DOI:10.19800/j.cnki.aps.1987.06.004

CUTICLES OF *PHOENICOPSIS* FROM NE CHINA WITH DISCUSSION ON ITS TAXONOMY*

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Summary

I. Foreword

Genus *Phoenicopsis* is one of the common genera from Mesozoic floras in Eurasia. Based on the external characters of leaves and dwarf shoot, it was established as a form-genus by Heer and classified to the Taxineae of Coniferae (Heer, 1876, p. 48), with *P. angustifolia* Heer as type-species which was collected from the Middle Jurassic Prisajan Formation of the Irkutsk basin, Siberia, USSR for the first time. During the same period, Heer also created *P. speciosa* Heer and *P. latior* Heer from the Amur River valley (1876, pp. 112—113). Later, Nathorst (1897) described *P. speciosa* from Spitsburgen, Krasser (1900, 1905) established *P. taschkessiensis* Krasser, *P. potonii* Krass. and *P. media* Krass. from Centre Asia and described some *Phoenicopsis* from Jilin, China; Kryshtofovich (1910, 1924) reported *P. speciosa* from S. Primorye, USSR and Liaoning, China, Seward (1911—1931) created *P. gunni* Sew. from Scotland and *P. steenstrupii* Sew. from W. Greenland and described some other species of this genus from Xinjiang, China. Besides, there were also some reports about *Phoenicopsis* by Potonié (1903), Yabe (1908), Salfeld (1909), Harris (1926), Capman (1927), Sahni (1928), Yabe & Oishi (1933) and others.

As to the cuticular researches on *Phoenicopsis*, the first work** seemed to have been done by Seward (1926) on the material of *P. steenstrupii* from the Nügssuaq Peninsula of W. Greenland. After this, Prynada (1928) also studied the culticles in *P. taschkessiensis*, *P.* cf. *speciosa*, etc. But more important and detailed work was done by Florin who incorporated some species of *Phoenicopsis* into his three new genera *Stephenophyllum, Windwardia* and *Culgoweria* mainly on the basis of their stomatic distributions in cuticles (1936, p. 75), and retained the name of *Phoenicopsis* under which some species with unclear cuticular characters were placed (Ibid., p. 137).

Since the 1960s, a number of studies on *Phoenicopsis* have been done by some Russian palaeobotanists, such as Vakhrameev & Doludenko (1961), Samylina (1963, '64, '67a, '72), Orlovskaja (1968), Vladimirovich (1968), Doludenko & Rasskazova (1972), Krassilov & Schorohova (1975). At the same time, some researches both on external and on cuticular *Phoenicopsis* also have been made by several Chinese palaeobotanists, such as Sze, H. C., Li, X. X. et al. (1963), Zhou, Z. Y. (1983), Sun, G. et al. (1986)***.

After making a summary on *Phoenicopsis* of Cretaceous—Jurassic from 31 localities of USSR, Samylina (1972) pointed out that besides its identity with *Stephenophyllum, Windwardia, Culgoweria* (abbreviated to *S. W. C.* below) in the external features, it was difficult to distinguish Flo-

* Subsidiary subject of the project supported by National Natural Science Foundation of China

** Holden (1915) had modes some relevant researches, but his paper has not been checked by the author.

*** Sun, G. et al., 1986, Palaeozoic and Mesozoic plants from Jilin. Atlas Palaeontologica, Jilin of China (in press).

rin's three genera from those species with clear cuticles put under *Phoenicopsis* reported at that time, such as *P. taschkessiensis, P. taschkessiensis* f. *papillata* Pryn., *P.* cf. *speciosa.* Moreover, the demarcation lines of the cuticular characters among the genera *S. W. C.* sometimes were not certain. Therefore, she proposed to reduce *S. W. C.* to a lower rank in classification as three subgenera, namely, *Phoenicopsis (Phoenicopsis)**, *P. (Windwardia)* and *P. (Culgoweria)*.

According to researches on a large number of culticles in *Phoenicopsis* secured from NE China, it has been made out that there certainly existed many transitional cases in the cuticular characters among Florin's *S. W. C.*-types, especially between those of the *Windwardia*-type and the *Culgoweria*-type in the case of stomatic distributions with irregular single files or bands. Besides this, there also existed transitions from the hypostomatic to amphistomatic types in different parts of leaves with the *Stephenophyllum*-type cuticles; this case also has been found in some other genera of Ginkgophytes such as *Sphenobaiera, Ginkgo Czekanowskia,* and, in fact, it had already been sensed by Florin (1936, p. 84) though he still insisted on his classification about the genera *S. W. C.*

In addition, it should be noticed that during Florin's classification work mentioned above, the cuticles of the type-species of *Phoenicopsis* from Irkutsk, USSR still remained unstudied and the anatomic knowledge of *P. angustifolia* was made clear only after the 1960s. Therefore, it seems that Florin's work was, in a sense, limited conditionally to that time though his research work had been beneficial to the taxonomy of *Phoenicopsis*. For the recent years, along with the deepgoing research on *Phoenicopsis* with rich cuticular materials on a worldwide scale, one can recognize more and more about the cuticular characters and their variations and seems to get rid of some menmade factors in the classification of *Phoenicopsis* as far as possible.

