сивность экссудации органических кислот корневой системой. Семена гречихи проращивали на слое агарового геля, который содержит в своем составе кислотно-основный индикатор с последующей визуальной оценкой изменения окраски индикатора вокруг первичного корня, и отбирали растения с наибольшей зоной изменения цвета индикатора. В полевых условиях подтверждена эффективность метода путем фенотипирования растений и выявлены значительные отличия в формировании структуры урожая и продуктивности отобранных растений. Статистический анализ показателей озерненности и массы зерна показал, что у отобранных растений эти показатели более чем в 6 раз превышали контрольные варианты, со степенью достоверности 99%.

Ключевые слова: метод отбора, фенотипирование, проростки, корневые экссудаты.

UDC [591.524.12:574.5]

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SPATIAL-TEMPORAL DYNAMICS OF LITTORAL ZOOPLANKTON COMMUNITY OF THE OLEKSANDRIVKA RESERVOIR

The analysis results of spatio-temporal dynamics of zooplankton communities from littoral of the Oleksandrivka reservoir are presented. The features of the seasonal changes in species composition, faunal and ecological spectrums, quantitative indicators (density and biomass) and the dominant species complexes of littoral zooplankton was revealed. The analysis of seasonal dynamics of qualitative and quantitative development of zooplankton in the littoral zone within the upper, middle and lower parts of the Oleksandrivka reservoir was conducted.

Keywords: Ecology, the Oleksandrivka reservoir, littoral, zooplankton community.

Introduction. At present, the anthropogenic factors have ecological importance for aquatic ecosystems [1-2]. Examples of human activities involve the restructuring of individual components of ecosystems (including groups of animals) [3], their structural and functional organization [4], and transforming rivers to reservoirs with different hydrological regime [5]. Many reservoirs were created over the past 50-60 years [6] and today they are the main type of water in Ukraine [7]. Special interests have littoral hydrobiocenosis that differ significantly from the pelagic and play an important role in the functioning of aquatic ecosystems [8]. They are characterized by high rates of biodiversity [9] and biological productivity [10] and the complex structural and functional organization [11]. This littoral zone occupies a large area of water, such as in the Kiev reservoir it is 38% [9]. Particular attention is drawn to the reservoir of the South-Ukrainian energy complex, which is an important part of the Oleksandrivka reservoir.

Zooplankton is an important component of aquatic ecosystems, which plays an important role in the circulation of matter and the energy transformation [2]. Most of the zooplankton belongs to the primary and secondary consumers [12]. Zooplankton is the foundational supply base for the young and planktonophagous fish at higher trophic levels [13].

Purpose – analysis of seasonal dynamics of structured littoral zooplankton communities in the Oleksandrivka reservoir.

Materials and methods. The object of our research were species of same groups of zooplankton: rotifers (class Eurotatoria), cladocerans (class Branchiopoda, order Cladocera), copepods (class Copepoda) and ostracods (class Ostracoda). Monogononth rotifers, copepods and cladocerans were determined to the species, bdelloid rotifers and ostracods – to subclass and class. The dynamics of the same seasonal changes was analyzed on the basis of data obtained from the Oleksandrivka reservoir during the different seasons (spring, summer and autumn) in 2009–2010.

The material sampled by filtering 50 liters of water through a conical plankton net [14] from four standardized sampling stations [15]: I – the left bank of the upper part, N 47^{0}51.429' E 31^{0}07.721'; II – the right bank of the middle part, N 47^{0}42.802' E 31^{0}11.267'; III – the left bank of the middle part, N 47^{0}44.110' E 31^{0}44.681'; IV – the right bank of the lower part, N 47^{0}42.042' E 31^{0}13.704'. Within each station, the samples were taken at various points (habitats): in the thickets of higher aquatic plants (overgrown) and clean areas of littoral macrophytes pond (not overgrown). At the station of the upper part of the Oleksandrivka reservoir dominated the formations of the common reed (*Phragmites australis* (Cav.) Trin. Ex Steud.). At the station of the middle and lower parts of the reservoir dominated the formations the claspingleaf pondweed (*Potamogeton perfoliatus* L.). The projective cover of higher aquatic plants increases from the top of the reservoir to its middle reaches – from 30 to 50%.

