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ECOLOGICAL FEATURES OF WATER PLANTS IN STEPPE RIVERS IN THE CENTRAL CAUCASUS

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Abstract

The aim of this research is to explore the ecological features of aquatic plants in rivers of the steppe region in the Central Caucasus. The research methods involve field surveys, collection of plant samples, and analysis of water parameters such as temperature and chemical composition. Laboratory studies of the collected samples, including microscopic analysis of plant structures, were also employed to gather data. One outstanding result of the research is the identification of adaptations of aquatic plants to the conditions of the steppe climate and changes in water regimes. The research shed light on the diverse plant species thriving in this environment and their intricate relationships with the surrounding habitats. Additionally, the study allows for conclusions regarding the impact of human activities on river ecosystems and suggests measures for the conservation and sustainable utilization of water resources in this region. The findings underscore the importance of preserving the delicate balance within steppe river ecosystems, considering their susceptibility to anthropogenic influences. Conservation efforts should be directed towards mitigating the identified stressors and disturbances to maintain the biodiversity and ecological integrity of these regions.

Keywords: Aquatic flora, confinement, eutotroph, ecotope, ecobiomorphs, macrophytes

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1. Introduction

This paper presents the results of a comprehensive review of the aquatic phytocomponent (systematics, ecology, biology) of the Central Ciscaucasia; features of phenological and limnological parameters. The proposed system of life forms of aquatic macrophytes reflects the evolutionary changes of the analyzed groups adapted to existence in the aquatic environment, which form free-floating turion forms; illustrate the phenomena of transformation (overgrowing) of natural and artificial water ecosystems and all the negative phenomena accompanied by anthropogenic pressure. The relevance of the study lies in the fact that it gives an idea of the ecological characteristics of aquatic plants in the steppe rivers of the Central Caucasus, which can serve as a basis for conservation efforts and management strategies for these important ecosystems. This research may be of interest to researchers and professionals in the fields of ecology, botany, aquatic biology, limnology, and environmental science, particularly those studying or working in the Central Ciscaucasia region. It may also be of interest to government and non-government organizations involved in environmental protection and management, as well as to individuals interested in the impact of anthropogenic pressure on natural and artificial water ecosystems.

Anthropogenic impact on the natural environment, acquiring a global scale, leads to the degradation of the phytocomponent of the biosphere (vegetation cover). The most significant study of the vegetation cover of aquatic ecosystems, which are the most important component of the natural environment, the custodian of life and the biosphere, have been subjected to anthropogenic impact since the 20th century with particular force (Khublaryan, 1999; Krivorotov & Ivashchenko, 2022). The lack of detailed knowledge about the processes that characterize modern ecosystems makes it difficult to implement the Concept of sustainable development (Zalikhanov, 2002a, 2002b).

The relevance of the problem of studying and preserving biodiversity is undoubted and should be among the priority areas of fundamental research (Gurova, 2019).

2. Problem Statement

The problem addressed in this research is the limited understanding of the ecological dynamics of water plants in steppe rivers within the Central Caucasus region. Despite the ecological importance of these plants, there is a gap in knowledge regarding their adaptations to the steppe environment, response to changing water regimes, and the potential impact of human activities on their ecosystems.

This knowledge gap hinders effective conservation and management strategies for the aquatic plant communities in steppe rivers. Therefore, there is a need to investigate the ecological features of water plants in this specific geographical context to contribute to a more comprehensive understanding of the region's aquatic ecosystems and inform conservation efforts.

Changes in the natural environment are projected on the quantitative and qualitative composition of aquatic plants, with a wide application aspect of use: technical, fodder, medicinal, essential oil, coastal protection and strengthening, water purification, and other plants (Nurniezov et al., 2019; Nagalevsky et al., 2020).

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3. Research Questions

The research aims to address the following questions:

i. What are the key ecological features of water plants in steppe rivers within the Central Caucasus region?

ii. How do these water plants adapt to the steppe environment and respond to changing water regimes?

iii. What is the potential impact of human activities on the ecosystems of water plants in Central Caucasus steppe rivers?

By exploring these research questions, the study aims to provide insights into the ecological dynamics of water plants in the region, contributing to a better understanding of their conservation needs and sustainable management.

