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Publisher: Taylor & Francis
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Annals and Magazine of Natural History: Series 4

Publication details, including instructions
for authors and subscription information:
<http://www.tandfonline.com/loi/tnah10>

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Published online: 16 Oct 2009.

To cite this article: M. Grand'Eury (1869) XIV.—Observations on the Calamites and Asterophyllites , Annals and Magazine of Natural History: Series 4, 4:20, 124-128, DOI: [10.1080/00222936908696011](https://doi.org/10.1080/00222936908696011)

To link to this article: <http://dx.doi.org/10.1080/00222936908696011>

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The answer seems to be sufficiently simple: nearly all the animals (practically *all* the animals, for the small number of higher forms feed upon these) belong to one subkingdom, the Protozoa, whose distinctive character is that they have no special organs of nutrition, but that they absorb nourishment through the whole surface of their jelly-like bodies. Most of these animals secrete exquisitely formed skeletons, sometimes of lime, sometimes of silica. There is no doubt that they extract both of these substances from the sea-water, although silica often exists there in quantity so small as to elude detection by chemical tests. All sea-water contains a certain quantity of organic matter in solution. Its sources are obvious. All rivers contain a large quantity; every shore is surrounded by a fringe which averages about a mile in width of olive and red sea-weeds; in the middle of the Atlantic there is a marine meadow, the Sargasso Sea, extending over three millions of square miles; the sea is full of animals which are constantly dying and decaying; and the water of the Gulf-stream especially courses round coasts where the supply of organic matter is enormous. It is therefore quite intelligible that a world of animals should live in these dark abysses; but it is a necessary condition that they should chiefly belong to a class capable of being supported by absorption, through the surface, of matter in solution, developing but little heat, and incurring a very small amount of waste by any manifestation of vital activity. According to this view, it seems highly probable that at all periods of the earth's history some form of the Protozoa, Rhizopods, Sponges, or both, predominated greatly over all other forms of animal life in the depths of the warmer regions of the sea—whether spreading, compact, and reef-like, as the Laurentian and Palæozoic *Eozoon*, or in the form of myriads of separate organisms, as the *Globigerinæ* and *Ventriculites* of the chalk. The Rhizopods, like the Corals of a shallower zone, form huge accumulations of carbonate of lime; and it is probably to their agency that we must refer most of those great bands of limestone which have resisted time and change, and which come in here and there with their rich imbedded lettering, to mark, like milestones, the progress of the passing ages.

XIV.—*Observations on the Calamites and Asterophyllites.*

By M. GRAND'EURY*.

Calamites.—The *Calamites* were regarded by the older naturalists as reeds, and owed their name to that supposition.

* Translated by W. S. Dallas, F.L.S., from the 'Comptes Rendus' March 22, 1869, tome lxxviii. pp. 705-709.

M. Brongniart was one of the first to approximate them to the Equisetaceæ, guided by the analogy of their most important external characters.

Dr. Petzholdt, and subsequently M. Richter, thought that decisive evidence in favour of this approximation was to be found in the internal structure of these stems; but the differences in their observations still left doubts on the subject, and the question thus remained enveloped in much obscurity.

The investigation that I have made of upright *Calamites*, which are very common in the Coal-measures of the Loire, will, I think, enable me to answer it in a satisfactory manner, and to give a more complete definition of the *Calamites*.

In the first place, the frequent presence of more or less complete septa at the joints is a perfect proof that these stems were fistular.

Again, in nearly all of them we find, generally surrounding the nucleus, a sort of internal epidermis, of cellular nature, which is smooth or sometimes marked on the outside by lines projecting opposite to the inner crests of the bark. This epidermis, which was also found by Dr. Petzholdt in *Calamites*, cannot have detached itself here from the inner surface of the coaly (*houillifiée*) envelope, of which it does not possess the form, and from which it is naturally separated, when it seems to have retained its relative position, by from half to two millimetres. Moreover it is connected with the septa, and forms with them one and the same system, which seems to unite with the bark, where it is contracted at the level of the articulations, by a sort of internal denticulations. There is also, between the coaly envelope and the inner epidermis, a thin structureless zone, which has evidently been occupied by tissue now destroyed. This tissue, which must have been lax and perhaps lacunar, as it is always completely destroyed, certainly corresponds to the vascular tissue of the *Calamites*, and may probably have represented in them the circle of lacunæ essential to the *Equiseta* (Duval-Jouve).

From this it seems to me that we may define the true *Calamites* as follows:—

Stems articulated, fistular, and septate, of which the outer part, which is comparatively thin, is formed by three concentric zones, namely:—1, an exterior cortical layer, now converted into coal; 2, a thin subjacent zone of vascular tissue, now invariably destroyed; 3, a sort of inner lining epidermis, which is carbonified.

Cortical envelope marked interiorly with regular flutings, interrupted and alternate at the articulations. Inner epidermis smooth or scarcely striated. Vascular cylinder thin, smooth within as having been covered by the inner epidermis, and adorned on the

outside with ribs, which are interrupted and strictly alternate at the articulations, having been in contact with the cortical envelope, which has faithfully preserved its form.

Outer surface of the bark more feebly fluted and articulated than the inner surface, of which it forms a reflection weakened in proportion to the thickness of the bark. Opposite to the articulations branch-scars are present, but not constantly; and there is no evident trace of the insertion of leaves.

In place of these there are sometimes, but not always, some small tubercular swellings, which, originating in the interior, only appear distinctly on the outside when the bark is thin; but as there is at the surface no scar indicated by the absence of the epidermis and by vascular passages, and defined and bounded by a precise line, such as is seen in most stems of the coal-measures, and also on account of their position at the summit of the ribs, they are only the representatives of the rudimentary teeth of an aborted sheath. So that the *Calamites* were destitute both of leaves and sheaths.

