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THE OTTAWA NATURALIST.

VOL. XIV. OTTAWA, JUNE, 1900. No. 3

SOILS AND THE MAINTENANCE OF THEIR FERTILITY THROUGH THE GROWTH OF LEGUMES.

By FRANK T. SHUTT, M.A., F.I.C., F.C.S., F.R.S.C.,
Chemist, Dominion Experimental Farms.

Four years ago I had the honour to bring before the members of the Montreal Natural History Society an account of the work accomplished by the Chemical Division of the Experimental Farms during the eight years that had passed since these valuable institutions, designed to promote the agricultural interests of Canada, had been established by our Government.* In that brief review it was shown that our chemical work practically covered the whole field of agriculture, and included the analysis of soils, naturally-occurring fertilizers fodders, dairy products, insecticides and fungicides, in addition to the carrying on of such investigations in connection with economic plant and animal production as required the aid of chemistry for their successful prosecution.

On the present occasion, instead of making a general *resumé* of our researches and results, I purpose considering a single branch of investigation, one that has been carried on in the fields and laboratories of the Experimental Farm with signal success and that has yielded results of the highest value to those who wish to maintain or recover the productiveness of their land. I refer to to the improvement of soils through the growth of legumes.

* A lecture delivered in the Summerville Course (Montreal), April 1896, and entitled "Chemical Work in Canadian Agriculture."

PLANT FOOD AND ITS SOURCES.

To understand and appreciate the full significance of my subject, the improvement and recuperation of soils by the growth of legumes, it will be necessary for us to first consider the sources of plant food, the nature of soils, and the manner in which soils are affected by cultivation.

The analysis of plants shows that they are composed of some thirteen chemical elements, present, as might be expected, in varying proportions, according to the nature of the plant and the part of it examined. Though these are built up by the plant into numerous combinations, we can readily recognize in all vegetable structure three distinct classes of compounds, viz.: water, mineral or ash compounds, and organic compounds. The elements comprising these are drawn from two sources, the atmosphere and the soil, both of which, as we shall see, furnish this food in forms or compounds suitable to plant life, for it is well to remember that the uncombined elements are practically valueless, considered as plant foods for farm crops.

The following scheme permits one to see at a glance the constituents of plant food, their sources and products:

PLANT CONSTITUENTS.

2 Soils

THE ORGANIC ELEMENTS	Carbon	Carbonic Acid (Carbon, Oxygen)	Starch	Albuminoids	AIR DERIVED ELEMENTS
	Oxygen	Water (Oxygen, Hydrogen)	Sugar		
	Hydrogen		Fibre		
	NITROGEN		Oil		
THE INORGANIC ELEMENTS	Calcium		PHOSPHORUS		SOIL DERIVED ELEMENTS
	Magnesium		Silicon		
	POTASSIUM		Sulphur		
	Sodium		Chlorine		
	Iron				
	Manganese				

The carbonic acid gas of the air, though present only to the extent of 4 parts in 10,000, furnishes all the carbon required for the organic compounds of plants, of which starch, sugar and albumen are the chief. These compounds constitute fully 80 per cent. of their water-free substance, and are those which give to all vegetable tissues their chief value as food for man and beast. Some idea of the extent to which plants appropriate their nourishment from this source may be gained from the statement that an acre of wheat, by virtue of the green colouring matter of its foliage in the presence of the sunlight, will remove during its season of growth nearly one ton of carbon, or as much as would be contained in a column of air over that area three miles in height. Though this is a very large amount, the practical agriculturist needs not to concern himself with this class of food; for nature always furnishes an abundant, a practically unlimited, supply.

Water is invariably found in all the tissues of plants, from 75 to 95 per cent., as in green stem and foliage, to 8 or 10 per cent., as in the seed. From one point of view, water is to be regarded as the most important of all forms of plant food, since without it all other nourishment is unavailable. Though not of the soil, looked at geologically, it is only water present in the soil which is of use to plants. Their whole supply is drawn by the rootlets from this source. Apart from irrigation, we can only indirectly control this supply. Indirect methods for the conservation of soil moisture, chief of which are under-drainage and surface cultivation (which by the formation of a dry earth mulch arrests or checks surface evaporation), are now considered matters of the greatest importance and worthy of equal consideration with problems for supplying plant food. For indeed water not only forms a large proportion of all plant tissues, but it is the vehicle whereby all soil food is appropriated and assimilated. That nourishment which plants take from the air is certainly in the form of a gas, but that which they absorb from the soil must be in the form of a dilute solution. Solids, as such, cannot be utilized; they must first be dissolved. If they cannot be attacked either by the soil water or the slightly acid fluid that exudes from the rootlets, then no matter how rich such solid materials may be in food constituents, they are of no value to crops. The knowledge of this fact has within the last few years led to many important changes in the use and application of the so-called chemical fertilizers.

