Arch. Ryb. Pol.	Archives of Polish Fisheries	Vol. 6	Fasc. 1	27 - 35	1998

RELATION BETWEEN EGG SIZE AND BODY SIZE AND AGE OF FEMALES IN BROOK TROUT (*Salvelinus fontinalis* Mitchill)

Daniel Dlaboga, Ryszard Bartel**, Krzysztof Bieniarz*, Piotr Epler**

*Department of Ichthyobiology and Fisheries, Academy of Agriculture in Cracow
**Laboratory of River Fisheries in Gdańsk, Inland Fisheries Institute in Olsztyn

A B S T R A C T. Maximum and minimum diameter of swollen eggs, and size of females (total length, and body mass) were measured. The eggs were obtained from 355 females in course of an artificially induced spawning . Ten eggs from each female were measured. The results indicate that: 1 – brook trout egg size is not related to the size of females but to their age, 2 – measuring one diameter (maximum or minimum) only is sufficient to estimate the egg size, 3 – brook trout eggs are ellipsoidal, with slight difference between maximum and minimum diameter, 4 – the eggs become more globular as females size increases.

Key words: SALMONID FISH, BROOK TROUT, SIZE OF EGGS.

INTRODUCTION

Brook trout was introduced to Europe (including Poland) from North America in the second half of 19th century (Jędruszczyk-Ząbek 1988, Migdalski, Fichter 1989, Goryczko 1991). Fish were introduced mainly to upper parts of streams, since it was thought to be better adapted to such conditions than the autochthonous brown trout. It became, however, an efficient competitor of the latter, creating a risk of outcompeting the brown trout from its habitat (Żarnecki 1955). Extensive stocking of streams with brook trout carried out by PZW (Polish Anglers Association) revealed that it was not possible to create natural populations relying on natural spawning only. Thus, introductions to natural waters were stopped in 1986.

Brook trout, however, and its hybrids with other salmonid fish species, are perfect game fish (Grudniewski 1991) for special fishing grounds.

Angling on artificial fishing grounds becomes a more and more popular way of recreation, thus rearing of game fish should be profitable. Detailed knowledge on the biology of game fish is essential for successful rearing. There is no information on the relation between egg size and size or age of brook trout females. Such relations differ among fish species, and various methods of measurement are applied (see: reference

review, Bartel 1971b).

The issue seems interesting as egg size affects size of hatched larvae, and larger larvae are more likely to survive and to grow faster (Blaxter, Hempel 1963, Juszczyk 1951, Sadov 1963).

The aim of the present study was to answer the question whether egg size of brook trout is related to the size (length, mass) or to the age of the female. Additionally, it was investigated if it was necessary to measure both egg diameters, or if one of them sufficed to estimate the egg size.

MATERIAL AND METHODS

Eggs and females of brook trout (*Salvelinus fontinalis* Mitchill) used in the study were obtained from the ponds of the Laboratory of River Fisheries in Gadańsk (Inland Fisheries Institute in Olsztyn). The eggs were collected from the same females at the age of 2 years (114 individuals), 3 years (96 individuals), 4 years (53 individuals), and 5 years (16 individuals). The first samples were collected in 1966. Eggs were also collected from the female offspring of the fish sampled in 1966: 2 years old (5 individuals), 3 years old (25), and 4 years old (18). These fish were sampled for the first time in 1970.

In 1971, eggs from 28 five years old females from another stock were also collected.

Total number of 355 females, and 10 eggs from each were studied. Body length and mass of the fish ranged from 14.0 to 49.0 cm, and 30 to 1700 g respectively.

Fully swollen eggs were measured 1 h after their first contact with water (Zotin 1955, 1961, Winnicki, Bartel 1967, Winnicki 1968). In all the eggs, the shortest and the longest diameter was measured, from which the mean diameter was calculated for each egg. The eggs were measured using a light microscope with calibrated eye-piece, with 0.01 mm accuracy.

The females were measured (*longitudo totalis*) with 1 cm accuracy, and weighed with 10 g accuracy.

The results were subjected to statistical analysis (Eland 1964).

Mean maximum and minimum diameters were calculated for the eggs of each female. The relation between the two diameters was analysed, and correlation coefficient "r" was calculated. Relations between egg diameters and:

- female length (regression coefficient "b")
- female mass (regression coefficient "b")

– female age (regression coefficient "b")

were established. Maximum to minimum diameter ratio was also calculated to estimate egg shape, and its relation to fish size, using the data obtained for 114 females in 1966.

RESULTS

RELATION BETWEEN EGG DIAMETERS AND LENGTH OF FEMALES (Table I).

