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Singularity of Flora in Southern Water Basin of OB-Irtysh Interfluve of Western Siberia

D.A. Durnikin and A.E. Zinovyeva

Altai State University, Barnaul, Russia

Abstract: Aquatic flora of more than 355 different types of lakes, 18 medium and small rivers, including numerous ponds and temporary pools has been studied by stationary and route methods. Singularity of aquatic flora of Ob-Irtysh interfluve and specific distinguishes were considered. The different ways of allocating of the degree of individual flora, which might be expressed by different indicators were suggested. These indicators include the relict elements or endemic species found among aquatic flora. In addition, the singularity and specificity of flora are characterizing by ecotopes with specific species and plant groups at the borders of their habitats. Singularity of aquatic flora can be expressed through the features of life forms of single species.

Key words: Aquatic flora · Aquatic plants · Coastal aquatic plants · Singularity · Endemics · Relict species · Life forms · The habitat borders · Origin · Migration routes.

INTRODUCTION

Singularity of flora of any territory characterizes by distinguishing features, the individuality degree and can be expressed by different indicators. In present, there are two general methodological approaches to assess the flora singularity. The first approach consists in selection of autochthonous and allochthonous elements of flora [1-2], which reflect by the empirical regression equation and calculates the singularity rate of species and generic composition. The second approach is related to the presence of endemic species in flora. The belonging of entire habitat of the certain species to the certain territory is a criterion of endemism i.e. this is geographical term. The degree of flora singularity is the percentage of endemic species and analysis of endemism reveals the features and flora origin. The degree of flora singularity might be determined by assessment of phylogenetic, chorological and ecological features of endemics [3], which are the significant and unique distinctive indicators from other floras. The endemism is an indicator of singularity of territorial flora and determined by included species, which habitats located within the certain territory. These species are local endemics, characterized by limited habitat and serve as the absolute indicator of flora singularity. Another category of endemic species which habitats extend over territory of flora belongs to subendemics, are also important for the analysis and can indicate the flora singularity if studied territory is the center of their origin.

Another indicator of flora singularity is the presence of relict species. Their presence in local, isolated and located hundreds kilometers apart habitats indicates the history of flora, migration processes occurred during different geological periods. The investigation of endemism and relictness elucidate the problem of florogenesis of the single regions, peculiarities and flora origin. Registration of quantitative and qualitative composition of endemics is significant for floristic zoning. The position of the endemic species in the system of the genus indicates its genetic relationships and possible origin, what together with the chronological data provide an opportunity to distinguish the similarities of the flora and floras of the other territories, suggest ways and conditions of florogenesis. The level of endemism of aquatic flora of southern Ob-Irtysh interfluve, determined by single species *Typha veresczaginii* Kryl. et Schischk. is extremely low. The low level of endemism was observed in all regions of Western Siberia including the area of southern Ob-Irtysh interfluve. Only the area of the eastern edge of the continent, the influence zone of Pacific monsoon (Sredneamurskaya, Udyl-Kizinskaya, Amgun-Amur and Evoron Chukchagirskaya hollows) with clear flora specificity similar to the aquatic flora of the

Correspondence Author: Durnikin, Altai State University, Prosp. Lenina 61, Barnaul 656049, Russia.

south of Eastern Asia [4–6] is most abundant by endemic and relict species in Russia. The uniqueness appears mostly in combination of the species from floras with different genesis, high taxonomic diversity of relict elements which ecologically related with monsoon regions of the south of Eastern Asia and genera represented by autochthonous species such as *Nelumbo*, *Brazenia*, *Euryale*, *Eriocaulon* and *Fimbrystylis*.

The composition of aquatic flora in Western Siberia reflects the general features of flora structure in temperate regions of Holarctic. Analysis of horologic structure partly determines the migration routes of species into the study area. Migration of species occurred mostly in Pliocene and Pleistocene in arid climate as well as the shifting of natural-climatic zones during warming to the north and in cold weather - to the south. Considering the history of the development of the West Siberian tertiary flora in water reservoirs resulted in conclusion that its development was mainly autochthonous, i.e. the flora originated from local cretaceous aquatic flora. Later, the flora has developed in Western Siberia in spite of simultaneous involvement of European-Siberian, Siberian-Japan and Siberian-American or common moderate Holarctic elements at all stages of development history. This indicates an overall cretaceous basis of all local floras in temperate zone of the northern hemisphere and the movements (migrations) of single plants, their groups or entire formations, which settling in a new territory, were a part of the local formation and gave rise to a new flora, sometimes different from initial. In the present, the flat part of the south of Western Siberia occupies transitional part between boreal humid and arid regions of the continent and its aquatic flora is enriched by boreal species with Holarctic and Eurasian types of habitat (140 species). In a contrast, there is a group of species with Holarctic, Eurasian and other types of habitat related to the arid region. Total part of species geographically related with arid or subtropical areas is less 6%.

