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SIZE STRUCTURE AND BODY CONDITION OF BROWN TROUT (*Salmo trutta trutta m. fario* L.) FROM MOUNTAIN-TYPE RIVER IN LUBLIN UPLAND

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Summary. The size structure and the condition of brown trout from a mountain-type river were determined based on 367 individuals of the species. The fish were caught three times in 2007 in the river Ciemięga at two sites: in Dys and Pliszczyn. Overall, the total length of the trout ranged from 7 to 45 cm, and their body weight ranged from 4 to 830 g. At both sites, brown trout with overall length of 10 to 15 cm dominated, and additionally at the Pliszczyn site there were also numerous fish with lengths from 15 to 20 cm. Higher values of the condition factor were characteristic of brown trout from the Dys site (K = 1.08), where the river is more like a lowland river in character.

Key words: brown trout, size structure, fish condition, mountain type river

INTRODUCTION

Brown trout (*Salmo trutta trutta m. fario* L.) is one of the most attractive fish species for cooking and for anglers. At the same time, it is the basic species for fishery management in mountain rivers [Augustyn 1999, Fisher and Burroughes 2003, Augustyn *et al*. 2006].

The range of brown trout ascension in Poland includes the mountainous and submontane areas, mainly the northern and southern parts of the country (tributaries of the Baltic Sea and mountain rivers) [Kukuła 1999, Witkowski *et al*. 2006, Radtke *et al*. 2007, 2010a, b]. It is also present in upland area rivers with features similar to mountain rivers, e.g. the Tanew River and its tributaries in Roztocze [Rechulicz *et al*. 2009].

Fishery management in mountain rivers requires appropriate management of brown trout populations. Such management is feasible thanks to the use of

population size structure assessments and fish condition. This allows for the enrichment of information on the biology and habitat of the species and also to adapt and evaluate the effectiveness of fishery management conducted in those waters [Zalewski *et al*. 1985, Błachuta and Witkowski 1997, Augustyn *et al*. 2006].

The ichthyofauna of south-eastern Poland has been relatively poorly investigated, with few studies on brown trout populations in mountain-type rivers in the Lublin Upland [Witkowski and Kotusz 2008, Rechulicz *et al*. 2009]. The purpose of this study was to determine the size distribution and condition factor of brown trout present in the River Ciemięga located in the Lublin Upland, which is classified as a mountain-type river.

MATERIAL AND METHODS

The research area is situated in the upper course of the Ciemięga River, a left-bank tributary of the Bystrzyca River. This river is 36 km long, 25.7 kilometres of its course being considered mountain-type river, trout and grayling zone. The catchment basin of Ciemięga River is 157 km^2 and the average water discharge amounts to 0.58 $m^3 s^{-1}$ [Michalczyk *et al*. 1997, Gliński and Stępniewska 2005]. In 1990, the Ciemięga Valley Landscape Protection Area was created in the valley of Ciemięga.

The analyses were performed on brown trout (*Salmo trutta m. fario* L.) caught with IUP -12 three times in year 2007: in spring, summer and autumn [Penczak 1967]. On the mountain-type part of Ciemięga River two 100-meter long study sites were chosen. The first site was located in the vicinity of village Dys, where the river bed is sectionally regulated, 3.5–4 m wide and 0.40–0.90 m deep (Tab. 1).

The second site was located near the village Pliszczyn, where the river is natural – it is wider and its depth ranges from 0.30 to 0.45 m (Tab. 1). Between the study sites one and two, above the village Pliszczyn, there is a several-meter weir which prevents the migration of fish upstream.

In total 367 individuals of brown trout were caught, including 66 individuals at site Dys and 301 at site Pliszczyn. All the fish were measured for their total length (*Tl – Longitudo totalis*) and body length (*Sl – Longitudo corporis*) (to 1mm). They were also weighed (*W*) (to 1 g). After the measurements, all the fish were returned to the river at the spots where they had been caught.

Condition factor (Fulton) (*K*) for all individuals of brown trout was calculated using the following formula:

$$K = \frac{W}{Tl^3} \ 100$$

where**:**
K – condition factor (Fulton),
W – body weight in grams,
Tl – total length in centimetres.

