, the most continuous section of these younger rocks being that seen in the Keltie Water, at Callander. We have long been acquainted with this section, but can see no reason for separating these rocks out from amongst the grits and phyllites with which they are evidently interbedded. The following may be taken as the general structure, succession, and lithological characters of the rocks seen at Callander, the Pass of Leny, and the Keltie Water. Immediately to the north of the line of fault, and exposed in Kilmahog quarry and the bed of the Keltie, are a series of beds of graphitic shale, with lenticular bands of limestone, for which the quarry was originally worked, and which are seen to dip at angles of 50 degrees to the north-west. To the north of these less altered beds a series of purple shales with phyllites and beds of grit and greywacke occur,

dipping again at angles of from 50 to 60 degrees to the north-west, and evidently conformably succeeding the underlying and less altered beds. These again are succeeded by massive beds of grit and conglomerate, with zones of phyllites, as seen on the shores of Loch Lubnaig, passing eventually upwards into the mica-schists, quartz-schists, and limestones of Balquhidder and Glen Dochart, and showing, so far as we have been able to observe, no evidence of any stratigraphical break.

In conclusion, the structure, age, and relationships of this marginal belt of rocks seen in Highland Perthshire must still remain an open question. For the reasons we have already discussed we are still unable to accept Nicol's theory that the true position of this belt of arenaceous and argillaceous rocks is that seen in the south-western part of the mountain chain, while that shown in Perthshire is owing to faulting and overthrust. Could this be definitely shown to be the case, then we could understand the position of these unaltered beds in this marginal belt. On the other hand it would seem from the Government Reports that Sir A. Geikie would prefer to separate out these less altered beds from the main mass of the grits and phyllites, relegating the latter to the crystalline rocks of the Highlands. But he is unable to find any line of demarcation between the two. In the meantime, until further evidence is forthcoming, we are inclined to look upon this marginal belt of grits and phyllites, with the less altered beds of shale and limestone, as forming one stratigraphical group, conformably underlying and older than the schists and limestones of the interior. Nor do we think that the less altered appearance of certain of the beds militates against this view, as the amount of metamorphism varies exceedingly along the line of strike.

Let us now proceed to a consideration of some of the more recent advances which have been made in the study of those altered basic rocks known as epidiorites and hornblende schists. It is not necessary that we should here enter into any of the earlier opinions held concerning these rocks. Of all the schists found in the Highlands, these hornblende schists seemed to lend the most support to the old view that they had been precipitated from the thermal waters of some primeval ocean, the presence of hornblende, garnet, and other minerals in a highly crystalline condition seeming to support this view of the origin of these rocks. But from the advance of our knowledge concerning the changes which have been produced upon both igneous and aqueous rocks by dynamic metamorphism, it is now well known that most of these schists were originally ordinary sediments, and even igneous rocks, upon which a foliated or schistose structure has subsequently been superinduced by the straining and shearing of the rocks.

It was in the district of the Lizard, in Cornwall, that these hornblende schists were first studied in detail by Prof. Bonney. In his earlier papers on this district, Prof. Bonney expressed the belief that these rocks were of aqueo-volcanic origin, and that the planes of foliation corresponded to the original planes of sedimentation. He even thought that he could detect in them lines of current bedding. In a paper giving the results of a re-examination of these rocks by Prof. Bonney and Major-General C. G. M'Mahon, and published in the Quarterly Journal of the Geological Society for 1891,[10] the authors admit that the hornblende schists are, in part at least, of igneous origin, and explain their banded structure by movements in the mass previous to consolidation, these views being more fully developed in subsequent papers.

Perhaps the most important of all the later contributions made towards the study of these rocks, and one from which we may date the beginning of the more recent researches into their structure and origin, is a valuable paper by Mr. J. J. H. Teall, contributed to the Geological Society of London in the year 1885.[11] In this paper he shows that two more or less parallel dykes intruded into the archæan gneiss of Western Sutherlandshire have been altered from their original structure as an intrusive dolerite into a hornblende schist, and that this alteration had taken place after the dolerite had become consolidated, the change having been brought about by dynamo-metamorphism. He shows that even in hand specimens taken from this dyke a distinct passage can be traced from the dolerite into the hornblende schist. The following may be taken as a summary of the results arrived at in the paper:—(1) That the hornblende schist has been developed from a dolerite by causes operating after the consolidation of the dolerite, and that the metamorphism has been accompanied by a molecular re-arrangement of the augite and felspar; (2) that the molecular re-arrangement has in certain cases taken place without the development of foliation; and (3) that the plasticity which has led to the development of foliation is that due to high pressure at ordinary temperature.

In the year 1887 another important contribution towards the study of these rocks was published in the *Geological Magazine*[12] by Mr. J. J. H. Teall, in which he proposed to account for the banded structure seen in certain gneisses of the Lizard, on the hypothesis that they had been originally igneous rocks associated together as a plutonic complex. As I have already during this session, along with your President, Mr. H. Coates, discussed the application of this theory to a particular instance seen at Balhoulan Quarry, Pitlochry, it will be unnecessary for me to enter into any further description of the theory, and it will be sufficient to refer you to the

original article by Mr. Teall, and to that just cited, as published in our *Transactions* for this year.

In a paper contributed to the Geological Society of Glasgow in the year 1896,[13] the author gave an account of that extensive sill of basic igneous rock which underlies the Loch Tay limestone, and is generally seen to outcrop to the surface along with the limestone. It may be studied near the village of Killin, at the south-west end of Loch Tay, where it is exposed in several fine sections. Along the road which leads to the steamer pier, and in the woods of Finlarig, the hornblende schist may be seen in contact with the limestone. At this point the limestone dips towards the north-west at an angle of 45 degrees, and is underlaid by this sill of basic rock. The relationship of the basic rock to the limestone may also be well seen in the southern front of Sron Clachan, from which point it may be traced to the south side of the glen at the head of Glen Ogle. Down Glen Ogle various exposures of the basic rock in contact with the limestone may be observed. Traced round to Glen Beich, a fine section of the hornblende schist is exposed at the foot of that glen. The limestone and hornblende schist may then be traced at various points to the head of Glen Beich, where some fine sections are exposed, showing the hornblende schist and limestone traversed by numerous veins of pink quartz felsite. An interesting outlier of limestone with the accompanying sill of basic rock may be seen at the summit of Meal-na-Creig, a mountain situated to the south-east of Ardeonaig. This mountain is also traversed by a series of mineral veins which were at one time mined for galena. We think there can be no doubt that this mass of basic rock must have originally been intruded amongst the clastic rocks in the form of a sill. At certain points, as in Finlarig Wood, Killin, the mica-schist shows evidence of a more extreme metamorphism along the line of contact with the hornblende schists, while at various points it shows evidence of breaking across from one horizon to another. Again, smaller sills, or apophyses, evidently connected with the main mass, may be seen at various points along the line of outcrop.

Macroscopically, a specimen of the typical hornblende schist is seen to be made up of alternating foliae of light and dark coloured minerals, which under the microscope are seen to be felspar and hornblende. When the rock is highly foliated and shows a marked schistose structure, indicating that it has undergone a more or less intense metamorphism, the felspars generally exhibit a granular appearance, as if they were of clastic origin. This structure is now well known to be the result of the shearing of the rocks by earth creeps, which have crushed and broken the felspars into this granular form. In the more schistose types of these altered

basic rocks the hornblende generally presents the characteristic long needle-like forms, or occurs as grains or irregular masses in the hornblende schist. The amount of metamorphism which the sill has undergone seems to vary considerably at different points. Thus at Killin it has passed into a typical hornblende schist, having at this point evidently undergone the maximum of change. On Meal-na-Creig and in Glen Quaich the structural change has not been so great, as at these points it does not exhibit the schistose structure, though the original component minerals of the basic rock show evidence of having undergone the usual changes consequent upon being subjected to the action of dynamo-metamorphism.

Many obscure and difficult problems still await solution in connection with these altered basic rocks. It is probable that when they have been subjected to a detailed examination they will be found to consist of different types of basic lava. Again, the conditions under which they were erupted is still a matter surrounded by much mystery; for while they generally show evidence of having been intruded as sills amongst the clastic rocks, as in the case of the mass underlying the Loch Tay Limestone, it is probable, on the other hand, that some of them may have been erupted at the surface as lava flows. This view is borne out by the presence of green chlorite-schists, which have evidently originally been volcanic ashbeds. It is often, however, very difficult to determine correctly what the original relationship of many of these masses of basic rock may have been. So completely have they been rolled out between the shearing planes of the mica schists that their original lines of contact with the clastic schists have become more or less obliterated.

We proceed now, in conclusion, to a brief consideration of some of the more recent advances that have been made in the study of those later intrusive rocks, which are found so well developed in Highland Perthshire, as in the Moor of Rannoch, the valley of Loch Tay, Glen Lednock, and elsewhere. Along the whole of the southern Grampians we find these later intrusive rocks more or less developed, as for instance the extensive tracks of intrusive granites in Aberdeen and Kincardine in the east, and those around the head of Loch Etive and Loch Lomond in the west.

Undoubtedly the most striking feature of these later intrusive rocks, and one which has long been known, is the association together in one plutonic mass of some of the members of the two extreme types of acid and basic igneous rocks. Thus, at Cairn Chois, in Glen Lednock, we have a granite and a diorite intimately connected together; while at Tomnadashan, on Loch Tay, a similar relationship is seen to exist between a granitite and a mica-diorite.

Again, at the head of Loch Lomond, there is a well-known example of an acid and a basic igneous rock associated together in one great intrusive mass, to which the term "plutonic complex" has been applied.

Within the last few years, principally through the influence of a valuable paper by Messrs. J. R. Dakyns and J. J. H. Teall, published in the *Quarterly Journal of the Geological Society* for the year 1892, it has come to be recognised that the association together of these representatives of the two extreme types of igneous rocks cannot be looked upon as representing two distinct and separate acts of volcanic intrusion. On the contrary, they have been separated out from the same magma.

Before proceeding to a notice of this paper by Messrs. Dakyns and Teall, we should like to draw your attention to the fact that these later views of the chemical segregation from the same magma of two extreme types of igneous rock had already been to a certain extent anticipated by earlier geologists. Thus we find F. Odernheimer, in a paper on "The Mines and Minerals of the Breadalbane Highlands,"[14] published in the year 1841, applying the segregation theory to account for the association together of the above-mentioned acid and basic rock seen at Tomnadashan, on Loch Tay. Speaking of this plutonic complex, he says;—"It is not very possible to ascribe a previous age to either greenstone or porphyry; they seem to be contemporaneous, and the veins of greenstone in porphyry and of porpyhry 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. Along with later writers upon these rocks, we had adopted the view that they represented two distinct periods of intrusion, though we were acquainted with the remarkable fact that nowhere does the granitite, which was supposed to be the later eruptive rock, pass out of the mica-diorite into the surrounding schists. Had this been the case, then it would have tended to favour the view of a separate intrusion for each rock. But as the granitite does not pass out of the mica-diorite, we think it strongly presumptive evidence that they have both been segregated from the same magma."

In the paper we have just mentioned, by Messrs. Dakyns and Teall, "On the Plutonic Rocks of Garabal Hill and Meall Breac,"[15] published in 1892, a valuable contribution has been made to the study of these plutonic complexes. This locality is situated

near the head of Loch Lomond and on the confines of Perthshire and Dumbartonshire. The rocks seen in this plutonic complex vary from the most acid to the most basic type, and include granite, tonalite, and diorite, which pass into such highly basic rocks as wehlrite, picrite, and serpentine. At some places it is possible to draw a distinct line of demarcation between the diorite and the tonalite, but at others the transition from one rock to another is so gradual as to make any such sharp distinction impossible. On the whole, these authors say;—"The south-eastern portion of the plutonic belt is more basic than the north-western. At certain points along the edge of the boss the diorite and tonalite are seen to invade the surrounding schists, sending veins and strings into the latter, and in some cases completely isolating blocks of the schist." And again;—"The area occupied by granite is largely in excess of that occupied by diorite. Taking the whole plutonic area as amounting to 12 or 13 square miles (say $12\frac{1}{2}$), 10 of these are occupied by granite and only $2\frac{1}{2}$ by diorite. Diorite, therefore, only forms $\frac{1}{5}$ of the total area. The area occupied by ultra basic rock is exceedingly small, amounting at the most to $\frac{1}{8}$ square mile."

The hypothesis put forward by Messrs. Dakyns and Teall to account for the association together in one boss of such extreme types of igneous rock is that they were all originally intruded as one magma, the more basic part having cooled first around the margin into peridotites, these being succeeded by the diorites and tonalites, and finally the granite as the most acid type having cooled last, and nearest the centre of the mass. They also state that similar phenomena are to be seen in other parts of the southern Highlands, and they instance a case in Glen Tilt where a mass of plutonic rock, partly acid and partly basic, may be seen. As a rule, they say, the one rock gradually passes into the other, but at some points the granite is seen to vein the diorite, which shows the acid rock to be the younger of the two. This is identically the same phenomenon as that which we have just instanced as occurring at Tomnadashan, on Loch Tay.

Like the altered basic rocks and clastic schists, these later intrusive rocks are shrouded in a mystery heavy and difficult to lift. What is their age, and can they be connected with any period of volcanism, are among the more important questions that still await solution. It will be remembered that Prof. Judd, in his second paper upon the "Secondary Rocks of Scotland,"[16] published 1874, brought forward the view that these plutonic rocks were but the roots of volcanoes laid bare through extensive denudation, and that he attempted to connect them with the volcanic products of Old Red Sandstone age. In this paper Prof. Judd also institutes

a comparison between the volcanic phenomena of the Tertiary rocks of the Hebrides and the granites of the Highlands, along with the lavas and agglomerates of central Scotland. He shows that both in the Hebrides and in the southern Highlands the granites are seen to pass upwards into syenite-granite and felsite, and that "Unmistakable evidence, both stratigraphical and palaeontological, and of totally independent character in either case, has led us to the conclusion that the subaerial felstone and porphyrite lavas of Lorne, the similar subaqueous lavas of central Scotland, and the intrusive masses of identical ultimate chemical composition in the Grampians, were all formed during the same geological periods —those constituting the latter part of the Palaeozoic epoch." Prof. Judd then proceeds to instance the case of Ben Nevis, for which he claims a similar structure to the Tertiary volcanoes of the Hebrides, passing from a basal granite through agglomerate into a felstone towards the summit.

Whether we agree with Prof. Judd or not in the reading of the structure of Ben Nevis, it has always seemed to us that his connecting of these eruptive bosses of plutonic rock with the volcanic series of Lorne and central Scotland was a masterly generalisation, and the recent work of the geological survey in the south-west Highlands has tended to confirm this view.

In the Government Report of the Geological Survey for the present year, Sir A. Geikie refers to Mr. Kynaston as having found that a group of dykes and sills of porphyrite can be seen to pass from the andesites of Lorne across the older rocks and enter the Ben Cruachan granites. He also thinks that the porphyrite dykes and sills have a strong petrological and chemical relationship to the granites on the one hand and the andesites on the other. It is likely then that further investigation may tend to confirm the view, originally propounded by Prof. Judd, that the intrusive plutonic rocks of the southern Highlands are but the plutonic representatives or roots of those volcanoes which were active during later Palaeozoic times, and whose volcanic products we find interbedded amongst the Old Red Sandstone and the Carboniferous sediments.

We have attempted in this paper to bring before the members a concise view of some of the more recent advances which have been made in the study of the rocks of Highland Perthshire. Involved as they are with the general structure of the southern Highlands, it has been necessary for us to refer to other localities along the southern Grampians outside of our own county. To interpret the geological structure of Highland Perthshire you will often find it of advantage to go farther afield, and at least to extend your investigations to the neighbouring counties. Again, it has been

necessary for us to go back upon some of the earlier work done amongst these rocks; for, as we have shown, many of our later views upon the geological structure of the southern Grampians had already been anticipated by earlier geologists. It will also be apparent from what has been said that we have by no means as yet reached that final stage of knowledge, in which the complicated puzzle of the structure of Highland Perthshire lies unravelled in all its parts. Much still remains to be done, and it is to be hoped that the members of this Society will not be behind in the fascinating work which lies ready to their hand. Your reward is sure, for "Nature never did betray the heart that loved her."

APPENDIX.

List of Works referred to in the preceding Paper.

[1] Murchison and Geikie—On the Altered Rocks of the Western Islands of Scotland and the North-Western and Central Highlands. Quart. Journ. Geol. Soc., Vol. XVII., page 171. 1861.

[2] Harkness—On the Rocks of Portions of the Highlands of Scotland South of the Caledonian Canal, and their Equivalents in the North of Ireland. Quart. Journ. Geol. Soc., Vol. XVII., page 256. 1861.

[3] Nicol—On the Geological Structure of the Southern Grampians. Quart. Journ. Geol. Soc., Vol. XIX., page 180. 1863.

[4] Coates and Macnair—The Rocks of Highland Perthshire; their Origin, Plication, and Denudation. Trans. Perth. Soc. Nat. Science, Vol. I., page 221. 1891.

[5] Geikie—Presidential Address to the Geological Society. Quart. Journ. Geol. Soc., Vol. XLVII., page 74. 1891.

[6] Geikie—New Geological Map of Scotland. 1892.

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[8] Macnair—The Altered Clastic Rocks of the Southern Highlands; their Structure and Succession. Geological Magazine, Vol. III., pages 167 and 211. 1896.

[9] Geikie—Annual Reports of the Geological Survey of the United Kingdom for the years 1893, 1895, 1896, 1897.

[10] Bonney and M'Mahon—Results of an Examination of the Crystalline Rocks of the Lizard District. Quart. Journ. Geol. Soc., Vol. XLVII, page 464. 1891.

[11] Teall—The Metamorphosis of Dolerite into Hornblende-Schist. Quart. Journ. Geol. Soc., Vol XLI., page 133. 1885.

[12] Teall—On the Origin of Certain Banded Gneisses. Geological Magazine, Vol. IV., page 484. 1887.

[13] Macnair—On the Altered Basic Rocks of the Highlands, as exemplified by the Sill of Hornblende-Schist underlying the Loch Tay Limestone. Trans. Geol. Soc. of Glasgow, Vol. X., page 302. 1896.

[14] Odernheimer—On the Mines and Minerals of the Breadalbane Highlands. Trans. of the Highland and Agricultural Society of Scotland, New Series, Vol. VII., page 541. 1841.

[15] Dakyns and Teall—On the Plutonic Rocks of Garabal Hill and Meall Breac. Quart. Journ. Geol. Soc., Vol. XLVIII., page 104. 1892.

[16] Judd—The Secondary Rocks of Scotland. Second Paper. Quart. Journ. Geol. Soc., Vol. XXX., page 220. 1874.

CORRIGENDA.

Page 168, line 13 from top, for "1860" read "1861."

Page 176, line 11 from top, insert reference number "6" after "Sir A. Geikie."