Phenological features of vegetation components of aquatic ecosystems (Zhukovskaya et al., 2019; Zubarev, 2020). Seaweed features of the seasonal dynamics of the species diversity of algae are traced in the change of some forms of algae by others, occupying a prominent place in the functioning of the aquatic ecotope (due to the phenological characteristics of individual representatives). The change of some taxa (species) of algae by others is clearly traced. Spring, summer and autumn groups and their centenarians have been determined; spring ones are conditionally distinguished (table 1, figure 1).

Table 1. The structure of phenological groups of the studied species

Group name	View examples
spring	Tabellaria sp., Eudorina elegans, Volvox aureus, Closterium lunula, Pediastrum simplex and etc.
summer	Navicula sp., Spirulina major, Gopphoshaeria aponina, Spirulina major, Euglena gracilis and etc.
autumn	Chamaesiphon curvatus, Schizotrix laterina, Cymatopleura vulgaris, Diploneis sp., Navicula rostrata, Nitzschia acuta, N. narva, N. vermicularis, Suriella striatula, Gleocapsa sp., Volvox sp. and etc.
long-liver	Microcystis aeruginosa, Oscillatoria sancta, Myxocharisis paradoxa, Flagellaria crotonensis, Synedra ulna, Chlorosaccus ulvaceus, Crucigenia tetrapedia, Navicula radiosa and etc.

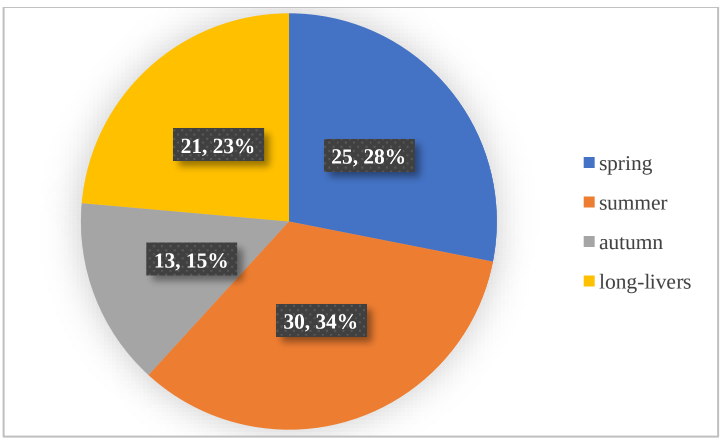

Figure 1. The structure of the studied groups according to phenology

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4. Purpose of the Study

The purpose of this work was a comprehensive characterization of the water component. To achieve this goal, it was necessary to solve the following main tasks:

i. Inventory of the hydrophilic flora of the study area;

ii. Establishment of phenological features;

iii. To investigate the ecological features of the plant component of aquatic plants, in connection with their habitat;

iv. Establishment of biomorphological features of aquatic plants, in connection with the conditions of growth.

5. Research Methods

This work is based on the results of field studies conducted in the study area in 2008-2011. The material was collected using a detailed route method with the specifics of studying higher aquatic vegetation.

6. Findings

The findings of the study revealed significant insights into the ecological features of water plants in steppe rivers of the Central Caucasus. The research identified diverse plant species that demonstrate remarkable adaptability to the specific environmental conditions of steppe river ecosystems. Additionally, the study highlighted the intricate relationships between these water plants and their surrounding habitats.

Furthermore, the research findings emphasized the susceptibility of these ecosystems to anthropogenic influences, such as changes in water regimes due to human activities. The study identified potential stressors and disturbances that impact the water plants and their associated biodiversity.

Overall, the findings contribute to the understanding of the delicate balance within steppe river ecosystems and provide valuable information for conservation efforts and sustainable management practices in the Central Caucasus region.

Macrophytes (phenological features).

As a result of the studies, the phenological homogeneity of the analyzed part of the flora was established, in contrast to the meadow-steppe flora (Table 2).

April coincides with the vegetation of shoots of aquatic ecosystems, the processes of which last until October.

