琉球列島奄美大島の絶滅危惧植物アマミヒイラギモチ（モチノキ科）の植物体サイズと葉の二型性

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journal or publication title	The journal of phytogeography and taxonomy
volume	56
number	1
page range	7-11
year	2008-09-30
URL	http://doi.org/10.24517/00053378

Journal of Phytogeography and Taxonomy **56** : 7-11, 2008

Hiroaki Setoguchi[1], Masaharu Nakagawa[1] and Arata Momohara[2] : **Plant-size and leaf dimorphism of the vulnerable species *Ilex dimorphophylla* (Aquifoliaceae) on Amamioshima Island in the Ryukyu Archipelago**

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Abstract

The tree *Ilex dimorphophylla* Koidz. (Aquifoliaceae) is a vulnerable species that is endemic to the summit of Mt. Yuwan on Amamioshima Island, Japan. This plant shows characteristic leaf dimorphism, which increases its horticultural value, and many individuals have been illegally removed from the natural habitat. We examined the number of shoots, leaf morphology and plant size of the species in the natural habitat. Based on field observation for two years, we found 84 shoots, of which 32 (38.1%) had entire mature leaves, whereas 52 (61.9%) had only serrate juvenile leaves. Majority of the examined shoots surveyed fell into the smallest size classes : < 100 cm in height (ca. 45%) and < 25 mm in diameter at the trunk base (ca. 60%). Leaf dimorphism was clearly demarcated in trees at 130–210 cm in height and 15–27 mm in diameter at the trunk base.

Key words : Amamioshima Island, Aquifoliaceae, *Ilex dimorphophylla*, leaf morphology, Ryukyu Islands.

Introduction

Ilex dimorphophylla Koidz. (Aquifoliaceae) is an evergreen tree endemic to Mt. Yuwan on the Amamioshima Island of the Ryukyu Islands, Japan (Koidzumi 1928) (Fig. 1). This species is vulnerable because of its illegal removal from its natural habitat for horticultural use, and has been designated a critically endangered species (class I-A) based on IUCN criteria (Japan Society of Plant Taxonomists 1993 ; Environment Agency of Japan 2000). The number of individuals of this species has decreased over the last several decades, and the current wild population has been estimated to be less than 50 individuals (Environment Agency of Japan 2000).

Molecular data indicate that this species may have been widely distributed in the Ryukyu Islands and introgressed with other *Ilex* species during the climatic oscillations of the Quaternary period (Setoguchi and Watanabe 2000). The present distribution of *I. dimorphophylla*, which is confined to the summit area of Mt. Yuwan, suggests that this species is probably a relic. The small habitat area, small size of the population and continuous pressure from illegal removal exposes the species to the risk of extinction. A reduction in population size is a serious factor in promoting extinction (e.g., Gilpin and Soulé 1986 ; Guerrant 1992 ; Primack 1995). To conserve *I. dimorphophylla*, it is essential to de-

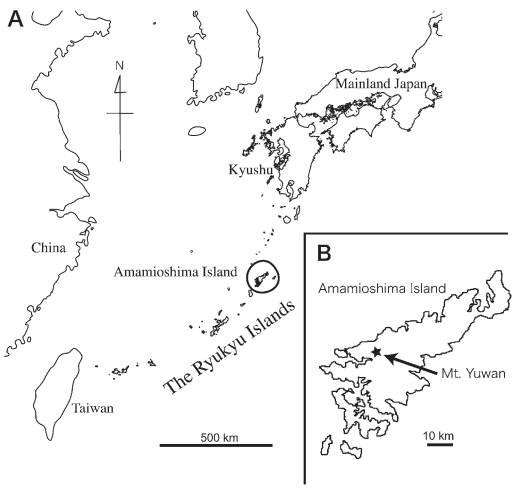

Fig. 1. Geographic location of (A) Amamioshima Island, the Ryukyu Islands, Japan, and (B) Mt. Yuwan on Amamioshima Island.

termine the number of individuals in the natural habitat to assess the current status of the population.

