



ASYMMETRY OF MALE GONAD OF THE SEA TROUT (*SALMO TRUTTA TRUTTA* L.) IN THE FIRST YEAR OF LIFE

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ABSTRACT

Paired gonads occur in the majority of teleostean fish species. In females a greater mass and fertility of the left one ovary has often been reported, while much less attention has been devoted to a comparative analysis of gonads in males. In this study an assessment of asymmetry of male gonads in sea trout in the first year of life has been made on the basis of their mass determination. The observations were made on 218 males, aged 5-6.5 and 12 months, caught in the streams located in north-western Poland. In the first year of life, immature and mature testis shown asymmetry. In the majority of males studied (77%) the left gonad was greater. In 5% of the males the gonads were of the same size, while in 18% of the males the right was greater. The mass of the right gonad was on average 79% of the mass of the left testis. The difference in mass between left and right gonads was on average 14% of the mass of both gonads (21% of the larger gonad) and was statistically significant $p < 0.001$. The statistically significant differences in mass between the left and right gonad were from 6-month old males. In the separated groups of male with a greater left gonad, the difference in mass between larger and smaller gonads was twice greater than in the group with the greater right gonad. Differences between mass of left and right gonads in immature and mature males were similar (chi-squared test, $p > 0.05$).

Key words: asymmetry, *Salmo trutta*, sea trout, testes

INTRODUCTION

Even number of gonads is a characteristic feature of the majority of teleostean fish species [5, 11]. They are often morphologically differentiated. Gonad's asymmetry has been most often reported in females together with an assessment of fertility of both ovaries [3, 6, 7, 10, 12, 13, 15]. Morphological differences in the male gonads has been studied much less frequently [9, 12].

The aim of this study was to assess the morphological differences in the male gonads in sea trout in the first year of age, on the basis of their mass determination.

MATERIAL AND METHODS

The material included 218 males of sea trout (*Salmo trutta trutta* L.) caught in the two streams located near Szczecin (north-western Poland), during the first year of life. The fish aged 5-, 6-, 6.5- and 12 months, were harvested on 28 August, 28 September, 13 October and 17 March, from Wałęci Brook (the first three samples) and Trawna (one sample), respectively. The numbers of individuals caught in particular samples are given in Table 1. The brooks had earlier been stocked with swimming fry of sea trout obtained by artificial spawning of breeders caught in River Rega, with incubation in the Polish Anglers' Association (PAA) hatchery in Goleniów.

The whole individuals were fixed in Bouin fluid. The length of the body of the individuals (*longitudo caudalis*) was measured to an accuracy of 1 mm. They were weighted to an accuracy of 0.1 g, then the gonads were cut out and weighted separately left and right to an accuracy of 0.1 mg. Because of too small mass the testes of the fish younger than 5 months were not analysed. The condition coefficient was calculated [CF= mass of the full fish (g) x 100 x length of the fish⁻³ (cm)] and the gonadosomatic index [GSI= mass of gonads (g) x 100 x mass of full fish⁻¹ (g)]. The status of the gonad development was evaluated according to the scale proposed by Dziewulska and Domagała [3].

Asymmetry of the gonad was assessed for all fish and for separated groups with left gonad and right gonad heavier. Differentiation between the left (*l*) and the right (*r*) gonad mass was shown as: one gonad mass expressed as a

percentage of the both gonad mass ($\frac{l}{l+p}$; $\frac{p}{l+p}$), differences between greater and smaller gonad mass expressed as

a percentage of the both gonad mass ($\frac{l-p}{l+p}$ or $\frac{p-l}{l+p}$) and as a percentage of the mass of greater gonad ($\frac{l-p}{l}$ or

$\frac{p-l}{p}$), smaller gonad mass expressed as a percentage of the greater gonad mass ($\frac{p}{l}$ or $\frac{l}{p}$) (Table 2).

The statistical significance of differences between mass of left and right gonad was determined by the Mann-Whitney *U*-test. A chi-squared test was used to compare differences between mass of left and right in maturation groups at the level of $p=0.05$.

RESULTS

The individuals examined were in good condition according to the condition coefficient, which varied from 0.9 to 1.6. The length of the fish individuals varied from 6.7 to 16.7 cm, their mass varied from 3.3 to 62.2 g, while their gonadosomatic index varied from 0.02 to 1.89. The data on the fish are given in Table 1.

