CHARACTERISTICS OF THE REPRODUCTIVE SYSTEM IN SEXUALLY ADULT FEMALES OF *Sander lucioperca* (L.) FROM DIFFERENT POPULATIONS IN THE PERIOD OF THE REPRODUCTIVE CYCLE

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Abstract. Histological studies of the reproductive system in *Sander lucioperca* females from different populations that live in the water bodies of the Dniester and the Prut basin were performed. It was found that in the females of Dubăsari reservoir the gonads contain two generations of oocytes, whereas in the individuals from Costesti - Stânca reservoir the ovary is filled with only one generation of eggs. In the individuals from Dubăsari reservoir with asynchronous oocyte development throughout the annual reproductive cycle, only one portion of the eggs is spawned, while the second generation of eggs undergoes resorption. As a result, *S. lucioperca* in both reservoirs spawns eggs only one time.

Keywords: oocyte, eggs, gonads, resorption, vitellogenesis, vacuolization, *Sander lucioperca.*

Rezumat. Caracterizarea sistemului reproducător la femelele sexual mature de *Sander lucioperca* (L) din diferite populaţii în perioada ciclului reproductiv. A fost efectuat studiul histologic al sistemului de reproducere la femele din diferite populaţii de *Sander lucioperca*, din bazinele acvatice are râurilor Nistru şi Prut. S-a constatat că gonadele femelelor din lacul de acumulare Dubăsari conţin două generaţii de oocite, în timp ce la cele din Costeşti – Stânca, ovarele conţin doar o generaţie de icre. La indivizii din rezervorul Dubăsari cu dezvoltarea asincronă a oocitelor de-a lungul ciclului de reproducere anual se generează doar o pontă, iar a doua generaţie de oocite este supusă resorbţiei. Astfel, *S. lucioperca* din ambele rezervoare depune icre o singură dată.

Cuvinte cheie: oocit, icre, gonade, resorbţie, vitelogeneză, vacuolizare, *Sander lucioperca*.

INTRODUCTION

Detailed studies on the elucidation of gametogenesis features in *Sander lucioperca* have been performed by TRUSOV (1947; 1949). According to the author, in the females from Lake Ladoga and the Gulf of Pärnu there is some asynchrony in the oocytes growth in phases of vitellogenesis. However, it does not lead to a portioned spawning and it was noted synchronic development of eggs in *Sander lucioperca* individuals from the Don, the Volga and the Kuban rivers. On the basis of comparative histological examination of the gonads during the annual reproductive cycle, TRUSOV established the dependence of sexual cells development on the environmental conditions of their habitat. In the water basins, at different latitudes, in females there were found not only different degree of sexual cells development asynchrony, but different duration of the particular phases of development during the annual cycle (KOSHELEV, 1984).

The gametogenesis of *S. lucioperca*, inhabiting water bodies of the Dniester basin, was described in detail in the papers of many authors. According to the data of STATOVA (1962), in sexually mature individuals from Dubăsari reservoir before the construction of Novo-Dnestrovsc hydroelectric station, the development of germ cells in the initial phases of trophoplasmic growth in the period from August to October is asynchronous, but in the process of vitellogenesis, the oocytes became equal in their development and toward spawning produced a single generation of eggs. In more recent studies, KARLOV (1975) pointed to the emergence in the given water basin of up to 36% of the individuals with asynchronous oocyte development, which lasted until their ovulation.

At the studies of *S. lucioperca* oogenesis in Cuchurgan reservoir STATOVA (1973) emphasized the differentiation of the females after the character of gametogenesis: in some individuals the sexual cells developed asynchronously during the whole reproductive cycle, while in other individuals they developed synchronically. The author connected the differences in gametogenesis with the individuals got in the reservoir from the Dniester River when floods occurred.

In her work on the lower sector of the Dniester, CEPURNOVAVA (1975, 1991) notes a one-time spawning *S. lucioperca*, despite some asynchrony in the development of oocytes in vacuolization phase, which is smoothed in subsequent phases of trophoplasmic growth.

The present paper includes studies of the reproductive system of *S. lucioperca* females inhabiting in the anthropogenically modified conditions of Dubăsari and Costeşti-Stânca reservoirs, which are located in the Dniester basin and the Prut basin respectively.