The amount of water used by crops in their feeding, that is, absorbed by their roots and lost by transpiration through their leaves, is enormous, equalling several hundred of tons per acre. Taking the mean of a number of determinations, Hellriegel found that for every ton of dry matter produced in plants, in the neighbourhood of 325 tons of water were required. An acre of Indian corn probably uses in this way during its growth 1,000 tons of water.

Notwithstanding these considerations, it is, from the practical standpoint, those elements, or rather compounds, other than water, withdrawn from the soil that, as agriculturists, we must regard as most important. It is their removal by successive cropping *without any concomitant return, that results in soil* exhaustion and reduces the yield below the mark of economical production.

What are these elements? *First, there are the mineral or* ash constituents. These comprise calcium, magnesium, iron, potassium, sodium, silicon, sulphur, phosphorus and chlorine, and occasionally traces of several of the rarer elements. As already explained, these are found in the plant variously combined, and not in the elemental condition. They form, say, from .1 per cent. to 3.0 per cent. of the weight of fresh plant tissue, the proportion depending largely on the part examined. Though crops differ in their demands for ash constituents, the amount withdrawn per acre by average yields of farm crops usually lies between 200 lbs. and 300 lbs.

Now with regard to the above-mentioned elements, the majority of them are present in soils in quantities so abundant, and the amounts required by plants by comparison so extremely small, that their return to the soil by the farmer may be neglected. Indeed, as the result of scientific research as well as of practical experience, it is known that to maintain fertility—as far as these inorganic constituents are concerned—it is only necessary generally to replace two or, at most, three of them. They are commonly spoken of in agriculture as potash and phosphoric acid, with lime as third in importance.

The following table presents the approximate amounts of these elements abstracted, per acre, by some of the more common farm crops:

PLANT FOOD REMOVED BY CROPS.*

Crop.	Pounds per Acre.						
	Gross Weight.	Nitrogen.	Phos. Acid.	Potash.	Lime.	Silica.	Total Ash.
Wheat, 20 bush.	1,200	25	12.5	7	1	1	25
Straw	2,000	10	7.5	28	7	115	185
Total	....	35	20	35	8	116	210
Barley, 40 bush.	1,920	28	15	8	1	12	40
Straw	3,000	12	5	30	8	60	176
Total	....	40	20	38	9	72	216
Oats, 50 bush.	1,600	35	12	10	1.5	15	55
Straw	3,000	15	6	35	9.5	60	150
Total	....	50	18	45	11.0	75	205
Corn, 65 bush.	2,200	40	18	15	1	1	40
Stalks	3,000	35	2	45	11	89	160
	....	75	20	60	12	90	200
Peas, 30 bush.	1,800	......	18	22	1	1	64
Straw	3,500	......	7	38	71	9	176
Total	....	......	25	60	75	10	240
Mangels, 10 tons	20,000	75	35	150	30	10	350
Meadow Hay, 1 ton	2,000	30	20	45	12	50	175
Red Clover Hay, 2 tons	4,000	......	28	66	75	15	250
Potatoes, 150 bush.	9,000	40	20	75	25	4	125
Flax, 15 bush.	900	39	15	8	3	.5	34
Straw	1,800	15	3	19	13	3	33
Total	....	54	18	27	16	3.5	87

* The Chemistry of Soils and Fertilizers, Snyder.

Secondly, we have nitrogen. The percentage of this element in the tissues of plants will vary from .1 to 3.0, the largest proportion being found in the seeds. With the exception of the legumes, farm crops, indeed all plants, obtain their necessary supply of nitrogen from that contained in the humus of the soil. This so-called organic nitrogen is not directly assimilable, but must first be converted by certain soil micro-organisms into compounds known as nitrates. The process by which this change of inert nitrogen into valuable food forms takes place, is known as nitrification and is one of the most remarkable and important in the whole field of agriculture.

The amounts of nitrogen as nitrates consumed by crops is variable; while some remove not more than 20 lbs. per acre, others utilize 100 lbs. or more. Of the legumes (clover, peas, beans, &c.) and the source of their nitrogen we shall speak more particularly later on.

The cropping of the land, therefore, we are to understand, depletes it more particularly of certain amounts of potash, phosphoric acid, and nitrogen—the so-called essential elements of fertility, To maintain productiveness, it is essential that the stores of these elements in available forms be preserved ; to increase productiveness they must be added to.