Table 1. Morphological characteristics and water physical and chemical parameters* at sampling sites on River Ciemięga

Specification \ Site	Dys	Pliszczyn
Distance from river spring	26 km	33 km
Width of river bed, m	3.50–4.00	4.50–6.00
River depth, m	0.40–0.90	0.30–0.45
Bottom characteristics	Sand and gravel bottom. sectionally mud and a lot of submerged macrophytes	Gravel and sand bottom. a few macrophytes
River bed characteristics	River bed irregular with not big meander. high and steep banks with plants: *Urtica dioica* L. *Lamium album* L.. a few trees	River bed shallow. straight. flat banks. high valley. trees along banks: *Alnus glutinosa* Gaertn.. *Salix alba* L.
River modifications	River sectionally regulated. near bridge banks with concrete blocks	Natural river. without modifications. a weir above the study site
Water pH	7.76	7.60
Water conductivity, μS cm^{-1}	628.11	556.11
Water temperature, °C	9.40	9.23
Oxygen saturation, %	89.02	93.91
Dissolved oxygen, mg dm^{-3}	9.78	10.69

*mean values for three seasons (spring. summer and autumn)

Additionally, the length-weight relationships of brown trout from both site were expressed by the equation: $W = a\,L^b$, and also after data transformation by the following formula:

$$\log W = b \log L + \log a$$

where:
W – body mass in grams
L – total length (*Tl*) and body length (*Sl*) in centimetres
a and b – parameters describing linear regression
log – logarithm (base 10) [Schneider *et al*. 2000].

The results for the total length, body length, body weight and condition factor of fish were statistically analysed using t-test at the level of $p < 0.05$. The correlation between the condition factor and the season was determined using univariate analysis of variance [SAS 9.1, Statistica 6.0].

RESULTS

The brown trout caught in River Ciemięga were characterised by total lengths ranging from 7 to 45 cm. Both the smallest and the largest fish were caught at the Pliszczyn site (Tab. 2). The mean total length of the trout from the Pliszczyn site was slightly higher, though the difference was statistically insignificant (F = 1.2653, p = 0.0705) (Tab. 2). At the same time, the analysed fish groups showed similar variability of this parameter (SD = 4.26–4.79).

Table 2. Number of individuals (*N*), total length (*Tl*) (in cm), body length (*Sl*) (in cm), body mass (*W*) (in g) and condition factors (*K*) of brown trout from study sites on Ciemięga River, SD – standard deviation, CV – coefficient of variation (%)

Feature	Site	N	Mean	Min	Max	SD	CV
Tl	Dys	66	14.86 [a]	9.30	24.50	4.26	28.66
	Pliszczyn	301	16.02 [a]	7.00	45.00	4.79	29.91
Total		367	15.81	7.00	45.00	4.71	29.82
Sl	Dys	66	13.18 [a]	8.00	21.80	3.83	29.05
	Pliszczyn	301	13.89 [a]	6.00	40.00	4.22	30.40
Total		367	13.76	6.00	40.00	4.16	30.22
W	Dys	66	43.27 [a]	7.00	152.00	37.10	85.76
	Pliszczyn	301	51.93 [a]	4.00	830.00	69.32	133.48
Total		367	50.37	4.00	830.00	64.76	128.57
K	Dys	66	1.08[a]	0.49	1.53	0.20	18.18
	Pliszczyn	301	1.00[b]	0.73	1.32	0.10	10.16
Total		367	1.01	0.49	1.53	0.13	12.64

[a, b] means with same letters are not significantly different at p = 0.05.

The most numerous group of trout at the Dys site was composed of individuals with total length from 10 to 15 cm. At the Pliszczyn site the same group was also dominant, but there were also individuals with length from 15 to 20 cm (Fig. 1). Additionally, that population had a better ratio of total length to the hypothetical frequency distribution (Fig. 1).

The body weight of the analysed trout fell within the range from 4 to 830 g. The trout from the Pliszczyn site had a slightly higher mean body weight, but the differences were statistically insignificant. This group of fish was also characterised by an almost twofold higher variability of this feature (Tab. 2).

Trout from both study sites were characterised by different domination in the biomass structure. At the Dys site, about 65% of the individuals were represented by small fish with weight of 4–40 g, 40% of which were the smallest fish (Fig. 2). The biomass structure of fish from the Pliszczyn site was dominated by individuals of 21–60 g that constituted almost 70% of the whole population. At

the same time, the number of the smallest trout at this study site was over 50% lower than at the Dys site. It is also worth mentioning that trout with body weight ranging from 101 to 140 g had a similar frequency at both study sites (Fig. 2).

