Additional Notes on the Structure of Fossil Tree Ferns.*

By

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The writer described in 1927 two new species of Mesozoic tree fern stems, showing internal structure, under the names of *Cyathocaulis naktongensis*, gen. et sp. n. and *Cibotiocaulis Tateiwai*, gen. et sp. n. The former species is determined based on some materials from the Jurassic of South Korea and from the Cretaceous of Wakayama Prefecture, while the latter based on only one incomplete material also from the Jurassic of South Korea. Both of them exhibit the characteristic external features and internal structure, similar to those of the living genera of the Cyatheeae, from which, however, differ in having inwardly curved stelar margins at the leaf gaps and in the presence of medullary root traces. Both species are to be distinguished from each other in the features of petiolar bases.

After described them, the writer is going to consider that the difference of two species is too small to separate them in different genera, and they should be included into a genus, so that the latter species was emended as *Cyathocaulis Tateiwai* (1938). Recently, the writer studied another fossil tree fern stem, showing structure, from Mindoro, one of the Philippine Islands. This is very similar to the above described Japanese species, but is distinguished by the presence of a few cortical meristemes. This difference has no generic value, so that this was described as *Cyathocaulis Yabei*, sp. n. (1941).

The cortical meristemes of the Philippine species are so small in size and so few in number that they may be overlooked. It was true that the writer recognized, in the preparations of Japanese species, a few small bundle-like tissues in the cortex, whose preservation was, however, too bad to define their true nature, and he did not touch on such a structure.

In spring of 1940, the writer had an opportunity to visit Korea and to collect numerous specimens of fossil tree ferns, at the places where the original specimens were collected, in order to do further studies which were missed in the former investigation. After making some preparations,

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the presence of cortical meristeles was made clear in both species, so that it is desirable to add this fact and some others to the former informations in 1927.

***Cyathocaulis nakdongensis*, OGURA.**

Cyathocaulis nakdongensis, OGURA. Journ. Fac. Sci. Tokyo Imp. Univ. Sect. III. Vol. 1, p. 352, 1927.

Materials from Korea.

Original specimens were collected by Dr. I. TATEIWA from N. Kyöngsang Dô of Korea, of which four specimens were sent to the writer (Nos. 2A, 2B, 2C & 2D). In the preparations from them doubtful tissues of cortical meristeles were observable only in one or two. Near the places where the TATEIWA's specimens were collected, the writer could find numerous fragments of fossil tree ferns and brought back about fifty specimens

Fig. 1. *Cyathocaulis nakdongensis*, no. 57. Polished cross surface, showing the stem surrounded with thick root mass; vascular system of the stem well visible. $\times \frac{1}{2}$.

(Nos. 2, 3, 4, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 54, 55, 56 & 57). Some of them are nearly round, but mostly more or less flattened. Most of them are thick, as their stems are surrounded by their own thick root cluster; the stem is about 8–10 cm. in diameter, while the whole diameter measures 10–20 cm. or more (Fig. 1). One of the largest

specimens (No. 43) measures 60 cm. in length and 30 cm. in thickness. Most of them are preserved somewhat better than the TATEIWA's specimens, and some new observations could be made.

The Cortical Meristele. The structure of the main stele and medullary meristeles surrounded by their own sclerenchymatous tissues, the mode of departure of leaf traces, the presence of cortical as well as medullary root traces are just as given in the former information, and there are no necessity to give further demonstrations (Fig. 2). It should be noticed here

only the presence of cortical meristemes, which were failed to find in the former study. They are few in number and small in size, so that they cannot be observed in the polished surface, and to observe them the large preparations through the whole part of the stem should be made.

Among the preparations newly made, one (No. 57) contains only two cortical meristemes in the whole cortex, while in other preparations, in which a part of the cortex is damaged, four (No. 54), three (No. 21), two (Nos. 56 & 46), one (No. 26) or no (Nos. 15 & 38) cortical meristemes are found, though there are some other doubtful tissues at the corresponding places. Comparing these preparations, it may be

concluded that they are few, at most five or six in a cross section, so that in the incomplete preparations the cases without them may be met with. That the writer missed their presence in the former study is based on this fact. As their number is few, the course of the cortical meristemes may be

Fig. 3. *Cyathocaulis naktongensis*, no. 56. A part of the preparation near an outgoing leaf trace, showing a cortical meristeme on the left. $\times 8$.