The rate of soil exhaustion is indicated by the subjoined data of an orchard and field crop.

ESSENTIAL ELEMENTS OF FERTILITY REMOVED APPROXIMATELY IN 20 YEARS FROM AN ACRE OF SOIL.

	Nitrogen. Lbs.	Potash. Lbs.	Phos. Acid. Lbs.
Apples, fruit, leaves and wood (trees in full bearing)	1,300	1,800	300
Wheat, grain and straw	700	700	400
Mangels, roots and tops	1,500	3,000	700

THE NATURE OF SOILS.

Having now taken this cursory review of the plant's requirements, we must turn our attention to soils, and learn somewhat of their nature and the manner in which they are affected by cultivation. All arable soils consist chiefly of two classes of constituents: mineral or inorganic, derived from the disintegration of the original rock surface of the earth, and organic, resulting from the decay of past generations of plants, and grouped under the general term humus. Besides these, air and water are present, making the soil a suitable and comfortable medium for the growth of plants, and playing an important part in the preparation of their food. And, lastly, as we have learned in recent years, there are in every fertile soil myriads of micro-organisms, working, under conditions that afford them warmth and moisture and air, in the convertion of inert or locked-up plant nourishment of the soil into substances and compounds more or less immediately available for crops. The transformation of the useless nitrogen of humus, first into nitrites and finally into nitrates, is an important example of the valuable work done for agriculture by these microscopic plants.

We must not now stay to consider in detail the origin of soils nor the various natural agencies and forces that have been and are now at work in their formation. The whole subject is one of peculiar interest and magnitude, and merits a much more careful and systematic treatment than would be possible in this lecture. I can do little more than mention the fact that agriculturally, as well as geologically, the name of soils is legion. There are clay soils and sandy soils, so called from the predominance of clay and sand respectively, and soils rich in humus, and a host of intermediate soils known as loams. Save in the case of transported soils, such as the deltaic soils formed at the mouth of rivers, their mineralogical composition will accord with that of the underlying rock. But whatever the nature of soils, their chief agricultural function always remains the same, viz., to furnish certain mineral substances, among which potash, phosphoric acid and lime are the most prominent; to offer, in combined forms, nitrogen, a further essential for plant life; to hold moisture and air necessary for the growth of plants, and to form a firm, comfortable and warm support for their growth.

Before proceeding to speak of the amounts of plant food in soils, it is desirable that I should call your attention to the importance of humus as a soil constituent, since the method of employing clover at a fertilizer, which I am to bring before you to-night, is dependent in a very large degree for its value upon the fact that it adds vast quantities of this material to the soil. I shall endeavour to do this very briefly.

THE AGRICULTURAL IMPORTANCE OF HUMUS.

1st. It is the natural store-house and conservator of nitrogen, which element is the most expensive of all plant foods when it becomes necessary to purchase it in commercial fertilizers.

2nd. It furnishes the food upon which the soil micro-organisms live and which by their life functions convert its organic nitrogen into nitrates.

3rd. It possesses considerable amounts of the mineral food constituents. These, in the further decomposition of the humus—a process continually going on in summer—are liberated in forms available to growing crops. We have reason to believe from recent research that the mineral humates furnish a large proportion of the potash, lime, etc., used by crops.

4th. It serves to increase the absorptive and retentive power of soils for moisture.

5th. It regulates and protects against extremes of soil temperature.

6th. It opens up and mellows heavy soils.

7th. It serves to materially diminish the loss of fertilizing elements by drainage, thus permanently improving in the best way light soils.

From these considerations, it is evident that humus is to be regarded as a soil component of a very high order.

The relation of humus content to nitrogen present in soils of similar origin under similar meteorological conditions, is practically constant. It has been noticed that the amount of humus present gives an excellent though not an infallible indication of the amount of organic nitrogen the soil possesses. Further, it has been observed that as the humus disappears the nitrogen goes with it. Cultivation, that is, exposing the substance of the soil to the air, as by our ordinary farm methods with the plow, harrow, etc., tends to dissipate the humus and, as a natural consequence, to decrease the nitrogen. Soils growing grain exclusively year after year lose, it is stated, more nitrogen by this humus oxidation than is removed in the crop, and this loss is greatest in those soils which are richest in nitrogen. At the Minnesota Experiment Station it was determined that for every 25 pounds of nitrogen absorbed by the crop (grain following grain for a number of years) 146 pounds of nitrogen were lost, due to oxidation of organic matter.