In short, the author thinks that it seems suitable to give the taxa with the *S. W. C.*-types' leaves like the subgenera of *Phoenicopsis* a relatively wider definition (sensu lato) in their identifications. Meanwhile, the impression fossil plants with the externals of *Phoenicopsis* still can be put under the name of the genus *Phoenicopsis* but they have to await further researches.

In NE China, *Phoenicopsis* has been studied for more than 80 years so far. The earlier researches were made by Krasser (1905) from both Jiaohe (Thio-ho) and Huoshiling (Ho-Schi-ling-tza) of Jilin, Kryshtofovich (1924) from Badaohao (Pataoho) of Liaoning, Yabe and Oishi (1933) from Weijiapu (Wei-chia-pu-tzu), Benxi of Liaoning and Jiaohe and Huoshiling of Jilin. For the recent 30 years, there has been a lot of work on *Phoenicopsis* by Sze, H. C., Li, X. X. et al. (1963), Zhang, Z. C. (1976), Zhou, Z. Y. et al. (1980), Zhang, W. et al. (1980) and the author (1979, 1985**, '86). But, the present paper makes a detailed research on the culticles of this genus from NE China for the first time.

The material described in the present study is part of a large collections of *Phoenicopsis* from L. Cretaceous—U. Jurassic of Huinan, Jilin and Jus'hua (Huolinhe Coal-Mine), E. Nei Monggol of China. This paper describes three new species of *Phoenicopsis* and a species of spores, namely,

Phoenicopsis (Windwardia) jilinensis sp. nov.

P. (Culgoweria) jus'huaensis sp. nov.

P. (C.) huolinheiana sp. nov.

Cyclogranisporites sp.

Some epiphytic fungi associated with *Phoenicopsis* will be reported in detail in a separate paper.

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* The type species of *Phoenicopsis, P. angustifolia,* possesses the *Stephenophyllum* -type cuticles, and the name of *Stephenophyllum has become a junior syn. of Phoenicopsis* during the nomenclature of this subgenus according to "International Code of Botanical Nomenclature" (1966). Therfore, *P. (Phoenicopsis)* should be used instead of *P. (Stephenophyllum)* (referring to Samylina, 1972, p. 46).

* Sun, G., 1985: On Late Triassic flora from Tianqiaoling of Jilin, China (to be published).

II. Geographic and Geological Distributions

Since the first discovery of *Phoenicopsis* from the Irkutsk and Amur River areas of USSR, it has mainly been found from the east and northeast areas of Euasia, such as Siberia, Centre Asia, Monggol, China, Korean Peninsula and Japanese Islands. The scattered localities of this genus also lie in regions with medium or higher latitudes on the global scale, e.g., Sutherland of Scotland (Seward, 1911), Nügssuaq of W. Greenland (Seward, 1926), Francois-Joseph Land Is. (Florin, 1936), Aninia of Romania and Cape Lisburn of Alaska (Dijkstra, 1973), Alberta and British Columbia of Canada (Bell, 1956), Argentina (Archangelsky, 1968), Tasmania and Casterton-Victoria of Australia, S. Africa (Dijkstra, 1973), etc. Some species put under *Phoenicopsis* with a query were also reported from the Organ area of USA (Fontaine, 1905), etc.

Samylina (1972) and Krassilov et al. (1975) studied the phytogeography of *Phoenicopsis* and made some sketch maps showing the distributions of this genus. But, the maps were not integrate mainly resulting from lack of material from E. Asia, especially from China, Korean Pen. and Japanese Is. On the basis of large collection and studies of *Phoenicopsis* in China for more than 40 years, two new maps showing the distribution of *Phoenicopsis* are published in the present paper, including about 80 localities dispersed widely over North China and scattered in south-central and southeastern China (Figs. 1, 2). The territory of *Phocnicopsis* in China, which has been recognized so far, extended to about 25°N (Hexian of Guangxi—Jiaoling of Guangdong) in the southernmost, to Akto of SW Xinjiang in the westernmost and Huma of N. Heilongjiang (about 52°N) in the northernmost.

