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AFFECT OF THE ENVIRONMENTAL NON-BIOLOGICAL FACTORS ON EMBRYONIC AND LARVAE GROWTH OF MULLETS IN THE AREA OF THE AZOV AND BLACK SEAS

Impact of salinity and temperature on early ontogenesis of mullets has been studied. It was found that optimum salinity values for spawning and embryonic growth of mullets in the Azov and Black Seas were close to the neutral buoyancy of the impregnated and swollen eggs varied within the range of 16 - 18 ‰ for striped mullet, 18 - 22 ‰ for golden mullet and 17 - 20 ‰ for So-iuy mullet. Optimum values for these species respectively made up: 20 – 23 ˚C, 19 - 21˚C and 18 – 20 ˚C. After starting of external feeding and finishing of metamorphosis the larvae of striped mullet and So-iuy mullet demonstrated euribiontic character for environmental factors and ones of golden mullet – stenobiontic features.

Keywords: *mullets, neutral buoyancy, salinity, eggs, acclimatized species.*

SETTING OF THE PROBLEM

Black Sea mullets are valuable species for marine fisheries which for a long time have been widely farmed in the estuarine farms in the Black Sea. However, depressive state of their populations (stipulated by overfishing in some years and deterioration of conditions of the natural reproduction), observed for several recent decades, greatly reduced the amount of fishing and resulted in decline of traditional mullet farming in the estuaries of the Azov and Black Seas [1]. It made reasonable to examine in details the biology of these species as well as to start activities for reproduction of the Black Sea mullet and introduced Pacific mullet.

As a result of research by YugNIRO methods for rearing of striped mullet (in cooperation with VNIRO) [2], golden mullet [3] and So-iuy mullet [4 - 6] have been developed. However, in spite of existing biotechnologies, many problems concerning reproduction of these species are still poorly studied.

Amongst the most important ones are study of the adaptive mechanisms providing efficient reproduction of mullets in the Azov and Black Sea area (the northern part of the range), as compared with the centre of their natural ranges with the salinity of 31 - 37 ‰, in tropical and subtropical zones of the World Ocean [7 - 10].

The study of this problem is in our opinion the necessary condition for improvement of certain stages in biotechnology of rearing and increased efficiency of artificial reproduction of mullets and consequently productive capacity of the fish-farming water bodies.

In this connection the purpose of the present paper comprises the study of impact of most important non-biological environmental factors (salinity and temperature) on embryonic and larval growth of mullets.

MATERIAL AND METHODS

Material was sampled for 1985 – 2012, at YugNIRO experimental site “Zavetnoye” (the Kerch Strait), and at the fish farming site “Budaki” of the Pilot mullet plant (Odessa Region). The objects of studies were breeders, embryos and larvae of three mullet species, namely striped mullet, golden mullet and So-iuy mullet.

Breeders of mullets with ovocytes at IV and V maturity stages were sampled during their spawning migrations from the Sea of Azov into the Black Sea. In 1989 – 1993 artificially farmed So-iuy mullet (breeding stock) was used for work. To stimulate the maturity of mullet females methods of hormone injections were applied [6]. Impregnation of eggs and their incubation was carried out in water with various salinity (from 3 - 5 up to 45 ‰).

Buoyancy of eggs and standard growth of mullet embryos and pre-larvae were studied within the salinity range of 5 - 45 ‰. The value of neutral buoyancy was taken as a water salinity value under which the greater portion of eggs was suspended (on the surface and in water depth). All the experiments were carried out three times.

The data were processed applying the widely adopted statistic methods [11] and electronic tables Excel.

RESULTS AND DISCUSSION

Mullet eggs are pelagic, the normal growth of embryos takes place only in sea water, the density of which is close to that of an impregnated and swollen egg [12]. Therefore when undertaking the artificial reproduction of mullets in order to create the favorable conditions for eggs incubation and growth of early larvae it is the most important to determine the neutral buoyancy value varying greatly for fishes of one species, depending on the habitat area and being connected with the reproduction conditions[13, 14].

