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Fish biology

# CHANGES OF GONADOSOMATIC INDEX (GSI) AND EGG DIAMETER IN THE GRAYLING *THYMALLUS THYMALLUS* (L.) IN ANNUAL CYCLE

# ZMIANY WSKAŹNIKA GONADOSOMATYCZNEGO (GSI) I ŚREDNICY IKRY U LIPIENIA *THYMALLUS THYMALLUS* (L.) W CYKLU ROCZNYM

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The most intense growth of grayling ovaries takes place in autumn and winter (September – March), of testes – in summer (July – September). Older females and males all seasons have a higher GSI, and the diameter of developing eggs is higher.

## INTRODUCTION

Among freshwater fishes of Europe, the grayling *Thymallus thymallus* (L.) is one of the species which are of angling importance in mountain and submontane rivers. Because of this in many countries it is farmed under artificial conditions, and the resulting progeny is released in rivers. In spite of the existing and improving culture methods (Kupka 1966, Kowalewski 1988, Roth, Nef 1967, Sommani 1953) many aspects of its biology and ecology, and especially reproduction require further studies.

The aim of this study was to trace changes of gonad weight and egg size in mature fish under natural conditions in annual cycle. For this purpose the population from the river Dunajec has been selected which is characterized by a high growth rate and fertility (Błachuta et al. 1982).

## MATERIAL AND METHODS

The graylings were caught in the middle section of the river Dunajec (Vistula basin, S. Poland), at ± month intervals using electrofishing equipment (December-April) and fishing rods – artificial flies (May–October), from May 1978 to April 1979. A total of 396 fish was used in the studies, 198 ♀♀ and 198 ♂♂, sexually mature. More detailed data on the material are summarized in tab. 1. The fish were measured to the nearest 1 mm, and weighed to the nearest 1 g, and gonads to the nearest 0.001 g. The age was read from scales taken from the 2nd or 3rd row above the lateral line, between the dorsal (D) and the adipose (Ad) fin (Błachuta et al. 1986). The gonadsomatic index (GSI) was calculated for

Tabela 1

Materials of *Thymallus thymallus* used for studies

| Sampling data | Sex | n | Tl (mm) | w (g) | age |
|---|---|---|---|---|---|
| 23 I 1979 | f | 1 | 330 | 340 | $2^+$ |
| | m | 5 | 323–352 | 315–400 | $2^+$ |
| 20 II | f | 15 | 297–373 | 270–550 | $2^+ - 3^+$ |
| | m | 25 | 305–357 | 270–405 | $2^+$ |
| 20 III | f | 6 | 309–350 | 305–440 | $2^+$ |
| | m | 8 | 247–340 | 140–375 | $1^+ - 2^+$ |
| 14 IV | f | 21 | 228–357 | 125–575 | $1^+ - 4^+$ |
| | m | 19 | 255–391 | 175–510 | $1^+ - 3^+$ |
| 20 V 1978 | f | 19 | 274–357 | 200–350 | $2^+ - 4^+$ |
| | m | 16 | 268–373 | 185–415 | $1^+ - 4^+$ |
| 17 VI | f | 29 | 236–380 | 115–505 | $2^+ - 4^+$ |
| | m | 17 | 263–388 | 180–475 | $2^+ - 4^+$ |
| 17 VII | f | 19 | 267–364 | 170–395 | $2^+ - 4^+$ |
| | m | 16 | 265–363 | 150–400 | $1^+ - 3^+$ |
| 13 VIII | f | 21 | 274–361 | 180–425 | $4^+$ |
| | m | 23 | 288–320 | 215–280 | $2^+$ |
| 17 IX | f | 14 | 274–320 | 170–330 | $2^+ - 3^+$ |
| | m | 19 | 249–383 | 130–390 | $1^+ - 4^+$ |
| 18 X | f | 17 | 275–368 | 140–415 | $2^+ - 3^+$ |
| | m | 20 | 255–397 | 185–485 | $1^+ - 4^+$ |
| 11 XI | f | 23 | 285–352 | 180–325 | $2^+ - 3^+$ |
| | m | 22 | 294–347 | 200–320 | $2^+ - 3^+$ |
| 24 XII | f | 13 | 282–395 | 205–665 | $2^+ - 4^+$ |
| | m | 8 | 255–386 | 140–495 | $1^+ - 2^+$ |

both sexes, expressing the gonad weight as percentage of body weight. The egg diameter was calculated for each fish from three samples containng 50 eggs, taken from various parts of the ovary (anterior, mid and posterior).

## RESULTS

### Gondosomatic index

The GSI changes in grayling females and males in consecutive months are presented in fig. 1.