Fig. 2. *Cyathocaulis naktongensis*, no. 54. A part of the preparation, showing general structure; some of the tissues ill preserved. $\times 2$.

r, root; st, stele; sc, sclerenchymatous sheath; lt, leaf trace; cr, cortical root trace; mr, medullary root trace; mb, medullary meristeme; cb, cortical meristeme.

assumed. They appear in pair as small protuberances of the stelar ring, when it bulges out as for a leaf trace, and after separating from it they ascend along the leaf trace and finally fuse there (Fig. 3). Their course is therefore rather short and is similar to that of some living Cyatheacean species, and when the leaf traces overlap with each others, some pairs may be found in one cross section.

The cortical meristele is small, much smaller than the medullary meristele, and consists of mass of some small tracheids. It is situated near the main stele, mostly interrupting the sclerenchymatous sheath of the latter. It is therefore distinguishable from the root traces, which are situated outside the sclerenchymatous sheath and consist of a small bundle surrounded by a broad cortical tissue.

Additional Notes. In most cases the stem is surrounded by thick root masses, and in some preparations (Nos. 15, 21 & 56) hairy structure is found on the stem surface, protected by the roots. It consists of filiform, uniseriate, multicellular hairs, arranged closely together, just as those of living species of *Dicksonieae* (Fig. 4). This point is important, because the stelar system is rather similar to that of the living *Cyatheeae*, whose stem is, however, surrounded by scaly hairs, while the filiform type is similar to that of the *Dicksonieae*.

Fig. 4. *Cyathocaulis nakdongensis*, no. 21. A part of the periphery of the stem, showing a cluster of filiform hairs. $\times 40$.

Fig. 5. *Cyathocaulis nakdongensis*, no. 21. A part of the root mass, showing the root hairs. $\times 40$.

Hairy structure is also found on the periphery of some roots in the root mass. It consists of long unicellular hairs, representing, with no doubt, the root hairs (Fig. 5). They are thinner than the stem hairs.

Another peculiar structure is found among the root mass. It is similar to the root in form and size, but differs in having an arc-formed tracheidal band in its center. Some of such tissues are found among the root mass; they represent the bundles of the petiole, whose fundamental tissue is mostly decayed away and is replaced by root mass, just as we meet with in many living ferns (Fig. 6).

Materials from Wakayama-Prefecture.

To obtain further materials, the writer visited in 1941 the place where he formerly (1926) collected some specimens, but it was in vain, as the

Fig. 6. *Cyathocaulis naktongensis*, no. 56. A part of the root mass, showing the intermingled remains of petiolar bundles, each with an arc-shaped tracheidal band. $\times 10$.

Fig. 7. *Cyathocaulis naktongensis*, Wakayama no. D. A part of the preparation near an outgoing leaf trace, showing a cortical meristele on the upper side. $\times 8$.

place changed to a fruit garden, so that some additional preparations were newly made from the original specimens. Comparing them with original preparations, the writer could confirm the presence of the cortical meristeles (Nos. C, D & I). In most incomplete preparations none of them is observable, and even in larger one they count only one or two. Their size, structure and course are, however, the same with those of Korean specimens (Fig. 7).

Though the materials from Wakayama are somewhat smaller than those from Korea, their internal structure is quite the same with that of the latter. The structure of the medullary meristele and its own sclerenchymatous sheath, which is one of the characters useful for specific distinction, is also identical in both materials.

***Cyathocaulis Tateiwai*, OGURA, emend.**

Cibotiocaulis Tateiwai, OGURA. JOURN. FAC. SCI. IMP. UNIV. TOKYO. SECT. III, Vol. 1, p. 346, 1927.

Cyathocaulis Tateiwai, OGURA. Anatomie d. Vegetationsorgane d. Pteridophyten. Handb. d. Pflanzenanat. 2. Abt. 7. p. 353, 1938; Jubl. Publ. Prof. YABE, Vol. 2, p. 918, 1941.

