

First Record of *Yoshizakia indopacifica* S.-M.Lin, J.Huisman et C.Payri (Liagoraceae, Rhodophyta) from Japan

Taiju Kitayama^{1,*} and Showe-Mei Lin²

¹Department of Botany, National Museum of Nature and Science,
Amakubo 4–1–1, Tsukuba, Ibaraki 305–0005, Japan

²Institute of Marine Biology, National Taiwan Ocean University,
Keelung 20224, Taiwan, Republic of China

* E-mail: kitayama@kahaku.go.jp

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Abstract A benthic marine red alga, *Yoshizakia indopacifica* S.-M.Lin, J.Huisman et C.Payri (Liagoraceae, Nemaliales, Rhodophyta) was found from the late Dr. Makoto Yoshizaki (1943–2011)'s Japanese algal collection. Although the generic name was derived from him, this is the first record of this alga from Japan. This alga is similar to young stage of *Liagora japonica* Yamada in appearance, but *Y. indopacifica* is different from *L. japonica* and the liagoracean species with similar external morphology in having a combination of the following features: dioecious thalli, fine branches with regular diameter throughout (0.2–1.2 mm), dense ramification in their terminal, spermatangial formed in clusters at the distal ends of fertile assimilatory filaments, cells of carposogonial branches unfused after fertilization, involucrel filaments not intermingled with gonimoblasts, diffuse gonimoblast filaments.

Key words: Japan, Liagoraceae, red alga, Yonaguni Island, *Yoshizakia indopacifica*.

Marine algal flora of Japan contains many species of the red algal family Liagoraceae, in which many calcified species are difficult to be identified just based on branching patterns. Before the year 2000 in Japan, only a monographic study on the taxonomy of the family was published (Yamada, 1938), and only two genera and fifteen species were recognized in this family: *Helminthocladia* (3 spp.), *Liagora* (12 spp.) (Yoshida *et al.*, 1995). In the last two decades, however, recent progress of molecular analyses and microscopic anatomy in the red algae has changed dramatically not only the taxonomic lists of this family, but also the marine algal inventory list of Japan. In particular, the largest liagoracean genus *Liagora* J.V.Lamouroux was suggested to be polyphyletic (Huisman, 2002) and was segregated repeatedly into smaller genera (Lin *et al.*, 2011; Lin *et al.*, 2013). As a result, to date at

least thirteen genera and twenty-eight species of the Liagoraceae have been reported from Japan: *Akalaphycus* (2 spp.), *Dermonema* (3 spp.), *Dotyophycus* (1 sp.), *Ganonema* (3 spp.), *Helmithocladia* (2 spp.), *Hommersandiophycus* (1 sp.), *Izziella* (1 sp.), *Liagora* (9 spp.), *Patenocarpus* (1 sp.), *Stenopeltis* (1 sp.), *Titanophycus* (1 sp.), *Trichogloea* (2 spp.), *Trichogloeopsis* (1 sp.) (Yoshida *et al.*, 2015; Guiry and Guiry, 2016).

Yoshizakia S.-M.Lin, J.Huisman et C.Payri is a monotypic genus established recently on the basis of *Y. indopacifica* S.-M.Lin, J.Huisman et C.Payri, which is widely distributed in the western Pacific Ocean (Taiwan, New Caledonia) and the Indian Ocean (Western Australia) (Lin *et al.*, 2013). The genus was named for a Japanese phylogonist, the late Dr. Makoto Yoshizaki (1943–2011), for his significant contributions to the taxonomy of Liagoraceae (Lin *et al.*, 2013).

However, *Y. indopacifica* was not reported from Japan when it was first published to science.

After re-examining the collections of the Liagoraceae from Japan made by the late Dr. Yoshizaki, we found some dried specimens of *Y. indopacifica* in the herbarium of National Museum of Nature and Science (TNS). In this study, we report the occurrence of *Y. indopacifica* in anatomical morphology.