During the first two months after spawning the ovary weight is low and amounts to c. 0.8 % body weight, and until June a decrease in the GSI value is observed. This is

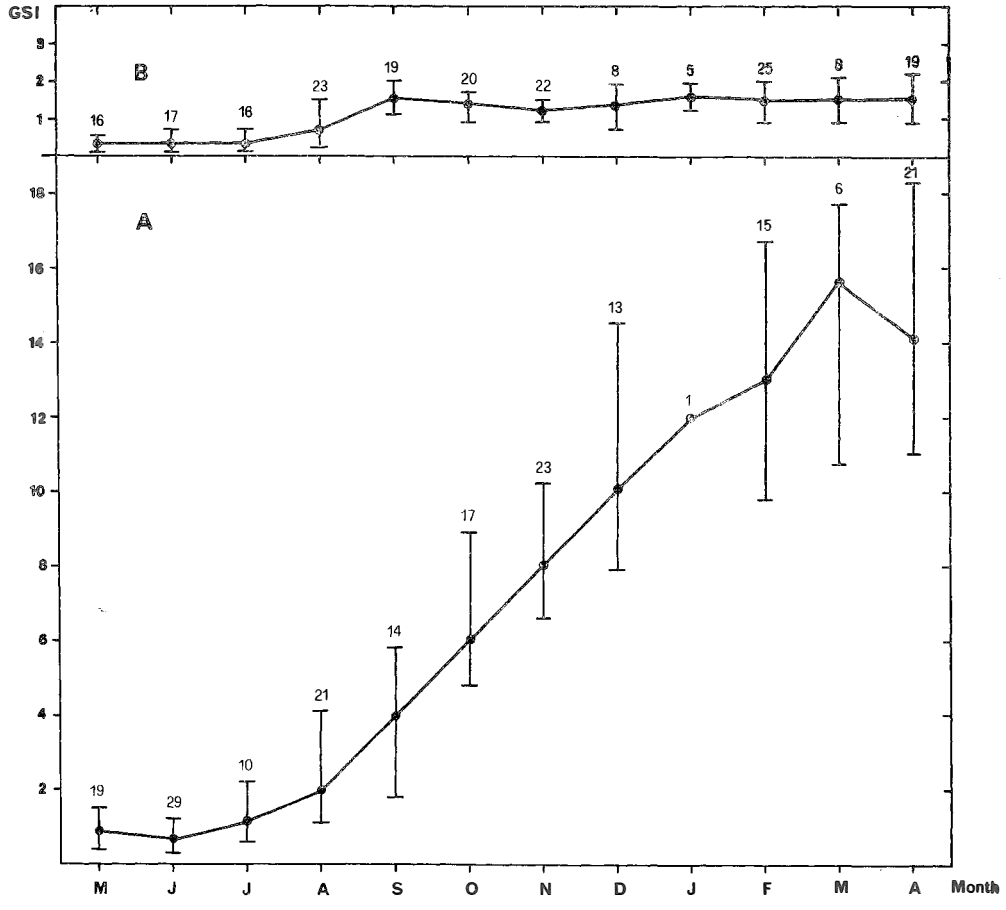


Fig. 1. Changes of gonadosomatic index (GSI) in consecutive months (A – females, B – males)

associated with the gradual resorption of eggs not expelled during spawning. Beside young oocytes, degenerating eggs and empty follicular envelopes (10–15%) have been observed. From that moment until August the ovary weight increasses slowly. The most intense growth takes place as late as autumn and winter (September-March), and the highest GSI values are observed in March and at the beginning of April – 15.7 and 14.1 respectively.

In males the rate of testis development is somewhat different. During the first three months after spawning (May–July) the GSI values are low and amount to c. 0.3%. The quickest growth takes place from July to September. From that moment until spawning the testis weight is practically constant and varies within a very narrow range, the GSI being 1.12–1.63.

Changes in the GSI depending on the age of fish are presented in tab. 2. Because in the material examined fish aged below 2 and above 4 years were few, only two most numerous age classes ($2^+$ and $3^+$) have been analyzed. It follows from the comparison that older graylings, both females and males, have each month distinctly higher GSI values.

