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SOME CHARACTERISTICS OF LAKE TROUT *SALMO TRUTTA* M. *LACUSTRIS* L. REDDS IN THE UPPER WDA RIVER SYSTEM (NORTH POLAND)

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ABSTRACT. Observations of lake trout, *Salmo trutta* m. *lacustris* L., spawning, including recording redd parameters, were conducted in the 2003-2004 to the 2007-2008 seasons at spawning grounds located in the upper Wda River system. Spawning was noted from mid October to early January at a temperature range of 1.1-10.8°C, but primarily within the 3.0-8.0°C range. Redds were measured following spawning in selected segments of the spawning grounds. The parameters measured were as follows: tailspill size, pot depth, water depth near the tailspill, water velocity above the tailspill. Substrate samples were taken from some of the redds in spring to determine particle size distribution. In total, 51 redds were measured, and substrate samples were collected from fifteen of them. The tailspill length ranged from 40-150 cm, and water depth was from 15 to 55 cm. The geometric mean diameter of the substrate (D_g) ranged from 3.0-17.4 mm, and the sand content (fraction < 1 mm) was from 3.0-36.5%. Water velocity above the redds ranged from 40 to 120 cm s^{-1}, and this differed significantly statistically among the streams investigated; the lowest rates were noted in the upper reaches of the system (Pilica). Furthermore, in this part of the system the mean geometrical diameter of the substrate was twofold smaller and the share of sand twofold higher than in the lower part of the river system. The size of the tailspills was positively correlated with female size, pot depth, and water velocity. In practical terms, it can be generalized that female length corresponded to approximately 55% of the tailspill diameter.

Key words: *SALMO TRUTTA*, SPAWNING REDDS, SUBSTRATE STRUCTURE, REDD DIMENSIONS

INTRODUCTION

Researchers have long been interested in salmonid spawning, and it is generally known that these fish species bury their eggs in redds (a nest of gravel) and that redd size is linked to female size (Ottaway et al. 1981, van den Berghe and Gross 1984, Crisp and Carling 1989). Counting and recording the parameters of redds helps to estimate

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the abundance, size structure, and dynamics of spawning stocks of salmonid fish (Rieman and Myers 1997, Edo et al. 2000, Al-Chokhachy et al. 2005, Gallagher and Gallagher 2005). A positive dependency is noted between larvae abundance and the number of redds built earlier (Beard and Carline 1991, Beland 1996), which confirms the possibility of using the number of redds to determine the level of recruitment. Further, the substrate grain size and, especially, the sand content have a fundamental impact on the survival and development of the deposited eggs (Chapman 1988). All of these circumstances indicate that knowing the redd parameters is an important aspect of the research into and management of stocks of salmonid species.

The most abundant lake trout, *Salmo trutta* m. *lacustris* L., population in Poland occurs in Lake Wdzydze in the Pomeranian Lake District. It is considered to be an autochthonous relict form that developed after being isolated by the last glaciation (Kaj 1961). The location of the traditional lake trout spawning grounds in the Wda River system was relatively thoroughly investigated many years ago (Sakowicz 1961). The population size of lake trout have declined substantially in the past fifty years as a result of increasing environmental change (Radtke and Dębowski 1996), and, in consideration of its isolation, its continued existence is threatened. To date, there has been little detailed data available regarding the parameters and substrate structure of lake trout redds in Lake Wdzydze. While some information on the course of natural spawning in the upper Wda River system was reported by Sakowicz (1961), some redd parameters from this system were not described until recently (Radtke 2005). The current paper is aimed at describing the basic parameters of the spawning redds of this threatened local form of lake trout, and to present the relationship between selected parameters in reference with other populations of this species.

MATERIALS AND METHODS

STUDY AREA

The Wda River is a left-bank tributary of the lower Vistula River (Baltic Sea). In its upper course the river flows through Lake Wdzydze, which is inhabited by lake trout. The trout spawning grounds are in the Wda River and a tributary, the Trzebiocha River (Fig. 1). The widths of the Wda and Trzebiocha rivers at the spawning grounds are from 7.0 to 9.0 m, while the mean depth is 0.2-0.5 m (Table 1). Due to the deteriorating con-