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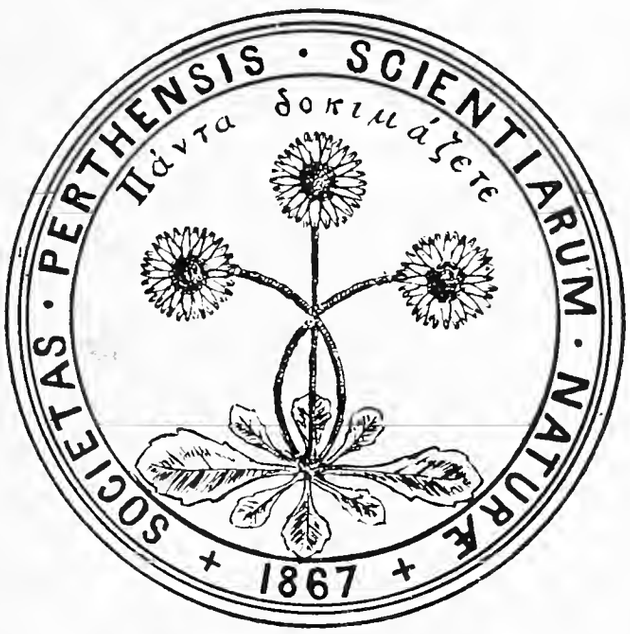

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XVIII.—*Birds of the Mountain Tops.*

By Lieut.-Colonel W. H. M. Duthie, R.A.

(Read 9th December, 1897.)

Beyond the curlew-haunted sweeps of desolate moorland, beyond the heathery knolls and birch-clad glens, the home of grouse and blackgame, above the wild wind-swept corries, and near the tops of the highest hills, three of our British Birds are born and reared at a height of not less than 2000 feet above sea level; they are the Snow Bunting, the Dotterel, and the Ptarmigan.

The home of the Snow Bunting is in the far north, within the Arctic circle, but in winter its area of distribution is considerably extended southwards, and it is no uncommon sight at home, in cold weather, to meet with small flocks of "Snowflakes" as they are called, flitting over the frozen ground. It is only within the last few years that the fact, long suspected, has been proved that a few of these winter visitors, possibly in increasing numbers, remain behind their fellows and breed in some of the least frequented mountains of our Scottish Highlands, where their nests, composed of dry grass, and lined with deers' hair and ptarmigans' feathers, have been found concealed among the debris of fallen rocks and stones.

The Dotterels come to us in the springtide as birds of passage from the south, and, after resting awhile, the great majority pass onwards to their normal breeding grounds, the fells of Scandinavia, and the great *tundras* which border the northern seas; but some, like the Snow Buntings, stay with us throughout the summer, and nest in the months of June and July on high hills in some of the northern counties of England and in Scotland, but these, few in number, are sparingly scattered over considerable areas of ground not easy of access, and being, like all plovers, extremely shy and wary in their habits during the period of incubation, they are seldom seen, and their nests rarely found. I once had the good fortune to find the eggs under curious circumstances. We started one June morning to explore a high mountain in Inverness-shire, where it was known that a pair or two of Dotterels were in the habit of nesting. After leaving the lodge, the keeper called back to his wife to let loose his dog, which he had forgotten, and when a fine wavy-coated retriever came dashing through the burn, and bounded up the hillside, we little knew that to him we should be indebted for the success of our expedition, but such was the case. A light mist was clinging to the hill tops, which we hoped would disperse as the day progressed, but there was no wind, and it became denser, and when, after a stiff

climb, we reached our goal, a broad table-land at a height of 3000 feet, we were enveloped in a fog so thick that we could scarcely see ten yards around us. The walking was easy, over a comparatively level floor of flat stones embedded in a carpet of soft elastic moss; this was ground which we knew to be well suited to the tastes of the birds we sought. Hopeless as under the circumstances our task appeared to be, we trudged along backwards and forwards in regular beats, and had nearly completed our survey of the plateau, when the dog suddenly flushed a Dotterel, which, with a cry of alarm, fluttered away with draggling wings and disappeared in the mist; she was at once joined by her mate, whose voice we heard in answer to her own. We could find no nest, so we took up a position at a ltttle distance away and watched, hoping that the bird would return. After waiting for half-an-hour, during which time rain began to fall heavily, the keeper started off in the direction taken by the bird, thinking that by her behaviour she had young, and had called her chicks after her, while I remained watching. In a few minutes' time the dog reappeared, looming large in the mist, hunting evidently on the back tracks of the Dotterel, and presently stood still in an attitude of pointing; on going to the spot I found the three eggs lying under his nose. The nest was a slight dint in the ground, and the eggs, of a rich brown colour, marked with black blotches, were in perfect harmony with the moss on which they were placed.

The Ptarmigan, as a British bird, is entirely confined to Scotland, where it remains on the mountains all the year round, changing its dress as the ground varies in colour and aspect according to the successive seasons. In the springtime, the pure white plumage, which matched the dazzling winter snow, becomes mottled with grey, yellow, and brown to suit the rocks and summer clothing of the hills, and when the autumn blasts begin to whiten the mountain sides, the Ptarmigan gradually re-assumes its winter garb. The mountain hare, the companion and close associate of the Ptarmigan, varies its coat in the same manner, the change being effected by a supplementary process, independently of moulting or shedding of fur, and thus Nature helps to protect these creatures from their common enemies, the eagle and the fox.

After a succession of hot tramps in August on the moors, it is a pleasant variety for the sportsman to have a by-day and climb up to the stony tops with a gun and a trusty retriever and search for Ptarmigan. Even if birds be few and sport indifferent, the fresh exhilarating air and the magnificent views obtained in fine weather always repay the toil and fatigue incurred. Sometimes, when well up above the heather zone, a wary old cock grouse, one of the bullies of the moor, may be surprised and brought to bag with much

satisfaction. The Ptarmigan are not easy to find, and, when lying close, they are indistinguishable from the moss and stones among which they crouch. Probably the first sign of their presence is a low churring noise, like the sound of a fisherman's reel, which proceeds from an unseen bird sitting perhaps within a few yards of us. When disturbed they are seen running before us like a brood of speckled fowls; they rise at first out of shot and disappear behind a cornice of rock, but, if persistently followed, they may generally be overtaken, and, when the covey is broken up, good sport may be obtained, especially if a companion is working another face of the hill. Sometimes, from their position when shot, they fall a hundred feet or more below the shooter, and require time and patience to retrieve.

A visit to the haunts of Ptarmigan is always refreshing, for it brings us face to face with wild nature, and, standing in her presence, we learn to know and love her better, as we watch—through the medium of her great interpreters, the mountains—all her varied expressions: her calm beauty in sunshine, her mystery in clouds, and her terrible grandeur in storm. Nowhere is stillness more complete, nowhere is storm more impressive, than in the deep solitude of the eternal hills. Perfect silence does not exist upon this earth, but there are certain days, among the mountains, when the nearest approach to it may be felt—days on which the air is so quiet and still that one's ears are strained in vain to catch the faintest sound of distant rivulet or rustling grass, and it is a relief to shout, if only to hear one's own voice echoed back from the crags across the glen.

And how glorious is the storm! In the narrow vale we may, perhaps, hear the rumbling of thunder far away, and take no heed, for the limited area of sky above is clear and bright, but the piling up of heavy clouds is going on unperceived, and, suddenly, before it is realised that the sun is darkened, a flash of lightning illuminates the hills, and the great organ of the heavens peals out, and rolls its sonorous music overhead—

> "Far along,
> From peak to peak, the rattling crags among,
> Leaps the wild thunder! not from one lone cloud,
> But every mountain now hath found a tongue,"

and, before the echoes of the first explosion die away, another, and yet another crash is added to the turmoil which rages around us.

Fortunate we are if we can find shelter under a leaning rock, when the rain and hail come pouring down, drenching the hillsides and making every rill a stream, and every stream a river.

We were fishing in Sutherland during the month of May, and had tried many of her beautiful lochs with unsatisfactory results, owing to

the weather, which had been fickle, alternating in high winds and flat calms, and one afternoon, which was no exception to previous experience, after a sharp storm of thunder with heavy squalls, we were left floating on a mirror between earth and sky; the wooded islands, with their wealth of flowers, and the bare barren hills which surrounded us were reflected in all their details in the motionless water. A pair of sandpipers chattered as they ran along the margin of a sandy bay, and a meadow pipit on the hillside piped his melancholy, discontented note in harmony with our own mood.

Looking up to the desolate grey mountain tops we talked of Ptarmigan, and recalled to mind many memories of past scrambles among their haunts. We had never seen a Ptarmigan's nest, nor had we visited the birds themselves in the breeding season, and we longed for an excuse to stretch our legs after being so long in a cramped position in the boat. The keeper said he knew where there were plenty of birds, but the discovery of a nest was by no means a certainty; he promised, however, to show us the eyrie of a golden eagle, which, although late in the season, was still in occupation, so, having two strings to our bow, we decided to go on the morrow. The morning broke fine and clear, with

> "the wind in the east
> Neither fit for man nor beast,"

and, mindful of the old fishing rhyme, we left our rods at home, and started with a clear conscience for the hills.

A grand mass of mountain, standing conspicuous above the rest, was our objective point, as it was known that the stony plateaux below its double peak were inhabited by Ptarmigan.

Before commencing the ascent, a long tedious walk lay before us up a narrow glen, at the head of which the steep rampart of rocks seemed from a distance to be insurmountable, but the steady swinging pace, which is acquired in mountain climbing, overcame all obstacles, and in time we were perched up on a high crag surveying the scene around us with our glasses.

Several lochs over which we had cast our flies lay shining like shields of silver through the haze which the east wind had brought up; on a patch of emerald green close to a tarn some deer were quietly feeding, and we heard a raven croaking among some rocks above our heads. On reaching the top of the ridge, we enjoyed our first sight of the eagles, whose nest we had come to visit; they came sailing over our heads, and wheeled about lazily in wide circles after the manner of their kind. While we watched them, a third eagle appeared on the scene, whose presence was resented by the home birds, one of which fiercely attacked the intruder, and a combat took place between them; they struck at each other with their

feet and wings, and occasionally uttered a strange barking cry. The object of each was to rise above the other, and so they ascended higher and higher, and for a time were lost to sight among the clouds; eventually the stranger departed, sailing away to his own home among the far away hills. Birds of prey are very tenacious of their territorial rights, and when established in the spring time in their ancestral eyries, which are often of great antiquity, they look upon a certain area around them as their own special hunting ground, and, while freely admitting birds of other families within this sphere, they object to the presence of those of their own species.

Golden Eagles are beginning to recover their position in Scotland, and in some districts they are decidedly on the increase owing to the protection afforded to them by proprietors of deer forests, but their nests need to be carefully watched against the incursions of egg stealers.

We had now left the heather behind us, and the bracken, and the cloud-berry with its white blossoms, and were walking in a wilderness of rocks and stones. On the slopes these were lying one upon another in loose confusion, with edges sharply cut as if recently broken by a hammer; on the flats they rested on a thick carpet of moss, lichen, and bilberry, over which a dwarf juniper crept, and clung like ivy to the ground, and a few hardy ferns were holding their own in chinks and crevices of the larger rocks. We noticed an abundance of small pink and white flowers no larger than peas, which it was difficult to realize as those of the common thrift, or sea pink, which, with better nourishment, covers the rocks along the seashore with crimson blossoms; but everything is dwarfed at this height, and nothing is allowed to grow to any size by the fierce winds which tear over these desolate solitudes. Below us, and stretching away to the far horizon, was spread out a seemingly interminable sweep of brown moorland and grey mountains, which was only relieved from monotony by the splashes of light playing on the waters of innumerable tarns and streams, and by the shadows of the clouds as they chased one another over the landscape.

The eagles' nest was below us, so we first paid our attention to the Ptarmigan, and quartering the ground like spaniels, we searched the stone-strewed plateaux and rocky ridges at an average height of 2300 feet, but although we found plenty of feathers and fresh signs of Ptarmigan, we got no sight nor sound of a single bird.

After a long fruitless search, we descended to the eagles' crags. The large nest was round and neatly made, and rested on a flat slab under an overhanging rock, so placed that it was impossible to look into it from above, and it was quite inaccessible from below. The ground beneath the nest was strewn with bones, hares' feet, and

feathers. We concealed ourselves as best we could under cover of some fallen rocks, and ate our lunch, hoping that the eagles would come and feed their young, whose movements in the nest we heard, but the traditional eagle's eye had been on us, and we waited in vain.

One shoulder of the mountain still remained unexplored, and we climbed up again to resume our search for the Ptarmigan's nest, though with little hope after the morning's experience, but success came at last, and in one of our beats we discovered a bird sitting at our feet. Had we walked a yard or two to the right or left, we should have passed by without seeing her, her golden colour so closely resembled a piece of yellow moss. She remained immovable, with neck gracefully curved; her head was turned towards us with a look of surprised curiosity, she for had probably never seen a human being before. We stooped down to stroke her back, and on touching her she flew off, showing a good deal of white on the wings. There were seven eggs in the nest, which was a hollow in the ground between two stones, lined with a little dry grass, and a few feathers from the bird's own breast. The eggs are smaller than those of the red grouse, and fainter in colour. This was the only Ptarmigan we saw in our search of many hours; doubtless we had passed others, but, by remaining motionless, they escaped notice. The males are grayer in their plumage than the females at this time of the year, and would be on the stones, while the latter were brooding on the moss-covered ground.

We walked homewards more than ever impressed with the loneliness of the mountain tops. Since we had left the glen no sound had fallen upon our ears, except the scream of the eagles and the wailing cry of a red-throated diver, which floated upwards from a distant tarn. No doubt, in a wild corrie well-known to us, on the other side of the mountain on which we walked, a Snow Bunting in full beauty of wedding dress was singing a soft love song, but the notes, drifting away on the breeze, were unheard except by his mate who was busily employed preparing her nest among the stones. How different it is in other places where birds resort at this time of year! The woodlands are now filled with melody; among the haunts of men the trill of the blackbird's song mingles with children's voices, and with the sound of hammer and anvil in the village forge; and on the rocky shores myriads of seafowl sit together on the cliff ledges and scream and croon in chorus to the raging surf, but Nature gives the keynote to all her creatures. The bursting of new-born leaves and flowers encourages the enthusiasm of joyous song, the wild cries of sea-birds suit the restlessness of ocean waves, while the solemn grandeur of the strong mountains seems to impose a silence which the few sounds that break it only serve to intensify.

XIX.—*A Botanical Ramble on Ben Lettery, Connemara.*

By Miss Macnab.

(Read 13th January, 1898.)

The strange group of mountains known as the Twelve Pins rises from the bogs of Connemara in the very heart of this bleak and lonely region. Their great rounded quartzite summits dominate every part of the district; at times seen rising above the Atlantic mists which fill the valleys and add weirdness and mystery to the scene; again, glittering like marble in the sunshine; later still, all aglow and transfigured with the rosy tints of sunset.

No one who has admired from a distance their changing beauty but must wish to penetrate further into these mountain fastnesses, and, as their average height is only about 2200 feet, this is no great undertaking in good weather for those who enjoy a scramble.

We chose Ben Lettery, the most southern of the twelve, as being easily accessible, and one of the best view-points of the district. From Clifden, where we were staying, the Light Railway and the early morning train carried us to the lonely wayside station of Ballynahinch. The country is bleak and bare, with little or no cultivation, the number of stones forming the principal feature. In some places every bit of soil is covered with them, and one might imagine a town fallen into ruins and the stones left lying as they fell. The dykes are made of great stones loosely piled together, and, as we left Ballynahinch, and took the pleasant road through woods and by the side of sparkling lochs, we noticed the long spike-like flowers and round fleshy leaves of *Cotyledon umbilicus* growing among the stones where apparently nothing else could find root-hold. The lochs were fringed with bulrushes and covered with fine white and yellow water-lilies, and the better-built walls, especially the parapets of the bridges, were green with *Ceterach officinarum*, *Asplenium Trichomanes*, *Asplenium Ruta-muraria*, and *Polypodium vulgare*. By the wayside we gathered *Erythræa centaurium* and *Lotus corniculatus*, and *Lythrum Salicaria* was very plentiful, in some parts quite colouring the landscape.

After about three miles the slope of the mountain rose before us, and we stopped at a solitary cabin to ask our way. Quite a superior specimen this of an Irish cabin, thatched and whitewashed, with a donkey and some geese and pigs feeding outside, and only the poultry sharing the living-room with the family. Much more primitive was a cabin we had visited a day or two before, in which all we could make out in the dim light was a great peat fire smouldering in the middle of the floor, and whose master, an old man, ragged but

courteous, after the fashion of the Irish peasant, explained the general discomfort of his abode by remarking, "You see, miss, the cattle have to come in at night!" Here, at the foot of Ben Lettery, the people, busy with their small hay crop, evidently wondered at our folly in climbing a hill on such a hot day, when we might remain comfortably at the bottom. They directed us, however, to leave the road and follow a mountain stream, and this proved a delightful route. Our stream pursued a varied and adventurous course; leaping down from the heights above in a succession of sparkling waterfalls; passing through deep gorges and lying dark and silent beneath high overhanging cliffs; lingering in sunny pools, as though unwilling to leave those breezy moorlands for the dull monotony of the bogs below. Beautiful ferns grew all along its banks, and we were specially attracted by the abundance of Hart's Tongue and of the Royal Fern, which grows here, as all over the west of Ireland, in most luxuriant profusion. In a clump of moss overhanging the stream was found the tiny Alpine Meadow-Rue, but, though we had been told that the Mountain Sorrel grew here, we searched for it in vain in the rocky sides of the ravine. After a while we left the friendly guidance of the stream, and started across the boggy ground. Here we noticed the bog-plants; the Bog Asphodel, with its bright yellow flowers; the yellowish tongue-shaped leaves of the Butterwort; the Sundew, its small white flower on its slender upright stem, and the red dew-tipped hairs on its leaves glistening and attractive to unwary insects; most abundant of all, *Anagallis tenella*, the Bog Pimpernel, whose delicate blossoms formed a carpet over which it seemed sacrilege to tread. We forgot that we were ankle-deep in water and soaking moss as we stooped to examine its lovely cup-shaped flowers, with their rosy transparent petals, and its graceful sprays of tiny leaves.

Presently we reached firmer ground, and here on the heathery slope we would fain have lingered. It was so pleasant in the warm sunshine to rest on the springy heather, to watch the progress of the cloud-shadows over the hills, to listen to the distant music of the stream, the lively chirp of the grasshopper, the drowsy hum of the wild bee. We were in the very heart of the mountains, and the Twelve Pins, like solemn sentinels, shut away every trace of the outer world. The heather was all about us, *Erica cinerea*, in such beauty as we had rarely seen it, and among the purple were lovely patches of purest white; *Calluna*, with its many tufts of white easily distinguished by the lighter green of the leaves; and the beautiful *Dabeocia*, or St. Dabeoc's Heath, not to be found in Britain outside Connemara. Its great crimson bells hung upon the slope beside us, and we noticed and admired the length and rich colour of its blossoms,

and its numerous leaves, bright green above, white and woolly below.