**Table 2**

Age – dependent GSI changes in annual cycle of females and males
*Thymallus thymallus*

| Sex, age \ Month | M | J | J | A | S | O | N | D | J | F | M | A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ♀♀ $2^+$ | 0.50 | 0.52 | 0.92 | 1.66 | 3.99 | 5.87 | 7.80 | 9.41 | 12.04 | 12.53 | 15.53 | 13.67 |
| ♀♀ $3^+$ | 1.04 | 0.99 | 1.54 | 2.44 | 4.26 | 6.65 | 9.57 | 11.37 | – | 16.16 | – | 15.33 |
| ♂♂ $2^+$ | 0.22 | 0.28 | 0.28 | 0.77 | 1.60 | 1.47 | 1.14 | 1.37 | 1.63 | 1.52 | 1.56 | 1.34 |
| ♂♂ $3^+$ | 0.27 | 0.30 | 0.27 | – | 1.71 | 1.31 | 1.10 | 1.53 | – | – | – | 1.61 |

## Egg diameter

Changes in the egg size during the whole year are presented in fig. 2. The increase in the oocyte diameter has a course similar to that of the entire ovary. In May and June the oocyte diameter does not undergo any greater changes and amounts to 0.67 and 0.71 mm, respectively. The gradual growth takes place only beginning with July, and is the quickest from September. Immediately before spawning the eggs are 2.67 mm in diameter.

The analysis of diameter of eggs of females aged $2^+$ and $3^+$ has shown that the latter have distinctly larger oocytes during all the months of a year.

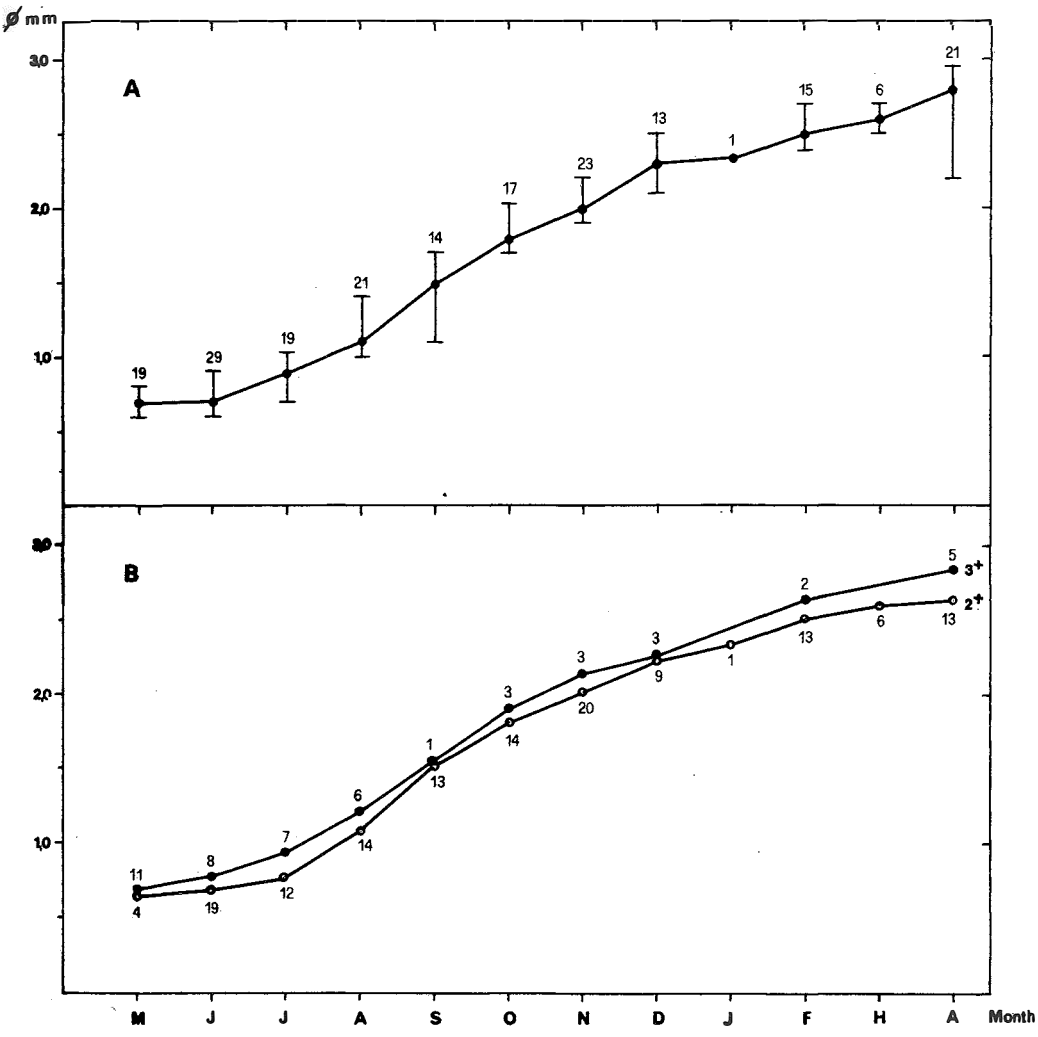


Fig. 2. Changes of egg diameter in consecutive months (A – all females aged from $1^+$ to $4^+$, B – females aged $2^+$ and $3^+$)

## DISCUSSION

A knowledge of the cyclic character and development rate of fish gonad, may have, beside its scientific value, a high practical significance, especially in case of economically important species. Because of this the studies on the stages of sexual maturation in fish, both micro- and macroscopic, started early and the literature is abundant.

