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FINDING
OF ACROSORIUM YENDOI YAMADA (DELESSERIACEAE, RHODOPHYTA),
A NEW TO KAMCHATKA SPECIES,
IN AVACHA GULF

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Recent finding of the red alga *Acrosorium yendoi*, new to Kamchatka, during observations in a laboratory marine aquarium, containing sediments and water from the Avacha Gulf (Southeastern Kamchatka), was supported by its discovery in this water area using the method of parallel floristic observations both under laboratory and natural conditions. *A. yendoi* was previously recorded in more southern areas of the Pacific coast of Russia (Sea of Japan), as well as in Japan, China, and Korea. As a result of our studies, the species is registered in the flora of Eastern Kamchatka, and this significantly expands the understanding of *A. yendoi* range, shifting it to the north and changing the phytogeographic characteristics of the species.

Keywords: *Acrosorium*, Kamchatka, area, aquarium research, parallel floristic observations, climate warming

The study of aquarium algae in a laboratory marine aquarium, containing soil and water from the Avacha Gulf (Southeastern Kamchatka), was initially undertaken by us as a monitoring research of this group of marine organisms that create a habitat for other hydrobionts in an artificial reservoir. However, this investigation had unexpected results. In the aquarium, algae new for this region were registered: *Lukinia dissecta* Perstenko, 1996 and *Acrosorium yendoi* Yamada, 1930 (Rhodophyta) [Selivanova, Zhigadlova, 2021, 2022]. We recognized them not as invasive aquarium elements, but as real natural species that got into the aquarium with water and soil. The occurrence of unusual algae in the aquarium was assumed to be an indicator of their actual presence in the Avacha Gulf water area and a stimulus to search and find these species in nature. Being focused on this problem, we carried out expeditionary work. Soon, our assumption about the actual growth of these algae in nature was fully confirmed for *L. dissecta*: it was registered in Kamchatka water area in June 2021 [Selivanova, Zhigadlova, 2023]. Continuing the search for new species became the aim of this study. As a result, the second species recorded in the aquarium, *A. yendoi*, was also found in natural conditions during field work in the Avacha Gulf. The finding allowed to clarify the available information about the geography of this species.

MATERIAL AND METHODS

In the course of this study, an original observation method was used in the laboratory marine aquarium in parallel with the classic sampling of algological material in nature. The method proved to be quite productive for searching and finding algal species new for the investigated region.

Algological material was sampled in the Avacha Gulf using light diving equipment from a small vessel. Aquarium and natural algae samples from Southeastern Kamchatka were identified under an Olympus CX31 light microscope. When identifying, we compared the material with the original description of a taxon and information from other publications on this species [Perestenko, 1994; Yamada, 1930; Yoshida, 1998]. Samples were photographed with an Olympus SZ-20 digital camera. The material is stored in the laboratory of hydrobiology of KB PGI FEB RAS.

RESULTS AND DISCUSSION

The studied natural samples of *A. yendoi* (Fig. 1A, B) were taken on 21 April, 2022, in the Vilyuchinskaya Bay (the Avacha Gulf), near the Cape Razdelny, from a 14-m depth, from rocky-pebble soil with sand deposits. The sampling was carried out by Ermolenko E.

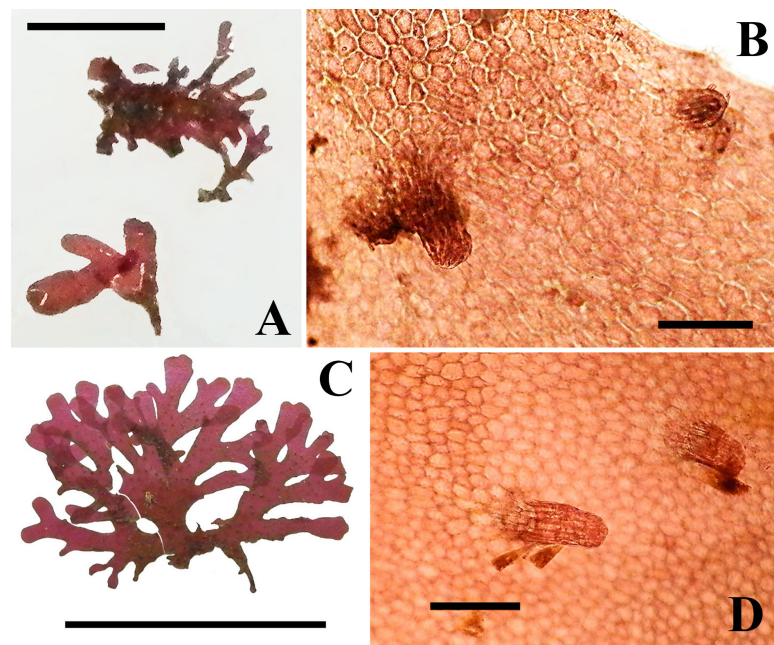


Fig. 1. *Acrosorium yendoi* Yamada, 1930 from the coastal waters of Southeastern Kamchatka (A, B) and laboratory marine aquarium (C, D): A, young natural plants; C, mature aquarium plants; B, D, fragments of the blades of natural and aquarium plants with rhizoidal outgrowths. Scale: A, 1 cm; C, 2 cm; B, D, 200 μ m

During diving works in the Vilyuchinskaya Bay, small, rather depressed young plants were sampled; those grew in early spring at a temperature of +1...+2 °C which is probably uncomfortable for them. However, their general morphology and anatomy were consistent with those of mature plants grown in the aquarium at a higher temperature, +6...+7 °C, and these ones, in turn, correspond to the original description of the species. The thallus is purple-red and membranous; it is attached to the substrate by numerous rhizoids. Branching is irregularly dichotomous. The branches intertwine using rhizoidal outgrowths. The plates have a smooth edge; microscopic one- to three-layer veins are revealed on a cross-section.

