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Short communications

DEPENDENCE OF EGG DIAMETER ON THE SIZE AND AGE OF CULTIVATED FEMALE LAKE TROUT (*SALMO TRUTTA* M. *LACUSTRIS* L.)

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ABSTRACT. The aim of this study was to determine the impact of the size and age of cultivated female lake trout on the size of their eggs. The material was collected from 1995 to 1999 at the Olszówka Fish Farm in southern Poland. Eggs were obtained from 310 trout females with a total length range of 30-53 cm (fish aged three to seven years). Following the hardening phase, the maximum and minimum diameters of the eggs were measured and the water volume (calculated based on water displacement) of thirty eggs was determined. The mean egg diameter ranged from 4.08 to 5.85 mm. The variance of egg size within age groups was not large, and the coefficient of variation (V, %) ranged from 2.64 to 6.91. The results indicate that the egg size of lake trout cultivated in ponds was significantly dependent on the size of the females and to a lesser degree on their age.

Key words: LAKE TROUT (*SALMO TRUTTA* M. *LACUSTRIS*), EGG SIZE, AGE AND SIZE OF FEMALES

Egg size is a trait that is species specific and variation among individuals is related to female size or age or the impact of environmental factors. The size of eggs is most frequently related to fish size, which means that as the females grow so does egg size. This dependence was observed in rainbow trout, *Oncorhynchus mykiss* (Walb.) (Juszczyk 1951, Pekarkova 1956, Dumas 1961, Schäperclaus 1961, Scott 1962, Steffens 1963), brown trout, *Salmo trutta* m. *fario* L. (Pekarkova 1956, Allen 1958, Mc Fadden et al. 1965, Hardy 1967), and sea trout, *Salmo trutta trutta* L. (Juszczyk 1951, Farid Pak 1968, Papała et al. 1998), lake trout, *Salmo trutta* m. *lacustris* L. (Sakowicz 1961, Szczerbowski 1966), and Atlantic salmon, *Salmo salar* L. (Pope et al. 1961).

Some authors believe, however, that female age is the deciding factor in egg size. Skrochowska (1953) reported that younger trout had smaller eggs while those in older

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specimens were larger. Similar conclusions were drawn by Bielanina (1964), who studied this dependency in Arctic rainbow smelt, *Osmerus eperlanus dentex natio dvinensis* Smitt, by Sklower (1930) with regard to brown trout, by Bartel (1971a) in rainbow trout, by Dlaboga et al. (1998) in brook trout, *Salvelinus fontinalis* (Mitch.), and by Bartel et al. (1999) in Danube salmon, *Hucho hucho* (L.). Some authors maintained that female age as well as size have an impact on egg size, *e.g.*, Terlecki and Kempińska (1956) in common whitefish, *Coregonus lavaretus* (L.) and vendace, *Coregonus albula* (L.), Kaj (1955) for common whitefish and Kaj and Włoszczyński (1957) in pike, *Esox lucius* L.

It was also determined that under the conditions of cultivation egg size can also be affected, by, among other factors, feeding conditions and the type and quantity of feed (Dumas 1961, Scott 1962, Podubsky and Stredronsky 1967, Bartel 1971a) and the origin of the fish (strain) (Farran 1938, Leitriz 1960, Pope et al. 1961, Blaxter and Hempel 1963, McFadden et al. 1965, Smirnov et al. 1968, Bartel 1971a).

The aim of the current investigation was to determine the impact the size and age of cultivated female lake trout had on the size of eggs.

The lake trout brood stock was cultivated at the Olszówka Hatchery owned by the Polish Anglers' Association in Bielsko Biała in southern Poland. In 1994, two-year smolts were selected to be reared as spawners, and from 1995 to 1999 eggs for measurements were collected annually during artificial spawning. The females were measured to the nearest 0.5 cm in order to describe their total length (TL). The collected eggs were submerged in water for hardening (Zotin 1955, 1961, Winnicki and Bartel 1967, Winnicki 1968). The maximum (y_{max}) and minimum (y_{min}) diameters were measured (Bartel 1971b) as was the water volume displaced by thirty hardened eggs (y^1). Measurements were collected from a total of 310 females ranging in age from three to seven years that spawned in the 1995-1999 period. The number of females that spawned in subsequent years ranged from 12 to 101 (Table 1).

The dependence of egg size (y^1, y_{max}, y_{min}) on female length for all 310 females and for the largest age group of 101 five-year females was determined. Additionally, the dependence of egg size on female age was determined based on the mean diameter ($\bar{y}$) of eggs according to age groups.

The female total length (TL) ranged from 30 to 53 cm. The mean female length increased with age (A) and was 33.6 cm and 47.8 cm in three- and seven-year females,

respectively (Table 1). The mean diameter ($\bar{y}$) of the eggs of individual females ranged from 4.08 to 5.85 mm, while in subsequent age groups the mean diameter of ten eggs ranged from 4.45 mm to 5.31 mm in four- and seven-year females (Table 1). The mean diameter of lake trout eggs was not highly varied among the age groups with a coefficient of variation (V%) that ranged from 2.64 to 6.91 (Table 1). The ratio of maximum to minimum egg diameter ranged from 103.2 to 105.5%.