These facts are of the widest importance and worthy of study by our farmers not only in the older provinces, but also in those Western areas which to-day are overlaid by such phenomenally fine soils.

During the past twelve years a great many Canadian soils—both virgin and cultivated—have been examined in the laboratories of the Experimental Farms. We have placed on record in our reports complete analyses of over one hundred samples, and data of a more or less incomplete character respecting many more. The soils examined are representative of many districts and large areas in all the provinces of the Dominion,* but we cannot now discuss the data of these analyses in detail. It must suffice to say that judged by the standards accepted by agricultural chemists we find many soils in Canada fully as rich in plant food as the most fertile soils of any part of the world. I refer now particularly to soils over large areas in Manitoba and the North-west Territories—quite the equal, as shown by analysis, of the renowned black soil of Russia. In all the other provinces there are virgin soils of more than average fertility, comparing most favourably with those of other countries. As is only natural to expect, there are areas also of poor, impoverished soils.

It is well to have some idea of the amounts of plant food contained in an acre of soil, taken, say, to a depth of eight inches, a quantity that would weigh in the neighbourhood of 2,500,000 lbs. From data obtained in the Experimental Farm laboratories, I estimate our soils of extreme richness will contain from 10,000 to 20,000 lbs. of nitrogen, from 15,000 to 25,000 lbs. of potash, and

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* In the year 1897 a paper giving the results of our soil work to date was presented to the Chemical Section of the British Association. It appears *in extenso* in the Report of the Chemical Division of the Experimental Farms, 1897.

from 5,000 to 10.000 lbs. of phosphoric acid. Similarly, in soils of good average fertility we find: nitrogen, 2,500 to 5,000 lbs.; potash, 5,500 to 11,000 lbs., and phosphoric acid 3,500 to 6,000 lbs.

From comparing these figures with those that I gave representing the amounts used by various crops, it would at first sight appear as if adding plant food to the soil were quite unnecessary, a "carrying of coals to Newcastle"; that where there is such an abundance of food there would be no economy in supplying more. The explanation lies in the fact that while the vast stores that we have mentioned are truly present, but a *very small percentage of them is immediately available to plants.* In this we recognize a wise provision of nature, for if it were otherwise soils might soon become exhausted by the leaching of the food constituents below the reach of roots, and by the selfish practices of farmers who care nought for posterity and return nothing to the soil. I have alluded to the agencies and forces instrumental in soil formation; it is by a continuation of these and by the solvent action of root sap that soil constituents are being continually prepared for the use of the higher plants. We have to recognize that the very small proportion of the nitrogen present as nitrates, and those minute percentages of phosphoric acid and potash soluble in water or in 1% citric acid solution—a solvent of approximately the same activity and strength as root sap—represent all the quantities immediately available to crops, and give a measure of the soil's productiveness. We have made determinations of this soluble plant food in many Canadian soils. One instance is given below of a rich and fertile black loam from British Columbia.*

*COMPARISON of "Available" with "Total" Amounts of Potash and Phosphoric Acid.

No.	Soil.	Potash.			Phosphoric Acid.		
		Total Potash.	Available Potash.	Percentage of total Potash available for plant use.	Total Phosphoric Acid.	Available Phosphoric Acid.	Percentage of total Phosphoric Acid available for plant use.
1	Surface	0.23	0.00483	2.20	0.19	0.01020	5.66
2	Between 12 and 18 ins.	0.23	0.00299	1.36	0.19	0.01055	5.85
3	Between 18 and 24 ins.	0.26	0.00169	0.64	0.12	0.00588	4.90

From the data presented it is evident that the amounts per acre of mineral plant food of immediate agricultural value are very small, compared with the amounts of total plant food present. Nor must we suppose that the whole of these supplies—small as they are—can be secured by any crop, for its root system occupies necessarily a more or less restricted area and does not envelope every soil particle. A poor physical condition of the soil and lack of sufficient moisture are factors that still further prevent the utilization of this available plant food. One of the chief functions of mechanical processes for disturbing soil is to hasten the conversion of inert material into these more valuable compounds. The principal object—indeed, in most instances the only object—in applying manures and fertilizers is to add to this store of available plant food. The quantity of soluble food so added is insignificant, compared with that already present in an insoluble state, but the increased yields resulting, fully corroborate the statement that a soil's productiveness should be measured by the amounts of its plant food which are more or less available, rather than by the amounts of that shown by extraction by a method of analysis employing strong mineral acids. This view can scarcely be unduly emphasized; it explains, as we shall see, in a large degree, the value of the clover crop as a fertilizer, which we shall now consider.