MATERIAL AND METHODS

For the histological studies, mature females of *S. lucioperca* were used, caught during the spring – winter period (April-February) 2006-2011 from Dubăsari and Costeşti- Stânca reservoirs in amount of 56 and 42 individuals, respectively. The gonad samples were fixed in Bouin's fluid, followed by treating according to standard methods. Gonad maturity stages and phases of oocyte development were determined according to MEIEN (1939), developed for teleosteans, with additions introduced by TRUSOV (1949) for Zander, as well as according to the recommendations of SAKUN & BUTSKAIA (1963). Sections with a thickness of 7 µ were stained after Mallory (ROSKIN & LIVENSON, 1957). Micrographs were made using a microscope "Lomo, Mikmed-2" with video camera, using 10x magnification of eyepiece, 15x of lens.

RESULTS AND DISCUSSIONS

Dubăsari reservoir. According to the histological studies of the gonads in Dubăsari reservoir there inhabit *S. lucioperca* females with one, as well as with two generations of oocytes. In previous studies (TOMNATIK, 1964; TOMNATIK & KARLOV, 1971), there were also observed females with asynchronous vitellogenesis. However, the authors believed that asynchrony in the development of oocytes does not lead to portioned spawning and, eventually, only one generation of eggs ovulates. When forming two generations of oocytes, our studies also indicate the spawning of only the first portion of the eggs, while the second generation of germ cells undergoes resorption (Fig. 1).

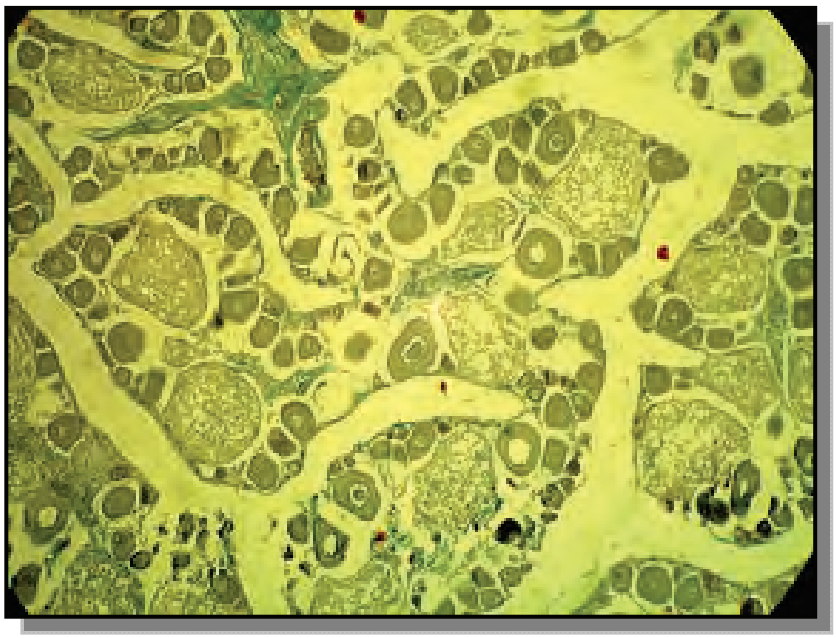

Figure 1. Gonads after the spawning of the first egg portion. Oocytes of the 2nd generation at the beginning stage of resorption (Ocular 10x, objective 15x).

In females with simultaneous development of germ cells in the gonads after spawning, the whole complex of oocytes of the 2nd maturity stage remains that characterizes the one time spawning fish.

According to our earlier studies (FULGA & BODAREU, 1992), the spawning in *S. lucioperca* began in the first and second decades of May. In modern conditions of Dubasari reservoir the females spawn eggs a month earlier than usual. In control catches there are individuals with gonads at stage five in the second decade of April. In this case the crucial role is played by the temperature factor. According to some researchers (STATOVA, 1959; TRUSOV, 1949) the transition of *S. lucioperca* ovary in the fifth maturity stage occurs quickly and lasts a few hours, so it is difficult to determine the spawning time. As the authors point out, the time and duration of the spawning period may vary depending on the temperature of the reservoir. As a result of increased water temperature in winter and spring, the females caught at the beginning of the second decade of May had already the second after spawning stage of gonads. In this state the ovaries remain until September and then move in the third stage of maturity. During this period, the development of eggs is asynchronous. According to the results of previous years (STATOVA, 1962; FULGA & BODAREU, 1992) the oocytes transition to the original accumulation of fat droplets was accomplished in late October and, by the spring (March-April), the oocytes have completed the process of accumulation of yolk granules and moved into the forth stage of gonad maturity. The authors noted the uneven growth of germ cells in the initial phases of trophoplasmic growth period. When gonads passing into the three-A maturity stage the asynchrony in the development of eggs begins to flatten.

