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MYCOLOGY AND ALGOLOGY

New Record of Red Alga *Thorea Hispida* (Thore) Desv. (Rhodophyta) in Moscow River, Russia

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Abstract—In Moscow oblast, *Thorea hispida* (Thore) Desv. was first recorded at the beginning of the 20th century. Subsequently, *T. hispida* was found in 2004 in Moscow River within the territory of Moscow, where it still occurs. This species is included in the Red List of the Russian Federation, the Red List of Moscow oblast, and the Red Lists of some European countries. The new data on the distribution of *T. hispida* in Moscow River is presented in the paper, and some problems concerning the morphology and conservation status of this species are discussed.

Keywords: Thorea hispida, red algae, Rhodophyta, morphology, conservation status of species, Moscow River, Red List.

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INTRODUCTION

Thorea hispida (Thore) Desvaux (Synonym: *Thorea ramosissima* Bory) is one of the most common and well-studied species of the freshwater red algae of the Thoreaceae family (phylum Rhodophyta, class Florideophyceae, order Thoreales). It occurs in different countries of Europe, Asia, and the Americas [1]. *T. hispida* is included in the Red Lists of some European countries, for example, Bulgaria [2], Slovakia [3], Germany [4], Lithuania [5], Poland [6], Serbia [7], and Ukraine [8]; at the same time, this species is not included in the Red List of the International Union for Conservation of Nature [9]. Despite the fact that it is a widespread species, populations of *T. hispida* are usually few in number [8].

On the territory of European Russia, in particular, in Moscow oblast, the species was first discovered in the early 20th century [10]. On the territory of the Russian Federation, it was also noted in Primorsky krai, but these data need confirmation. Currently, *T. hispida* is included in the Red List of the Russian Federation [11].

T. hispida is a rheophilic species found in water bodies characterized by a rapid current, where it most often inhabits shallow depths (approximately 0.5 m). It sometimes occurs in low-current waters [12]. *T. hispida* colonizes various submerged substrates (natural and artificial): wooden piles of bridges, trunks and branches of decaying trees, stone and concrete blocks, and even nylon cables at locks and bridges [13, 14]. It is often found among young specimens of green algae (for example, *Enteromorpha* or *Cladophora*) [8].

In the present study, we present new data on the distribution of *T. hispida* in Moscow River and the results of studying the morphology of this species and also discuss some of the problems related to its conservation status.

MATERIALS AND METHODS

Thalli of the gametophytes of *T. hispida* were collected during ice-free periods at different sites of Moscow River in 2004–2017. Part of the material was conserved as herbarium, and the other part was fixed with a 4% solution of formaldehyde. The material is stored in the algological collection of the Department of Mycology and Algology, Biological Faculty, Moscow State University.

Morphological studies of thalli were carried out using a Leica DM2500 microscope (Leica Microsystems, Germany) equipped with a Leica DFC495 digital camera and a Leica M80 stereomicroscope (Leica Microsystems, Germany) equipped with a Leica IC80HD digital camera.

RESULTS AND DISCUSSION

Morphology of *T. hispida* thallomes. Thalli of the gametophytes of *T. hispida* are macroscopic, soft and mucous, 10–20-cm long (rarely up to 35 cm), repeatedly and abundantly branched, with a diameter of 0.5–3.0 mm (Fig. 1). Thalli are dark, brownish-green, almost black; they become dark purple in the herbarium.

