HETEROGENEITY IN DEVELOPMENT OF THE OVARIES OF BLEAK, ALBURNUS ALBURNUS (L.) IN LAKE KORTOWSKIE IN NORTH-EASTERN POLAND*

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Key words: Alburnus alburnus, development of ovaries, heterogeneity.

Abstract

Bleak ovaries during the period preceding the reproduction and during reproduction in Lake Kortowskie were studied as concerns reproductive diversity applying standard histological methods. Among 90 females, 88 represented batch spawning while 2 females the total spawning. Presence of female total spawners suggests that sexual maturity can occur in case of the crossbreeds of bleak with one of the total spawner species crossing with bleak.

NIEJEDNORODNOŚĆ W ROZWOJU JAJNIKÓW UKLEI, ALBURNUS ALBURNUS (L.) W JEZIORZE KORTOWSKIM W PÓŁNOCNO-WSCHODNIEJ POLSCE

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Słowa kluczowe: Alburnus alburnus, rozwój jajników, niejednorodność.

Abstrakt

Zbadano, stosując standardowe metody histologiczne, jajniki 90 samic uklei w okresie poprzedzającym rozród i rozrodczym w Jeziornie Kortowskim. U 88 samic stwierdzono cechy porcji tarła, a u 2 całkowitego. Występowanie samiec o całkowitym tarle sugeruje, że może dochodzić do osiągania dojrzałości płciowej przez mieszkańce uklei z którymi spośród czterech krzyżujących się z ukleją gatunków ryb (płóć, kleń, jelec, leszcz) o całkowitym tarle.

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Introduction

Among the species of polycyclic Teleostei fish there are species that are total spawners and species that are batch spawners. On the ovaries of the total spawner species, during the period preceding the reproductive season, vitellogenetic oocytes are present while there are no oocytes in the stage of cortical alveoli. The vitellogenetic oocytes, after reaching the stage of full maturity are excreted during spawning and their numbers determine the actual year fertility of those species. This is the determined fertility (HUNTER et al. 1992). In the ovaries of batch spawner females, during the period preceding the reproductive season, vitellogenetic oocytes that form the first batch of spawn and oocytes in the stage of cortical alveoli, of which consecutive batch of the spawn will form during the reproductive season are present (SAKUN, BUCKAÂ 1968). The year potential fertility is not determined before commencement of spawning and the species with that organization of ovaries development are referred to as species with undetermined fertility (HUNTER et al. 1992). Both the organization of the development of vitellogenetic oocytes in ovaries of female fish and the spawning type are characteristics of individual species (MURUA, SABORIDO-REY 2003). However, in rudd and silver bream – the batch spawning species, females that are total spawners are encountered (TRÂPICYNA 1975, KOPIEJEWSKA 1996, KOPIEJEWSKA 1997, KOPIEJEWSKA, KOZŁOWSKI 2006, 2007). Both species belong to the Leuciscinae subfamily characterized by a relatively large number of combinations of natural crossbreeds (KOTTELAT 1997, ÂKOVLEV et al. 2000) and both species cross with total spawner species: rudd with roach and bream, silver bream with bream (KUDERSKIJ 1956, WHEELER 1969, NIKOLUKIN 1972, SCHWARTZ 1972, 1981, KENNEDY, FITZMAURICE 1973, BRASSINGTON, FERGUSON 1976, KUTUZOV 1983, ECONOMIDS, WHEELER 1989). The crossbreeds of those species reach sexual maturity (KUDERSKIJ 1956, WHEELER 1969, NIKOLUKIN 1972, KUTUZOV 1983, KOPIEJEWSKA et al. 2004). Sexually mature females of rudd and bream crossbreeds (as indicated by experimental research) can be total as well as batch spawners (KOPIEJEWSKA et al. 2007). It can be assumed, as a consequence, that total spawner females in the populations of the rudd and silver bream can be the crossbreeds of rudd and silver bream with total spawner species. Bleak, Alburnus alburnus, is also a species belonging to the Leuciscinae subfamily (KOTTELAT 1997). It is characterized by batch spawning and it crossbreeds with total spawner species such as roach, chub, dace and bream (KUTUZOV 1983, BIALOKOZ, MŁYNIEC 2000). So far, sexually mature crossbreeds of bleak with those species are not known. The purpose of the presented study was to determine whether among the female bleaks there are total spawner females.
Materials and Methods

During the years 2004 and 2005, during the period preceding reproduction and during reproduction season 90 female bleaks were collected from Lake Kortowskie (north-eastern Poland) – Table 1.

The central cuts of the right and left part of the ovaries of those females were fixed in buffer formalin, dehydrated and next placed in paraffin. Slices 7 μm thick were stained with haematoxylin and eosin (ZAWISTOWSKI 1986).

