

# Distribution and new Localities of *Zannichellia palustris* L. (Zannichelliaceae) in Japan

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**Abstracts.** The current distribution of *Zannichellia palustris* L. (Zannichelliaceae), which is an endangered, submerged species in brackish and fresh waters, was surveyed in Japan. Eleven prefectures categorized *Z. palustris* as “living” or “unknown.” The current distribution is confirmed only in eleven communities of eight prefectures. Of these, three communities have been recorded for the first time.

## Introduction

*Zannichellia palustris* L. (Zannichelliaceae) is an annual or perennial submerged aquatic species, which inhabits brackish and fresh waters. It is widely distributed in tropical and temperate latitudes (Tomlinson 1982). The taxonomy of *Zannichellia* L. has not been studied entirely and has been confused not only in Japan but also throughout the world (Cook 1996, Kadono 1994). Although it is distributed throughout Japan, it has become rare in recent years (Kadono 1994). It is listed as a “Threatened species” (Environment Agency of Japan 2000). Although it is presumed that *Zannichellia* plants are dispersed by water and probably also by animals (Cook 1996), their dispersal is not well understood. In addition, there is less information on the plant’s genetic structure in Asia, including Japan, which is necessary for conservation and determining the method of dispersal.

We aim to reconstruct the taxonomic organization and obtain genetic information for the above-mentioned subjects. First, we report the current distribution of *Z. palustris* in Japan, to obtain basic information for future studies.

## Materials and Methods

Previous data on distribution were checked by referring to the specimens deposited in major herbaria and the literature on the Japanese flora. Herbaria were as follows: Kyoto University (KYO); Tokyo Metropolitan University (MAK); University of the Ryukyus (RYU); Hokkaido University (SAPS); Sapporo Museum Activity Center, Hokkaido Prefecture; University of Tokyo (TI); National Science Museum, Japan (TNS); Tohoku University (TUS). For literature, various Red Data Books and flora of each region were used. All Red Data Books of each prefecture that have already been published were referred. Based on the data derived from specimens and literature, detailed investigations of localities were conducted. Additional surveys were conducted for locations suited to habitats of *Zannichellia*. Places

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where *Zannichallia* plants have been found since at least 2004 were recorded as localities. Plant materials were collected for herbarium specimens and DNA analysis. Details of localities are not shown in this paper with regard to conservation, but voucher specimens are deposited in public herbaria.

## Results and Discussion

### Distribution data from herbarium specimens and literature

Of the *Z. palustris* specimens deposited in major Japanese herbaria, those collected from Japan are listed below.

**Hokkaido Pref.:** Lake Tofutsu, Koshimizu, Syari, 20000726, Mami Yamazaki, Makoto Mochida (Sapporo Museum Activity Center); Bekkanbe-Ushi River, Akkeshi, 20000807, Yachiyo Takashima (SAPS); Harutori Lake, Kushiro, 19760824, Yasuro Kadono (KYO). **Aomori Pref.:** Maegata, Shiura, Kita-Tsugaru, 19820828, Kazumi Tsuchiya (KYO, MAK, TI, TNS); Obuchi-numa, Rokkasho, 20040822, Manami Jin (TUS). **Miyagi Pref.:** Shichigahama, 19320529, K. Naohara (KYO, TUS); Ushibashi, Yamamoto, 19870624, T. Mori (TUS); Shinhama, Yamamoto, 19890616, T. Mori (TUS); Kasanohama, Yamamoto, 19910619, T. Mori (TUS); Miyato-Island, Naruse, 20000719, H. Kasai (TUS). **Chiba Pref.:** Shirahama, 19520612, Hideo Kasai (TNS); Kido-Hama, Naruto, 19600504, Toichi Wakana (MAK, TNS); Hasunuma, 19580601 Kiyotaka Hisauchi (TNS); Naruto, 19580610, Syunki Okuyama (TNS). **Osaka Pref.:** Otsu River, Izumiotsu, 19680613, K. Seto (KYO, TI, TNS). **Hyogo Pref.:** Kobe, 19390703 (MAK). **Hiroshima Pref.:** Tadanoumi, Takehara (MAK, TUS). **Okayama Pref.:** Gokan, Tamano (KYO); Satoshio, 19301109, Kiyooki Sato (TI); Satoshio, 19300510, Kiyooki Sato (TNS). **Yamaguchi Pref.:** Iwai-Jima, Kaminoseki, 1936, Tomitaro Makino (MAK). **Fukuoka Pref.:** Tikuzen, 1909, Sakutarō Azuma (MAK). No specimens of *Z. palustris* in Japan are deposited in RYU.

In these specimens, there are several taxa: *Z. palustris* L.; *Z. palustris* L. var. *indica* (Cham.) Graebner; *Z. palustris* L. subsp. *pedicellata* (Buck-Ham.) Hook. f. var. *japonica* Makino; *Z. palustris* L. var. *pedunculata* (Reichb.) A. Gray. All these specimens are considered as *Z. palustris* L. in this paper, because of their confusing taxonomy.

