

## ART. XLVIII.—On a Recent Discovery of Carboniferous Batrachians in Nova Scotia; by J. W. DAWSON, LL.D., F.R.S.

## 1. General Remarks.

THE erect Sigillariæ enclosed in the sandstone overlying coal-group 15 of Section XV, Division 4 of the South Joggins section, are perhaps the most remarkable repositories ever discovered of the remains of Paleozoic land animals. As I have shown in discussing their character in my memoirs on the South Joggins Coal Formation,\* and my "Acadian Geology," some of these trees became embedded in sandy deposits, and being rendered hollow by decay of their inner bark and the crumbling of their woody axes, remained for a long time as open holes or pits, gradually filling with vegetable debris and the wash of rains and land floods. They thus became places of habitation for land snails and millepedes, and pit-falls into which the smaller batrachians, prowling for prey among the undergrowth of the coal forest, fell and were unable to extricate themselves. In this way the successive layers of deposit became stored with skeletons of batrachians which they have retained in an admirable state of preservation.

Only one sandstone at the Joggins is known to contain these reptiliferous trees, though erect Sigillariæ are known at more than sixty different levels, and many of these erect stumps have been broken up in the hope of making such discoveries. In the past summer, however, shells of *Pupa vetusta* were found by Mr. Albert J. Hill and the writer in an erect tree in Section XXVI of Division 4, about 800 feet higher in the series; and of course where these shells occur remains of other land animals may also be discovered.

Since the discovery by Sir Charles Lyell and the writer of the remains of *Dendrorepelon Acadianum* in one of the erect trees of group 15, I have several times visited the locality, and have endeavored to take advantage of the exposure of new trunks by the encroachments of the sea. In the summer of 1859 I took down a second stump which afforded nine skeletons of four species, as well as remains of Millepedes and shells of Pupa. In 1860, I dissected two other stumps, which yielded six additional skeletons including two new species. In the whole six batrachian species were more or less perfectly represented, and were described by Prof. Owen or myself. Mr. Scudder subsequently made a careful study of the remains of Millepedes, and referred them to five species belonging to two genera.† In the present year another tree very richly stored

\* Journal of Geological Society of London, vols. ix, x, xi, xvi, xviii, xix.

† Air-breathers of the Coal Period, 1863. Acadian Geology, 1868, pp. 362 and 495. Scudder in Memoirs of Boston Soc. of Nat. History, 1873.

with remains was obtained, and its contents will form the subject of the present communication. Two others were extracted for me by the kindness of Mr. Hill, superintendent of the Cumberland Mine, but proved to be filled merely with sandstone without animal remains. This is an illustration of the fact that, even in this bed, only certain trees remained open long enough to become burial places of land animals.

All the remains found in these singular repositories are those of air-breathing animals, except certain worm-like bodies of uncertain nature, which Mr. Scudder suggests may be remains of Leeches. Further, as the reptiles which fell into these pits could have been only such as were capable of walking on land, the erect trees contain none of the ichthyic and elongated forms which have been described from Ireland, from Germany and from Ohio.\* Such forms no doubt existed in Nova Scotia, but could not be laid up in coffins formed of Sigillaria trunks. The species preserved in these are therefore all of more or less lizard-like form, and have well developed limbs. Some of them, as we shall find, are also remarkable for ornate cuticular appendages, more akin to those of modern lizards than to those of batrachians. Again, though we know from the footprints of *Sauropus unguifer*,† found in Cumberland County at no great distance from the Joggins, and from those of *Sauropus Sydneusis*‡ found in Cape Breton, as well as from the osseous remains of the alligator-like *Buphetes*, that there were large terrestrial Labyrinthodonts in the coal swamps of Nova Scotia, these were of course too bulky to fall into the erect Sigillariæ; consequently the remains found are those of the smaller species only.

The state of preservation of the specimens is also peculiar. All the bones of each specimen are sure to be present; but inasmuch as most of the carcasses had time to decay completely before they were finally covered up, the bones are often much scattered, and have apparently fallen into the interstices of the vegetable fragments on which they lay, so that the skeletons are usually disarticulated, and the bones, though individually perfect, are so entangled in the matrix that it is impossible to uncover the whole of them. In other, though rare cases, the body seems to have been covered at once, and its soft parts, and especially the skin, being either preserved by the tanning action of the vegetable matter, or converted into adipocere, remain in a coaly state, and completely cover the bones, so that these cannot be extracted except in fragments and by the destruction of the cuticle which invests them. Thus, while these remains afford the greatest facilities for the detailed and

\* By Huxley, Von Meyer and Cope.