The gonads of the 5 and 6 month-old individuals were mostly in class I of maturity, only a few were in class II (3% and 4%, respectively). Among the 6.5 month old individuals also the majority were in class I (84%), a few in class II (13%), and one showed attempted maturation (the tubules containing maturing cells made 20% of the transversal cross-section of the gonad). From among the 12-month old individuals 44% had gonads in class I, 37% had gonads in class II, 5% and 14% were in classes VIII and IX, respectively.

The mass of the gonads was much diversified in each fish sample. In 5 month old specimens the mean mass of both gonads was 5.26 mg, varying in the range 1.3-11.0 mg (Table 1). In about 63% of the individuals the left gonad was heavier than the right one, in 12% - the masses of both gonads were close, while in 25% of the specimens studied the right gonad was heavier (Fig. 1). The mass of the left gonad represented 54% of the mass of both gonads. The right testis constituted 87% of left gonad. On average the left gonad was greater than the right one by about 7% of the mass of both gonads (13% of the mass of left gonad) (Table 2). The differences in the masses of the left and the right gonads were statistically insignificant (Mann-Whitney *U*-test, $p=0.361$). In the separated groups of males with the left or right gonad greater, the difference in mass between larger and smaller gonads was more distinct in the first group than in the latter (Table 2).

In 6-month old fish, the mass of both gonads was 8.07 mg and varied in the range 2.2-13.5 mg (Table 1). In about 86% of the individuals the left gonad was heavier than the right one, while in 14% of the fish the right was heavier (Fig 1). The mass of the left gonad represented 58% of the mass of both gonads. The right testis constituted 72% of the left gonad. On average, the left gonad was heavier than the right one by 17% of the mass of both gonads (28% of the mass of the left gonad). The differences in the mass between the left and right gonads were statistically significant (Mann-Whitney *U*-test, $p=0.025$). In the group with the left gonad greater, the difference between larger and smaller gonads was twice greater than in the group with right gonad greater (Table 2).

In 6.5 month old fish the mean mass of both gonads was 9.43 mg and it varied in the range 4.1-14.3 mg (Table 1).

Table 1. Major characteristics of males studied with left and right gonad mass separately (\pm SD)

Fish age (month)	No. of fish	Mean fish fork length (cm)	Mean mass of fish (g)	Fulton condition factor	Gonado-somatic index	Gonad mass (mg)			Mann-Whitney <i>U</i> -test	p	Percentage of fish with gonad mass	
						left	right	both			left>right	right>left
5	32	8.29 \pm 1.0	7.58 \pm 3.2	1.27 \pm 0.1	0.075 \pm 0.04	2.82 \pm 1.3	2.44 \pm 1.2	5.26 \pm 2.4	0.913	0.361	62.5	25.0
6	21	9.64 \pm 1.2	12.29 \pm 4.3	1.32 \pm 0.1	0.068 \pm 0.02	4.71 \pm 1.9	3.36 \pm 1.6	8.07 \pm 3.2	2.238	0.025*	85.7	14.3
6.5	37	10.22 \pm 0.9	14.46 \pm 4.1	1.32 \pm 0.1	0.066 \pm 0.02	5.17 \pm 1.8	4.26 \pm 1.5	9.43 \pm 3.0	2.287	0.022*	67.6	24.3
12	128	11.93 \pm 2.0	24.22 \pm 11.3	1.32 \pm 0.1	0.210 \pm 0.27	26.00 \pm 36.5	19.40 \pm 36.3	45.56 \pm 72.2	5.201	<0.001*	92.4	7.5
Mean									3.580	<0.001*	77.1	17.8

*significant differences ($p < 0.05$, Mann-Whitney *U*-test).

Table 2. Comparison of the left and right gonad mass of sea trout in different ratios (%)

