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CHARACTERISTICS OF BROWN TROUT (*SALMO TRUTTA* M. *FARIO* L.) REDDS IN SELECTED STREAMS OF THE RUDAWA RIVER BASIN

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ABSTRACT. The quantity and characteristics of brown trout redds located in four streams of the Rudawa River basin in the Cracow Valleys Park (Park Dolinki Krakowskie) were investigated. The study was performed in late fall 2001 in the Będkówka, Kluczwoda, Racławka and Rudawka streams, all of which are left bank tributaries of the Rudawa River. A total of 328 redds were noted. The characteristics of twelve redds from each stream were described in detail, including water depth above the dome, water speed above the dome and the surface area of the redd. The contribution of certain gravel sizes in the composition of the domes was also investigated. There were no differences among the streams with reference to the surface areas of the redds or the water speed above the domes. The surface area of the redds ranged from 2081 to 3044 cm^2, while water speed above the dome varied from 73 to 82 cm s^{-1}. Significant differences in the water depth above the dome were noted among the different streams (from 12.58 cm in the Kluczwoda to 33.62 in the Rudawka). The contribution of fine gravel fraction (= 1 mm) also varied significantly among the streams. The highest sediment content was recorded in the Rudawka and Kluczwoda streams at 14.22 and 13.28% of the total weight of the gravel sample, respectively. This indicates that, despite the large number of redds in these watercourses, the final results of spawning could be very poor because of the probability of the asphyxiation of embryos by sediments. The Będkówka Stream is the most productive and promising trout spawning ground in the whole basin, and, as such, should be put under special protection.

Key words: BROWN TROUT REDDS, NATURAL SPAWNING

INTRODUCTION

The Polish Anglers Association (PZW) was responsible for fisheries and angling management in the Rudawa River basin from 1950 to 1995 (presently fishing region no. 19). In fall 1995, the Society of Sport Angling was granted the fishery management rights to fishing region no. 19, which had become heavily degraded as was evidenced by the fact that only 70 brown trout spawners were caught by electrofishing throughout the 40-hectare basin. The artificial spawning of the broodstock mentioned above was undertaken, and fry was released into several tributaries of the Rudawa River in 1996 and 1997 (Węglarski et al. 2001). Regular electrofishing studies undertaken in 1999, 2000 and 2001 indicated the presence of a strong population of brown trout (*Salmo trutta* m. *fario*) in most of the repopulated streams (Nodzyński 2002, Nowak

2002, Mikolajczyk et. al. 2003). Trout redds were also observed as well as numerous fish in the spawning grounds. The aim of this study was to characterize the brown trout spawning redds in chosen streams of the Cracow Valleys where the number of redds was the highest.

MATERIAL AND METHODS

The streams investigated are situated in the Cracow Valleys Park. They are left bank tributaries of the Rudawa River, which flows into the Vistula River in the center of Cracow. The water quality in most of the streams is very high. However, the location of numerous villages along the lower reaches of the streams provoked the regulation of the riverbeds and has had a visible, negative impact on the water quality and cleanliness of the banks (Turzański 1977). The study was performed between November 25 and December 10, 2001, in the Rudawka, Kluczwoda, Racławka and Będkówka streams. They are small chalk streams, born in manifold headsprings in rocky valleys. They are characterized by a very constant temperature (6-8°C) and flow. Three people walking upstream from the river mouth to the first hydrotechnical installa-

