114. *Cunninghamia nodensis* sp. nov., from the Palaeogene
Noda Group, Northeast Japan^{*)}

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This paper is the second one by us on the fossil plants from the Noda Group, Iwate Prefecture, Northeast Japan, and deals with the description of *Cunninghamia nodensis* newly recognized from the Minato Formation.

Coniferales Taxodiaceae

Genus *Cunninghamia* R. Brown, 1826

Extant species are only two, *Cunninghamia konishii* Hayata restricted in distribution to Formosa, and *C. lanceolata* HoOk (= *C. sinensis* R. Brown) to South China, Formosa and Viet-Nam. Rather sporadical fossil records of this genus in Japan have been known as follows.

Cunninghamia eocenica Matsuo, 1967; Eocene Takashima Group (detached cones and cone-scales).

C. izumiensis Matsuo, 1966; Upper Cretaceous Izumi Group (leafy branches and a detached cone = *C. sp.* Matsuo, 1954).

C. konishii Hayata; Miki, 1941, Pliocene to Pleistocene plant beds in Southwest Japan (leafy branches and detached cones); Miki, 1950, Pliocene to Pleistocene plant beds in Southwest Japan (leafy branches, cones and cone-scales).

C. protokonishii Tanai and Onoé, 1960; Tanai and Onoé, 1961, Miocene Onbara Formation, Okayama Prefecture (a leafy branch); Murai, 1962, Middle-Upper Miocene Sakamotozawa and Masuzawa Formations, Iwate Prefecture (leafy branches); Huzioka, 1963, Middle Miocene Utto Formation, Akita Prefecture (a leafy branch); Ishida, 1970, Middle Miocene Yanagida Formation, Ishikawa Prefecture (a leafy branch); Huzioka and Uemura, 1973, Upper Miocene Miyata Formation, Akita Prefecture (leafy branches).

C. sp. Matsuo, 1970, Upper Cretaceous Omichidani Formation, Ishikawa Prefecture (leafy branches).

Cunninghamiostrobis yubariensis Stopes and Fujii, 1910; Senonian (s. s.) Upper Yezo Group, Hokkaido (a detached cone).

No cuticular study on the fossil *Cunninghamia* leaves in Japan had so far been carried out until the present work. The cuticles here described were prepared by the maceration with $\text{HNO}_3 + \text{KClO}_3$ followed by diluted NaOH.

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Cunninghamia nodensis Kimura and Horiuchi sp. nov.

Figs. 1-5

Type specimen: Holotype; MI-08032 (slide, MI-08032a). All specimens and slides here described are deposited in Department of Astronomy and Earth Sciences, Tokyo Gakugei University. *Horizon:* Minato Formation, Noda Group (The exact horizon will be shown in our later paper by the columnar section).

Diagnosis: Ultimate branches stout, 1-4 mm across at the inter-node, reaching 7 mm across at or near the node, consisting of 1-3 in number at a node. Leaves spirally arranged on every branch at an angle of 50-90 degrees. Leaves lanceolate in form, with acutely pointed apex, decurrent base without petiole and microscopically loosely undulated margins. Leaves dimorphic in size; usual ones 0.8-1.7 cm long and 0.2-0.3 cm wide; small ones 0.3 cm long and 1.2 mm wide, restricted on the basal part of each ultimate branch.

Cuticle hypostomatic. Upper cuticle consisting only of normal cells. No special cells along the median part and leaf margins. Upper normal cells rectangular in form, 48-160 μ long and 15-20 μ wide; end walls square or oblique, straight or slightly undulated; anticlinal walls mostly straight but sometimes slightly undulated, and with knob-like thickenings inward, 6-9 μ in interval on each side, each knob-like thickening sending off a spine-like projection from its tip inward, nearly perpendicularly to the wall. Several circular granules,

Figs. 1-5. *Cunninghamia nodensis* sp. nov. 1: Leafy branches (holotype, MI-08032). Many leafy branches were obtained. Margins of leaves are macroscopically entire, but microscopically loosely undulated. 2: Upper cuticle consisting only of normal cells, inside of which knob-like thickenings with spine-like projections are distinct. Normal cells located at or near the leaf-margins and the leaf-apex are generally longer and narrower than those located along the median part of a leaf (slide no. MI-08032e). 3: Lower cuticle of the right half of a leaf, consisting of a stomate cells zone, a median normal cells zone (left) and a marginal normal cells zone (right). The arrow points the border between the lower and the upper cuticles, where deformed normal cells are not recognized (slide no. MI-08032a). In extant species, marginal normal cells are usually deformed to form the serration. 4: A part of stomate cells zone enlarged from Fig. 3 to show four distinct stomata in which subsidiary and encircling cells are similar in form and size, and the inner thickenings of subsidiary cells are clearly seen. 5: Lower normal cells on which many circular granules are scattered over the cell-surface, but not over its margins. Such granules are more crowded in marginal normal cells (slide no. MI-08032b).