Seventeen prefectures categorize *Z. palustris* as “living” or “unknown” in the Red Data Book (Environment Agency of Japan 2000) (Table 1). According to prefectural literature, eleven prefectures categorize *Z. palustris* as “living” or “unknown.”

### Current distribution of *Zannichellia palustris* in Japan

In this study, the distribution of *Z. palustris* was confirmed at eleven localities of eight prefectures in Japan (Table 1 and Fig. 1). Of the prefectures where *Z. palustris* has been reported in the literature, the presence of *Z. palustris* is not confirmed in Tottori, Yamaguchi, Hiroshima, Oita, and Okinawa Prefectures. Although there is a possibility of regeneration through germination of soil-seed pool, they may be extinct. The presence of *Z. palustris* in Okinawa Prefecture has not been confirmed in recent years (Okinawa Prefectural Government 2006), and in our survey as well. However, new localities may be discovered in future investigations because many islands have not fully been investigated for submerged plants in brackish waters. For the same reason, we assume that new localities may be located in Hokkaido and Aomori Prefectures, where many natural brackish water areas remain that have not been investigated in detail.

Although it had been reported that *Z. palustris* was extinct in Chiba Prefecture (Chiba Historical

Table 1. Distribution of *Zannichellia palustris* in Japan

Prefectures	Distribution <sup>a</sup>		Each prefecture		This study	
	in RDB <sup>b</sup>	Distribu- tion <sup>a</sup>	References	Distribu- tion <sup>a</sup>	Localities	Voucher
Hokkaido	○	○	Hokkaido Pref. Gov. (2001)	○	Lake Tofutsu, Koshimizu; Lake Yudo, Toyokoro	TNS9528810-9528818; 9528819, 9528820
Aomori	△	○	Aomori Pref. Gov. (2000)	○	Lake Takahoko, Rokkasyo; Lake Obuchi, Rokkasyo; Lake Ogawara, Kamikita	TNS9528835, 9528836; TUS314888; TNS 9528778
Miyagi	○	○	Miyagi Pref. Gov. (2001)	○	Miyato-Island, Higashi-matsu- yama	Ohba-20040927(CBM-BA <sup>d</sup> )
Chiba	○	×	Chiba Historical Material Research Foundation (2003)	○	Shinhamma-Kamoba, Ichikawa	TNS9528783, 9528784, 9528802-9528804
Kanagawa	○	×	Takakuma <i>et al.</i> (2004)	×		
Nagano	△	-	Nagano Pref. Gov. (2002)	-		
Osaka	△	×	Murata (2003)	×		
Tokushima	○	○	Tokushima Pref. Gov. (2001)	○	Naruto	TNS9528886
Tottori	○	○	Tottori Pref. Gov. (2002)	×		
Shimane	△	○	Shimane Pref. Gov. (2004)	○	Nishiki-Hama, Higashi-Izumo	TNS9528826-9528831
Yamaguchi	△	○	Yamaguchi Pref. Gov. (2002)	×		
Okayama	○	○	Okayama Pref. Gov. (2003)	○	Okanan-Airport, Okayama	TNS9528821-9528825
Hiroshima	○	○	Hiroshima Pref. Gov. (2004)	×		
Oita	○	○	Oita Pref. Gov. (2001)	×		
Miyazaki	△ <sup>c</sup>	-	Editing Committee for the Red Data Book of Miyazaki Prefecture (2000)	○	Nobeoka	TNS9528833, 9528834
Kumamoto	○	-	Kumamoto Pref. Gov. (2004)	-		
Okinawa	△	△	Okinawa Pref. Gov. (2006)	×		

a. ○: living, △: unknown, ×: extinct, -: no record, b. Environment Agency of Japan (2000), c. Mistake of identification, d. Natural History Museum and Institute, Chiba