The grayling, because of its angling importance, is bred in many countries, also artificially (see bibliography of the genus *Thymallus* – Armstrong et al. 1986). The knowledge of the processes taking place in its gonads can contribute considerably to increase of the quantity of stock material.

The species spawns in one portion at short time intervals (1–2 days) (Fabricius, Gustafson 1955). In the Dunajec and its tributaries this happens as a rule in the first days of April (Witkowski, Kokurewicz 1978, Witkowski, Kowalewski 1988).

Like in other species, in the grayling the GSI changes show rather marked stages. The decrease in the value of the index in females during the first two months after spawning is associated with resorption of unexpelled eggs. The duration of the process in other species may reach several months. In *Coregonus albula* L. the decrease in the relative weight of ovaries continues during two months (Backiel 1952), in *Abramis brama* (L.) only one month (Bryliński, Długosz 1970). In *Rutilus rutilus* (L.) from waters of natural thermal regime resorption of empty follicular envelopes lasts from 1.5 to 2 months, and in heated reservoirs the time is still much shorter (Długosz 1983). The slow increase in the GSI observed in female graylings from June to August is associated, like in other fishes, with the stage of ovary reconstruction, the ovary being at that time in the period of its slow growth (Witkowski et al. 1984). A period of rapid gonad growth begins in this species already in September. From that moment the ovary weight increases very rapidly. During that period the females show also the greatest food demands which is reflected by the highest indices of filling (Błachuta 1987). This is also confirmed, though indirectly, by the increased feeding intensity of females in September and October (Witkowski, Kowalewski 1988). According to Witkowski et al. (1984) during those and subsequent months, as a result of rapid process of vitellogenesis, the oocytes accumulate yolk platelets and lipid droplets. Such a diversification of the growth rate of ovaries into two periods was recorded also in *Perca fluviatilis* L., *Rutilus rutilus* (L.), *Coregonus albula* L. *Abramis brama* (L.), *Stizostedion lucioperca* (L.), *Cottus gobio* L., *C. poecilopus* Heck. (Backiel 1952, Brylińska, Długosz 1970, Chicewicz 1959, Meien 1927, 1940. Starmach 1965).

A high GSI value close to that observed just before spawning is reached by male graylings already 7–8 months earlier. In a closely related species *Coregonus albula*, breeding in late autumn or in the beginning of winter the intense testis growth takes place within a much shorter period and is completed 3–4 months before spawning (Backiel 1952).

The changes in the weight of ovary in annual cycle result from the process taking place inside it. In case of oocytes the growth has a course similar to that of entire ovaries. The differences in the egg diameter observed between individuals of various age classes confirm data of other authors (Domagała, Trzebiatowski 1987) who have shown that older, and thus as a rule larger females produce larger eggs. The changes observed, both of gonadosomatic index and egg diameter, in the European grayling are characteristic of fishes of a cyclic, single, spring spawning (Koželov 1984).

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## ZMIANY WSKAŹNIKA GONADOSOMATYCZNEGO (GSI) I ŚREDNICY IKRY U LIPIENIA *THYMALLUS THYMALLUS* (L.) W CYKLU ROCZNYM

### STRESZCZENIE

Badania przeprowadzono na materiale liczącym 396 osobników lipieni (198 ♀♀ i 198 ♂♂) złowionych w Dunajcu we wszystkich miesiącach roku w latach 1978–1979 (Tab. 1).

W ciągu sezonu wegetacyjnego rozwój gonad dojrzałych płciowo lipieni wykazuje wyraźną etapowość. Spadek GSI jajników w ciągu dwóch miesięcy po tarle związany jest z resorbcją niewydalonych jaj. Okres wolnego wzrostu przebiega od czerwca do lipca, a przyśpieszonego od września do marca. Jądra rozwijają się najszybciej od lipca do września, osiągając pod koniec tego okresu wartości GSI zbliżone do przedtarłowych (Rys. 1).

Osobniki starsze przez cały okres roku mają wyższe wartości GSI niż młode (Tab. 2), a starsze samice charakteryzują się większymi rozmiarami jaj (Rys. 2).

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