According to the ideas of A.I. Tolmachev [7], any natural flora (including aquatic flora) consists of the most specific complex of species, which the formation time is the period of present flora formation and the most ancient species - the remains of previous floras on this territory become relics. The longer was a process of continuous development of vegetation cover in the certain area and habitat conditions are more conservative the higher probability of the presence of different age relics. We have developed the classification of relict elements after florogenetic analysis of aquatic flora in the southern Ob-Irtysh interfluve, which can be applied for whole Western Siberia. This species (in the most cases – the land ecosystems) belongs to own relict habitat which remain from extended previously existed habitat or might be isolated from extended habitat in case of non-relict nature of greater fragment.

Classification of relict elements was carried out using the data on paleogeography, paleobotany and palynology [8-12].

MATERIALS AND METHODS

South of the Ob-Irtysh interfluve is 160.000 km^2 area between 51° and 57° N. Administratively, the area is within the Altai krai and adjacent areas of the Novosibirsk and Omsk regions, including Kazakhstan.

Geomorphologically, the territory occupies a large Barabinsk-Kulundinskaya depression, limited by Irtysh Ridge on the west, Ob plateau in the east, Vasyuganskoe plateau in the north and Altai foothill plains in the south.

In the period from 1998 to 2012, the flora of more than 355 different types of lakes, 102 of which extends more than 1 km^2, 18 medium and small rivers, numerous ponds and temporary pools, Kulundinskiy main-line irrigation canal and Burlinskiy irrigation canal have been investigated. All studied reservoirs on the south of the Ob-Irtysh interfluve are relatively and evenly distributed both in latitude and longitude.

Flora characteristics were studied by stationary and route methods. The routes covered almost whole territory of southern Ob-Irtysh interfluve. The author has collected more than 4500 sheets of herbarium and provided 580 floristic descriptions.

The studies were conducted in the Altai region as well as in the East and North of Kazakhstan regions. The main attention was paid to investigation of the specific composition, taxonomy, ecology and distribution of water and coastal water plants. The flora of many lakes, small and medium-sized rivers in Barabinsk forest-steppe in Novosibirsk and Omsk regions was studied.

In total, 170 plant species from 65 genera and 36 families were identified in the aquatic flora of the southern Ob-Irtysh interfluve were observed. All the plants belong to the three groups - Equisetophyta (2 species), Polypodiophyta (2 species) and Magnoliophyta (166 species). The basis of aquatic flora of the southern Ob-Irtysh interfluve is composed by angiosperm plants - 97.6%, 109 species are monocotyledonous - 109 species and dicotyledons - 57 species.

RESULTS AND DISCUSSION

We Have Selected the Following Groups of Relicts

Oligocene *Relics*: 1. *Ancient hydrophilic*. According to existing paleocarpologic data from Western Siberia, *Ceratophyllum submersum* L. belongs to the group of hydrophilic relics. Probably, this species was included into florocenotype of hydrophilic vegetation in freshwater reservoirs and was widely distributed in the Paleogene on common territory of Eurasian-American continent without a clear separation to the regional variants. 2. Hydrohygrophilous herbalists. Representative - *Carex acuta* L. This species belongs to florocenotype of hydrohygrophilous grasslands and herbalists. This group is represented by air-water forms, i.e. partially submerged in the water and most of these continue the development on dried soils after water abatement.

Miocene Relics: 1. *Hydrophilic*. These are the species continuously existing in Western Siberia, possibly from early Miocene. All Miocene groups of relics have been paleocarpologically described. Some of these species in the studied area characterizes by secondary habitats as the result of more recent invasions. These relics are *Potamogeton pectinatus* L., *P. natans* L., *P. vaginatus* Turcz., *Lemna trisulca* L. and *Ceratophyllum demersum* L. and included into florocenotype of hydrophilic vegetation of freshwater reservoirs. 2. Hydrohalophilic. These species belong to hydrophilic vegetation of saltish and saline water reservoirs. Represented by *Najas marina* L. 3. Hydro-hygrophilous herbalists. This group is generally represented by air-water forms, partially submerged in the water and most of them develop on dried ground after water abatement. This group of species includes: *Sparganium emersum* Rehm., *S. minimum* Wallr., *Carex rostrata* Stokes, *C. riparia* Curtis, *Heleocharis palustris* (L.) Roem. et Schult., *Rumex maritimus* L., *R. repens* L., *Hippuris vulgaris* L., *Cicuta virosa* L. and *Menyanthes trifoliate* L. All these species are included in to florocenotype of hydro-hygrophilous grasslands and herbalists.

