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Short communications

CO-OCCURRENCE OF THE SIGNAL CRAYFISH (*PACIFASTACUS LENIUSCULUS* (DANA)) AND THE SPINY-CHEEK CRAYFISH (*ORCONECTES LIMOSUS* (RAF.)) IN A FOOTHILL-LIKE RIVER (NORTHERN POLAND)

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ABSTRACT. The aim of the study was to determine the current state of the crayfish in a foothill-like river, Naryjska Struga, in northern Poland, where the noble crayfish, *Astacus astacus* L., occurred until the 1950s. The spiny-cheek crayfish, *Orconectes limosus* (Raf.), was noted to inhabit the Naryjska Struga River in the 1960s, while the signal crayfish, *Pacifastacus leniusculus* (Dana), escaped into the river from a nearby cultivation facility in the 1979-1981 period. The Naryjska Struga River connects two lakes that to date remain inhabited by the spiny-cheek crayfish. The signal crayfish was discovered to inhabit the river in 2000. During the period from 2002 to 2005, annual crayfish observations were conducted along the entire length of the river, and Evo traps were used to make monitoring catches on an approximately 500-m length of the river. The effectiveness of monitoring catches, measured as the quantity of specimens caught trap⁻¹ night⁻¹ in each year of the study ranged from 1.58 to 6.18 and was dependent on the intensity of previous poaching. The share of signal crayfish in the monitoring catches in each of the study years ranged from 98.8 to 100.0%. The remaining share was comprised of the spiny-cheek crayfish. During the study period, the male specimens of the signal crayfish game population had a total length range of 7.2 to 12.3 cm, (average of 9.86 ± 0.98 cm) at a weight range of 12.6 to 83.5 g (average of 39.3 ± 14.0 g). The length of the female specimens ranged from 7.1 to 12.2 cm (average of 9.71 ± 0.96 cm) at a weight range of 11.2 to 57.8 g (average 29.9 ± 8.6 g). Specimens longer than 9.0 cm comprised 83.2% of the sample caught. The habitat conditions in Naryjska Struga River proved to be advantageous for the signal crayfish, and this species limited the previously-occurring spiny-cheek crayfish to a 1.2% share of the entire crayfish game population in the river.

Key words: SIGNAL CRAYFISH (*PACIFASTACUS LENIUSCULUS*), SPINY-CHEEK (*ORCONECTES LIMOSUS*), COMPETITION, TRAP CATCHES

During crayfish field studies conducted in the Mazurian region in 2000, populations of the signal crayfish, *Pacifastacus leniusculus* (Dana), and the spiny-cheek

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crayfish, *Orconectes limosus* (Raf.), were found unexpectedly in the Naryjska Struga River (northern Poland), which had been inhabited initially by the noble crayfish, *Astacus astacus* L. (Krzywosz and Krzywosz 2001). The signal crayfish was introduced in Poland in 1972 (Kossakowski et al. 1978, Gondko and Girsztowtt 1987, Krzywosz 1994). The signal crayfish could have reached the river from a nearby cultivation facility where, from 1979 to 1981, a portion of the juvenile signal crayfish population imported from Sweden was reared (Kossakowski, unpublished data). At this time the spiny-cheek crayfish was already the dominant species in both the studied region and nearly throughout the country and was displacing the remnants of the indigenous Polish crayfish from their habitats (Leńkowa 1962, Kossakowski 1966).

The aim of the studies conducted in the 2002-2005 period was to describe the state of the signal and spiny-cheek crayfish populations occurring in a foothill-like river (Naryjska Struga in northern Poland) and to identify the effects of competition between these two species since this could provide data to assess the role that the signal crayfish may play in Polish waters.

The Naryjska Struga is a river that connects Lake Narie with Lake Mildzie; it is about 7 km in length with an average width of approximately 5 m and covers a drop in altitude of 24.9 m. The mean drop of the river is 3.6‰, which permits classifying it as grayling waters (Huet 1954, 1959). The water temperature in the river in summer does not exceed 16°C.

Crayfish monitoring catches were conducted in the summer following molting since it is at this time that all of the crayfish are in a similar physiological state and react actively to bait. The catches were conducted with Swedish-manufactured Evo traps along a designated 500 m length of the river located in a deep ravine that was overgrown with forests. Catches were also conducted at the mouth of the river where it flows into Lake Mildzie and in the lake itself. The crayfish caught were counted, measured to the nearest 0.1 cm, weighed to the nearest 0.1 g, sexed, and the species was determined. The share of crayfish with defective claws, which indicated their loss in an earlier life stage, was determined. This is related to predation and competition for territory and food, which is the basis for crayfish autonomy (Mc Vean 1982). The statistical difference between the mean body lengths of each sex and both sexes combined in the studied years (2002-2005) was calculated with the multiple range test. The differences in the mean lengths between the two sexes in each year of the

study were calculated with the comparison of means. The least significant differences method was applied. STATGRAPHICS PLUS software was used in the calculations at a confidence level of 95%.