We have already mentioned that the legumes—of which clover is a prominent member—have a source for their nitrogen other than and additional to that present in the soil. Like other plants, they are unable to absorb free nitrogen of the air through their leaves; like in other plants, that which they absorb through their rootlets must be as nitrates. In what way, then, is the indisputable fact that they can make use of atmospheric nitrogen to be explained? The careful researches of Hellriegel, Wilfarth, and other chemists have shown that the legumes obtain the nitrogen of the air existing in the interstices between the soil particles through the agency of certain micro-organisms present in the soil. These bacteria, whose special function is the assimilation of free nitrogen, attach themselves to the roots of the growing clover or other legume, forming thereon nodules or tubercles. These nodules, swarming with countless hosts of the germs, are to be found in sizes varying from a pin's head to a pea, and frequently scattered in vast numbers over the roots of the legume. When they are not present, the clover, as regards its nitrogenous food, is in the same category as other plants. The nitrogen elaborated by these microbes is passed on to the host plant and there built up into the usual nitrogenous compounds of the tissues of the roots, stem and leaves. These facts, so briefly put, represent the most important discovery in agricultural science of the nineteenth century.

For the reason that, as far as we know, the legumes alone offer themselves as suitable hosts to these germs and are thus able to appropriate nitrogen that is useless to all other vegetation, they have been termed nitrogen-collectors. All other plants, in contradistinction, are known as nitrogen-consumers. The legumes are especially rich in nitrogen, and though we are unable to say exactly what proportion of this element is taken by them from the air by the means I have mentioned, we may be sure that under favourable conditions the greater part is from that source.

To be continued.

THE LABRADOR FLYING SQUIRREL.

By J. D. SORNBORGER, Cambridge, Mass., U.S.

Three specimens of *Sciuropterus*, sent me by my friend Rev. Walter W. Perrett, from Makkovik, Labrador, seem so different from previously described forms, that I propose for them the name : SCIUROPTERUS SABRINUS MAKKOVIKENSIS, new subspecies, the Labrador Flying Squirrel.

Both above and below, this form is the darkest of the flying squirrels of eastern North America. The composition of its predominant colours, compared with those of a specimen from Moose Factory, by means of the colour top,* is approximately :

* The "colour top" made by the Milton Bradley Company, of Springfield, Mass. See C. B. Davenport, Science, 1899, p. 416 ; A. G. Mayer, Proc. Bost. Soc., Vol. XXVII, p. 246. This method of colour determination was suggested to me by Prof. C. B. Davenport, now of the University of Chicago, and, though subject to many limitations, is, in most instances, far better than any other method known to me.

		% Black.	% Red.	% Yellow.	% White.
Labrador specimens	Above....	40.	40.	15.	5.
	Below....	10.	17.	13.	60.
Moose Factory specimen	Above	35.	40.	19.	6.
	Below	3.	1.	32.	64.

Above, however, it is darker than the table shows. Only tawny areas were matched with the colour top, the scattered black hairs and the black tips of the party-coloured hairs were, so far as possible, ignored since it was impracticable to accurately measure their effect.

The proportions of colours on the party-coloured hairs of a number of specimens from various localities are approximately :

	Plumbeous.	Tawny.	Black.
Labrador specimens	17.	4.	2.-3.
Moose Factory	15.	5.	0.
Cumberland House	19.	3.	a trace
Matamagaminque, Canada	17.	4.	0.

The skin from Cumberland House is the most like the Labrador form in the colour of the back of any I have examined.

Perhaps the most noticeable character of *makkovikensis* is the sooty tail, which is darkened for more than half its length. A skin in the collection of Mr. C. F. Batchelder, from Tadousac, Quebec, though immature and in summer pelage, approximates this condition, and it would seem to show that the conditions producing the dark form are operative at least so far west on the north shore of the St. Lawrence as the Saguenay River.

From a comparison of the measurements given in this article *S. s. makkovikensis* may be assumed to be the largest of North American flying-squirrels with perhaps the exception of *S. alpinus* (and specimens from Alaska ?).

My acknowledgments are due to Mr. Outram Bangs, Mr. C. F. Batchelder, Mr. Gerrit S. Miller, Jr., of the U. S. National Museum, and particularly to Dr. Walter Faxon, of the Museum of Comparative Zoology, for the use of material and for other favours received.

CRANIAL MEASUREMENTS (in millimeters).