Age (month)	All fish						Fish with left gonad heavier						Fish with right gonad heavier					
	$\frac{l}{l+p}$	$\frac{p}{l+p}$	$\frac{l-p}{l+p}$	$\frac{l-p}{l}$	$\frac{p}{l}$	$\frac{l}{p}$	$\frac{l}{l+p}$	$\frac{p}{l+p}$	$\frac{l-p}{l+p}$	$\frac{l-p}{l}$	$\frac{p}{l}$	$\frac{l}{p}$	$\frac{l}{l+p}$	$\frac{p}{l+p}$	$\frac{p-l}{l+p}$	$\frac{p-l}{p}$	$\frac{l}{p}$	$\frac{p}{l}$
5	53.58	46.42	7.15	13.35	86.65	115.41	57.68	42.32	15.36	26.63	73.37	136.30	44.25	55.75	11.55	20.71	79.29	126.12
6	58.30	41.70	16.59	28.46	71.54	139.79	60.50	39.50	20.99	34.70	65.30	153.14	46.15	53.85	7.69	14.29	85.71	116.67
6.5	54.84	45.16	9.69	17.67	82.33	121.46	57.15	41.85	16.29	28.02	71.98	138.93	44.90	55.10	10.20	18.51	81.49	122.72
12	57.43	42.57	14.85	25.87	74.13	134.89	59.99	40.01	19.97	33.29	66.71	149.91	45.76	54.24	8.48	15.63	84.37	118.53
Mean	56.04	43.96	12.07	21.34	78.66	127.89	59.08	40.92	18.15	30.66	69.34	144.57	45.26	54.74	9.48	17.28	82.72	121.01

l – left gonad mass.
r – right gonad mass.

In about 68% of the individuals in this age the left gonad was heavier than the right one, in 8% both gonads have close masses, and in 24% of the individuals the right gonad was heavier (Fig. 1). The mass of the left gonad represented 55% of the mass of both gonads. The right testis constituted 82% of left gonad. The left gonad was on average greater than the right one by about 10% of the mass of both gonads (18% of the mass of the left gonad). The differences in mass between the left and right gonad were statistically significant (Mann-Whitney *U*-test, $p=0.022$). In the group with the left testis greater the difference between larger and smaller gonads was more distinct than in the group with the right gonad greater (Table 2).

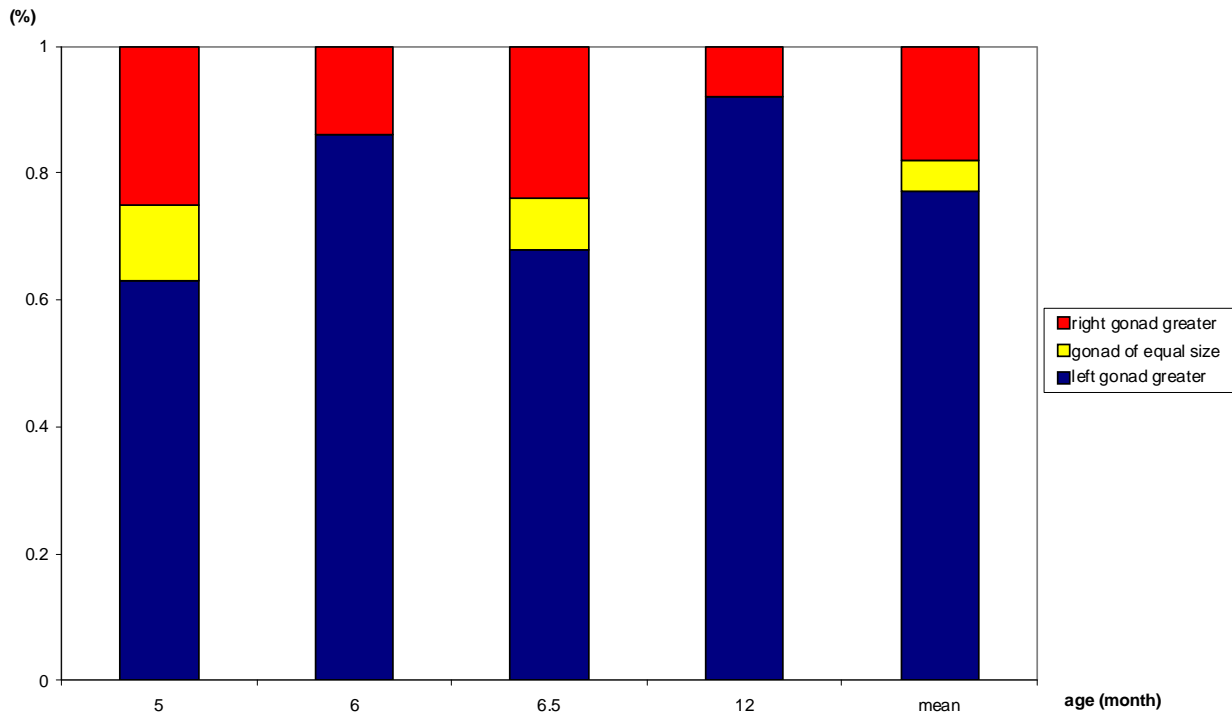


Fig. 1. Percentage of sea trout males with asymmetric gonads in the age groups studied based on gonad mass