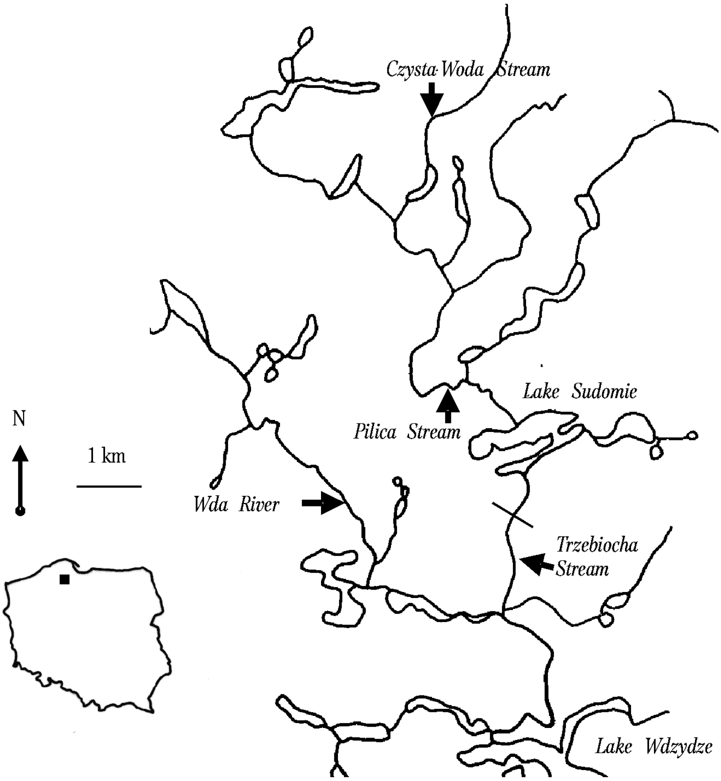


Fig. 1. Location of main lake trout spawning areas in the upper Wda River system.

ditions at the spawning grounds in Trzebiocha, in 1991 trout were introduced to the upper part of the tributary where they had not occurred previously, among other locations in Pilica (upper Trzebiocha) and it's tributary, Czysta Woda, where the new lake trout population is self-reliant. There are traces of former drainage in the spawning ground segments of the Trzebiocha, and the thermal regime is influenced by a group of lakes located about 2 km upstream from the spawning grounds (Fig. 1). The main lake trout spawning grounds in Pilica are located about 3 km upstream from Lake Sudomie, where stream bed was channelized previously. The average width of the stream in the segment of spawning grounds investigated was 4.0-6.0 m, and depth ranged from 0.2 to 0.5 m. Czysta Woda is a small, regulated stream that has only a slight gradient (Table 1). There are outwash formations in the upper part of the Wda system, and they are mostly forested, which influences the stable water flow in the streams investigated.

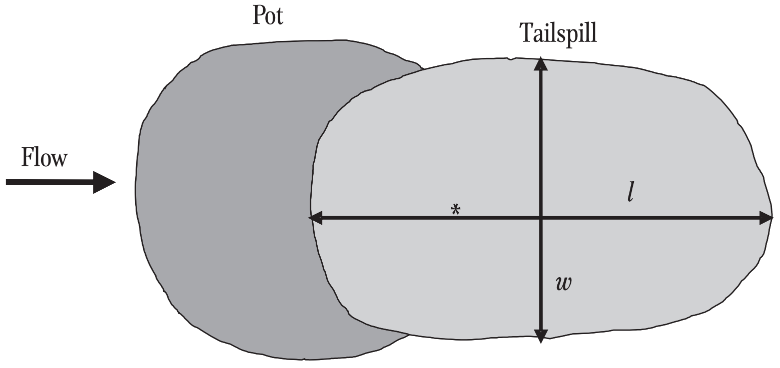
TABLE 1

Morphological characteristics of investigated spawning streams

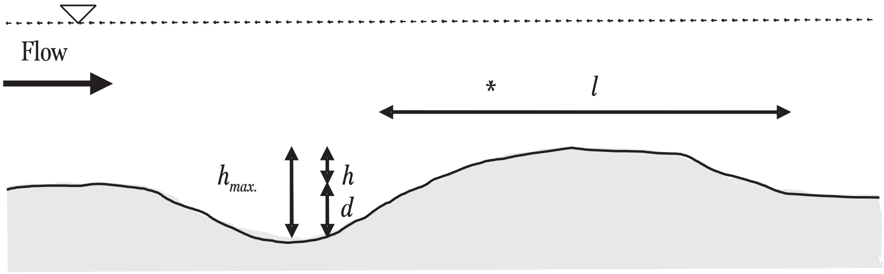
Stream	Width range (m)	Depth range (m)	Slope (‰)	Distance from source (km)	Catchment area (km^2)
Trzebiocha	7.0-9.0	0.2-0.5	1.3	24.1	206.2
Pilica	4.0-6.0	0.2-0.5	0.9	13.5	116.0
Wda	7.0-9.0	0.2-0.5	3.0	20.2	111.3
Czysta Woda	2.0-3.0	0.2-0.3	1.7	6.0	30.8