<table>
<thead>
<tr>
<th>Date</th>
<th>n</th>
<th>Body length (Sl cm)</th>
<th>Body weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>02.06.2004</td>
<td>16</td>
<td>8.9–12.7</td>
<td>8.7–27.7</td>
</tr>
<tr>
<td>10.06.2004</td>
<td>2</td>
<td>9.0–9.8</td>
<td>9.2–9.9</td>
</tr>
<tr>
<td>25.06.2004</td>
<td>10</td>
<td>8.7–12.6</td>
<td>11.0–27.9</td>
</tr>
<tr>
<td>28.06.2004</td>
<td>5</td>
<td>10.5–12.7</td>
<td>15.0–30.0</td>
</tr>
<tr>
<td>14.07.2004</td>
<td>7</td>
<td>9.6–11.7</td>
<td>10.4–23.5</td>
</tr>
<tr>
<td>24.05.2005</td>
<td>22</td>
<td>9.3–12.2</td>
<td>11.7–24.8</td>
</tr>
<tr>
<td>01.06.2005</td>
<td>10</td>
<td>9.2–12.3</td>
<td>9.0–24.0</td>
</tr>
<tr>
<td>15.06.2005</td>
<td>9</td>
<td>9.6–12.3</td>
<td>11.5–26.0</td>
</tr>
<tr>
<td>24.06.2005</td>
<td>9</td>
<td>10.1–12.1</td>
<td>10.6–20.7</td>
</tr>
</tbody>
</table>

The oocytes development stages were determined according to SAKUN and BUCKA (1968) as well as WALLACE and SELMAN (1981), TYLER and SUMPTLEM (1996), MURUA and SABORIDO-REY (2003). In the ovaries the following stages were identified: primary growth, cortical alveoli, vitellogenesis and maturation. The percentage shares of oocytes in the stages of cortical alveoli and vitellogenesis were determined according to the formula by ABERCROMBIE after MARRABLE (1962):

\[ N = \frac{nT}{(T + D)} \]

where \( N \) – numbers of oocytes, \( n \) – number of cross sections of oocytes in a given maturity stage in three serial slices of the left and right part of the ovaries, \( T \) – slice thickness, \( D \) – arithmetic average of the diameters of 20 oocytes at a given stage of maturity. The Abercrombie formula in studies of that type can be applied which was proven in the work by KOPIEJEWSKA (2003).
Results

Among 40 female bleaks collected for studies in 2004, 38 had the ovaries possessing characteristics of batch spawner and 2 with the characteristics of total spawner (Figure 1A, 1B, 1C, Table 2). In the ovaries of females showing the characteristics of batch spawner simultaneously two groups of oocytes: in the stage of vitellogenesis / maturing and oocytes in the stage of cortical alveoli were present. In the ovaries of one of the females possessing the characteristics of total spawner there were oocytes in the stage of maturing only and there were no oocytes in the stage of cortical alveoli. In the ovaries of the second female there were follicles

![Diagram](image-url)

**Fig. 1.** Cross sections of ovaries of bleak from Lake Kortowskie: A – oocytes in the final stage of vitellogenesis (fv) and oocytes in the stage of cortical alveoli (ca) in ovaries of bleak during the period preceding spawning, B – oocytes that are ripe (r) and oocytes in the stage of primary growth (pg); absence of oocytes in the stage of cortical alveoli in the ovaries of the bleak 11.7 cm in length and 23.5 g in weight collected for studies on 14.07.2004, C – post-ovulatory follicles (pof) and oocytes at the stage of primary growth (pg); absence of oocytes in the stage of cortical alveoli in the ovaries of the bleak 10.3 cm in length and 12.1 g in weight collected for studies on 14.07.2004, D – atrophy of oocytes of the oldest generation (a) in the ovaries of the bleak collected for studies on 14.07.2004, E – post-ovulatory follicles (pof), oocytes in the initial stage of vitellogenesis (iv), oocytes in the stage of cortical alveoli (ca) in ovaries of the bleak after the first spawning. Scale = 100 μm
from ovulation of oocytes and there were no oocytes in the stage of *cortical alveoli*. During the period of June and the first half of July, only in the above mentioned female with characteristics of a total spawner the post-ovulatory follicles were observed while in case of the other females the oocytes of the eldest generations did not ovulate. At the end of June and in July the oocytes of those generations were subject to atrophy (Figure 1D).