In the former study, the genus *Cibotiocaulis* was established based on one incomplete specimen from N. Kyöng-sang Dô of Korea. Studying this specimen, the writer separated this from the former genus, *Cyathocaulis*, in that, (1) the petiolar bases remain on the stem surface and (2) the leaf traces show the arrangement of *Cibotium* type. Afterwards, he considers that the difference of both species is too small and they should belong to

a single genus, so that he emended this as *Cyathocaulis Tateiwai* (1938). This conclusion was ascertained from the study of newly collected materials.

Materials from Korea.

Near the place where the TATEIWA's specimen (No. 5) was collected, the writer could find numerous fragments of fossil ferns, and some of them were brought back (Nos. 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81 & 86). This place is not so far from that where the former species is found (about 6 km. apart). They are much smaller

than the former species, because the stem, measuring about 7–8 cm. in diameter, is mostly exposed or surrounded by a thin root mass, and may be distinguished from the latter in the features of the surface. One of the largest specimens (No. 64) measures 21 cm. in length and 10 cm. in diameter (Fig. 8).

Fig. 8. *Cyathocaulis Tateiwai*, no. 64. Stem surface, showing remains of petiolar bases with some vascular bundles. $\times \frac{1}{2}$.

The Leaf Trace. When the stem is exposed, it is remarkable that the bases of petioles somewhat bulge out of the stem surface, just as described in the former information. On the base of such a petiole are found numerous leaf trace strands, whose arrangement is not wholly distinct, but their characteristic type of arrangement reminds us at once that of the Cyatheaceae. In the former study the writer observed the leaf traces to be continuous at the petiolar base and then to separate into small strands, just as living *Cibotium* species. In the present investigation, it is found that this is not the case, but the leaf traces are separate even in the petiolar base; this is confirmed also from the features in cross sections, so that the behavior in the departure of leaf traces is mostly similar to that of *Cyathocaulis naktongensis* or to that of

living Cyatheae. That the writer came to the different result in the former study was based on the incompleteness of the material.

The Cortical Meristele. Another point of new investigation is the recognition of cortical meristeles, which were missed in the former study.

The mode of their appearance is quite similar to that of the former species; they are few in number, four in a complete cross section (No. 63), and in incomplete preparations, four (No. 71), three (No. 66), two (Nos. 67 & 78) or none (No. 76) of them are found. Their size, form and course are quite similar to those of the former species (Fig. 9), so that their detailed description will be omitted here.

Fig. 9. *Cyathocaulis Tateiwai*, no. 66. A part of the preparation near an outgoing leaf trace, showing a cortical meristele on the lower side. $\times 8$.

Fig. 10. *Cyathocaulis Tateiwai*, no. 76. A part of the pith, showing the medullary meristeles surrounded by sclerenchymatous sheaths. $\times 8$.

Additional Notes. In the former study, the presence or absence of sclerenchymatous sheath round the medullary meristele could not be determined owing to bad preservation. In the new materials we can see its presence nearly in all of the medullary meristeles. This tissue surrounds each meristele more or less completely or is interrupted in one or two places (Fig. 10). This is one of the different points from the former species, in which the sclerenchymatous sheath is largely separated or scarcely developed, though in some larger meristeles the sheath surrounds them more or less completely.

The presence of filiform hairs on the outer surface of the stem, which was described in the former information, is also newly confirmed (No. 78). Their structure is similar to the former species. As formerly described, filiform hairs are present in the stems of Dicksonieae among the living Cyatheaceae, while in those of Cyatheeae scaly hairs are characterized. On these facts, the writer considered this species having an affinity with Dicksonieae rather than Cyatheeae, and gave the name *Cibotiocaulis*. This conclusion is ought to be corrected, because it is now confirmed that such hairy structure is also found in the former species. Both species are thus to be included in one genus.

In some roots round the stem are found hairy structure, incompletely

preserved, which may represent the root hairs, just as described in the former species.

Conclusion.

1. In *Cyathocaulis naktongensis* there are few cortical meristeles, which appear accompanying with the outgoing leaf traces. They are few and small. The presence of filiform hairs on the stem surface is also confirmed.

2. In *Cibotiocaulis Tateiwai*, most of the anatomical characters are identical with the former species; the presence of a few cortical meristeles and filiform hairs on the stem surface is also the same, so that this species is very similar to the former one, and rather may be included in the former genus, being thus emended as *Cyathocaulis Tateiwai*.