OBSERVATIONS OF SPAWNING AND DESCRIPTIONS OF REDDS

Observations of lake trout spawning and their redds were conducted in the 2003-2004 to 2007-2008 spawning seasons at spawning grounds in the Wda, Trzebiocha, Pilica, and Czysta Woda streams (Fig. 1). From October to January, field observations were made at irregular intervals (every few days) along selected segments of the streams by walking slowly along the banks and noting down observations made wearing polarized glasses. During spawning, the female makes a small depression, or pot, in the gravel with rapid tail movements, into which eggs are deposited and buried. The redd is visible as a lighter patch in the darker, undisturbed substrate. After spawning, the trout from Lake Wdzydze were observed digging at several points at the head of the redd thanks to which the shape of it is clearly elliptical, and a small depression forms in front of the redd and the edge of it is often less distinct (Fig. 2a). After spawning is completed, the redds were measured. The parameters measured were: length (l), width (w), tailspill height (h), and pot depth in relation to stream bottom (d) (Fig. 2). The mean depth of the streams near the tailspill was measured in three points: at the sides and the back of the tailspill. The length of redds is generally greater than width, but as this is not a hard and fast rule, a more precise way of determining size was needed for comparing redds and their characteristics. This new parameter describes the size of the taispill which is the arithmetic mean of the length and the width of the redd ($(w + l)/2$). In many cases, due to the varied bottom, it is difficult to determine exactly the height of the tailspill or the depth of the pot. This is especially difficult in sandy streams where, after the substrate is cleaned by the female the redd can sink into the surrounding bottom. This is why another parameter was introduced – maximum tailspill height (h_{max}) that is the sum of the pot and the height of the tailspill; this is easy to determine in practice and is the difference between the water column above the pot and above the



a . Top view



b . Side view

Fig. 2. View and basic parameters of trout redd; a – top view, b – side view. Point of water velocity measurement is marked by asterisks. Explanations of symbols are in the text.

tailspill (Fig. 2b). When it was difficult to determine precisely the bottom depth near the tailspill, only the maximum height of the tailspill was recorded (Table 2). Water velocity was measured in the mid point of the water column above the head of the redd (Fig. 2). Measurements were taken shortly after spawning, since the redd could erode or become sandy over time. Only redds with distinct pots and tailspills were measured, while those that had small pots or indistinct tailspills were classified as attempted. Water temperature was measured during the spawning observations.

Forty-five redds were measured in the 2004-2005 to 2007-2008 seasons, and at eighteen of these females were observed building and then spawning in them. The shallow streams and good visibility permitted determining the approximate length of the females by comparing them with other objects of known length on the stream bottom (Curry and Noakes 1995). The estimated total length of the females was measured in 5 cm length classes. For a comparison of sizes and substrate structure, data was included from 6 redds that had been observed in the same system segment in the 2003-2004 period (Radtke 2005).

The substrate from fifteen redds was analyzed. Grab samples of the substrate were collected in spring immediately following fry emergence, which was registered with previously installed traps (Radtke unpublished data). The substrate was collected at the head of the tailspill into bags of densely-woven material stretched over a metal frame measuring 50×25 cm. After drying, the samples weighed from 4.6 to 9.4 kg (mean 7.5 kg) and were passed through sieves of ten different mesh sizes ranging from 0.8 to 63.0 mm. The weight share of each fraction was calculated. Single large stones in the samples had a significant impact on the other smaller fractions so the largest fraction (> 63.0 mm) that occurred in three of the fifteen samples was excluded from the analysis. The following substrate parameters were determined:

- geometric mean diameter of substrate particles (D_g) according to the formula: $D_g = (d_1^{w1} \times d_2^{w2} \times \ldots \times d_n^{wn})$, where d_n is the median diameter fraction size on n-th sieve, and w_n is the tenth part of the weight share of the fraction held back by n-th sieve (Lotspeich and Everest 1981),
- median particle diameter size (D_{50}), which is the mean particle diameter for 50% of the accumulated weight share,
- the sorting index indicates the variation in substrate particles, $S_o = (D_{75}/D_{25})^{0.5}$, where D_{75} and D_{25} represent the particle size of 75% and 25%, respectively, of the accumulated weight share,
- the fredle index that describes gravel permeability – $f_i = D_g\, S_o^{-1}$
- weight share (%) of the sand fraction < 1 mm.

