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BIOMARKERS OF EFFECT: GROSS AND HISTOPATHOLOGICAL INDICATORS *ATHERINA BOYERI* OF THE CASPIAN SEA, KAZAKHSTAN SECTOR

Feature of ichthyofauna North-eastern part of the Caspian Sea is the presence of it includes not only the valuable commercial fish species, but also of low value species who participate in the formation of the food chain. Fish, as the top trophic unit of the aquatic ecosystem, are considered indicators of pollution, therefore pathological studies allow us to estimate and predict effects of finding toxic substances in water. This article presents the results of the morphometric and histological study Caspian Aterina (Atherina boyeri), inhabiting the North-Eastern part of the Caspian Sea. As a result of the study, were found that the biomarkers-effect are pathological changes gill tissue and liver. So, in the gills are observed destructive lamella changes, phenomena of hyperplasia of the primary and secondary gill epithelium and degeneration of cartilage elements. The liver changes manifested in the form of parenchymal hepatocytes dystrophy and vascular reaction. The observed pathological changes gills and liver may affect the survival Atherina boyeri and these organs can serve as biomarkers of effect. Histological study of muscle and gonad it did not reveal any changes pamorphological and observed processes are reversible. In these studies, substantiates use of Caspian Aterina (Atherina boyeri) as a test type of monitoring the water of the Caspian Sea basin and including to predict the number of and quality of harvested species.

Key words: Caspian atherina, A. boyeri caspia (Eichwald, 1838), Caspian Sea, histological changes, gills, liver.

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Эффект биомаркерлері: Каспий теңізінің Қазақстан аймағындағы Каспий атеринасы (*Atherina boyeri*) балықтарына жасалған жалпы және гистопотологиялық көрсеткіштері

Каспий теңізінің солтүстік-шығыс аумағының ихтиофаунасының ерекшелігіне өнеркәсіптік маңызы бар балықтармен қатар, қорек тізбегін қалыптастыруға қатысатын құнсыз балық түрлерінің болуын айтуға болады. Балықтар су экожүйесіндегі трофикалық қатардың жоғары өкілдері ретінде ластанудың индикаторы болып табылады. Сыртқы ортадағы өзгерістерді анықтаудың бір әдісі – балықтардың физиологиялық күйін зерттеу. Сол себептен патоморфологиялық зерттеулер судағы токсинді заттардың таралуының зардаптарын бағалауға және болжауға болады. Мақалада Каспий теңізінің солтүстік-шығыс бөлігін мекендейтін атерина балығына жүргізілген морфометриялық және гистологиялық зерттеудің нәтижелері келтірілген. Зерттеу нәтижесінде желбезек ұлпасы мен бауырдағы патоморфологиялық өзгерістер эффект-биомаркері бола алатындығы анықталды. Сонымен қатар балықтардың желбезектерінде ламеллалардың деструктивті өзгерістері:

бірінші реттік және екінші реттік желбезек эпителийлерінің гиперплазиясы мен шеміршекті элементтердің дегенерациясы байқалды. Балықтардың бауырындағы өзгерістер гепатоциттердің паренхиматозды дистрофиясы және тамырлар реакциясы түрінде байқалды. Байқалған желбезек пен бауырдағы патоморфологиялық өзгерістер Atherina boyeri балықтарының өміршеңдігіне әсер етуі мүмкін және зерттелген мүшелерді эффект-биомаркерлері ретінде қолдануға болады. Бұлшық ет ұлпасы мен гонадаларды гистологиялық зерттеу барысында патоморфологиялық өзгерістер анықталмады және байқалған процестер қайтымды сипатқа ие. Берілген зерттеулерде Каспий атеринасы (Atherina boyeri) балықтарын Каспий теңізінің суына маниторинг жүргізуде, кәсіптік маңызы бар балықтардың сапасы мен санын болжауда тест-объект ретінде қолдану ұсынылады.

Түйін сөздер: Каспий атерина A. boyeri caspia (Eichwald, 1838), Каспий теңізі, гистологиялық өзгерістер, желбезек, бауыр.

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Биомаркеры эффекта: валовые и гистопатологические показатели атерины каспийской (*Atherina boyeri*) казахстанского сектора Каспийского моря

Особенностью ихтиофауны Северо-Восточной части Каспия является наличие в ее составе не только ценных промысловых видов рыб, но и малоценных видов, которые участвуют в формировании пищевой цепочки. Рыбы как верхнее трофическое звено водной экосистемы считаются индикаторами загрязнения, поэтому патоморфологические исследования позволяют оценить и прогнозировать последствия нахождения токсических веществ в воде. В данной статье приведены результаты морфометрического и гистологического изучения атерины каспийской (Atherina boyeri), обитающей в Северо-Восточной части Каспийского моря. В результате исследовании были обнаружено, что биомаркерами-эффекта выступают патоморфологические изменения жаберной ткани и печени. Так, в жабрах наблюдаются деструктивные изменения ламелл, явления гиперплазии первичного и вторичного жаберного эпителия и дегенерации хрящевых элементов. В печени изменения проявлялись в виде паренхиматозной дистрофии гепатоцитов и сосудистой реакцией. Наблюдаемые патоморфологические изменения жабер и печени могут сказываться на выживаемости Atherina boyeri и эти органы могут служить биомаркерам эффекта. Гистологическое изучение мышечной ткани и гонад не выявило паморфологических изменений и наблюдаемые процессы имеют обратимый характер. В данных исследованиях обосновывается использование атерины каспийской (Atherina boyeri) в качестве тестового вида мониторинга водного бассейна Каспийского моря, и в том числе для прогнозирования численности и качества промысловых видов.