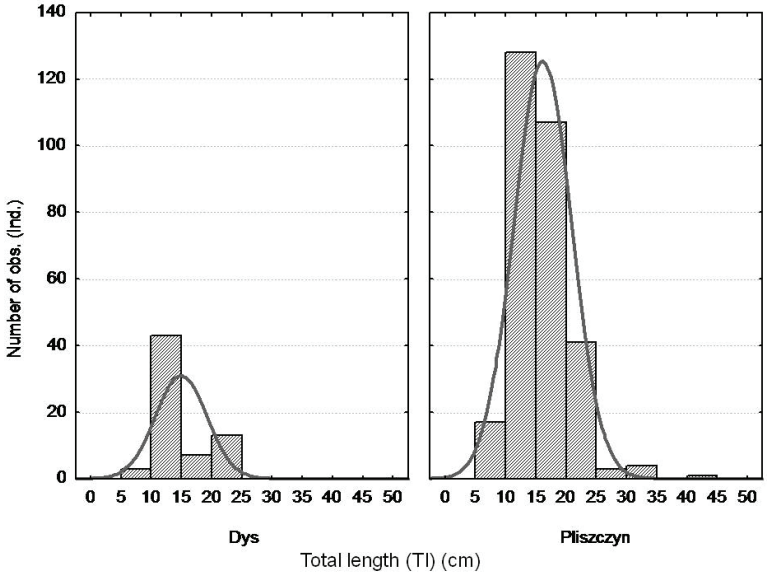

Fig. 1. Total length (*Tl*) distribution of brown trout from Ciemięga River

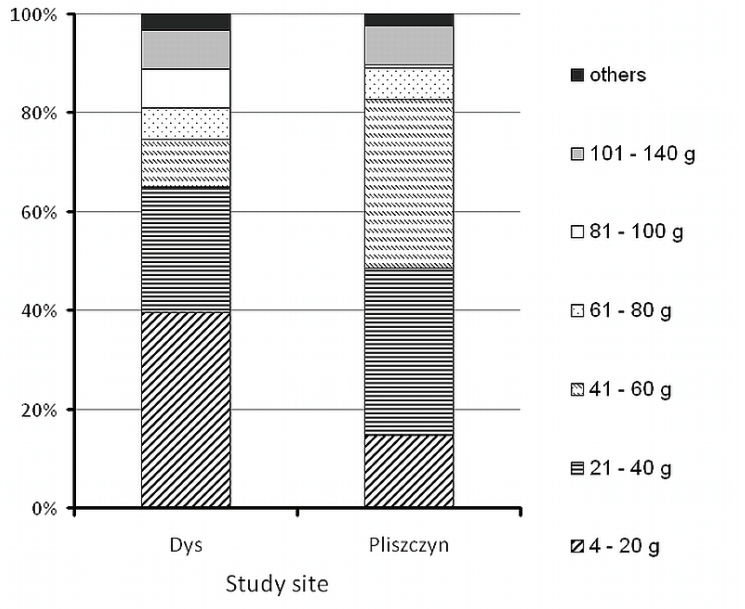

Fig. 2. Dominance structure in the biomass of brown trout from the Ciemięga River

The condition factor of the trout from the River Ciemięga ranged from 0.49 to 1.53 (Tab. 2). The trout from the Dys site had a condition factor of 1.08 and, as evidenced by statistical analysis, this proved statistically significantly higher than the coefficient for the trout from the Pliszczyn site (df = 365, p = 0.000001, F = 3.776) (Tab. 2). The analysis of this parameter showed that these variations are dependent on the season. The highest values of the condition factor were recorded for trout from both sites in spring (Dys: p = 0.0001, F = 11.46, Pliszczyn: p = 0.0001, F = 183.55). Detail analysis of the parameter showed that there was a seasonal variation of its values. The values of the condition factor for trout from both sites were the highest in spring (Dys: p = 0.0001, F = 11.46, Pliszczyn: p = 0.0001, F = 183.55). For the trout from the Dys site, this parameter had similar values in the other two seasons, whereas the trout from the Pliszczyn were in increasingly weaker condition from one season to the next, and the differences proved to be statistically significant (Fig. 3).

Table 3. Length (*Tl* and *Sl*) – weight (*W*) relationship parameters of brown trout from River Ciemięga after formula: $\log W = b \log L + \log a$

	Site	*b*	*a*	R^2
Total length (*Tl*)	Dys	3.4664	1.0086	0.9500
	Pliszczyn	3.4109	0.9900	0.9823
Body length (*Sl*)	Dys	2.8869	1.6911	0.9558
	Pliszczyn	2.8615	1.6615	0.9872