For general qualitative analysis 34 samples were collected using the conical net. Further processing of samples and analysis were performed on the basis of generally accepted methods. The species composition of zooplankton was identified in the laboratory due to identification guide [14, 16-19].

The results and their discussion. In the spring within all research stations was marked only the sites free of vegetation, and diversity of zooplankton was presented with 29 species: rotifers – 13 species, cladocerans – 85, copepods – 8. During the daily studies in the summer in common reed sites and in the sites without water plants 73 species of littoral zooplankton were registered: rotifers – 33 species, cladocerans– 26, copepods crustaceans – 14. In autumn 54 species of zooplankton were found in sites without aquatic plants and with reeds: rotifers – 16 species, cladocerans – 26, copepods – 12.

If we consider the representation of the species, during different seasons the serious reconstruction occurred. Species diversity of the littoral zooplankton increased in summer in 2,5 times in comparison with spring, and decreased in 1,4 times in autumn. Seasonal changes in species diversity of littoral zooplankton can be explained by the same reasons [5]. In summer comparing with the spring, the projective coverage and the overgrowness level of the habitat significantly increased, creating more favorable conditions for the development of aquatic littoral. Thus, in the spring samples were registered cryophilic species of rotifers – *Brachionus angularis*, *Br. nilsoni*, *Notholca acuminata*, *N. squamula*, which were absent during the summer and autumn research. Instead, a number of thermophilic representatives were met in the summer: rotifers of the genus *Lecane*, *Leptadella* and *Trichocerca*, *Tripleuchlanis plicata* et al.

The similarity of the species composition lists in different seasons was characterized by the Jaccard index as the very low: between spring and summer – J = 30,4; between spring and autumn – J = 27,2; between summer and autumn – J = 39,3. Especially low was the similarity between species composition lists of rotifers, while crustaceans, especially copepods, were characterized by more stable composition during different seasons (Table 1). Thus 17 species of littoral zooplankton encountered during all three seasons: rotifers *Brachionus calyciflorus*, *Br. quadridentatus*, *Euchlanis deflexa*, *E. Dilatata* and *Keratella quadrata*; cladocerans *Alona rectangula*, *Bosmina longirostris*, *Chydorus piger*, *Ch. sphaericus*, *Daphnia cucullata* and *Graptoleberis testudinaria*; copepods *Acanthocyclops americanus*, *Cyclops vicinus*, *Eucyclops serrulatus*, *Eurytemora velox*, *Mesocyclops leuckarti* and *Thermocyclops crassus*.

Table 1. **The seasonal dynamics of species composition (J) of different groups of littoral zooplankton in the Oleksandrivka reservoir**

Groups \ Seasons	Spring and summer	Spring and autumn	Summer and autumn
Eurotatoria	20,4	24,3	27,6
Cladocera	25,7	24,3	45,0
Coprepoda	48,1	36,7	50,0

The faunal spectrum of littoral zooplankton during different seasons was characterized by the prevalence of rotifers complex in spring, in summer – the prevalence of rotator and rotifers-cladocerans complexes and in autumn – the prevalence of cladocerans complex (Fig. 1). This was due to the formation during different seasons favorable conditions for filter feeders in the Oleksandrivka reservoir, and the prevailing were the rotifers and cladocerans. So, in the original research, the rotifers and cladocerans crustaceans had the highest species richness in different seasons.