—	Anterior end of nasal to anterior end of supraoccipital.	Greatest length of lower jaw.	Length of lower molar series on alveoli.	Greatest zygomatic breadth.	Least interorbital breadth.	Medial length of frontals.	Basilar length of Hensel.
7709. Collection of E. A. & O. Bangs. ♂	38.	23.4	8	21.	8.	14.	30.8
7710. Collection of E. A. & O. Bangs. ♀	41.4	25.9	8.	25.	8.9	16.	33.
7711. Collection of E. A. & O. Bangs. ♀	39.3	21.	8.	26.2	9.	15.2	
4915. Collection of E. A. & O. Bangs. ♂	35.	21.	7.	21.2	7.5	15.	27.9
4958. Collection of E. A. & O. Bangs. ♀	36.	22.3	6.7	22.4	7.1	14.	29.
4959. Collection of E. A. & O. Bangs. ♂	35.	21.3	6.9	22.	6.9	14.2	27.9
37216. Collection of the U. S. N. Museum	......	....	....	23.2	7.8	16.	
1540. Collection of J. D. Sornborger ...	......	25.	8.2	24.	8.1	16.1	32.
1541. Collection of J. D. Sornborger ...	......	25.	8.2	25.	8.2	16.	
1542. Collection of J. D. Sornborger ...	39.2	24.2	8.	23.6	8.	16.	

LENGTH OF HIND FEET (in millimeters, from dry skins).

7709. Collection of E. A. & O. Bangs	40.	39.5
7710. Collection of E. A. & O. Bangs	37.	37.5
7711. Collection of E. A. & O. Bangs	37.5	37.5
7069. Collection of the U. S. National Museum	41.	41.
6505. Collection of the U. S. National Museum	40.	-
5515. Collection of the Museum of Comparative Zoology	40.	39.5
7189. Collection of the U. S. National Museum...	38.	38.
7190. Collection of the U. S. National Museum................	49.	
5430. Collection of the Museum of Comparative Zoology	40.	39.5
5431. Collection of the Museum of Comparative Zoology	38.	39.
1624. Collection of C. F. Batchelder..........	36.	35.
1540. Collection of J. D. Sornborger.....	40.5	
1541. Collection of J. D. Sornborger.........................	41.	42.
1542. Collection of J. D. Sornborger.........................	42.	

MATERIAL EXAMINED.

Fort Yukon, Alaska.

5433. Collection of the Museum of Comparative Zoology.

Tongas, Alaska.

5435. Collection of the Museum of Comparative Zoology.

Big Island, Great Slave Lake.

7069. Collection of the U. S. National Museum.
6505. Collection of the U. S. National Museum.
5432. Collection of the Museum of Comparative Zoology.

Red River Settlements.
5438. Collection of the Museum of Comparative Zoology.
Red River.
5439. Collection of the Museum of Comparative Zoology.
Selkirk Settlements.
5437. Collection of the Museum of Comparative Zoology.
Red Deer, Alberta.
7710. Collection of E. A. & O. Bangs.
7711. Collection of E. A. & O. Bangs.
Gull Lake, Alberta.
7709. Collection of E. A. & O. Bangs.
Idaho Co., Idaho.
6960. Collection of E. A. & O. Bangs.
Idaho.
5435. Collection of the Museum of Comparative Zoology.
Home Bay.
5516. Collection of the Museum of Comparative Zoology.
Cumberland House.
22030. Collection of the U. S. National Museum.
Hudson Bay.
13189. Collection of the U. S. National Museum.
Moose Factory.
5515. Collection of the Museum of Comparative Zoology.
Lake Superior.
1563. Collection of the Museum of Comparative Zoology.
Matamagaminque, Canada.
5430. Collection of the Museum of Comparative Zoology.
5431. Collection of the Museum of Comparative Zoology.
7189. Collection of the U. S. National Museum.
7190. Collection of the U. S. National Museum.
Greenville, Maine.
4915. Collection of E. A. & O. Bangs.
Digby, Nova Scotia.
2032. Collection of E. A. & O. Bangs.
Pak's Cove, Nova Scotia.
4958. Collection of E. A. & O. Bangs.
4959. Collection of E. A. & O. Bangs.
Tadousac, Quebec.
1624. Collection of C. F. Batchelder.
Makkovik, Labrador.
1540. Collection of J. D. Sornborger.
1541. Collection of J. D. Sornborger.
1542. Collection of J. D. Sornborber.
SKULL.—37216. Collection of the U. S. National Museum.
Matamagaminque, Canada.

BIRD NOTES, ETC.

The sub-editors will be much obliged if members will send them notes of interest for publication. These should be sent in before the 15th of each month.