† Geological Magazine, vol. ix.

‡ Acadian Geology, p. 358.

even microscopic examination of the parts, they do not often furnish skeletons with their members *in situ*, as in many of those described by Von Meyer, Huxley and Cope.

The tree of 1876 was found by me in "the reef" or extension of the sandstone seaward, and near the low-water mark. The upper part of the stump, probably filled with sandstone, had been removed by the waves, but about two feet of the lower part remained. It was extracted with as much care as possible by two miners with picks and crowbar, and the disk-like fragments, into which it naturally split, were carried up to the foot of the cliff and subsequently numbered and dissected at leisure. In the hurry of working against time to escape the tide, the men it seems left in the hole a portion of the lowest layer, and a fragment of an upper one. The former was afterwards removed by Mr. J. C. Russel of Columbia College, New York, and the latter was found by Mr. Hill. Both have been kindly placed in my hands by these gentlemen, so that the whole of the material has been collected and carefully labelled, in such a manner as to keep together the parts belonging to each skeleton.

This tree was about eighteen inches in diameter, and in the lower part was partially flattened by lateral pressure, so that its diameter in one direction was only a little over a foot. The material filling the somewhat thick coaly bark may be described as a more or less arenaceous silt or soil, blackened with vegetable matter, and replete with fragments of carbonized bark, mineral charcoal and fine vegetable debris. There are also numerous leaves of *Cordaites*, and abundance of the fruits which from their frequent occurrence in such hollow trees, I have elsewhere named *Trigonocarpum sigillariae*. In some places the sediment was finely laminated, the laminae being often much contorted. In other places the earthy matter existed in patches or interrupted layers, nearly free from vegetable matter, and especially abundant toward the sides of the trunk. The cementing substance is in general carbonate of lime, many portions of the mass effervescing freely with an acid, but in some spots there are hard concretions of pyrite. The material has evidently been introduced gradually, in small quantities at a time, and the earthy matter seems to have run down the sides, spreading more or less toward the center; but in general accumulating around the circumference. The number of skeletons recovered in a more or less complete state was no less than thirteen in all, belonging probably to six species, besides other bones contained in Coprolites, and several Millepedes, and shells of *Pupa vetusta*, the latter almost entirely in the lowest layers.

The first animal introduced was a specimen of *Hylerpeton Dawsoni* Owen, whose bones and scutes, after decay of the

connecting parts, had slid down the slope of silt from one side toward the center of the space. Next, after a few inches of filling, came a specimen of *Dendrerpeton Acadianum* Owen, whose bones lie along the center of the layer and nearly in one plane. Above this a large flake of bark had fallen in, forming an imperfect floor over the remains. Then, after an inch or two of carbonaceous matter had been deposited, came a somewhat flat surface which seems to have remained uncovered for some time, and on this lie the *dissecta membra* of three skeletons belonging to *Dendrerpeton Acadianum*, *D. Oweni*, and a new species of *Hylerpeton*. Above this was a confused mass of considerable thickness, in which were found another specimen of the new *Hylerpeton*, and remains representing a third animal of the same or an allied genus, also four specimens of *Hylonomus Lyelli*, and portions apparently of an immature *Dendrerpeton*. Still higher in position, was a layer with large portions of the cuticle of a *Dendrerpeton*, probably *D. Acadianum*; and above this, at the surface of the stump, were some remains and impressions of bones probably indicating another specimen of *Dendrerpeton*. Taking these specimens in the order above given, we may notice the new facts which they have disclosed on a preliminary examination.

## 2. Remains of *Hylerpeton*.

The sole species of this genus heretofore known, *H. Dawsoni*, was discovered by me in 1860, and was described by Professor Owen from remains so scanty that he expressed considerable doubt as to its affinities. I afterward worked out, from a few fragments of the matrix, the evidence that its teeth were simple, without plicated dentine, that it had a large canine or tusk in the anterior part of the upper jaw, and that it possessed a walking foot. The present specimen throws much additional light on its structure. It had at least twelve teeth in each ramus of the mandible, and they are large in proportion to the size of the animal, bluntly conical and somewhat acuminate, and faintly striate at the apex. The vomerine bones are beset with numerous small blunt teeth. The skull is long, and its bones thin and marked merely with delicate incised lines rather than wrinkles. The forms of the stout ribs and scattered vertebræ would indicate that the body was broad and squat. The skull must have been about two inches in length, the body probably four or five, and there are some small vertebræ which may indicate a short tail. The limbs were large and strong, the femur being an inch and a quarter long, and its shaft a fifth of an inch in diameter and with thick bony walls. The vertebræ are short and biconcave, and with large dorsal spines, the belly was protected by numerous imbricated bony scales of two