Relation between length of females and mean egg diameter.

Regression coefficient "b" ranged from – 0.08 (for 5 years old females of 1969) to 0.03 (2 years old fish of 1966, and 3 years old fish of 1971). The regression was statistically significant (p.05) in one case, and in one – highly significant (p.01).

Relation between length of females and maximum egg diameter.

The lowest regression coefficient value – 0.004 was obtained for 2 years old females of 1966, and the highest, 0.04, in 4 years old females of 1968. In two cases (3 and 5 years old fish of 1971) the regression was highly significant (p.01).

Relation between length of females and minimum egg size.

Regression coefficient ranged from 0.03 (in 2 years old females of 1970) to 0.03 (in 4 years old fish of 1968). Regression was highly significant in two cases: (p.01, for 4 years old females of 1968, and 5 years old ones of 1971). In the other 6 cases it was not significant.

RELATION BETWEEN BODY MASS OF FEMALES AND EGG DIAMETERS (Table II)

Relation between body mass of females and mean egg diameter.

The lowest regression coefficient – 2.58 was obtained for 2 years old females of 1970, and the highest - 0.93 in 3 years old fish of 1971. Regression was significant (p.05) in case of 4 years old females of 1968, and highly significant (p.01) for 5 years old fish of 1971. In the other 6 cases the regression was not significant.

Relation between body mass of females and maximum egg diameter.

Regression coefficient ranged from 0.75 (2 years old fish of 1970) to 1.09 (3 years old fish of 1971). Regression was significant (p.05) for 3 years old fish of 1971, and highly significant (p.01) for 3 and 5 years old fish of 1971.

Relation between body mass of females and minimum egg diameter.

The lowest regression coefficient 4.4 was obtained for 2 years old females of 1970,

TABLE I

Relation between egg diameters and body length of females

Year	Num-bers	Age	Female length (cm)			Mean egg diameter (mm)			Maximal egg diameter (mm)			Minimal egg diameter (mm)			Regression coefficient "b" and parameter "a" from the equation y=bx + a		
			x	SD	range	x	SD	range	x	SD	range	x	SD	range	mean diameter	maximal diameter	minimal diameter
1966	114	2	25.54	2.87	18-31.5	4.01	1.13	3.69-4.29	4.14	0.19	3.82-4.44	3.89	0.13	3.6-4.14	a = 3.93	a = 4.23	a = 3.74
															b = 0.03	b = 0.004	b = 0.006
1967	96	3	30.47	2.18	24-35	4.58	0.14	4.29-4.89	4.62	0.14	4.42-5	4.47	0.14	3.9-4.79	a = 4.30	a = 4.54	a = 4.09
															b = 0.009	b = 0.005	b = 0.01
1968	53	4	36.21	2.06	31-41	4.79	0.14	4.5-5.22	4.98	0.44	4.67-5.32	4.66	0.15	4.3-5.12	a = 3.84	a = 3.30	a = 3.53
															b = 0.02*	b = 0.04	b = 0.03**
1969	16	5	41.78	1.47	39.5-46	5.14	0.12	4.95-5.36	5.3	0.14	5.08-5.56	4.98	0.11	4.8-5.15	a = 5.55	a = 5.98	a = 5.12
															b = O.O8	b = 0.01	b = -0.003
1970	5	2	15.7	1.48	14-18	4.01	0.05	3.95-4.07	4.14	0.04	4.08-4.19	3.86	0.07	3.8-3.95	a = 4.34	a = 4.22	a = 4.47
															b = 0.02	b = -0.005	b = -0.03
1971	25	3	31.6	1.89	28-35	4.88	0.15	4.55-5.09	5.01	0.16	4.66-5.2	4.76	0.14	4.4-4.95	a = 3.82	a = 3.79	a = 3.85
															b = 0.03	b = 0.03*	b = 0.02
1972	18	4	33.25	5.2	27-41	4.75	0.21	4.44-5.38	5.07	0.15	4.66-5.69	4.61	0.13	4.43-5.3	a = 4.70	a = 4.82	a = 4.59
															b = 0.001	b = 0.002	b = 0.002
1971	28	5	32.94	4.17	28-49	4.92	0.13	4.44-5.95	4.89	0.22	4.59-5.13	4.78	0.20	4.82-4.3	a= 3.89	a = 4.04	a = 3.01
															b = 0.02**	b = 0.03**	b = 0.02**

