Umbrella Pine, Sciadopitys verticillata: Past and Present Distribution in Japan

Abstract. *The umbrella pine,* Sciadopitys verticillata *S. and Z., a native Japanese conifer species and the only present member of the genus* Sciadopitys, *has become rapidly restricted in its geographic distribution since the beginning of intensified human activities. In Japan the genus was more widely distributed throughout the Pliocene and in the postglacial hypsithermal and slightly later times (R IIIa). In other parts of the world the genus has not appeared in the fossil record since the early Pleistocene. Conservation of this species is needed.*

Review of the geological and geographical distribution of the umbrella pine, *Sciadopitys verticillata* S. and Z., in Japan provides a basis for further studies of its past distribution in the world and its evolutionary development, particularly in relation to its place of origin. Figure 1 shows the present and past distribution of the genus *Sciadopitys* in Japan, based on the findings of leaves, seeds, cone scales, and pollen (*1–4*). The trees are now growing in the temperate regions, at altitudes between 300 and 1500 m (*5*), and are associated with montane conifers such as *Abies firma, Chamaecyparis obtusa, C. pisitera, Pinus densiflora, Pseudotsuga japonica,* and *Tsuga sieboldii.* The present distribution probably does not extend beyond the range indicated in Fig. 1, and certainly not to the northern part of Japan.

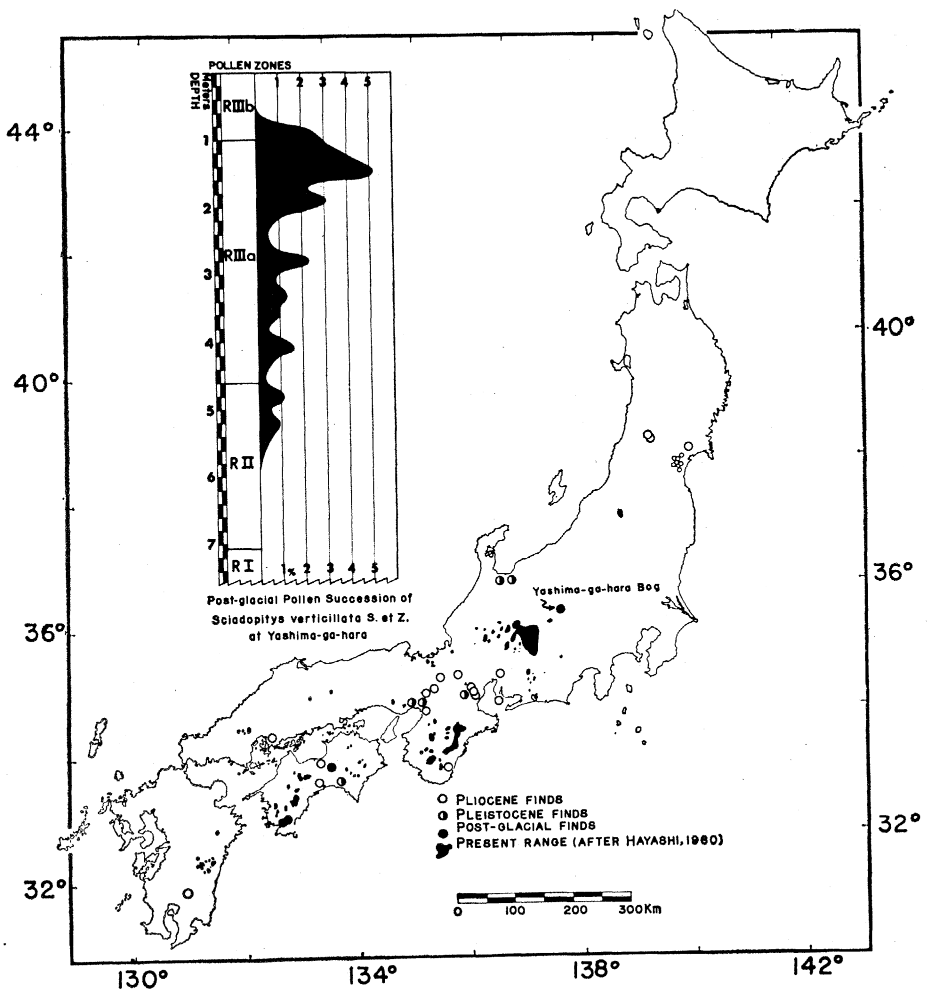

Fig. 1. Present and past distribution of *Sciadopitys verticillata* S. and Z., native Japanese conifer. The diagram of postglacial pollen succession, in which percentages are based on the total arboreal pollen number, indicates that the species has died out in the neighboring areas relatively recently (early R III*b*), as a result of human activity.