But we had not yet reached our goal. The rocky head of Ben Lettery still towered high above us, boldly outlined against the clear summer sky, and, by a stiff scramble over stones, round huge boulders, and up flights of rocky steps, we reached the top. The view is a splendid one. We looked straight down upon the flat boggy country, lying between the Pins and the sea, and the broken fiord-like coast was spread out like a map before us. Little villages were dotted here and there, and from many a lonely cabin we could see the blue smoke rise from the peat-fires. To the west was the Atlantic with its indented coast-line and its horizon dim with mist, and white and solitary stood out the lighthouse at Slyne Head, one of the most westerly points in Ireland, and indeed in Europe. To the south was Galway Bay, with the shadowy outline of the Aran Isles, and, more faintly-pencilled still, the blue hills of Clare. The Aran Isles, three in number, lie like barriers across Galway Bay, and are of the deepest interest to archæologists for their wealth of antiquities—pagan and Christian. The largest, Aranmore, has also a legendary and poetic interest, for old Irish writers tell how in clear weather might be descried from its cliffs the Hy Brysail, or Enchanted Island, the paradise of the pagan Irish, "whose bowers beyond the shining wave at sunset oft are seen." And Moore has described how as a youth he wandered dreaming along the shores of Aranmore—

> "And when the western wave grew bright
> With daylight's parting wing,
> I sought that Eden in its light
> Which dreaming poets sing."

As we looked down upon Galway Bay it was of the deepest blue, and the whole country is so spangled with lakes that there is more sparkling water than land to be seen. Hundreds of tiny lakelets fill up every hollow towards Clifden, glittering like mirrors in the sunshine. Just below us were the four large lakes of Connemara, better known to the angler than to the general tourist, and the Castle of Ballynahinch, in its beautiful setting of lake and wood—its trees almost the only ones to be seen. Not far off are the quarries of green marble, for which Connemara is so justly famous.

Growing upon the rocks at our feet were *Lycopodium alpinum* and *Lycopodium Selago*, and we found plenty of Armeria, while in sheltered crannies *Saxifraga umbrosa*, London Pride, or to give it its Irish name, St. Patrick's Cabbage, was clinging in close cushions to the bare rocks.

Saxifraga umbrosa and *Saxifraga geum*, the two largest of the British Saxifrages, are peculiar to west and south-west Ireland, and, like Dabeocia and *Erica Mediterranea*, are not to be found elsewhere

in the British Isles. To see them again we must go to south-west France and the Pyrenees. Their presence here forms a strange link between this out-of-the-way corner of Britain and the distant mountains of Spain, and has given to naturalists plenty of scope for theories as to how they found their way here. It has been suggested that they are the legacy of Spanish invasions and of Spanish traffic with Ireland in early and mediæval times—that we see in them relics of that Spanish intercourse of which there are still traces in the quaint old town of Galway, in the architecture of its great houses now falling into ruins and with little to show of their former glory; in the bright colours of the national costume which still lingers here; in the names, and even in the features of the people. "Naturalists, however" (to quote from the delightful *Open-Air Studies* of an Irish botanist), "are now agreed that a former extension of the coast-line of Europe allowed the plants to migrate overland from Portugal to Ireland, and that, aided by a mild and equable climate, they have here remained to tell us of byegone ages and of vanished lands."

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

By Robert Smith, B.Sc.

(Read 13th January, 1898.)

It is a simple observation that the plants conspicuous in the landscape are comparatively few in number. These few are the so-called "social" species, whose individuals are so plentiful as to dominate over all the other plant inhabitants of the same area. Thus, on the moor the heather is the dominant social species, occupying by far the greater part of the ground. With the chief species are associated some which are kept down by it, and others which are dependent upon it for food, shade, or shelter. Such a community, made up of chief species, subordinate species, and dependent species, constitutes a Plant Association in the sense used in this paper.

There are many social species in our district which may dominate in a Plant Association, and all stand out from their neighbours by certain well-defined characters.

I.—The most conspicuous are the Trees, whose tall growth excludes them from much competition with smaller forms.

II. Shrubs are similarly, although to a less degree, raised above the humbler herbs, and constitute important societies. Of these, *Calluna* has by far the greatest extension. Other *Ericaceæ*, although usually subordinate to it, may here and there find a more suitable spot where they rise to the rank of dominant species. On the high

Alpine ridges of the Grampians dwarf willows, mountain azalea, *Potentilla Sibbaldi*, etc., have the ground at their own disposal. In the waste grounds of the lower part of the basin whin, broom, sloe, rasp, rose, etc., may each form societies.

III.—Grasses play an important part in carpeting the soil from the property they have of forming turf, especially when mown or eaten down by grazing animals. Their societies are best developed on the moister parts of the hills, although *Nardus stricta* can be found on the worst and driest soils. *Agrostis vulgaris*, *Deschampsia cæspitosa*, *D. flexuosa*, *Festuca ovina*, and *Phalaris arundinacea*, are amongst the best marked species. *Lolium perenne* is the social species of the hayfield, but rapidly disappears when the soil is allowed to lapse from cultivation.

IV.—On the cold moist earth and in the marshes Sedges (*Carex*, *Scirpus*, *Eriophorum*, etc.) largely take the place of grasses.

V.—Certain Rushes, e.g., *Juncus squarrosus* on peaty soil and *J. communis* in the marshes.

VI.—Amongst Herbs, the social species are especially those whose broad leaves can effectually shut out light from intruders, and whose rhizomes usurp most of the ground. No better examples can be given than *Petasites* and *Tussilago*.

VII.—Ferns tend to live socially, especially the bracken (*Pteris aquilina*), in woods and on well-drained hillsides. The male fern (*Lastræa Filix-mas*) often forms a sub-society under the shade of trees.

VIII.—Of the Mosses, *Sphagnum* plays the most important part as a social species; the remains of its great societies form peat.

IX.—Only a few *Lichens* cover much ground, although many form small societies. *Cladonia rangiferina* on our moors, and *Cetraria islandica* on the alpine plateaux, are the best marked forms.

Besides these groups of social species one must mention three others which are much more dependent for their sociability on the environmental conditions.

X.—Aquatic Plants.—Here are included such societies as that of *Elodea*, which has of late choked so many canals and ponds, *Chara*, *Potamogeton*, *Nymphæa*, etc. Each of these depends primarily on the constant presence of water.*

XI.—Marine Plants.—Salt and water are here the necessary conditions. *Zostera* is our only species from amongst the flowering

* For many interesting observations on the societies of aquatic plants one should consult the papers by M. Magnin on "The Vegetation of the Lakes of the Jura Mountains."

plants, but the group includes those sea-weeds whose zones of vegetation are so well indicated in descending from high to low water-mark on rocky shores, e.g., *Enteromorpha*, species of *Fucus*, and *Laminaria*.

XII.—Halophytes, or salt-loving plants, such as *Ammophila*, *Elymus*, *Salicornia*, *Triglochin maritimum*, etc.

These groups include all the social species of any importance in our district. In this paper I am to consider only those of greatest interest, either from the part they play in the landscape, or from their value with regard to the sub-division of the Tay basin into natural botanical regions.

TREE ASSOCIATIONS.

The leading part which trees play in the scenery of a country is evident. The class as a whole is a social one, thriving best when its members grow side by side, close enough to resist the sweep of the wind, and to retain the amount of moisture necessary for their growth. But only a few of the class are social species. Many, such as the ash, elm, sycamore, poplar, and rowan, are, as a rule, sparsely mixed through woods where beech, oak, pine, and birch may dominate.

The Beech, *Fagus sylvatica*, Linn.—The beech is essentially a social tree. In Scotland it is an introduced element planted by man, but where it finds a suitable home in our carse-lands and plains it tends to drive out the other species planted with it. In walking through a crowded wood of mixed trees, one sees on looking up at the "crowns" that the huge outgrowing branches of the beeches are overshadowing and crowding the neighbouring species.

The beech is a shade-giving species to a greater degree than almost any other of our common wood trees. One might arrange the trees in the order of the shade they afford, beginning with those giving least, as follows:—birch, larch, Scots pine, ash, elm, oak, beech, and spruce. The greatest gap in the series would be between oak and beech.

Because of the deep shade, plants grow with difficulty under beech trees. Seedlings of most other trees grow poorly, if at all, although beech seedlings grow well. In the darker parts of the wood the flora is very poor, only a few grasses and mosses prevailing. But where the trees are less crowded, or are mixed here and there with other species, so that more light enters, a richer association of plants springs up.

In this habitat, where moisture, shade, and richness of humus

are assured, the plants have characteristics in harmony with those conditions. The leaves of many possess a thin cuticle and many stomata, so that transpiration goes on freely (*Anemone*, *Oxalis*, *Circœa*, *Sanicula*, *Adoxa*, *Mercurialis*, *Paris*, etc.). The grasses have their stomata on both surfaces of the leaf, and especially on the upper surface (*Brachypodium*, *Milium*, *Melica*, etc.). No annual plants are regular inhabitants of the beech woods. All produce rhizomes, tubers, bulbs, or some such underground structures in which they may pass the unfavourable seasons of the year. Such subterranean growths are characteristic of places, like beech woods, where a loose, rich humus is present, and is continually being sifted and enriched by the burrowing of earthworms.

Certain plants, although not necessarily shade-plants, can still thrive in these woods. Some, by means of climbing up the tree trunks, can raise their leaves to a region of greater light, whilst their roots still remain in the moist, porous soil, *e.g.*, the honeysuckle and the ivy. Others lodge in forks or crevices of the trees, where a little humus may have gathered, and thus may come nearer the brighter light. Many such perched plants, or epiphytes, can be noted in a woodland walk, especially grass, fern (*Polypodium vulgare*), dandelion, seedlings of trees, etc. Although in Scotland climbing plants and epiphytes form a small part of the wood-association, yet in the dark forest of the tropics they constitute—as lianas, epiphytic orchids, etc.—by far the greater part of the sub-dominant vegetation. Other wood plants obtain the necessary light by vegetating and flowering early in the season, before the leaves of the overhanging branches shut out the fuller light of summer; thus the ground under the bare leafless trees of April is brightened by the flowers of celandine, anemone, primrose, and wood-sorrel.

Certain other habitats in our district present similar conditions of humus, moisture, and shade, *e.g.*, shady dens and such places as the Woody Island. In these habitats, we find the same association of plants as in the beech woods. Almost all the plants mentioned in the following list as beech-wood plants are recorded in Mr. Barclay's "Flora of the Woody Island."

PLANT ASSOCIATION OF THE BEECH WOODS AND SHADY DENS.

*Anemone nemorosa, L.
Ranunculus Ficaria, L.
*Viola silvestris, Reich.
*Stellaria nemorum, L.
*S. Holostea, L.
*Geranium sylvaticum, L.
*Oxalis Acetosella, L.
Vicia sylvatica, L.
*V. sepium, L.
*Epilobium montanum, L.

*These species have been found by Professor Flahault, of Montpellier, in beech woods on the Cevennes.

Circæa lutetiana, L.
*Sanicula europæa, L.
*Conopodium denudatum, Koch.
Hedera Helix, L.
Adoxa Moschatellina, L.
*Lonicera Periclymenum, L.
*Asperula odorata, L.
*Valeriana officinalis, L.
*Primula acaulis, L.
P. veris, L.
Nepeta Glechoma, Benth.
*Stachys sylvatica, L.
*Mercurialis perennis, L.
*Allium ursinum, L.
Scilla festalis, Salisb.
*Paris quadrifolia, L.
Luzula vernalis, D.C.
*L. maxima, D.C.
Milium effusum, L.
*Dactylis glomerata, L.
Poa nemoralis, L.
Bromus giganteus, L.
*Brachypodium gracile, Beauv.
*Anthyrium Filix-fœmina, Roth.
*Lastræa Filix-mas, Presl.

This list of beech associates has been compiled from all the lists I have been able to procure of the beech woods and dens of our district. It agrees very closely with corresponding lists given by Warming for Scandinavia, etc., and by Höck for Germany.

The importance of the social species on the life-history of its subordinate associates is well brought out in the case of the beech. Let the beech be planted in a region where the climate and the soil are suitable, whether it be in Scotland, in the plains of Europe, or high on the mountains of South Europe, the mode of growth of the trees will produce approximately the same conditions of soil, moisture, and shade. In all these woods we shall find the shade plants, the plants with underground reserves, the liana forms, and early-flowering, light-seeking species. It does not follow that we find exactly the same species. In some cases a geological barrier may have kept back the passage of the attendant species, although allowing that of the dominant one; in other cases, where the association is richer in numbers, the weaker members may be exterminated in the struggle. But on the whole it will be found that the general type is retained.

The Oak, *Quercus Robur*, L.—The oak, the pine, and the birch resemble each other in the amount of light which they require, and they occur socially intermixed in the lower portion of the Tay Basin. The birch, however, is usually subordinate to the others.

But the oak by itself, especially in the form of coppice, is one of the most marked features in Scottish landscape. It forms a belt of tree vegetation all along the valley of the Tay above Dunkeld, and is characteristic of the slopes of our hills at low elevations. Especially does it thrive on old river-terraces. The present woods are regularly

*These species have been found by Professor Flahault, of Montpellier, in beech woods on the Cevennes.

exploited, and many of the trees have probably been planted by man, although many good-growing seedlings are to be seen springing up spontaneously. But, from what we know of the former forest conditions of Perthshire, the oak must have been very common, and, from the healthy condition of the trees in their present situation, we can assume that these woods represent part of the native vegetation of the region.

In Scotland the oak rises to a greater altitude than the beech, a fact quite in keeping with its latitudinal range, which extends further north than the beech. But on ascending the Alps we find that, contrary to our expectations, the oak ceases at a lesser altitude than the beech. The most probable explanation, adopted by M. Christ, is that the more fleshy leaves of the oak are less able to withstand the great torrential summer-storms which occur in those regions.

The contrast between the beech and the oak associations is striking, and is directly connected with the lesser shade of the latter tree. More trees are found freely mixed with it, and an undergrowth of shrubs—absent in the case of the beech—is very characteristic. In the list of plants associated with the oak the woody vegetation is given apart from the herbs to show its relative luxuriance. The vegetation is much richer than that of the beech woods, and the number of "shade" plants fewer. We still, however, find species which vegetate and flower early, before the overshadowing trees have sprung into leaf. In the lighter parts, and where the soil is poor, heather and juniper may obtain a hold, and introduce the moor vegetation.

The following list of the oak associates has been compiled from notes of the species observed in various oak woods between Dunkeld and Pitlochry, and has been compared with those of the Trossachs and Aberfoyle districts :—

PLANT ASSOCIATION OF THE OAK COPPICE.

ARBORESCENT VEGETATION.

Ilex aquifolium, L.
Prunus avium, L.
Pyrus Aucuparia, Ehrh.
Crataegus Oxyacantha, L.
Fraxinus excelsior, L.
Ulmus montana, Stokes.
Betula alba, L.
Alnus glutinosa, Medic.
Corylus Avellana, L.
Fagus sylvatica, L.
(Isolated examples.)
Populus tremula, L.

SHRUBS.

Rubus idæus, L.
R. fruticosus, L.
Lonicera Periclymenum, L.
Vaccinium Myrtillus, L.
Calluna Erica, D. C.
Erica cinerea, L.
Myrica Gale, L.
(In wet spots.)
Juniperus communis, L.

HERBS.

Anemone nemorosa, L

Viola silvestris, Reich.
Cerastium triviale, Link.
Hypericum pulchrum, L.
Oxalis Acetosella, L.
Vicia Cracca, L.
Lathyrus montanus, Bernh.
Fragaria vesca, L.
Potentilla Fragariastrum, Ehrh.
P. silvestris, Neck.
Circæa lutetiana, L.
Galium saxatile, L.
Valeriana officinalis, L.
Scabiosa succisa, L.
Scrophularia nodosa, L.
Melampyrum pratense, L.
Veronica officinalis, L.
V. Chamædrys, L.
Teucrium Scorodonia, L.
Ajuga reptans, L.
Pteris aquilina, L.
Anthyrium Filix-fœmina, Roth.
Lastræa Filix-mas, Presl.
Dicranum scoparium, Hedw.
Atrichum undulatum, L.
Polytrichum commune, L.
Hypnum cupressiforme, Dill.
H. purum, L.

The distribution of the oak includes the greater part of Europe, and even Western Asia in the region of the Caucasus. The oak association shows much greater variety of species in its continental range than that of beech, although throughout it preserves the general characteristics of the vegetation.

The Scots Pine, *Pinus sylvestris*, L.—The pine is grown on almost every soil in our valley, and at all altitudes below 2000 feet (Hooker places its upper limit in Britain at 2200 feet). The chief condition for its growth is light, and one sees how its lower branches gradually die off under the shade of the dense crown above. It seeds freely and, if unaffected in its distribution by man, seems to prefer the following habitats:—

1. Sandy plains, *e.g.*, Tentsmuir.
2. Summits of crags and similar dry, rocky places, *e.g.*, Craigiebarns.
3. Damp, peaty soil, *e.g.*, Cairnleith Moss, near Bankfoot.

I have also remarked it in similar situations in Norway, in the Hardanger region. Warming mentions it for similar situations in Denmark, etc., while M. Christ, in Switzerland, notes its occurrence on the first and second.

As we shall see further on, there is a great similarity between the habitats just mentioned and those in which we find *Calluna*. In fact, certain investigators believe that *Calluna* is originally a subordinate plant of the pine forest, and that it is owing to the changes brought about by man in deforestation and sheep-pasturing that the area of *Calluna* has been increased (Krause). There is little doubt that much of the present heath land was formerly covered by forest, and even now we can see the natural regeneration continually going

on. It is a familiar fact that, in certain parts of our district, it is only necessary to protect the vegetation by means of enclosure to ensure the natural growth of many seedling trees. In 1829, 300 acres were thus enclosed by the Duke of Buccleuch on his estate in Selkirkshire; soon afterwards a luxuriant tree vegetation, chiefly of birch, hawthorn, rowan, pine, and willow, grew up (Farquharson). We may all have noticed amongst the heather on the moors numerous young plants of pine, birch, willow, and rowan nibbled down year by year by the grazing sheep. Wherever sheep are pastured the same fact has been recorded (Darwin in Surrey, Flahault in South France, Krause in Germany, etc.).

Of course, before such a natural regeneration could go on, there must be some old pine trees in the neighbourhood to form seed. How far the winged seeds of the pine can be carried still requires to be more precisely noted, but it does not seem to be very far. The most reliable statistics are those by Fliche, who puts 115 metres as the greatest distance to which seed can be borne from the parent plant.

The following list of the associates of the pine has been made up from notes on pine woods near Stanley, Bankfoot, Dunkeld, Lundie, etc. It has been compared, and on the whole found to agree in character, with my own lists for Norway, and with those given by Warming, Höck, etc., for Denmark, Germany, and Russia.

PLANT ASSOCIATION OF SCOTS PINE WOODS.

(Larch and Spruce are often planted with the Pines, and Birch, Elm, Ash, and Aspen occur self-sown.

Ranunculus acris, L.
Viola silvestris, Reich.
Potentilla silvestris, Neck.
Galium saxatile, L.
Scabiosa succisa, L.
Carduus palustris, Willd.
(In marshy ground.)
Vaccinium Myrtillus, L.
V. Vitis-Idæa, L.
Calluna Erica, D.C.
Erica Tetralix, L.
(In marshy ground.)
Pyrola minor, L.
Euphrasia officinalis, L.
Salix repens, L.
Empetrum nigrum, L.
Juncus conglomeratus, L.
(In marshy ground.)
Luzula campestris, D.C.
Agrostis vulgaris, With.
Deschampsia cæspitosa, Beauv.
D. flexuosa, Trin.
Holcus lanatus, L.
Festuca ovina, L.
Dicranum scoparium, Hedw.
Polytrichum commune, L.
Plagiothecium undulatum, L.
Juniperus communis, L.
Lomaria Spicant, Desv.
Lastræa Filix-mas, Presl.