Material and Methods

The red algal specimens referable to *Yoshizakia indopacifica* were found in the algal herbarium of National Museum of Nature and Science (TNS) under the records of "*Liagora japonica*" collected from Hikawa, Yonaguni Isl., Okinawa Pref., Japan and dated on 10 Feb., 1989. The specimens were also prepared as duplicates of No. 200 of "Algae Marinae Japonicae Exsiccatae, Fasc. VIII" (Kitayama, 2016), which were issued to 40 herbaria in 28 countries.

For anatomical observations, photomicrographs were taken on a microscope with a digital camera. Several young tips taken from thallus branches were examined and the fragments were sectioned by hand. As the young tips were only lightly calcified, so that they were not treated with any HCl solution as did in Lin *et al.* (2013). The sections were mounted in glycerin solution after staining with 1% aniline blue solution.

Results

Order Nemaliales Schmitz in Engler, 1892

Family Liagoraceae Kützinger, 1843

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[Figs. 1–6]

Type locality: Nan Wan, Pintung County, S. Taiwan [Holotype: NTOU-NW-2ii2010-75] (Lin *et al.*, 2013).

Vegetative morphology: Thalli are erect, up to 7 cm in height, pale gray, purple to reddish brown

in color. Thalli are bushy, composed of several terete axes with 5–12 orders of irregularly dichotomous branches arising from a small discoidal holdfast (Fig. 1). Main axes are moderately to heavily calcified, while terminal branchlets are lightly calcified. The thalli are multiaxial, composed of assimilatory filaments with round to elongate, pigmented cells (Fig. 2) and colourless medullary filaments.

Reproductive morphology: Gametophytes are dioecious. Spermatangia (arrowheads) are produced from spermatangial parental cells (asterisks) in clusters on the distal ends of the assimilatory filaments (Figs. 2, 3). Spermatangia are spherical, 2–3 μm in diameter. Carpogonial branches (cb) are more or less curved, four- or five-celled, situated in the lower part of assimilatory filaments (Fig. 4). After presumed fertilization, gonimoblasts (g) are produced from the carpogonia, while involucrel filaments (arrows) are cut off from the vegetative cells above and below supporting cells (sc) (Fig. 5). Carposporophytes are diffuse without interminglement of gonimoblasts and involucrel filaments (arrows) (Fig. 6).