STATISTICAL ANALYSIS

The dependencies between various redd parameters were described by calculating the Pearson (r) correlation, and the relationships between water velocity and the other parameters was determined using the Spearman (r_S) nonparametric correlation. The Spearman correlation was also used to determine the dependencies between the particle size parameters of the substrate with the other redd parameters. The size of redds from different streams was not compared in the analyses since the redds were recorded randomly in selected stream segments and not from the entire spawning ground. Because of this, the data collected might not be fully representative of redd size. The water velocity above the tailspills was compared among the streams with the non-parametric Kruskal-Wallis test, and then the Mann-Whitney U test was applied to check pairs of streams. Data from Czysta Woda was excluded from this analysis due to the small number of samples. The Mann-Whitney U test was also used to compare the geometric mean particle diameter of the substrate (D_g) and the share of sand between the traditional spawning sites in the lower part of the system (Trzebiocha and Wda) with those in the upper part of it (Pilica).

RESULTS

Adult lake trout were observed in the Wda and Trzebiocha rivers as early as September when single pairs of spawners were caught during fry monitoring catches (unpublished data). Lake trout spawning were observed from mid October to early January with the peak usually in mid November. Redd-building females with males waiting near the spawning grounds were noted at a water temperature range of 1.1-10.8°C, and most frequently at a range of 3.0-8.0°C. Based on irregular observations of the spawning grounds made over several years, it was determined that the Lake Wdzydze female trout builds one redd comprised of one tailspill. Singly instances were noted when a female made another tailspill in an established redd that had been created earlier by another female. A frequent phenomenon was the building of redds in the same location year after year. Redd construction was observed mainly at night and in the morning, as well as during the day when it was cloudy. Redd construction (and spawning) was usually initiated and completed within 24 to 48 hours.

Fifty-one redds were described during the spawning season of 2003-2004 to 2007-2008 (Table 2). Tailspill length ranged from 40-150 cm, and width was 47-130 cm. Stream depth in the segments observed near the redds was similar and did not exceed 55 cm.

TABLE 2

Mean values ± SD (range) of main redd parameters

Stream name and redd number	Tailspill length (cm)	Tailspill width (cm)	Maximum tailspill height (cm)	Pot depth (cm)	Water depth (cm)	Water velocity (cm s^{-1})
Trzebiocha; n = 16	91.9 ± 28.3 (55 – 150)	77.6 ± 20.0 (55 – 110)	18.6 ± 5.3 (11 – 29)	12.2 ± 5.5[a] (4 – 23)	38.6 ± 9.2[a] (22 – 55)	80.1 ± 12.0 (54 – 95)
Pilica; n = 20	77.0 ± 26.5 (40 – 120)	74.5 ± 20.1 (47 – 110)	19.1 ± 7.2 (7 – 35)	14.2 ± 7.7[b] (2 – 25)	37.8 ± 8.7[b] (25 – 55)	67.3 ± 9.7 (43 – 83)
Wda; n = 11	100.3 ± 30.2 (70 – 150)	92.5 ± 23.5 (63 – 135)	19.4 ± 8.5 (8 – 31)	11.6 ± 6.9[c] (5 – 25)	35.4 ± 9.3[c] (25 – 55)	90.3 ± 16.3 (60 – 110)
Czysta Woda; n = 4	81.2 ± 34.2 (50 – 120)	72.5 ± 17.5 (55 – 90)	18.5 ± 5.4 (11 – 24)	12.0 ± 5.5 (4 – 16)	21.0 ± 4.9 (15 – 55)	66.2 ± 37.6 (40 – 122)
Total; n = 51	87.0 ± 29.1 (40 – 150)	79.2 ± 21.3 (47 – 135)	19.0 ± 6.7 (7 – 35)	12.8 ± 6.6[d] (2 – 25)	36.0 ± 9.8[d] (15 – 55)	76.2 ± 17.5 (40 – 122)