kinds, one oblong and narrow, the other broad and obliquely shield-shaped. There are indications of thoracic plates of larger size than the scales. On the whole this species was probably a somewhat clumsy creature, of toad-like form and slow gait, and with a dentary apparatus suited to pierce and crush crusts and shells. It is perhaps significant of its habits, in these respects, that the layers of this tree in which its bones occur are alone those in which shells of *Pupa vetusta* are found.

The second species of *Hylerpeton*, which I may provisionally name *H. longidentatus*, was of somewhat smaller size, with the bones of the skull thinner and more slender, and the teeth very long and sharply pointed, with the apex finely striate but with no corrugation of the dentine. The vomer is covered with minute teeth, and there are long and slender canines. The best preserved mandible shows eighteen teeth which are strongly inclined backward. The scales are very narrow and there is a large thoracic plate. The general form of body may have been as in the last species, but the skull was probably narrower and the feet longer.

Another species of this genus, or belonging to a genus intermediate between it and *Hylonomus*, is represented by a confused mass of bones showing long and narrow jaws, armed with short and blunt teeth, of which, at least thirty occur on each side of the lower jaws. The sculpture of the bones is as in the previous species, but the pulp-cavities of the teeth are smaller and their walls stronger, and they show no sculpture on the apex; in which respects they resemble those of *Hylonomus*. The vertebræ also are more elongated and the femur is a large bone indicating a powerful hind limb. The abdominal scutes are very long and narrow, resembling slender semi-cylindrical rods, a point in which this species differs from all the others found with it, although it resembles some of those found in Ireland and Ohio. This species I would name provisionally, in allusion to the form of its teeth, *Hylerpeton curtidentatum*.

In all these species of *Hylerpeton*, the teeth are simple, and are ankylosed to the bone and placed in linear series in a shallow groove.

### 3. *Remains of Dendrerpeton.*

The remains of this genus will afford additional facts as to the differences in individuals of various ages, and as to the details of the skeleton in the species *D. Oweni*, previously known by only one imperfect example. The specimen now found would seem to show that it resembled very much the larger species, except in the form of the teeth and scales. But the most interesting facts presented by a cursory examination of the specimens relate to the skin and its appendages. It is

now evident that in addition to the abdominal and gular scales, *Dendrerpeton* possessed thoracic plates of considerable size, resembling those of other Labyrinthodonts. The large mass of skin found in the tree of 1876, taken in connection with the smaller portions found on previous occasions, and described in detail in my "Air-breathers of the Coal-period," enables us to form a very good general idea of the appearance and clothing of the animals of this genus. To the naked eye the skin presents a shining and strongly rugose surface, reminding one of that of modern newts when contracted by immersion in alcohol, though on a coarser scale. Under the lens, the surface appears granular and with a higher power the granulation is seen to result from minute scales imbedded in the cuticle, and much smaller than those, in previous finds, which I have referred to *D. Oweni* and to *Hylonomus*. On some portions of it there are delicate transverse lines about a quarter of an inch apart, and apparently corresponding to those which on the newts and *Menobanchus* mark the bands of subcutaneous muscles. The bony scales of the abdomen have disappeared, except a few scattered in the matrix. But the most remarkable dermal appendages, are those triangular lappets or frills of which I have in previous papers described detached examples, and have compared them with the gular and cervical lappets and frills of iguanas, geckos and *Draco*; and which also suggest analogies with the processes that support the gills in perenni-branchiate batrachians, and with the lateral folds of the skin in *Menopoma*. These appendages are flat and of appreciable thickness, about half an inch in length, and an eighth of an inch in breadth, terminating in an edge or obtuse flat point, which seems to have been horny, while the appendage itself must have been flexible. They are marked with small scaly oval areoles or projections, placed somewhat in rows, and each with a minute puncture in its center. The markings on both sides are similar. These appendages are arranged in series along what appears to be the skin of a fore leg, and also in groups apparently on the anterior part of the body, perhaps the neck or shoulder. They appear to be closely connected with a series of much smaller angular points which extend along the edge of the skin near the supposed leg, and probably fringe the sides of the abdomen. The evidence that this integument belongs to *Dendrerpeton Acadianum* is derived from the presence in its anterior part of skull-bones having the markings of that of this species, and from the occurrence of a jaw and other bones in the neighboring matrix. The specimen to which the skin belonged may have been about a foot in length. Taking it in connection with what is known of the skeleton, we can reproduce the external appearance of the animal. It was