Pliocene Relicts: 1. *Hydrophilic*. This group is represented by new Pliocene inclusions of florocenotype of hydrophilic vegetation of freshwater reservoirs such as *Salvinia natans* (L.) All., *Potamogeton obtusifolius* Mert. et Koch., *P. alpinus* Balb., *P. perfoliatus* L., *P. praelongus* Wulf., *P. pusillus* L., *P. compressus* L., *Caulinia minor* (All.) Coss. et Germ., *Hydrocharis morsus-ranae* L., *Myriophyllum spicatum* L. and *M. verticillatum* L.. 2. Hydro-hygrophilous herbalists. All species combined into this group are included into florocenotype of hydrohygrophilous grasslands and herbalists – *Typha angustifolia* L., *Sagittaria sagittifolia* L., *Butomus umbellatus* L., *Scirpus lacustris* L., *S. tabernaemontani* C. C. Gmelin, *Polygonum hydropiper* (L.) Spach. and *R. sceleratus* L. Most of these species formed cenosises. This group also includes the species which rapidly occupy secondary destroyed ecotopes and thus, hiding ecogenetic and florocenotic relationships - *Juncus gerardii* Loisel., *Rorippa palustris* (L.) Besser. 3. Littoral halophilic herbalists - *Triglochin maritimum* L. This species belongs to the littoral vegetation of saltish and salt waters, which is joint variant of the Miocene protocomplex developed along the coasts of Tethys Ocean.

Gelazy-eocene (Pleistocene) Relics: 1. *Hydrophilic*. This group includes the vegetation of freshwater reservoirs – *Potamogeton gramineus* L., *P. trichoides* Cham. Et Schlecht., *P. friesii* Rupr., *P. lucens* L., *P. rutilus* Wolf., *Zannichellia palustris* L., *Stratioites aloides* L., *Spirodela polyrriza* (L.) Schleid., *Rorippa amphibia* (L.) Besser, *Nymphaea candida* Georgi, *Nuphar pumila* (Timm) DC., *N. lutea* (L.) Smith., *Ranunculus polyphyllus* Waldst. et Kit. ex Willd., *Elatine hydropiper* L., *Oenanthe aquatic* (L.) Poiret. and *Nymphoides peltatum* (S.G.Gmelin) O. Kuntze. 2. Hydro-hygrophilous herbalists – *Typha latifolia* L., *Sparganium erectum* L., *Alisma gramineum* Lej., *A. plantago-aquatica* L., *A. lanceolatum* With., *Sagittaria natans* Pall., *Scirpus radicans* Schkuhr., *Carex aquatilis* Wahlenb. s. str., *C. atherodes* Spreng., *Caltha palustris* L. s.l., *Heleocharis acicularis* (L.) Roem. et Schult. s. str., *Carex bohemica* Schreb., *Juncus bufonius* L., *J. arcticulatus* L., *Ranunculus reptans* L., *Scheuchzeria palustris* L., *Elatine alsinastrum* L., *Calla palustris* L. s.l., *Naumburgia thyrsiflora* (L.) Reichenb., *Carex acutiformis* Ehrh., *C. pseudocyperus* L., *C. vesicaria* L. and *C. cespitosa* L. All species of this group likewise Pliocene relic belong to hydrohygrophilous grasslands and herbalists, most of those formed the cenosises. 3. Hydrohalophilic. These species belong to hydrophilic vegetation of saltish and saline water reservoirs. is omplex ncludes nly wo species-*Zannichellia pedunculata* Reichenb., *Caulinia flexilis* Willd. 4. Littoral halophilic herbalists. This group includes *Bolboschoenus maritimus* (L.) Palla, *Halerpestes sarmentosa* (Adam) Kom., which belong to littoral vegetation of saltish and salt reservoirs.

The presence of different age relics in different florocenotypes reveals the general ways of flora and phylocenogenesis on ecotone area of studied aquatic flora of southern Ob-Irtysh interfluve. The complex and mosaic pattern of modern aquatic flora of southern Ob-Irtysh interfluve appeared as the result of combined effect of three factors: evolution, migration and extinction (partial or complete). Evolution occurred simultaneously with migration, although very limited and characterized by slow and gradual migration is usually supplemented by evolutionary changes, at least at the subspecies level.