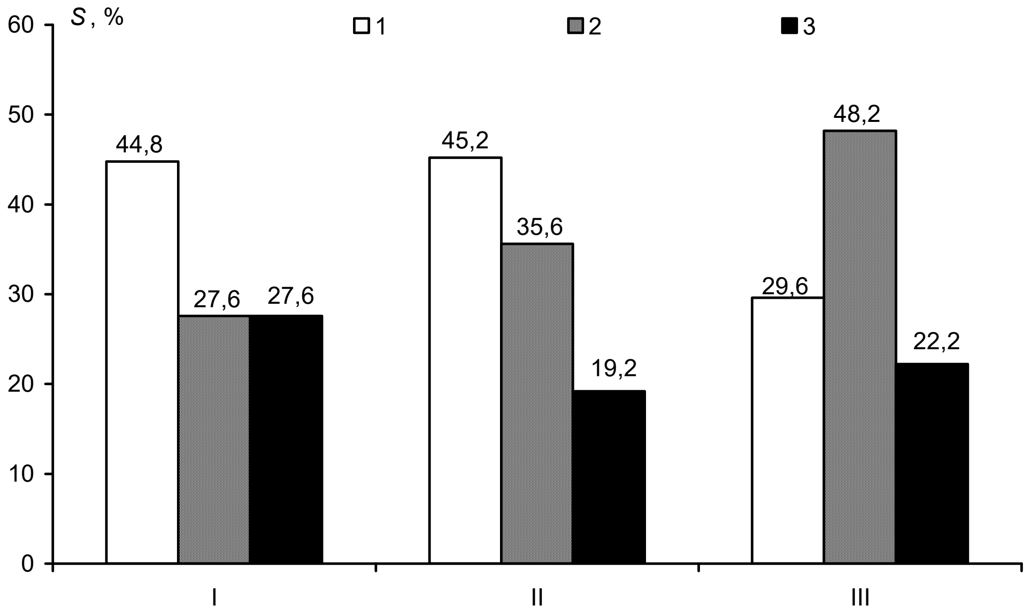

Fig. 1. The seasonal dynamics of faunal spectrum of littoral zooplankton in the Oleksandrivka reservoir.
Notes: *S* – number of species; 1 – rotifers, 2 – cladocerans crustaceans, 3 – copepods crustaceans; I – spring, II – summer, III – autumn

The ecological spectrum of different littoral zooplankton groups of the Oleksandrivka reservoir in the spring was characterized by a predominance of thepelagic group: pelagic – 16 species (55,2% of the total), littoral-phytophilous – 9 (31,0%), demersal-phytophilous – 4 (13,8%). Summer pelagic species continued to dominate in the ecological group (28 species – 38,3% of the total), exceeding slightly the proportion of littoral-phytophilous (24 species – 32,9%) and demersal-phytophilous (21 species – 28,8%) groups. In autumn littoral zooplankton did not have the dominant group: pelagic – 18 species (33,3% of the total), littoral-phytophilous – 17 species (31,5%) and demersal-phytophilous – 19 species (35,2%) groups. The dominance during different seasons of the pelagic ecological groups can be explained by the persistence of river conditions within the littoral zone of the Oleksandrivka reservoir, like in the Kyiv reservoir [5, 20]. Growth in summer particles of demersal-phytophilousand littoral-phytophilous groups can be explained by the formation of overgrown habitat [21]. The summarized value of the ecological zooplankton groups considering its faunal spectrum in different seasons is presented in Fig. 2.