Ключевые слова: атерина каспийская, A. boyeri caspia (Eichwald, 1838), Каспийское море, гистологические изменения, жабры, печень.

Introduction

Currently increasing relevance have research related the identification of ecosystem responses and (or) its individual components to the action of unfavorable factors [1]. Constant changes environmental quality lead to the need for continuous monitoring, for better environmental management. One of the widely used methods of biological type of monitoring is bioindication. A considerable interest has been acquiring search for test objects (biomonitors) and biomarkers – molecular, cellular, physiological, organismic and population parameters for monitoring the quality of the aquatic environment [2-4]. Quite obvious that for each ecosystem can be used several indicator species and biomarkers that are sensitive to environmental factors, including anthropogenic.

The study of the enzymatic system of aquatic organisms can be used to monitor level of water pollution by tetrabromobisphenol. So, serum research silver crucian (Carassius auratus) showed that the activity of aspartate aminotransferase (AST), alanine aminotransferase (AlT) and glutathione reductase increases when using tetrabromobisphenol at a concentration of 0.35 mg / l already from 4 days of toxicant addition and stored during the experiment (32 days) at the same time, there is a significant increase in AST. Provided that the concentration of tetrabromobisphenol exceeds 0.50-0.71 mg / l, after its cancellation levels AST, AlT, glutathione-S-transferase (GST), glucuronosyltransferase (UDPGT) and glutathione reductase in liver homogenates remain enlarged for a long time. Therefore, measurement of AST and ALT can be used in the normal monitoring water quality in areas at risk of tetrabromobisphenol and determination of glucuronosyltransferase (UDPGT) and glutathione reductase in liver homogenates for use in emergency situations in which this toxicant is emitted [5].

The effect of aqueous solutions of sulfonamides in micromolar concentrations for 96 h on nematodes (*Caenorhabditis elegans*) was studied and it was found that what they inhibit behavior indicator (including body bending frequency) and growth rates (reducing body length), behavioral changes were more pronounced. In addition, behavioral disturbance was noted in the descendants [6].

Triclosan (2,4,4'-trichloro-2'-hydroxy-diphenyl ether; TCS) is an antibacterial agent and is part of a variety of household and personal care products. Now found in natural waters and bottom sediments. In addition, having a high hydrophobicity, triclosan is able to accumulate in the fatty tissue of various aquatic organisms, methylated to methyl triclosan (2,4,4'-trichloro-2'-methoxy diphenyl ether). So, it was shown triclosan and its metabolite change the morphology and density of blood cells, causing violations of the respiratory gill epithelium abalone (*Haliotis tuberculata*) [7].

The search for available methods for monitoring water pollution is relevant, with organisms that are dominant in aquatic communities of greatest interest. The present studies substantiate the use of the Caspian atherine (ordinary atherina, small atherina) of the *Osteichthyes* class as a biomonitor for the quality of water in the Caspian Sea. The species was described as A. mochon Cuvier, 1829 [8,9], but then reduced to synonymy *A. boyeri* [10], is a marine euryhaline fish [11], inhabiting both brackish and strongly saline regions [8,9] and in the desalinated waters of the Caspian Sea in the pelagic zone. It should be noted that the *Atherina boyeri* is regarded as a secondary target of the craft.

Materials and research methods

Atherina boyeri females were selected for the study in the amount of 72 specimens from trawling material from the North-Eastern part of the Caspian Sea during the 2017 autumn ichthyological expedition. Morphometric and pathomorphological studies were performed on 15 female year-olds (Figure 1).

Figure 1 – Atherina boyeri, selected for study

Fish were anesthetized in ice-cold water, killed by a slit behind the gill cover and fixed in 10% formalin for subsequent morphometric and histological examination. All studies were conducted at the Department of Biodiversity and Bioresources of the Al-Farabi Kazakh National University. Morphometric measurements of fish were carried out according to I.F. Pravdin[12]. The general condition factor (CF) was calculated as the ratio of body weight to total length and the Fulton condition condition index (K index), which is an indicator of fish health [K = 100 x (weight / (total length) ^{3}]).

Histological studies of gills, liver, muscles, and gonads were performed by standard methods [13]. Stained sections were studied using a Leica DM 6000M optical microscope. Statistical data processing was performed using standard methods and statistical programs Microsoft Excel 2013.

Results and discussion

Table 1 presents growth and weight indices of Caspian atherine (Atherina boyeri). The weight of the females-yearlings was 7,03 ± 0,35 g and the length was 93,5 ± 2,42 mm.

In the table 2 show the general state (CF) and Fulton state factors (K index). The average indicators of the general condition (CF) are 61,00 ± 3,05 and the Fulton state factor is 0,63 ± 0,08.