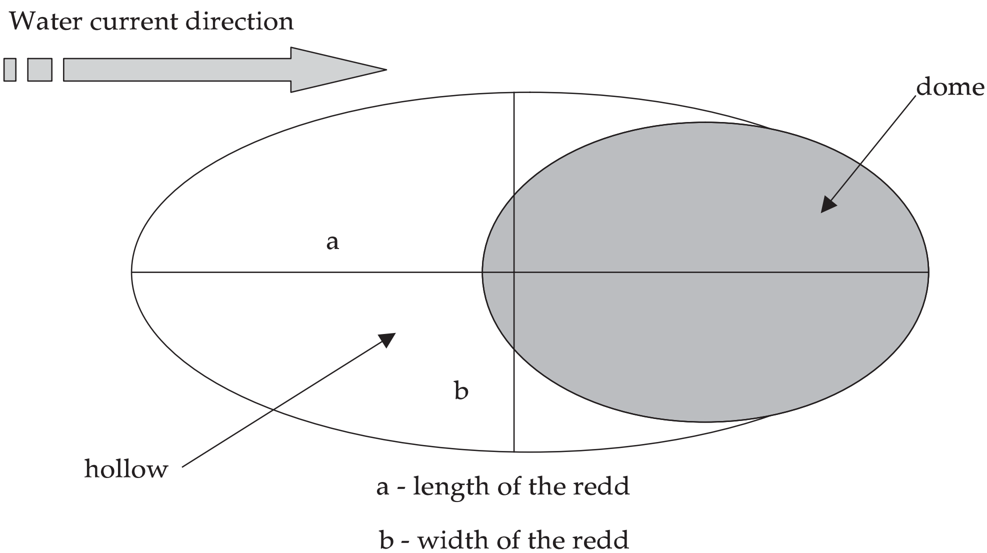

Fig. 1. Schematic presentation of trout redd (view from the top).

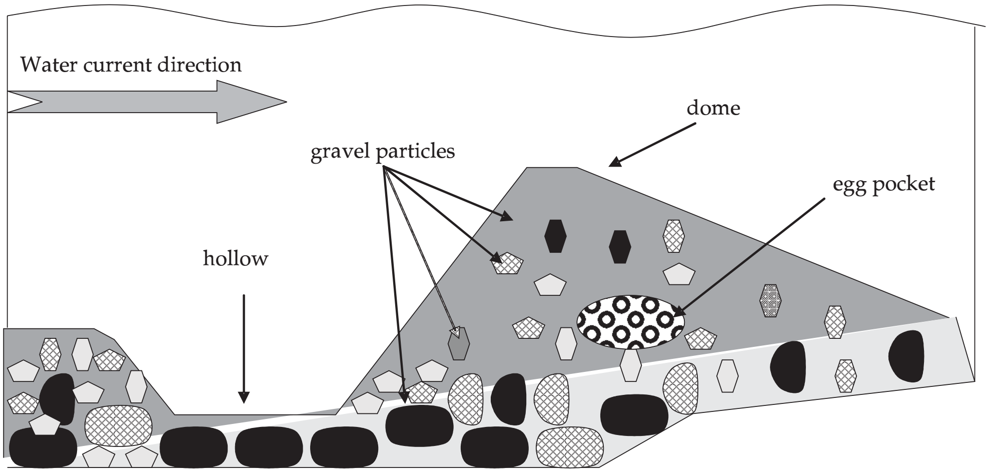

Fig. 2. Schematic presentation of trout redd (view from the side).

tion, which does not allow the fish to migrate upstream, recorded all the trout redds. The first twelve redds from each stream were chosen for detailed measurements of:

– water depth above the dome (cm);
– surface area of the redd calculated as the surface of an ellipse (cm^2), i.e., the total length and width of the redd (Fig. 1);
– water current speed above the dome ($cm\ s^{-1}$), measured with a waterproof anemometer TESTO 440 (Testo GmBH, Lenzkirch, Germany);
– placement of redds in relation to the water current and banks.

A sample of approximately 150 g of the gravel from the dome was collected using a plastic goblet (200 ml volume). A set of strainers (32, 16, 8, 4, 2, 1, 0.5 mm and smaller) was used to measure the gravel size. The contribution of certain gravel size to the composition of the dome is presented as the percentage of the total weight of a given gravel sample.

The nonparametric Mann-Whitney U-test was used to compare the values of a given parameter among the streams. Differences were considered significant at $P \leq 0.05$.