Currently, in females with a single generation of oocytes, it can be still observed the unevenness in their development until the transition into a phase of initial accumulation of fat. In catches there are caught females with gonads at stages three-A of maturity in early October. In February, the oocytes in these individuals results in the accumulation of yolk granules and their gonads correspond to three-A-four stage of maturity (Table 1). The oocyte transition in the phase of filled yolk oocyte in the winter months also was noted in previous studies (KARLOV, 1975).

Costeşti-Stânca reservoir. In Costeşti-Stânca reservoir *S. lucioperca* is a single time spawning fish. Its gonads contain one generation of oocytes, as evidenced by the histological studies of female ovaries after they have completed their spawning. Females, in the ovaries of which were found traces of spawning fall in catches in early April. Among the spawned fish, there are also present individuals with gonads at four-A and five stages of maturity that prove the asynchronous maturation of individuals and extended spawning period, which lasts until the second decade of May.

After spawning the female gonads become the six-second stage of maturity and contain only oocytes of protoplasmic growth and follicular membrane in the process of resorption (Fig. 2). It is known that after the resorption of the follicular membrane the ovary passes in the second stage of maturity. According to the studies performed in the past century (STATOVA, 1959; CEPURNOVA, 1975) in *S. lucioperca* from Dubăsari reservoir this process lasts about a month. According to our data, the transition of gonads of sexually mature females from Costeşti – Stânca reservoir into the second stage of maturity occurs within a month and the duration of the protoplasmic growth of oocytes in repeatedly maturing fish is about three months (Table 1).

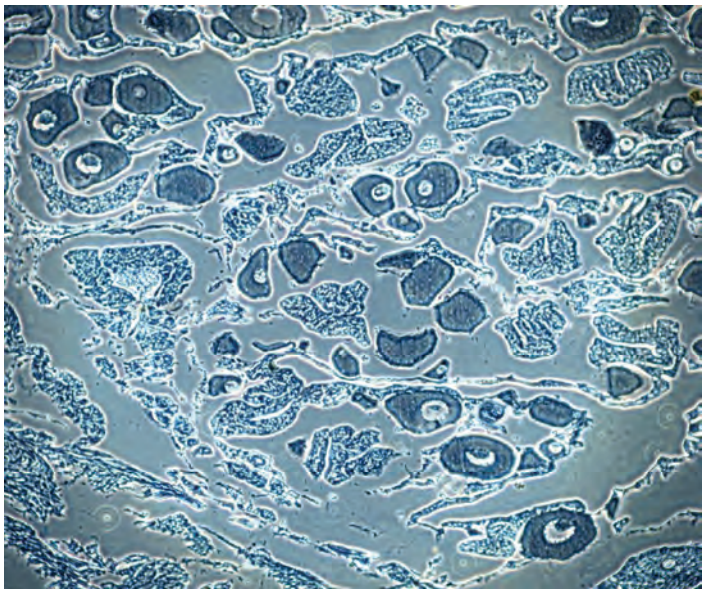

Figure 2. Fragment of zander ovary after spawning (Ocular 10x, objective 15x).

Table 1. State of the reproductive system of sexually mature females of zander from different populations.