Table 1 – Height and weight indicators *Atherina boyeri***,** females

№	Weight, g	Mass without internal organs, g	Overall length, mm	Body length without tail, mm
1	6,34	5,73	104	97
2	5,64	5,19	97	91
3	5,03	4,51	96	81
4	6,17	5,62	98	93
5	7,13	6,43	103	96
6	7,71	7,14	103	97
7	7,01	6,44	101	97
8	7,42	6,51	112	96
9	10,33	9,22	118	101
10	6,62	6,13	99	84
11	5,71	5,22	98	83
12	6,74	6,21	103	98
13	7,02	6,39	102	97
14	7,13	6,51	99	93
15	9,45	8,72	116	102

Table 2 – Condition factor (CF) and Fulton's condition index (K index) *of Atherina boyeri*

№	Condition factor (CF)	Fulton's condition index (K index)
1	55,1	0,56
2	53,5	0,62
3	47,0	0,57
4	57,3	0,66
5	62,4	0,65
6	69,3	0,71
7	63,8	0,68
8	58,1	0,53
9	78,1	0,63
10	53,3	0,68
11	53,3	0,61
12	60,3	0,62
13	62,6	0,66
14	65,8	0,73
15	75,2	0,61

When histological examination structures of the respiratory epithelium of gill lobes all fish marked focal changes, manifested in the form of hyperplasia, which affects both the primary gill epithelium and the secondary. The individual lamellae are shortened or typical symmetry is lost due to the destruction of blood vessels and necrobiotic changes in respiratory cells. Over the entire length of the lamellas, an expansion is noted intercellular space between the layers of respiratory cells. Mucous cells are found along the entire length. Diffuse blood supply of supporting cells. Focal adhesion of adjacent lamellas. Focal depletion of the cellular composition of the primary gill epithelium and an increase in cellularity, mainly due to mucous cells, the nuclei of which are shifted to the periphery of the cell (figures 2-4).

Histological examination of the liver of *Atherina boyeri* traced two features in the microscopic picture of the organ parenchyma. The first is manifested in the "openwork": hepatocytes appear empty with a centrally located large nucleus or displaced core on the periphery of the cell with a reduced nucleus. At high magnification are found in the cytoplasm of large vacuoles. Second, hepatocytes appear enlarged in volume with fine-grained contents in the cytoplasm, while the nucleus is large, lightened with heterogeneously located chromatin. Picture of diffuse expansion of the Disse space. In general, in all individuals, the lobular structure of the liver is preserved (figures 5-7).

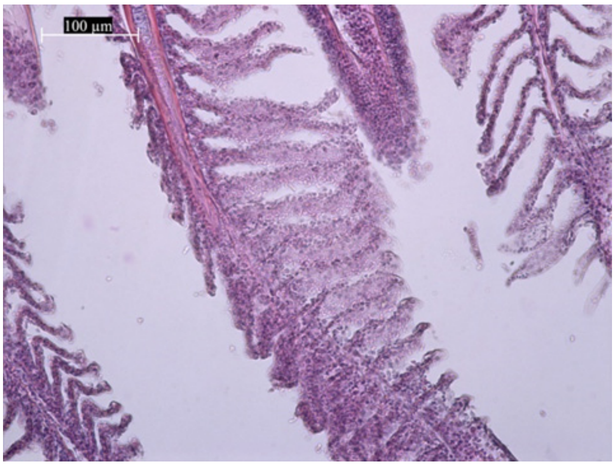

Figure 2 – Hyperplasia of the secondary gill epithelium and destruction of capillaries.
Hematoxylin-eosin. Increasing × 10

Figure 3 – 1 – expansion capillaries lamella, expanding intercellular spaces, mucous cells along the entire length of the lamella; 2 – the flattening of the respiratory epithelium of secondary gill epithelium. Separate lamellae on tops like maces thickened. Hematoxylin-eosin. Increasing × 10

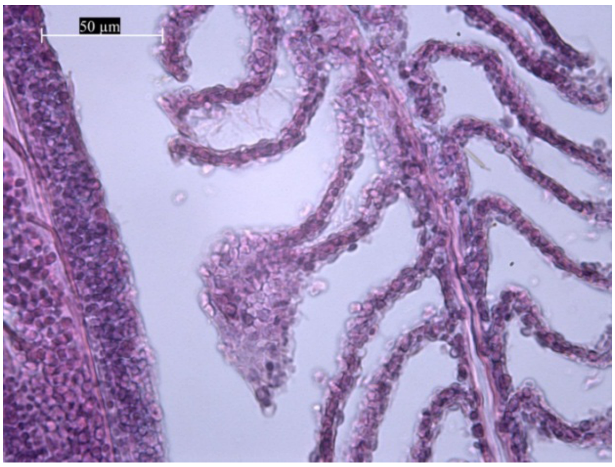

Figure 4 – Lamella shape change: thickening like a mace, fusion of lamellae tops.
Hematoxylin-eosin. Increasing × 20

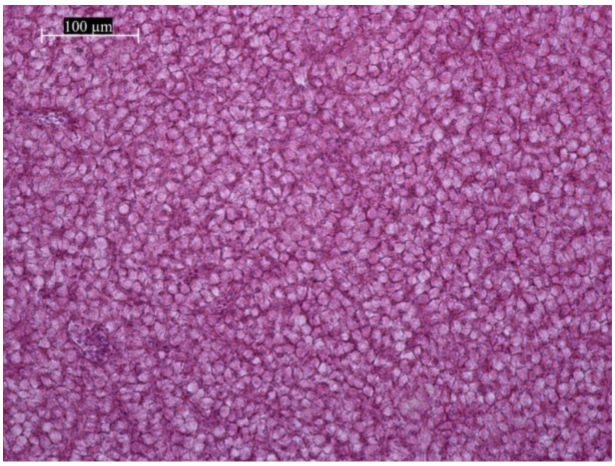

Figure 5 – The nuclei of hepatocytes shifted to the periphery of the cell. Vascular congestion.
Hematoxylin-eosin. Increasing × 10