Early spring, in terms of vegetation, are - Alopecurus arundinaceus (Reed foxtail), Carex acuta (Sharp sedge), C. Pseudocyperus (False sedge), Eleocharis palustris (Marsh bog), Hydrocharis morsus-ranae (Frog water crab), Phragmites australis (Southern reed), Scirpus lacustris (Scirpus lacustris), Typha angustifolia (Narrow-leaved cattail), T. Latifolia (broad-leaved cattail), Typha laxmannii (Laxmann's cattail) (vegetation ends in November, the exception - the genus Carex - completes the annual cycle); late spring - Salvinia natans (Salvinia floating) and Caulinia minor (Kaulinia small) (end of vegetation - mid

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or end of September - Equisetum palustre (Marsh horsetail), Potamogeton crispus (Curly pondweed), P. Lucens (Brilliant pondweed).

Flowering and fruiting of the studied representatives have a long period; flowering of the vast majority of species is observed in June - August, fruiting - July-September (Table 2).

Table 2. Spatio-temporal (seasonal) features of some species of the studied flora

Plant type	**Phenophase**			
	vegetation	**flowering**	**fruiting**	**sporulation**
1	2	3	4	5
Carex acuta (Sharp sedge)	III-X	V-VI	VII-VIII	
C. pseudocyperus (False sedge)			VI	
C. riparia (shore sedge)				
Eleocharis palustris (Marsh bog)	III-XI	V-VIII	VII-IX	
Hydrocharis morsus-ranae (Common watercress)			VII-X	
Phragmites australis (Common reed)		VII-X	VIII-XI	
Scirpus lacustris (Lake Schenoplektus)		VI-VIII	IX-X	
Typha angustifolia (Narrow-leaved cattail)			VII-IX	
T. latifolia (Cattail cattail)		VI-VII	VII-VIII	
T. laxmannii (Laxmann's cattail)		VI-VIII	VII-IX	
Equisetum palustre (Marsh horsetail)	IV-IX			VI-VII
Potamogeton crispus (Curly pondweed)		V-VI	VI-VIII	
P. lucens (Brilliant Pod)		VI-VIII	VIII	
Alisma gramineum (chastukha gramineous)	IV-X		VII-IX	
Batrachium rionii (Rion silkworm)			VII-X	
B. trichophyllum (hairy silkwort)				
Butomus umbellatus (Umbrella Susak)		VI-VII	VIII-IX	
Callitriche palustris (Common bogweed)		VI-IX	VII-X	
C. rostrata (Short-fruited bogweed)		V-VI	VII-VIII	
C. vulpine (bogwort bisexual)			VI-VII	
Catabrosa aquatic (Water handrail)		VI-VII	VII-VIII	
Glyceria maxima (Mannik water)		VI-VIII	VII-IX	
Juncus effuses (Spreading rush)		VI-VII	VII-VIII	
J. inflexus (Sitnik declining)			VII-IX	
J. compressus (Compressed rush)			VII-VIII	
J. bufonius (Toad rush)				
Lythrum salicaria (Willwort loosestrife)		VI-IX	VIII-IX	
Persicaria amphibian (Highlander amphibian)				
P. lapathifolia (Spreading knotweed)		VI-VIII		
P. berchtoldii (Berthold's Highlander)		VII-VIII		
Utricularia vulgaris (Common pemphigus)		VI-IX	VII-X	
Zannichellia major (Zanichellia large)		VI-VIII		
A. plantago-aquatica (Plantain chastukha)	IV-XI			
Bolboschoenus maritimus (Sea tubers)				
Ceratophyllum demersum (Submerged hornwort)		VI-IX		

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C. submersum (Semi-submerged hornwort)		VI-VII	VII-VIII	
Lemna minor (Lemna minor)		V-VI	VII-X	
Myriophyllum spicatum (Urut spiky)		V-VIII	IX-X	
M. verticillatum (Urut whorled)		VI-VIII	VII-X	
Potamogeton pectinatus (Comb pondweed)				
P. perfoliatus (Pondweed)		VII-VIII	VIII-X	
Sparganium erectum		VI-VIII	VII-X	
Thelypteris palustris (Sweet Fenugreek)				VII-X
Caulinia minor (Caulinia small)	V-X	VII-IX	VIII-X	
Salvinia natans (Salvinia floating)				VIII-X

The landscape heterogeneity of the region, the difference in climatic indicators of the territory determines the chorological diversity (asynchrony) of mass flowering and fruiting of macrophytes (up to 80%); information about the ecological preferences of background macrophytes is given in table 3.