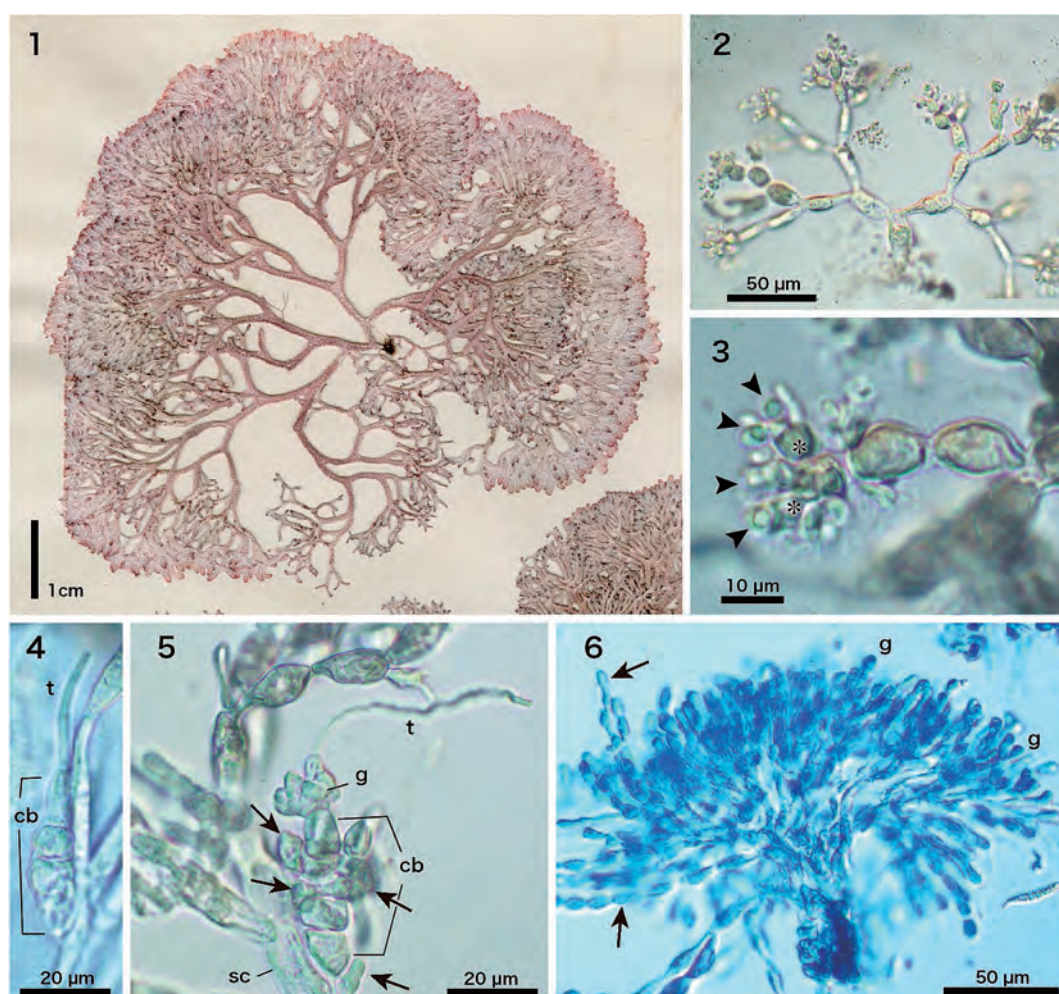
Specimens examined: "*Liagora japonica*", Hikawa, Yonaguni Isl. Yaeyama Co., Okinawa Pref., Japan. (24°26'N, 122°59'E); 10 February 1989; leg. M. Yoshizaki (TNS-AL 196838–196840, 198330).

Japanese name: Yoshizaki-konahada (nom. nov.).

Distribution: *Indian Ocean*: Western Australia (Lin *et al.*, 2013); *Pacific Ocean*: New Caledonia, Taiwan (Lin *et al.*, 2013), Japan (Yonaguni Island, present study).

Discussion

When Lin *et al.* (2013) established the genus *Yoshizakia* on the basis of their molecular data and carposporophyte development, they showed that *Y. indopacifica* is distinct from the other members of Liagoraceae in having a combination of anatomical features: cells of carpogonial branched unfused after fertilization, spermatangial formed in clusters, involucrel filaments not



Figs. 1–6. *Yoshizakia indopacifica* from Yonaguni Island, Okinawa Pref., Japan. 1. Dried specimen of female plant (TNS-AL 198330). 2. Assimilatory filaments with many spermatangia. 3. Spermatangia (arrowheads) on spermatangial parent cells (asterisks). 4. Carpogonial branch (cb) showing a trichogyne (t). 5. Early postfertilization stage showing a supporting cell (sc), carpogonial branch (cb), gonimoblasts (g) and initials of involucreal filaments (arrows). 6. Mature carposporophyte showing diffuse gonimoblasts (g) and loosely arranged involucreal filaments (arrows).

intermingled with gonimoblasts and diffuse carposporophytes. This is the first record of this monotypic genus from Japan, as a result, the number of genera of Liagoraceae in Japan reaches fourteen.