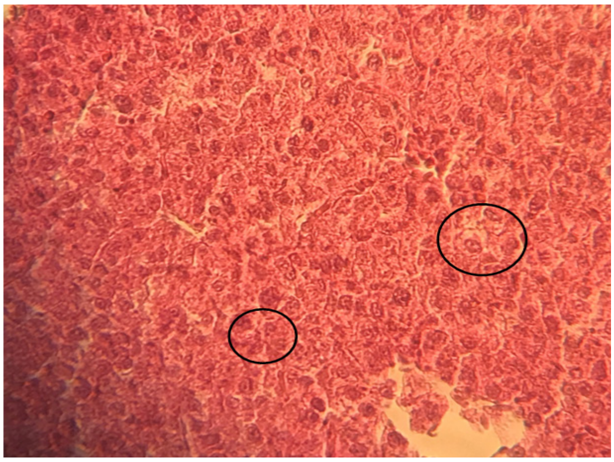

Figure 6 – Granular dystrophy of hepatocytes.
Individual hepatocytes loaded vacuoles.
Hematoxylin-eosin. Increasing × 20

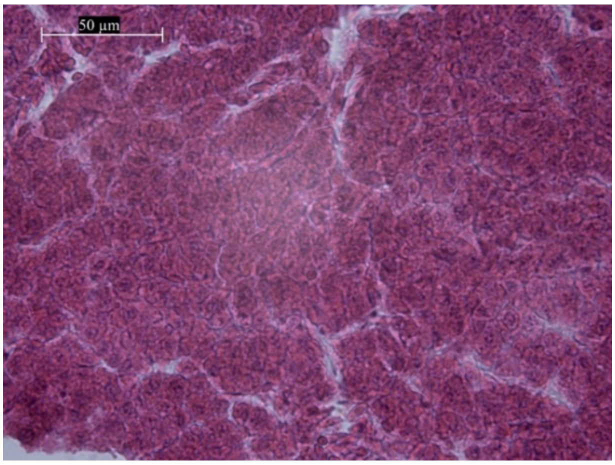

Figure 7 – Diffuse expansion of sinusoids.
Swelling of the stroma. Cell walls appear thickened.
Hematoxylin-eosin. Increasing × 20

In muscles, transverse striation is preserved, fibers with peripherally arranged nuclei. In some individuals focal loss of muscle fibers, individual fibers with small vacuoles (Figures 8 and 9).

In the reproductive system of studied fish not observed destructive changes in germ cells. On histological sections of the ovaries are located different sized oocytes of cytoplasmic growth, oocytes of the first order on the phases of vitellogenesis with the phenomenon of vacuolization of peripheral cytoplasm and an increase in the number of nucleoli in the nucleus (Figure 10-12).

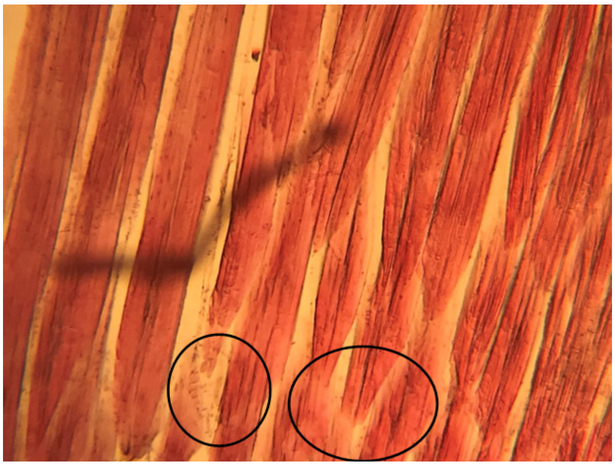

Figure 8 – Loss of muscle fibers.
Hematoxylin-eosin. Increasing × 20

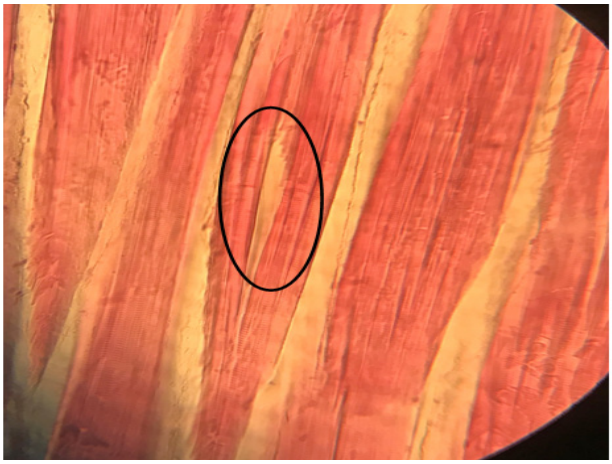

Figure 9 – Disorganization of muscle fibers.
Hematoxylin-eosin. Increasing × 40

Fish used for assessing the quality of the aqueous medium and serve as bioindicators of environmental pollution. Biomarkers act as “early warning” signals that can detect an adverse effect in biota before it is observed at the population, community or ecosystem level [14]. The results of these studies demonstrate that the use of various potential biomarkers allows you to set the most sensitive indicators to detect water pollution. It is known that the gills provide breathing processes osmoregulation and excretion in fish. It is the gills that are sensitive to changes in water quality, due to the greater area of contact with the external environment through thin epithelium [15]. The observed pathological changes indicate about lowering respiratory capacity and the occurrence of osmotic imbalance. The liver has been recognized as a target organ for various pollutants. In our study, a histopathological examination of the liver revealed a circulatory disorder associated with the pathological conditions of the parenchyma of the organ and regressive changes. The observed pathological effects can have a negative impact on the sustainability of fish to stressful influences and the ability to react to changes in the environment, and including susceptibility to disease that eventually affects survival. In this case, the gills and liver can serve as a biomarker of the effect [16].