Table 3. Macrophytes and their ecotopological confinement

№	Name		Main characteristics
	Families	**Kind**	
	Alismataceae (Partiales)	Alisma gramineum Ley. (chastuha cereal)	Thermophile. Non-flowing shallow waters, mostly swampy reservoirs (the Kuma River - floodplains, the vicinity of the village of Velichayevsky). The view is adapted to clayey-silty soils, slightly saline water bodies; from 20-100 cm. growth depth
	Alismataceae (Partiales)	Alisma plantago-aquatica L. (Plantain chastukha)	Wide ecological range. They are confined to the shores of eutrophic fresh or slightly saline slow-flowing water bodies (silty or silty-sand deposits). The species was recorded in waterlogged habitats with stable flooding. The usual depth of attachment is 30-50 cm, to conditions with pronounced bottom sediments. Forms pure thickets. Does not develop with increased mineralization.
	Butomaceae	Butomus umbellatus L. (Umbrella susak)	The habitat of B. umbellatus is the banks of rivers and ponds, swampy meadows, areas with a water depth of up to 100 (0-70) cm. It occurs in conditions with a wide range of substrate (soil) characteristics, with a wide ecological valency. Resistant to anthropogenically disturbed conditions. Tolerates salinity.
	(Susakovs)	Ceratophyllum demersum L. (Submerged hornwort)	High adaptation to environmental conditions. Shallow water (20-60 cm) is the ecophase of eutrophic reservoirs of ecosystems with a rich nutrient substrate. Forms pure thickets in ecologically disturbed conditions.
	Ceratophyllaceae (hornworts)	Ceratophyllum submersum L. (Semi-submerged hornwort)	Eutotrophic non-flowing or low-flowing fresh and saline water bodies, depth 20-60 (up to 70) cm. Common in water bodies with a high level of water mineralization.
	Ceratophyllaceae (hornworts)	Bolboschoenus maritimus (L.) Pall. (Sea tubers)	With a wide ecological spectrum. Shallow fresh or slightly saline water bodies; flooded areas, ditches, rice paddies; wet salt marshes. Depth 10-50 cm.
	Cvperaceae	Carex acuta L. (Sharp	Common in coastal shallow waters (0-50 cm); slow-flowing or stagnant meso- and eutrophic aquatic