**significant(p<0,05) regression coefficient*

***highly significant (p<0,01) regression coefficient*

TABLE II

Relation between egg diameters and body mass of females

Year	Num-bers	Age	Female mass			Mean egg diameter (mm)			Maximal egg diameter (mm)			Minimal egg diameter (mm)			Regression coefficient "b" and parameter "a" from the equation y=bx + a		
			x	SD	range	x	SD	range	x	SD	range	x	SD	range	mean diameter	maximal diameter	minimal diameter
1966	114	2	0,11	0,06	09-0,38	1,01	0,13	3,69-4,29	4,14	0,19	3,82-4,44	3,89	0,13	3,60-4,14	a = 4,0	a = 4,18	a = 3,85
															b = 0,1	b = -0,20	b = 0,22
1967	96	3	0,38	0,07	22-0,51	4,58	0,14	4,29-4,89	4,62	0,14	4,42-5	4,47	0,14	3,90-4,79	a=4,49	a=4,64	a=4,35
															b = 0,24	b = 0,10	b = 0,37
1968	53	4	0,67	0,14	0,38-1	4,79	0,14	4,5-5,22	4,98	0,44	4,67-5,32	4,66	0,15	4,30-5,12	a=4,57	a=4,44	a=4,4
															b = 0,34*	b = 0,81*	b = 0,4**
1969	16	5	0,82	0,09	0,68-1	5,14	0,12	4,95-5,36	5,30	0,14	5,08-5,56	4,98	0,11	4,80-5,15	a=4,84	a=4,99	a=4,68
															b = 0,37	b = 0,37	b = 0,37
1970	5	2	0,65	0,14	03-0,07	4,01	0,05	3,95-4,07	4,14	0,04	4,08-4,19	3,86	0,07	3,80-3,95	a=4,14	a=4,19	a=4,08
															b = -2,58	b = -0,75	b = -4,4*
1971	25	3	0,36	0,08	0,24-0,46	4,88	0,15	4,55-5,09	5,01	0,16	4,66-5,24	4,76	0,14	4,40-4,95	a = 4,55	a = 4,62	a = 4,46
															b = 0,93'*	b =1,09**	b = 0,77**
1972	18	4	0,51	0,25	0,23-1,05	4,75	0,21	4,44-5,38	5,07	0,15	4,66-5,69	4,61	0,13	4,43-5,30	a = 4,73	a = 4,86	a = 4,61
															b = 0,04*	b = 0,07	b = 0,01
1971	28	5	0,48	0,37	0,24-1,70	4,92	0,13	4,44-5,95	4,89	0,22	4,59-5,13	4,78	0,20	4,82-4,30	a = 4,75	a = 4.75	a = 4,64
															b = 0,36**	b = 0,36**	b = 0,34**

**significant(p<0,05) regression coefficient*

***highly significant (p<0,01) regression coefficient*

and the highest, 0.77, for 3 years old females of 1971. Regression was significant (p.05) in two cases: in 2 years old fish of 1970, and in 3 years old ones of 1971. It was highly significant (p.01) for 4 years old fish of 1968, and 5 years old ones of 1971.

RELATION BETWEEN EGG DIAMETERS (Table III)

Correlation coefficient "r" ranged from 0.34 (4 years old females of 1968) to 0.98 (5 years old females of 1971). Correlation was significant (p.05) in one case, and highly significant (p.01) in 6 cases. It was not significant in only one case.

MINIMUM TO MAXIMUM EGG DIAMETER RATIO (EGG SHAPE), AND RELATION BETWEEN BODY SIZE OF FEMALES AND EGG SHAPE

TABLE III

Relation between maximum and minimum egg diameter

Generation	Female age (years)	Numbers	Correlation coefficient	Regression coefficient "b" i parameter "a" from the equation y=bx + a
1966	2	114	r = 0,73**	a =1,750 b = 0,516**
1967	3	96	r = 0,89**	a = 0,02 b = 0,945**
1968	4	53	r = 0,34*	a = 4,101 b=0,113*
1969	5	16	r=0,81**	a =1,693 b = 0,621**
1970	2	5	r = 0,51	a = 0,360 b = 0,895
1971	3	25	r = 0,96**	a = 0,674 b = 0,815**
1972	4	18	r = 0,85**	a = 0,870 b = 0,760**
1971	5	28	r = 0,98**	a = 0,430 b = 0,860**

**significant(p<0,05) regression coefficient*
***highly significant (p<0,01) regression coefficient*

Maximum egg diameter was equal to 102-111.3% of the minimum diameter.

Highly significant (p.01), negative relation was obtained between body length of females, and maximum to minimum diameter ratio. Regression coefficient "b" values were equal to 0.17 and 0.01, respectively.