The first appearance of the genus recorded by macroscopic remains can be assigned to the Japanese Miocene. The work of Miki reviewed briefly, from the macroscopic remains, its distribution in Japan from the Miocene (*4*); however, the extent to which past floristic information can be elucidated by means of megafossils alone is limited. The distribution of this genus in the Pliocene shows a wider range than that in the present day. Its most northern limit in the Pliocene (*2*) is about 38.5°N, in northeastern Japan. This is in contrast to the previous inference that the northern limit was about 35.0°N (*4*). During the Pliocene, *Sciadopitys* was distributed more extensively not only in Japan but in both the Asiatic and European continents.

The macro- and microscopic records of northern Europe show that this genus, together with other Taxodiaceae and such genera as *Keteleeria, Liquidambar, Pterocarya, Nyssa,* and *Zelkova,* disappeared at the onset of the first glaciation. In Europe, species of these genera did not escape the drastic climatic changes of the glacial periods, but in Japan many of them survived. In spite of its extinction in Europe in the beginning of the Pleistocene, *S. verticillata* extended its range in Japan to reach closer to the Japan Sea than at present. It is not known whether this extension of range occurred during a warm or a cold period. Palynological evidence that the species was abundant in the cold period is found in the so-called Manchidani formation (*3*), possibly corresponding to the Mindel glaciation. This formation is located far south of the present northern limit.

The pollen record of the postglacial period extends our knowledge of the distribution by adding quantitative information not otherwise provided. Nakamura (*6*) originally established the Japanese postglacial pollen zones, R I, R II, and R III, most probably corresponding to von Post's postglacial zonation, I, II, and III respectively. According to my recent study (*7*) R III time can be divided into two pollen zones R III*a* and R III*b*. R III*a* zone is characterized by maxima of the subalpine conifers, decrease of montane hardwood deciduous species, and rather high absolute pollen number per unit of dry weight of peat, and R III*b*, by rapid increase of *Pinus diploxylon* type, *Cryptomeria japonica, Betula, Salix,* and nonarboreal pollen, and decrease of

Picea and *Abies*. The R III*b* zone indicates more or less open habitats throughout lowlands. The R III*a* zone began probably about 3000 years ago (*8*), and a boundary between R I (immediately after the cold period) and R II (corresponding to the hypsithermal) is 9740 ± 440 years before 1950 (Y-1130).

Even during the postglacial period, pollen remains of *S. verticillata* were found outside of its present range of distribution. Much more concrete evidence as to the extensive postglacial distribution of the species can be obtained at Yashima-ga-hara bog, which is located about 50 km northeast of the present area of greatest abundance (Fig. 1). As shown in a pollen diagram of *S. verticillata* (Fig. 1), the pollen occurrence ranges from about 0.5 to 5.0 percent of the total arboreal pollen. There is some difficulty in determining whether or not these findings are of airborne pollen transported over the long distance of about 50 km. However, comparisons of the percentages of pollen species from surface samples with percentages of foliage cover in the surrounding forest showed that in all forest areas pollen of distant origin is insignificant compared with local pollen production (*8, 9*). In this case, the continuous occurrence of its pollen indicates the presence of *S. verticillata* in the surrounding area of Yashima-ga-hara bog during this period. It first appeared in the middle of zone R II, and reached its maximum late in zone R III*a*. But in early R III*b* it rapidly decreased, and not even a single grain was found in later stages.