As to the stratigraphic range of *Phoenicopsis*, the earliest occurrence seems to be in the Lower Ladian Hiramatsu Formation of Yamaguchi Pref. in SW Japan. Besides, all the earlier horizons, such as Kumakura Fm(T_2^2), Yamanoi Fm (T_3^1) and Momonoki Fm (T_3^1), are also in SW Japan (Kimura, 1980, p. 381). Up to now, many findings of this genus in Upper Triassic have been reported from eastern China, Korea and Japan, including Tianqiaoling of Jilin (Sun, G., 1979, etc.), Laoheishan of Heilongjiang (Sun, G., 1982*), Dajianggang of Jilin (Sun, G. et al., 1983) of NE China; Goyangri (Gimpo Group), Myeongam and Cheondaeri (both of Nampo Gr.) from S. Korea (Kimura & Kim, 1984); Nariwa and Yamaguchi of SW Japan (Oishi, 1932b; Kimura, 1980); Jiaoling of Guangdong (Xiaoping Fm) and Jian'ou of Fujian (Jiaokeng Fm) of SE China**. Abundant materials showed the flourish of *Phoenicopsis* during the Late Triassic in E. Asia; this seems to imply that one should reconsider the validity of *Phoenicopsis* which can be only regarded as a representative of M.—E. Jurassic flora in China.

III. Significance

Phoenicopsis seems to be one of the important indicators for the restoration of palaeoclimate during the Mesozoic. A vast amount of actural material has shown that this genus was living mainly under a temperate climate in Mesozoic. Krassilov supposed that *Phoenicopsis* had grown at the highest position on the slope land in deltaic facies (1972, p. 143, text-fig. 23) and that it can be regarded as an indicative (dominant) genus for the Arctotriassic geoflora (Krassilov & Schorohova, 1975, pp. 11—12).

According to the latitudinal changes in the distributions of *Phoenicopsis* in Mesozoic) Eurasia, the author thinks that it also seems to be capable of indicating the expansion or migration of climatic zones. More precisely, it seems that *Phoenicopsis* first occurred in the coastal areas of E. Asia in M. Triassic and had been with the begining of prosperity during L. Triassic there (Fig. 3, I); afterwards, it had distributed mainly in the interior of the east and central parts of Asia during

* Sun, G., 1982, Late Triassic plants from Laoheishan of Dongning County, Heilongjiang and their geological significance (in press).

** The regional stratigraphy of China (1974, 1979).

M.—E. Jurassic (Fig. 3, II), and thenceforth, in general, it has been dispersed in the northeast or north parts of Eurasia Land in L. Jurassic—E. Cretaceous even L. Cretaceous (Fig. 3, III). The covering areas of *Phoenicopsis* gradually extended first to northwest and then to north in directions from Triassic to Cretaceous, implying that the subtropic-temperate zones were gradully expanding from south to north, generally in the N-hemisphere during Mesozoic. On the other hand, the extinction of *Phoenicopsis* was probably connected with the great geological event which brought about a sudden climatic change and covered the whole world at the end of Mesozoic.

IV. Systematic Descriptions

Gymnospermatophyta

?Ginkgopsida

Czekanowskiales

Phoenicopsis Heer, 1876

Phoenicopsis was established by Heer (1876) as a form-genus for the first period. The classification in specific rank has been based on some external characters for a long time, such as width of leaf, number of veins, existence or absence of interstitials (Zwischennerven) and features of leaf bases. Mainly with the adoption of this classification, more than 20 named species and about 30 uncertain species with a query in nomenclature have been reported in the world (Dijkstra, 1973, and others).

As mentioned in the foreword, Samylina (1972) and Doludenko et al. (1972) have made a new proposal instead of Florin's three genera, with the classification of *Phoenicopsis* into three subgenera: *P.* (*Phoenicopsis*), *P.* (*Windwardia*) and *P.* (*Culgoweria*). The author supports this suggestion with a discussion on some new material of *Phoenicopsis* from China in the present paper.

Up to now, there are about 23 species (incl. varieties), in which the cuticles are worldwide recognized, excluding some species such as *P. speciosa* and *P. latior,* which cuticles of type-specimens have not been reported so far.

Subgenus *Phoenicopsis* (*Windwardia*) (Florin) Samylina, 1972 stat.

External features of this subgenus are identical with those of *Phoenicopsis*. Cuticles amphistomatic: with atomatic bands in lower epidermis; stomata multiseriate with interruption or in bands scatteredly arranged in upper epidermis. Stomatic apparatus hyplocheilic, monocyclic or bicyclic; guard cell of gymnospermatic type. Walls of cells straight. Vascular bundle endarch-collateral (referring to Florin, 1936, p. 90).

Based on the Chinese material as mentioned in the foreword, there existed a number of transitional patterns between the *Windwardia*-type (amphistomatic, with stomatic band in lower cuticle and irregular files in upper one) and the *Culgoweria*-type (amphistomatic, with monostichous both in lower and upper cuticles). therefore, it is sometimes difficult to classify them in subgenus rank if only on the basis of incomplete leaves. Thus, as stated above, it would be better to use a wider definition (sensu lato) for identifications of the present subgenus, and also of *P.* (*Culgoweria*) even *P.* (*Phoenicopsis*).