All the females collected for the studies in 2005 had ovaries with characteristics of batch spawners. Oocytes in the stage of *cortical alveoli* were present in the ovaries simultaneously with the oocytes in the stage of vitellogenesis or maturing during the period preceding the reproduction season (Table 2) as well as after the first spawning simultaneously with the post-ovulatory follicles. Following the first spawning, in the eldest generations of oocytes in that stage, vitellogenesis started (Figure 1E).

| Table 2 |

| Share of oocytes in the stages of: vitellogenesis/maturing and *cortical alveoli* in the ovaries of bleak from Lake Kortowskie during the period preceding the reproductive season of the years 2004–2005 |

<table>
<thead>
<tr>
<th>Body length (cm)</th>
<th>Body weight (g)</th>
<th>Final stage of vitellogenesis/mature</th>
<th>Final stage of <em>cortical alveoli</em></th>
<th>Initial stage of <em>cortical alveoli</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>Ø µm</td>
<td>SD</td>
</tr>
<tr>
<td>Year 2004</td>
<td></td>
<td>%</td>
<td>Ø µm</td>
<td>SD</td>
</tr>
<tr>
<td>9.4</td>
<td>9.7</td>
<td>52.3</td>
<td>736</td>
<td>35.83</td>
</tr>
<tr>
<td>10.3</td>
<td>13.2</td>
<td>50.2</td>
<td>967</td>
<td>79.73</td>
</tr>
<tr>
<td>10.8</td>
<td>16.2</td>
<td>38.0</td>
<td>914</td>
<td>59.41</td>
</tr>
<tr>
<td>12.0</td>
<td>27.9</td>
<td>51.2</td>
<td>962</td>
<td>38.83</td>
</tr>
<tr>
<td>12.5</td>
<td>27.3</td>
<td>41.2</td>
<td>862</td>
<td>62.24</td>
</tr>
<tr>
<td>Year 2005</td>
<td></td>
<td>%</td>
<td>Ø µm</td>
<td>SD</td>
</tr>
<tr>
<td>9.2</td>
<td>9.0</td>
<td>51.6</td>
<td>725</td>
<td>34.89</td>
</tr>
<tr>
<td>10.0</td>
<td>12.3</td>
<td>54.9</td>
<td>921</td>
<td>45.09</td>
</tr>
<tr>
<td>10.9</td>
<td>18.9</td>
<td>51.4</td>
<td>925</td>
<td>69.12</td>
</tr>
<tr>
<td>11.4</td>
<td>21.0</td>
<td>56.1</td>
<td>832</td>
<td>73.83</td>
</tr>
<tr>
<td>12.3</td>
<td>24.0</td>
<td>55.2</td>
<td>906</td>
<td>73.71</td>
</tr>
</tbody>
</table>

* oocytes at final and middle *cortical alveoli* stages

The first spawning of the bleak took place during the first half of the third decade of June. All the females examined, during that period, had post-ovulatory follicles in the ovaries. However, during the earlier period (May 24, June 1 and 15) in each sample of the females there was one female that has completed the spawning. In the ovaries of those females post-ovulatory follicles and oocytes at the initial stage of vitellogenesis were present.
Discussion

The results obtained confirm that bleak is a batch spawner with undetermined fertility (HUNTER et al. 1992). The results showed that among batch spawner females, females that are total spawners with defined fertility can be found. Batch spawning, according to BURT et al. (1988), FORDHAM and TRIPPÉL (1999) is linked to small body size and relatively small size of the ovaries. The bleak females that were total spawners in this study did not stand out by the body size and were within the range of body length and weight of batch spawner females. Similarly, in the silver bream populations, total spawner females were average or among the larger ones in the group of females that were batch spawners (KOPIEJEWSKA 1997, KOPIEJEWSKA, KOZŁOWSKI 2007). In the population of rudd, the female that was the total spawner was the smallest among the batch spawner females (KOPIEJEWSKA, KOZŁOWSKI 2006).

In the populations of *Cottus gobio* and *Noemacheilus barbatulus* (batch spawners) populations are found in which females spawn once a year. The changes in the number of the batches of oocytes are linked to the growth rate, environment productivity and geographic latitude at which the population is present (MANN et al. 1984). In the population of rudd in the Volga River delta, total spawning in some of the females was found three times during the periods of studies. In the ovaries of the females after spawning the oocytes in the stage of primary growth, cortical alveoli and numerous resorbed empty follicles were found (TRAPICYNA 1975). Experimental studies on sexual maturing of crossbreeds of rudd and bream indicated that crossbreeding of fish species with different types of spawning results in different types of spawning in case of those crossbreeds (KOPIEJEWSKA et al. 2007). It can be assumed that total spawner rudds in the delta of the Volga as well as the total spawner bleaks from the presented studies could be the sexually mature crossbreeds with total spawner species. As a consequence, bleak was another species of Leuciscinae, the crossbreeds of which with Leuciscinae species that are total spawners with which bleak can crossbreed (KUTUZOV 1983) that achieves sexual maturity. The issue requires conducting studies on crossbreeds of bleak with species crossbreeding with it that are total spawners under experimental conditions.

Conclusions

The studies showed that reproductive heterogeneity of females can be found in populations of bleak, which manifests in presence of females that are total spawners among the batch spawners. Presence of total spawner females suggests that sexual maturity can be reached by crossbreeds of bleak with one of the species crossbreeding with bleak (roach, silver bream, dace, bream) that is a total spawner.
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