This association stands in direct contrast to that of the beech. Here shade-plants are almost awanting, and the flora is essentially

that characteristic of the heather moor. The plants have, as a rule, a thick cuticle, reduced leaves, waxy coverings, or other modifications which have the effect of reducing the amount of transpiration.

In comparing the flora of our pine woods with that of similar Norwegian woods, one is struck by the great rarity of certain species in the former which are quite common in the latter, *e.g.*,

Cornus suecica, L.	Pyrola secunda, L.
Linnæa borealis, L.	Lycopodium annotinum, L.
Vaccinium uliginosum, L.	

These plants are all found widely enough distributed in Scotland, although rare, and all are accessory to our pine woods or to the neighbouring heaths. There seems good reason to conclude that the destruction of the forests has been the cause of this rarity, and their re-institution in Britain will only be through the establishment of old woods.

A similar explanation probably applies to those saprophytic forms, like *Lathræa*, *Neottia*, *Goodyera*, etc., which are so rare in our woods. Certain of them, such as *Corallorhiza*, which we know to be a wood-plant in many regions, we usually find on the heaths, where heather supplies the shade and food given elsewhere by trees. In his lecture to this Society on "Rare Plants in the Carse of Gowrie," Mr. Dow mentions that the disappearance of *Goodyera repens*, R. Br., from a wood in the neighbourhood of Longforgan was co-incident with the opening up of the wood by the felling of trees. A similar case has come under my own observation in St. Fort wood, where in 1893 I noted more than twenty plants of *Goodyera* growing in a deeply shaded part, while in 1894, '95, and '96, I have been unable to find any. That part of the wood has been largely opened up by the great storm of the winter of 1893. The same storm was, I have heard, the means of restricting the area of *Goodyera* in woods in the neighbourhood of Gattanside, Melrose.

Although the larch is an important social tree in our valley it is not native, and its association presents but little difference from that of the pine.

The Birch, *Betula alba*, L.—The birch is interesting to us as the tree which attains the highest altitude in Britain (Hooker, 2500 feet). It is also the tree which extends furthest north in Europe, and is, in fact, the only European one which reaches Greenland. But in Switzerland the conifers are found at a greater altitude than the birch. This is a case comparable to that of the oak and the beech, and again it seems to be due to the summer storms of Switzerland being unfavourable to the growth of the thin-leaved birch. This is the explanation suggested by Wahlenberg (Christ, p. 191).

The birch is a tree which withstands the cold exceedingly well. The average temperature at which its leaves appear is about 9° C. (Drude, p. 249), and according to Kihlmann it is not the cold alone which limits its distribution, but rather the cold combined with the drying wind of winter or of early spring.

Its general distribution is very wide, including Central and North Europe, Russia, and Siberia even to Kamtschatka. Connected with this wide distribution we have the fact that its habitat may be very varied. In our valley, we see it growing on the sands of Tentsmuir, in the moist humus of beech and oak woods, on the slopes of Birnam, the rocks of Craigiebarns and other similar places, and on the cold, wet Highland moors.

On enclosed ground, on the moors and hills, the birch springs up spontaneously much more freely than any other tree. From the amount of remains of birch trunks and branches in the peat-mosses, this tree must once have covered a very great portion of our moorlands.

The trees afford little shade, and the associated species are largely those of the bare heaths; the shelter, however, usually ensures a slightly richer growth.

The Heather, *Calluna Erica*, D.C.—This is the most characteristic social species of Scotland. In the Highlands, it covers mile after mile with an almost unbroken brown or purple mantle. The study of the life-conditions of the heather association is of special interest to Scottish botanists, for we are in the region of its maximum development. We find the same association in England and Ireland, in Scandinavia and Germany, but as we pass eastwards and southwards it diminishes in importance (Krause). Outside of this area, North-West Europe, the *Calluna* shrub rarely appears in the long unbroken stretches so familiar to us. In Russia, it is a secondary element in the pine forests. In the Alps and Carpathians, we find it in the woods of coniferous trees. In the Cevennes, Professor Flahault reports it as sub-dominant in the Spanish chestnut woods. I have found it near its southern limit in the Esterel Mountains in the French Riviera. There it was in a forest of *Pinus pinaster*, Ait., and only assumed an important place in the sub-dominant vegetation as we ascended the northern slope of the hills.

Numerous German investigators have studied and attempted to explain the great development of *Calluna* heath in North-West Europe. Climate seems partly the cause, for the limits of the plant in Russia are marked by a change from the moist conditions obtaining in North-West Europe to those of the continental steppes; and the fact that it is mostly found in woods in Russia may be ascribed to

the intermediate conditions these offer between moisture and drought. But some, especially Krause, believe that it is due to the much greater influence man has had on the land in these western regions. Firstly, by means of deforestation, and, secondly, by the actual "cultivation" of the heath by regular burning. Krause concludes that most, but not all, *Calluna* heaths have formerly been covered with trees. His exceptions are chiefly regions analogous to Tentsmuir, largely formed from blown sea sand.

Although we cannot yet say how far these ideas are applicable to Scotland, still we see enough to understand that man's influence is a very important factor. Heather in most districts is regularly looked after by man. If left to itself, it becomes very long and woody, and of little good for fodder. According to Græbner, it ceases to flower after fifteen years, and dies out in twenty-four, or thereabout. What will happen when it dies out will depend on circumstances. On the drier parts of our hills the old heather becomes patchy from the growth of lichens *(Cladonia)*. When moisture becomes more constant grasses or sedges may spring up; or in some cases seeds of heather may be blown from other parts and regenerate the heather area. But it is rarely that we come across heather thus left to itself. As a rule, it is regularly burned every few years to provide young tops for the grouse. On the burnt part grasses, herbs, and young heather from the old roots spring up. The grazing sheep exercise a selective influence on the vegetation in favour of the heather, so that it has the best chance of surviving and re-peopling the moor.

We find *Calluna* heath on a great variety of soils. On Tentsmuir it inhabits a sandy soil; it is very abundant on moorland, both wet and dry, particularly on peat. Probably, however, it requires recurrent periods of dryness. It also grows well on rocky slopes with a loose covering of soil, sufficiently deep to allow its long roots to obtain a hold. It is usually regarded as one of those plants which especially prefer a siliceous soil. It is essentially a light-loving species, and whenever it grows in woods it plays a secondary part.

The following list of the associates of the heather has been made from notes taken on the Grampians, Sidlaws, Fifeshire moors, and the Pentlands. From the list have been omitted the species peculiar to more marshy spots where *Erica Tetralix* dominates.

PLANT ASSOCIATION OF THE *CALLUNA* HEATH.

Ranunculus acris, L.
R. repens, L.
Viola silvestris, Reich.
Polygala vulgaris, L.
Hypericum pulchrum, L.
Linum catharticum, L.
Genista anglica, L.
Lathyrus montanus, Bernh.
Potentilla silvestris, Neck.
Galium saxatile, L.

Scabiosa succisa, L.
Antennaria dioica, R. Br.
Achilles Ptarmica, L.
Campanula rotundiflora, L.
Vaccinium Vitis-Idæa, L.
V. Myrtillus, L.
Erica Tetralix, L.
E. cinerea, L.
Trientalis europæa, L.
Veronica officinalis, L.
Euphrasia officinalis, L.
Thymus Serpyllum, L.
Rumex Acetosella, L.
Empetrum nigrum, L.
Juncus squarrosus, L.
J. conglomeratus, L.
Luzula campestris, D.C.
Scirpus cæspitosus, L.
Eriophorum vaginatum, L.
E. angustifolium, Roth.
Carex (numerous species).
Anthoxanthum odoratum, L.
Agrostis vulgaris, With.
Deschampsia flexuosa, Trin.
Molinia varia, Schrank.
Festuca ovina, L.
Nardus stricta, L.
Juniperus communis, L.
Lomaria Spicant, Desv.
Lycopodium Selago, L.
L. clavatum, L.
L. alpinum, L.

In these plants we see many adaptations to the hard and varied conditions of life on the moors. The wind sweeps cold and strong over these great areas, drying up all weakly plants. In summer, the sun may beat down intensely until the ground is dry as tinder; and again, for days, the moors may be enshrouded in a cold, still mist, when little transpiration is possible. The chief moor-plants possess small leaves with much reduced surface (*Calluna*, *Erica*, *Juniperus*, *Empetrum*, etc.), often evergreen, and enclosed in thick glazed cuticles. A number of the grasses can in-roll their leaves during drought, and thus reduce their surface (*Nardus*, *Festuca*, *Agrostis*), and the heaths have their leaves permanently back-rolled.*

SUCCESSIONS OF ASSOCIATIONS.

In a well-defined association there occur, as has already been pointed out:—

1. A chief or dominant species;
2. One or more sub-dominant social species, restrained from occupying the whole space by conditions of soil and climate, or by the greater power of the dominant species;
3. Intermingled solitary species (*i.e.*, never living socially);
4. Symbions—in the wide sense, including saprophytes, parasites, shade-plants, epiphytes, etc.

Between the dominant and sub-dominant species a great struggle

* A simple account of these adaptations can be found in Professer Miall's "Round the Year," or in Kerner and Oliver's "Natural History of Plants;" perhaps the most important work on the subject is that by Niedenzu (Engler's Botanische Jahrbücher, xi. 1889–90, pp. 134–263).

is continually going on, and slight changes are sufficient to enable one of the latter to rise to first place. Over any area of ground there is taking place, gradually or quickly, a regular succession of social forms. This is easily seen in the peopling of freshly opened earth, where each society prepares the way for the next, and is then in turn driven out by it. The beginning of such a succession we see in the growth of lichens on the bare rock, gradually eroding its surface and preparing a place for the germination of moss-spores, then a little humus is formed where a seed may sprout; thus one succeeds the other until the rock has a carpet of vegetation.

The late Dr. Buchanan White and others have well exemplified this in their studies on the growth of the shingles, islands, and backwaters of the Tay. On the banks of the river, near Ballinluig, I have observed one example of the order in which the plants appear on the bare shingles. The first scattered herbs, with no definite society, are replaced and dominated by the broom (*Cytisus scoparius*, Link.). After a few years, however, the broom becomes long and woody, and finally dies out, its place being taken by grass associations, which thrive on the richer soil it has left. The amount of nitrogen collected by the micro-organisms in its root-tubercles has probably much to do with the power which the broom has of enriching the soil. Amongst the grass one finds seedlings of trees, and above Ballinluig a young plantation of self-sown pines has sprung up on one of these old river shingles. I give the lists of the broom and grass associations of the shingles in parallel columns for the sake of comparison.

SHINGLE BEDS ON THE BANKS OF THE RIVER TAY NEAR BALLINLUIG.

Association of *Cytisus scoparius*, Link.	Association of Grasses.
	Ranunculus acris, L.
Viola canina, L.	Viola canina, L.
Silene maritima, With.	
	Cerastium triviale, Link.
	Stellaria graminea, L.
Cytisus scoparius, Link. (Dominant.)	Cytisus scoparius, Link. (Rare.)
	Trifolium repens, L.
	Lotus corniculatus, L.
	Potentilla Fragariastrum, Ehrh.
	Alchemilla vulgaris, L.
Alchemilla alpina, L.	
	Rosa canina, L.
	Pimpinella Saxifraga, L.

	Galium verum, L.
Scabiosa succisa, L.	Scabiosa succisa, L.
Achillea millefolium, L.	Achillea millefolium, L.
Senecio Jacobea, L.	
Carduus lanceolatus, Willd.	
	Carduus arvensis, Hoffm.
	Centaurea nigra, L.
Taraxacum officinale, Web.	Taraxacum officinale, Web.
	Campanula rotundifolia, L.
Calluna Erica, D.C.	
	Primula acaulis, L.
Fraxinus excelsior (seedlings).	
Thymus Serpyllum. Fr.	Thymus Serpyllum, Fr. (rare).
Prunella vulgaris, L.	Prunella vulgaris, L.
	Plantago lanceolata, L.
	Rumex Acetosa, L.
Rumex Acetosella, L.	
	Quercus Robur, L. (seedlings).
Agrostis vulgaris, With.	Agrostis vulgaris, With.
	Cynosurus cristatus, L.
	Poa annua, L.
Festuca ovina, L.	Festuca ovina, L.

On Tentsmuir very many such changes are going on. We see the loose dunes of wind-blown sand being gradually fixed by bent grasses (*Ammophila arundinacea*, Host., and *Elymus arenarius*, L.). From this basis many associations spring up, that of *Sphagnum*, or some other marsh moss, in the wet parts, *Salix repens*, L., on the moist sand, *Carex arenaria*, L., on the drier parts. Over the *Sphagnum* and moss, *Erica Tetralix*, L., forms here and there a close colony, and further inland *Calluna* covers the ground. A higher development still is reached in the pine and birch woods, and culminates in the ploughed fields and mixed tree plantation around Earlshall.

In the clearings of woods such successions of vegetation rapidly succeed each other. In the Emmock Woods, near Dundee, on a clearing which has been peopled by broom for a number of years, the broom now shows signs of dying out. A thick turf of grass is superseding it, with *Agrostis vulgaris* as dominant and *Deschampsia flexuosa* and *Holcus lanatus* as sub-dominant species. Seedlings of trees, especially rowan and birch, are found here and there, showing that the wood is beginning to reconstitute itself.

The natural alternation of pine and birch in a wood has repeatedly been observed. This may be due to the quicker growth of birch

when a clearing is made. It then rapidly passes the pine, and for a time holds it in check.

We can observe a struggle going on between *Calluna* and its associate the blae-berry (*Vaccinium Myrtillus*, L.). Where the two grow together *Calluna* has almost always the upper hand. The distribution of *Vaccinium*, however, is much wider than *Calluna*. It reaches a much higher altitude on our mountains, and it can grow in shadier woods. In both these stations it forms associations unmolested by *Calluna*. On the Sidlaws, where trees sheltering *Vaccinium* have been felled, *Calluna* can be observed gradually encroaching upon the area of *Vaccinium* and confining it to the remaining wood. The great range of altitude possessed by *Vaccinium Myrtillus* is shared by *Vaccinium uliginosum*, L., both surpassing *Calluna*, *Erica*, and other *Vaccinium* species. This is probably connected with the fact that these two are the only species with deciduous leaves. This enables them in winter to better withstand the cold. (We can compare this with the fact, already mentioned, that the thin-leaved deciduous birch reaches a higher altitude than the evergreen Coniferæ.) The deciduous leaves of the *Vaccinium Myrtillus* and *Vaccinium uliginosum* are thinner and more delicate than the evergreen leaves of the other species mentioned. This in part accounts for their dominance over the other species in shady woods. (*Vaccinium uliginosum* is not one of our wood plants, but in Norway I have found it, along with *Vaccinium Myrtillus*, to be one of the most characteristic plants of the pine woods. We have already referred to a possible explanation of its rarity in our country.)

Other interesting observations can be made on the changes brought about by *Sphagnum*—in the filling up of lochs or in the burying of old forests. Over the felled trees in wet places *Sphagnum* gradually creeps, and soon completely covers them. With the return of drier conditions, *Calluna* may spring up on the surface of the moss, and finally the old forest may be reinstated (Geikie, etc.).

One principle stands out in the consideration of these successions of vegetation. In the changes of the *Sphagnum* bog, the growth of the seedlings on the moor, the succession of plants on a forest clearing, in the peopling of the sand dunes—in all alike, we see a natural tendency towards the regeneration of the forest, which must in our region be looked upon as the primitive state of stable equilibrium. These changes afford us the biological evidence for the belief founded on history, tradition, and geology, that formerly a much larger area was covered by our forests; and they also show that all natural tendency is in favour of the reforestation of our mountains.

RELATION TO THE NATURAL BOTANICAL SUB-DIVISION OF THE TAY BASIN.

It is now the feeling of many botanists that the most natural botanical sub-divisions of any region must be those marked out by the most important social species. Humboldt emphasized this very strongly, and many after him have applied it to different countries. This is the basis of the late Dr. Buchanan White's natural sub-division of Perthshire into alpine, sub-alpine, lowland, and littoral districts. Watson was partly following the same lines when he instituted his arctic and agrarian zones, determined by such plants as *Pteris aquilina*, *Erica Tetralix*, *Calluna*, etc.

Following the divisions laid down by Dr. Buchanan White, we shall find that each can be subdivided naturally into a certain definite number of associations.

In the Alpine district, although such species as *Salix herbacea*, L., *Vaccinium Myrtillus*, L., *Empetrum nigrum*, L., *Alchemilla alpina*, L., etc., form fairly large and well-defined associations, still the conditions of life are such that it is more natural to limit the associations by the climatic changes than by the area covered by any one plant, for competition between each other is of much less importance than the struggle with the extreme conditions of the weather. Thus, in these regions the subdivisions into plant association of the alpine plateau and plant association of the alpine crags seems the most natural.

But in the Sub-Alpine district there is much less difficulty. Here *Calluna* and grass associations extend over most of the area, and can often be sharply defined from each other. The largest grass associations are those of *Nardus stricta*, L., *Agrostis vulgaris*, With., *Festuca ovina*, L., and *Molinia varia*, Schrank. The tree associations of this region are pine, birch, and oak. The bracken is characteristic of its lower border.

In the Lowland district the associations are formed chiefly by the cultivated plants introduced by man, by whin and broom, by broad-leaved perennial herbs, and by woods of mixed trees, including those of beech.

The Littoral district is inhabited by the salt-loving plants, and by the marine associations. The former include *Carex arenaria*, *Ammophila*, *Elymus*, *Salicornia*, *Triglochin*, etc., and the latter *Zostera marina*, L., and the social-living seaweeds.

The social communities in fresh water are partly outside such an arrangement, for their conditions of life are comparatively uniform and vary only slightly with the altitude.

Each of these four series of associations, Littoral, Lowland, Sub-

Alpine, and Alpine, has its special characteristics. In the littoral zone, salt is the chief factor and man's influence is at a minimum. The lowland zone owes its peculiarities almost entirely to man's influence in agriculture, and little of primitive nature remains. In the sub-alpine zone man is still an extremely important agent in the changes which he induces through pasturing, game-preserving, and forestry; but here much more of the natural vegetation is present. The alpine zone is again beyond man's control, and is determined by the prevalent arctic conditions of extreme change.

This method of subdividing the land according to the predominating social species is of extreme value in correlating our plant-life with that of continental nations. By tracing each association through its continental range we see clearly to what part of the general European flora each division of our district belongs. From the associations we have treated, especially from the *Calluna* heath association, the resemblance between our flora and that of Scandinavia and North Germany must have been evident. Kerner (p. 898), in his sub-divisions of the earth's flora, places the British flora as part of the Baltic flora, which also includes Scandinavia, North Germany, and West Russia. He uses as his guiding principle the resemblance between the social species of these respective countries.

I add a list of the works referred to in this paper, and of a few others which have also assisted in its preparation. This bibliography may serve as a guide to the chief papers dealing with the plant associations of our region. Further references can be found in the works mentioned, especially in those of Warming and Drude, and in Engler's "Botanische Jahrbücher."