In the 12 month old individuals the mean mass of both gonads was 45.56 mg and varied in the range 2.6-565.9 mg (Table 1). In about 92% of the male fish in this age the left gonad was heavier than the right, while in the 8% the right one was greater than the left (Fig. 1). The mass of the left gonad represented 57% of the mass of both gonads. The right testis constituted 74% of left gonad. On average the left was heavier than the right by about 15% of the mass of both gonads (26% of the mass of the left gonad). The differences in mass between the left and right gonad were statistically significant (Mann-Whitney *U*-test, $p<0.001$). In the group with the left gonad greater, the difference between larger and smaller gonads was twice more than in the group with right gonad greater (Table 2). Differences between mass of left and right gonads in immature and mature males were not statistically significant (chi-squared test, $p>0.05$).

DISCUSSION

In the majority of the fish species studied, the left gonad is dominant. The fertility of the left ovary is greater than that of the right (*Salmo trutta* – [2]; *Mallotus villosus* – [13]; *Solea solea* – [14]), the left ovary is heavier than the other (*Salmo trutta* – [15]; *Salmo trutta* – [10]; *Salmo trutta* – [3]; *Engraulis encrasicolus* – [12]; *Coregonus autumnalis* – [6]), or it is longer than the right one (*Salmo trutta* – [10]; *Salmo trutta* – [4]). Asymmetry of the gonads was observed as early as during the gonadogenesis [1]. According to other authors the situation was the reverse and the left ovary was shorter than the right one in *Coregonus lavaretus* [7], or its fertility was smaller in *Oncorhynchus nerka* (Rounsefell, 1957 as cited in [13]).

In the study by Wójcik [15] the mass of the left gonad in the females of *Salmo trutta* was greater than that of the right one by about 8% of the mass of both ovaries, while in the study by Sobociński et al. [10] - by 20%. In the females of *Oncorhynchus mykiss* the differences in mass between the ovaries were statistically insignificant [15]. In the females of *Coregonus lavaretus* the left ovary was by 15-20% shorter [7].

Similarly as in females the *Salmo trutta* males examined in this study also revealed gonad asymmetry and dominance of the left gonad but less pronounced. In the majority of males the left gonad was greater (77%), while only in 18% the right one was dominant. In females of *Salmo trutta* from the same samples as the males studied in this work as many as 92.7% of the females had the left gonad heavier (in 5.9% females it was the opposite) and in

84.3% of them the left gonad was also longer (in 6.7% females it was the opposite) [3]. The difference in mass between the left and right gonads in the males examined in this work was about 12% of the mass of both gonads, while in females 17% [3]. A similar tendency was observed for other species. In *Coregonus autumnalis* the differences were nearly twice greater in females than in males (11.1 and 6.5 % of the mass of left gonad) [6]. In the females of *Engraulis encrasicolus* the dominance of the left gonad was greater expressed than in the males [12].

Autumnalis had the left gonad greater) and degree of asymmetry were size independent in males but become progressively more marked in females of a given somatic mass. Vallisneri and Scapolatempo [12] reported that the differences were more pronounced in the reproductive months; on the other hand Harrod and Griffiths [6] did not observe this tendency. The degree of asymmetry in the ovary mass increased with infection intensity of parasites (*Ichthyocotylurus erraticus*) up to a threshold but this tendency was not noted in males [6].

Not only morphological differences between gonads were investigated. Quillet et al. [8] noted not equal sensitivity to mutation of the rainbow trout intersexes gonads. The right gonad was more likely to mutate than the left one.

CONCLUSION

1. In the first year of life, left testis of the sea trout was heavier than the right one in about 77% of individuals, in 5% of the individuals the masses of the gonads were similar, while in 18% the right gonad was greater
2. In the separated groups with the left and right gonad greater, the differences between greater and smaller gonad was twice more in the first group than the latter.
3. On average, the mass of the left gonad represented 56% of the mass of both gonads in the first year of life.
4. The statistically significant differences in mass between the left and right gonad were from 6-month old males.
5. Differences between mass of left and right gonads in immature and mature males were similar.

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