



Recognizing the species of *Thuja* (Cupressaceae) based on their cone and foliage morphology

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Abstract

Thuja, with 5 extant species, exhibiting a disjunctive distribution between East Asia (3 species) and North America (2 species), was investigated with respect to the morphological characters of foliage and cones by LM and SEM. Here we provide 2 keys to all 5 species of *Thuja* based on the cones and foliage respectively, which not only can be used for identifying extant *Thuja* at the species level, but also have a great potential for recognizing and/or linking the fossil species to living ones, and further tracing the evolutionary history of the genus.

Keywords Cone, Foliage, East Asia-North America disjunction, Species identification, *Thuja*

Introduction

The genus *Thuja* L. (Cupressaceae), with a disjunctive distribution between East Asia and North America, consists of five extant species. Of these, two species occur in North America, i.e., *T. occidentalis* occurs in the Northeastern United States, the Southern Appalachian Mountains of the United States, southeastern Canada, and in the Great Lakes region of both countries. While *T. plicata* occurs in the coastal Northwestern United States, coastal British Columbia in Canada, and in the interior Rocky Mountains in both countries (data from <http://esp.cr.usgs.gov/data/little/>). The other three species grow in East Asia, i.e., *T. koraiensis* in the Korean Peninsula and Changbai mountain area of China, *T. standishii* in Honshu and Shioku, Japan and *T. sutchuenensis* in the Daba Mountains, Chongqing, China (Farjon 2005; Fu & al. 1999).

All the species of *Thuja* are monoecious evergreen trees or shrubs with spreading branches, those of the second and third orders being disposed in a plane. Leaves scale-like, decussate, only the leaves on the primary branches decurrent. The ultimate (sub) branchlets have dimorphic leaves, i.e., ovate-rhombic in the middle and boat-like laterally, with a ridge less than 4 mm on the abaxial surface and overlap with the facial leaves, no obvious white stomatal band on the abaxial surface. Pollen cones terminal, solitary, subglobose, with 6–10 microsporophylls, bearing 2–3 abaxial bracts. Seed cones terminal on short, straight branchlets, mature and dehiscent in the same year. Bract-scale complexes 8–10, spreading, decussate, only 2–3 larger pairs are fertile, bracts umbonate. The flattened seeds 1–2 per cone scale, tapering towards both ends with two marginal wings of equal size and shape, surrounding the seed but leaving a notch at both ends (Farjon 2005; Fu & al. 1999; Schulz & al. 2005).

The evolutionary history of *Thuja* is still controversial. For instance, McIver and Basinger (1989) proposed that it originated in North America, based on fossil and extant seed cone morphology, and suggested that all extant species except *T. sutchuenensis* might have arisen from an ancestor similar to *T. polaris* found in the Paleocene sediments of Ellesmere Island, Canadian Arctic Archipelago in North America. According to this scenario it spread from North America into Asia.