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XXI.—*Grasses and other Forage Plants.*

By Alfred Brown.

(Read 13th January, 1898.)

In these notes on Agricultural Grasses and Forage Plants, I shall only be able to touch the borders of the subject, as the time at my disposal is rather limited.

Members of this large family, *The Gramineæ*, are, as we all know, found in every clime and thrive in every range of temperature, from the Polar lands to the Equator, from the low-lying shores of the sea to the Alpine limits of perpetual snow.

Of all our flowering plants perhaps there are none so important to mankind as the grasses; the various uses they are put to are too numerous to mention.

For convenience we might divide them roughly into at least three classes :—

1st. Those of which the seed is used as food for mankind, and which are generally called cereals.

2nd. Those grasses which we cultivate for their foliage, and which the farmer uses for pasture or forage.

3rd. Those grasses which the farmer looks on as weeds, but

which, although classed under this somewhat ungrateful and elastic term, have still, one and all of them, their particular duties to perform in the economy of nature, whether binding together the sands of our seashores with their network of roots, or reclaiming and rendering solid the muddy flats of rivers and the spongy stretches of bogland on our Highland moors.

However, I must confine my remarks to that very important class the members of which are used as pasture and forage plants, although I do not wish to keep strictly to those which are of use to the farmer only, as that would narrow very much our field of interest. Some of us, having little concern in things agricultural, may be much interested in those grasses which we commonly find in lawns.

Surely everyone, no matter how thoughtless, cannot but be struck in one way or another with the beauty and varied forms of our grasses, whether seen in the velvety lawn or the waving hayfield, in the closely cropped hill pasture or clothing the banks of some stream with their bright green foliage and graceful flower stems.

Besides delighting our eyes with their beauty, they have, as I have already said, all got their various uses, and are adapted to grow in some particular soil or situation, and it is in pointing out these that I wish to have your attention this evening.

If we examine a lawn we will probably be able to single out several varieties of grasses distributed over the surface. Amongst them we shall find the crested dogstail, the wood meadow grass, the hard fescue, the fine-leaved fescue, the rough-stalked meadow grass, the fine bent grass, and here and there the coarser ryegrass.

Taking them, then, in this order, first we have the crested dogstail, *Cynosurus cristatus*, one of our most useful grasses, although the wiry nature of its flower stems makes the farmer doubtful about it; but if kept closely cropped, and used in its proper place, there can be no doubt of its value. For hay it is of little use; but as it stands dry weather well it is very suitable for sowing on high-lying ground or for forming a bottom grass in the permanent pasture.

It is never sown alone except in lawns and bowling greens, and in these cases it takes a longer time to form a turf than a mixture of grasses, but the sower's patience is rewarded by the fine sward that results.

It is a perennial, varying from $1\frac{1}{2}$ to 2 feet in height, its seeding capacity being about three times that of ryegrass.

Poa nemoralis, or wood meadow grass, is, as its name tells us, to be found growing naturally in shady woods. It is not much used in agriculture, although its presence in the permanent pasture should be valuable on account of its extreme earliness, being as it is one of the

first grasses to come away in the spring. It is much used in lawn grass mixtures and for sowing in shaded situations.

Poa trivialis, or rough-stalked meadow grass. This grass very closely resembles another *Poa*, namely the smooth-stalked meadow grass, *Poa pratensis*, and it is often mistaken for this variety, as the roughness is sometimes scarcely sufficient to distinguish between the two; but there is one interesting and important difference between them, and it is this, while they both have procumbent or creeping stems, those of *trivialis* lie along the surface of the soil, whereas those of *pratensis* creep underground.

This, of course, has an important bearing on the agricultural value of the two grasses, as *trivialis*, on account of its exposed stolons, is more adapted for use in moist meadows; while *pratensis*, with its stolons running underground, can defy drought, and is therefore peculiarly adapted to grow in dry, loose soils, where other grasses, at least the stronger growing species, such as timothy and cocksfoot, would not succeed. These properties also make it useful as a lawn grass.

Then there are the dwarfer-growing varieties of fescue; namely, the hard fescue, *Festuca duriuscula;* the sheep's fescue, *Festuca ovina;* and the fine-leaved fescue, *Festuca tenuifolia*. These, from an agricultural point of view, may all be classed as one, as the difference is purely botanical, all of them possessing the same properties, and the difference in their appearance to the ordinary observer being scarcely noticeable.

Their principal merits lie in their growing on poor, sandy soil, and their power of withstanding drought. Their produce is not heavy, therefore they should not be sown thickly in meadows where better grasses would thrive.

These grasses, perhaps more particularly the hard fescue, form the greater part of the high-lying pastures in our highlands.

Agrostis alba var. *stolonifera*, fine bent grass or *Fiorin*. This grass has been experimented with for a number of years, and has had a great deal said both for and against it, but on the whole it has not proved itself of much value to the farmer. It is a difficult grass to grow from seed, the most successful plan for its culture being to plant the young stolons or cuttings.

The common agrostis, *Agrostis vulgaris*, is of little use, unless it be for growing in lawns. It has the merit of growing freely in dry, exposed situations, where other grasses would not survive.

The next is one of the best known and most useful of all our grasses, *Lolium perenne*, or, as it is commonly known, perennial ryegrass. This grass the farmer trusts to more than any other, with, perhaps, the exception of Italian ryegrass, for the bulk of his hay

crop. It has been cultivated in this country for over 200 years, and is at the present time far more extensively grown than any other grass we have.

There has always been a great deal of argument against the use of this grass for permanent pasture, as it is said that the ryegrass with its rapid growth crowds out or starves the slower-growing true perennials; and that later, not being of a lasting nature, it dies out and leaves the space it occupied to be filled with weeds. However, I do not think, and might say I am certain, that the case is not so bad as this, unless where an excessive amount of ryegrass has been sown. If the ryegrass be thoroughly clean and sown in proper proportion, it will be found a very valuable plant in all permanent pastures. For the first and second years it will provide the bulk of the crop, and at the same time act as a nurse to the more tender grasses. It is in this capacity that we always use it in sowing down lawns, but the proportion must be very small. One very valuable property of this grass is that in seeding it loses less of its nutritive properties than perhaps any other grass we have.

The foregoing are a few of the grasses we find in almost every lawn; but let us look for a few minutes at some of our stronger-growing agricultural grasses.

While talking of ryegrass I must not forget to mention the Italian variety, *Lolium Italicum*. This grass is found in every hay field, although one, unless looking closely, is apt to pass it as the perennial variety. It is easily distinguished by its stronger growth and the awns or fine hairs with which the lower pales are furnished.

For cutting green it is one of the best grasses which can be sown, its produce being early, heavy, and of good quality. When sown along with perennial ryegrass it is valuable in temporary leys of one to three years' duration, producing a much heavier crop than could be got by sowing perennial ryegrass alone.

The best seed is brought from France, but, as it is always very dirty with weeds, it has to be carefully recleaned. It thrives best on good soil where there is abundance of moisture.

Walking through a pasture, or by the side of any stream, one of the first grasses to attract our attention by its sturdy growth and bold flower heads is the cocksfoot, *Dactylis glomerata*, one of the best of our pasture grasses. Whether the soil be wet or dry, heavy or light, cocksfoot will hold its own. The experienced farmer knows that to get the good of it, he must have it kept closely cropped, otherwise its stems become coarse and uneatable. Its aftermath is very rapid and abundant.

The place for cocksfoot in Scotch farming is without doubt in

the permanent pasture or rotation grass lands; but as it is apt when two or three years old to form clumps, it should never be sown alone, but always with other grasses. The seed being smaller and lighter than ryegrass, one pound of it will sow as much as two pounds of the latter. The best seed comes from New Zealand, it being cleaner and stronger in growth than the European samples.

Then there are other two or three grasses which force themselves on our notice, and which are almost always rivals with the cocksfoot in the struggle for existence, notably the meadow foxtail and timothy. These two grasses resemble one another very closely in the shape of their flower heads, but you can at once tell them by touch, the timothy being hard and rough, while the foxtail is soft and woolly.

Meadow foxtail, *Alopecuris pratensis*, is a valuable grass, and deserves to be more widely cultivated; but it is a difficult grass to introduce, owing to its poor germinating quality, though of late years this has been steadily improving. It is a grass indispensable in the permanent pasture, but as it takes two or three years to come to its full growth it is of little or no use in alternate husbandry.

It is very early, and forms by the end of April abundance of juicy leaves which are greedily devoured by horses and cattle. It is only suitable for sowing on rich, moist soil, as on light land its growth is weak and apt to give out. In sowing, one pound of foxtail is equal to four pounds of ryegrass seed, while about two pounds to an acre is the quantity usually sown.

Timothy or catstail grass, *Phleum pratense*, unlike the foxtail, is more adapted for hay than permanent pasture, as it is very apt to die out in about three years' time; and not only this, but the abundance of stems it throws up makes it fitter for hay purposes. Timothy is seen at its best on damp, stiff soils, and has the merit of withstanding cold and wet.

Another grass, not quite so well known to agriculturists as some of the preceding, is the tall oatgrass, *Arenatherum avenaceum*. This grass has been the subject of a deal of discussion, as some authorities have it that there are two distinct varieties, one with a bulbous root and another with a fibrous. This latter is said to be the true tall oatgrass.

Of course this is a very important matter to farmers and worth thorough investigation, as while the fibrous-rooted variety, according to Mr. Wilson of Carbeth, is said to be the most nutritious of all our grasses, still, if it is apt to become bulbous in certain soils, it would have to be carefully used and kept out of all fields intended for alternate husbandry, as it would be almost impossible to clear the ground of its tubers.

Then there is the yellow oatgrass, *Avena flavescens*. This species is not nearly so coarse as the taller sort and is truly fibrous, so that I am inclined to think it is the better grass of the two for agricultural purposes. It is not suited for growing on stiff clay or wet land, but does well on medium soils.

I have tried to confine my remarks to grasses which are likely to interest the farmer or the ordinary observer, but the subject is too wide a one to be dealt with properly in a paper like the present. I should have liked to enter more fully into this subject and said something about that other great family of forage plants, the *Leguminosae* or pod-bearers, which rank next to the grasses in value to the farmer, including as they do the clovers, vetches, peas, beans, lucerne, saintfoin, etc.

I will, however, just say a word or two about one of them—the kidney vetch, *Anthyllis vulneraria*. Most of us are acquainted with this plant as one of our common wild flowers, often found growing on dry, stony ground and brightening up the spot with its pretty yellow flowers and silky seed pods. This plant, although much neglected in Scottish agriculture, is well worthy of attention, as its leaves are very nutritious and much liked by sheep and cattle. It is easily grown, and makes itself at home on the poorest and driest of soils. No doubt this is owing a good deal to its long tap root and the power it has, along with other members of the same family, of storing up nitrogen by the action of the curious-looking excrescences with which its roots are furnished. Sown in the permanent pasture, and perhaps more especially on dry, stony ground, it will be found a decided acquisition to our forage plants.

Reading papers and giving descriptions of these plants is all very good in its way, but what is wanted is that the farmer should take an intelligent interest in the various grasses which compose his hay and pasture fields, so that he can analyse and tell the true value of his crop, and not take it for granted that because his pasture is green or his hay crop heavy that the nutritive value ranks accordingly, for this is by no means the case. Unfortunately this accomplishment, although a valuable one, is rather rare and confined principally to experts who make it their profession. It stands to reason that if the farmer wishes to get the full value of his land he must study the various problems of agricultural botany, so that he may be able to make a judicious selection of those plants most suited for any particular soil.

Keeping this in view, let him study the questions of how plants feed, what substances constitute their food, and how this food should be presented to them, so as to have the best results with the least amount of waste.

XXII.—*Notes by a Naturalist round Dunkeld.*

By C. M'Intosh, Inver.

(Read 10th February, 1898.)

The Larch Disease. It is more than 30 years since it was observed that the larch was suffering from the attacks of an insect,—I believe an aphis,—causing blistering, malformation, and, latterly, destruction of the tree. As I am not an entomologist, I cannot say much about its life history or the species to which it may belong. During the winter months the insects are to be seen in a dormant or inactive state on the twigs and branches, especially about the knot-like buds; in the spring they become active, spreading over the leaves when these appear. On the leaves they deposit a cluster of eggs, each egg attached by a fine silk-like thread to nearly the same point on the leaf. The insect, meanwhile, remains in the cluster and partially covers itself and its eggs with a white wool-like substance, which it exudes from the pores of its body. The appearance of the insect, especially in its dormant state, is like a tortoise on a very small scale, very dark brown in colour. Frequently there is a small drop of resin in this nest-like cluster. From the eggs brood after brood of these insects appear during the summer months. The effect of the working of these insects on a larch is that much bleeding of resin takes place, the quantity exuded by badly infected young larches being so great that a person could not pass through a young planting without having his clothes besmeared. The stems, branches, and twigs, especially of young larches, become deformed with swellings and resin-smeared blisters. On the swollen blistered parts a fungus appears,—*Lachnella Calycina*,—a very small cup-shaped fungus belonging to the *Peziza*. Whether it is the fungus or the aphis, or both in conjunction, that causes the destruction is a question which I cannot answer. In this connection, however, the late John Macgregor, who was for many years forester to His Grace the Duke of Atholl, maintained that this fungus was only to be found on the part of the larch where the insect had been at work, and not on dead branches which had been cut from healthy larches. In other words, there must be an intimate connection between the aphis and the fungus. Tulief classes this fungus as a wound fungus.

The disease became so serious that the planting of larches on the Atholl estate was partially discontinued and much fir was planted instead. About twelve years ago, I observed what I thought an increase in the number of certain insect-feeding birds, especially of the Tit kind, and from observation and enquiries made I became convinced that the Great Tit, the Cole Tit, the Blue Tit, the Long-tailed Tit, together with the Gold Crest, had become much more

numerous. This was more apparent in the winter season, and the probabilities are that the birds were winter visitors. It is worthy of note that the Great, the Cole, and Blue Tits have always been common in the locality, but the Long-tailed Tit and the Gold Crest were far from being so. So much so, that old woodmen and keepers scarcely know them. This does not rest merely on my own observation, but on enquiries made of men who were likely to be acquainted with the matter—keepers and foresters. Coincident with this increase of the birds mentioned, the aphis plague on the larch has gradually abated. For the past ten years at least, the abatement has been very marked, so that now the woods in this part are well free from it to any injurious extent, and with the aphis the fungus is also disappearing. The injurious effects of the disease may still be observed on the swollen and blistered lower branches of young larches, which, though now dead or dying, were growing whilst the plague was active, and on these the fungus can still be seen. The lower part of the stem bears also the same traces of the plague; whilst above, both stem and branches are normal.

In the winter time, I have watched the Long-tailed Tits minutely searching the twigs of the larch, examining every bud, as is their manner, where the aphis undoubtedly was to be found in its inactive state. The other tits preyed on the aphis also, but the Long-tailed Tit and the Gold Crest appeared to be the most active. The Great, the Cole, and the Blue Tits feed to some extent on seeds, but the Gold Crest and Long-tailed Tit are mostly, if not altogether, insectivorous. I am of opinion that the present improved condition of the larch is due to the agency of the birds mentioned; other agencies may have helped, but they seem to have played the principal part. An increase of these birds has taken place during the winter and has had the effect of almost exterminating the plague by their destruction of the winter broods of that aphis.

I shall now give a few notes about some of the birds of the district.

The Raven. From late autumn to spring the raven is frequently to be met with in this locality. For a number of years a pair might be seen almost every morning and evening crossing the valley from Craig-y-Barns towards Birnam Hill, and a pair or sometimes two pairs may be seen almost any day hovering between Craig-y-Barns and Craig Vinean. They are said to follow the sheep that come from higher grounds to winter. In 1888, I counted as many as four pairs above Kinnaird Rock. They do not now, however, nest in the district, so far as I know (the gamekeepers take care of that); one of their former nesting places was Kennacoil Rock. Although no doubt they destroy eggs when they can find them, yet keepers confess that the common rook does more damage than they.

Among the other birds that at one time nested in the district, but are now rarely to be seen, are the Common Falcon, the Buzzard, the Gled or Kite, and the Magpie. It is curious, however, that the Jay, although it gets a bad name among gamekeepers, and is persecuted accordingly, manages to hold its own.

The Rook. Many people do not know that the rook does not roost in its nesting place unless during the breeding season. I noticed the rooks and jackdaws that nest about Dunkeld House generally met there towards the close of the day, and after a lot of cawing and aerial evolutions left—the rooks and most of the daws betaking themselves down the valley, and a small flock of daws going upward. The evening meet did not always take place, but with daylight the daws arrived at the usual meeting place, followed by the rooks a short time afterwards, about five minutes. There appeared to be two flocks of daws, and the rooks were certainly in two distinct companies, with a space of time between them. The rooks always followed the same track, passing the Episcopal Chapel, the Birnam Hotel, and along Little Dunkeld Church Park, and crossing the river above the bridge, but sometimes resting on the trees on the south side, then after a great palaver betook themselves to their feeding grounds. On misty or foggy mornings, or with contrary winds, they flew close to the ground, but when the weather was fine they kept at a greater elevation. Possibly the daws may roost about Birnam and Newtyle Quarries, but I have been unable to get any one to tell where the rooks spend the night.

SUMMER BIRDS OF THE DISTRICT.

1. *The Sand Martin.* Arrives 10th to 24th April, usual time about 24th.
2. *The House Martin.*
3. *The Swallow.* } Latter end of April, beginning of May.
4. *The Swift.* '87, 16th May; '88, 15th May; '89, 16th May; '94, 7th May.
5. *The Willow Warbler.* '86, 24th April; '87, 28th April; '88, 1st May; '89, 29th April; '90, 25th April; '94, 20th April.
6. *The Wood Warbler.* '87, 6th May; '88, 8th May; '89, 3rd May; '90, 1st May.
7. *The Sedge Warbler.* '88, 28th May; '89, 22nd May.
8. *The White Throat.* '87, 9th May; '88, 8th May; '89, 3rd May; '90, 20th May.
9. *The Red Start.* '87, 23rd April; '88, 25th April; '89, 26th April; '90, 25th April; '94, 20th April.
10. *The Tree Pipit.* '86, 29th April; '87, 29th April; '88, 29th April; '89, 25th April; '90, 24th April; '94, 20th April.

11. *The Wheat Ear.* '87, 14th April; '88, 4th April; '89, 13th April; '90, 4th April.
12. *The Stone Chat.* Only about Murthly.
13. *The Whin Chat.* Not very common; about May.
14. *The Spotted Fly Catcher.* '88, 15th May; '89, 19th May; '90, 20th May.
15. *The Black Cap Warbler.* Not often seen, but a pair with a young brood appeared at Inver and remained for some days about the gardens.
16. *The Chiff Chaff.* For two seasons a bird of the warbler kind appeared, frequenting, for the most part, tall spruce or beeches, but taking an occasional turn on willow and other bushes. Its peculiar call went on unceasingly, "Chiff, Chaff, Chief." An Englishman put it thus, "Cheery Chief, Chaff Cheery." It resembled the Wood Warbler in its movements and general appearance, but its colours were not nearly so bright. They did not appear in the district last season.