RESULTS

A total of 328 redds were recorded in the four streams investigated. Spawners were observed in approximately 30% of the spawning grounds. The redds were spread uniformly along the length of the investigated part of the streams, with the exception of the regulated mouth of each stream (300 to 500 m long). Details concerning the number of redds, the length of the streams, etc. are presented in Table 1.

TABLE 1

Total number of redds and characteristics of the investigated streams

Stream	Length of the investigated stream (m)	Number of redds observed	Mean number of redds per 100 m of river course
Będkówka	± 7000	93	1.32
Kluczwoda	± 5500	91	1.65
Racławka	± 5000	22	0.44
Rudawka	± 5500	122	2.21

SURFACE AREA OF THE REDDS

There were no significant differences concerning the surface areas of the redds among the investigated streams (Fig. 3). The mean ± SD surface area was the largest in the Rudawka Stream (3044 ± 1013 cm^2), followed by Racławka (2691 ± 1335cm^2),

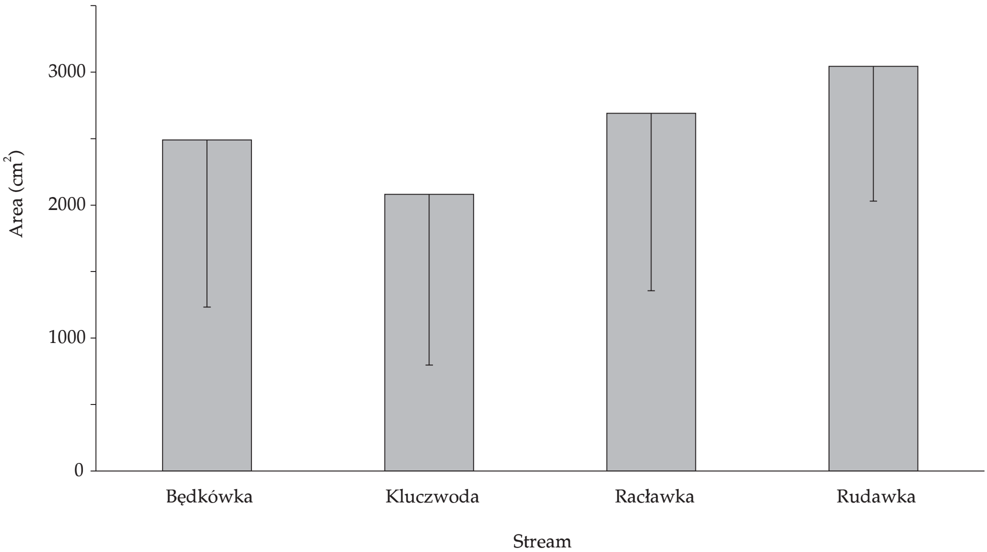

Fig. 3. Mean ± SD area of redds in given watercourses.