a) n = 14; b) n = 17; c) n = 10; d) n = 45

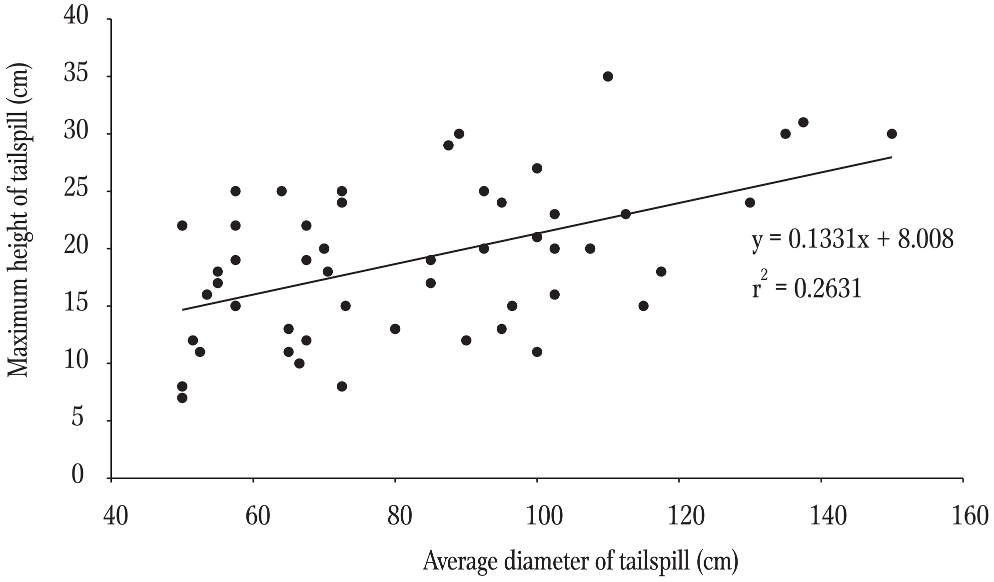


Fig 3. Relationship between tailspill diameter and maximum tailspill height with regression line.

There was strong correlation between tailspill length and width (r = 0.87, P < 0.001), and there were significant dependencies between some redd parameters, water velocity, and female length (Table 3). A highly significant positive correlation ($r = 0.53$, $P < 0.001$) was noted between the mean tailspill diameter and its maximum height (h_{max}) (Fig. 3). There was also a significant positive correlation between tailspill size and water velocity. The combined water velocity above the tailspills ranged from 40 to 122 cm s^{-1}, and was usually between 60 to 90 cm s^{-1} (Table 2, Fig. 4). These differences in water velocity in the streams analyzed were statistically significant (Kruskal-Wallis test, $P < 0.001$), and while there were no differences between the Trzebiocha and the Wda rivers (Mann-Whitney U test, $P > 0.05$), there were significant differences in water velocity between the Pilica and the other streams, namely with the Wda ($P < 0.001$) and the Trzebiocha ($P < 0.01$). No dependency was noted between the tailspill size and the bottom depth surrounding them.

TABLE 3

Correlations between selected redd parameters and female length; $^{+}$ – Pearson's correlation coefficient, $^{++}$ – Spearman's rank correlation coefficient

	Pot depth^{+} (n = 45)	Tailspill height^{+} (n = 45)	Maximum tailspill height^{+} (n = 51)	Water velocity^{++} (n= 51)	Female length^{+} (n = 18)
Tailspill length	0.44**	0.19 ^{ns}	0.52***	0.29*	0.90***
Tailspill width	0.33*	0.36*	0.49***	0.37*	0.92***
Tailspill diameter	0.40**	0.28 ^{ns}	0.53***	0.33*	0.97***

**P < 0.05; ** P < 0.01; *** P < 0.001; ^{ns} non-significant*

In the eighteen redds in which spawning was observed, there was a highly positive dependency between female length and the size of the tailspill, and the strongest correlation was with the average diameter of the tailspill ($r = 0.97$, $P < 0.001$) (Fig. 5). In practice, female length corresponds to about 55% of the tailspill diameter. Additionally, there was a significant correlation between female length and the maximum tailspill height ($r = 0.48$, $P < 0.05$). There was substantial difference in the substrate particle size in the redds observed (Table 4). The geometric mean size of substrate particles (D_g) was calculated for the individual redds and was within a range of 3.0-17.4 mm, while the share of sand ranged from 3.0 to 36.5%. In Pilica the geometric mean size of substrate particles (D_g) was twofold smaller and the sand content twofold higher than at the traditional spawning grounds in the lower part of the system. These differences were significant (Mann-Whitney U test, $P < 0.01$).

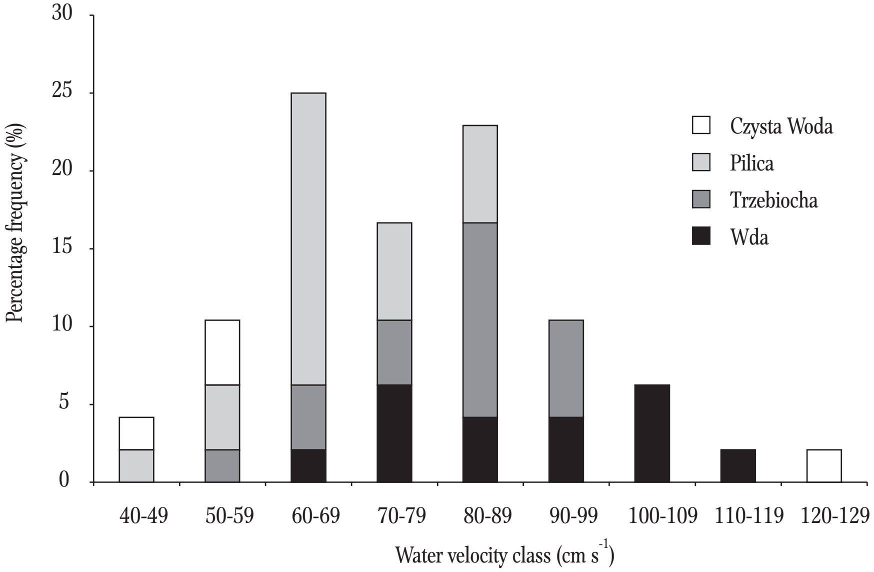


Fig. 4. Histogram of water velocity above redd tailspills in investigated streams.