Thus, aquatic flora on studied area is combined of: remained and unchanged, or slightly altered ancient forms that lived on certain area before the Quaternary period (86 species or 50.6% of the total number of species) and species appeared as the result of changes in tertiary and quaternary forms affected by life conditions (factors of bone and biotic environment) formed in the Pleistocene-Holocene (84 species, 49.4%). Long-term dynamics of the salt composition, which began in the Neogene, has determined the development of some representatives of hydro-hygrohalophilic complex. The following species of complex have remained and survived in Holocene until present – *Najas marina* L., *Zannichellia pedunculata* Reichenb., *Althenia filiformis* F. Petit., *Caulinia flexilis* Willd., *Triglochin maritime* L., *Rumex maritimus* L. and *Bolboschoenus maritimus* (L.) Palla. The presence of representatives of the salt-water complex determines singularity of aquatic flora of southern Ob-Irtysh interfluve, features of own specific ways of development and formation of the flora in the continental waters of the Eurasian continent. All species of salt-water complex have passed a long evolutionary and ecological adaptation process to different abiotic factors and first of all to reservoirs with different mineralization. Adaptive characteristics of some species are unique, for example, the species of genera *Althenia* and *Ruppia*. These highly specialized species characterize by high salt-resistance and live mostly in the chloride-sodium waters. According to the literature data [13], *Althenia filiformis, Ruppia drepanensis* Tineo. and *R. maritime* L. live in reservoirs with mineralization range $5 < TDS < 80$ g/l and hardly live in the fresh and light-salted water. In this case, the subeuryhaline species are not typical marine species and a range of salt-resistance is 30-40 g/l. According to our observations and studies on the Lake Maralbay (East-Kazakhstan Region, Kazakhstan), the flowering of *Althenia* and *Ruppia* in late May - early June occurred at water mineralization 1.5 g/l, i.e. almost in fresh water. This is new data on biology and ecology of these species. Thus, these plants are able to grow in water with salinity range from 1.5 to 80 g/l and flowered in relatively fresh water. In the inland waters, this range of mineralization is hardly survival for any other aquatic plants. Probably, the reason for high ecological plasticity is a centuries-old dynamics and variability of salt content in specific habitats. Typically, these habitats are related to ecotopes, unique for this area. The general ecological characteristics of these habitats, preserved for a long time results in preservation of single species or their complexes in these habitats which entirely or partially changed alongside the climate change in the area. The species preserved in these habitats affected by stabilizing selection and alien species were not able to dominate, therefore possess the low or absence of competitive potential in conditions of certain habitat.

Singularity of aquatic flora can be stipulated by the plant group on the borders of own habitats although uncertain borders and disjunction of the habitats of aquatic and coastal-aquatic plants in the most cases are related with stabilizing water conditions. In addition, intermittent and inconstancy of hydroecotopes (especially in a closed drainage system), slightly impaired in the southern Ob-Irtysh interfluve by transit rivers, significantly affects the nature of the habitat borders of many hydrophytes. Freshwater species which are not able to settle on the west or east throughout discrete mineralized lakes on extended interfluves are distributed along river valleys and spread for hundreds of kilometers into the arid areas. Therefore, the habitat borders of freshwater species distribution in the arid plains crossed by rivers are often has convoluted edge. Despite the uncertain borders and disjunction of habitats of hydrophytes, there is group of species on this area which geographically related with arid or sub-tropical regions. In most cases, these species occupy the northern and eastern borders of habitats. For example, the species on the eastern and northeastern border of distribution, occurring mostly in the steppe and forest-steppe zones of Eurasia. This type includes 3 species - *Althenia filiformis, Ruppia drepanensis* and *Puccinellia dolicholepis* V.Krecz. (northeastern border of habitat). Species *Potamogeton macrocarpus* Dobroch. occupies the northern border of habitat, *Ranunculus radicans* C.A. Meyer - southwestern and *Ranunculus natans* C. A. Mey -western border. In addition, recent genetic studies of Czech scientists have shown that the region located in the mountains of Central Asia and adjacent lowlands of Siberia (including southern Ob-Irtysh interfluve) is the biodiversity center of genus Stuckenia (Potamogetonaceae) [14]. Ecotopological conditions

formed in the mountains and related with the cold oligotrophic waters are convenient for the growth of narrow-leaved species and varieties such as *Stuckenia filiformis* (Pers.) Börner. (=*P. filiformis*) and *P. filiformis* var. *austrosibiricus* (Kascina) Czepinoga (=*P. rostratus* Hagstr., *P. austro-sibiricus* Kaschina). *Stuckenia pectinata* (L.) Börner. (=*Potamogeton pectinatus* L.), *Stuckenia macrocarpa* (Dobrochot.) Tzvelev (=*P. macrocarpus*) and *Stuckenia vaginata* (Turcz.) Holub (=*P. vaginatus* Turcz.) were found in the flat areas in the fresh and saltish waters.