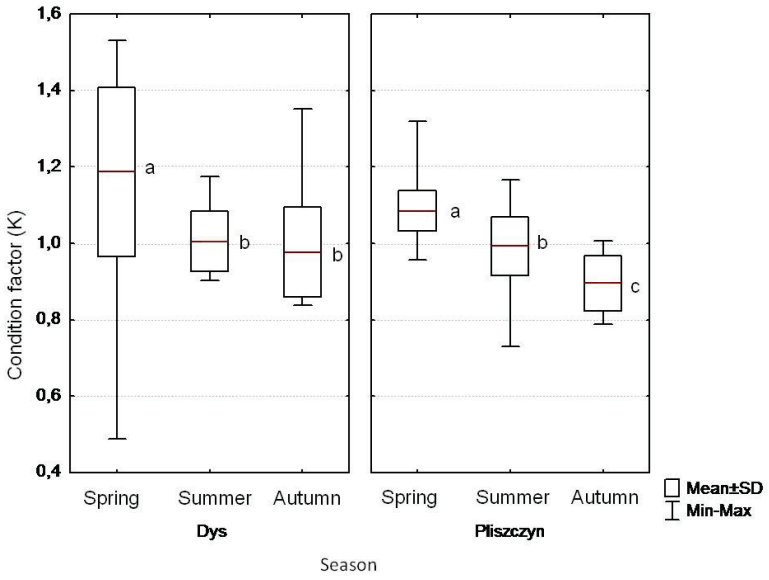

Fig. 3. Change of condition factor (K) of brown trout from Ciemięga River depending on the season, a, b – means with same letters are not significantly different at p = 0.05

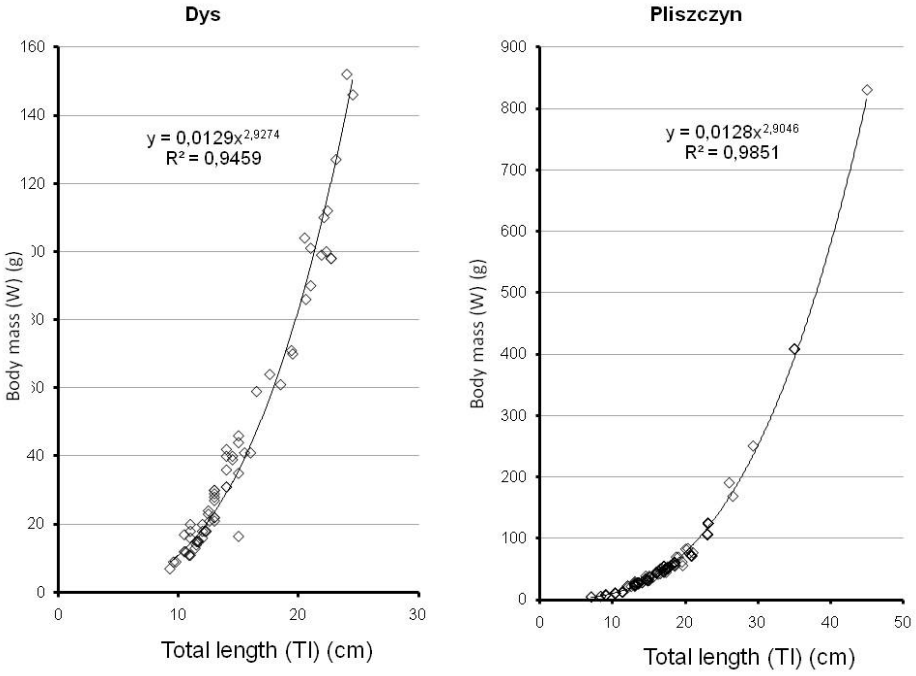

Fig. 4. Length-weight relationship of brown trout from Ciemięga River

Analysis of the relation between total length (*Tl*) and body weight (*W*) of the trout showed that both populations were characterised by similar distribution, and the fitting of the distribution curve was expressed by a similar value of R^2. For trout from the Dys site the length-weight relation was expressed with the equation: $W = 0.0129Tl^{2.9274}$; $R^2 = 0.9459$, and for those from the Pliszczyn site with the equation: $W = 0.0128Tl^{2.9046}$; $R^2 = 0.9851$ (Fig. 4). Similar relations (similar values of parameters *a*, *b* and R^2) were obtained in logarithmic transformation of the data, and the results obtained for trout from both study sites are presented in Table 3.