ADVERTISEMENTS.

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MENTE ET MALLEO.—At the recent Convocation in the Faculty of Arts of McGill University, Montreal, the degree of LL.D. (Doctor of Laws) was conferred upon Mr. Joseph F. Whiteaves, F.G.S., Palæontologist and Zoologist of the Geological Survey of Canada, for distinguished services in the two fields of scientific research with which he is officially connected at Ottawa. Dr. F. D. Adams, Logan Professor of Geology at McGill, introduced Mr. Whiteaves to Principal Peterson, the Chancellor and other members of Convocation present. Dr. Whiteaves has been a member of the Club for nearly twenty years.

Alfred Ernest Barlow, M.A. of McGill University, and also of the Geological Survey, well known for his advanced views and researches in the geology of the primitive crust of the earth as exhibited in portions of Eastern Canada, received the post-graduate degree of D.Sc. (Doctor of Science) in course at the same Convocation. Dr. Barlow is one of the Associate-Editors of THE OTTAWA NATURALIST.

We tender our hearty congratulations to both, and trust that they may be spared for many years to continue their valuable investigations for the advancement of science in Canada.

THE TWO-LINED SALAMANDER, *SPELERPES BILINEATUS* (Green).

By WALTER S. ODELL, Ottawa.

This active amphibian is, according to Prof. Wilder, widely distributed over the United States, and presumably over Canada, but on account of its habits may not be readily found. The adult newt is from seven to nine c.m. in length, resembling the general form of lizards. The head is long and flat, the body graceful and slender, having a flattened tapering tail-fin about half its length. *Spelerpes* in colour is dark brown with a dorsal stripe light brown or fawn colour, lighter at its outer edges and bordered by a dark brown stripe—hence its name "*bilineatus*." It is marbled along the sides; the ventral side is a light lemon colour, without pigment spots. Its heart, like that of frogs, has but one auricle, while the heart of lizards has two. But unlike the frogs it has no lungs, but depends upon the surface of its integument and the walls of the pharynx for respiration. As it is nocturnal in its habits, the adult is not frequently seen.

LOCALITY AND HABITAT.—The adults are found in and about running brooks plentifully supplied with small stones, and underneath bits of fallen logs that lie in the immediate vicinity of the edges of brooks. The larvæ are sought for in water at the bottoms of gravelly pools or underneath flat stones in springs or small mountain brooks. They much resemble small minnows at this stage, and when disturbed dart away with as great swiftness. It was this fact which first brought them to my attention. Finding several so-called minnows in a tiny spring in the gravel pits at Britannia, where it was unlikely minnows would be found, I was led to examine them closer, and to my surprise found a strange animal, between an eel and a minnow, with a head like the latter, having gills projecting like horns from each side; with four feet having toes not webbed, and with a long tail like an eel's.

Specimens were sent to Prof. L. Stejneger of the Smithsonian Institution at Washington. He very kindly identified them for me, and also referred me to Prof. Wilder, Northampton, Mass., who is the author of a paper on this subject. I had been unable to obtain adults, although the Hon. F. R. Latchford in a short paper *re* "Ottawa Salamanders," in THE OTTAWA NATURALIST, January, 1877, described where several species were found. From information as to habitat gathered in Prof. Wilder's papers, several larvæ were found without difficulty when Britannia was visited on Christmas Day. On the 20th January, 1900, four adults and seven larvæ were collected, but as I neglected to replace the cover on the aquarium, three adults escaped into the room and were never found, even after most careful search. The remaining adult remained in the aquarium, only because through some accident he was minus a tail when found, and was thus unable to climb over the edge. From the 20th January to the 12th February his tail had grown 7 mm. and has since grown to date, March 5th, 1.5 cm. Since specimens were obtained on the 1st September, 1899, and later, little opportunity has been found for observing their development. The following notes on the eggs are from Prof. Wilder's admirable paper, not from observation.

The eggs of *S. bilineatus* may be obtained during May and June. He records them as found between May 27 and June 12 in Massachusets; here a little later. "They are deposited in a single layer on the lower side of submerged stones, each batch containing from 30 to 50 eggs, generally in the more rapidly flowing portions of the brook, attached separately to the surface of the stone by gelatinous threads proceeding from the outer envelope. Within the eggs the embryos lie free. When the stone is overturned the eggs resume their normal position.....The eggs are protected by three membranes, two that fit closely and an outer loose one......It is by means of strings proceeding from this that they are attached to the surface of the stone.....The eggs are holoblastic, lack the black pigment of the frog's egg, and hatch in from 15 to 17 days.....The young swim actively when hatched, which they do early, and continue for a long time in the larval state, probably two to three years."