RELATION BETWEEN EGG DIAMETERS AND AGE OF FEMALES (Table IV)

Highly significant relation between age of females and maximum and minimum

diameter of eggs was obtained for fish of the sixties. Regression coefficient "b" was equal to: 0.36, 0.38, and 0.34 respectively. In the other fish groups, no significant relation was observed.

DISCUSSION

TABLE IV

Relation between egg diameters and age of females

Group	Numbers	Regression coefficient "b" i parameter "a" from the equation y=bx + a		
		mean diameter	maximal diameter	minimal diameter
A	4	a = 3,38	a = 3,29	a = 3,29
		b =0,35**	b = 0,34**	b = 0,344**
B	3	a = 3,34	a = 3,72	a = 2,74
		b = 0,30	b = 0,30	b = 0,52
C	4	a = 3,71	a = 4,65	a = 3,54
		b = 0,27	b= 0,06	b = 0,29

**significant(p<0,05) regression coefficient*
***highly significant (p<0,01) regression coefficient*
Group "A" - 2-, 3-, 4-, 5- years old of the sixties
Group "B" - 2-, 3-, 4- years old of the seventies
Group "C" - females as in group "B" together with 5 years old of 1971

Statistical analysis revealed significant relation between maximum and minimum egg diameter. In one case only (2 years old females of 1970) the relation between these parameters was not significant. Most probably this resulted from low number of fish (only 5 individuals). Thus, it seems that in brook trout egg size may be estimated from one diameter only (contrary to rainbow trout): maximum or minimum one. The regression coefficients (Table I) indicate that with an increase of maximum egg diameter by 1 mm, minimum diameter increases by 0.5-0.9 mm. The relationship between the diameters, and their fairly stable ratio (minimum diameter was equal to 102.5-111.3% of the maximum one) indicate that brook trout egg shape does not vary too much and only with the size (body length and mass) of females: the bigger the female, the more globular the eggs.

Brook trout eggs, however, are ellipsoidal, similarly to eggs of other fish species (Vistula trout – Skrochowska 1953, pike – Toner, Lawler 1969, lake trout – Goryczko 1960, Winnicki, Bartel 1967, brown trout – Hardy 1967, rainbow trout – Bartel 1971a).

In most cases, the relationship between diameters and size (body length and mass) of females was not significant statistically, indicating, similarly as in rainbow

trout, that egg size did not depend on female size. The results indicate that egg size is related to the age of females (as in rainbow trout, Bartel 1971). Highly significant relation was found, however, in only one population (females of the '60) which consisted of four fairly numerous age groups (16-144 fish).

Population of the '70 consisted of two separate stocks of spawners. One of them, with 3 age groups, consisted of the offspring of the previously studied females. Another one, with only one age group, was not related to them. All age groups of the '70 were less numerous (5-28 fish). All of this has probably resulted in a lack of significant relations between age of females and egg size in this group.

CONCLUSIONS

1. Brook trout eggs are ellipsoidal, with small difference between maximum and minimum diameter.
2. Brook trout egg shape is related to size of females: larger females produce more globular eggs.
3. Egg size may be estimated from one diameter only (maximum or minimum one).
4. Brook trout egg size does not depend on size of females but on their age.

REFERENCES

Bartel R.1971a - Pomiary średnicy jaj pstrąga tęczowego (*Salmo gairdneri* Rich.) - Rocz. Nauk Rol. 93-H-3,: 7-15

Bartel R.1971 b - Czynniki decydujące o średnicy jaj pstrąga tęczowego (*Salmo gairdneri* Rich) - Rocz. Nauk Rol. 93-H-4; 7-35

Blaxter J.H.S., Hempel G.1963 - The influence of egg size on herring larvae (*Clupea harengus* L.) - J.Cons. perm. int. Explor Mer. 28: 211-240.

Eland R. 1964 - Statystyka matematyczna w zastosowaniu do doświadczalnictwa rolniczego - PWN Warszawa; 290-375.

Goryczko K. 1960 - Rozmnażanie troci z jeziora Wdzydze - Maszynopis Kat. Ryb. WSR Olsztyn; 25-30

Goryczko K. 1991- Pstrąg źródlany (*SalveIinus fontinalis* Mitchill 1815) - Ryby słkodkowodne Polski (red. M. Bryliński), PWN:138-141

Grudniewski Cz. 1991- O rybach dla wędkarzy - PWRi L Warszawa, 179-183

Hardy C.J.1967. The fecundity of brown trout from six Canterbury Streams New Zeland Marine Department Fish./ Tech. Rep. Wellington 24;14-15

Jędruszczuk-Ząbek A. 1988 - O pstrągu prawie wszystko, biologia i gospodarka Wiad. Wędk. 4:10-17

Jóźwiak J., Podgórski J. 1994 - Statystyka od podstaw. PWE Warszawa; 243-280

Juszczyk W.1951- Ilość ikry pozostającej w jamie brzusznej samic troci (*Salmo trutta* L:), pstrąga tęczowego (*Salmo irideus* Gibb.) i krzyżówki pstrąga potokowego (*Salmo trutta m. fario* L.) z trocią (*Salmo trutta* L.) po sztucznym wytarciu - PAU, Prace Rolniczo Leśne 59:18-20

Migdalski E., Fichter G.1989 - The fresh and salt water - fishes of the world Greenwich House, New York;119-121.