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(Sedge)	sedge)	ecosystems. It is distributed along the banks with soil flooding and hygrophilous meadows. C. acuta needs soils rich in humus.
Cyperaceae (Sedge)	Carex pseudocyperus L. (False sedge)	Shores and coastal shallow waters of freshwater reservoirs (with different levels of trophicity). Prefers silty or silty-peaty soils. Halophobic, demanding on water mineralization. Under anthropogenically disturbed conditions, the cenopopulation degrades.
Cyperaceae (Sedge)	Carex riparia Curt. (Coastal sedge)	Shores and coastal shallow waters of fresh water reservoirs. Has less halophobe features than Carex pseudocyperus.
Cyperaceae (Sedge)	Carex vulpma L. (Fox sedge)	Shallow waters of eutrophic reservoirs, on silty and silty-peaty soils. It is also noted for hygrophilous meadows with stable flooding and low water level fluctuations.
Cyperaceae (Sedge)	Eleocharis palustris (L.) Roem. Et Schult. (Swamp swamp)	Coastal and swampy shallow waters of stagnant and low-flowing reservoirs of various trophicity, depth 0 - 50 cm. Fresh and slightly saline reservoirs.
Cyperaceae (Sedge)	Scirpus lacustris L. (Lacustrine Schenoplektus)	Closed or slow-flowing fresh and salt water bodies, hygrophilous meadows, ditches, rice paddies. Max. depth up to 1.5 m.
Cyperaceae (Sedge)	Scirpus tabernaemontani C.C. gmel. (Schenoplectus Tabernemontana)	Shores and coastal shallow waters, depth 0-60 cm, eutrophic freshwater or weakly saline stagnant water bodies.
Haloragaceae	Myriophyllum spicatum L. (Urut spiky)	Eutrophic freshwater and slightly saline water bodies, depth 20-250 cm.
Haloragaceae	Myriophyllum verticillatum L. (Urut whorled)	Ponds, lakes, rivers and canals, depth 30-180 cm; meso- and eutrophic freshwater reservoirs with large sandy or silty-sandy deposits. It reaches its best development at a depth of 30-50 cm. It is resistant to increased anthropogenic eutrophication of the reservoir.
Juncaceae (Sitnikovye)	Juncus effusus L. (Spreading rush),	Occurrence - in shallow waters of fresh water bodies, hygrophilous meadows, in conditions with stable flooding. Revealed in ditches, on rice paddies, etc., they are most developed in the bog-terrestrial and bog-coastal ecophases. They tolerate temporary drying of the soil and increased anthropogenic load.
Lemnaceae (Lemnaceae)	Lemna minor L. (small duckweed)	Reservoirs of various trophicity, freshwater and brackish, flooded hollows, swampy meadows, rice paddies (depth 3-15 cm)
Lentibulariaceae (Publicaceae)	Utricularia vulgaris L. (Common pemphigus)	It grows in the hydrophase at depths of 10-60 cm in eutrophic stagnant water bodies with silty-peaty and peaty soils. Not found under other conditions.
Lythraceae (Derbennikovye)	Lythrum salicaria L. (Looseberry)	Eurytope, indifferent to the physical and chemical composition of soils and waters. It is found in almost all types of water bodies. Optimum development reaches on the coastal swampy areas of eutrophic reservoirs. Individuals of this species are able to exist in conditions

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		of increased anthropogenic load.
Najadaceae (Nayads)	Caulinia minor (All.) Cost. et Germ. (Small naiad)	Thermophile. It is typical for the species to develop in swampy-melting areas (stagnant or weakly flowing), rich in bottom sediments.
Poaceae (Grass or Bluegrass)	Catabrosa aquatica (L.) Beauv. (Water handrail)	It develops in the conditions of an ecotone, during the transition of the coastal ecological phase to the terrestrial one. It is common for the shores of stagnant reservoirs with fresh water, sandy places with elements of high humidity. The level of adaptation to anthropogenic transformation is low.
Poaceae (Grass or Bluegrass)	Glyceria maxima (C. Hartm.) Holub. (Lepeshnyak great)	Wide ecological range of substrate conditions (bottom sediments). Forms pure thickets. Growth depth 20-30 (up to 200) cm. Shallow waters (meso- and eutrophic lakes), river oxbow lakes, ditches and rice fields.
Poaceae (Grass or Bluegrass)	Phragmites australis (Cav.) Trin. ex Steud. (Common reed)	Wide ecological valence. It is common in reservoirs of various types, not picky about the quality of the substrate. Often dominates in hygrophilous meadows, wetlands, areas with shallow groundwater.
Polygonaceae (buckwheat)	Persicaria amphibia (L.) S.F. Gray (Highlander amphibian)	Hydrophase, coastal, marsh and terrestrial ecophase of freshwater and slightly saline water bodies: lakes, ponds, oxbow lakes, canals. Wide ecological range, undemanding to the physical and chemical quality of soils. Adapted to the conditions of anthropogenic eutrophication of the reservoir.
Potamogetonaceae (Pardaceae)	Potamogeton crispus L. (Curly pondweed)	It occurs in meso-, eutrophic stagnant or low-flowing reservoirs with fresh or slightly saline water. Ecologically plastic, withstands an increase in anthropogenic eutrophication of the reservoir. Habitat depth 30-300 cm (juveniles 15-20 cm).
Potamogetonaceae (Pardaceae)	Potamogeton lucens L. (Brilliant pondweed)	Distributed in alluvial areas of large meso-eutrophic closed freshwater reservoirs with sandy, clayey, clayey-silty sediments at a depth of 20-300 (optimally 60-100) cm.
Potamogetonaceae (Pardaceae)	Potamogeton natans L. (Floating pond)	It is common in meso- and eutrophic slow-flowing or closed fresh water bodies, in shallow waters. Depth 50-120 cm. Distributed in areas with opaque water. High anthropogenic eutrophication of the reservoir leads to a decrease in the viability of cenopopulations.
Potamogetonaceae (Pardaceae)	Potamogeton pectinatus L. (Comb pondweed)	It occurs in water bodies of all types at depths from 20 to 200 (300) cm, with sandy, sandy-silty, silty and silty-peat bottom sediments. It is also observed in water bodies polluted by sewage. Greater preference is given to reservoirs with high mineralization of water.
Potamogetonaceae (Pardaceae)	Potamogeton perfoliatus L. (Pondweed)	Occurrence - meso- and eutrophic closed and flowing water bodies with sandy, silty and silty-peaty bottom sediments at depths of 50-300 cm. The best development of the species is observed in the hydrophase. In swampy shallow waters, dwarf forms are found.
Potamogetonaceae	Potamogeton berchtoldii Fieb. (Rdest	Occurrence - shallow areas in the hydrophase at a depth of 15-50 cm. Prefers freshwater eutrophic closed or