This decrease is associated with fairly recent increases of *Pinus diploxylon* type and nonarboreal pollen, and decreases of climax forest tree pollen which might have been caused by recent human interference (*8, 10*). Human activities have led to large changes in the distributional ranges of many plant species through the destruction of some and the introduction of others. The stratigraphic record of pollen therefore reflects past and present human activities as well as other environmental changes. In particular, the decrease in number and restriction of the distributional range of *S. verticillata* may have been influenced by the usefulness of its wood for building houses. For example, most present-day Japanese families have their own bathtub and other kinds of tubs, most of which are made from the wood of *S. verticillata*. Although the wood is of great practical utility, there is a greater seed sterility and growth of the trees is less rapid in comparison with other conifers. Clearly conservation measures are urgently needed to prevent the eventual extinction of this species, native only in Japan today (*11*).

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References and Notes

1. S. Kokawa, *J. Inst. Polytech. Osaka City Univ. D* **12**, 123 (1961); S. Miki, *ibid.* **8**, 221 (1957); **9**, 125 (1958); J. Nakamura, *Nat. Sci. Rept. Kochi Univ.* **2**, 1 (1952); *Res. Rept. Kochi Univ.* **2**, 1 (1953); J. Nakamura and I. Yamanaka, *Bull. Soc. Ecol.*, **1**, 88 (1951); J. Nakamura and J. Katto, *ibid.* **3**, 15 (1953); *ibid.*, p. 108 (1953); *Ecol. Rev.* **14**, **117** (1955); M. Tsukada, unpublished data.
2. K. Sohma, *Ecol. Rev.* **14**, 121 (1956); *ibid.*, p. 235 (1957); *ibid.*, p. 273 (1958).
3. A. Tai, *Chikyu Kagaku* (*Earth Sci.*) **64**, 8 (1963).
4. S. Miki, *Successions of Five Native Species in Kiso Based on the Plant Remains* (Nagano Forest Bureau, Nagano, Japan, 1955).
5. Y. Hayashi, *Taxonomical and Phytogeographical Study of Japanese Conifers* (Norin-Shuppan, Tokyo, 1960).
6. J. Nakamura, *Res. Rept. Kochi Univ.* **1**, 1 (1952).
7. In preparation.
8. M. Tsukada, *J. Inst. Polytech., Osaka City Univ. D* **9**, 235 (1958).
9. ———, *ibid.*, p. 217.
10. ———, *Quaternary Res. Japan* **1**, 48 (1958).
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Dehydration of Seeds in Intact Tomato Fruits

Abstract. *Although the moisture content of the placenta and pericarp of tomato fruits older than 15 days never dropped below about 94 percent, the seeds dehydrated to approximately 50 percent moisture as these organs developed and matured. There was a loss in the total amount, as well as the percentage, of water per seed. Part of this dehydration was mediated by the seeds themselves and part appeared to be due to other portions of the fruit.*

Casual observation would lead one to assume that the seeds in mature fleshy fruits of certain species contain a moisture content considerably below that of the remainder of the fruit. A check of several such species, including watermelon, cucumber, lemon, and tomato, substantiated this. A survey of the literature indicated that although there were numerous reports on the chemical and enzymatic changes during growth of seeds and fruits, little attention had been given to water metabolism during the development of such organs (*1*). A study was therefore undertaken to examine the dehydration of seeds in intact tomato fruits.

Tomato, *Lycopersicon esculentum* Mill. var. Marglobe and Bonny Best, was selected for a detailed examination because this plant could be grown easily in the greenhouse as well as in the garden, thus furnishing a continuous supply of experimental material. It was also found in preliminary experiments that the seeds of tomato fruits showed a more uniform development than did the seeds of other species examined.

The plants were grown under the prevailing conditions in the greenhouses of the Department of Botany, University of Chicago, in fertile soil in 20-cm unglazed pots, or in the garden. Flow-

Table 1. Moisture content of Marglobe tomato seeds from fruits of various ages.

Age (days)	Moisture (%)		Fresh weight per seed (mg)	Dry weight per seed (mg)	Water per seed (mg)
	Fresh basis	Dry basis			
22	90.5	950.0	12.6	1.2	11.4
25	88.5	769.2	11.3	1.3	10.0
27	84.3	538.9	11.5	1.8	9.7
32	80.8	420.0	10.4	2.0	8.4
37	61.0	156.1	10.5	4.1	6.4
41	56.8	131.6	8.8	3.8	5.0
48	50.6	102.5	8.1	4.0	4.1
53	49.3	97.3	7.3	3.7	3.6
59	60.2	140.5	8.9	3.7	5.2