Sadow N.H.1963 - Strojenie i formirovanie obolocek jajc osetrowych i niektorych predstawitielej kostistych ryb - Trudy Inst. Morf. Zivot; 38-40

Skrochowska S.1953 - The rearing of the sea trout (*Salmo trutta* L.) in artificial ponds - Bull. d l'Acad. Pol. Sc. et Lett. B-1951;179-226

Sobczyk M.1994 - Statystyka - PWN Warszawa;192-253

Toner E.D., Lawler G.H.1969 - Synopsis of biological data of the pike *Esox lucius* (Linaeus 1758) - FAO Fish Syn. 30, Rev.1:83-91

Winnicki A.1968 - Rola i właściwości osłonek jajowych ryb łososiowatych- Maszynopis WSR Olsztyn; 46-48

Winnicki A., Bartel R.1967. The effect of limited water intake on the strength of egg coverings in the salmonid fishes. Zool. Pol.17, 1-2:59-72.

Zotin A.J.1955. Potreblenije vody razvivajuscimisia jaicami lososievych i osietrovych ryb iz okruzajuscei sredy. Wopr. Icht. 4: 82-104

Zotin A.J.1961. Otnositielnaja plodovitost ryb i razmiery ryb. Wopr. Icht.1, (19):307-313

Żarnecki S.1955. Pstrąg źródlany (*Salmo fontinalis*) w jeziorach tatrzańskich Kosmos, R, 4, 5: 205-211

STRESZCZENIE

ZALEŻNOŚĆ ROZMIARÓW IKRY PSTRĄGA ŹRÓDLANEGO (*Salvelinus fontinalis* Mitchill) OD WIELKOŚCI SAMIC

Do badań użyto ikrę i samice pstrąga źródlanego (*Salvelinus fontinalis* Mitchill) hodowane w stawach Terenowej Pracowni Rzecznej w Gdańsku Instytutu Rybactwa Śródlądowego w Olsztynie. Ikrę pobierano od tych samych samic w wieku dwóch, trzech, czterech i pięciu lat. Pierwszego poboru ikry dokonano w 1966 r. Oprócz tego pobrano ikrę od samic w wieku dwóch, trzech i czterech lat, które były potomstwem samic z roku 1966. Pierwszego poboru ikry od tej grupy samic dokonano w 1970 r.

W roku 1971 zbadano też ikrę od 28 samic pięcioletnich pochodzących z innego stada tarlaków.

Łącznie pobrano ikrę (po 10 sztuk od każdej samicy) od 355 samic, których długość wynosiła od 14,0 do 49,0 cm a masa od 30 do 1700 g. Ikrę mierzono po 1 godzinie od momentu pierwszego zetknięcia się z wodą t.j. po zakończeniu okresu pęcznienia. W każdym ziarnie ikry mierzono najdłuższą i najkrótszą średnicę, a następnie na podstawie tych dwóch pomiarów obliczano średnią średnicę dla każdej ikry.

Badania wykazały, że: 1 - rozmiary ikry pstrąga źródlanego nie zależą od rozmiarów samic lecz od ich wieku, 2 - do określenia wielkości ikry wystarczy pomiar jednej z dwóch średnic (maksymalnej lub minimalnej), 3 - kształt ikry pstrąga źródlanego jest elipsoidalny o małej różnicy pomiędzy maksymalną a minimalną średnicą, 4 - w miarę powiększania się rozmiarów samic, kształt ikry coraz bardziej zbliża się do kuli.

ADRESY AUTORÓW:

Daniel Dlaboga
Prof. dr hab. Krzysztof Bieniarz
Prof. dr hab. Piotr Epler
Katedra Ichtiobiologii i Rybactwa
Akademia Rolnicza w Krakowie
30-149 Kraków, ul. Spiczakowa 6

Prof. dr hab. Ryszard Bartel
Pracownia Rybactwa Rzecznego
Instytut Rybactwa Śródlądowego
80-761 Gdańsk, ul. Reduta Żbik 5