BIRDS—SEMI-MIGRANTS.

1. *Pied Wagtail.* Most leave the district, but a few remain all winter.
2. *The Grey Wagtail.* Leave the district entirely, but return.
3. *Meadow Pipit* and *Lark.* Leave this district, but remain in the country; arrive end of March.
4. *The Common Bunting.* Does not appear to range beyond Murthly.
5. *Black-headed Bunting.* Leaves the district.
6. *The Song Thrush* or *Mavis.* Is practically a migrant in this part of Perthshire, leaving the district about the end of October. In a few favoured spots, solitary birds may be seen throughout the winter, and it is not unlikely that it is these birds that are heard singing sometimes three or four weeks before the general arrival occurs. The weather appears to affect the migration of the Song Thrush more than some of our other migrants that journey to more distant parts. The following are the dates when the Song Thrush was first heard singing in this district: '86, 11th February; '87, 28th January; '89, 24th January; '90, 27th January; '91, 5th February; '92, 9th February; '93, 7th February; '95, 7th March. But the general arrival of the Song Thrushes occurred on the following dates:—'86, 13th March (cold spring); '87, 26th February; '88, 5th March; '89, 20th February; '90, 6th February; '91, 7th February; '93, 8th February; '94, 8th February; '95, 13th March. On 13th March, 1895, Song Thrushes were still scarce and not arriving in such numbers as usual.

MOOR BIRDS.

1. *Golden Plover.*
2. *Grey Plover.*
3. *Lapwing.*

} Spring.

RIVER BIRDS.

1. *The Sea Pie* or *Oyster Catcher.* Appearing with Lapwing in February and March.
2. *The Black-headed Gull.* Almost same date.
3. *The Tern.* Not appearing till April or May.
4. *The Ring Plover.* A few rest on the shingle about Dalmarnock.
5. *The Sandpiper.* April; begins to arrive up the river.

A few of the *Lesser Black-backed Gulls* are to be seen along the banks of the Tay all winter. It is almost certain that they have been attracted and kept by the number of salmon that have died from the effects of the salmon disease. During the season, I noticed one pair that left, but which returned with two more with immature plumage. Last year while the volunteers were encamped on a park at the river side, gulls of all kinds congregated there, several of which I failed to identify.

The Little Auk, *The Guillemot*, *The Razor Bill*, and *The Stormy Petrel* have been found occasionally in the district.

XXIII.—*A Preliminary List of Perthshire Mosses.*

By Robert H. Meldrum.

(Read 10th February, 1898.)

Lists of Mosses from particular localities in the County of Perth have been published on various occasions, but no list for the County as a whole has yet appeared. An attempt at such a list is subjoined for the purpose of showing what species have been found, and so directing attention to those which one would expect to occur, but which have not, so far as I know, been yet detected here.

That I have omitted several species which do occur is certain, and I hope that any one possessing information about the occurrence of such species will kindly notify me of the fact, and if possible send a specimen for the Museum Herbarium.

That some of the records here given are errors is also certain, but this is a more difficult matter to rectify, especially when one has not had an opportunity of examining the specimens on which the record was

founded. I believe, however, that the rectification of all these errors, if that were possible, would not exclude more than one or two species from the list, although in some cases the number of stations might be reduced.

I have enclosed within parentheses the name of the collector or recorder of those species Perthshire specimens of which I have neither seen nor collected. All the other species I have either gathered or seen, but not in all cases from every station here recorded. On some future occasion, when my information is more complete, I hope to give the distribution of each species with reference to the county divisions adopted by Dr. White, and, in the case of the rarer or more doubtful species, to indicate the authority for all the stations given.

In preparing the list I have utilised, in addition to my own Herbarium, that of the late Dr. White, now in the Society's Museum. I have also consulted the various Floras, Periodicals, and Transactions which are contained in the Museum Library, and am indebted for some information on the subject to botanical correspondents who have collected in the County.

The nomenclature, and the generic and specific order followed, are those adopted in the "Handbook Catalogue of British Mosses," by H. N. Dixon.

1 Sphagnum cymbifolium, Ehrh. Common. Vars. squarrosulum and congestum occur.
papillosum, Ldb. Ben Lawers, Ben Lui.
rigidum, Schp. Common as the var. compactum.
molle, Sull. Ben Lawers.
5 tenellum, Ehrh. Distributed.
subsecundum, Nees. Common. Var. contortum common.
laricinum, Spr. Distributed. Var. platyphyllum occurs.
teres, Angstr. Doune, Ben Ledi, Ben Lawers, Dunkeld.
squarrosum, Pers. Not uncommon.
10 acutifolium, Ehrh. Common. Several varieties occur.
Girgensohnii, Russ. Ben Lawers, Ben Ledi, Killin.
fimbriatum, Wils. Distributed.
intermedium, Hoffm. Distributed.
cuspidatum, Ehrh. Not uncommon. Var. plumosum occurs.
15 Andreæa petrophila, Ehrh. Common in the Highlands, less so in the Lowlands. Vars. alpestris and sparsifolia occur.
alpina, Sm. Common on the Grampians; rare on the Ochils. Var. compacta occurs.

Andreæa Rothii, W. & M. Grampians. Var. falcata more common.

crassinervia, Bruch. Ben Lui (Ewing).

Tetraphis pellucida, Hedw. Methven, Killin, Dunkeld, Blair Atholl, Ben Lui.

Browniana, Grev. Ben Lui (Ewing).

Catharinea undulata, W. & M. Very common. Var. minor occurs.

angustata, Brid. Doune (M'Kinlay).

Oligotrichum incurvum, Ldb. Common in alpine and sub-alpine districts.

Polytrichum nanum, Neck. Not uncommon about Perth, Blair-Atholl.

aloides, Hedw. Common. Var. Dicksoni, Kenmore.

urnigerum, L. Distributed. Var. humile occurs.

alpinum, L. Common on the mountains.

sexangulare, Ehrh. Ben Lawers, Ben Lui.

piliferum, Schreb. Common.

juniperinum, Willd. Common.

strictum, Banks. Not uncommon.

gracile, Dicks. Blairgowrie, Callander, Glen Falloch, Ben Lawers.

formosum, Hedw. Distributed.

commune, L. Very common. Vars. perigoniale and minus occur.

Buxbaumia aphylla, L. Rannoch, Ben Ledi, near Perth.

Diphyscium foliosum, Mohr. Not uncommon in the Highlands

Pleuridium subulatum, Rab. Common about Perth, Blair-Atholl.

alternifolium, Rab. About Perth.

Ditrichum homomallum, Hpe. Not uncommon. Var. zonatum, Ben Lawers.

flexicaule, Hpe. Distributed. Var. densum occurs.

Swartzia montana, Ldb. Common on the Grampians.

inclinata, Ehrh. Ben Lawers (Fergusson), Ben Lui (Ewing).

Seligeria Doniana, C.M. Dupplin, near Cherrybank, Kincardine Glen, Blair Atholl.

pusilla, B. & S. Blair-Atholl, Glenshee.

tristicha, B. & S. Blair-Atholl.

recurvata, B. & S. Blair-Atholl.

Brachyodus trichodes, Fürnr. Note of locality lost. Gathered by Dr. F. B. White.

Ceratodon purpureus, Brid. Very common.

Rhabdoweisia fugax, B. & S. Highlands.
denticulata, B. & S. Highlands.
Cynodontium Bruntoni, B. & S. Distributed.
polycarpum, Schp. Grampians. Var. laxirete, Glenlyon.
strumiferum, De Not. Reported from Dalnaspidal (Boyd).
virens, Schp. Grampians. Var. serratum occurs.
Wahlenbergii, R. & C. Sow of Atholl.
Dichodontium pellucidum, Schp. Common. Var. fagimontanum, Ben Lawers.
flavescens, Ldb. Near Cherrybank, Glengarr.
Trematodon ambiguus, Hornsch. Schiehallion (Braithwaite).
Dicranella heteromalla, Schp. Common. Var. stricta, Amulree.
cerviculata, Schp. Blairgowrie, Dalnaspidal.
crispa, Schp. Ben Lawers, Kenmore.
secunda, Ldb. Not uncommon in the Highlands.
rufescens, Schp. Common about Perth.
varia, Schp. Common.
Grevilleana, Schp. Glentilt, Glenshee.
Schreberi, Schp. Craighall (Fergusson), Killin (Holt).
squarrosa, Schp. Common in alpine and subalpine districts.
Blindia cæspiticia, Ldb. Ben Lawers.
acuta, B. & S. Common in the Highlands. Var. trichodes occurs.
Dicranoweisia cirrata, Ldb. Not uncommon.
crispula, Ldb. Grampians.
Campylopus subulatus, Schp. Moncreiffe and Kinnoull Hills.
Schimperi, Milde. Grampians.
Schwarzii, Schp. Grampians.
flexuosus, Brid. Common. Vars. uliginosus and paradoxus occur.
pyriformis, Brid. Not uncommon.
fragilis, B. & S. Not common.
atrovirens, De Not. Common on the Grampians.
brevipilus, B. & S. Doune, Breadalbane, Persie.
Dicranodontium longirostre, B. & S. Trossachs, Ben Ledi, Breadalbane Mountains. Var. alpinum occurs.
Dicranum fulvellum, Sm. Breadalbane Mountains, Sow of Atholl.
falcatum, Hedw. Breadalbane Mountains, Glentilt.
Starkii, W. & M. Grampians.
schisti, Ldb. Ben Lawers, Ben Lui.
molle, Wils. Ben Lawers, Ben Lui, Ben Challum.

Dicranum undulatum, Ehrh. Dupplin Woods.
spurium, Hedw. Trossachs (Stirton).
Bonjeani, De Not. Common. Var. juniperifolium occurs.
scoparium, Hedw. Common. Vars. paludosum, orthophyllum, and spadiceum occur.
majus, Turn. Common.
fuscescens, Turn. Not uncommon. Vars. congestum and flexicaule occur.
Scottianum, Turn. Rannoch.
montanum, Hedw. Craighall, Pitlochry.
uncinatum, C.M. Ben More, Ben Challum.
asperulum, Mitt. Ben Ledi, Stuc-a-chroin.
Leucobryum glaucum, Schp. Common.
Fissidens exilis, Hedw. Cherrybank.
viridulus, Wahl. Bonhard.
pusillus, Wils. Blair-Atholl (M'Inroy).
bryoides, Hedw. Common.
osmundoides, Hedw. Not uncommon in the Highlands.
adiantoides, Hedw. Common.
decipiens, De Not. Cherrybank.
taxifolius, Hedw. Common.
Grimmia apocarpa, Hedw. Common. Vars. rivularis, gracilis, and pumila occur.
conferta, Funck. Callerfountain, Moncreiffe Hill, Ben-y-Gloe. Var. pruinosa, Doune.
funalis, Schp. Grampians.
torquata, Hornsch. Grampians.
pulvinata, Sm. Very common.
orbicularis, Bruch. Dupplin.
trichophylla, Grev. Common,
subsquarrosa, Wils. Kinnoull, Moncreiffe, Callerfountain, Balthayock.
decipiens, Ldb. Stenton, Callerfountain, Dunsinane, Ben Lui.
Hartmani, Schp. Blairgowrie, Rannoch, Killin, Ben Ledi
patens, B. & S. Grampians.
Doniana, Sm. Highlands.
ovata, Schwgr. Breadalbane, Ben Vrackie.
commutata, Hübn. Moncreiffe, Callerfountain, Stenton, Craig Chailleach.
leucophæa, Grev. Callerfountain, Kilspindie.
Rhacomitrium ellipticum, B. & S. Breadalbane.
aciculare, Brid. Common.

Rhacomitrium protensum, Braun. Highlands.
fasciculare, Brid. Common.
heterostichum, Brid. Very common. Vars. alopecurum and gracilescens occur.
sudeticum, B. & S. Grampians.
lanuginosum, Brid. Common.
canescens, Brid. Common. Var. ericoides frequent.
Coscinodon cribrosus, Spr. Near Perth.
Ptychomitrium polyphyllum, Fürnr. Not uncommon.
Hedwigia ciliata, Ehrh. Common.
Acaulon muticum, C.M. About Perth, Dunkeld.
Phascum cuspidatum, Schreb. About Perth, Blair-Atholl. Var. piliferum occurs.
Pottia truncatula, Ldb. Common.
intermedia, Fürnr. About Perth.
lanceolata, C.M. Blair-Atholl (M'Inroy).
latifolia, C.M. Glenshee, Glentilt, Ben Lawers.
Tortula rigida, Schrad. Blair-Atholl (M'Inroy).
muralis, Hedw. Very common.
canescens, Mont. Near Perth.
subulata, Hedw. Common.
mutica, Ldb. Tidal parts of Tay and Earn.
lævipila, Schwgr. Not uncommon.
intermedia, Berk. Distributed.
ruralis, Ehrh. Not uncommon.
princeps, De Not. Blair-Atholl, Glenfarg, Killin.
papillosa, Wils. About Perth.
Barbula rubella, Mitt. Common. Vars. dentata and ruberrina occur.
tophacea, Mitt. Distributed.
fallax, Hedw. Not uncommon. Var. brevifolia occurs.
recurvifolia, Schp. Ben Lawers, Cherrybank, Glenshee.
spadicea, Mitt. Not uncommon.
rigidula, Mitt. Not uncommon.
cylindrica, Schp. Not uncommon.
icmadophila, Schp. Ben Lawers.
Hornschuchiana, Schultz. Glenshee (Fergusson).
revoluta, Brid. Not uncommon.
convoluta, Hedw. Distributed.
unguiculata, Hedw. Common.
Leptodontium flexifolium, Hpe. Ben Lui, Ben Ledi, Callander, Sma' Glen.
recurvifolium, Ldb. Creag Mohr (Holmes).
Weisia microstoma, C.M. Not uncommon about Perth.

Weisia tortilis, C.M. Callerfountain.
viridula, Hedw. Common.
mucronata, B. & S. Ben Lui (Ewing).
tenuis, C.M. Bonhard, Dupplin, Blair-Atholl.
rupestris, C.M. Distributed.
curvirostris, C.M. Highlands. Vars. commutata and scabra occur.
verticillata, Brid. Invermay, Glen Tilt.
Trichostomum crispulum, Bruch. Shore of Loch Tay.
mutabile, Bruch. Callerfountain and Rannoch as the var. littorale.
tenuirostre, Ldb. Breadalbane Mountains. Var. Daldinianum occurs.
tortuosum, Dixon. Common, especially on the mountains. Vars. dicranoideum and fragilifolium occur.
fragile, Dixon. Ben Lawers, Ben Lui.
Cinclidotus fontinaloides, P.B. Tay, above Perth; Earn, at Forgandenny; Craighall.
Encalypta commutata, N. & H. Ben Lawers, Craig Chailleach, Ben Ledi. Var. imberbis, Ben Lui.
vulgaris, Hedw. Distributed.
ciliata, Hoffm. Not uncommon on Grampians and Ochils.
rhabdocarpa, Schwgr. Ben Lawers, Craig Chailleach, Glen Tilt, Ben Lui.
streptocarpa, Hedw. Common.
Anœctangium compactum, Schwg. Common on the mountains. Var. pellucidum occurs.
Zygodon lapponicus, B. & S. Not uncommon on the Grampians.
Mougeotii, B. & S. Not uncommon.
viridissimus, R.Br. Common. Var. rupestris occurs.
Stirtoni, Schp. Kinnoull, Moncreiffe, Killin, Ben Lawers.
conoideus, H. & T. Killin (Hunt).
Ulota Ludwigii, Brid. Killin, Trossachs, Glen Falloch.
Drummondii, Brid. Not uncommon in the Highlands.
Bruchii, Hornsch. Common.
crispa, Brid. Not uncommon. Var. intermedia occurs.
phyllantha, Brid. Distributed.
Hutchinsiæ, Hamm. Ben Ledi, Breadalbane Mountains.
Orthotrichum rupestre, Schleich. Common. Vars. Sturmii and Franzonianum occur.
anomalum, Hedw. Moncreiffe, Kinnoull. Var. saxatile more frequent.
cupulatum, Hoffm. Not common. Var. nudum more frequent.

Orthotrichum leiocarpum, B. & S. Not uncommon.
Lyellii, H. & T. Common.
speciosum, Nees. Glen Tilt (West).
affine, Schrad. Common. Vars. rivale and fastigiatum occur.
rivulare, Turn. Rivers Tay, Earn, Almond, Teith.
Sprucei, Mont. Dead waters of the Earn, Birnam.
stramineum, Hornsch. Not uncommon.
tenellum, Bruch. Blair-Atholl, Killin.
pulchellum, Sm. Blair-Atholl.
diaphanum, Schrad. About Perth.
Œdipodium Griffithianum, Schwg. Grampians.
Splachnum ampullaceum, L. Highlands.
sphaericum, L.f. Highlands.
vasculosum, L. Ben Lawers, Ben More, Glenshee.
Tetraplodon mnioides, B. & S. Highlands.
Tayloria tenuis, Schp. Ben Lawers, Killin.
lingulata, Ldb. Ben Lawers, Craig Chailleach, Ben Lui.
Discelium nudum, Brid. Near Perth (Don), Mouth of the Earn (White).
Ephemerum serratum, Hpe. Kinnoull.
Physcomitrium pyriforme, Brid. Blair-Atholl, Blairgowrie.
Funaria fascicularis, Schp. About Perth.
ericetorum, Dixon. About Perth, Breadalbane, Blair-Atholl.
Templetoni, Sm. Killin.
hygrometrica, Sibth. Very common.
Amblyodon dealbatus, P.B. Ben Lui, Craig Chailleach, Glen-tilt.
Meesia trichoides, Spr. Breadalbane Mountains. Vars. alpina and minor.
Aulacomnium turgidum, Schwgr. Ben More, Ben Challum, Creag Mohr, Ben Dheiceach.
palustre, Schwgr. Common.
Timmia austriaca, Hedw. Ben Lawers, Creag Mohr.
norvegica, Zett. Ben Lawers, Craig Chailleach.
Catoscopium nigritum, Brid. Ben-y-Gloe, Glenshee, Ben Lawers, Ben Lui.
Conostomum boreale, Sw. Grampians.
Bartramia Œderi, Sw. Breadalbane, Glenalmond, Craighall, Blair-Atholl.
ithyphylla, Brid. Common in the Highlands.
pomiformis, Hedw. Common. Var. crispa occurs.
Halleriana, Hedw. Balquidder, Dunkeld, Ben Lui.