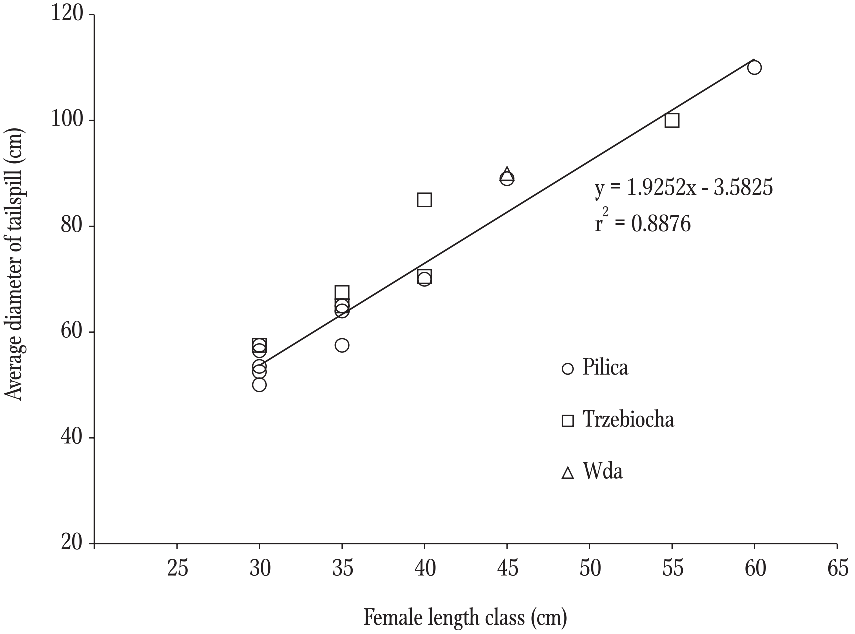


Fig. 5. Relationship between female length and tailspill diameter with regression line.

TABLE 4

Mean values ± SD (range) of investigated substrate parameters; D_g – geometric mean diameter of particles, D_{50} – median size of particles, S_o – sorting coefficient, f_i –fredle index

Stream name and redd number	D_g	D_{50}	S_o	f_i	Percent of sand
Trzebiocha; n = 6	13.1 ± 3.5	20.1 ± 5.5	2.7 ± 0.8	5.5 ± 2.7	10.3 ± 4.9
	(8.8 – 17.4)	(14.3 – 29.2)	(1.9 – 3.8)	(2.5 – 8.6)	(3.0 – 16.9)
Pilica; n = 8	6.2 ± 2.3	8.9 ± 4.1	3.5 ± 0.6	1.9 ± 1.1	21.9 ± 7.8
	(3.0 – 10.1)	(3.1 – 15.6)	(2.5 – 4.3)	(0.7 – 4.0)	(12.0 – 36.5)
Wda; n = 1	11.6	19.2	2.2	5.1	9.9

The fredle index was significantly lower in the samples from Pilica than in the other redds. This indicates that conditions for spawn development in the upper river system are worse. Among the fifteen redds from which substrate samples were collected, no significant differences were noted in the fundamental particle parameters and other redd parameters; this could have resulted from too few samples. The only significant correlations ($P < 0.05$) occurred between the sort coefficient – S_o and water velocity (r_s = - 0.53), and between S_o and the maximum tailspill height (r_s = - 0.53). There were significant correlations ($P < 0.05$), however, between all of the particle size parameters and some of the basic redd proportions, such as the ratio of redd length to width l/w and the ratio of tailspill width to maximum height w/h_{max} (Table 5). The coarser the substrate was, the more elongated the tailspill was. With finer substrates, the tailspill was flatter.