These Salamanders in their larval state are suitable specimens for an aquarium, requiring little attention if placed along with some of the water moss, *Fontinalis*. One placed in a jar with *Fontinalis* last September has not been touched since, merely a little water supplied at intervals and feeding small larvæ of flies have been his only care.

"The adults, because of their peculiarities in respiration and the consequent necessity of keeping their skin moist, cannot be kept either in water or a dry atmosphere, but may easily be kept for months in an ordinary fernery where the atmosphere is constantly saturated with moisture."

The adults here exhibited have been kept since Christmas, 1899, in a small fernery made for the purpose 10" x 10" x 14" holding a shallow zinc tray one half of which is planted with the ordinary greenhouse plant called Lycopodium, the other is coarse sand and gravel; in this sand a small dish is sunk level containing water. This miniature tank is an aquarium on a small scale and contains small stones, gravel and sand, *Anacharis* and *Spirogyra*, and furnishes a suitable abode for some small larvæ. It supplies at the same time sufficient moisture for the adults and for the Lycopodium. A glass cover must be kept at all times over the fernery to prevent the escape of the captives, who seem to require little food. Mine have had some larvæ of flies occasionally put in the small tank; no other attention has been given them.

ZOOLOGICAL NOTES.

1. THE SQUID, IN ST. JOHN HARBOUR, SEPT. 2, 1899.

While in the City of St. John, N.B., I had the privilege to witness a sight which was both unusual and interesting, and, in my estimation, worthy of record. On the morning of September 2nd, 1899, the harbour of St. John, in many of its approaches and shores was visited or literally infested with an unprecedentedly large school of Squids (*Ommatostrephes illecebrosa*, LeSueur). This is the common "squid" of the Gulf of St. Lawrence, Newfoundland and North Atlantic waters, generally used by fishermen as bait in the cod fishery, and belongs to the section *Decapoda* of the *Cephalopoda dibranchiata*. My attention was first called to the occurrence of this creature by a number of small boys who had in their possession a number of narrowly elongate and transparent or hyaline shafts or arrow-like pens about nine inches in length.

On reaching the basin at the foot of King street, I noticed the shores literally strewn with the dead bodies of these calamaries or sea-arrows, as they are sometimes called. I was informed by sailors on the wharf that between fifty and sixty barrels had been gathered that morning, between tides, by Norwegian sailors. They are considered good eating by many, although not used to any extent in this direction in Canada. Captain Ross, an old seaman and resident of St. John, who visited the harbour that day, informed me that "squid" is extremely rare in St. John harbour.

Mr. Robert Chalmers, of the Geological Survey of Canada, informs me that in 1886 a school of squids visited the passage between Miscou and Shippegan Island, said to be chased by cod. Three specimens of this species from St. John Harbour were secured by the writer and preserved in alcohol. They are now in the National Museum, Ottawa.

There were many persons in St. John who held the view that the squid seen in the harbour that day had been chased by some whale.—H. M. A.

2. BRITISH AMERICAN ECHINODERMS.

During the voyage of H. M. S. Challenger in the Norts Atlantic, a number of echinoderms were obtained in the dredgiing which may help to throw light upon the doubtful form obtaned by the writer in one ofthe calcareous nodules from the Pleistocene clays of Besserers,* near Ottawa, and recently noticed by Sir Wm. Dawson in the December issue of THE OTTAWA NATURALIST.

In the Challenger report on the Echinodermata by Alex. Agassiz, part 9, 1881, on page 201, *Schizaster fragilis* is recorded from "off the coast of Nova Scotia," and on page 221 the same species is also recorded from the Gulf of St. Lawrence.

Strongylocentrotus Drobachiensis is recorded on page 211 from the east coast of America, and is found most abundantly throughout the shallows of the shores of the Maritime Provinces.

Echinus acutus, Lamarck, was obtained off "Halifax" as recorded on page 13, whilst *Echinus elegans*, Dub. & Kov., also occurs there.

Echinarachnius parma, Gray, was collected off the coast of Labrador.

Echinarachnius parma, Gray, and *Strongylocentrotus Franciscanus*, A. Ag., on pages 216 and 212 respectively of the same Challenger report, from the Pacific waters of the St. George's Bank, Vancouver Island.—H. M. A.

* "Note on an Echinoderm, etc." OTTAWA NATURALIST, Vol. 13, No. 9, pp. 201—203. December, 1899.

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