CONCLUSIONS

Thus, the Singularity of Aquatic Flora Can Be Expressed by Following Indicators:

- Relic elements. To identify different age relict elements, the palynological and paleocarpological data should be analyzed. The presence or absence of different age relics in different florocenotypes reveals the general ways of floro- and phylogenesis in the studied area.
- Endemic species. Apparently, the low level of endemism is observed in almost all the inland territory of Eurasia. In Russia, the territories of continental borders and zones of ocean monsoons are the most enriched with endemic species. For example, the aquatic floras of the Far East with clear specificity of flora which brings it closer to the aquatic flora of the south of East Asia.
- Rare ecotopes with specific species. In the south of the Ob-Irtysh interfluve these are the members from genera *Althenia* and *Ruppia*, characterizing by unique adaptive abilities. This is a highly specific species with high salt-resistance and living mainly in the chloride-sodium waters.
- A group of plants on the borders of own habitats;
- Life forms. The study of the range of life forms in the botanical and geographical areas of the south of the Ob-Irtysh interfluve revealed the diminishing of the number of mobile and inactive forms from forest-steppe to steppe regions. This pattern is determined by the zonal-climatic reasons: arid climate, reduced water content, increase of mineralization and high dynamics of the surface water level regime. In addition, stolon-forming aquatic grasses such as *Sagittaria sagittifolia*, *S. natans*, *Agrostis stolonifera* and *Stratiotes aloides*, taproot land-water grasses (*Rumex aquaticus*) and partially heterotrophic aquatic grasses (members of the genus *Utricularia*) disappear, moving from forest-steppe to steppe regions and removing of some living forms from the common group.

REFERENCES

1. Tolmachev, A.I., 1974. Introduction into the Plant Geography. Leningrad: Leningrad State Univ., pp: 244.
2. Malyshev, L.I., 2000. Assessment of singularity of flora based on taxonomic structure. In Botanical Studies in Siberia and Kazakhstan: Collection of Scientific Works. Barnaul: Altai Univ., 6: 3-10.
3. Kamelin, R.V., 1973. Florogenetic Analysis of Natural Flora in Mountainous Part of Central Asia. Leningrad: Nauka, pp: 354.
4. Kryukova, M.V., 2005. Aquatic Flora of the Lower Amur. Vladivostok: Dal'nauka, pp: 160.
5. Kitagawa, M., 1979. Neo-Lineamenta Florae Manshuricae. Vaduz: J. Cramer, pp: 715.
6. Ohwi, J., 1965. Flora of Japan. Washington DC: Smithsonian Inst., pp: 1067.
7. Tolmachev, A.I., 1986. Methods of Comparative Floristic and Florogenesis. Novosibirsk: Nauka, pp: 196.
8. Jarzen, D.M., S.R. Manchester, G.J. Retallack and S.A. Jarzen, 2007. Advances in Angiosperm Paleobotany and Paleoclimatic Reconstruction. E. Schweizerbart, pp: 189.
9. Mai, D.H., 2001. Die mittelmiozänen und obermiozänen Floren aus der Meuroer und Raunroer Folge in der Lausitz, Teil II: Dicotyledonen. Palaeontographica. Abt. B, 257(1-6): 35-174.
10. Chandler, M.E.J., 1963. Revision of the Oligocene flora of the Isle of Wight. Bull. Brit. Mus. (Natur. Hist.) Bot., 6(3): 321-384.
11. Spicer, R.A., A. Ahlberg, A.B. Herman, S.P. Kelley, M.I. Raikevich and P.M. Rees, 2002. Palaeoenvironment and ecology of the middle Cretaceous Grebenka flora of northeastern Asia. Palaeogeography, Palaeoclimatology, Palaeoecology, 184: 65-105.
12. Dorofeev, P.I., 1963. Tertiary Floras of Western Siberia. Moscow: Akad. Nauk SSSR, pp: 343.
13. Sviridenko, B.F., 2000. Aquatic Flora and Vegetation of Northern Kazakhstan. Omsk: Gos. Pedagog. Univ., pp: 196.
14. Kaplan, Z., 2008. A taxonomic revision of Stuckenia (Potamogetonaceae) in Asia, with notes on the diversity and variation of the genus on a worldwide scale. Folia Geobot., 43: 159-234.