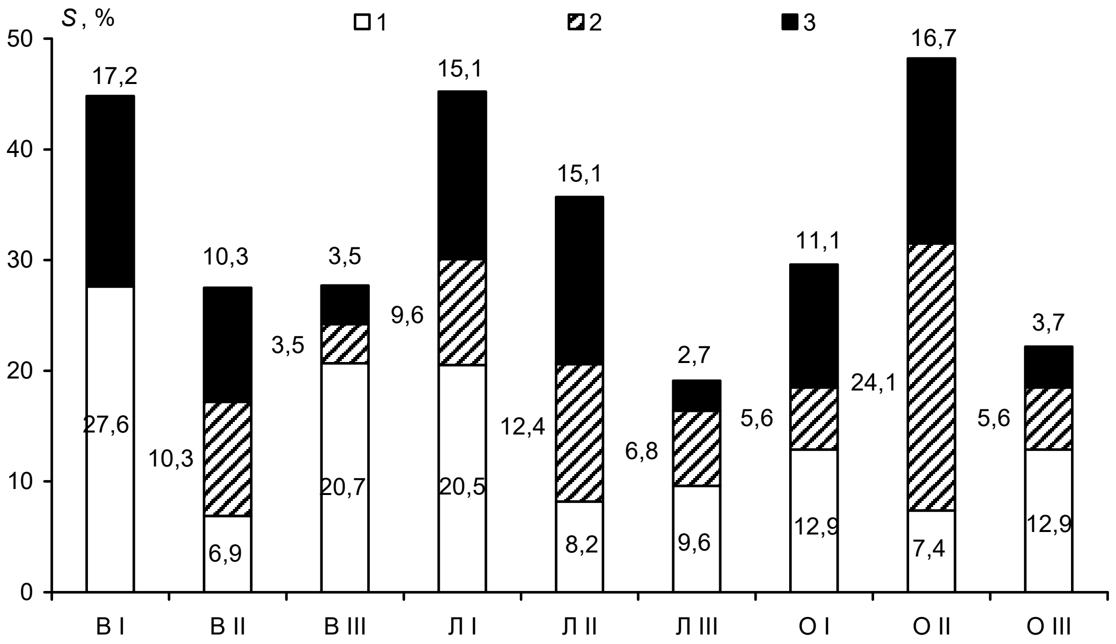

Fig. 2. The ecological spectrum changes of the Oleksandrivka reservoir littoral zooplankton in different seasons.
Notes: *S* – size of species; 1 – pelagic group, 2 – demersal-phytophilous, 3 – littoral-phytophilous; I – rotifers, II – cladocerans, III – copepods

Spring littoral zooplankton in quantitative terms in afternoon time was characterized by "very low" or "low" development. Its density varied within 2,8-19,9 thousand ind./m^3, and biomass – 0,02-0,21 g/m^3. Among quantitative indicators the species of rotifers complex and larvae of copepods crustaceans mainly nauplia stages of development dominated (Table 2).This trend is normal for communities of spring littoral zooplankton in reservoirs [5, 22].

Table 2. **The seasonal dynamics of density (thousand ind./m^3) and biomass (g/m^3) of different groups of littoral zooplankton in the Oleksandrivka reservoir (M±m)**

Groups \ Seasons	Spring n = 8	Summer n = 16	Autumn n = 10
Eurotatoria	3,3±0,9/ 0,02±<0,01	13,6±4,8/ 0,03±0,01	0,6±0,2/ <0,01±<0,01
Cladocera	0,7±0,2/ 0,01±<0,01	17,8±5,2/ 0,63±0,21	1,5±0,3/ 0,10±0,03
Copepoda	0,4±0,1/ 0,02±<0,01	3,9±1,7/ 0,21±0,10	1,6±0,7/ 0,09±0,03
Copepoda larvae	4,8±1,1/ 0,04±0,01	21,7±6,5/ 0,17±0,06	2,8±1,0/ 0,03±0,01
Ostracoda	–	0,3±0,1/ 0,03±0,01	0,1±<0,1/ 0,01±<0,01
Bivalvia larvae	–	1,0±0,5/ <0,01±<0,01	<0,1±<0,1/ <0,01±<0,01
In general	9,2±2,0/ 0,09±0,02	58,3±18,6/ 1,08±0,39	6,7±1,8/ 0,23±0,07

Notes: the numerator – the density, the denominator – the biomass

In summer daytime the littoral zooplankton development was "very low", "low", "below average" and "average" (Table 2). Its density varied within 0,2-282,4 thousand ind./m^3, and biomass – <0,01-5,35 g/m^3. Rotifers and copepods' larvae dominated for quantitative indicators, with the predominance of the copepods' stages of development. The rotifers prevailed in the upper part of the reservoir, in other parts of reservoir – cladocerans did. The domination of cladocerans-copepods complex is customary for the development of summer zooplankton communities in a reservoir, that associated with a more complex biotopical variety, with the ecological and trophic spectrum of zooplankton and the complexity of the living conditions for small filter feeders. Although representatives of the rotifers complex had significant density within the upper part of reservoir, which is associated with the high flow in Oleksandrivka reservoir and the influence of the complex of geophilic species from the river Pivdennyi Bug.

The littoral zooplankton was characterized by "very low" and "low" development in daily time of autumn (Table 2). Its density varied within 0,4-21,3 thousand ind./m^3, and biomass – 0,01-0,73 g/m^3. Among the quantitative indicators larvae of copepods dominated, mainly copepodite stages of development. Prevalence of rotifers complex associated with a longer period of the vegetation of higher aquatic plants, remains of which have formed overgrown habitat and create conditions for the development of various ecological groups of zooplankton [5, 22].

Significant seasonal changes occurred in the dominant groups of zooplankton communities. Rotifers *Brachionus calyciflorus* and *Keratella quadratain*, and the larval stage of copepods were the dominant in the spring in different parts of the reservoir. Rotifers *Brachionus quadridentatus*, *Euchlanis dilatata* and *Trichocerca bidens*, cladocerans – *Bosmina longirostris*, *Diaphanosoma brachyurum* and *Disparalona rostrata*, copepods – *Mesocyclops leuckarti* form the summer dominant complex of species. In autumn dominant complex was formed of rotifers *Euchlanis dilatata*, cladocerans – *Daphnia cucullata*, *D. rostrata* and *Sida crystallina*, and of copepods – *Acanthocyclops americanus* and *Eurytemora velox*.