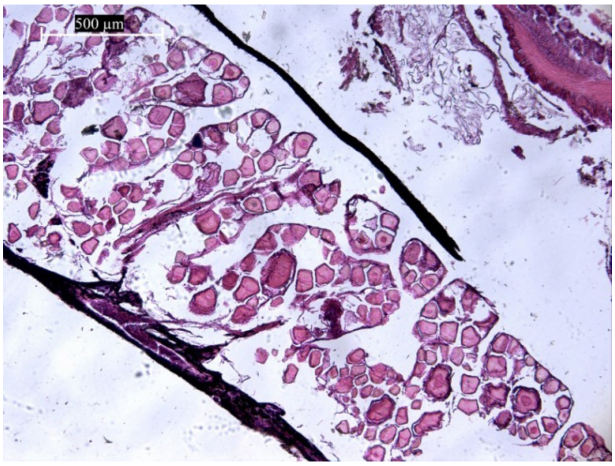

Figure 10 – Histostructure gonads of *Atherina boyeri* Hematoxylin-eosin. Increasing × 10

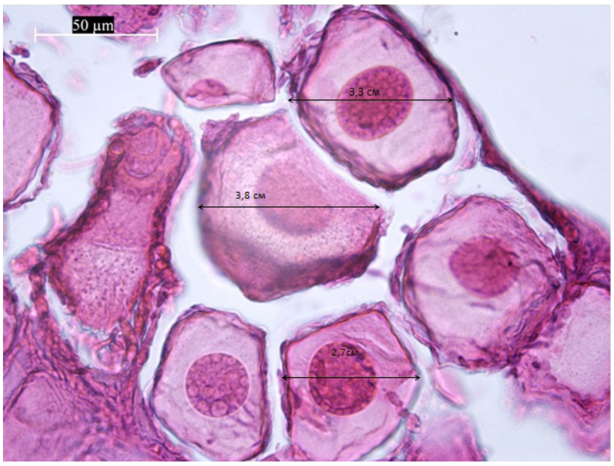

Figure 11 – Different dimensions oocytes cytoplasmic growth Hematoxylin-eosin. Increasing × 40

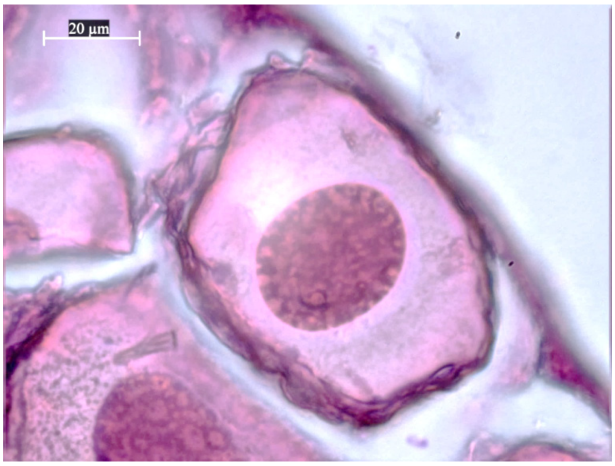

Figure 12 – The oocyte first order.
Hematoxylin-eosin. Increasing × 1000

Conclusion

It is well known that changing environmental conditions cause the appearance of a large number of females in fish. In our studies, all the females in the gonads were no destructive changes.

We propose to use *Atherina boyeri* as a test species for monitoring the Caspian Sea, which provides for the expansion of knowledge about the reaction of fish to various pollutants under experimental conditions, including for validation.

Therefore, it can be argued that the focal view of Atherina boyeri can serve as a biomarker of the state of the water basin of the Kazakh sector of the Caspian Sea and to predict the number and quality of commercial species.

Conflict of interest

All authors have read and are familiar with the content of the article and do not have a conflict of interest.

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References

1 Ongo G., Trovato M., Mazzei V. et al. Ligia italica (Isopoda, Oniscidea) as Bioindicator of Mercury Pollution of Marine Rocky Coasts // PLoS. One. – 2013. – Vol. 8, No 3. – P. 1-10.

2 Trujillo-Jiménez P, Sedeño-Díaz J.E., López-López E. Assessing the health condition profile in the freshwater fish Astyanax aeneus in Champoton River, Mexico // J. Environ. Biol. – 2014. -Vol. 35, No 1. – P. 137-145.

3 Benedetti M., Gorbi S., Fattorini D. et al. Environmental hazards from natural hydrocarbons seepage: integrated classification of risk from sediment chemistry, bioavailability and biomarkers responses in sentinel species // Environ. Pollut. – 2014. – Vol. 185. – P.116-126.

4 Brenner M., Broeg K., Frickenhaus S. et al. Multi-biomarker approach using the blue mussel (Mytilus edulis L.) to assess the quality of marine environments: Season and habitat-related impacts // Mar Environ Res. – 2014. – Vol. 95. – P.13-27.

5 Yang S. Xu F.,Zheng B. Wu F.,Wang S. Multibiomarker responses upon exposure to tetrabrombisphenol A in the freshwater fish Carassius auratus //Aquat. Toxicol. – 2013. – Vol. 15. – P. 248-256.