The effectivity of the catches conducted under similar conditions and periods was measured as the number of crayfish per trap, and this might be a close approximation of the population density of the crayfish inhabiting this area (Edsman and Söderbäck 1999). The crayfish density in the Naryjska Struga measured as the number of individuals caught trap⁻¹ night⁻¹ in each of the study years ranged from 1.58 to 6.40 (Table 1).

TABLE 1

Monitoring catches of crayfish in Naryjska Struga

Parameter	Catch date				
	2000 17/18 June	2002 26/27 August	2003 15/16 July	2004 22/23 July	2005 11/12 July
Trap (pieces)	17	20	53	35	30
Catch (pieces)	105	128	84	136	172
Catch effectiveness (indiv. trap ⁻¹ night ⁻¹)					
Signal crayfish	6.12	6.35	1.57	3.86	5.73
Spiny-cheek crayfish	0.06	0.05	0.01	0.03	0.00
Total	6.18	6.40	1.58	3.89	5.73
Share in the catches (%)					
Signal crayfish	99.05	99.22	98.81	99.26	100
Spiny-cheek crayfish	0.95	0.78	1.19	0.74	0.00

Crayfish were caught during the day at a similar level of effectiveness. Males with claw defects comprised 19.2% and females 21.7% of the game population of signal crayfish from Naryjska Struga. The relatively low effectiveness of the 2003 catches was related to the fact that a substantial increase in poaching occurred not only for crayfish but also for the fish inhabiting this river. Increases in catch effectiveness in 2004 and 2005 are an indication that the populations of signal crayfish are recovering with levels reaching those of 2000 and 2002 (Table 1). In these years the mean number of crayfish per trap caught in the studied river was higher than catches made in oligotrophic California lakes where the average catch per trap was 3.9 individuals trap⁻¹ night⁻¹ (Goldman and Rundquist 1977), those made in Swedish lakes where from 0.8-3.5 individuals were caught trap⁻¹ night⁻¹ (Brinck 1977), and in catches made in the Mazurian Lake Poblędzie where 5.4 specimens were caught trap⁻¹ night⁻¹ (Krzywosz, unpublished data).

The signal crayfish was the decisive dominant in the catches made in Naryjska Struga. The share of the spiny-cheek crayfish was minimal and did not exceed 1.2% (Table 1). Along the length of the river the situation was similar; only on a short segment near the mouth of the river where it flows into Lake Mildzie did the share of spiny-cheek crayfish in the catches increase slightly. Only small numbers of signal crayfish were noted in Lake Mildzie in the immediate vicinity of the Naryjska Struga river mouth. Monitoring catches indicated that only spiny-cheek crayfish occurred in the other parts of the lake. Perhaps the muddy bottom of the lake near the river mouth acts as an impenetrable barrier for the further expansion of the signal crayfish.

TABLE 2

Characteristics of materials collected from the Naryjska Struga in the 2002-2005 period

Catch date	Sex	Number of crayfish* (indiv.)	Body length (mm)	Mean body length \pm SD (mm)	Body weight range (g)	Mean body weight \pm SD (g)
2002 27/28 August	Female	71 (33)	7.1-12.2	96.9 \pm 10.8 ^{bc}	12.6-59.5	28.6 \pm 9.5
	Male	56(33)	7.2-12.0	97.9 \pm 12.4 ^A	12.6-70.7	36.3 \pm 15.5
	Total	127(66)	7.1-12.2	97.4 \pm 11.5 ^{ab}	12.6-70.7	32.0 \pm 13.0
2003 15/16 July	Female	46 (39)	7.3-11.6	93.1 \pm 10.2 ^a	13.9-44.3	28.0 \pm 9.1
	Male	37 (36)	7.1-12.1	97.4 \pm 11.5 ^A	13.1-83.5	41.4 \pm 16.6
	Total	83 (75)	7.1-12.1	95.0 \pm 11.0 ^a	13.1-83.5	34.5 \pm 14.8
2004 22/23 July	Female	62 (58)	7.3-12.2	96.1 \pm 9.0 ^{ab}	11.2-59.9	30.9 \pm 8.7
	Male	73 (60)	8.4-12.3	98.9 \pm 8.2 ^A	26.2-80.3	38.5 \pm 12.6
	Total	135 (118)	7.3-12.3	97.6 \pm 8.6 ^{ab}	11.2-80.3	36.2 \pm 12.0
2005 11/12 July	Female	100 (83)	7.9-12.0	99.5 \pm 8.0 ^c	15.8-57.8	31.1 \pm 7.2
	Male	72 (63)	7.5-12.0	99.3 \pm 8.0 ^A	14.3-74.4	38.5 \pm 11.9
	Total	172 (146)	7.5-12.0	99.4 \pm 8.0 ^b	14.3-74.4	34.2 \pm 10.1
Total 2002-2005	Female	279 (213)	7.1-12.2	97.1 \pm 9.6	11.2-57.8	29.9 \pm 8.6
	Male	238 (192)	7.2-12.3	98.6 \pm 9.8	12.6-83.5	39.3 \pm 14.0
	Total	517 (405)	7.1-12.3	97.8 \pm 9.7	11.2-83.5	34.2 \pm 12.3