Changes in the eggs of mullets in the process of growth, impregnation and swelling affect their natural buoyancy. More active hydration of ovocytes, reduction in size of mature eggs, increase in relative volume of fat drop, predominance of low density fractions in lipid composition – waxes (up to 80 %) are cases of adaptation as a result of which density of eggs for Black Sea mullets reduces to a larger extent that in fishes from the range centres [13]. All these provide buoyancy of their eggs in water with relatively low salinity (17 - 18 ‰).

Similar changes took place in So-iuy mullet in the process of acclimatization in the Azov and Black Seas areas. In the Strait of Amur So-iuy mullet is found at salinity of 31 - 33 ‰ [15, 16], in breeding stock the neutral buoyancy of eggs was fixed at 23 - 30 ‰, and in fishes of natural populations of the introduced species the neutral buoyancy of eggs is found in the range of from 14 up to 20 ‰ (mainly at 17 - 18 ‰). The discrepancies revealed are associated with changes in morphological and physiological-biochemical values of eggs for these fish groups [17].

Eggs of Black Sea mullets may be impregnated within the wide range of salinity: for the striped mullet - at 15 - 35 ‰, for the golden mullet – at 10 - 40 ‰, however the normal growth of embryos and high percentage of larvae hatching are observed only at salinity of 17 - 25 ‰ [18].

In the course of research undertaken it was revealed that unlike the aboriginal mullets the eggs of So-iuy mullet are impregnated in a wider range of salinity. As it is shown by the data given in Figure 1a, in water with salinity of 5 - 45 ‰ the percentage of eggs impregnation make up 60 - 82%. It was found that So-iuy mullet eggs might be impregnated even at lower salinity (2 - 3 ‰). In fresh water no impregnation took place, as spermatozoons lost their motility– only their fluctuation motions were recorded (our observations).

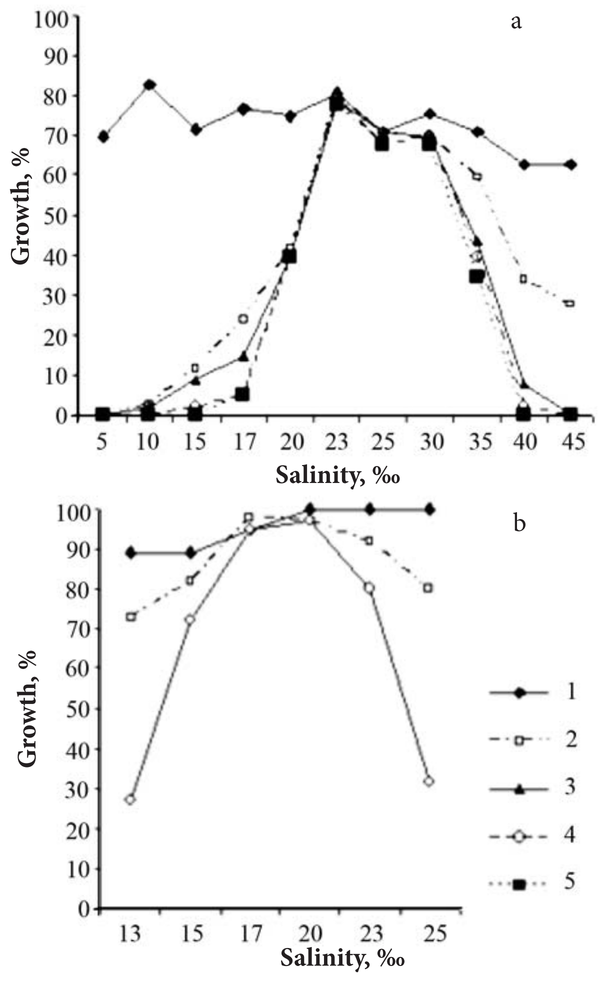

Figure 1. **Impregnation of eggs and embryonic growth of So-iuy mullet in the water with various salinity**: a – breeding stocks (fish farmed under artificial conditions), b – natural populations (1 – cleavage, 2 – gastrula, 3 – organogenesis, 4 – motile embryo, 5 – hatching)