Ilex dimorphophylla shows characteristic leaf-shape dimorphism; juveniles have serrate leaves with spiny teeth, whereas mature individuals have entire mature leaves (Fig. 2) on the upper branches and serrate leaves on the lower branches (mostly sprout branches from the tree base). The leaf size of this species is

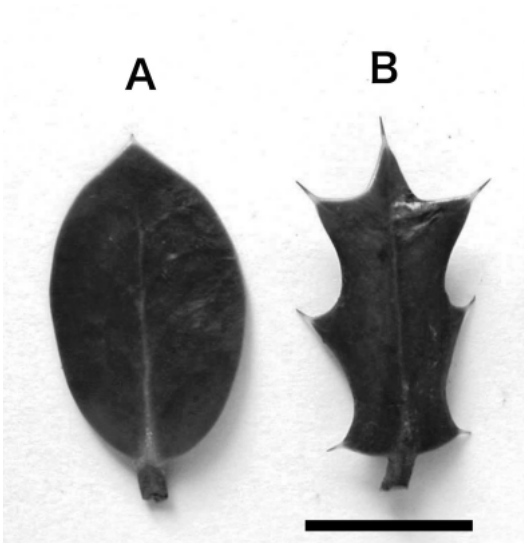

Fig. 2. Leaf dimorphism of *Ilex dimorphophylla*. A, entire mature leaf; B, serrate juvenile leaf. Scale bar = 1 cm.

small relative to that of other *Ilex* species: juvenile leaves are ca. 1.5–3.0 cm in length, whereas mature leaves range from ca. 1.0 to 2.0 cm in length and ca. 0.8 to 1.5 cm in width (Hatusima 1975; Yamazaki 1989, 1999). However, the correlation between plant size and leaf shape has not been examined.

In the present study, we measured tree size (height and diameter at the trunk base) of *I. dimorphophylla* in its natural habitat of Mt. Yuwan on Amamioshima Island to contribute to a better understanding of the current status of this vulnerable species. Moreover, we examined the relationship between tree size and growth stage as represented by leaf morphology.

Materials and methods

Field observations and measurements of *I. dimorphophylla* individuals were conducted in 2000, and were supplemented in 2001 on Mt. Yuwan, Amamioshima Island. The distribution of this plant is confined to stunted forest near the summit, up to 600–690 m in altitude, and our survey was confined to the forest and adjacent area. We measured the diameter at the trunk base and the height of each shoot of the trees. This plant sometimes develops lining underground rhizomes that form clonal ramets of the mother tree. Therefore, we could not consistently identify the individuality, we measured each shoot. The diameter at the trunk base was measured using electrical calipers or a measuring stick. If the trunk base was not round, then the average diameter was estimated based on three measurements from different angles (120° from to each other). Tree height was measured using a graduated extension pole. The leaf type (serrate juvenile or entire mature) was noted for each shoot. If the trees had both serrate and entire leaves, we scored the tree as entire mature. The spatial distribution of each shoot was plotted on a map; however, this information will remain confidential to protect the plants from theft.

We carefully confirmed the rhizome connection among shoots to identify whether the shoots are ramets or genets.

Results and discussion

We found 84 shoots of *I. dimorphophylla* within ca. 0.3 km^2 of stunted forest near the summit of Mt. Yuwan, between 630 and 690 m in altitude. Of these 84 shoots, 32 (38.1%) had entire mature leaves, whereas 52 (61.9%) had serrate juvenile leaves.