DISCUSSION

The size structure and the condition factor of brown trout (*Salmo trutta trutta m. fario*) in the mountain-type River Ciemięga situated in the Lublin Upland were analysed in the study. The trout population in the river had the size of 7–45 cm and did not statistically differ in relation to the habitat, which was confirmed by a lack of statistical differences. However, the fish from the Pliszczyn site had higher total length and body weight values. According to Allen [1985] and Zalewski *et al*. [1985], the relative variation of the size structure depends on a number of habitat parameters, and primarily on the genotype and origin of the

fish, availability and diversity of food, and on water temperature. One of the reasons for the differences in size and even in the numbers of the trout could be the several meter-long weir situated upstream of the Pliszczyn site as it prevents the fish from upstream migration. Due to the proximity of the River Bystrzyca, the population living below the weir in the Ciemięga is probably continuously supplemented with larger fish that enter the river in search of better feeding conditions or, at the time of spawning, in search of convenient spawning conditions [Zalewski *et al*. 1985, Augustyn 2008].

The analysis of the size structure of the Ciemięga trout revealed that the fish can represent age classes 0+ and IV+, and some of the largest fish could be even older [Brylińska 2000]. Especially at the Pliszczyn site the presence of the smallest and the largest fish indicates the existence of both the fry and the spawners of the species (Tab. 2). The fact that brown trout spawn in this section of the river has been corroborated by anglers who confirmed the existence of spawning nests. The Ciemięga section above the weir (at the Dys site) does not provide suitable habitat conditions for natural spawning of the species (Tab. 1). According to Brylińska [2000], populations of this species in some mountain rivers are maintained only by regular fry-stocking. Both upstream and downstream from the weir, the River Ciemięga is each year stocked by user with 7000 brown trout fingerlings [http://www.pzw.org.pl/lublin/].

Observations revealed that brown trout from the Dys site were characterised by statistically significantly higher values of the condition factor (Tab. 2). At that site, the river has the character of a lowland river, with a slower flow, which makes for greater abundance and diversity of potential food. River sections with a high flow rate (mountain-type) are usually habitats with insufficient food for this species. It should also be mentioned that the Ciemięga trout are usually in poor condition, only occasionally good, compared with North American trout [Barnham and Baxter 1998].

The changes in the values of the condition factor for the analysed trout, observed in relation to the season, can be attributed to the biology of the species which intensively feeds in spring and summer, favoured by the abundance of food. Whereas, directly before the spawning (in the autumn) the fish definitely reduce their food intake, which leads to their poorer condition (Fig. 3).

The length-weight relation of brown trout in the Ciemięga was characterised by values of parameter *b* in the range from 2.86 for the body length to 3.46 for the total length (Tab. 3). Those values turned out to be similar to the parameters observed for the caudal length of trout in the Kan River in Turkey [Arslan *et al*. 2004].

The brown trout population from the River Ciemięga can be described as stable with a diversified, habitat-dependent size structure. Despite the fact that the species naturally spawns in some sections of the river, every year its population is stocked with fry. Owing to its attractiveness, brown trout is a species of priority not only to anglers but also to poachers. Therefore, it is extremely important to monitor the population level of this species and to ensure the observance of closed seasons, protected dimensions and catch limits.

CONCLUSIONS

1. Brown trout in the River Ciemięga represent several size and weight categories, ranging from 7 to 45 cm and from 4 to 830g, respectively.

2. The brown trout from the station downstream from the weir, close to the conjunction of the Ciemięga with the larger river, had slightly larger body sizes.

3. At both study sites the dominant group among the brown trout were fish with total length ranging from 10 to 15cm.

4. The analysed brown trout were characterised by condition factor values from 0.49 to 1.53 (mean value 1.01). As regards this parameter, they did not differ from other populations of the species in other Polish regions and the world.

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STRUKTURA WIELKOŚCI I KONDYCJA PSTRĄGA POTOKOWEGO (*Salmo trutta trutta m. fario* L.) Z RZEKI TYPU GÓRSKIEGO NA WYŻYNIE LUBELSKIEJ

Streszczenie. Strukturę wielkości i kondycję pstrąga potokowego z rzeki typu górskiego określono na podstawie 367 osobników tego gatunku. Ryby odławiono trzy razy w 2007 r. w rzece Ciemięga na dwóch stanowiskach: w Dysie i w Pliszczynie. Ogółem długość całkowita pstrągów zawierała się w przedziale od 7 do 45 cm, a ich masa wahała się w granicach od 4 do 830 g. Na obu stanowiskach dominowały pstrągi potokowe o długości całkowitej od 10 do 15 cm, a na stanowisku w Pliszczynie dodatkowo licznie występowały ryby o długości od 15 do 20 cm. Większym średnim współczynnikiem kondycji charakteryzowały się pstrągi potokowe ze stanowiska w Dysie (K = 1,08), gdzie rzeka Ciemięga ma charakter zbliżony do rzeki nizinnej.

Słowa kluczowe: pstrąg potokowy, struktura wielkości, kondycja ryb, rzeka typu górskiego