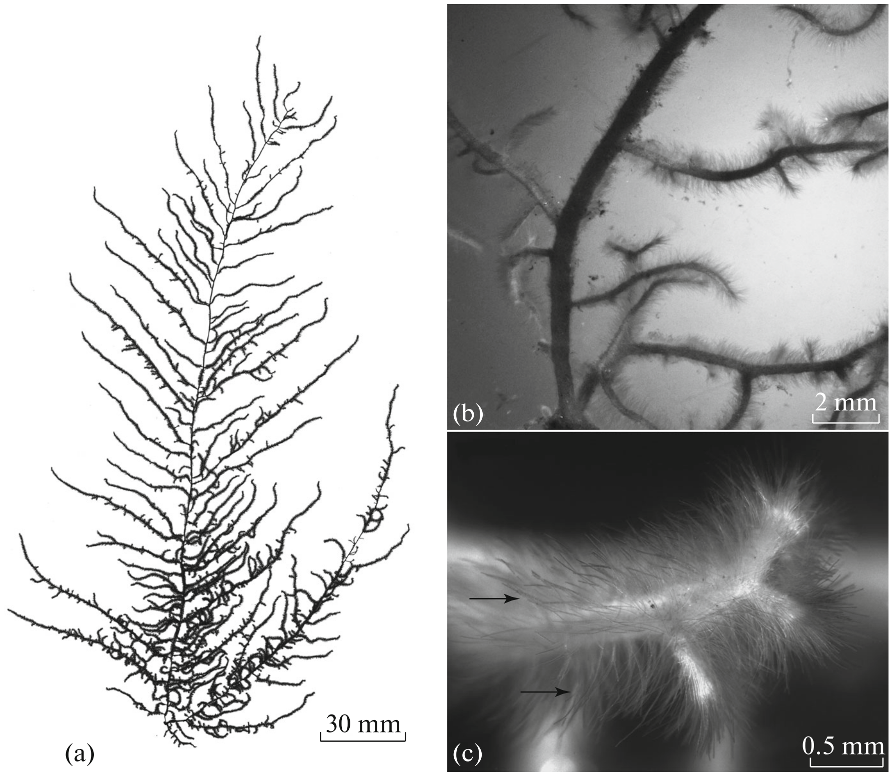

Fig. 1. Gametophyte *T. hispida*. (a) General view of the thallus, (b, c) details of a thallus with branches (arrows show assimilatory filaments).

The thallus of a gametophyte is multiaxial, consisting of medullary filaments and cortical assimilatory. The medullary region (central axis) of a width of 100–300 μm consists of branched and intertwined colorless filaments. The assimilatory filaments are branched or unbranched, colored, and represented by two types. Long assimilatory filaments are 400–1000 μm in length, mostly simple or sometimes bifurcated at the base, less often in the middle part, consist of 15–28 cells with a length of 20–45 μm, a width of 4–8 μm. The short assimilatory filaments are branched, more often closer to the apex, and consist of 3–7 cells; cells are of a cylindrical or oval shape, 8–12 mm long, 4–11 μm wide. Short and long filaments form a relatively dense cortex layer approximately 60–80 μm wide; long filaments protrude beyond this layer, and the thalli look pubescent because of this (Figs. 1, 2a). Monosporangia are located on the tips of short assimilatory filaments, they are single or grouped by 2–3, ovoid or pear-shaped, 15–22 μm long, 7–8 μm wide (Fig. 2b). Gametangia were not found. Sporophytes (*Chantransia*-stage) were not detected.

T. hispida is characterized by wide variations of morphological characters. Our samples correspond to the protolog and later detailed descriptions of this species [1, 12, 15, 16].

Local distribution of *T. hispida*. The first recorded findings of *T. hispida* on the territory of Moscow oblast date to the beginning of the 20th century; the species was encountered sporadically in this area. *T. hispida* was registered on the territory of Odintsovo, Orekhovo-Zuevskii, Pavlovsky-Posadskii, and Dmitrovskii raions. After that, the species was not detected for a long time (for several decades) in Moscow oblast [10].

We found *T. hispida* in September 2004 in Moscow River on the territory of Moscow (Vorobyovy Gory, near Andreevskii Bridge, 55°42′49.3″ N, 37°34′41.2″ E). Thalli were found at both banks of the river on the underwater concrete structures of the bridge and parapets. They were also present on stones and various iron objects found on the riverbed. Most of the thalli were registered at a depth of 10–40 cm. The thalli growing closer to the water surface were periodically air-exposed as a result of the action of the waves.