Phoenicopsis (*Windwardia*) *jilinensis* sp. nov.

(pl. I, figs. 1—7; pl. IV, figs. 1—3; text-fig. 4)

Diagnosis: About 6 leaves nearly in a cluster. leaves linear, with parallel margins, more than 7.5 cm long and 3.5 mm wide in upper parts of leaves, narrowing more gradually towards bases of leaves. Veins clear and parallel, about 5 in number in upper-middle parts of leaves; about 2 interstitials with numerous striations between each pair of veins. Leaf-apices and short shoot missing.

Cuticles amphistomatic. Upper cuticle somewhat thicker, with less stomata than in lower ones; wall straight or nearly straight; nerve course usually obscurely marked; stomatic band about 250—320 μ wide. Stomatic apparatuses elliptic or nearly round, 55—70×35—60 μ in size, scattered in bands; orientations basically longitudinal, hyplocheilic, monocyclic or incompletely bicyclic; guard cells sunken; subsidiary cells strongly th-

ickened along their inner margins to form a cutinised rampart about 4—6 μ wide. Common cells of stomatic band usually 20—32×15—24 μ in size and shorter than those of vein strips. Most of epidermal cells with a round papillar about 5 μ in diameter, while rest ones flatly ribbed; ribs usually about 2 μ wide and up to 9μ long (Fig. 4B).

Lower cuticle with nearly rectangular or elongately polygonal cells in common; cells 48—75×8—12 μ in size; vein courses usually marked and consisting of 3—4 strips with more narrowly rectangular cells. Stomatic bands variable in width, usually consisting of 3—4 files crowded in arrangement. Stomatic apparatus elliptic-spindly, 62—80×33—48 μ in size, with longitudinal or nearly longitudinal orientations, hyplocheilic. monocyclic or incompletely bicyclic; guard cell 5—6 in number slightly and evenly cutinised; mid lateral subsidiary cells (with one on each side) usually longer than others. Common cells of stomatic bands relatively shorter than those of non-stomatic bands which are often ribbedly cutinised (Fig. 4C).

Remarks: The present species bears a resemblance to the *Phoenicopsis manchurica* Yabe et Oishi from NE China (Yabe & Oishi, 1933, p. 233, pl. 33, figs. 12, 13) in external features. However, it seems difficult to compare in detail with each other mainly because of lacking cuticular studies of the latter. *P. (W.) silapensis* Sam. from the Siliangpin Fm of E. Siberia (Samylina, 1972, p. 74, pl. 16, figs. 1—5) is more or less close to the new species in cuticles ,but it is different in the existence of papillars on all of the cells in lower cuticle and in the distinct features of the stomatic apparatus.

Locality & Horizon: Zhangjiatun village, Huinan County of Jilin, China; Sumigou Formation (J_3).

Subgenus *Phoenicopsis* (*Culgoweria*) (Florin) Samylina, 1972, stat.

External features of the present subgenus are identical with those of *Phoenicopsis*. Cuticle amphistomatic; stomata monostichous, approximately equal in number both in upper and in lower epidermis. Stomatic apparatus with longitudinal orientation, hyplocheilic, monocyclic or bicyclic (mainly incompletely bicyclic). Walls of epidermal cells straight or slightly sinuous. Subsidiary cells 4—6 in number and usually more strongly cutinised than common cells around them (referring to Florin, 1936, p. 80).

The plants belonging to the present taxa were reported in China only by Zhou, Z. Y. from the E. Jurassic Xiwan Fm of Hexian, Guangxi (1983, p. 46) in the past. This paper describes two new species, *P. (C.) jus'huaensis* sp. nov. and *P. (C.) huolinheiana* sp. nov. The present subgenus is discovered and recognized from N. China and in the Younger Mesozoic of China for the first time.

Phoenicopsis (*Culgoweria*) *jus'huaensis* sp. nov.

(pl. II, figs. 1—7; text-fig. 5)

Diagnosis: About 12 leaves linear in shape, occurring together and converging at one end; short shoot obscurely marked. Leaf with parallel margins, more than 11.5 cm long and about 3 mm wide in upper part of leaf and narrowing gradually towards base. About 4—6 veins in widest portion of leaves and numberous striations between each pair of veins.

Cuticles amphistomatic, more regularly monostichous both in upper and in lower cuticles; stomatic arrangement in upper cuticle more crowded than in lower one.

