

Livistona chinensis var. *subglobosa* on Aoshima, Japan

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1. *Livistona chinensis* palms in the central zone.

Livistona chinensis var. *subglobosa* occurs on the islet of Aoshima, Japan, the northern limit of the range of natural regeneration. Here it is the dominant species of the flora on Aoshima and forms mono-specific stands in many areas.

Livistona R. Br., with ca. 34 species, is distributed in the Horn of Africa and Yemen, throughout east and south-east Asia, Malesia to the Solomon Islands and Australia where there is a great diversity of species (Uhl and Dransfield 1987). The ecology of *Livistona* species is varied. *Livistona chinensis* var. *subglobosa* Becc. is distributed in south-eastern China, northern Taiwan, through the Ryukyu Islands to as far north as Kyushu and Shikoku islands (Dransfield 1997), where it occurs in subtropical woodland and littoral forest. According to Horikawa (1972), south-western Shikoku Island is the eastern and northern limit of growth of *L. chinensis*. Here, *L. chinensis* var. *subglobosa* is found in a small area of Ashizuri Promontory, in Kochi Prefecture (Suzuki 1982). This population is remnant, and apparently not capable of sustained self-regeneration. Therefore, the islet of Aoshima, in Miyazaki Prefecture in south-eastern Kyushu, is the northern limit of the range of natural regeneration, with the population being demographically stable with abundant self-regeneration. *Livistona chinensis* is indeed the dominant species of the flora on Aoshima (Fig. 1). Despite its dominance, an understanding of the ecology of *L. chinensis* is limited as the entire population of *L. chinensis* on Aoshima is protected within the boundary of the Aoshima Shinto Shrine, and therefore cannot be disturbed or interfered with in any way.

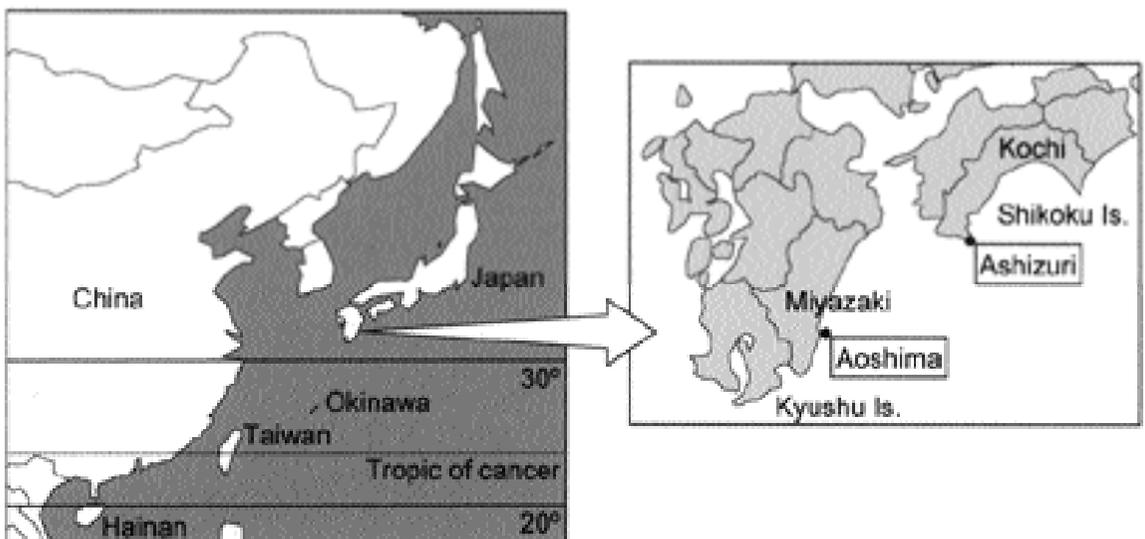
The Shinto Shrine on Aoshima was established in the ninth century, and since that time the islet has become known colloquially as the 'Islet of the Gods.' The English translation of the islet's name is 'ao,' meaning green or blue, and 'shima,'

meaning island. The natural environment has been protected under the stewardship of the Shinto Shrine, that owns all land on the islet. Since 1925, the Japanese Government has recognized the importance of the natural environment on Aoshima, and has therefore forbidden any disturbance or maintenance.

General descriptions of *Livistona chinensis* on Aoshima

Aoshima, an islet of 4400 m², is located on the south-eastern coast of Kyushu in Miyazaki Prefecture (31°48'N, 131°28'E), facing the Sea of Hyuga (Fig. 2), and is situated on a basement of so-called 'washboard rocks' (Fig. 3). Elevation is near sea level and topography is mildly undulating. The Kuroshio Current flows northwards from Taiwan through the Ryukyu Islands, thus creating a warm climate on Aoshima that is similar to that on oceanic subtropical islands. Air temperature does not fall below 0°C, the difference between daily maxima and minima is relatively small, and humidity is high, even in winter, compared to the main island of Kyushu (Araki and Kanemaru 1984). This mild climate allows various subtropical and even some tropical plants to grow on Aoshima.