The maximum density of thalli of *T. hispida* (up to 30 specimens per 1 m^2) was registered near Andreevskii Bridge, on stony surfaces, at a depth of 15–30 cm. It is interesting that the population was local; thalli were less common at both banks upstream and downstream from this site, and algae were not detected at all at 200–300-m distance. The population of *T. hispida* was observed each subsequent year in the area of Andreevskii Bridge, but the thalli were smaller in size and their number was lower than in 2004. In summer 2011, *T. hispida* was found in Moscow River in Moscow oblast (much upstream, approximately 50 km

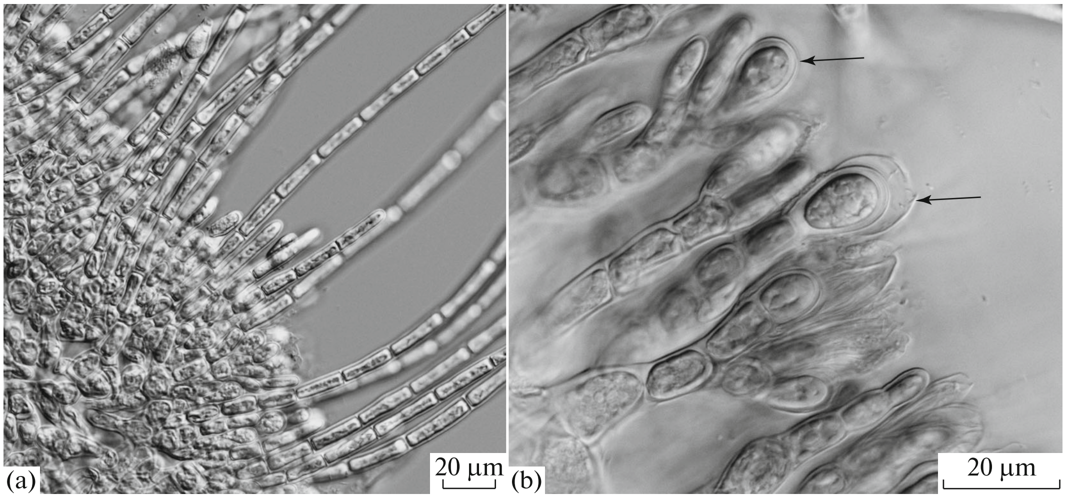

Fig. 2. Details of the structure of *T. hispida* gametophyte. (a) Short and long assimilatory filaments, (b) short assimilatory filaments with monosporangia (shown by arrows).

from Moscow, 55°42′05.8″ N, 36°43′17.4″ E) near the Zvenigorod Biological Station of Moscow State University.

Therefore, in Moscow River, *T. hispida* occurs stochastically. For several decades, this species was not observed for this watercourse. Similar cases are mentioned in other studies. For example, in the British Isles, the population of *T. hispida* was recorded in 1989, 140 years after the previous observation [14]. In the rivers of Serbia, *T. hispida* began to be regularly observed since 1996, after 87 years from the last confirmed discovery [7]. For *T. okadae* Yamada (another species of the genus *Thorea*) in Japan, it is indicated that the alga was discovered after nearly a decade of its complete absence [17].

On the one hand, the frequency of the occurrence of a *T. hispida* population can be explained by the fragmentation of the species range. On the other hand, this may be due to certain features of the life cycle of *T. hispida*, namely, the ability of the species to persist for a long time at a sporophyte stage that is difficult to identify [13]. The sporophyte is microscopic and develops in the form of small (several millimeters) cushion-shaped turfs consisting of branched single-thread filaments; the sporophyte stage morphologically corresponds to the genus *Chantransia* and is usually spoken of as the *Chantransia* stage. It is known that the *T. hispida* gametophyte begins to develop directly on the sporophyte from the apical cell after the reduction division [18]. Perhaps, for the successive alternation of generations, certain environmental conditions are necessary. For example, it was found in culture that a combination of a rise in temperature (up to 20°C) and a low luminous intensity stimulates the development of macroscopic gametophytes from the *Chantransia* stage of this algae [18–20].