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(Pardaceae)	Berchtold)	slow-flowing reservoirs. Found in the dams of steppe rivers, swampy-melting shallow water. An increase in anthropogenic eutrophication of the reservoir leads to the death of the population.
Ranunculaceae (Ranunculaceae)	Batrachium trichophyllum (Chaix.) Bosch. (hairy silkworm)	Heliophyte, neutrophyte and rheophil. It is confined to coastal shallow waters of mesotrophic (and/or eutrophic) stagnant fresh water bodies, to water bodies with a low level of salt content. Activity of growth processes for reservoirs with low water levels. 20-70 cm growth level, rarely within 100 cm (the indicated conditions do not provide active growth and development; biomorphs are depressed).
Sparganiaceae	Sparganium erectum L.	It grows along the banks of rivers, ponds, oxbow lakes, canals, reservoirs, in areas with stable flooding. It reaches its best development in the coastal ecophase. In conditions of prolonged hydrophase, it can form floating leaves. Indifferent to the physical and chemical properties of the substrate. Individuals of this species can develop under conditions of increased anthropogenic load.
Thelypteridaceae (Telipterisaceae)	Thelypteris palustris Schott	Grows in the coastal and coastal swamp ecophases of eutrophic water bodies with high acidity of the environment on silty, silty-peat and peat soils. Not found under other conditions.
Typhaceae (Cattails)	Typha latifolia L. (Large-leaved cattail)	The best development is achieved in the coastal ecophase of eutrophic freshwater or slightly saline water bodies of various types (non-flowing or weakly flowing) on silty or silty-peaty soils. Occurrence - littoral ecophase, depth 10-50 cm. Resistant to significant flooding or drying.
Typhaceae (Cattails)	Typha angustifolia L. (Angustifolia cattail)	It is widely distributed in lakes, ponds, branches and oxbow lakes, canals, in the terrestrial ecophase and in areas with stable flooding. Neutral to soil qualities. The depth of growth reaches 300 cm. With prolonged drying of the soil, it dies.
Typhaceae (Cattails)	Typha laxmannii Lepech. (Laxman's cattail)	Littoral-marsh and terrestrial ecophase near eutrophic closed and slow-flowing fresh and low-saline water bodies of various types (lakes, ponds, steppe rivers). Depth 10-30 cm.
Zannichelliaceae (Zannicelliaceae,)	Zannichellia major Boenn. ex Reichenb (Zannickellia greater)	It is confined to eutrophic freshwater or weakly saline stagnant water bodies of various nature. It reaches optimal development in areas with silty deposits at depths of 30-100 cm.

The preliminary classification (Table 4) is based on the study of aquatic and semi-aquatic plants in the conditions of the Central Ciscaucasia.