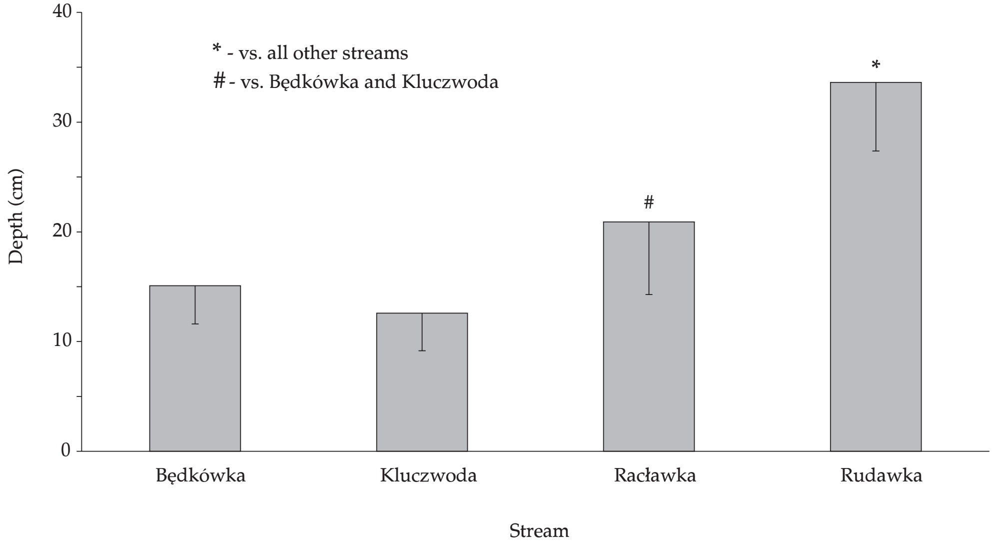

Fig. 4. Mean ± SD depth of water above the dome of redds in investigated watercourses.

Będkówka (2490 ± 1257 cm^2) and Kluczwoda (2081 ± 1284 cm^2). The single, largest redd was observed in the Będkówka Stream. It was 110 cm long and 55 cm wide (4749 cm^2).

WATER DEPTH ABOVE THE DOME

There were significant differences in the water depth above the redd dome among the streams (Fig. 4). Water depth (mean ± SD) was the biggest in the Rudawka Stream (33.62 ± 6.25 cm) and was significantly different from all the other streams. In the Racławka Stream, water depth was 20.91 ± 6.63 cm and was significantly deeper than in the Będkówka and Kluczwoda streams (15. 08 ± 3.48 cm and 12.58 ± 3.42 cm, respectively).

WATER CURRENT SPEED ABOVE THE REDD

There were no significant differences in the current speed among the investigated streams (Fig. 5). Water speed (mean ± SD) varied from 73 ± 25 cm s^{-1} in the Racławka to 82 ± 19 cm s^{-1} in the Kluczwoda Stream.

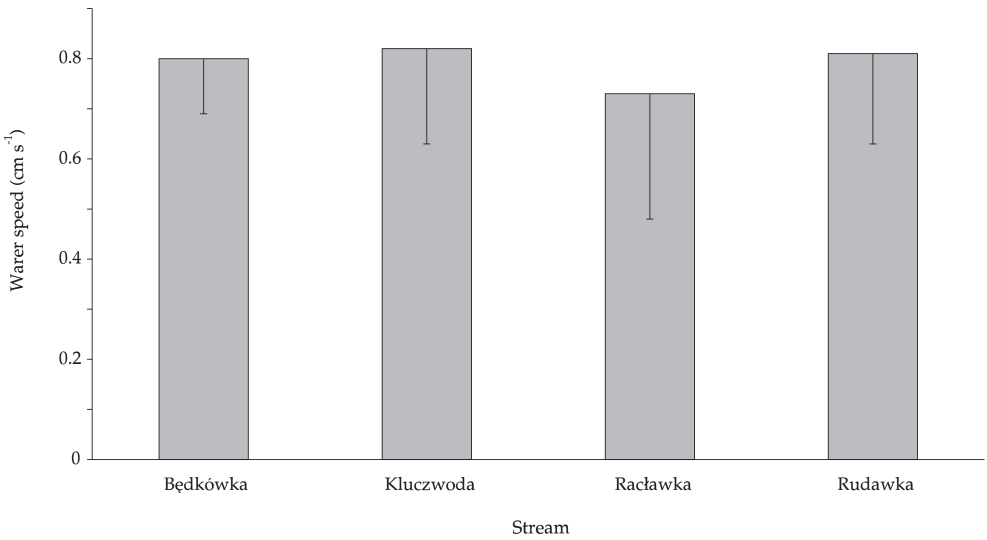

Fig. 5. Mean ± SD water current speed above the dome of redds.