6 Yu Z., Zhang J., Chen X.,Yin D., Deng H. Inhibitions on the behavior and growth of the nematode progeny after prenatal exposure to sulfonamides at micromolar concentrations // J. Hazard. Mater. – 2013. – Vol. 15. – P. 198-203.

7 Gaume B., Bourgougnon N., Auzoux-Bordenave S. et al. In vitro effects of triclosan and methyl-triclosan on the marine gastropod Haliotis tuberculata // Comp. Biochem. Physiol. c Toxicol. Pharmacol. – 2012. – Vol. 156, No 2. – P.87-94.

8 Dumont H. Ecocide in the Caspian Sea. // Nature. – 2005. – Vol. 337. – P. 673–674.

9 Dumont H. The Caspian Lake: History, biota, structure, and function. // Limnol. Oceanogr., -2008. – Vol. 43, No 1. – P. 44–52.

10 Леонов А.В. Математическое моделирование сезонной динамики концентраций соединений биогенных элементов и биопродуктивности вод северной части Каспийского моря // Каспийский плавучий университет. Научный бюллетень № 1. – 2000. – №2. – С. 71-80

11 Агатова А.И., Лапина Н.М., Торгунова Н.И., Кирпичев К.Б. Биохимические исследования морских экосистем солоноватых вод // Водные ресурсы. – 2001. – Т. 28, №4. – С. 470-479.

12 Васильев А.С., Белов А.Б., Коновалов М.Л. О сезонной изменчивости термохалинных и динамических процессов Каспийского моря. – М.: ГОИН, 2002. – 32 с.

13 Шалгимбаева С.М., Джумаханова Г.Б., Куликов Е.В., Асылбекова С.Ж. Сравнительная характеристика гистологических изменений в жабрах некоторых видов рыб отрядов Cypriniformes и Perciformes озера Зайсан // Известия НАН РК. – 2013. – Т. 299, №5. – С. 67-72.

14 Шалгимбаева С.М., Джумаханова Г.Б., Шалгимбаева Г.М., Булавина Н.Б. Влияние иммуномодулятора «Риботан» на состояние жабр у молоди осетровых рыб, выращиваемых в бассейновых условиях Капшагайского НВХ // Материалы Международной научно-практической конференции "Современные проблемы охотничьево хозяйства Казахстана и сопредельных стран" (Алматы, 11-12 марта 2014 г.). – Алматы: Казохотрыболовсоюз, 2014. – С. 439-444.

15 Джумаханова Г.Б., Шалгимбаева С.М., Жаркова И.М. Гистологические исследования жабр и печени некоторых рыб Алакольской системы озер // Материалы Второй научной школы молодых ученых и специалистов по рыбному хозяйству и экологии с международным участием, посвященной 100-летию со дня рождения И.Б. Бирмана (Звенигород, 19-25 апреля 2015 г.). – Москва: ВНИРО, 2015. – С. 24.

16 Sarmoldayeva G.R., Shalgimbayeva S.M., Omarova Zh.S., Jumakhanova G.B., Kairat B.K., Dautbayeva K.A. The histomorphologic research on reproductive system of Carp (Cyprinus carpio L.) females in Lake Balkhash // KazNU Bulletin. Biology series. – 2017. – Vol. 71, No 2. – P. 32-39.

17 Dautbayeva K.A., Shalgimbayeva S.M., Omarova Z.S., Jumakhanov G.B. The feeding habits of bream (Abramis brama) and roach in the Northern part of the Caspian Sea // KazNU Bulletin. Biology series. – 2017. – Vol. 70, №2. – P. 22-30.

18 Джумаханова Г.Б., Шалгимбаева С.М., Касымбекова Г.Ы., Черепкова Н.В. Патоморфологические изменения в органах воблы Камышлыбашского рыбопитомника // Материалы III научной школы молодых учёных и специалистов по рыбному хозяйству и экологии, с международным участием, посвященной 140-летию со дня рождения К.М. Дерюгина. "Перспективы рыболовства и аквакультуры в современном мире" (Звенигород, 15-21 апреля 2018 г.). – Москва: Изд. ВНИРО, 2018. – С. 81.

19 Жумагазеева Д.Ж., Джумаханова Г.Б., Шалгимбаева С.М. Патоморфологический анализ некоторых органов атерины // Материалы III научной школы молодых учёных и специалистов по рыбному хозяйству и экологии, с международным участием, посвященной 140-летию со дня рождения К.М. Дерюгина. "Перспективы рыболовства и аквакультуры в современном мире" (Звенигород, 15-21 апреля 2018 г.). – Москва: Изд. ВНИРО, 2018. – С. 87.

20 Корбозова Н.К., Джумаханова Г.Б., Шалгимбаева С.М., Кудрина Н.О. Патоморфологические изменения в органах сеголеток белого амура Ctenopharyngodon idella, выращиваемого в прудовых условиях // Материалы III научной школы молодых учёных и специалистов по рыбному хозяйству и экологии, с международным участием, посвященной 140-летию со дня рождения К.М. Дерюгина. "Перспективы рыболовства и аквакультуры в современном мире" (Звенигород, 15-21 апреля 2018 г.). – Москва: Изд. ВНИРО, 2018. – С. 101.