Values with the same letter notation do not differ significantly statistically ($P > 0.05$)

Indices: a, b, c refer to subsequent study years: A refers to males in subsequent study years; a and b refer to males and females (together) in subsequent study years

* - in parentheses the number of individuals without claw defects. Only these were considered to calculate body weight

The signal crayfish has occurred in the Naryjska Struga for more than two decades. Throughout this time, this species has encountered the spiny-cheek crayfish, which had occurred previously in both the river and the adjacent lake. It is possible that

a mutual relationship between these two species in the studied area has already managed to form and consolidate. The signal crayfish has displaced or at least limited the population of spiny-cheek crayfish in the river. It is possible that the spiny-cheek crayfish population in the Naryjska Struga no longer occurs permanently and that the single individuals observed could have reached the river from Lake Narie (located at a higher elevation) by overcoming the weir at the lake outflow. In recent years significant numbers of spiny-cheek crayfish deaths have been noted throughout Poland, which indicates that the potential of this population is lower (Krzywosz 2004).

The similar body lengths of the signal crayfish game population (Table 2) and their distribution (Fig. 1) in Naryjska Struga in subsequent years might also be an indication of this population's stability. The body length of the signal crayfish game population in Naryjska Struga ranged from 7.1 to 12.3 cm at a mean of 9.78 cm (± 0.97 cm), and the dominant group (70.8%) of crayfish ranged from 9.0 to 10.9 cm. The mean length of males in each of the study years was similar and did not differ statistically. However, the females caught in 2003 were significantly smaller in comparison with those caught in 2002 and 2005 (Table 2). This could have resulted from previous and substantial overexploitation of the river, which was indicated by the low effectiveness of crayfish

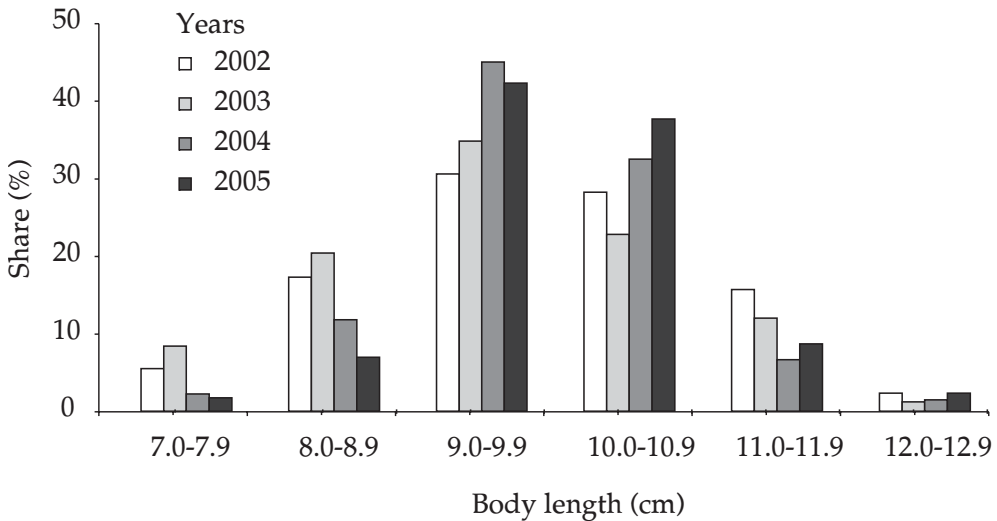


Fig. 1. Body length distribution of the game population of signal crayfish in the Naryjska Struga in the 2002-2005 period.

catches in 2003 (Table 1). In 2003 and 2004, females were significantly smaller than the males. The lowest crayfish catch effectiveness was also noted in these years which indicates that previously they had been exploited intensively. The preceding may mean that the larger female game population is caught more frequently than the larger males that accompany them.

