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Bioecological and physiological-biochemical features of cassocks (*Lemnaceae*) in culture

[1]S.H. Homidchonova, [2]N.A. Mahmudova
[1]Fergana Medical Institute of Public Health

Abstract: The article presents the result of the study of three species of duckweed: duckweed (*Lemna minor* L.), duckweed (*Lemna gibba* L.) and duckweed (*Lemna trisulca* L.). The subject of the study is inthe pouring of various nutrient media on the growth and development of duckweed in culture.

It should be emphasized that the treatment of polluted water in biological ponds with the use of hydromacrophytes is effective and not time-consuming. This method of cleaning polluted effluents can be especially promising in the conditions of the Republic, because the duration of the warm period is 210-215 days.

Key words: Species of duckweed, *Lemnaceae*, water resources

Relevance of the topic. The result of human economic activity is a large amount of wastewater. A huge number of such hazardous pollutants as pesticides, ammonium and nitrate nitrogen, phosphorus, potassium and others are washed away from agricultural areas, including the areas occupied by livestock complexes [13]. Pollution of water bodies leads to a change in the structure of communities, their species and quantitative composition. Intensive pollution by agricultural and domestic effluents [13]. Pollution of water bodies leads to a change in the structure of communities, their species and quantitative composition. Intensive pollution by agricultural and domestic effluents lead to overgrowth and waterlogging of water bodies, and industrial - to disruption and complete degradation of biocenoses [22].

Wastewater, which can be defined as water formed as a result of household and other human activities, is purified usingthree basic methods: physical, chemical and biological. Biological methods of cleaning water bodies with the help of higher aquatic plants have proven themselves in the system of treatment of municipal wastewater, as the most environmentally and economically profitable, thanks to the simplicity of technology and low operating costs.

With regard to the provision of water resources, Uzbekistan is in the most unfavorable natural conditions. The amount of available clean water in the region is gradually decreasing due to its extensive use and natural factors. Uzbekistan is widely implementing measures to protect the environment, in particular the rational use of water resources and the solution of urgent scientific problems of relevant water treatment biotechnologies of various industries through the cultivation of higher aquatic plants. It should be emphasized that the treatment of polluted water in biological ponds with the use of hydromacrophytes is effective and not time-consuming. This method of cleaning polluted effluents may be especially promising in the conditions of the Republic, since the duration of the warm period is 210-215 days [35].

The purpose of this study is to study the bioecological and physiological-biochemical features of *Lemnaceae* in culture.

The objectives of the research included:

— study of the ecological and biochemical features of individual species of duckweeds in culture (duckweed, duckweed, duckweed, duckweed three-lobed);
— study of the influence of various nutrient media on the growth and development of cassocks;
— study of the role of cassocks in biological wastewater treatment.

The objects of research were three species of duckweed: duckweed (*Lemna minor* L.), duckweed (*Lemna gibba* L.) and duckweed (*Lemna trisulca* L.). The subject of research is inthe pouring of various nutrient media on the growth and development of duckweeds in culture.

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В период с 1849 по 2004 г од на Арале встречено 30 видов макрофитов. Цветковые растения представлены 24 видами, из них 7 видов — гелофиты: *Butomus umbellatus* L., *Phragmites australis (Cav.) Trin. ex Steud., Sagittaria* trifolia L., *Scirpus kasachstanicus Dobroch., S. tabernaemontani C. C. Gmel., S. triqueter* L., *Typha angustifolia* L.; 17 видов — гидрофиты: *Nymphoides peltata (G. S. Gmel.) O. Kuntze, Myriophyllum spicatum* L., *Najas marina* L., *Potamogeton crispus* L., P. *filiformis Pers*., P. lucens L., P. *macrocarpus Dobroch., P. nodosus Poir., P. pectinatus* L., P. *perfoliatus* L., *P. pusillus* L., *Ruppia cirrhosa (Petagna) Grande, R. maritima* L ., *Zanichellia palustris* L., Z. *pedunculata Reichb., Zostera marina* L., *Z. noltii Hornem.* К гидрофитам также относятся 6 видов харовых водорослей: *Chara aculeolata Kütz., Ch. polyacantha A. Br., Ch. tomentosa* L., *Lamprothamnium papulosum (Wallr.) Gr., Nitella hyaline (DC.) Ag., Nitellopsis obtusae (Desv.in Laws.) Gr*. [16].