21 Джумаханова Г.Б., Шалгимбаева С.М., Пазылбек М.Ж., Қасымбекова Г.Ы., Сармолдаева Ғ.Р. Қошқаркөл көліндегі кейбір кәсіптік балықтардың ішкі мүшелеріне жасалынған гистопатологиялық зерттеулер // әл-Фараби атындағы Қазақ ұлттық университетінің Биология мұражайының 80 жылдығына арналған «Қазақстан және оған шектес аумақтардаеы биоалуантүрлілікті табиғатта және коллекцияларда сақтау» атты халықаралық ғылыми-практикалық конференция материалдары (Алматы, 13-14 қазан 2016 ж.). – Алматы: Қазақ университеті, 2016. – Б. 45-48.

22 Омарова Ж.С., Шалгимбаева С.М., Джумаханова Г.Б., Жумагазеева Д.Ж. Ботрицефалез карпа из рыбоводного хозяйства Кызылординской области // Материалы III научной школы молодых учёных и специалистов по рыбному хозяйству и экологии, с международным участием, посвященной 140-летию со дня рождения К.М. Дерюгина. "Перспективы рыболовства и аквакультуры в современном мире" (Звенигород, 15-21 апреля 2018 г.). – Москва: Изд. ВНИРО, 2018. – С. 120.

23 Правдин И.Ф. Руководство по изучению рыб. – М.: Пищевая промышленность, 1966. – 375 с.

24 Роскин Г. И., Левинсон Л. Б. Микроскопическая техника. – М.: Советская наука, 1957. – 469 с.

25 Ромейс Б. Микроскопическая техника. – М. : Иностранная литература, 1953. – 718 с.

References

1 Agatova A.I., Lapina N.M., Torgunova N.I., Kirpichev K.B. (2001) Biokhimicheskiye issledovaniya morskikh ekosistem solonovatykh vod [Biochemical studies of marine ecosystems of brackish waters]. Water resources. vol. 28, no. 4, pp. 470-479.

2 Benedetti M., Gorbi S., Fattorini D. et al. (2014) Environmental hazards from natural hydrocarbons seepage: integrated classification of risk from sediment chemistry, bioavailability and biomarkers responses in sentinel species. Environ. Pollut. vol. 185, pp.116-126.

3 Brenner M., Broeg K., Frickenhaus S. et al. (2014) Multi-biomarker approach using the blue mussel (Mytilus edulis L.) to assess the quality of marine environments: Season and habitat-related impacts. Mar Environ Res. vol 95, pp.13-27.

4 Dautbayeva K.A., Shalgimbayeva S.M., Omarova Z.S., Jumakhanov G.B. (2017) The feeding habits of bream (Abramis brama) and roach in the Northern part of the Caspian Sea. KazNU Bulletin. Biology series. vol. 70, no. 2, pp. 22-30.

5 Dumont H. (2005) Ecocide in the Caspian Sea. Nature. vol. 337, pp. 673–674.

6 Dumont H. (2008) The Caspian Lake: History, biota, structure, and function. Limnol. Oceanogr. vol. 43, no 1, pp. 44–52.

7 Dzhumahanova G.B., Shalgimbaeva S.M., Zharkova I.M. (2015) Gistologicheskiye issledovaniya zhabr i pecheni nekotorykh ryb Alakol'skoy sistemy ozer [Histological examination of the gills and liver of some fish of the Alakol lakes system]. Materials of the 2nd Scientific School of Young Scientists and Specialists in Fisheries and Ecology with international participation, dedicated to the 100th anniversary of the birth of I.B. Birman. VNIRO, Zvenigorod, Moscow, April 19-25, 2015, pp. 24.

8 Dzhumakhanova G.B., Shalgimbaeva S.M., Kasymbekova G.Y., Cherepkova N.V. (2018) Patomorfologicheskiye izmeneniya v organakh vobly Kamyshlybashskogo rybopitomnika [Pathological changes in the organs of the vobla of the Kamyshlybashsky hatchery]. Materials of the 3rd scientific school of young scientists and specialists in fisheries and ecology, with international participation, dedicated to the 140th anniversary of the birth of K.M. Deryugin "Prospects for fisheries and aquaculture in the modern world". VNIRO, Zvenigorod, Moscow, April 15-21, 2018, pp. 81.

9 Dzhumakhanova G.B., Shalgimbaeva S.M., Pazylbek M.Zh., Kasymbekova G.Y., Sarmoldayeva G.R. (2016) Qoshqarkól kólindegi keıbir kásiptik balyqtardyń ishki múshelerine jasalyngan gıstopatologııalyq zertteýler [Histopathological examination of internal organs of some professional fish in Koshkarkol lake]. Materials of international scientific-practical conference "Preservation of biodiversity in nature and in collections in Kazakhstan and surrounding territories" dedicated to the 80th anniversary of the Biology Museum of the Al-Farabi Kazakh National University. Qazaq ýnıversıteti, Almaty, October 13-14, 2016, pp. 45-48.

10 Gaume B., Bourgougnon N., Auzoux-Bordenave S. et al. (2012) In vitro effects of triclosan and methyl-triclosan on the marine gastropod Haliotis tuberculate. Comp. Biochem. Physiol. c Toxicol. Pharmacol. vol. 156, no 2, pp. 87-94.