Although the specimens of *Yoshizakia indopacifica* were collected from Japan for a long time, it was not identified by Japanese phycologists as the alga is morphologically similar to young thalli of *Liagora japonica*, which has been

reported from Japan (Yoshida *et al.*, 2015), Korea (Lee and Kang, 1986) and Philippines (Silva *et al.*, 1987). Young plants of *L. japonica* have dense ramifications of narrow branches with more or less regular diameter, whereas the old plants have sparse ramification of broad branches (up to 3 mm) (Yamada, 1938, p. 17). However, *Y. indopacifica* is distinguishable in outward appearance from *L. japonica* in having dense ramification in the terminal and narrow

branches with regular diameter (0.2–1.2 mm) throughout all stages. In order to understand fully the distribution of *Y. indopacifica* and other species composition of the Liagoraceae in Japan, more fieldtrip investigations in Japan are needed.

Moreover, *Yoshizakia indopacifica* has a difficulty in anatomical observation because of their complexities and similarities between vegetative cells and reproductive cells. The cells cut off from the carpogonial branches after fertilization in the materials from Japan (Fig. 5, arrows) should be initials of the involuclal filaments based on the observation of Lin *et al.* (2013, Figs. 6–10). In general, the cells of carpogonial branches do not produce any sterile or involuclal cells in the Liagoraceae. In particular, it is difficult to distinguish the initials of involuclal filaments from the vegetative cells if the cells are just stained with aniline blue. The cells in the pressed specimens often become very flat and cannot be seen well in terms of cell shape and size. Lin *et al.* (2012) suggested the hematoxylin staining technique is a good solution for distinguishing the reproductive cells from the ordinary vegetative cells by using freshly preserved liquid specimens. We will need to obtain new fresh material of *Y. indopacifica* from Japan for examining its reproductive structure at early postfertilization in details.

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References

- Guiry, M. D. and Guiry, G. M. 2016. AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. <http://www.algaebase.org>; searched on 4 June 2016.
- Huisman, J. M. 2002. The type and Australian species of the red algal genera *Liagora* and *Ganonema* (Liagoraceae, Nemaliales). *Australian Systematic Botany* 15: 773–838.
- Kitayama, T. 2016. *Algae marinae Japonicae Exsiccatae*, Fasc. VIII (Nos. 175–200). National Museum of Nature and Science. Tsukuba.
- Lee, I. K. and Kang, J. W. 1986. A check list of marine algae in Korea. *The Korean Journal of Phycology* 1: 311–325.
- Lin, S.-M., D'Archino, R. and Hommersand, M. H. 2012. A new method of cystocarp development in the red algal *Callophyllis* (Kallymeniaceae) from Chile. *Journal of Phycology* 48: 784–972.
- Lin, S.-M., Huisman, J. M. and Payri, C. 2013. Characterization of *Liagora ceranoides* (Liagoraceae, Rhodophyta) on the basis of *rbcL* sequence analyses and carposporophyte development, including *Yoshizakia indopacifica* gen. et sp. nov. from the Indo-Pacific region. *Phycologia* 52: 161–170.
- Lin, S.-M., Yang, S.-Y. and Huisman, J. M. 2011. Systematics of *Liagora* with diffuse gonimoblasts based on *rbcL* sequences and carposporophyte development, including the description of the new genera *Neoizziella* and *Macrocarpus* (Liagoraceae, Rhodophyta). *European Journal of Phycology* 46: 249–262.
- Silva, P. C., Meñez, E. G. and Moe, R. L. 1987. Catalog of the benthic marine algae of the Philippines. *Smithsonian Contributions to the Marine Sciences* 27. iv + 179 pp., 2 figs., 1 table.
- Yamada, Y. 1938. The species of *Liagora* from Japan. *Scientific Papers of the Institute of Algological Research, Faculty of Science, Hokkaido Imperial University* 2: 195–215.
- Yoshida, T., Suzuki, M. and Yoshinaga, K. 2015. Check-list of Marine Algae of Japan (Revised in 2015). *Japanese Journal of Phycology* 63: 129–185.
- Yoshida, T., Yoshinaga, K. and Nakajima, Y. 1995. Check list of Marine Algae of Japan (revised in 1995). *Japanese Journal of Phycology* 43: 115–171.