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Table 4. Ecobiomorphs of the aquatic grasses department

Type 1.	**Hydatohpytes**		**Name**
Subtype 1.	*Rooting hydatophytes*		
	Class 1.		Perennial rhizomatous hydatophytes
		Group 1.	long-stemmed
		Section 1.	Low ecobiomorphs: Ruppia maritima (Marine Ruppia), R. Spiralis (Twisted Ruppia).
		Section 2.	Medium high ecobiomorphs: Zannichellia palustris (Marsh Tzanikellia), Z. Pedunculata (Long-legged Tzanikellia), Z. Major (Large Tzanikellia), Myriophyllum verticillatum (Whirlwind Urut).
		Section 3.	High ecobiomorphs: Myriophyllum spicatum (Urut spiky).
	Class 2.		Perennial rhizome-turion hydatophytes
		Group 2.	long-stemmed
		Section 4.	Low ecobiomorphs: Potamogeton bertchtoldii (Berchtold's Pod), P. Filiformis (Filiform Pod).
		Section 5.	Medium high ecobiomorphs: Potamogeton nodosus (Knobby Pod).
		Section 6.	High ecobiomorphs: Potamogeton crispus (curly pondweed), P. pectinatus (comb pondweed), P. lucens (brilliant pondweed), P. perfoliatus (pierced-leaved pondweed).
	Class 3.		Annual rooting hydatophytes without overwintering buds
		Group 3.	long-stemmed
		Section 7.	Low ecobiomorphs: Caulinia minor (Kauliniya small).
	Class 4.		Hydatophytes rhizomatous or without overwintering buds (capable of existing as annuals or perennials)
		Group 4.	long-stemmed
		Section 8.	Low ecobiomorphs: Batrachium rionii (hairy silkwort), B. trichophyllum, Callitriche palustris (marsh bog).
		Section 9.	Medium high ecobiomorphs: Batrachium aquatile (water silkworm), B. Diviricatum (divergent silkworm)
Subtype 2.	*Free-swimming hydatophytes*		
	Class 5.		Perennial turion free-floating hydatophytes
		Group 5.	long-stemmed
		Section 10.	Medium high ecobiomorphs: Ceratophyllum demersum (Submerged Hornwort), C. Submersum (Semi-Submerged Hornwort).
		Group 6.	Foliate
		Section 11.	Low ecobiomorphs: Lemna trisulca (Three-lobed duckweed).
Type 2.	**Pleistohpytes**		
Subtype 3.	*Rooting pleistophytes*		
	Class 6.		Perennial rhizomatous pleistophytes
		Group 7.	long-stemmed
		Section 12.	High ecobiomorphs: Persicaria amphibian (Highlander amphibian).
		Group 8.	Socket

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		Section 13.	High ecobiomorphs: Nuphar luteum (yellow water lily), Nymphaea alba (white water lily).
	Class 7.		Perennial rhizome-turion pleistophytes
		Group 9.	long-stemmed
		Section 14.	High ecobiomorphs: Potamogeton natans (Floating Pod).
Subtype 4.	*Free-floating pleistophytes*		
	Class 8.		Perennial turion free-floating pleistophytes
		Group 10.	long-stemmed
		Section 15.	Low ecobiomorphs: Utricularia vulgaris (Common pemphigus).
		Group 11.	Socket
		Section 16.	Low ecobiomorphs: Salvinia natans (Salvinia floating).
		Group 12.	Foliate
		Section 17.	Low ecobiomorphs: Lemna minor (small duckweed), L. turionifera (turion-forming duckweed).
	Class 9.		Perennial stolon-turion free-floating pleistophytes
		Group 13.	Socket
		Section 18.	Low ecobiomorphs: Hydrocharis morsus-ranae (common watercress).
Type 3.	**Helophytes**		
	Class 10.		Perennial rhizomatous helophytes
		Group 14.	long-stemmed
		Section 19.	Low ecobiomorphs: Lythrum salicaria (Seaweed loosestrife), Carex melanostachya (Black-eared sedge), C. Diluta (Light sedge), C. Hirta (Hairy sedge), C. hordeistychos, Veronica beccabanga (Common Veronica), Glyceria notate (Mannik, marked).
		Section 20.	Medium-high ecobiomorphs: Oenanthe aquatic (Water sedge), Sium sisaroideum (Sizar-shaped marshmallow), Ranunculus lingua (Linguistic buttercup), Carex pseudocyperus (False sedge), C. ripana (Coastal sedge), C. vulpine (Fox sedge), C. Paniculata (Paniculata sedge), C. Acuta (Sharp sedge), C. Vesicaria (Public sedge), C. Acutifolia (Altai sedge), C. Otrubae (Cut sedge), C. Lasiocarpa (Hairy sedge), Cladium mariscus (Sword- common grass), Catabrosa aquatic (Water handrail), Veronica anagallis-aquatica (Veronica key), Glyceria fluitans (Floating mannik), G. arundinacea (Reed mannik).
		Section 21.	High ecobiomorphs: Phragmites australis (Southern reed), Sparganium angustifolium (Narrow-leaved mulberry), S. Erectum (Direct mullet), S. microcarpum, (Small-fruited mulberry), Glyceria maxima (Large mullet).
		Group 15.	Socket
		Section 22.	Low ecobiomorphs: Thelypteris palustris (Marsh bog), Eleocharis austriaca (Austrian bog), E. palustris (Marsh bog), E. mitracarpa (Cap bog), E. uniglumis (One-scaled bog), Typha minima (Small cattail), Alisma gramineum (Grass chastuha) A. lanceolatum (lanceolate chastuha), Juncus effuses (Spreading rush), J. compressus (flattened rush), J. atriculatus (jointed rush).
		Section 23.	Medium-high ecobiomorphs: Rorippa sylvestris (Forest chrysanthemum), Butomus umbellatus (Umbrella susak), Scirpus