Time	Stages of gonad maturity	Phases of oocyte development
Dubăsari reservoir		
2nd decade of April	V VI	Maturation Ovulation
May	VI-II	Resorption of the empty follicular membranes and of second generation oocytes
June	II	Protoplasmic growth
July	II	Protoplasmic growth
August	II-III	Vacuolization of cytoplasm
September	III	Primary yolk accumulation
October 1st decade	III-A	Initial fat accumulation
February	III-A-IV	Completion yolk granules accumulation and fat droplets merge into larger formations
Costești-Stânca reservoir		
1st decade of April	IV-A V VI	Finishing of trophoplasmic growth Maturation Ovulation
2nd decade of May	VI- II	Resorption of the empty follicular membranes
June	II	Protoplasmic growth
July	II	Protoplasmic growth
2nd decade of August	II-III	Vacuolization of cytoplasm
September	III	Primary yolk accumulation
October 2nd decade	III-A	Initial fat accumulation

The transition of the ovaries from the second to the third stage of maturity in females from Costeşti-Stânca reservoir occurs in the second decade of August till October and lasts about two months. In *Sander lucioperca* individuals from Dubăsari reservoir the transition duration in stage three of gonad maturity lasts two months (STATOVA, 1962), while and in the Dniester estuary – four months, from June until late September (CEPURNOVA, 1991).

In the females of *Sander lucioperca* from Costeşti-Stânca reservoir as well as in the individuals from Dubăsari reservoir the development of eggs in the process of vacuolization occurs asynchronously (Fig. 3) and also continues during filling vacuoles with yolk. In *Sander lucioperca* individuals at the northern boundary of the range, in the Gulf of Pärnu and Lake Ladoga, uneven growth of oocytes is observed up to their transition to ovulation (KOSHELEV, 1984).

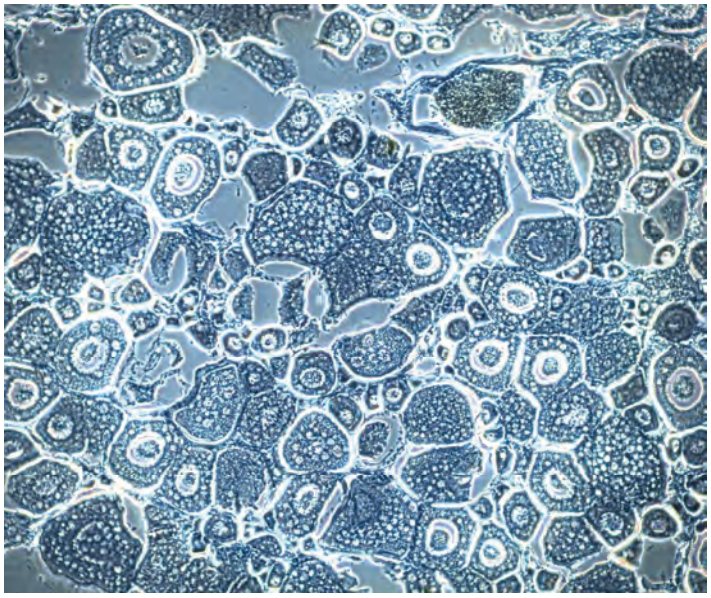

Figure 3. Asynchronous development of oocytes in the phase of vacuolization (Ocular 10x, objective 15x).

The phase of primary accumulation of yolk is characterized by the appearance of vacuoles in the cytoplasm of oocytes filled with yolk. The presence of a significant amount of such cells indicates the gonad transition to stage three of maturity. Such females were caught in early October. The initial phase of fat accumulation is characterized by the presence in the oocyte cytoplasm of clumps of yolk and scattered fat droplets between them. Oocyte membranes progressed in their development. In the radial membrane the striation is clearly visible. Between the cells of the follicular epithelium there are visible borders. In late October, during the transition of the gonads in the three-A stage of maturity and of oocytes to the original accumulation of fat droplets (end of October), the asynchrony in their development is smoothed. As a result, in females, starting with stage three-A of maturity the gonads contain a single generation of eggs (Fig. 4). In some individuals 60% of the oocytes filled with yolk are affected by the resorption process (Fig. 5).