We used Jaccard dominant index for the comparison of the dominant species complexes, and very low number of similarities in different seasons was recorded (Table 3). Meantime none species was not presented in dominant complexes for three seasons. The significant restructuring of dominating complex of littoral zooplankton is linked with temperature conditions, significant fluctuations in the concentration of organic matter in the water [5, 21].

Table 3. **The seasonal dynamics of dominante specias complex ($J_{dom.}$) of littoral zooplankton in the Oleksandrivka reservoir**

Seasons	Spring	Summer	Autumn
Spring	X	0,0	0,0
Summer	0,0	X	18,2
Autumn	0,0	18,2	X

The seasonal distribution of littoral zooplankton in different parts of the Oleksandrivka reservoir is characterized by the middle degree of similarity in the species composition in spring, but much lower in summer and autumn (Table 4). In spring the biotopical diversity was absent, and littoral was characterized by the presence of sites free of vegetation. The middle size of the reservoir facilitates mixing littoral and pelagic zooplankton. In the summer and autumn, the reed formation developed actively, which entered in association with other types of higher aquatic plants. Zooplankton species composition of the upper and lower part of the reservoir in the summer had the lower similarity (J = 8,4 and 36,2), in middle part – higher (J = 53,3). In the autumn habitats were mild and macrophytes began to fall off the bottom.

Table 4. **The seasonal dynamics of species composition (J) of littoral zooplankton in different parts of the Oleksandrivka reservoir**

Parts of reservoir	The upper part	The middle part	The lower part
Spring			
The upper part	X	50,4	55,6
The middle part	50,4	X	40,4
The lower part	55,6	40,4	X
Summer			
The upper part	X	24,5	16,7
The middle part	24,5	X	31,8
The lower part	16,7	31,8	X
Autumn			
The upper part	X	26,1	10,5
The middle part	26,1	X	33,4
The lower part	10,5	33,4	X

In spring littoral zooplankton was characterized by "very low" and "low" density and biomass in hydrobiocenoses without macrophytes (Table 5). The quantitative indicators increased from the upper to the lower parts of the reservoir. The latest trend is clearly seen in summer when density and biomass of littoral zooplankton were "very low" and "low" in the upper part of the reservoir. Density and biomass of littoral zooplankton were "very low", "low" and "below average" in the middle part of the reservoir. Density and biomass of littoral zooplankton were "very low", "low" and "below average" in the middle part of the reservoir. Density and biomass of littoral zooplankton were "low", "below average" and "average" in the lower part of the reservoir. In autumn littoral zooplankton was characterized by "very low" and "low" density and biomass. The complex of the dominant species within the intertidal zone of the reservoir in a season had changed and most of them have a similar structure (J dom. = 50–100).

Table 5. **The seasonal dynamics of density (thousand ind./m^3) and biomass (g/m^3) of littoral zooplankton in different parts of the Oleksandrivka reservoir (M±m (lim))**

Seasons / Reservoir	Spring n = 8	Summer n = 16	Autumn n = 10
The upper part	3,8±1,1 (2,8–4,9)/ 0,04±0,02 (0,02–0,06)	1,2±0,4 (0,2–1,9)/ 0,03±0,01 (0,01–0,04)	4,2±1,5 (1,5–6,8)/ 0,11±0,04 (0,05–0,19)
The middle part	10,6±3,2 (5,4–19,9)/ 0,10±0,04 (0,05–0,21)	46,4±14,0 (7,8–110,3)/ 0,85±0,35 (0,12–2,76)	5,2±1,5 (0,4–9,6)/ 0,22±0,08 (0,01–0,53)
The lower part	11,5±2,8 (8,8–14,2)/ 0,08±0,03 (0,06–0,11)	140,0±41,0 (42,4–282,4)/ 2,59±0,91 (0,59–5,35)	14,0±6,3 (6,7–21,3)/ 0,42± 0,21 (0,11–0,73)

Notes: the numerator – the density, the denominator – the biomass; n – size of sumples