The maximum and mean body length (carapax) attained by the game population of the signal crayfish from the Naryjska Struga was higher than that of American populations in the Sacramento River (Shimizu and Goldman 1983) and Lake Tahoe (Goldman and Rundquist 1977). The crayfish from Naryjska Struga were smaller, in turn, than the lengths attained by the same species in the Mazurian Lake Poblędzie (Krzywosz and Krzywosz 2002) (Table 3). The cause of body size differences in populations from various sites can probably be attributed to various environmental conditions that influence the rhythms of life and crayfish density, which, in turn, has an impact on the availability of food. The smallest individual size in the game population was noted in the Sacramento River, and this is probably due to the high density and strong competition for food. Catches there are as high as $2.5 \text{ kg trap}^{-1} \text{ night}^{-1}$ (Shimizu and Goldman 1983), which was many-fold higher than that in Naryjska Struga, where the crayfish attained the greatest body length. The crayfish from Naryjska Struga were smaller, however, than those from Lake Poblędzie where their density was twice as low as that in Naryjska Struga (Krzywosz and Krzywosz 2002).

TABLE 3

Body size (carapax) of the game population of signal crayfish from various sites, the age attained, and maximum water temperature

Site	Sex	Body length (mm)		Max. age (years)	Max. water temperature (°C)	Author
		mean	max.			
Naryjska Struga River	Female	47.1	59.3	-	16	Present study
	Male	50.0	62.4	-	-	
Sacramento River	Female+Male	37.0	51.5	7	25	Shimizu and Goldman (1983)
Lake Tahoe	Female+Male	33.8	52.0	11	20	Goldman and Rundquist (1977)
Lake Poblędzie	Female	57.8	77.2	8	24	Krzywosz and Krzywosz (2002)
	Male	63.4	85.7	-	-	

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STRESZCZENIE

WSPÓŁBYTOWANIE RAKA SYGNAŁOWEGO (*PACIFASTACUS LENIUSCULUS* (DANA)) Z RAKIEM PRĘGOWATYM (*ORCONECTES LIMOSUS* (RAF.)) W POTOKU O CHARAKTERZE PODGÓRSKIM (PÓŁNOCNA POLSKA)

W latach 2002-2005 prowadzono obserwacje i połowy kontrolne raków Naryjskiej Strugi (północna Polska), mającej charakter rzeki podgórskiej, zasiedlonej od lat 60. przez raka pręgowatego, *Orconectes limosus* (Raf.) i od lat 80. przez raka sygnałowego, *Pacifastacus leniusculus* (Dana). Na raka sygnałowego w rzece natknięto się w 2000 r. podczas badań terenowych. Połowy kontrolne prowadzono nocą przy użyciu pułapek typu „Evo”. Ich efektywność w poszczególnych latach, mierzona ilością odłowionych osobników pułapka⁻¹ noc⁻¹, wahała się od 1,58 do 6,18 i była uzależniona od nasilenia wcześniejszych połowów kłusowniczych (tab. 1). Efektywność połowów w Naryjskiej Strudze była wyższa od uzyskiwanej w jeziorach kalifornijskich (do 3,9 szt. pułapka⁻¹ noc⁻¹), szwedzkich (do 3,5 szt. pułapka⁻¹ noc⁻¹) i jeziorze Poblędzie na Mazurach (do 5,4 szt. pułapka⁻¹ noc⁻¹). W Naryjskiej Strudze dominował rak sygnałowy, który również chętnie wchodził do pułapek w dzień. Udział raka pręgowatego w połowach nie przekraczał 1,2%, co wskazuje na to, że w okresie ponad dwudziestoletniego współbytowania nie sprostał on konkurencji raka sygnałowego.

Złowione osobniki mierzono z dokładnością do 0,1 cm i ważono z dokładnością do 1,0 g. W badanym okresie, wśród populacji łownej samców raka sygnałowego, występowały osobniki o długości całkowitej od 7,2 do 12,3 cm, średnio 9,86 cm ($\pm 0,98$ cm) i masie od 12,6 do 83,5 g, średnio 39,3 g ($\pm 14,0$ g), zaś wśród samic osobniki o długości od 7,1 do 12,2 cm, średnio 9,71 cm ($\pm 0,96$ cm) i masie od 11,2 do 57,8 g, średnio 29,9 g ($\pm 8,6$ g) (tab. 2). Osobniki o długości ciała od 9 cm wżyz stanowiły 83,2% odłowionej próby (rys. 1). Długość ciała samców w badanym okresie nie różniła się istotnie ($P > 0,05$). Natomiast samice łowione w latach, w których uzyskiwano niską efektywność połowu były istotnie mniejsze od samic łowionych w pozostałych okresach (tab. 2).

Maksymalne i średnie długości ciała (carapaxu) osiągnięte przez populację raka sygnałowego w Naryjskiej Strudze były wyższe od długości osiągniętych przez populacje amerykańskie w rzece Sacramento i jeziorze Tahoe, a niższe od osiągniętych w mazurskim jeziorze Poblędzie (tab. 3). Wiązało się to ze zróżnicowaniem warunków środowiska i różnym zagęszczeniem raków na porównywanych stanowiskach.