Shoot height ranged from 10 to 870 cm, and 45.2% (38) of shoots were in the height class of <100 cm (Fig. 3). The plant size distribution indicated that the number of shoots was decreased in the larger size more than 300 cm in height (Fig. 3) (and 26–75 mm in diameter at the trunk base; data not shown). This tree size structure has been recognized to be common for natural forests, and is described by "an inverse J-shaped distribution" (e.g., Kitazawa et al. 1959; Tagawa 1977; Hartshorn 1978; West et al. 1981; Kohyama 1986). We could not determine

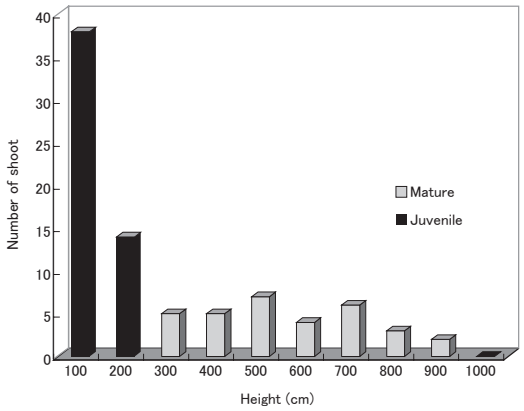

Fig. 3. Distribution and frequency of *Ilex dimorphophylla* height.

the trace of illegal removal from the natural habitat based on the plant-size distribution. The height delineation between trees with serrate juvenile leaves and those with entire mature leaves was clearly evident and occurred at 200 cm (Figs. 3, 4). The shortest shoot with entire mature leaves (26 mm in diameter) was 210 cm in height.

The diameter at the trunk base ranged from 2 to 250 mm, with the majority of shoots (59.5%) falling into the size class of < 25 mm. Only shoots with diameter < 27 mm (i.e., in size classes < 130 cm in height) had serrate juvenile leaves, whereas mature leaves were found on shoots with > 200 cm in height (Fig. 4). The thinnest shoot with entire mature leaves was 15 mm in diameter and 210 cm in height.

There were correlations between tree diameter and height (Fig. 4). The correlation coefficient between the tree diameter and height was 0.892. Serrate juvenile leaves occurred in shoots < 130 cm in height and <27 mm in diameter at the trunk base. Entire mature leaves occurred in shoots >210 cm in height and >15 mm in diameter at the trunk base. Thus, the plant size delineating the leaf dimorphism of *I. dimorphophylla* was 130–210 cm in height and 15–27 mm in diameter at the trunk base. The leaf dimor-