Philonotis fontana, Brid. Very common. Vars. compacta and falcata occur.
adpressa, Ferg. Ben Lawers, Glenshee.
calcarea, Schp. Cherrybank, Ben Lawers, Ben Lui, Callander.
Breutelia arcuata, Schp. Common.
Leptobryum pyriforme, Wils. Inchture, Glentilt, frequent in Greenhouses.
Webera polymorpha, Schp. Breadalbane Mountains.
acuminata, Schp. Breadalbane Mountains.
elongata, Schp. Not uncommon in the Highlands.
cruda, Schwgr. Not uncommon.
nutans, Hedw. Common. Var. longiseta, Methven Moss.
cucullata, Schp. Ben Lawers.
annotina, Schwgr. Near Perth, Ben Lui, Ben More.
Ludwigii, Schp. Ben Lawers, Ben Challum. Vars. latifolia and elata occur.
commutata, Schp. Ben Lawers. Var. catenulata, Ben Lawers.
carnea, Schp. Blair-Atholl, Bank of the Earn near Forgandenny.
albicans, Schp. Common. Var. glacialis, Breadalbane.
Plagiobryum Zierii, Ldb. Not uncommon on Grampians, Ochils.
demissum, Ldb. Ben Lawers, Craig Chailleach.
Bryum filiforme, Dicks. Frequent on the mountains.
pendulum, Schp. Distributed.
uliginosum, B. & S. Inverarnan (Hunt).
inclinatum, Bland. Not uncommon.
pallens, Sw. Not uncommon.
Duvalii, Voit. Ben Lawers, Ben More, Glenshee.
turbinatum, Schwgr. Ben More, Ben Lawers, and Ben Lui as the var. latifolium.
bimum, Schreb. Distributed.
pseudo-triquetrum, Schwg. Not uncommon.
pallescens, Schleich. Ben Lawers, Strathtummel, Dalnaspidal, Ben Lui.
affine, Ldb. Falls of Lochay (Hunt). Var. cirratum, Ben Lawers (Stirton).
intermedium, Brid. Distributed.
cæspiticium, L. Not uncommon.
capillare, L. Common. Var. Ferchelii, Killin.
barbatum, Wils. Ben Ledi (Stirton).

Bryum erythrocarpum, Schwgr. Blair-Atholl, Ben Lui.
atropurpureum, W. & M. Blair-Atholl, Logiealmond.
alpinum, Huds. Not uncommon in the Highlands; occurs also in the Lowlands, as at Perth.
Mildeanum, Jur. Ben Lawers, Ben Chonzie.
argenteum, L. Not uncommon.
roseum, Schreb. Dunkeld, Aberfeldy, Blair-Atholl.
Mnium affine, Bland. Near Killiecrankie.
cuspidatum, Hedw. Not uncommon.
rostratum, Schrad. Not uncommon.
undulatum, L. Frequent.
hornum, L. Common.
serratum, Schrad. Not uncommon.
orthorrhynchum, B. & S. Ben Lawers,
riparium, Mitt. Aberdalgie.
spinosum, Schwgr. Ben Lawers, Glenshee.
stellare, Reich. Not uncommon in the Ochil Glens.
cinclidioides, Hübn. Ben Lawers, Craig Chailleach, Ben Challum.
punctatum, L. Common.
subglobosum, B. & S. Kinnoull, Aberdalgie, Aberfeldy.
Cinclidium stygium, Sw. Ben Lawers, Craig Chailleach, Ben Ledi, Glenshee.
Fontinalis antipyretica, L. Common. Vars. gigantea and gracilis occur.
squamosa, L. Tay, Earn, Glenshee.
Cryphæa heteromalla, Mohr. Near Callander (**Bry. Brit.*), Bridge of Earn (Sadler).
Neckera crispa, Hedw. Not uncommon. Var. falcata occurs.
pumila, Hedw. Ben Lui (Ewing). Var. Philippeana, Callander (M'Kinlay).
complanata, Hübn. Not uncommon.
Homalia trichomanoides, Brid. Not uncommon.
Pterygophyllum lucens, Brid. Not uncommon in the Highlands.
Leucodon sciuroides, Schwgr. Distributed. Var. morensis, Craig Chailleach.
Pterogonium gracile, Sw. About Perth, Killin, Stenton.
Habrodon Notarisii, Schp. Killin, Ben Lawers.
Myrinia pulvinata, Schp. Kinfauns, Dead Waters of the Earn.
Antitrichia curtipendula, Brid. Not uncommon.
Porotrichum alopecurum, Mitt. Common.
Myurella julacea, B. & S. Breadalbane Mountains.
apiculata, B. & S. Breadalbane Mountains.

* Wilson's *Bryologia Britannica.*

Leskea polycarpa, Ehrh. Tidal parts of Tay and Earn.
nervosa, Myr. Ben Lawers (Stirton).
Anomodon longifolius, Hartm. Ben Lawers (Greville).
attenuatus, Hübn. Ben Lawers *(*B. M. F.)*
viticulosus H. & T. Not uncommon.
Pterigynandrum filiforme, Hedw. Grampians. Var. heteropterum occurs.
Heterocladium heteropterum, B. & S. Cherrybank, Glenfalloch, Breadalbane, Blair-Atholl.
squarrosulum, L. Ben Lawers.
Pseudoleskea atrovirens, B. & S. Ben Lawers, Blair-Atholl.
catenulata, B. & S. Ben Lawers, Blair-Atholl, Loch Loch.
Thuidium abietinum, B. & S. Callerfountain, Dunsinane, Breadalbane Mountains.
decipiens, De Not. Glenshee, Ben Lawers.
tamariscinum, B. & S. Common.
recognitum, Ldb. Breadalbane.
Philiberti, Limpr. Craig Chailleach (Dixon), Ben Lui (Dixon).
Climacium dendroides, W. & M. Common.
Cylindrothecium concinnum, Schp. Breadalbane Mountains, Loch Loch.
Orthothecium rufescens, B. & S. Breadalbane, Atholl.
intricatum, B. & S. Ben Lawers, Ben Lui, Loch Loch, Trossachs.
Lescuræa striata, B. & S. Ben Lawers as the var. saxicola (West).
Isothecium myurium, Brid. Common.
Pleuropus sericeus, Dixon. Common.
Camptothecium lutescens, B. & S. Not uncommon.
nitens, Schp. Near Glenfarg.
Brachythecium plicatum, B. & S. Ben Lawers, Craig Chailleach.
glareosum, B. & S. Ben Lawers (Stirton).
albicans, B. & S. Common.
salebrosum, B. & S. Recorded from Glentilt (M'Inroy).
rutabulum, B. & S. Common.
rivulare, B. & S. Not uncommon.
Starkei, B. & S. Ben Lawers, Ben Lui.
glaciale, B. & S. Ben Lawers, Ben Challum.
reflexum, B. & S. Ben Lawers.
velutinum, B. & S. Common.
populeum, B. & S. Common.
plumosum, B. & S. Common.
cæspitosum, Dixon. Near Perth.

* Braithwaite's *British Moss Flora.*

Brachythecium illecebrum, De Not. Near Perth.
purum, Dixon. Very common.
Hyocomium flagellare, B. & S. Loch Voil.
Eurhynchium cirrosum, Jur. Ben Lawers.
piliferum, B. & S. Not uncommon.
crassinervium, B. & S. Aberdalgie, Invermay, Glen Devon, Quarrymill.
prælongum, B. & S. Not uncommon. Var. Stokesii occurs.
Swartzii, Hobk. Distributed.
pumilum, Schp. Cherrybank.
Teesdalei, Schp. Rannoch, Blair-Atholl.
tenellum, Milde. Blair-Atholl, Pitroddie.
myosuroides, Schp. Common.
Hyocomium striatum, B. & S. Not uncommon.
rusciforme, Milde. Common.
murale, Milde. Kinnoull.
confertum, Milde. Not uncommon about Perth, Blair-Atholl.
Plagiothecium depressum, Dixon. Aberdalgie, Trossachs.
Borrerianum, Spr. Not uncommon.
Müllerianum, Schp. Craig Chailleach, Ben Lui.
pulchellum, B. & S. Not uncommon in the Highlands.
striatellum, Ldb. Grampians.
denticulatum, B. & S. Common. Var. obtusifolium occurs.
sylvaticum, B. & S. Near Perth, Glentilt.
undulatum, B. & S. Common.
Amblystegium serpens, B. & S. Common.
irriguum, B. & S. About Perth, Callander, Blackford.
fluviatile, B. & S. Dupplin.
filicinum, De Not. Common. Vars. Vallisclausæ and gracilescens occur.
curvicaule, Ldb. Ben Lawers. Var. strictum, Ben Lawers.
Hypnum riparium, L. Dead waters of the Earn. Var. longifolium, near Cherrybank.
stellatum, Schreb. Common. Var. protensum, Cherrybank.
chrysophyllum, Brid. About Perth.
Sommerfeltii, Myr. Blair-Atholl (M'Inroy).
Halleri, L.f. Ben Lawers, Ben Cruban.
aduncum, Hedw. Not uncommon as the var. Kneiffii.
Sendtneri, Schp. Callander (Braithwaite).
fluitans, L. Common.

Hypnum exannulatum, Gümb. Not uncommon in Highlands
Vars. purpurascens and stenophyllum occur.
uncinatum, Hedw. Common. Var. plumulosum occurs.
revolvens, Sw. Common.
intermedium, Ldb. Near Cherrybank.
commutatum, Hedw. Not uncommon.
falcatum, Brid. Breadalbane, Cherrybank. Var. gracilescens, Ben Lawers.
sulcatum, Schp. Ben Lawers.
incurvatum, Schrad. Blair-Atholl (M'Inroy).
cupressiforme, L. Very common. Vars. resupinatum, filiforme, ericetorum, and tectorum occur.
imponens, Hedw. Ben Lawers.
Patientiæ, Ldb. Common about Perth, Craighall, Glen Devon.
revolutum, Ldb. Ben Lawers.
hamulosum, B. & S. Breadalbane Mountains.
callichroum, Brid. Breadalbane Mountains.
Bambergeri, Schp. Ben Lawers.
procerrimum, Mol. Ben Lawers.
molluscum, Hedw. Common.
crista castrensis, L. Not uncommon.
palustre, L. Common.
arcticum, Somm. Ben Lawers, Ben Challum, Glenshee.
eugyrium, Schp. Ben Lawers.
ochraceum, Turn. Grampians, Ochils.
scorpioides, L. Common.
stramineum, Dicks. Breadalbane, Methven.
trifarium, W. & M. Grampians.
cordifolium, Hedw. Not uncommon.
giganteum, Schp. Distributed.
sarmentosum, Wahl. Grampians. Var. subflavum, Ben Lawers.
cuspidatum, L. Common.
Schreberi, Willd. Common.

Hylocomium splendens, B. & S. Common.
umbratum, B. & S. Trossachs, Ben Lui, Ben Lawers.
pyrenaicum, Ldb. Ben Lawers.
brevirostre, B. & S. Killin, Blair-Atholl.
loreum, B. & S. Common.
squarrosum, B. & S. Very common.
triquetrum, B. & S. Common.
rugosum, De Not. Ben Lawers, Craig Chailleach, Dunsinane, Kinnoull, Moncreiffe, Callerfountain, Invermay.

XXIV.—*The Geological Factors in the Distribution of the Alpine Plants of Perthshire.*

By Peter Macnair.

(Read 14th April, 1898.)

The problem of the distribution of our alpine plants is one which has attracted from time to time the attention of many of our leading botanists, though up to the present moment it can scarcely be said that any satisfactory answer has yet been given to this difficult question. The fact that on certain of our Highland mountains, such as Ben Lawers, Canlochan, Ben Lui, and others, there are to be found many species of alpine plants whose native habitat is supposed to have been the Scandinavian mountains, and which are now mostly confined to Lapland, Norway, and the Alps, has long been recognised. The Breadalbane mountains were first explored by Lightfoot and Stuart about the year 1773, while in 1779, we find Don making excursions into the Highlands of Forfarshire and adding considerably to our knowledge of the existence of alpine species on these mountains. Since then, these mountains have been carefully searched by many of our leading botanists, the result being that we have now quite an exhaustive knowledge of the different alpine plants which grow upon them, and the different stations where they are to be found. As the late Dr. Buchanan White has pointed out, it is a remarkable fact that Stuart does not seem to have ever visited Ben Lawers though he was well aware of the richness of the Craig-na-Caillach and Meall-nan Tarmachan ridge, and had visited more distant mountains than Ben Lawers in his botanical searches. Ben Lawers does not appear to have become known till towards the end of the last century, and, as we have already pointed out, it was between the years 1779 and 1812 that Don made that remarkable addition to the list of British plants, mainly from the Clova mountains, whose botanical treasures he was the first to reveal. About the year 1873, another valuable addition to the list of stations for these plants was made in the discovery, by Dr. Buchanan White and Colonel Drummond Hay, that Ben Lui was exceedingly rich in alpine flora. Such, then, is a brief notice of the discovery of these localities, and when we come to inquire into the geological factors in the distribution of these plants we shall be better able to appreciate their significance, for we shall see that they are not distributed at random, but according to certain geological laws which were in operation directing the lines of plication into which the Highland rocks were thrown during the great process of mountain building.

The problem of the distribution of these alpine plants may

be stated as follows:—On the summits of a series of mountains stretching from Ben Lui, on the confines of Perth and Argyllshire, north-eastwards through Meall-Ghaordie and along the ridge bounding the north of Loch Tay, and including such high peaks as Craig-na-Caillach, Meall-nan-Tarmachan, Beinn Ghlass, and, highest of all, Ben Lawers, and from Breadalbane north-eastwards into Clova, we find an exuberant development of alpine plants. It would be entirely superfluous for me to here enter into a description of the various rare species which occur on these mountains, for they are well known to you all. Most of you have climbed the Ben, and there, on the precipices which form the western side of the mountain, at an elevation of over 3000 feet, have gathered the alpine forget-me-not *(Myosotis alpestris)*, which in Britain is only to be found on the Breadalbane mountains, but which grows in great luxuriance in the Swiss Alps. We have climbed the mountain in all seasons of the year, even when the upper 2000 feet was enveloped in a thick mantle of snow and the winds came howling in long-drawn gusts from Glenlyon below, so that we had to crawl on hands and knees across the precipice to reach the summit, as it was impossible to pass it in an erect position. We have also wandered over the summit for a whole night that we might behold from the mountain the sun rise upon a new day. But dearest to our memory are those lovely days toward the end of summer when the whole precipice is radiant with the glory of the deep blue flowers of the alpine forget-me-not, when, after a long day's geologising over the mountain, we return to the precipice and gathering a few specimens place them carefully and lovingly in our bag among the rocks and minerals as a future remembrance of the days that are no more. Here in these precipices are to be seen some of the finest sections which we know of that band of sericite schist which forms such an important factor in the distribution of these alpine plants, one of its most characteristic features being here magnificently displayed, namely, the many intricate folds into which it has been thrown during the great earth movements which upheaved these mountains from the bottom of the sea where their materials were originally deposited. But regarding the importance of these rocks in the present distribution of our alpine plants we shall have more to say anon.

Ascending from these precipices to the summit ot Ben Lawers, we here find the same schistose rocks weathered into a series of rock-girt pits or hollows, which form the abode of *Saxifraga cernua*, its only station in Great Britain; adopting the theory that it, with its fellows, once covered the lowlands, its solitary position here has not been inaptly called its last citadel. Step by step, the upward march of the Germanic flora has pushed it from the plains to the hills and from

the hills to the mountains; one by one, the mountain citadels have fallen, the results rather of starvation within the walls than of assault from the enemies without, till here on the summit of Ben Lawers it takes its last stand in the final struggle. Along this ridge of mountains, many other alpine species are to be found, as *Gentiana nivalis*, *Salix herbacea*, *Saussurea alpina*, *Erigeron alpinus*, *Dryas octopetela;* while on the Clova mountains we have many of the Breadalbane plants and others, which are confined to the Clova mountains alone, as *Carex alpina*, *Astragalus alpinus*, etc.

Now, it is a remarkable fact that to the north and south of this ridge of mountains, stretching from Ben Lui to Canlochan, and upon which are found these rare alpine plants, we have other peaks rising to an equally high altitude, such as Ben Vorlich (3224 feet), Stuc-a-Chroin (3189 feet), Ben More (3843 feet), Am Binnein (3827 feet), Ben Ledi (2875 feet), Schiehallion (3547 feet), Ben-y-Ghloe, and others, which, though not absolutely destitute of alpine plants, are yet comparatively poor, both in species and individuals, so as to present a striking contrast to the alpine flora of the Breadalbane and Clova mountains, while in the latter regions the common plants grow both more luxuriantly and to greater dimensions, and on them grow these rarer species which we can find nowhere else in Britain.

Out of a consideration of this problem there arise such questions as these :—

How came these plants to be isolated upon the summits of our Highland hills?

Why should they be confined to this particular ridge of our Scottish Highlands?

Are they the remains of an alpine flora which at one time extended over the whole of Scotland? Or,

Were they conveyed to the summits at a period in the geological history of Scotland when the main mass of our country lay buried beneath the sea?

These and other such questions which they invoke have been considered again and again, both by geologists and botanists, but while on the one hand botanists are still sadly in ignorance of the laws which have governed the distribution of our British flora, so geologists on the other hand are equally ignorant of the exact physical changes which have taken place in our island during later geological times. We now turn to see how far the views of botanists and geologists, such as they have been set forth, offer a solution of the problem regarding the distribution of these plants. That they are not indigenous to our Perthshire mountains will be at once granted by all who have seen them there, the species being so few and the individuals so limited in numbers, while their isolated position on our Scottish

mountains tends to show that we must seek elsewhere for evidence of their original centres of distribution. Accepting the view that they must have been propagated from some centre, the question then arises—Where is the centre of distribution? It is now believed by many of our botanists, zoologists, and geologists that in geological times the various faunas and floras of which evidence is found in the rocks have had a boreal origin and have migrated from the north southwards. Now, in the case of our alpine plants, it seems that they, following the same law of distribution as the more ancient faunas of geological times, have had a similar boreal origin. Thus many of the plants of Lapland and Norway are specifically identical with those found in our Perthshire mountains, and as we trace them towards more southern latitudes we find they become gradually scarcer and eventually disappear.

In the year 1845, Prof. E. Forbes for the first time drew attention to a large amount of botanical, zoological, and geological evidence bearing upon the present distribution of the alpine fauna and flora of our islands. He recognised in the occurrence of these alpine plants upon our mountains evidence that, during the period when they migrated from their native habitat to the position which they occupy on our mountain summits, Scotland must have been in a much more arctic condition than it is now, so he fixed upon the glacial age as the period when these plants migrated into our country. He also recognised in the presence of such maritime plants as *Armeria maritima*, *Cochlearia grœnlandica*, *Plantago maritima*, etc., evidence that a considerable submergence of our country had taken place, as many of these maritime plants are now found at considerable altitudes upon our mountains. Thus the first plant in the three we have just mentioned, the common sea-pink of our shores, can be found in great numbers, at an elevation of from 3000 to 4000 feet, upon our Highland mountains, but we have to pass from that altitude to the sea shore before we again meet with it. As to the other two species which we have mentioned having a similar vertical distribution, it was concluded, by Forbes, that during the period these plants were introduced to our country the British Islands must have stood at a much lower level; in a word, the distribution of these plants upon our mountains indicates the old shore lines at which the present land surface must have stood. The whole evidence, he pointed out, tended to show that when these plants migrated to our country it stood at a much lower level, only the summits of the higher mountains appearing above the sea; that an intense cold existed, so that this sea was filled with icebergs containing sand, mud, and stones floated from more northern latitudes, and that during this period our Alpine plants managed to establish a footing upon our Highland summits; that gradually, as the land rose,

the Germanic flora spread across the intervening plain, and as the temperature grew milder pushed the Alpine plants to the few summits where they are now found to exist.