Within the framework of the project "Preservation of tugai forests and strengthening of protected area systems in the delta of the Amu Darya River in Karakalpakstan", an atlas was prepared, which includes the main species of higher plants (46 species) distributed in the territory of the Republic of Karakalpakstan. The literature describes such species of higher aquatic plants as yellow cup *(Nuphar luteum),* narrow-leaved hornwort *(Typha angustifoli),* knotweed (*Polygonum persicaria)* which are mainly found in the lower reaches of the Amu Darya [108].

On the territory of Uzbekistan, in natural conditions, such species of duckweed as duckweed three-lobed (*L. trisulca*), duckweed (*L. minor*), duckweed (*L. gibba*), common multiroot (*Spirodela polyrhiza*). Duckweed is distributed in Samarkand region and on the outskirts of Samarkand. Duckweed is common in Tashkent, Fergana, Samarkand and Bukhara regions. Duckweed is common in Samarkand (Samarkand) and Bukhara (Sharshauz) regions [26]. Some studies note that duckweed in Uzbekistan is more widespread than has been known in the literature so far. Thus, small duckweed was found in the delta of the Amu Darya River, in the floodplain reservoirs of the Karadarya and Naryn, and hunchback and three-part duckweed - in the lakes of the Chirchik River basin [29].

1.1. Species composition of cassocks and their study

Duckweed (Latin: Duckweed). *Lemnoideae* is a subfamily of aquatic monocotyledonous plants in the family *Araceae*.

Duckweeds originated from the ancestor of the modern waterfowl tropical genus *Pistia (Pistia*) from the aroid family [64, 78]. As a result of hydrophilic evolution, they have reached an extreme degree of reduction of all their organs, so in terms of simplicity of structure they occupy the first place among flowering plants [90].

The genus name *Lemna* may derive from the Greek "limie" - "lake", or "Limne" - "swamp" or from "lemma" - "scales", according to various authors, there are from three (four) to six genera and from 13 (28) to 38 (43) species distributed almost throughout the globe [89].

The Ryaskovs are among the botanical curiosities or mystery plants, hitherto little studied in relation to their biology and systematics. Nor has a single morphological terminology been developed to refer to all organs of the cassocks [11].

The taxonomy of the Rusks was studied throughout the nineteenth and twentieth centuries with important contributions from Schleiden (1839), Hegelmaier (1868), Thompson (1896, 1898), Daubes (1965), Hartog and Van der Plas (1970), and Landolt (1986). These scientists have significantly refined the genetic and species limits in a family that is currently described to contain 38 species in five genera [5, 7, 65].

Based on morphological, biochemical and genetic features, modern scientists distinguish 4 genera: Duckweed (*Lemna*), Multiroot (*Spirodela*), Wolffia (*Wolffia*) and *Wolffiella (Wolffiella) (*some scientists distinguish the fifth - *Landoltia*) [53, 65, 85, 64, 68].

Based on the data of modern research, the species that are part of the above genera of cassocks have been identified. The genus *Lemna* contains the following 14 species of plants (http://www.theplantlist.org/1.1/browse/A/Araceae/Lemna/) [65]:

1. Tropical duckweed (*Lemna aequinoctialis*) - distributed mainly in tropical and subtropical regions.
2. Ряска двусемянная (*Lemna disperma).*
3. Duckweed (*Lemna gibba*) - distributed almost throughout the planet, except Antarctica.
4. Japanese duckweed (*Lemna japonica*) - distributed in Japan, China, Korea, in the Far East of Russia.

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5. Duckweed (*Lemna minor*) is a cosmopolitan plant.
6. Small duckweed (*Lemna minuta*) - in North and South America.
7. Tiny duckweed (*Lemna perpusilla*) - distributed in the eastern part of the United States and in Queb.
8. *Lemna tenera* - distributed in Indochine, Sumatra and the northern territory of Australia.
9. Duckweed *obscura (Lemna obscura)* - distributed in the United States, Mexico, Colombia, Ecuador and the Bahamas.
10. Duckweed *trisulca (Lemna trisulca*) is a cosmopolitan plant.
11. Duckweed *turinoifera (Lemna turionifera*) - distributed in Asia, North America and temperate climatic waters of Europe.
12. *Lemna valdesiana.*
13. *Lemna valdeviana* – in the Americas.
14. *Lemna yungensis* – in Bolivia.