A. yendoi was originally described from Japan [Yamada, 1930] and recorded in the southern areas of the Russian Far East (Strait of Tartary and Peter the Great Gulf, Sea of Japan) [Klochkova, 1996; Kozhenkova, 2020; Perestenko, 1994]. In addition to Japan [Yoshida, 1998; Yoshida et al., 2015] and Russia, this species was registered in China [Checklist of Biota, 2008; Tseng, 2009] and Korea [Lee, Kang, 2001; Nam, Kang, 2012]. In Russian literature on phycology, *A. yendoi* is generally considered as a boreal-tropical, interzonal Pacific sub-Asian species [Perestenko, 1994] or a sub-Asian low-boreal-subtropical species [Klochkova, 1996].

In fact, the first finding of *A. yendoi* in Kamchatka was its record in the aquarium [Selivanova, Zhigadlova, 2021, 2022]. In these publications, we excluded the accidental introduction of algal spores from reliably known habitats of the species due to their geographic distance from the studied area. To explain the occurrence in the aquarium of algae unusual for the investigated water area, we assumed that spores or juvenile plants were contained in water or soil sampled for the aquarium from the Avacha Gulf. Observations on the dynamics of the aquarium ecosystem development revealed an extensive growth of algae; *Acrosorium*, with its small, creeping thallus, was so active that it almost distributed in all suitable surfaces of the substrate and became the prevailing species. Apparently, the conditions in the aquarium turned out to be favorable for its development. Temperature was most likely the limiting factor. Interestingly, it became clear relatively recently that this species is not so thermophilic. The work of Chinese researchers [Sun et al., 2010], who carried out a long-term monitoring of the biodiversity of benthic algae in the littoral zone of the Nanji Islands (National Marine Nature Reserve, South China Sea, China), showed that with a rise in water temperature, the proportion of subtropical species in a macroalgal community increased, while the proportion of moderately cold-water species noticeably decreased. Regarding *A. yendoi*, it was established as follows: its abundance in the littoral zone of the islands dropped by approximately 1.5 times over 40 years, with the transition from the category of prevailing species to the category of common ones [Sun et al., 2010]. These researchers assumed that a decrease in abundance of certain algal species results from the global climate warming. Kamchatka is also in the trend of increasing mean annual temperature of the surface layer of the Earth and World Ocean. Data obtained in a comparative analysis of two 30-year periods using the mean annual temperature curve for Petropavlovsk-Kamchatsky showed a rise in air temperature by 0.5 °C (<http://kammeteo.ru>). The water temperature increases, as the temperature of water masses rises; accordingly, the finding of species of marine hydrobionts considered to be warm-water ones is not so unexpected in Kamchatka water area. Probably, due to the climate warming, *A. yendoi* began to move north, *inter alia* to Kamchatka shores, and thus occurred in our aquarium.

Under natural conditions, this species might not have been found in the bay due to its small size, its low abundance, or simply poor knowledge on the algal flora of the region. The study of aquarium algae served as a sort of target indicator for its search in nature. To date, *A. yendoi* has been found in the Avacha Gulf water area, which allows to expand and clarify its natural range.

Conclusion. The finding of *Acrosorium yendoi* in Eastern Kamchatka waters significantly shifts the species range to the north compared to previously known one (data from more southern areas of the Pacific coast of Russia, Sea of Japan). Thus, *A. yendoi* should no longer be considered as a boreal-tropical, Pacific sub-Asian or low-boreal-subtropical species, but should be recognized as a wide-boreal Asian-Pacific species.

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**НАХОДКА В АВАЧИНСКОМ ЗАЛИВЕ
НОВОЙ ДЛЯ КАМЧАТКИ ВОДРОСЛИ
ACROSORIUM YENDOI YAMADA (DELESSERIACEAE, RHODOPHYTA)**

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Недавнее нахождение новой для Камчатки красной водоросли *Acrosorium yendoi* в ходе наблюдений в лабораторном морском аквариуме, содержащем грунт и воду из Авачинского залива (Юго-Восточная Камчатка), подкреплено её обнаружением в данной акватории с использованием метода параллельных флористических исследований в лабораторных и природных условиях. Ранее *A. yendoi* был известен из более южных районов тихоокеанского побережья России (Японское море), а также из Японии, Китая и Кореи. В результате наших исследований вид регистрируется во флоре Восточной Камчатки, что значительно расширяет представления об ареале *A. yendoi*, смещая его к северу и изменяя фитогеографические характеристики вида.

Ключевые слова: *Acrosorium*, Камчатка, ареал, аквариумные исследования, параллельные лабораторные и природные наблюдения, потепление климата