Observations of eggs from fishes of the breeding stock impregnated in the water with various salinities demonstrated that even at the stage of a small –cell morula the growth of a part of embryos ceased in water with salinity less than 20 ‰ and more than 30 ‰. Further with reducing salinity from 20 down to 5 ‰ and with its increasing from 30 up to 45 ‰ at all the stages of embryonic development the embryo mortality increased. Hatching of larvae was observed only within the range of salinity under which positive buoyancy for any certain portion of eggs was fixed, but not less than 40 ‰ (*Figure 1, a*). Obviously, the cause of death of embryos stuck in the surface film in the water with salinity of 40 - 45 ‰, as well as ones fallen on the bottom in the water of low salinity are disturbances in oxygen supply [19].

Thus, for So-iuy mullet from the breeding stocks larvae hatching was observed at 20 - 35 ‰, optimum - at 23 - 30 ‰ (*Figure 1 a*). In the course of acclimatization in the Sea of Azov and the Black Sea the optimum salinity at the early ontogenesis shifted to lower values. For fishes from the Azov population spawning in the Black Sea and in the Kerch pre-strait area it reduced to 17-20 ‰ (*Figure 1, b*).

The data obtained also evidence the high adaptive potential of So-iuy mullet enabling the species to reproduce in the water under a wide range of salinity. For a comparatively short period of time (not more than for 20 years after introduction) self-reproducing populations of So-iuy mullet occurred in the Sea of Azov and the Black Sea.

Neutral buoyancy of So-iuy mullet eggs sampled near the Budak spit (Odessa region) and in the Kerch Strait for the period of spawning migration was recorded in the water with salinity from 14 up to 20 - 21 ‰, mainly at 17 - 18 ‰. It is specific that for some females (approximately 25 %) 5 - 70 % of mature impregnated eggs can keep positive buoyancy in the water with salinity of 12 - 13 ‰.

Along with it, spawning and hatching of So-iuy mullet viable larvae at such salinity, in particular in the waters of the Sea of Azov, may be possible only under certain temperature conditions. As it was shown by us earlier [20], the normal completion of So-iuy mullet ovocytes maturation takes place under temperature 16 - 23 ˚C. Upon intensive warming of the Azov Sea water in spring and summer up to temperature above 23 - 24 ˚C, female maturation often ends with the total resorption of germinal cells, and larvae hatched weakened due to intensive consumption of nutrients in the ovum. As a rule, in the warm water of small salinity they are affected by bacteria.

We have found that for the growth of most So-iuy mullet eggs in the Azov and Black Seas sea water with salinity 17 - 20 ‰ at temperature of 18 - 20˚C is favorable, for striped mullet – 16 - 18 ‰ at 20 - 23˚C and for golden mullet – 17 - 22 ‰ at 19 - 21˚C. After starting the active feeding the favorable temperature range for striped mullet larvae is within 20 - 27˚C, maximum growth is registered at temperature 23 - 26˚C. In this period the salinity of water may be reduced down to 13 - 14 ‰ [18].

After starting the active feeding So-iuy mullet larvae also change their attitude to salinity. As we have revealed [21], that since 6 - 8 days old they are able to withstand the reduction in salinity down to 5 ‰, and after preliminary acclimatization for 2 days in brakish water they may adapt to fresh water (at water temperature 20 – 22 ˚C). Environment salinity reduction after starting the external feeding and especially after starting the silvering period has a stimulating effect on their development and growth.

In rearing So-iuy mullet larvae till 25 days old (till completion of metamorphosis) their increased survival rate was recorded in the brakish water (5 ‰) [22]. Reduced salinity promotes to increased rate of growth and enlarged content of delipidated dry matter and lipids in larvae tissues.

At the same time, for striped mullet juveniles in freshened down to 15 ‰ water the survival rate and growth rate were considerably less than under greater salinity. Variations are associated with increased energetic consumption while reducing the ambient salinity [23]. These data correspond to the outcomes of our research proving the greater stenohaline feature of early juveniles of golden mullet as compared with juveniles of striped mullet and So-iuy mullet.