TABLE 1

Dependence of egg diameter on the length of female lake trout

	Year				
	1995	1996	1997	1998	1999
Number of females (ind.)	12	39	101	81	77
Fish age (years)	3	4	5	6	7
Female total length (TL) (cm)					
mean	33.6	34.8	40.2	43.8	47.8
SD	2.23	2.50	2.97	2.58	2.25
V(%)	6.6	7.1	7.38	5.88	4.7
range	30.0-37.0	30.0-40.5	33.5-47.0	37.0-52.0	43.5-53.0
Mean egg diameter ($\bar{y}$) (mm)					
mean	4.68	4.45	4.70	4.77	5.31
SD	0.15	0.12	0.32	0.28	0.19
V(%)	3.2	2.7	6.8	5.87	3.58
range	4.40-4.91	4.23-4.75	4.08-5.30	4.26-5.85	4.87-5.81
Maximum egg diameter (y_{max}) (mm)					
mean	4.8	4.55	4.77	4.86	5.39
SD	0.15	0.12	0.33	0.29	0.19
V(%)	3.12	2.64	6.92	5.97	3.52
range	4.53-5.04	4.42-4.90	4.12-5.41	4.39-5.97	4.94-5.91
Minimum egg diameter (y_{min}) (mm)					
mean	4.55	4.35	4.63	4.68	5.22
SD	0.16	0.14	0.32	0.28	0.20
V(%)	3.52	3.22	6.91	5.98	3.83
range	4.31-4.78	4.03-4.60	4.04-5.23	4.13-5.74	4.71-5.70
Coefficients *b* and *a* of the regression equation y=bx+a					
$\bar{y}$	a=5.06	a=4.19	a=2.74	a=4.54	a=4.22
	b=-0.01	b=0.01	b=0.05**	b=0.01	b=0.02*
y_{max}	a=5.36	a=4.52	a=2.79	a=4.55	a=4.31
	b=-0.02	b=0.00	b=0.05**	b=0.01	b=0.02*
y_{min}	a=4.79	a=3.85	a=2.68	a=4.52	a=4.14
	b=-0.01	b=0.01	b=0.05**	b=0.00	b=0.02*

**regression coefficient at a level of significance of p=0.05*
*** highly significant regression coefficient (p=0.01)*
V(%) coefficient of variation of egg size

A highly significant dependence (significance level of p = 0.01) was determined between egg size, expressed as the volume of thirty eggs (y^1), and female size (x) (Table 2).

TABLE 2

Dependence of the volume of thirty eggs on the length of female lake trout

Year	Number of specimens	Fish age (years)	Female total length (TL) (cm)			Volume of thirty eggs y^1 (ml)			Coefficients *b* and *a* of the regression equation $y^1=bx+a$
			mean	SD	range	mean	SD	range	
1995-1999	310	3 - 7	42.3	5.07	30.0 – 53.0	2.14	0.42	1.4 – 3.4	a= -0.61 b=0.06*

** highly significant regression coefficient (p=0.01)*

However, a highly significant dependence (significance level of p = 0.01) between mean egg diameter and mean maximum (y_{max}) and minimum (y_{min}) and female age was determined only in the case of the largest age group of five-year lake trout. This dependence in seven-year trout was significant at a level of p = 0.05 (Table 1). The dependence of egg size, expressed as the volume of thirty eggs (y^1), on female age was significant at a level of p = 0.05 (Table 3); however, this dependence was not confirmed when mean egg diameter was used in the calculations.

TABLE 3

Dependence of the volume of thirty eggs on the age of female lake trout

Year	Number of specimens	Age			Volume of thirty eggs y^1 (ml)			Coefficients *b* and *a* of the regression equation $y^1=bA+a$
		Number of age groups (A)	SD	range	mean	SD	range	
1995-1999	310	5	1.58	3 - 7	2.14	0.42	1.4 – 3.4	a=0.57 b=0.28*

** significant regression coefficient (p=0.05)*

The results obtained concur with earlier investigations which indicated that egg size is impacted significantly by female size and which was observed earlier in rainbow trout (Juszczyk 1951, Pekarkova 1956, Dumas 1961, Schäperclaus 1961, Scott 1962, Steffens 1963), brown trout (Pekarkova 1956, Allen 1958, Mc Fadden et al. 1965, Hardy 1967), sea trout (Juszczyk 1951, Farid Pak 1968, Papała et al. 1998), lake trout (Sakowicz 1961, Szczerbowski 1966), and Atlantic salmon (Pope et al. 1961).

The results of the current investigation prove that the size (total body length TL) of female lake trout cultivated in ponds has a significant impact on egg size, while their age has a lesser impact.

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STRESZCZENIE

ZALEŻNOŚĆ MIĘDZY ŚREDNICĄ IKRY A WIELKOŚCIĄ I WIEKIEM HODOWANYCH SAMIC TROCI JEZIOROWEJ (*SALMO TRUTTA* M. *LACUSTRIS* L.)

Celem badań było określenie wpływu wielkości i wieku hodowanych samic troci jeziorowej na wielkość ich ikry. Materiały zbierano w latach 1995-1999 w gospodarstwie Olszówka (południowa Polska). Ikrę pozyskano od 310 samic troci o długości całkowitej ciała od 30 do 53 cm (wiek ryb 3-7 lat) (tab. 1). Po napęcznieniu ikry mierzono jej najdłuższą i najkrótszą średnicę oraz objętość 30 jaj określaną objętością wypartej wody. Średnice ikry wahały się od 4,08 do 5,85 mm. Zmienność wielkości ikry w grupach wieku była niewielka, współczynnik zmienności (V, %) wahał się od 2,64 do 6,91 (tab. 2 i 3). Otrzymane wyniki wskazują, że wielkość ikry u troci jeziorowej hodowanej w stawach zależała istotnie od wielkości samic, a w mniejszym stopniu od ich wieku.