Due to a number of biological features, plants are forced to absorb most heavy metals. Therefore, the question of the localization of metals in a plant organism is of great importance in studying their toxic effect and mechanisms of resistance. Different organs, tissues, and even different cells within the same plant tissue accumulate metals differently; their distribution in the whole organism can be extremely uneven. To date, easy-to-use histochemical methods have been developed that allow for a qualitative or semi-quantitative assessment of the distribution, accumulation and pathways of movement of metals in plants [100].
Rigid metal ions include: Al^{3+}, Be^{2+}, Ca^{2+}, Ce^{3+}, Co^{3+}, Cr^{3+}, Fe^{3+}, Ga^{3+}, H^{+}, In^{3+}, K^{+}, La^{3+}, Mg^{2+}, Mn^{2+}, Na+, Sc^{3+}, Sn^{4+}, Ti^{4+}, U^{4+} and Zr^{4+}. Soft metal ions: Ag^{+}, Au^{+}, Cd^{2+}, Cu^{+}, Hg^{+} , Hg^{2+}, Pd^{2+}, Pt^{2+}, Tl^{+} and $T1^{3+}$. Also distinguish a transitional group of ions or boundary: Bi^{2+}, Co^{2+}, Cu^{2+}, Fe^{2+}, Ir^{3+}, Ni^{2+}, Pb^{2+}, Ru^{2+}, Sn^{2+}, Zn^{2+}. As a rule, the most toxic are soft ions. Heavy metals play an important role in the vital activity of plants. Many of them are trace elements (copper, nickel, cobalt, zinc, etc.), involved in a wide variety of physiological processes: from photosynthesis to the regulation of gene activity. However, significant concentrations of trace elements can cause pathological changes in cells: the formation of reactive oxygen species, oxidative stress, etc. For a number of metals (cadmium, mercury, lead, silver), vital functions are not revealed, except for destructive ones [17].

Duckweed minor (*Lemna minor*) - is a hydatophyte, lplaintiffsaboute, vegetativeaboute annuals of it, swimmingits plant (Figure 1). Most of its vegetative body is in the water in a submerged state. The vegetative body of duckweed is a leaf-shaped stem (leaf) with one root located in the center of the lower surface of the leaf. The leaf is 3-4, 5 mm long and 2-3 mm wide. The root has a length of 5-7 cm or more. They are found in ponds and in bodies of water with slow-flowing water. As observations show, duckweed shoots with fleshy large leaves and thick roots are characteristic of water bodies with rich organic substances. In such places, the length of the duckweed leaf can often reach 3-4.5 mm, width - 2.5-3 cm. The plates are interconnected in small groups of 3-6 individuals. L. minor duckweed leaves vary depending on the growing conditions, that is, the degree of contamination of natural water bodies. It was found that in duckweed small *Lemna minor* 2n = 20, 30, 40 and 50, in the aneuploid state 2n = 36, 38, 41, 42, 43 [66].
Duckweed small reproduces mainly vegetatively. In the center of the leaf is the bud of renewal, from which the lateral pocket alternately forms daughter shoots. Of the 50 g of green mass, duckweed small daily can give about 13-15 g of shoots per raw mass.

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Figure 1 – Duckweed minor

It is most logical to focus on *the Lemnaceae* duckweed species for use in aquatic systems designed to absorb nutrients from livestock farm waste. Dry biomass production is higher than other plants and reaches 20.4 t/ha/year for *Spirodela polyrhiza* [56] and 54.8 t/ha/year for *Lemna gibba* [72, 74].

As a wastewater treatment plant, duckweed has several advantages over other aquatic macrophytes such as water hyacinth and salvinia. The first is the high rate of nutrient absorption, preferably ammonium ions [74]. Ammonium uptake is very important in the treatment of wastewater from pig farms, as nitrogen is found in these waters mainly in the form of an ammonium ion. Excess ammonium causes eutrophication of open water bodies and, as a result, the conversion of ammonium ions into nitrate ions and their ingress into groundwater [74]. A valuable property of duckweed is its preference for more efficient absorption of nitrogen in the form of ammonium (NH_4^+) [69] rather than nitrate (NO_3^-) [70].