lizard-like in form, with a somewhat flat and broad head and strong teeth with folded dentine. Its back was covered with a shining skin filled with microscopic horny scales. Its sides were marked by vertical bands separated by delicate indented lines. Anteriorly it was ornamented with numerous cutaneous lappets or pendants. The sides were bordered with a row of sharp horny points, and the throat, thorax and abdomen were protected by bony scales and plates, the scales of the throat being narrow and small and arranged in a chevron pattern.

*Dendroperon Oweni* probably had the scales of the back and the horny appendages larger in proportion, that is, if I have rightly referred to that species some similar remains to those above mentioned, found in 1859. *Hylonomus Lyelli* had a far more ornate set of cutaneous appendages, as evidenced by remains of skin found associated with its bones, also in 1859.\* The tree of 1876 contains no cuticular remains referable to these species.

#### 4. *Remains of Hylonomus.*

The bones of this genus are all, I think, referable to *H. Lyelli*, and to specimens about the size of those previously found. They throw little additional light on its character, except to indicate that it was probably very abundant, and to render it probable that the specimens formerly described were adult. Two of the skulls in the tree of 1876 are better preserved than those previously known, and confirm the statement already made as to the smoothness of the bones and the greater cranial elevation as compared with other batrachians of the Carboniferous period. This is indicated, among other things, by the skulls lying upon one side, which is not found to be the case with the other species.

In the admirable Report by Cope on the Batrachians of the Coal-formation of Ohio,† he places *Hylonomus* in the same family, *Tuditanidae*, with *Dendroperon*. This I think does not express its true affinities. The more elongate and narrow skull, with smooth bones, the differently formed vertebræ, the teeth with non-plicated dentine, the different microscope structure of the bone, the more ornate dermal appendages, all separate these animals from the Labyrinthodonts, and entitle them, as I have formerly held, to a distinct position as an order or sub-order, for which I proposed in 1863 the name *Microsauria*. I observe that in the report on the Labyrinthodonts prepared by Mr. Miall for the British Association in 1873, and in the Tabular View appended to it in 1874, while the group *Microsauria* is retained, *Dendroperon* is placed in it, as well as *Hyloperon*

\* Journal Geol. Soc., vol. xvi, also "Air-breathers," 1863.

† Paleontology of Ohio, vol. ii.

and *Hylonomus*. This I think is an error in so far as the first genus is concerned. I may add my continued conviction that *Hylonomus* and its allies present many points of approach to the lacertian reptiles, which I hope in future to be able to work out more in detail.

Several masses of Coprolite, filled with small broken bones, were obtained in breaking up the material surrounding the skeletons. I presume these bones belong to one or other of the smaller species of *Hylonomus*; but I have not yet found any of them to be sufficiently characteristic to warrant any confident statement on the subject. These Coprolites must have been produced by *Denticrurpeton* or *Hylcrurpeton*, most probably the former.

The above statements must be regarded as imperfect, and preliminary to more detailed description and illustration of the specimens. These will require long and patient work and microscopic examinations of the bones and the teeth, and when this is completed they will be placed in relation, as far as possible, with the remains previously found in Nova Scotia, and with what is known of coal batrachians elsewhere.

I think it quite possible that further examination may enlarge the number of species above mentioned. I have been guided mainly in the reference of the specimens to species by the structure of the teeth and the cranial bones; but some of these may yield new points of difference on further study. As all the specimens are preserved under the same conditions, there is less liability here, than in most cases, to multiply species unduly, in consequence of different states of preservation.

The fact that Cope has been able to catalogue, in his recent Report,\* 39 genera of Carboniferous batrachians, including about 100 species, and that these present so wide a range of size, structure and general conformation, affords a very remarkable illustration of that simultaneous occurrence of many forms of one type, which appears in so many other groups of fossil animals; and is particularly striking in this first known group of air-breathing vertebrates, which since 1843 have swarmed upon us from the coal-fields of both continents, and of which we probably know as yet but a small fraction of the species. It remains to be seen whether the Devonian, so rich in its land flora, and which has already afforded remains of insects, may not disclose some precursors of the Carboniferous batrachians.

\* Paleontology of Ohio, vol. ii.