About 27 species of plants are native to Aoshima, with *L. chinensis* var. *subglobosa* the dominant species forming mono-specific stands in many areas. Soils consist primarily of a sub-layer of sand and sea shells on a bedrock basement, and a shallow humus upper layer. Araki and Kanemaru (1984) suggested that the shallow soil on Aoshima was most suitable for shallow-rooted plants such



2. Location of Aoshima in Kyushu Island, Japan, the northern limit of natural regeneration of *Livistona chinensis*.



3. Aoshima islet covered with *Livistona chinensis* palms.



4. Inflorescence of *Livistona chinensis* palm in the eastern zone

as *L. chinensis*, and which may be the primary controlling factor for the palm's abundance. *Livistona chinensis* dominates the northern zone of the islet. Elsewhere other plants also occur. In the central zone, vegetation consists of *Clerodendrum japonicum* Sweet as well as *L. chinensis*; in the south-western zone *Alocasia macrorrhiza* Schott, *Ipomoea indica* (Brum.) Merrill, *Litsea japonica* (Thunb.) Juss., *Arundo donax* L., *Ardisia sieboldii* Mig., *Chimonobambusa marmorea* Makino and

Clerodendrum japonicum also occur, while in the eastern zone *L. japonica* and *A. donax* also occur.

The number of *L. chinensis* palms with an elongated (i.e., above ground) stem was estimated to be about 5000. A count of 4335 was provided in 1948, but that count has recently been revised upward. The density of palms is very high (Fig. 6). Light conditions on the forest floor are relatively dark, accompanied by high humidity especially

in the central zone of the islet. There are many young palms and seedlings growing within the forest over most of the islet.

The tallest palms, to 8 m high, were growing in the central zone where the surface soil was rich in humus (Fig. 1). In the eastern and northern zones, palms reached 6 m tall, and in the south-western zone they grow only to 5 m tall. In this last zone there was considerable competition from *Arundo donax*, particularly at the forest margins.

As for reproductive effort, only old and dead inflorescences were occasionally located (Fig. 4). It has been observed that flowering and fruiting has not occurred for several years on any part of the islet. Regeneration was observed on most parts of the islet, although young plants and seedlings were completely absent from a small area of the eastern zone where the soil surface was covered with dead palm leaves.

There are two hypotheses as to the origin of *L. chinensis* on Aoshima. One involves the dissemination of seeds or vegetative propagules from a southern origin via the Kuroshio Current (Honda 1918), and that the palm is a relatively newly established species on Aoshima. The other hypothesis involves a once widespread palm population that was forced to contract during the Tertiary period due to a cooling climate (Nakano 1925). Accordingly, the Aoshima population is therefore considered a relict of a formerly wider distribution. Confirmation of the past distribution of fan palms beyond their present geographical limits in Japan and nearby regions is held in the fossil record (Ôyama and Matsuo 1964; Chaloner and Creber 1990), but it is not known if these are attributable to *Livistona* or to another genus. Yoshida et al. (2000) conducted RAPD (random amplified polymorphic DNA) analysis of *L. chinensis* in locations in south-west Japan. Their results suggested that seeds or living trunks (or shoots) were disseminated by tidal currents from the south.

Staff of the Aoshima Shinto Shrine conducted a preliminary experiment on seed germination in *L. chinensis*, and found that seeds germinated even after having been soaked in seawater for 60 days. Although detailed data of the germination experiment are not available, their preliminary results support Honda's hypothesis of a southern origin assisted by northward tidal currents. Some of the palms that germinated during that experiment are now growing near the entrance to the Aoshima Shrine in the south-western zone of the islet (Fig. 5). It would be interesting to investigate the genetic distances between *L. chinensis* populations from Aoshima, Taiwan and

China to clarify the evolutionary and dispersal background of *L. chinensis* on Aoshima.

Aerial branching of *Livistona chinensis* on Aoshima

During our survey of *L. chinensis* on Aoshima, we found one palm, in the central zone, that had produced aerial branching (Fig. 7). This palm was c. 7 m tall, and it was difficult to distinguish the crowns of the stems from those of the surrounding palms within the canopy. However, both stems of the branching palm carried some green leaves, thus implying continuing growth for the stems. A nearby dead palm had coincidentally come to lean on the fork produced by the aerial branching, following a typhoon during the mid 1990s, and is therefore not the cause of branching, which was initiated much earlier.

There are no former reports of other individuals of the palm where branching has occurred (Nakajima 1984); however, there is anecdotal evidence suggesting that it has occurred previously on at least one occasion. We conclude that the aerial branching in the single individual on Aoshima was caused by some kind of extraneous factor.

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5 (top). *Livistona chinensis* palms in the south-western zone. Seeds from palms in the south-western population germinated after treatment with seawater.

6 (bottom). *Livistona chinensis* palms in the forest of eastern zone.



7. *Livistona chinensis* palm with an aerially branched stem (central zone).

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