Figs. 6-7 are *Cunninghamia lanceolata* (extant) and *C. konishii* (extant), showing a part of stomate cells zone for comparison. According to our observation, both species are clearly amphistomatic, especially so in *C. konishii* (from the Asakawa Arboretum, Forestry and Forest Productus Research Institute, Tokyo).

about $3\ \mu$ in diameter scattered on the surface of each normal cell.

Lower cuticle consisting of normal cells and stomate cells. Normal cells similar in form and nature to those of upper cuticle, $35\text{--}133\ \mu$ long and $12\text{--}38\ \mu$ wide, forming normal cells zone along a median part and margins. Circular granules, $5\text{--}10\ \mu$ in diameter scattered on the surface of each normal cell, 0–17, mostly 9 in number. Stomate cells consisting of guard cells, subsidiary cells and encircling cells, forming two symmetrical stomate zones on a leaf; a single stomate zone consisting of 6–7 stomate rows, but fewer near leaf apex. Guard cells rectangular or elongate-pentagonal in form, $22\text{--}40\ \mu$ long and $6.25\text{--}10\ \mu$ wide; apertures mostly parallel to the elongation of leaf but sometimes nearly perpendicular to it. Subsidiary cells polygonal, mostly hexagonal in form, with straight walls, $35\text{--}45\ \mu$ in diameter, surrounding a guard cell pair; inner cell walls thickened. Encircling

cells similar in size and form to subsidiary cells. Stomata 6–7 per $200\ \mu^2$ of stomate zone. (Fructification not known.)

Comparison and discussion: It would be difficult to establish the exact attribution of the present leafy branches depending only on their external form. Indeed, the present leafy branches look like those of *Torreya*. However, it is sure that the present leafy branches belong to the genus *Cunninghamia* and are distinguishable from those of other conifers hitherto known, because their subsidiary and encircling cells are quite similar in form and disposition to those of extant *Cunninghamia* species, and moreover the spinose structure on the normal cell walls is a characteristic feature of the genus.

The present *Cunninghamia nodensis* is characterized by its lanceolate leaf-form without marginal serration and hypostomatic cuticle.

We could not make the full comparison between *Cunninghamia nodensis* and other fossil *Cunninghamia* records in Japan, because the latter specimens were represented by the impression of leaves and solely by cones or cone-scales. *Cunninghamia izumiensis*, though without serrate margins in its leaves, differs distinctly from *C. nodensis* in its external leaf-form.

Cunninghamia nodensis differs from both the extant species in having shorter leaves without marginal serrations and no stomata on the upper side. Moreover, *Cunninghamia konishii* has narrower subsidiary and encircling cells (Fig. 7).

So far as we know, the fossil *Cunninghamia* leaves with preserved cuticle are as follows; *Cunninghamia angustifolia* Sveshnikova, 1967 (Late Cretaceous, Lena Basin), *C. borzeana* Givulescu, 1968, 1975 (Neogene, Rumania), *C. europaea* Szafer, 1961 (Miocene, Silesia), *C. heeri* Sveshnikova and Budanzev, 1963 (Oligocene, Moscow) and *C. sp.* Givulescu, 1972 (Neogene, Rumania).

Cunninghamia nodensis differs distinctly from *C. angustifolia* in its external leaf-form. *Cunninghamia nodensis* resembles *C. borzeana* in having no marginal serrations but differs distinctly in its external leaf-form, too. *Cunninghamia europaea* differs distinctly from *C. nodensis* in having strongly dentate leaf-margins. *Cunninghamia heeri* seems the most similar in cuticular character to *C. nodensis*, but differs in being amphistomatic and in different forms of subsidiary and encircling cells, and moreover in having marginal serrations.

So far as the fossil *Cunninghamia* is concerned, the circular granules on the normal cells have not been described, but their existence in other fossil *Cunninghamia* species is clear by our observation of their plates.

Alvin and Boulter (1974) mentioned that these granules (regarded by them as papillae) were a remarkable feature of *Cun-*

n Cunninghamia lanceolata and they were $3\ \mu$ in diameter. They are $5\text{--}10\ \mu$ in diameter in *C. nodensis*, $5\ \mu$ in *C. heeri* and $6\text{--}7\ \mu$ in *C. borzeana*, according to our measurement.

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