TABLE 5

Spearman's rank correlation coefficients between substrate parameters (D_g – geometric mean diameter of particles, D_{50} – median size of particles, S_o – sorting coefficient, f_i – fredle index) and proportions of basic tailspill dimensions (l – length, w – width, h_{max} – maximum height); all values are significant ($P < 0.05$, n = 15)

	D_g	D_{50}	S_o	f_i	Percent of sand
l/w	0.59	0.58	-0.64	0.65	-0.61
w/h_{max}	-0.61	-0.64	0.65	-0.59	0.56

DISCUSSION

The lake trout from Lake Wdzydze spawn in the Wda and Trzebiocha rivers, and there are no reports of spawning in the outflow of the lake or the lake itself (Sakowicz 1961). After some of the trout from Lake Wdzydze were translocated to several lakes in the Mazurian Lake District, they were observed to spawn in Lake Hańcza

(L. Chybowski – personal communication); however, spawning in lakes is strictly dependent on the presence of flowing water from submerged springs (Brabrand et al. 2002). In flowing waters, stream morphology influences the choice of spawning site (Baran et al. 1997, Zimmer and Power 2006), and water velocity and stream depth are the most significant (Smith 1973, Shirvell and Dungey 1983, Witzel and MacCrimmon 1983). It has also been noted that females seek out and prefer places for nest building that have distinct water flow through gravel substrate (Stuart 1954). Due to this, redd superimposition is noted, i.e., when a female builds her redd atop of another built previously by another female (Witzel and MacCrimmon 1983). This is not only linked to a limited number of suitable spawning spots, but also to the female behavioral tendency to spawn in existing redds (Essington et al. 1998). In the past, the redds of the Lake Wdzydze trout were decidedly larger, and the largest redds were probably built by several females (Sakowicz 1961). This also could have been due to the fact that fifty years ago the trout in Lake Wdzydze were more abundant and the spawners were larger.

The precise environmental requirements of depth, water velocity, and substrate structure are connected with the variety of stream bottom morphology and the presence of obstacles such as tree trunks, branches, rocks, etc. The trout from Lake Wdzydze generally built their redds in the Trzebiocha and Pilica near submerged tree trunks or low-hanging branches that provided cover for the females and deflected the water current creating sites with increased flow. However, since the Wda has a higher gradient, the females were observed to build redds in the middle of the river bed without obstacles. Similar differences were noted in *Oncorhynchus clarki lewisi* (Richardson) redd placement; during the dry period with weak water flow, the redds were built near the banks and near tree trunks and branches, while in the wet season when water flow is strong and velocity is higher, these fish built their redds in the middle of the river bed (Schmetterling 2000).

Although the small number of redds observed limits a more probing interpretation of the results obtained, a few generalizations can be made. Foremost, there were substantial differences in the substrate parameters between the redds at the traditional spawning grounds in the lower Wda system and those in the upper part of it. The nearly twofold smaller substrate particle size in Pilica could have been caused by the different character of the streams and its gentler gradient that result from the geomorphological differences in the two parts of the system. Confirmation of this is seen in the difference in the mean velocities of the individual streams. The substrate parameters of the redds in the Pilica indicate that conditions for spawn development are worse in this part of the river system which might explain the lack of these fish here prior to 1991 when they were introduced.

In the current study, the water depth at which the redds were built was similar to that noted in other streams (Smith 1973, Shirvell and Dungey 1983, Witzel and MacCrimmon 1983, Crisp and Carling 1989, Beard and Carline 1991). Although it is thought that bigger females make redds at deeper sites (Crisp and Carling 1989), no dependence between tailspill size and water depth was noted in the Wda River system. The water velocity above the tailspill was similar to that observed for brown trout, *Salmo trutta* m. *fario* L., in southern Poland (Mikołajczyk et al. 2003), but higher than that noted for *S. trutta* in different regions of Europe and North America (Smith 1973, Shirvell and Dungey 1983, Witzel and MacCrimmon 1983, Crisp and Carling 1989, Beard and Carline 1991, Sorensen et al. 1995). Although no significant dependence was noted between female length and water velocity above the tailspill, this might have been the result of the small sample size (n = 18). There was, however, a significant, positive correlation between tailspill diameter and water velocity (n = 51). Since the size of the tailspill is correlated with female length, this indirectly suggests that there is a dependence between water velocity and female length, a relationship that has been observed in other streams (Crisp and Carling 1989).

Although it is common among *S. trutta* females that each builds one redd (Elliott 1984, Crisp and Carling 1989), under some conditions, especially when the substrate is of a poorer quality, females will build more than one redd, which is known as the multiple-redd tactic (Barlaup et al. 1994). The redds built by the trout from Lake Wdzydze exhibited a dependency between substrate quality and redd proportions. However, since the substrate samples were collected in spring, it is possible that small particles sedimented into the redd during incubation.