More intensive growth of larvae and juveniles of golden mullet are recorded in the Black Sea water with salinity of 19 - 20 ‰. Before starting the external feeding and filling the swimming bladder the best parameters of survival and growth rate are observed at temperature 18 - 19 ˚C, and after starting the active feeding - at 22 – 23 ˚C [4].

Thus, while carrying out activities for mullets' artificial reproduction the optimization of such environmental factors as salinity and temperature is of great significance for their growth at early ontogenesis.

CONCLUSIONS

1. Impregnation of mullet eggs takes place within the wide range of salinity (from 5 - 10 ‰ up to 30 - 45 ‰), in the process of embryonic development the optimum rate for salinity gets narrow. In the course of mullet acclimatization in the Azov and Black Seas the range of salinity, being favorable for embryonic and larval growth, shifted to the side of smaller values and made up for striped mullet 16 - 18 ‰, for golden mullet – 17 - 22 ‰ and for So-iuy mullet – 17 - 20 ‰.

2. The optimum temperature for embryonic development of the Azov and Black Seas mullet is respectively 20 – 23 ˚C for striped mullet, 19 – 21 ˚C for golden mullet; 18 – 20 ˚C for So-iuy mulllet.

3. After starting the active feeding the survival rate and growth of striped mullet and So-iuy mullet increased at reduced salinity down to 5 - 14 ‰ and under increased temperature up to 25 – 28 ˚C. The golden mullet grows better in sea water at salinity of 19 - 20 ‰ and under the temperature of 22 – 23 ˚C.

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ВПЛИВ АБІОТИЧНИХ ЧИННИКІВ СЕРЕДОВИЩА НА ЕМБРІОНАЛЬНИЙ ТА ЛИЧИНКОВИЙ РОЗВИТОК КЕФАЛІ АЗОВО-ЧОРНОМОРСЬКОГО БАСЕЙНУ

Досліджено вплив солоності й температури на ранній онтогенез кефалі. Виявлено, що оптимальні значення солоності для нересту та ембріонального розвитку азово-чорноморської кефалі близькі нейтральній плавучості заплідненої й набряклої ікри і варіюють у межах 16 - 18 ‰ у лобана, 18 - 22 ‰ у сингіля та 17 - 20 ‰ у піленгаса. Оптимуми температури для цих видів, відповідно, складали: 20 - 23 °С, 19 - 21 °С і 18 - 20 °С. Після переходу на зовнішнє харчування й завершення метаморфоза у личинок лобана і піленгаса виявляється еврібіонтність до чинників середовища, у сингіля – стенобіонтність

Ключові слова: *кефаль, нейтральна плавучість, солоність, ікра, акліматизант.*

Л. И. БУЛЛИ

ВЛИЯНИЕ АБИОТИЧЕСКИХ ФАКТОРОВ СРЕДЫ НА ЭМБРИОНАЛЬНОЕ И ЛИЧИНОЧНОЕ РАЗВИТИЕ КЕФАЛЕЙ АЗОВО-ЧЕРОМОРСКОГО БАССЕЙНА

Исследовано влияние солености и температуры на ранний онтогенез кефалей. Выявлено, что оптимальные значения солености для нереста и эмбрионального развития азово-черноморских кефалей близки нейтральной плавучести оплодотворенной и набухшей икры и варьируют в пределах 16 - 18 ‰ у лобана, 18 - 22 ‰ у сингиля, и 17 - 20 ‰ у пиленгаса. Оптимум температуры у этих видов, соответственно, составляли: 20 - 23 °С, 19 - 21 °С и 18 - 20 °С. После перехода на внешнее питание и завершение метаморфоза у личинок лобана и пиленгаса проявляется эврибионтность к факторам среды, у сингиля – стенобионтность.

Ключевые слова: *кефали, нейтральная плавучесть, соленость, икра, акклиматизант.*