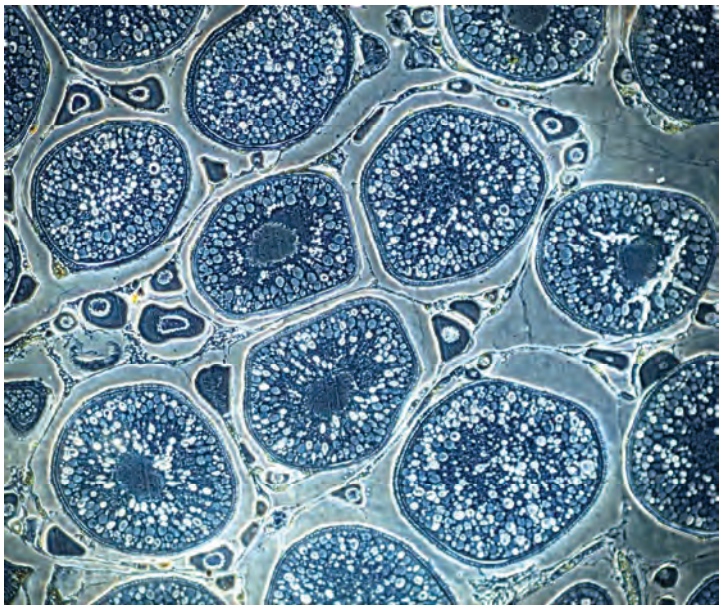

Figure 4. Synchronic development of oocytes in the phase on initial fat droplets accumulation (Ocular 10x, objective 15x).

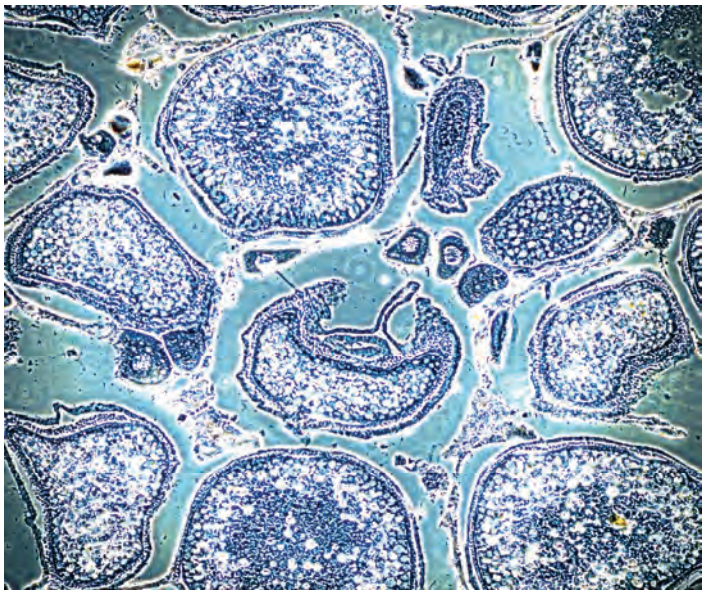

Figure 5. Ovary on the third maturity stage containing oocytes in the process of resorption (Ocular 10x, objective 15x).

In the seventies of the last century cases of mass resorption of oocytes in *Sander lucioperca* from Dubăsari reservoir were not observed (CEPURNOVA, 1975). But in subsequent years of studies, in this water basin, there were identified females with destructive changes in the development of germ cells that have completed vitellogenesis (FULGA & USATYI, 2008). Abnormalities in the structure of yolk oocytes in the absence of conditions for spawning have also been reported for zander in the Danube (KUKURADZE, 1969) and the Volga delta (KOSHELEV, 1984).

CONCLUSIONS

1. In Dubăsari reservoir, there inhabit *Sander lucioperca* females with one as well as with two generations of oocytes. In individuals with asynchronous development of oocytes during the whole year, in the reproduction cycle only one portion of eggs is spawn, while the second generation is subjected to resorption.

2. Due to the increased temperature of the water in the winter-spring period, in *S. lucioperca* from Dubăsari reservoir, it has been a shift of the particular phases of sexual cells development at earlier terms and as a result the zander spawning starts a month earlier than it was noted before the functioning of the Novo-Dniester hydroelectric station.

3. In Costeşti-Stânca reservoir the gonads *S. lucioperca* females contain one generation of oocytes. The duration of spawning season lasts about six weeks (the first decade of April – the second decade of May). The state of ovaries (the sixth-second stage of maturity) lasts one month and a half. The gonads of spawned females contain the entire oocyte complex corresponding to the second stage of maturity that characterizes single time spawning fish.

4. In *S. lucioperca* from Costeşti-Stânca reservoir as well as in individuals from Dubăsari reservoir with a single generation of oocytes the growth in the period vacuolization and of initial accumulation of yolk granules is asynchronous. Unevenness in the development of oocytes begins to flatten in the phase of primary fat accumulation. Only starting from stage three-A of maturity their gonads comprise a single generating of oocytes.

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