Conservation status of *T. hispida*. In general, the diversity of the freshwater red algae in Moscow and Moscow oblast has been little studied. *T. hispida* is one of the five freshwater algae species included in the Red List of the Russian Federation [11]. The species has the status "2a," i.e., a taxon that declines in numbers as a result of changes in conditions and destruction of habitats (NT by categories of IUCN). As mentioned above, *T. hispida* was discovered at the beginning of the 20th century in several districts of Moscow oblast, but there was no other finding for a long time after that. In 2004, *T. hispida* was found in Moscow River (74 years after the last find) within Moscow. In 2011, the thalli of *T. hispida* were noted in Moscow River in the Odintsovo raion of Moscow oblast (at the Zvenigorod Biological Station of Moscow State University).

It should be noted that anthropogenic pollution of water is often the cause of the disappearance and rare finds of *T. hispida*. Some authors believe that *T. hispida* prefers to develop in oligotrophic waters and can be considered an indicator of the water purity of the reservoir [7, 11, 14]. At the same time, other authors report on the findings of *T. hispida* in nutrient-rich (eutrophic) waters [16, 21]. Detailed physical, chemical, and hydromorphological characteristics of *T. hispida* habitats in Italy were presented in the work of Bolpagni et al. [13]. They found that *T. hispida* prefers to develop under conditions with relatively high concentration of nitrogen (up to 9.4 mg/L) and phosphorus (up to 173 mg/L), high electrical conductivity (up to 660 μS/cm), and high water turbidity. The species prefers to develop at a high flow velocity (0.1–1.0 m/s); at the same time, the water temperature (5.1–26.2°C) and pH (7.1–8.6) can vary greatly [13]. As a result, the authors concluded that, firstly, the species is incorrectly considered to be sensitive to water pollution, because it prefers to develop in watercourses with high availability of nutrients, and, secondly, *T. hispida* is not a species that is threatened with extinction.

Our data are consistent with the opinion of colleagues that the "rarity" of *T. hispida* can be explained, first of all, by the features of the life cycle of the species and the limited availability of the sites to be colonized. In the absence of abrupt changes in habitat conditions, one can expect that *T. hispida* will remain a permanent inhabitant of Moscow River. However, further studies are needed to assess the distribution and occurrence of this species in the watercourses of Moscow oblast and the territory of the Russian Federation in general.