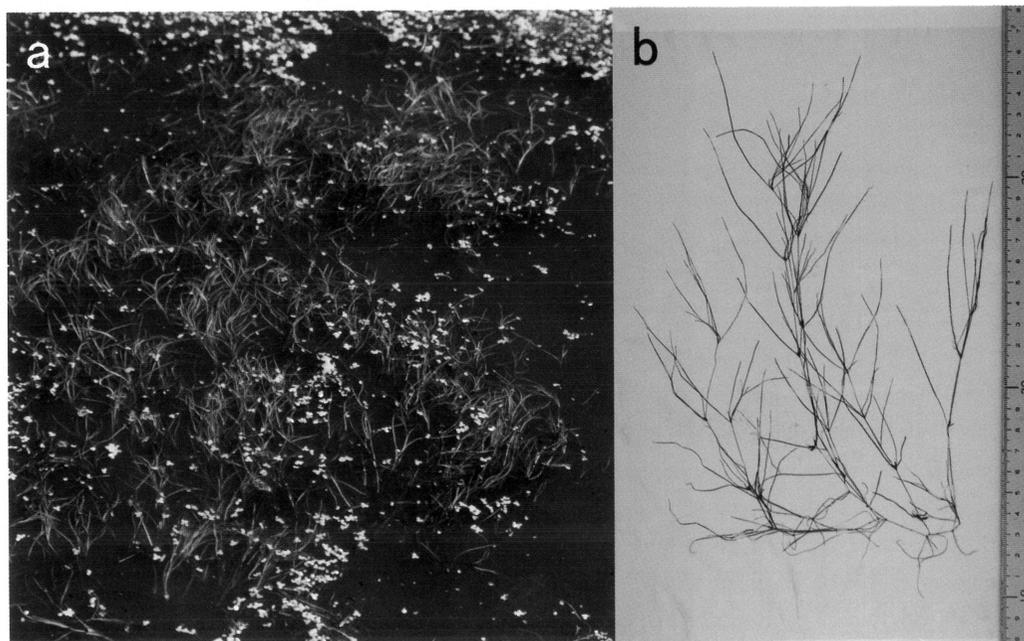


Fig. 1. *Zannichellia palustris* L. a. The community at okanan-Airport, Urayasuminami, Okayama, Okayama Prefecture. b. A specimen collected at Nobeoka, Miyazaki Prefecture. TNS9528834.

Material Research Foundation 2003), another new locality was found in this study. *Z. palustris* was found in Miyazaki Prefecture for the first time.

### **New localities for *Zannichellia palustris* in Japan**

Three new localities were found in this survey as follows.

a) Lake Ogawara, Kamikita, Aomori Prefecture

*Z. palustris* were collected at the southern area, about 100 m away from the lake's shore. Some submerged plants were sympatrically found. Because only several shoots were mixed in the submerged plants pulled out of the bottom of the lake, the size of the community of *Z. palustris* is not known. Although Hamabata (1999) investigated the distribution of aquatic plants in Lake Ogawara and reported seventeen aquatic angiosperms and three Characeae species, he was unable to find *Z. palustris*. We also found *Z. palustris* in Lake Takahoko, which is about 10 km north of Lake Ogawara. Herbarium specimens were collected at Maegata, Ichiura, on the west side of Aomori Prefecture in 1982; however, *Z. palustris* was not found in this survey.

b) Shinhama-Kamoba, Ichikawa, Chiba Prefecture

Dozens of *Z. palustris* plants were found in pond at Shinhama-Kamoba, Chiba Prefecture, which had been established on natural tideland of Tokyo Bay, as a ducking facility of the Imperial Household Agency in 1893. *Ruppia maritima* L. (Ruppiaceae), a brackish water submerged species, had been recorded in Shinhama-Kamoba (Chiba Historical Material Research Foundation 2003); however, this is the first time that *Z. palustris* was discovered here. The community is very important for studying the genetic structure of *Z. palustris* in Japan, because this is 300 km away from the nearest northern community (Miyato-Island, Miyagi) and 500 km away from nearest eastern community (Naruto, Tokushima).

c) Nobeoka, Miyazaki Prefecture

Although *Z. palustris* has been recorded in the flora of Miyazaki Prefecture (Hirata 1984), this record is based on mistakes in identifying *Potamogeton octandrus* Poir. as *Z. palustris* (personal communication by Tadashi Minamidani). Therefore, this record is the first in Miyazaki Prefecture. This community is characterized by the environment in river with stream current, while all other habitats are in still water.

### **Overview for conservation**

This study shows that *Z. palustris* is actually extinct at many localities recorded in herbarium specimens and literatures. This means that in Japan, *Z. palustris* is in critical situation. The current communities are only at eleven sites, which are geographically far apart from each other. Although the method of seed dispersal is not well known, if the seed cannot move long distances, communities will become isolated from each other. It is necessary to analyze their genetic structure for conservation.

*Z. palustris* in Japan is generally described as perennial (Otaki and Ishido 1980, Yamashita 1982, Kitamura *et al.* 1964). Apparently, as we observed, *Z. palustris* usually behaves as an annual in each of the locality and under cultivation. This species bears fruit with a high frequency because of its annual behavior. In addition, seeds of *Z. palustris* are often recorded from soil-seed pool (McFarland and Rogers 1998, Kautsky 1990). The use of the soil-seed pool, which has been shown as an effective method in conserving the genetic diversity of rare plants (Uehara *et al.* 2006), may aid in the conservation of *Z. palustris*.

In addition, lack of taxonomic study is problematic. Previous studies have used only West European plants (Van Vierssen 1982, Talavera *et al.* 1986), and a global study has not yet been implemented. In Japan, no taxonomic study has been performed. Because *Zannichellia* is a cosmopolitan genus, global taxonomic study is needed.

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### 摘 要

汽水～淡水域に生育する絶滅危惧沈水種イトクズモ *Zannichellia palustris* L. (イトクズモ科)の国内の生育状況を調査した。各都道府県の RDB で生存あるいは現状不明と報告されているのが11道県あり、実際に生育が確認できるのは8道県11群落のみであることがわかった。このうち3群落は新記録である。

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