11 Korbozova N.K., Dzhumakhanova G.B., Shalgimbaeva S.M., Kudrina N.O. (2018) Patomorfologicheskiye izmeneniya v organakh segoletok belogo amura Ctenopharyngodon idella, vyrashchivayemogo v prudovykh usloviyakh [Pathological changes in the organs of Ctenopharyngodon idella fingerlings of white carp grown in pond conditions]. Materials of the 3rd scientific school of young scientists and specialists in fisheries and ecology, with international participation, dedicated to the 140th anniversary of the birth of K.M. Deryugin "Prospects for fisheries and aquaculture in the modern world". VNIRO, Zvenigorod, Moscow, April 15-21, 2018, pp. 101.

12 Leonov A.V. (2000) Matematicheskoye modelirovaniye sezonnoy dinamiki kontsentratsiy soyedineniy biogennykh elementov i bioproduktivnosti vod severnoy chasti Kaspiyskogo morya [Mathematical modelling of the seasonal dynamics of the concentrations of compounds of biogenic elements and the biological productivity of the waters of the Northern part of the Caspian sea]. Caspian floating University. Scientific Bulletin No 1. vol. 2, pp. 71-80.

13 Omarova Z.S., Shalgimbaeva S.M., Dzhumakhanova G.B., Zhumagazeyeva D.Zh. (2018) Botritsefalez karpa iz rybovodnogo khozyaystva Kyzylordinskoy oblasti [Botricephalosis carp from fish farm of Kyzylorda region]. Materials of the 3rd scientific school of young scientists and specialists in fisheries and ecology, with international participation, dedicated to the 140th anniversary of the birth of K.M. Deryugin "Prospects for fisheries and aquaculture in the modern world". VNIRO, Zvenigorod, Moscow, April 15-21, 2018, pp. 120.

14 Pravdin I.F. (1966) Rukovodstvo po izucheniyu ryb [Guide to the study of fish]. Food industry, Moscow, Russia. pp. 375.

15 Romeis B. (1953) Mikroskopicheskaya tekhnika [Microscopic technique]. Foreign Literature, Moscow, Russia. pp. 718.

16 Roskin G.I. Levinson L.B. (1957) Mikroskopicheskaya tekhnika [Microscopic technique]. Soviet Science, Moscow, Russia. pp. 469.

17 Sarmoldayeva G.R., Shalgimbayeva S.M., Omarova Zh.S., Jumakhanova G.B., Kairat B.K., Dautbayeva K.A. (2017) The histomorphologic research on reproductive system of Carp (Cyprinus carpio L.) females in Lake Balkhash. KazNU Bulletin. Biology series. vol. 71, no. 2. pp. 32-39.

18 Shalgimbaeva S.M., Dzhumahanova G.B., Shalgimbaeva G.M., Bulavina N.B. (2014) Vliyaniye immunomodulyatora «Ribotan» na sostoyaniye zhabr u molodi osetrovykh ryb, vyrashivayemykh v basseynovykh usloviyakh Kapshagayskogo NVKH [Influence of the immunomodulator "Ribotan" on the state of the gills of sturgeon fry raised in the basin conditions of the Kapshagaysky NVH]. Materials of the International scientific-practical conference "Modern problems of hunting economy of Kazakhstan and neighboring countries". Institute of Zoology, Almaty, March 11-12, 2014, pp. 439-444.

19 Shalgimbaeva S.M., Dzhumakhanova G.B., Kulikov E.V., Asylbekova S.Zh. (2013) Sravnitel'naya kharakteristika gistologicheskikh izmeneniy v zhabrakh nekotorykh vidov ryb otryadov Cypriniformes i Perciformes ozera Zaysan [Comparative characteristics of histological changes in gills of some fish species of Cypriniformes and Perciformes groups of lake Zaisan]. News of the NAS RK. Series of Biological and Medical. vol. 299, no. 5, pp. 67-72.

20 Trujillo-Jiménez P, Sedeño-Díaz J.E., López-López E. (2014) Assessing the health condition profile in the freshwater fish Astyanax aeneus in Champoton River, Mexico. J. Environ. Biol. vol. 35, no 1, pp. 137-145.

21 Vasilyev A.S., Belov A.B., Konovalov M.L. (2002) O sezonnoy izmenchivosti termokhalinnykh i dinamicheskikh protsessov Kaspiyskogo morya [On the seasonal variability of thermohaline and dynamical processes of the Caspian sea]. GOIN, Moscow, Russia. pp. 32.

22 Yang S., Xu F., Zheng B. Wu F.,Wang S. (2013) Multibiomarker responses upon exposure to tetrabrombisphenol A in the freshwater fish Carassius auratus. Aquat. Toxicol. vol. 15, pp. 248-256.

23 Yu Z., Zhang J., Chen X.,Yin D., Deng H. (2013) Inhibitions on the behavior and growth of the nematode progeny after prenatal exposure to sulfonamides at micromolar concentrations. J. Hazard. Mater. vol. 15, pp. 198-203.

24 Zhumagazeeva, D.Zh., Dzhumakhanova, G.B., Shalgimbaeva, S.M. (2018) Patomorfologicheskiy analiz nekotorykh organov ateriny [Pathomorphological analysis of some organs of atherina] Materials of the 3rd scientific school of young scientists and specialists in fisheries and ecology, with international participation, dedicated to the 140th anniversary of the birth of K.M. Deryugin "Prospects for fisheries and aquaculture in the modern world". VNIRO, Zvenigorod, Moscow, April 15-21, 2018, pp. 87.

25 Ongo G., Trovato M., Mazzei V. et al. (2013) Ligia italica (Isopoda, Oniscidea) as Bioindicator of Mercury Pollution of Marine Rocky Coasts. PLoS. One. vol. 8, no 3, pp. 1-10.