Conclusions. 1.In spring littoral zooplankton of the Oleksandrivka reservoir comprises 29 species (13 species of rotifers, crustaceans – 8, copepods – 8), in summer – 73 species (33 species of rotifers, cladocerans – 26, copepods – 14), in autumn – 54 species (16 species of rotifers, cladocerans – 26, copepods – 12). 2. The similarity of the species lists, obtained in different seasons, was characterized by the Jaccard index as the low levels: between spring and summer – J = 30,4, between spring and autumn – J = 27,2, between summer and autumn – J = 39,3. Especially low was the similarity between the species composition of rotifers (J = 20,4–27,6), while crustaceans were characterized by greater stability during different seasons (J = 24,3-50,0). 3. In spring in the faunal spectrum of the species composition of littoral zooplankton dominated the rotifers complex (44,0% of all species of zooplankton), in summer – rotifers (45,6%) and rotifers-cladocerans complexes (80,8%), in autumn – cladocerans complex (48,2%). 4. The ecological spectrum of different groups of littoral zooplankton was characterized by a predominance of pelagic group in spring and summer (55,2 and 38,2 %) In autumn littoral zooplankton didn't have the dominate group: pelagic – 18 species (33,3% of the total), littoral-phytophilous – 17 species (31,5%) and demersal-phytophilous – 19 species (35,2%) groups. 5. In spring in afternoon time littoral zooplankton in quantitative terms was characterized by "very low" or "low" development. Its density varied within 2,8-19,9 thousand ind./m^3, and biomass – 0,02-0,21 g/m^3. In summer in daytime littoral zooplankton development was "very low", "low", "below average" and "average". Its density varied within 0,2-282,4 thousand ind./m^3, and biomass – <0,01-5,35 g/m^3. The littoral zooplankton was characterized by "very low" and "low" development in daily time of autumn. Its density varied within 0,4-21,3 thousand ind./m^3, and biomass – 0,01-0,73 g/m^3. 6. None species was presented in the dominant complexes for three seasons. Dominant species complexes were very low for similarities in different seasons ($J_{дом.}$ = 0–18,2). 7. The seasonal distribution of littoral zooplankton in different parts of the Oleksandrivka reservoir is characterized by middle degree of similarity in species composition in spring (J = 40,4–55,6), but much lower in summer (J = 16,7–31,8) and autumn (J = 10,5–33,4). The seasonal dynamics of density and biomass of littoral zooplankton were similar in different parts of the reservoir.

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Received to editorial board 18.12.16

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ПРОСТОРОВО-ЧАСОВА ДИНАМІКА УГРУПОВАНЬ ЛІТОРАЛЬНОГО ЗООПЛАНКТОНУ ОЛЕКСАНДРІВСЬКОГО ВОДОСХОВИЩА

Представлено результати аналізу просторово-часової динаміки угруповань зоопланктону літоралі Олександрівського водосховища. Виявлено особливості сезонних змін видового складу, фауністичного та екологічного спектрів, кількісних показників (щільності та біомаси) та домінуючих комплексів видів літорального зоопланктону. Здійснено аналіз сезонної динаміки якісних і кількісних показників розвитку зоопланктону в межах літоралі верхньої, середньої та нижньої частин Олександрівського водосховища.

Ключові слова: екологія, Олександрівське водосховище, літораль, угруповання зоопланктону.

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ПРОСТРАНСТВЕННО-ВРЕМЕННАЯ ДИНАМИКА СООБЩЕСТВ ЛИТОРАЛЬНОГО ЗООПЛАНКТОНА АЛЕКСАНДРОВСКОГО ВОДОХРАНИЛИЩА

Представлено результаты анализа пространственно-временной динамики сообществ зоопланктона литорали Александровского водохранилища. Выявлено особенности сезонных изменений видового состава, фаунистического и экологического спектров, количественных показателей (плотности и биомассы) и доминирующих комплексов видов литорального зоопланктона. Осуществлено анализ сезонной динамики качественных и количественных показателей развития зоопланктона в пределах литорали верхней, средней и нижней частей Александровского водохранилища.

Ключевые слова: экология, Александровское водохранилище, литораль, сообщества зоопланктона.