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REFERENCES

1. AlgaeBase. http://www.algaebase.org. Cited October 29, 2017.
2. Temniskova, D., Stoyneva, M.P., and Kirjakov, I.K., Red List of the Bulgarian algae. I. Macroalgae, *Phytol. Balc.,* 2008, vol. 14, no. 2, pp. 193–206.
3. Hindak, F. and Hindakova, A., Red list of cyanophytes and algae of Slovakia, in *Red List of Plants and Animals of Slovakia,* Balaz, D., Marhold, K., and Urban, P., Eds., Ochrana Prirody, 2001, pp. 14–22.
4. Rote Liste gefährdeter Pflanzen Deutschlands, in *Schriftenreihe für Vegetationskunde,* Ludwig, G. and Schnittler, M., Eds., Landwirtschaftsverlag, 1996, pp. 1–277.
5. Vitonytė, I., First record of red algae *Thorea hispida* in Lithuanian freshwaters, *Bot. Lith.,* 2011, vol. 17, no. 4, pp. 165–175.
6. Sieminska, J., Red list of algae in Poland, in *Red List of Plants and Fungi in Poland,* Mirek, Z., Zarzycki, K., Wojewoda, W., Szelag, Z., Eds., Krakow: Polish Academy of Science, 2006, pp. 37–52.
7. Simić, S. and Pantović, N., Observation on the rare algae *Thorea hispida* (Thore) Desvaux (Rhodophyta) from Serbia, *Cryptogamie: Algol.,* 2010, vol. 31, no. 3, pp. 343–353.
8. Dogadina, T.V., Gromakova, A.B., and Gorbulin, O.S., A new find of a *Rhodophyta* representative in the Seversky Donets River (Ukraine), *Al'gologiya,* 2009, vol. 19, no. 3, pp. 313–317.
9. IUCN Red List of Threatened Species, 2017. http://www.iucnredlist.org. Cited October 29, 2017.
10. Usacheva, I.S., *Vodorosli vodoemov Moskovskoi oblasti. Osnovy izucheniya vidovogo raznoobraziya (Algae Reservoirs of the Moscow Oblast. Basics of Studying the Species Diversity)*, Moscow: IVP RAN, 2002.
11. Belyakova, G.A., *Thorea hispida*, in *Krasnaya kniga Rossiiskoi Federatsii 2017* (The Red Book of the Russian Federation 2017). https://cicon.ru/toreya-resnitchataya.html. Cited October 29, 2017.
12. Sheath, R.G., Vis, M.L., and Cole, K.M., Distribution and systematics of the freshwater red algal family Thoreaceae in North America, *Eur. J. Phycol.,* 1993, vol. 28, no. 4, pp. 231–241.
13. Bolpagni, R., Amadio, C., Johnston, E.T., and Racchetti, E., New physical and chemical perspectives on the ecology of *Thorea hispida* (Thoreaceae), *J. Limnol.,* 2015, vol. 74, no. 2, pp. 294–301.
14. John, D.M., Johnson, L.R., and Moore, J.A., Observations on *Thorea ramosissima* Bory (Batrachospermales, Thoreaceae), a freshwater red alga rarely recorded in the British Isles, *Brit. Phycol. J.,* 1989, vol. 24, no. 1, pp. 99–102.
15. Simić, S.B., Đorđević, N.B., and Vasiljević, B.M., New record of red alga *Thorea hispida* (Thore) Desvaux (Rhodophyta) in the River Sava (Sremska Mitrovica, Serbia), *Water Resour. Manage.,* 2014, vol. 4, no. 1, pp. 47–52.
16. Carmona, J.J. and Necchi, O., Jr., Systematics and distribution of *Thorea* (Thoreaceae, Rhodophyta) from central Mexico and south-eastern Brazil, *Phycol. Res.,* 2001, vol. 49, no. 3, pp. 231–239.
17. Sato, H., Yokoyama, T., Madono, K., Tsuji, M., Mizuno, M., Uodome, T., Senoo, Y., Sugino, N., Nagano, M., Mitsuhashi, H., Asami, K., Michioku, K., and Harada, H., Occurrence patterns of the gametophyte of *Thorea okadae* (Rhodophyta) in the Yasumuro River, Kamigori, Hyogo Prefecture, Japan, with special reference to variations in river-water discharge, *Jpn J. Limnol.,* 2006, vol. 67, no. 2, pp. 127–133.
18. Necchi, O., Jr. and Carmona, J.J., Somatic meiosis and development of the juvenile gametophyte in members of the Batrachospermales sensu lato (Rhodophyta), *Phycologia,* 2002, vol. 41, no. 4, pp. 340–347.
19. Necchi, O., Jr. and Oliveira, M.C., Phylogenetic affinities of "Chantransia" stages in members of the Batrachospermales and Thoreales (Rhodophyta), *J. Phycol.,* 2011, vol. 47, no. 3, pp. 680–686.
20. Swale, E.M.F., The development and growth of *Thorea ratnosissima* Bory, *Ann. Bot.,* 1962, vol. 26, no. 1, pp. 105–116.
21. Eloranta, P. and Kwandrans, J., Indicator value of freshwater red algae in running waters for water quality assessment, *Oceanol. Hydrobiol. Stud.,* 2004, vol. 33, no. 1, pp. 47–54.

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