3. *Cyathocaulis Tateiwai* may be distinguished from *C. naktongensis* (1) in the petiole bases, which remain somewhat elevated in this species, while in the latter they fall off from their very bases, (2) in the root mass round the stem, which is rather poor in this species, while in the latter strongly developed, and (3) in the sclerenchymatous sheath of the medullary meristeles, which is rather complete in this species rather than in the latter.

4. *Cyathocaulis Yabei* from the Philippine Islands is another, but related species, showing also a few cortical meristeles. The distinction of these species lies in the structure of medullary meristeles and their sclerenchymatous sheathes:—

C. Yabei: medullary meristele may contain small pith; sclerenchymatous sheath absent.

C. naktongensis: medullary meristele contains no pith; sclerenchymatous sheath absent or present, if present, interrupted mostly.

C. Tateiwai: medullary meristele contains no pith; sclerenchymatous sheath more or less complete.

5. In the living Cyatheaceae, the medullary meristeles are always present, but the cortical ones are either present or absent; even among the species of the same genus one has them but another has not. Their presence or absence has not, therefore, the generic character. This may be also applied to the fossil Cyatheaceae, and it may be reasonable that in the genus *Cyathocaulis* both forms, with or without them, may be included.

Literatures.

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化石木生羊齒ノ構造ニ關スル追補 (和文摘要)

小 倉 謙

筆者ハ昭和2年化石木生羊齒ノ構造ヲ記シ、*Cyathocaulis nakdongensis* 及 *Cibotio-caulis Tateiwai* ノ二新屬新種ヲ發表セリ (東大理紀要・植物・1卷)。其ニ朝鮮慶尙北道ノ産ニシテ、前者ハ猶ホ和歌山縣ニモ産ス。兩種トモ現今ノヘゴ科ニ類スル大ナル莖ノ化石ニテ、葉隙ニ面スル中心柱ノ兩縁ガ髓中ニ深ク突入スルコト、皮層及髓中ニ根跡ノ存在スルコトナドニ於テ現今ノヘゴ科ト區別セラル。而シテ二屬ノ相異ハ葉柄ガ前者ニテハ基部ヨリ離落スルニ反シ、後者ニテハソノ基部ヲ殘留スル點ニアリ。然ルニソノ後ノ考察ニヨリ、兩者ノ相違ハ左程著ルシカラザルニ氣付キ、兩者ハ寧ロ同屬ニ編スベキモノト考ヘ、後者ヲ *Cyathocaulis Tateiwai* ト改稱セリ (Anatomie d. Vegetationsorgane d. Pteridophyten. 1938)。

ソノ後筆者ハフリッピン産木生羊齒ノ化石ヲ入手シ、ソノ構造ガ前二種ト相類スル故コレヲ同屬トシ、コレヲ *Cyathocaulis Yabei* ト命名セリ (矢部教授還曆記念論文集, 2卷. 昭和16年)。コノ種ノ特徴ハ少數ナガラ皮層中ニ維管束條ノ存在スルコトナリ。前二種ニハカ、ル皮走維管束條ヲ認メザリシガ、ソレラシキ組織ノ存在ニ疑問ヲ懷キテソノ點ヲ確メンタメ、新ニ慶尙北道ヨリ多數ノ標品ヲ獲テ詳細研究ノ結果、前二種ニモソノ存在ヲ確認スルニ至レリ。但シイヅレモ少數ニシテ一横斷面ニ數個ヲ算スルニ過ギズ。

尙ホ二種トモ莖ノ表面ニ毛ノ存在ヲ認メンガ、ソノ毛ハ鱗毛ニアラズシテ多細胞ヨリ成ル絲狀ノモノナリ。コレ現今ノたかわらび族 (Dicksonieae) ニ見ラル、型ナルガ、莖本體ノ構造ガ現今ノヘゴ族 (Cyatheae) (莖ニ鱗毛アリ) ニ最モ酷似スル點ト一致セザル所トス。

又莖ノ周圍ニハ多數ノ根集リテ根叢ヲナスモノナルガ、カ、ル根ノ周ニ根毛ノ存在ヲ認メタリ。

本研究ハ文部省科學研究費ノ一部ヲ以テ行ヘリ。又材料蒐集ニ關シ朝鮮總督府地質調査所長立岩巖氏並ニ同技手高橋英太郎氏ニ負フ所多シ。記シテ謝意ヲ表ス。