Since the time of Forbes, however, as you are well aware, the opinions of geologists have undergone a considerable change as to the exact physiographical conditions which prevailed in our country during the glacial period. The scratchings and groovings found upon the surface rocks of our country are no longer regarded as indicating the presence of icebergs in a sea beneath which Great Britain lay buried, with only a few of the higher mountain summits rising here and there as islands in this Arctic ocean. It is now generally believed that the groovings and scratchings, along with the accompanying boulder clay, are the results of land ice rather than of icebergs, and that during the period when they were formed the land was swathed in a great ice sheet, similar to that which covers Greenland at the present day, it being denied by some that we have any reliable evidence of a great submergence during the glacial period, while others maintain that such evidence which does exist clearly points in the other direction, namely in favour of a submergence of the land. We cannot here enter into a detailed examination of the geological evidence for and against the occurrence of a great submergence. The question is one beset with many difficulties, as the evidence is of such a scanty and fragmentary nature that it is often difficult to say which way it tells. The principal evidence in favour of such a submergence is, of course, that derived from the presence of high-level shell beds, such as those alleged to have been found at Chapelhall, near Airdrie, at an elevation of 510 feet; the well-known Clava section, at an elevation of 500 feet; and other similar high-level shell beds in England, Wales, and Ireland. With regard to the evidence in support of a great submergence supposed to be derived from the occurrence of these maritime plants at high altitudes, it will be remembered that Dr. Buchanan White in his presidential address to the East of Scotland Naturalists' Union, in 1884, not only referred to the geological evidence as all against a great submergence of the land, but also cast considerable doubt upon the value of these maritime plants as evidence of such a submergence, his own view being that these plants grow upon the mountains for the same reason as they grow upon the seashores, simply because they have more room to grow there. He considered that these maritime plants, with the Alpines, once covered all the lower ground, from which they have been exterminated in the struggle for existence.

If, then, it cannot be shown that this great submergence ever took place, it remains for us to fix some other period during the ice age at which the migration of these Alpine plants may have occurred.

It is generally supposed by those who deny that these plants reached our country during a great submergence of the land, that the most likely period at which this could have taken place would have been towards the close of the glacial period, when the last traces of the local glaciers had disappeared, or at least when they had retired to the higher reaches of the mountains. From evidence into which we cannot now enter, it is supposed that towards the close of the ice age the British Isles underwent a slow upheaval to a height probably corresponding with the 80-fathom line, the consequence being that the present bed of the North Sea was elevated into land through which flowed the Rhine, with the Thames, Ouse, Tay, and other British rivers now entering the North Sea as its tributaries. At this time the English Channel, St. George's Channel, and the Irish Sea were also land, forming a group of low-lying grounds uniting Britain and Ireland to the Continent, so that the immigration of the Scandinavian flora took place step by step across the plains from these boreal centres of dispersion until they covered the whole of the British Isles. Professor James Geikie, in "Prehistoric Europe," has gone the length of contending that an elevation of the present sea bottom to the 500-fathom line must have taken place, and his principal argument in favour of such an extensive upheaval is that derived from the presence of representatives of the Scandinavian flora in the Faroe Islands, which he maintains could not have reached these islands without a land connection with their centres of dispersal. Mr. A. J. Jukes Browne, however, in his "Building of the British Isles," after citing Mr. A. R. Wallace's views upon island floras, says: —"The Scandinavian character of the Faroe flora can be explained by other means than the great elevation which would have been required to unite it to Scotland, and we may therefore dismiss Professor Geikie's views of the geography of this period as quite unwarranted by the facts which are known to us."

It might here be noted that within the last two years the great submergence theory has again been brought before us in a prominent manner, and that principally owing to the researches of Mr. John Smith, of Kilwinning, who has shown that in Ayrshire we have evidence of a submergence to a height of over a thousand feet, a high-level shell bed being described as occurring at Dippal, in Ayrshire, at an elevation of 1061 feet, and quite evidently *in situ*, and with other beds covering an area of ten square miles. This author has also resuscitated the evidence supposed to be derived from the presence of maritime plants at high levels as favourable to the view of a great submergence, though, as we have already stated, Dr. Buchanan White has shown us that this evidence is exceedingly unreliable.

Without entering into details, it seems to us that so far as we are

able to judge, the evidence for a great submergence on the one hand, or against it on the other, is at the present time about equally balanced, for while these high-level shell beds found in Ayrshire seem to be undoubtedly *in situ*, and intercalated between the boulder clay, this would necessitate a submergence of over a thousand feet to account for their position there. It is, however, a singular thing that if this submergence took place all over Scotland the traces of it in other localities should be so scanty, in fact, that they should be practically non-existent at all.

Leaving, however, this difficult geological problem, the question arises, is it more probable that these Alpine plants should have migrated to this country during such a submergence as we have seen is contended for by some geologists and botanists, or during an elevation of the land as maintained by others. To us it seems the latter condition would be by far the most favourable to the immigration of the Scandinavian flora, for, though it were quite possible that they could have been carried on icebergs from the mainland, yet the evidence derived from the fauna as well as the flora goes to show that it is more probable that their dispersal took place during a land connection between Britain and the Continent.

Having thus discussed the probable conditions of the immigration of these plants into our country, and having seen that in all likelihood they must have at one time covered the whole of the lower grounds of these islands, it now remains for us to consider the manner in which they have been exterminated, so as to account for their present limited distribution upon these mountains which we have indicated at the beginning of this paper. As we have seen in the case of the maritime plants, it must be conceded at once that environment is the principal factor to which we must look for an explanation of the present distribution of these plants if it can be shown that on such mountains as Ben Lui, Craig-na-Caillach, Ben Lawers, or the Clova range there are any particular conditions of environment which would give these plants an advantage, so that in the gradual recession from the lowlands they should be able, because of these advantages, to make their final stand upon this ridge. As we have seen at the outset of this paper, altitude alone is not in itself sufficient to account for the present distribution of these Alpine plants on our Perthshire mountains; for we have many instances of mountain summits rising to an equal height and almost barren of Alpine plants, while others in the Highlands rise to even greater heights and are poor in Alpine plants, so that we must look to some other cause than altitude alone for a solution of the problem.

Axel Blytt, in his paper on the immigration of the Norwegian Flora, has attempted to show that certain meteorological or physical

conditions are favourable or otherwise to the establishment of these Alpine plants. Thus, mountains in proximity to or exposed to the influence of the sea are more favourable to the growth of certain species than those at greater distances or protected from the influence of the ocean—that some prefer an insular, while others prefer a continental climate. How far these conditions affect our Perthshire plants would, I think, be exceedingly difficult to say, as the two extreme types of continental and insular climates can scarcely be said to be sufficiently well marked within the region under discussion to enable us to argue with any degree of certainty as to the part which this factor has played in the distribution of our Alpine plants. Dr. Buchanan White, in referring to Axel Blytt's theory in his address to the East of Scotland Naturalists' Union, makes the following pertinent remarks:—"Before we can accept this," he says, speaking of Axel Blytt's views, "as an explanation of the reason why certain plants occur in Clova and not in Breadalbane and *vice versa*, the peculiarities of the distribution of each plant in countries where the difference of climate is more marked must be investigated, since it may turn out (and in some cases I have reason to think that it will turn out) that the facts do not agree with the theory."

It has long been suspected that geological structure and the nature of the rocks upon which these plants are to be found has played an important part in their distribution, thus we find Dr. Hugh Macmillan describing the rocks of Canlochan as composed of friable mica schists, which are well adapted for the growth of these plants. Botanists have also long been familiar with the highly micaceous nature of the rocks and soil of the Breadalbane ridge of mountains, making, as it does, a sure index of the locality from which the plants have been taken. And so thoroughly do these plants seem to become saturated, so to speak, in this micaceous soil, that the particles of mica adhere to them long after they have been pressed and placed in the herbarium. Dr. Buchanan White, in the address which we have already frequently cited, while pointing out that the influence of the rocks and soils upon these plants had already been partly investigated without any satisfactory results, believed that much was yet to be done in this direction, and advocated the conjoint study of this factor by botanists, mineralogists, and geologists. What further advances have been made in this direction will be the subject of the remaining part of our paper.

It has now become known, and that principally through the detailed mapping of the Geological Survey, that along the line of these mountains stretching from Ben Lui to Clova we have an outcrop of a well-marked band of schistose rocks whose significance as a factor in the distribution of our Alpine flora, I now venture to think, rests

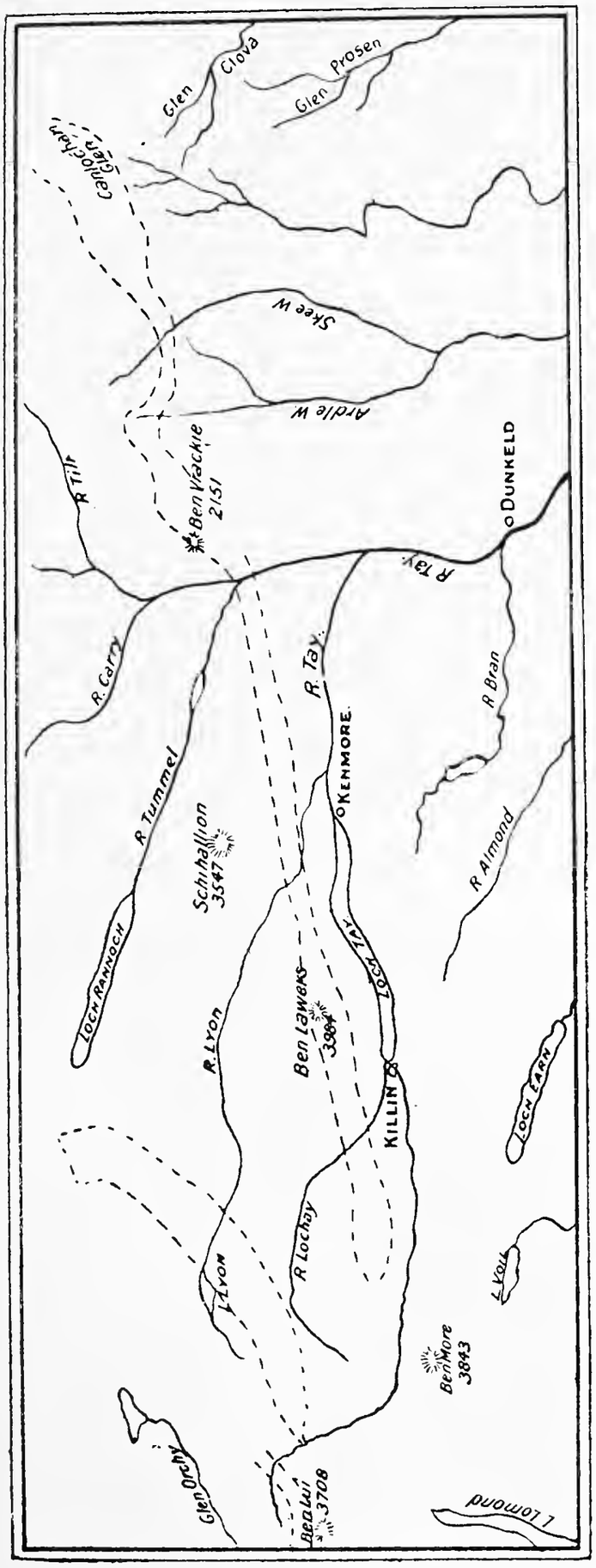
beyond the shadow of a doubt. Towards the western boundaries of our own shire the first exposure of this rock which we meet with is that seen on the north-east side of Ben Lui. Further to the north-west of Tyndrum we find these same schists faulted down against a series of quartzites and trending in a north north-east direction. Passing from Tyndrum down the valley of Glen Dochart we find the lower grounds of the valley occupied by the quartz schists and more arenaceous types of schist; on the higher grounds, however, of the ridge which separates Glen Dochart from Glen Lochay the band of fine sericite schist again appears. From this point it strikes north-eastwards, crossing the valley of the Lochay a little above the falls, where they are exposed in some fine sections. The steady north-east strike of these rocks carries them along the ridge on the north side of Loch Tay, where they are well seen in the many escarpments and beds of streams descending from Craig-na-Caillach, Meall-nan-Tarmachan, Beinn Ghlass, and Ben Lawers. The outcrop of this bed of schist traced still further towards the north-east, trends along the ridge which separates the valleys of the Tummel and the Tay, crossing these two valleys near their junction above Pitlochry, and from this point stretching through Ben Vrackie onwards to Canlochan and the Clova mountains. It has been termed by the Geological Survey the Ben Lawers and Canlochan Schist from its well-defined outcrop at these points.

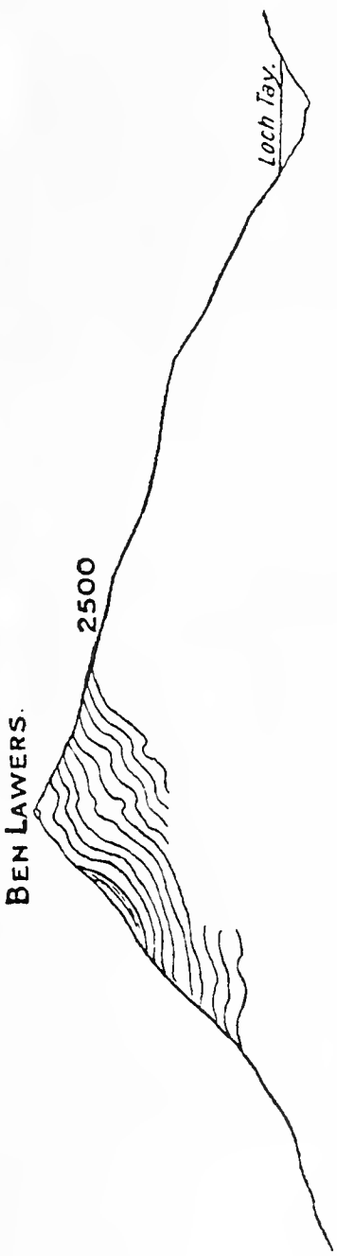
It is now a considerable number of years since I first recognized the existence of this well-marked band of sericite schist on the summits of the Breadalbane mountains, where it lies immediately above the quartz schists and more arenaceous mica schists, with garnets and beds of the Loch Tay limestone, which form the lower grounds, and in the ridge to the north of Loch Tay it is not until we reach an altitude of over 2000 feet that we come upon the boundary line between these lower beds and the higher zone of sericite schists. It would be quite unnecessary for us to here enter into any further details regarding the geological structure of these mountains. For those who would ask for further information on this point we would refer them to our papers in the *Geological Magazine*, where a more detailed account of their structure is given.

At the end of the paper we have given a sketch map of a portion of Highland Perthshire, which will convey at a glance the relationships of the outcrop of this bed of schist to the high grounds upon which these plants occur, and also a section across Ben Lawers showing the position the same schist holds in that mountain.

In conclusion, then, our contention is that in this band of sericite schist, whose positions we have just described, we have one of the most important factors in determining the distribution of our Alpine

plants, and that, wherever this band of schist rises to a sufficient altitude, there these plants have been enabled to maintain an existence in the great struggle which has exterminated them from the plains, the hills, and the majority of even our highest summits.





Sketch Map of Central Perthshire, and Section across Ben Lawers, showing outcrop of Sericite Schist.

LETTER TO THE EDITOR.

Marsh Titmouse in the Tay Valley.

38 Morningside Park,
Edinburgh, 16th October, 1897.

Dear Sir,—In view of Mr. Harvie-Brown's statement (*Trans.* Perthshire Soc. of Nat. Science, Vol. II., Part III., page 98) to the effect that the Marsh Tit had not, up to the time he was writing (November, 1894), been observed in the Valley of the Tay, it may be well to draw attention to what the late E. T. Booth wrote in 1882 in his "Rough Notes" (Part II.). We there read :—"A few may occasionally be met with in the Lothians; but, with the exception of a few stragglers in the neighbourhood of Dunkeld and near Perth, I have observed none that could be positively identified in the Highlands." Since the date of Mr. Harvie-Brown's paper, the species has been detected near Doune, in the Forth portion of Perthshire, by Lieut.-Colonel Duthie, as recorded in the "Annals of Scottish Natural History" for January, 1896.

The Marsh Tit is also entered (as "rare") in W. Horn's "Notes on the Birds of the North-west of Perthshire," read at a meeting of the Natural History Society of Glasgow on 25th February, 1879 (*Proceedings* IV., page 57); and Mr. Bruce Campbell, Edinburgh, tells me he identified one near Ballinluig in the summer of 1893.

WILLIAM EVANS.

[Mr. Evans informs us, in a subsequent letter, that he saw a pair of Marsh Tits in a ravine behind Bridge of Allan in Feb., 1898.—Ed.]

With reference to the above Letter, Mr. Harvie-Brown, to whom we have communicated it, says :—

I would be sorry to throw any direct doubt upon the late Mr. Booth's words, of which I was fully aware when I wrote in November, 1894. The few observed by Mr. Booth may, or may not, have been observed during migration. The same remark applies to the observation made by Mr. Bruce Campbell at Ballinluig. The observations of Col. Duthie, whom I personally encouraged to search for the bird, which he did for a long time in vain, do not refer to the "Tay" Valley, but to the "Forth" Valley. I myself have observed the species more than once on the opposite side of the Vale of Menteith, in the Forth Valley, and we have it breeding, as an autumn visitor here at Dunipace, also in the Forth Valley; and —although possibly an additional fact or record—the seeing of two of the species near Bridge of Allan in February is not surprising, considering its fairly-well known summer and winter distribution in Eastern Central Scotland. Mr. Evans' notes appear to me to prove nothing as to its *breeding* within the Tay watershed. We now know, thanks to Mr. Evans, that Marsh Tits *are* found in the Valley of the Spey, about and around Aviemore; and we know they breed in the Valley of the Forth, but, I hold, there is nothing to show, *by proof*, that

they are found breeding in the Valley of the Tay. Further, we would desire more proof and information of the record, vaguely given by Mr. W. Horn, of their presence in the North-west of Perthshire. We feel convinced, knowing Mr. Horn intimately, that his remarks refer *not to summer* habitation of these parts, but to autumn migration, *i.e.*, during the shooting season. And, moreover, even if *now* the Marsh Tit be actually discovered breeding anywhere within the Tay Basin, I would still hold that there has appeared no *past authentic* proof of the fact. It is only natural to suppose that, if it has migrated south between Spey and Forth, intermediate areas may in time be occupied, but, as we have elsewhere indicated, we believe in the fact that expansions or extensions of range of many species are much more likely to take place along the lines of the exact routes of migration of many species *in spring*, than along the lines *merely* of *autumn or winter* migrations, whether general or only local. We may add that the two phases of general and local movements, while closely allied to one another, nevertheless, especially in their initial stages, often show very different *immediate* results. Meanwhile, we require proofs.

J. A Harvie-Brown.

Note.—It may be seen we still use the term "within the watershed," although this was criticised by no less an influential authority than the Ibis. We failed at the time, and still fail, to understand the force of the argument then used, nor do we think the term "watershed" can correctly have any other meaning than "water-parting"—a term proposed to be used instead in the same article (Ibis, July, 1898, p. 440). We cannot, in fact, realize that there is any dubiety in the expression or meaning of "watershed" as used by us.—J. A. H.-B.