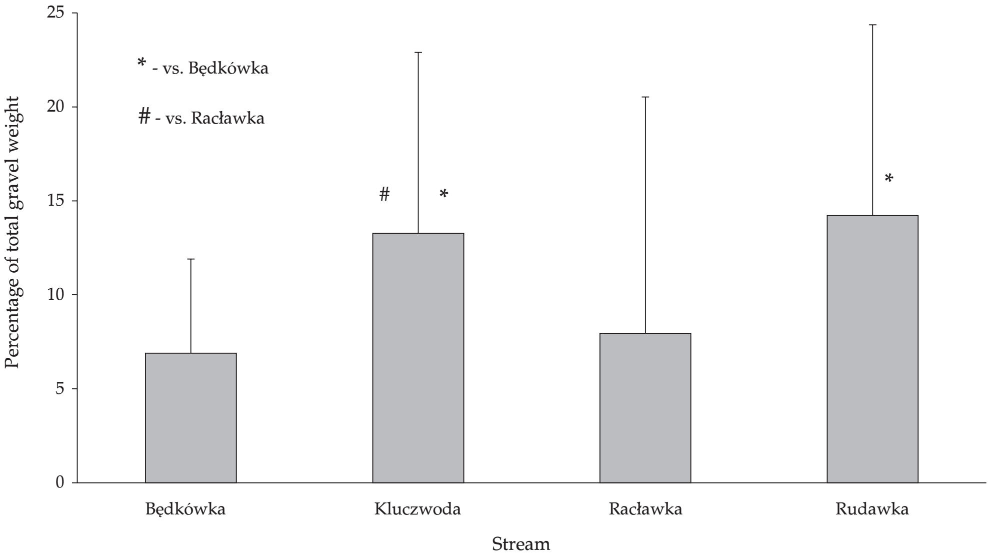

Fig. 6. Mean ± SD contribution (% of weight) of fine fraction (diameter ≤ 1 mm) gravel in the redds.

CONTRIBUTION (% OF WEIGHT) OF FINE AND COARSE GRAVEL FRACTIONS IN THE REDDS

Significant differences were noted among the investigated streams with regard to the fine gravel (sand) fraction (≤ 1 mm) (Fig. 6). The lowest content (% ± SD) of this fraction was noted in the redds in the Będkówka Stream (6.89 ± 5.02) and was significantly lower than in the Rudawka (14.22 ± 10.15) and Kluczwoda (13.28 ± 9.62) streams. The contribution of this fraction in the Racławka trout redds was also low (7.95 ± 58) and was significantly smaller than in the Kluczwoda gravel samples.

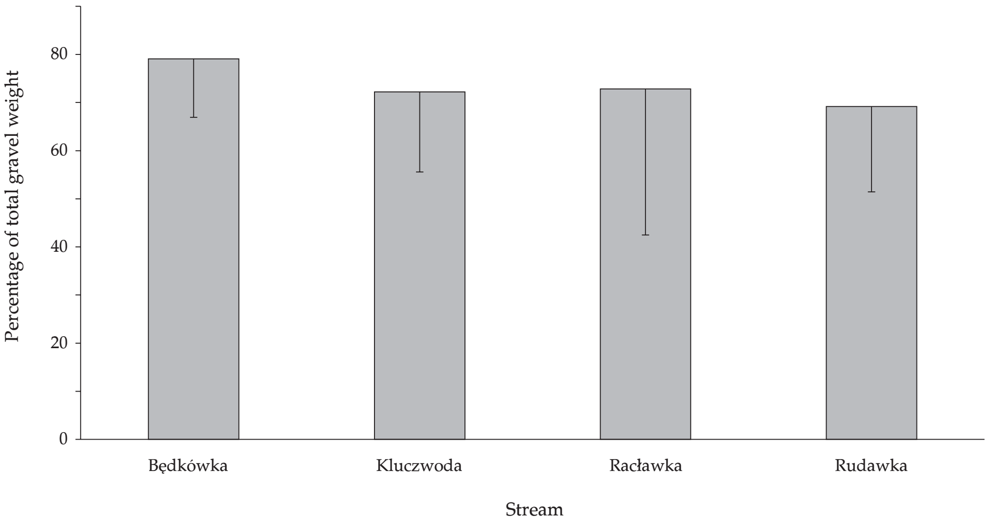

Fig. 7. Mean ± SD contribution (% of weight) of coarse fraction (diameter ≥ 8 mm) gravel in the redds.