Upper cuticle somewhat thicker than lower cuticle; epidermal cell usually elongately polygonal, 40—80×12—16 μ in size; walls straighter; nerve course more or less marked, 24—48 μ wide, consisting of 3—4 strips with narrowly and elongately rectangular cells. Stomatic apparatus usually elliptic, 24—40×24μ in size, hyplocheilic, mostly incompletely bicyclic; orientation nearly longitudinal; subsidiary cells 4—6 in number; common cells of stomatic files often shorter than those of non-stomatic band ranging within about 96—120 μ in width; all of epidermal cells slightly cutinised

Epidermal cells of lower cuticle wider than those of upper cluticle; vein course obscurely marked; walls straight, obviously alternate between stomatic files and non-stomatic bands. Stomatic apparatus mostly elongately hexagonal—elliptic, about 48—72×24—32 μ in size, monocyclic in common; subsidiary cells 5—6 in number, marginally cutinised. Common cells of stomatic files often shorter; all of epidermal cells cutinised with 1 (in shorter cells) or 2—3(in elongated cells) ribs (Fig. 5B).

Remarks: *Culgoweria mirabilis* Florin from Francois-Joseph Land (Florin, 1936, pl. 34, fig. 2) is more or less close to the present species in cuticular characters, but differs mainly in the single files of stomata which are not marked and in the subsidiary cells not cutinised in inner margins. *C. xiwanensis* Zhou from Hexian, Guangxi of China (Zhou, Z. Y., 1983, p. 46, pl. 28, fig. 9; pl. 29, figs. 1—3) also seems to resemble the new species, but it differs in the epidermal cells in upper cuticle which are shorter and with a more crowded stomata than those in its lower cuticle which has no papillars.

Locality & Horizon: Jus'hua Town (Huolihe Coal-Mine), Jarud of E. Nei Monggol, China; Huolinhe Fm (J_3—K_1).

Phoenicopsis (*Culgoweria*) *huolinheiana* sp. nov.

(pl. III, figs. 1—9; pl. IV, figs. 4, 5; text-fig. 6)

Diagnosis: Short shoot nearly round and small, 4—2.5 mm in diameter, covered by small leaves obscure in shape; giving off a leaf-bundle consisting of 6—8 leaves. Leaf nearly linear and parallel-sided, narrowing gradually towards the base, more than 8.5 mm long and about 4 mm wide in upper part of leaf; leaf-apices missing. Veins slender and parallel, 4 in number in mid-upper parts of leaf, with about 2 interstitials between each pair of veins.

Cuticle amphistomatic. Upper cuticle somewhat thick; epidermal cells more or less narrowly elongated, 40×9.6—12 μ in size; walls straight or slightly sinuous; vein courses usually marked and consisting of 3—4 strips with narrowly elongated cells (40—50×6—7 μ in size); stomata nearly monostichous with some interruptions; apparatus less in number, mostly elliptic, monocyclic or incompletely bicyclic; subsidiary cells 5—6 in number, often with one or two bigger polar cells (Fig. 6, C).

Lower cuticle usually with elongately polygonal-rectangular epidermal cells; vein courses mostly obscure; stomata monostichous; apparatuses more than those in upper cuticle in number, not crowded, elongately hexagonal or pentagonal in shape, 94—140×60—78 μ in size, usually with two bigger polar subsidiary cells (40—80×24—32 μ in size); guard cell sunken; inner margins of subsidiary cells mostly strongly cutinised to form a plum-like papillar group (Fig. 6D).

Epidermal cells of small leaves in short shoot usually elongately quadrilateral or polygonal, about 16—32×8—16 μ (occasionally up to 48—64 μ long) in size, shortened and somewhat bent gradually towards axis of short shoot, lying around it and cutinised strongly with something like a ring about 16 μ in width (pl. III, fig. 8; pl. IV, fig. 5). Stomata scattered, elliptic, about 40—48×24—40 μ in size, cutinised in inner margins.

About 7 spores and some epiphytic fungi well-preserved in association with the present epidermal cells. Ownership of the spores would be made definite based on classification in future studies.

Remarks: The present new species bears a more or less resemblance to *C. mirabilis* Florin from Francois-Joseph Land (Florin, 1936, p. 133, pl. 33, figs. 3—12; pl. 34, figs. 5—7; text-fig.15) in the characters of epidermal cells and stomatic apparatuses, but in the latter, the stomata are more in number and its lateral subsidiary cells are more strongly cutinised than the polar ones (Ibid., pl. 30, figs. 1, 2). In externals, the present new species is close to *P. gunni* Sew. from Culgower Bay of N. Scotland (Seward, 1911, p. 681, pl. 9, fig. 35), but in the British species the stomata are relatively more crowded, and its common cells of stomatic files are shorter and wider in shape, and with papillars.

Locality & Horizon: ditto.

Cyclogranisporites sp.

(pl. IV, figs. 6, 7)

Diagnosis: Equatorial outline nearly circular; trilete rays rather slender and simple, extending approximately to equator; exine of spore thin, easily folded and broken, scabrous or with fine and closely spaced grana on surface; spores 32—40 μ in size.