According to [67] duckweeds are used to remove contaminants from wastewater that have high levels of pollution. *L. punctata* has a good ability to extract nutrients from the wastewater of pig farms (with a high ammonium concentration of about 240 g/m3). The absorption rate of ammonium and phosphate ions is respectively about 1.0 g/^{m3}/h and 0.13 g/^{m3}/h [45]. *Spirodela polyrhiza* also absorbs nutrients from pig farm wastewater well – it can absorb up to 84% and 89% of total nitrogen and total phosphorus, respectively. A study of *Lemna* minor's ability to purify pig farm wastewater was set at 2.1 g/^{m2}/day and 0.6 g/m2/day, respectively [46].

When growing cassocks, municipal wastewater is enriched with oxygen, the degree of their purification from organic and mineral substances is intensified. In the cultivation of *Lemna minor* L. and *Lemna trisulca* L. manifest themselves as an active absorber of various wastes from wastewater [92].

Other advantages of duckweed are to reduce water losses during evaporation in water bodies by 10-30% [73].

Plants are able to concentrate radioactive substances and, thus, participate in the decontamination of water. Thus, in duckweed, the coefficient of accumulation of radioactive strontium during the three days of exposure ranged from 2,500 to 4,000 at a concentration of ^{90}Sr 10-7 - 10-10 Ku [22].

Duckweed reacts by changing color to yellow to all herbicides.

Duckweed minor (*Lemna minor*) - is a hydatophyte, lplaintiffsaboute, vegetativeaboute annuals of it, swimmingits plant (Figure 1). Most of its vegetative body is in the water in a submerged state. The vegetative body of duckweed is a leaf-shaped stem (leaf) with one root located in the center of the lower surface of the leaf. The leaf is 3-4, 5 mm long and 2-3 mm wide. The root has a length of 5-7 cm or more. They are found in ponds and in bodies of water with slow-flowing water. As observations show, duckweed shoots with fleshy large leaves and thick roots are characteristic of water bodies with rich organic substances. In such places, the length of the duckweed leaf can often reach 3-4.5 mm, width - 2.5-3 cm. The plates are interconnected in small groups of 3-6 individuals. L. minor duckweed leaves vary depending on the growing conditions, that is, the degree of contamination of natural water bodies. It was found that in duckweed small *Lemna minor* 2n = 20, 30, 40 and 50, in the aneuploid state 2n = 36, 38, 41, 42, 43 [66].

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Duckweed small reproduces mainly vegetatively. In the center of the leaf is the bud of renewal, from which the lateral pocket alternately forms daughter shoots. Of the 50 g of green mass, duckweed small daily can give about 13-15 g of shoots per raw mass. On the basisof indicators [88], it is estimated that the degree of purification of industrial waters of ZIF using pyaska is small and is 95% compared to the chemical method (78%) used in the gold recovery plant.

Conclusions. As a result of the research on the topic of the master's thesis "Bioecological and physiological-biochemical features of the cassocks (*Lemnaceae*) in culture", the following conclusions can be drawn:

1. Ряски (Lemna minor L., Lemna giba L., Lemna *trisulca* L.) – растения мелководных, загрязненных органическими веществами водоёмов. Наиболее широко распространена *Lemna minor* L. (ряска малая).
2. Different biological productivity of cassocks is shown, depending on the composition of the nutrient medium. The best nutrient media for their cultivation are the Landscape and Gorchem environments, as well as the organomineral environment.
3. It is shown that the content of the main components in the biomass of cassocks depends on the type of plants and the composition of the nutrient medium.
4. It is noted that the reactions of duckweed and duckweed humpback in conditions of wastewater are different and depend on the type and degree of dilution of wastewater. Duckweed is more stable, after a certain adaptation period in terms of growth rates it is ahead of duckweed plants.
5. Duckweeds play an important role in the biological treatment of polluted waters. They absorb and adsorb mineral and organic substances, thereby contributing to a more intensive course of self-purification processes.

It is revealed that the cleansing effect of *Lemnaceae* plants depends on the time of contact of these plants with water, on the temperature and degree of contamination, on the intensity of light and the season of the year, as well as on the species characteristics of aquatic plants.

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