On the other hand, there were no differences among the streams with regard to the contribution of coarse fraction (≥ 8 mm) in the gravel of the redds (Fig. 7). The contribution of this fraction varied from 69.18 ± 17.74% in the Rudawka to 79 ± 12.13% in the Będkówka streams.

DISSCUSSION

The reproduction of fish is a complicated process which depends largely on the quality of the environment. Like all other salmonids, brown trout needs clear, cool spring water and a suitable substrate of clean gravel for reproduction. Suitable spawning sites for brown trout are primarily determined by the flow and size of the substrate particles and particle aggregation (Bagliniere et al. 1979, Delacoste et al. 1995). Brown trout generally spawn in shallow areas with riffles and glides (Bagliniere et al. 1979), with the redds located at the head of the riffles or at the end of the glide (Witzel and MacCrimmon 1983). Sometimes, however, the redds are formed at mid-riffle (Euzenat and Fournel 1976). In the four Cracow Valleys streams investigated, the majority (49%) of the redds were located in mid-riffle, while another 19% were located laterally to the riffle close to the bank. Only 32% of the redds were built at the end of the glide (data not shown). This differs somewhat from the general rule presented above.

Trout redds are generally elliptical in shape. They consist of an elongated dome (with an egg pocket inside) and a circular trough (hollow) just upstream (Fig. 2). The area of the redds is proportional to the size of the spawners (Ottaway et al. 1981, Crisp and Carling 1989). Heggberget et al. (1988) described very large redds (mean 4.7 m^2) in Swedish rivers which had been built by relatively big trout spawners (1.8 kg). On the other hand, Fragnoud (1987) found in the rivers of south-east France that trout approximately 30 cm long laid their eggs in redds which were more than ten-fold smaller (0.32 m^2). The surface area of the redds in the Cracow Valley streams ranged from 0.208 m^2 in the Kluczwoda to 0.304 m^2 in the Rudawka Stream. This corresponds well with the size of the trout observed in these waters. Electrofishing investigations carried out in 1999 – 2001 showed that the majority of sexually mature brown trout are between 21 and 31 cm in body length (Nodzyński 2002, Nowak 2002).

Favorable habitats for brown trout are characterized by medium water flows. The water current speed which is considered to be the lower limit is 10 to 20 cm s^{-1} (Crisp and Carling 1989). Huet (1962) stated that spawning is not possible in areas with zero current speed. The current speed observed in the Cracow Valleys streams (73 to 82 cm s^{-1}) was relatively high and similar to those described by Nihouarn (1983) in the Scorff River basin in Brittany and by Witzel and Mac Crimmon (1983) in some streams in Ontario. The current speed measured in the present study was between 30 to 75 cm s^{-1}. Much lower current speeds (between 27 and 39 cm s^{-1}) were noted by other authors in Swedish and New Zealand rivers and streams (Heggbergt et al. 1988, Shirvell and Dungey 1983).