Generally, salmonid redd size is correlated with female size (Ottaway et al. 1981, Crisp and Carling 1989, Edo et al. 2000). This was confirmed by observations in the Wda River system, and although length measurements were imprecise, female length corresponded to approximately 55% of the diameter of the tailspill. The dependence of female length and tailspill diameter is strong and permits determining quite precisely the length of spawning females based on tailspill measurements. This might be of fundamental significance in determining the structure and size of the spawning stock (females) without making catches, which is especially important for rare or endangered fish (Edo et al. 2000). Additionally, the number and size of the females spawning can be used to estimate the number of eggs deposited and the level of recruitment based on female fecundity (Chadwick 1982) or excavated redds (Elliott 1984, Edo et al. 2000).

Redd counts are an inexpensive, widely applied method for monitoring and determining the abundance of salmonid populations (Rieman and Myers 1997, Al-Chokhachy et al. 2005, Gallagher and Gallagher 2005). Classification errors are possible by misinterpreting redd superimposition, multiple-redd tactics, or the incorrect classification of false or attempted redds (Beard and Carline 1991, Barlaup et al. 1994, Edo et al. 2000, Dunham et al. 2001). Errors can also result from underestimating the redds of the smallest fish, especially in streams inhabited by species whose smaller forms are stationary and the larger are migratory (Al-Chokhachy et al. 2005). In the current work, redds were categorized subjectively and not by sampling, and small pots lacking distinct tailspills were classified as attempted redds. In order verify that redds are, in fact, productive, and to eliminate false or attempted redds (i.e., empty redds) from the classification, the presence of spawn must be confirmed. Thus, further, more detailed studies of redd parameters and their relationships with environmental and biological factors are necessary in order to create a basis for estimating the spawning population size as well as the potential number of deposited eggs.

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STRESZCZENIE

NIEKTÓRE CECHY GNIAZD TARŁOWYCH TROCI JEZIOROWEJ *SALMO TRUTTA* M. *LACUSTRIS* L. W DORZECZU GÓRNEJ WDY

Celem badań prowadzonych w sezonach 2003/2004-2007/2008 była charakterystyka gniazd tarłowych zagrożonej, lokalnej formy troci jeziorowej, *Salmo trutta* m. *lacustris* L., zasiedlającej jezioro Wdzydze i dorzecze górnej Wdy (rys. 1, tab. 1). Tarło troci i formowanie gniazd obserwowano od połowy października do początku stycznia w temperaturze wody 1,1-10,8°C. Na 18 gniazdach obserwowano kopiące samice i tarło troci. Samica buduje z reguły jedno gniazdo składające się z owalnego kopca, a tarło trwa najczęściej 1-2 doby. Pomiary gniazd wykonano tuż po zakończonym rozrodzie uwzględniając: rozmiary kopców, głębokości dołków, głębokości dna dookoła kopców oraz prędkość przepływu nad kopcami (rys. 2). Ogółem zmierzono 51 gniazd (tab. 2). Z 15 gniazd wiosną pobrano substrat do analizy i określono podstawowe parametry substratu, tj.: średnią geometryczną średnicę cząstek (D_g), średnią wielkość cząstek (D_{50}), współczynnik sortu (S_o), „fredle index" (f_i) oraz udział wagowy frakcji piaszczystej < 1 mm. Gniazda były mniejsze niż obserwowane pół wieku temu. Długości kopców mieściły się w granicach 40-150 cm, a szerokości pomiędzy 47-135 cm. Głębokości dna dookoła kopców były podobne jak w innych potokach zasiedlonych przez *S. trutta i* mieściły się w zakresie 15-55 cm. Prędkości przepływu nad kopcami gniazd były stosunkowo wysokie i mieściły się między 40-122 cm s^{-1}. Zaobserwowano istotne różnice prędkości wody pomiędzy potokami, przy czym najwyższe notowane były we Wdzie, a najniższe w Pilicy (tab. 2, rys. 4). Istotne zależności występowały pomiędzy poszczególnymi parametrami kopców, a także między rozmiarami kopców a głębokością dołków i prędkością przepływu (tab. 3). Na 18 gniazdach, na których obserwowano kopiące samice, występowała istotna korelacja pomiędzy średnicą kopców a długością samic (rys. 5). Przeciętna długość samicy odpowiadała ok. 55% średnicy kopca. Średnie geometryczne średnice cząstek substratu mieściły się w granicach 3,0-17,4 mm, a udział piasku wynosił od 3,0 do 36,5%. Występowały istotne różnice w uziarnieniu substratu gniazd pomiędzy górną i dolną częścią zlewni (tab. 4). W górnej części (Pilicy) średnica cząstek była 2-krotnie niższa, a udział piasku 2-krotnie wyższy niż w dolnej Trzebiosze i Wdzie. Ponadto zaobserwowano, że w grubszym substracie kopce gniazd były bardziej wydłużone, natomiast w drobniejszym substracie kopce były bardziej płaskie (tab. 5).