These chief features of organization which the *Calamites* possess in common with the *Equiseta*, are associated with characters of subterranean vegetation likewise so capable of identification with those of these same existing plants, that they must be regarded as forming an extinct genus of the family *Equisetaceæ*.

Thus having been able to follow the removal of the floor of a coal-bed in which *Calamites Suckowi*, Brong., is very abundant in an upright position, I had the good fortune to see that vertical stems of this species emit at their articulations thin running rhizomes, which, after becoming elongated to from 0.50 to 1 metre, swell suddenly and rise up as ascending stems—that these, again, in their turn emit fresh definite rhizomes, but only from the elbow which they form in ascending, and so on, producing a succession of stems, which is not without analogy to what we see in *Equisetum variegatum*. It is even probable (but this I have not yet ascertained) that the vertical mother stem which gives rise to so many suckers, derives its own origin from a deep-seated rhizome. If this were the case, we should have, in these numerous groups of rhizomes springing one from the other, as it were the witnesses of an ancient marsh occupied by a species of *Calamite*, which, just like *Equisetum limosum*, would have spread over a great space of inundated land. However this may be, the mother stem, the definite rhizomes, and only the base of the ascending stems are furnished with simple or ramose rootlets.

As regards the other isolated *Calamites* of the fossil forests

of Saint-Etienne, in the casts of which we find the same traces of structure, they are straight, possess a few rootlets at the base, and appear to have an individual existence. But this individuality is perhaps more apparent than real; for their distribution in the fossil forests, and the agglomeration of the same stems in certain places, are favourable to the supposition that they sprang from slender indefinite rhizomes, of which nothing has remained for our investigation.

Lastly, there is nothing, even to the approximation of the articulations at the origin of the stems and rhizomes, that is not imitated by the living *Equiseta*.

Calamophyllites and *Asterophyllites*.—Nothing is at present settled as to the nature of the stems of which the arborescent *Asterophyllites* are the caducous branches, although a certain number of stems bearing branches of *Asterophyllites* have already been found. The uncertainty in which we are upon this subject is such that these branches have been ascribed both to the *Calamites* belonging to the group of vascular Cryptogamia and to the *Calamodendra* belonging to the Gymnosperms, their inflorescence, described as *Volkmannia*, being still incapable of solving the question, because the organized dust discovered in the sacs borne by some of them in the axils of their bracteal leaves might equally well consist of spores or of pollen. However, it is most desirable now to ascertain the real connexion of organs which are invariably dissociated, mutilated, and so profoundly altered.

I believe I have sufficient data to prove that the greater part of the *Asterophyllites* are not branches of *Calamites*, but of other stems, which even depart widely from them in their characters, and to which I give the name of *Calamophyllites*.

It would appear that the *Asterophyllites* cannot be the branches of the true *Calamites*, not only because these branches would be furnished with leaves whilst the stems are destitute of them, which has nothing absolutely impossible in it, but because, besides not being so well grooved and articulated, they have their leaves attached above the lines of articulation, and, what is far more significant, their secondary branches inserted in the axil of the leafy whorls, and not below them, as would be the case if they had the organization of the true *Calamites*.

Moreover all the branches which I have seen issuing from true *Calamites* have exactly all the essential characters of the latter, and have neither leaves nor any indications of having possessed them. I have frequently found, mixed together, considerable quantities of branches of various sizes, constructed

at their articulations exactly like certain *Calamites*—so much so that all, even to the slenderest, appear to have emitted whorls of branches, whilst the branches of *Asterophyllites* only gave origin to distichous ramifications, and this, moreover, unsymmetrically. I have even seen the apex of a *Calamite* with its articulated branch-shoots as destitute of leaves as the stem.

On the other hand, I have ascertained, from several most instructive specimens, that the stems which are surrounded and surmounted by branches of *Asterophyllites* resemble the latter in all points, have leaves or leaf-scars, and in general only a vague and distant resemblance to the *Calamites*.

From this, therefore, we may conclude that the arborescent *Asterophyllites* sprang, not from *Calamites*, but from leaf-bearing stems organized like themselves.

These stems are not rare, and I have already found several of them. *Hippurites longifolius*, Lindl., is evidently a fine and complete example, and *Calamites Goepperti*, Ettingsh., is another, deprived of its leaves. They form a group which may be characterized as follows:—

Stems articulate, very certainly hollow and septate, of herbaceous nature, not always regularly striate. Leaves caducous, attached to a cincture of articular protuberances situated above the line of articulation, and not in relation to the striæ or indistinct ribs situated below, erect or raised, linear, flat; they appear smooth or traversed by few and distinct or by numerous, very fine, equal and parallel nervures. Caducous branches of *Asterophyllites* inserted all round and essentially above the articulations, in the axil of the leafy whorls, leaving by their fall large discoidal scars situated completely above, and not opposite to the articulations.

I do not wish to assert here that all the arborescent *Asterophyllites* originate from similar stems, although their leaves are generally striated by fine, equal and parallel nervures. I have even good reasons for the opposite opinion; for I know of stems, analogous to *Calamites varians*, Sternb., which appear to have had leaves inserted at the end of the ribs; and I have seen an *Asterophyllite* which was to be referred to large stems invaginated at their articulations by leaves joined together at the base, as in the genus *Phyllothea*, and to which, on account of this peculiarity, I give the name of *Phyllothea stephanensis*.