УДК 615.9:616.36-099:576.2.24:577.161.3

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COMPARATIVE INVESTIGATION OF ANTI-TUBERCULOSIS DRUGS EFFECTS ON TESTICULAR CYP2E1 EXPRESSION AND MALE REPRODUCTIVE PARAMETERS UNDER SEPARATE AND COMBINED ADMINISTRATION IN MALE RATS

Comparative study of anti-tuberculosis drugs anti-androgenic effects and effects on testicular CYP2E1 has been performed. Testicular CYP2E1 mRNA and protein expression, serum total testosterone level, fertility and spermatogenesis parameters in male rats under simultaneous and separate administration of ethambutol, isoniazid, rifampin and pyrazinamide have been investigated. Analysis of the obtained data has proved the prominent role of ethambutol and isoniazid in gonadal toxicity of anti-tuberculosis drugs combination. Activation of CYP2E1-dependent metabolizing systems in testicular steroidogenic cells could stipulate at least a part of ethambutol, isoniazid and anti-tuberculosis drugs combination negative effects on testosterone level and spermatogenesis processes. Mechanisms of spermatogenesis alteration by rifampin and pyrazinamide need to be explored more extensively, but in the light of our observations they do not depend from testicular CYP2E1.

Key words: anti-androgenic effects, anti-tuberculosis drugs, protein expression, ethambutol, isoniazid.

Introduction. The epidemiological situation of tuberculosis in the world keeps worsening [1]. In general, all patients from countries with a known high incidence of resistant *M. tuberculosis* strains, all patients who had been treated previously, and all patients with life-threatening tuberculosis, receive as initial anti-tuberculosis therapy the same combination of isoniazid (INH), rifampin (RMP) and pyrazinamide (PZA), together with at least one additional medicine (ethambutol (EMB) and/or streptomycin) [2].

In such situation investigation of these compounds adverse effects becomes of vitally importance. We have previously shown the antifertility effects of anti-tuberculosis medicines combination in male rats with simultaneous increase in cytochrome P-450 2E1 (CYP2E1) mRNA in their testes [3, 4]. It is important to note that series of **studies clearly demonstrated inducibility of** CYP2E1 in testis, suggesting its possible role in chemicals bioactivation to their toxic metabolites directly in male gonads [4, 5, 6, 7]. Among this, it is well known that both toxic intermediates (which are able to interact with vitally important cells structures) and reactive oxygen species (ROS) overproduction (with the further development of oxidative stress) take place during CYP2E1-mediated xenobiotics metabolism [8].

It remains unclear which one of the four co-administered (ATD) plays a crucial role in testicular CYP2E1 expression modulation and the development of antifertility effects. Thus, in terms of our above mentioned results [3, 4] analysis of potential effects on male gonads of each component of the combination are urgently required. Such data could substantially contribute to our general understanding of causes of the man subfertility. To get the answer on this question we have decided to compare testicular CYP2E1 mRNA and protein expression, serum total testosterone (TS) level, fertility and spermatogenesis parameters in male rats under combined and separate administration of EMB, INH, RMP and PZA.

Materials and methods. Substances of EMB, INH, RMP and PZA were supplied by the SIC "Borzhagovsky Chemical-Pharmaceutical Plant" CJSC, Ukraine.

Wistar albino male with initial body weight (b.w.) 150–170 g (8-9 weeks old) and female rats 150-170 b.w. (9-10 weeks old), were purchased from Biomodel Service (Kyiv, Ukraine). They were kept under a controlled temperature (from 22 °C to 24 °C), relative humidity of 40 % to 70 %, lighting (12 h light-dark cycle), and on a standard pellet feed diet ("Phoenix" Ltd., Ukraine).

The male rats were divided randomly into 6 groups: 1-control (n=12); 2 – EMB administration (n=12); 3 – INH administration (n=12); 4 – RMP administration (n=12); 5 – PZA administration (n=12); 6 – simultaneous ATD administration (n=12). All ATD were suspended in 1% starch gel and was administered intragastrically by gavage in doses used in clinic [9], which for rats (with the coefficient for conversion of human doses to animal equivalent doses based on body surface area) were following: EMB – 155 mg/kg b.w./day, RMP – 74.4 mg/kg b.w./day, INH – 62 mg/kg b.w./day, PZA – 217 mg/kg b.w./day [10]. ATD were administered during entire spermatogenesis cycle, which (with