Remarks: The 7 specimens of spore with basically similar morphological characters which have been found are all preserved together with the epidermal cells of the small leaves of *Phoenicopsis* (*Culgoweria*) *huolinheiana* sp. nov. at present. From the viewpoint of morphological taxonomy, the present specimens should belong to the form-genus *Cyclogranisporites*. However, it still awaits further studies whether these specimens are the microspores of *Phoenicopsis* or those of the more advanced *P.* (*C.*) *huolinheiana* sp. nov.

Locality & Horizon: ditto.

图 版 说 明

本文描述的标本，除带*号者保存于吉林省地矿局区调所外，其余均保存于中国科学院南京地质古生物研究所标本室；除注明放大倍数外，其余均为原大。

图 版 I

1—7. *Phoenicopsis* (*Windwardia*) *jilinensis* sp. nov.
1.2 示叶外部形态，2 为正模 (Holotype)；野外号 2199-1*，2；登记号：(2199-2，为) PB14010。
3—4，上表皮；3 示气孔器带状松散分布形态，×150；4 示气孔器副卫细胞内侧角质强烈加厚，×450。薄片号：2199-1A，1B。
5—7，下表皮；5、6 示下表皮气孔器分布，×126，×240；7 示下表皮气孔器放大，×1000；薄片号(均为)：2199-2A。

图 版 II

1—7. *Phoenicopsis* (*Culgoweria*) *jus'huaensis* sp. nov.
1.示叶外部形态；野外号：H11-133，登记号：PB14011，正模 (Holotype)。
2.示上(左)、下(右)表皮，×73，薄片号：H11-133-1。
3、6.示上表皮；3 示气孔器单列形态，×100；6 示气孔器放大，×634；薄片号(均为)：H11-133-B。
4、5、7.示下表皮；4.示气孔器分布，×126；5.示气孔器单列形态放大，×254；7 为气孔器放大，×634。薄片号：(4、7，为) H11-133-4，(5 为) H11-133-W。

图 版 III

1—9. *Phoenicopsis* (*Culgoweria*) *huolinheiana* sp. nov.
1—3. 示叶外部形态，3 为 2 的部分放大，示叶基部及短枝，×2；1为正模 (Holotype)，野外号：H16a-50，登记号：PB14012；2 为副模 (paratype)，野外号：H1-101，登记号：PB14013。
4.上(A)、下(B)表皮，×126，薄片号：H16a-50-5A。
5. 上表皮，示星散单列中的气孔器及表皮细胞形态，×254，薄片号：H16a-50-5A。
6、9.示下表皮及其气孔。6 为下表皮气孔器分布形态，×100，薄片号：H16a-50-G；9 示气孔器副卫细胞内侧乳突状角质增厚，×634，薄片号：H16a-50-5A$_2$。
7、8.示小叶基部近短枝轴部附近的表皮细胞形态，7.×126；8.×126；薄片号：H1-101-2A，H1-101-W。

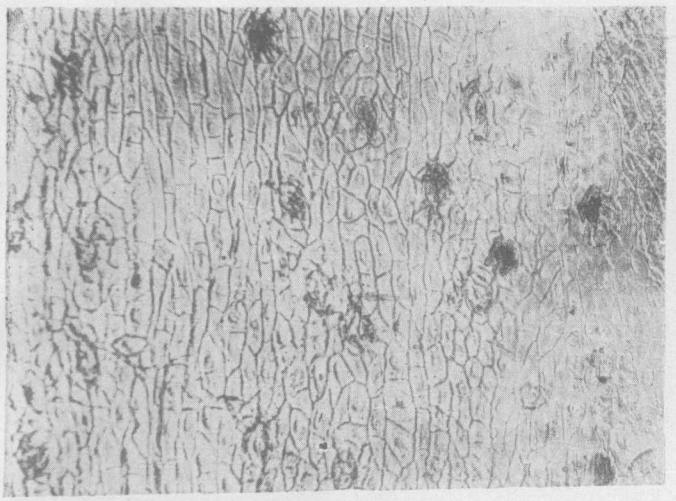
图 版 IV

1—3. *Phoenicopsis* (*Windwardia*) *jilinensis* sp. nov.
1.示上表皮细胞气孔器分布及乳头状凸起形态，×150，薄片号：2199-1G；2 示副卫细胞内侧强烈角质增厚，×634，薄片号：2199-2H；3 示上表皮上表面细胞及角质化形态，×660，薄片号：1799。

4、5. *Phoenicopsis* (*Culgoweria*) *huolinheiana* sp. nov.
4.示叶片上部的上 (右)、下(左)表皮形态，×100，薄片号H16-50-2B；5 示近短枝轴部的小叶的细胞形态，×100，薄片号：H1-101-E。

6—7. *Cyclogranisporites* sp.
6 示 4 枚孢子，×317；7 示 1 枚孢子，×630；均共生于*P.* (*C.*) *huolinheiana* sp. nov. 表皮一起，薄片号：H1-101-2B。