Another key factor which determines successful embryonic development is the granulometry of the redd dome covering the egg pocket. The granulometry of the bed is shaped by the current speed, depth and geological characteristic of the basin slope. The role of the redd is to provide shelter from predators and fast-flowing water. Substrate particle size is a determining factor in the choice of spawning grounds by broodstock (Ottaway et al. 1981). Many reports have linked survival and emergence to the presence and proportions of fines of specified sizes. In the classic work of McNeil and Ahnell (1964), it was concluded that the greatest pink salmon spawning success occurred in streams with the fewest fines (< 0.833 mm). In order to achieve high to very high escapement of fry, the contribution of this fraction should not exceed 10 to 12%. The most significant negative biological effects of fine sediments are the blockage of intragravel water and oxygen, the direct smothering and the suffocation of eggs and sac fry, and the entrapment of emerging fry (Peters 1967). In addition, sediments impact habitats indirectly by, for example, filling pools and decreasing invertebrate production (for a review see Waters 1995). On the other hand, gravel particles which are too large can limit the possibilities of spawners building redds. The best gravel composition was found in the Będkówka and Racławka streams where the fine fraction did not exceed 7-8%. Unfortunately, in the Rudawka and Kluczwoda streams the contribution of fine sediments in the redds was very high (14.22 and 13.28%, respectively) just a few days or weeks after spawning. This indicates that there was a high probability of asphyxiation and serious disturbance in egg development, since, as cited above, a ± 10% contribution of sediments smaller than 1 mm is the maximum to ensure spawning success (Burner 1951, Stuart 1953, McNeil and Ahnell 1964, Duff 1999). Since the number of the spawning nests (122) and their density (2.21 per 100 m of watercourse) was the highest in the Rudawka, the negative impact of unsuccessful spawning in this watercourse would be very significant for the population of brown trout in the Rudawa River basin. On the other hand, the mean share of the coarse gravel fraction (≥ 8 mm) which is considered as the most suitable for redd construction (Duff 1999) was very high (between 70 and 80%) in all the investigated streams.

In conclusion, the four investigated streams are potentially good trout spawning grounds. The high density of trout redds found in these streams indicates a strong population of brown trout in the main river, the Rudawa. Particular attention should be focused on protecting the Będkówka Stream, which appears to be the most promising trout spawning zone in the region. Measures to restrict soil erosion from agricultural lands are urgently needed to decrease the amount of sediments in the waters of the Kluczwoda and Rudawka streams.

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STRESZCZENIE

CHARAKTERYSTYKA GNIAZD TARŁOWYCH PSTRĄGA POTOKOWEGO (*SALMO TRUTTA* M. *FARIO* L.) W WYBRANYCH POTOKACH ZLEWNI RUDAWY

Zewidencjonowano oraz scharakteryzowano gniazda tarłowe pstrąga potokowego zlokalizowane w potokach Parku Krajobrazowego „Dolinki Krakowskie". Obserwacji dokonano późną jesienią 2001 w potoku Będkowka, Kluczwoda, Racławka i Rudawka. Stwierdzono obecność 122 gniazd w Rudawce, 93 gniazda w Będkówce oraz 91 i 22 gniazda odpowiednio w Kluczwodzie i Racławce (tab. 1). Z każdego potoku wybrano losowo 12 gniazd, na których dokonano szczegółowych pomiarów. Zmierzono długość i szerokość gniazda, w celu obliczenia jego powierzchni, zmierzono głębokość i szybkość prądu wody nad kopcem gniazda. Ponadto pobrano próbki żwiru z gniazd, w celu określenia procentowej zawartości poszczególnych frakcji grubościowych żwiru w materiale skalnym tworzącym gniazdo. Powierzchnia gniazd wahała się od 2081 do 3044 cm^2 i nie stwierdzono różnic odnośnie powierzchni gniazd pomiędzy potokami (rys. 1). Nie stwierdzono również różnic pomiędzy potokami pod względem szybkości nurtu wody nad gniazdem, który wynosił od 73 do 82 cm s^{-1} (rys. 3). Istotne różnice pomiędzy poszczególnymi potokami dotyczyły głębokości wody nad gniazdem (od 12.58 cm w Kluczwodzie do 33,62 cm w Rudawce, rys. 2) oraz udziału frakcji mulistych (≤ 1 mm^2) w materiale skalnym tworzącym gniazdo: stwierdzono wysoką ich zawartość (ponad 13%) w gniazdach usytuowanych w potoku Rudawka i Kluczwoda (rys. 4), co wskazuje na możliwość obumarcia złożonej tam ikry z powodu upośledzenia wymiany wody w gniazdach i braku tlenu. Najlepsze parametry żwiru wykazywały gniazda z Będkówki. Z tego względu oraz z powodu obecności w nim dużej ilości gniazd, potok ten powinien być otoczony szczególną opieką.

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