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		litoralis (Coastal bulrush), S. mucronatus (Spiky bulrush), Iris pseudacorus (False calamus iris), I. pseudonotha (False iris), Typha laxmanni (Laxman's cattail), Alisma plantago-aquatica (Plantain chastukha).
	Section 24.	Tall ecobiomorphs: Scirpus lacustris (Lacustrine Schenoplektus), S. Tabernaemotani (Tabernemontana Reed), S. Hyppolyti (Hippolyte Schenoplektus), S. Triqueter (Triangular Reed), Typha latifolia (broad-leaved cattail), T. angustifolia (narrow-leaved cattail), T , domingensis (Dominican cattail).
Class 11.		Perennial tuberous helophytes
	Group 16.	Socket
	Section 25.	Medium high ecobiomorphs: Sagittaria sagittifolia (Common arrowhead), Bolboschoenus maritimus (Sea tuber), V. t. var. compactus (compressed tuber).
Class 12.		Perennial stolon helophytes
	Group 17.	long-stemmed
	Section 26.	Medium-high ecobiomorphs: Agrostis stolonifera (shoot-forming bent grass).
Class 13.		Annual helophytes, without overwintering buds
	Group 18.	long-stemmed
	Section 27.	Low ecobiomorphs: Elatine alsinastrum (Weedy bug).

7. Conclusion

In conclusion, the study on the ecological features of water plants in steppe rivers in the Central Caucasus has provided valuable insights into the dynamics of these ecosystems. The research shed light on the diverse plant species thriving in this environment and their intricate relationships with the surrounding habitats.

The findings underscore the importance of preserving the delicate balance within steppe river ecosystems, considering their susceptibility to anthropogenic influences. Conservation efforts should be directed towards mitigating the identified stressors and disturbances to maintain the biodiversity and ecological integrity of these regions.

Overall, the study contributes to the broader understanding of the ecological nuances of steppe river ecosystems, informing future conservation strategies and sustainable management practices. Further research and collaborative efforts are recommended to ensure the long-term health and resilience of these crucial natural environments in the Central Caucasus.

The above system in a sense reflects the evolutionary changes in aquatic macrophytes developed as a result of adaptation to existence in the aquatic environment, which ultimately led to the development of free-floating turion forms (Amalova, 2011). Such changes were accompanied by progressive idioadaptive changes, first of all, by the appearance of underwater overwintering buds, which ensured the rapid resumption of vegetative offspring and the efficient use of resources of specific ecological niches (Kazmiruk, 2021; Sviridenko, 1991; Solovyova et al., 2019).

The system of life forms of aquatic macrophytes can serve as a basis for predicting the processes of overgrowth of natural and artificial reservoirs, as well as possible undesirable consequences of various kinds of anthropogenic impacts on reservoirs (Kalaida et al., 2020).

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