8.附生菌类，×403，薄片号：H1-101-2C。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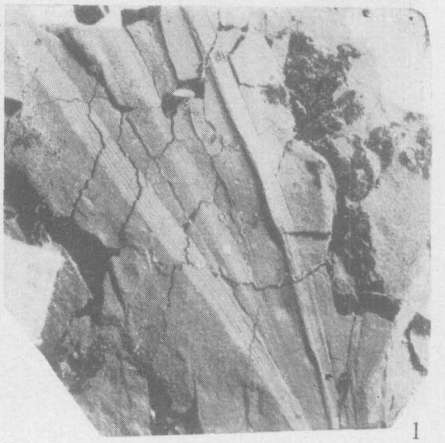
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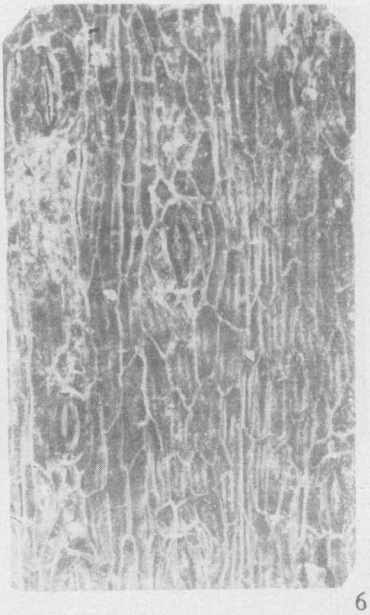
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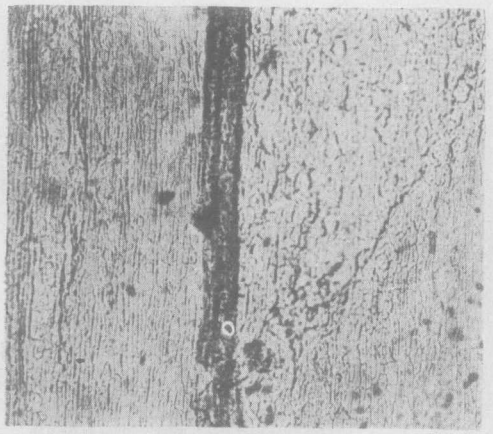

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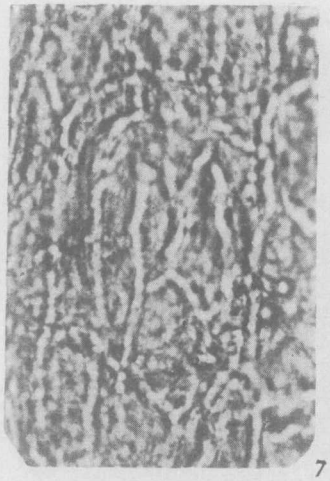