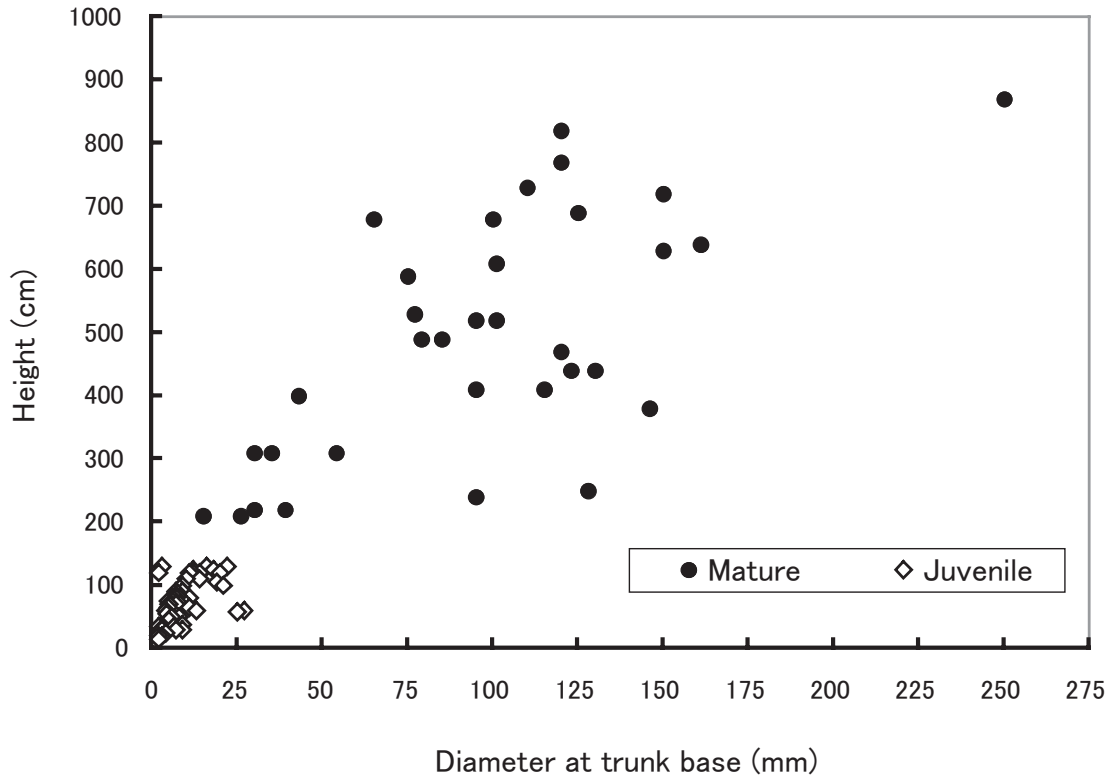

Fig. 4. Distribution and frequency of tree height and diameter at the trunk base, correlation of the two dimensions, and the leaf dimorphism in *Ilex dimorphophylla*. Mature, individuals with entire leaves; Juvenile, individuals with serrate leaves.

phism was particularly well-demarcated by tree height. Based on leaf morphology, we conclude that the boundary between juveniles and mature individuals defined as no overlapping shoots of the two leaf types, ranged from 130 to 210 cm in height. In general, juvenile and adult leaf dimorphism has been interpreted as a mechanical defense against herbivores (e.g., Atkinson and Greenwood 1989; Givnish et al. 1994; Bond et al. 2004), and/or as an adaptive response to features of the climate, including wind, cold, and abrupt changes from frosty nights to sunny days (e.g., McGlone and Webb 1981; Howell et al. 2002). However, because no herbivore feeds on theses plants on Amamioshima Island, the ecological significance of the serrate juvenile leaves in short trees of *I. dimorphophylla* remains unknown. Further studies are needed to evaluate the ecological significance of heterophylly in this species.

In the present study, we found 84 shoots of this vulnerable species remaining in its natural habitat. However, this plant was occasionally observed to form clonal ramets, and the number of genets may have been considerably fewer than the number of observed number of shoots. We carefully checked the rhizome connection among shoots to identify whether the shoots are ramets or genets, and estimated the presence of 71 genets.

Molecular analyses are needed to identify genets and to estimate the genetic diversity of this plant in its natural habitat. We tentatively examined Random Amplified Polymorphic DNAs (RAPDs) of the 84 shoots using 20 random primers; however, only three genotypes were distinguished within the population (Nakagawa and Setoguchi unpublished). Because the RAPDs was insufficient for polymorphisms and for reproduction of our results, other techniques such as single-sequence repeat (microsatellite) or amplified fragment length polymorphism marker (AFLP) analyses should be used to identify genets and to estimate the genetic diversity of the population.

Acknowledgements

We thank Mr. K. Fujimoto of the Ooshima Office and J. Miyawaki of the Ukenson Office, Kagoshima District Forest Office, for kind help with field observations. We also thank Dr. N. Nomura of the National Institute of Humanity and Nature for advice on the discussion. This study was supported by Grants-in-Aid for Scientific Research (#13575011) from the Japan Ministry of Education, Culture, Science, Sports and Technology.

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(Received June 2, 2008; accepted August 30, 2008)

瀬戸口浩彰[1]・中川政治[1]・百原　新[2]：琉球列島奄美大島の絶滅危惧植物アマミヒイラギモチ（モチノキ科）の植物体サイズと葉の二型性

アマミヒイラギモチ（*Ilex dimorphophylla* Koidz.）は奄美大島の湯湾岳山頂付近に発達した風衝林内に生育するモチノキ科の樹木である。本種における樹木サイズと葉の二型性について自生地で調査した。84シュートの生育を確認し，そのうちの32シュートが全縁の成熟葉を，残りの52シュートが鋭い鋸歯のある幼葉のみをもっていた。葉の二型性は樹木高で約130–210 cm，根元直径で15–27 mmを境にして分かれていることが明らかになった。

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