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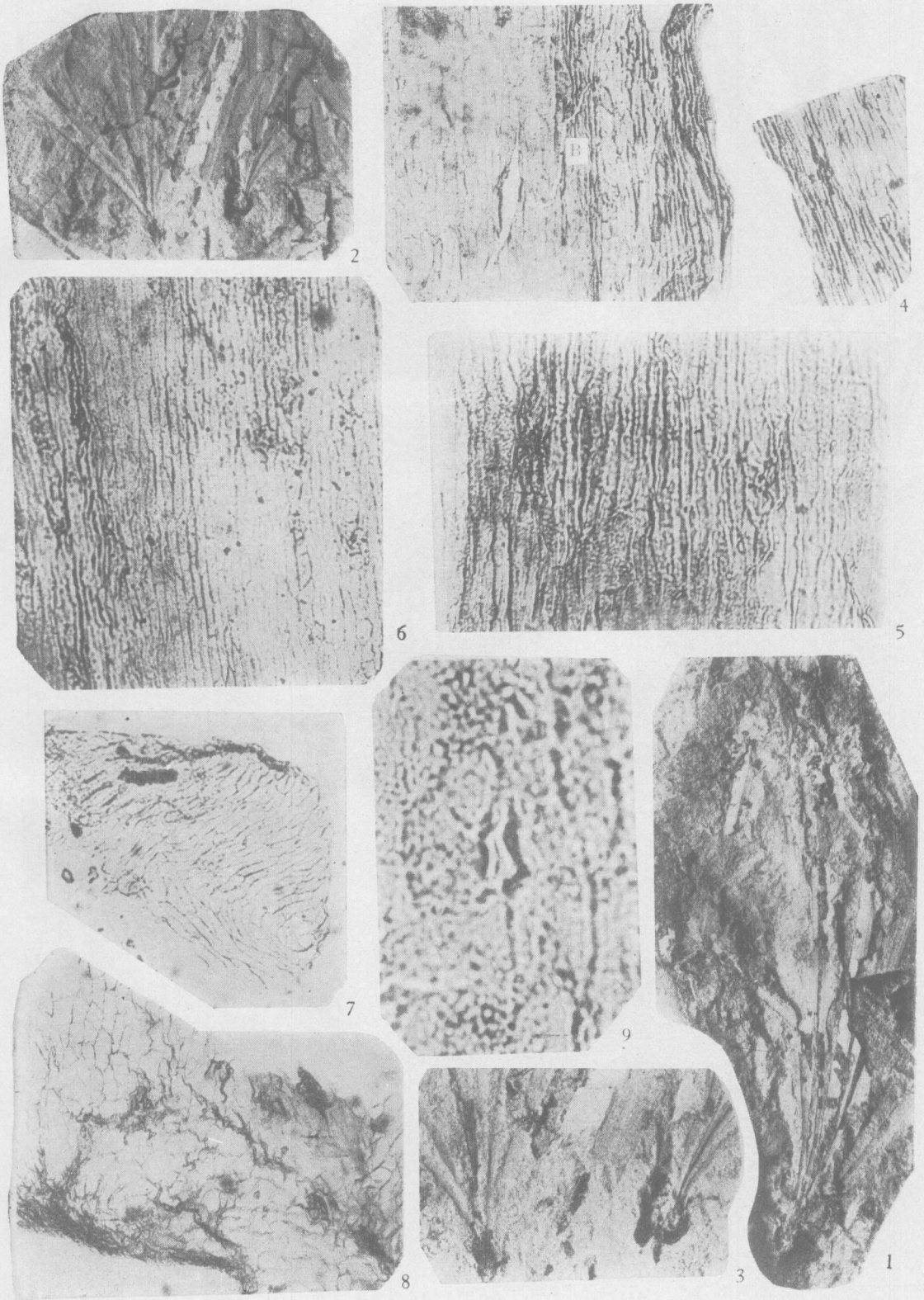


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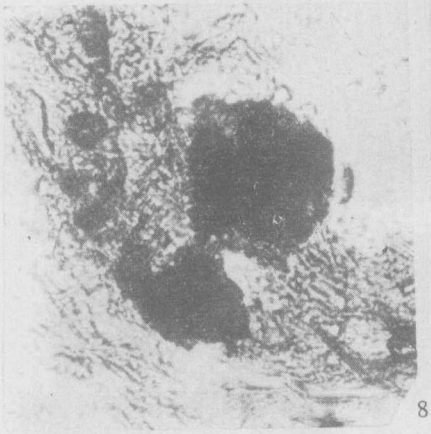
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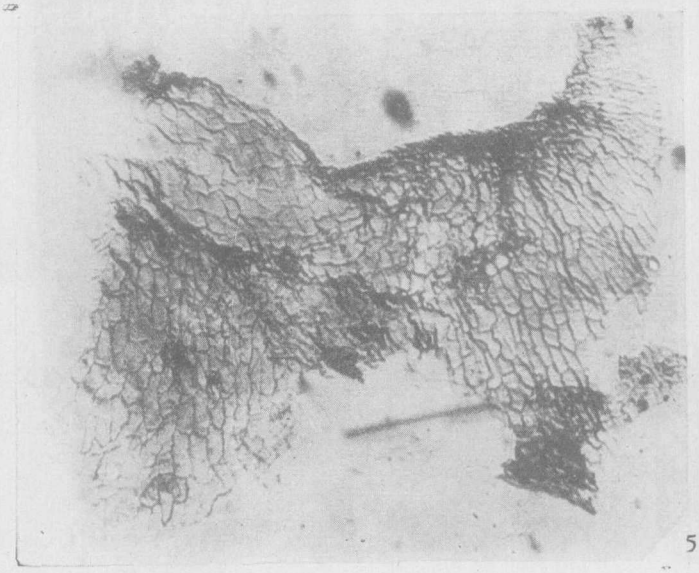
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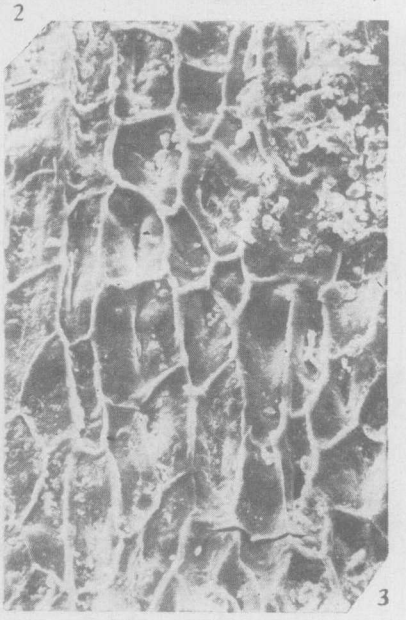
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