Arch. Pol. Fish. (2009) 17: 85-88
DOI 10.2478/v10086-009-0007-y

SHORT COMMUNICATION

The impact of raised water level on a winter anoxia lake on the population of narrow-clawed crayfish *Astacus leptodactylus* (Esch.)

Tadeusz Krzywosz, Piotr Traczuk, Dariusz Ulikowski

Received – 23 March 2009/Accepted – 15 April 2009;

Abstract. The aim of the study was to determine the impact raised water level in the winter anoxia Lake Oświn (northeastern Poland) had on the population of narrow-clawed crayfish, *Astacus leptodactylus* (Esch.). Raising the water level in the lake increased the surface are from 360 ha to 900 ha and improved habitat conditions. The species diversity of vegetation increased, as did the area of lake bottom covered by it (from 22 to 51%). The threat of winter anoxia was also reduced. The improved habitat conditions led to increased crayfish population density expressed through the mean catch efficiency, which increased by 252%. The share of individuals measuring more than 10 cm increased from 76% in 1991 to 95% sixteen years after raising the water level. During this period (1991-2007) the mean total length of crayfish increased significantly statistically ($P < 0.05$) from 10.5 to 12.7 cm. This means that during this period, the life expectancy of the dominant crayfish age group increased by about two to three years.

Keywords: narrow-clawed crayfish, *Astacus leptodactylus*, lake, population, environment

T. Krzywosz, P. Traczuk
Department of Lake Fisheries in Giżycko
The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn, Poland

D. Ulikowski [✉]
Department of Sturgeon Fish Breeding
The Stanisław Sakowicz Inland Fisheries Institute in Olsztyn
Pieczarki 50, 11-610 Pozezdrze, Poland
Tel. +48 (87) 428 36 66; e-mail: ulikowski@infish.com.pl

In Poland, the narrow-clawed crayfish, *Astacus leptodactylus* (Esch.), is designated as an endangered species and is under legal protection. It occurs only at a few sites in northeast Poland (Białokoz et al. 1996, Strużyński et al. 2001). There is no information regarding the initial inhabitation of Lake Oświn (northeast Poland) by the narrow-clawed crayfish. This is why it is difficult today to trace the route and to establish when this crayfish reached Lake Oświn. According to Kossakowski (1966), this native species of the Black and Caspian seas catchment area migrated through the canal built to link the Volga and Dźwina rivers in the eighteenth century to the Baltic and White seas. By the nineteenth century, it was abundant in the northwest regions of Russia and was spreading toward the west. After the crayfish plague epizootic (*Aphanomyces astaci*) in Europe in the late nineteenth and early twentieth centuries, narrow-clawed crayfish from Russian were introduced into the waters of Central Europe, where the noble crayfish, *Astacus astacus* (L.), had been all but decimated. It was widely believed at the time that this species was immune to the plague, but this theory would be proved wrong. This is how the western reach of narrow-claw crayfish distribution moved markedly (and artificially) to the north and west of Europe (Machino and Holdich 2006, Southy-Grosset et al. 2006).

Lake Oświn is the most important basin in the Seven Islands Nature Reserve, which, thanks to its unique natural qualities, is designated as a protected area under the Ramsar Convention regarding wetlands of international significance. In 1954, the surface area of Lake Oświn was 360.3 ha and maximum depth was 3.5 m, at a mean depth of 1.1 m (Kondracki and Szostak 1960). According to Patalas (1960), there was no thermal stratification in Lake Oświn in the mid 1950s, and the Secchi depth then ranged from 0.3 to 0.9 m. Later studies by Bryliński et al. (1986) indicated that the lake exhibited signs of advanced age. The lake vegetation included the following: six species of submerged plants, seven with floating leaves, eight reed species, and ten wetland species. In total these covered 22% of the bottom surface area. Winter anoxia, that decimated the fish population, were often observed in the lake. The prevailing conditions were extremely harsh for crayfish, one requirement of which is a high oxygen concentration (Holdich 2002). Despite this, the narrow-clawed crayfish survived the winter anoxia, during which even fish with low oxygen requirements died. It is probable that the population inhabiting this lake was able to find a niche with conditions that allowed it to survive the most difficult periods.

In an attempt to improve the environmental conditions in the lake, an overflow was constructed at the water outflow in 1993. This raised the water level by about 80 cm, and increased the lake surface area to 899.9 ha. The threat of winter anoxia was reduced, and habitation conditions for crayfish improved considerably. Currently, about 50 species of emerged, wetland vegetation species occur, while there are 17 species of submerged hydrophytes with floating or pleustonic leaves. In comparison to the 1980s, the area occupied and stabilized by the two basic submerged vegetation species (e.g., *Ceratophyllum demersum* and *Striatiotes aloides*) has increased. At the moment, this assemblage forms a strip of submerged vegetation along 90% of the contact zone between emerged vegetation assemblages and open lake waters, which, together with floating leaf vegetation, occupy 29% of the lake surface area. Currently, 51% of the lake bottom is occupied by vegetation, which is twofold more than before the water level was increased (Gromadzki and Wiśniewski 2005). Such a shift in environmental conditions could impact the narrow-clawed crayfish population inhabiting this lake. The aim of the current work was to determine the impact of increased water level on the narrow-clawed crayfish population in the winter anoxia Lake Oświn.

Long-term research of this basin was the source of the data used to compare the crayfish population before and after the water level increase. Data from three years were used: 1991 (two years before the water level increase), 1996, and 2007 (both following the water level increase). Crayfish catches in these years were conducted using traps deployed in the same locations and at the same time of year (September). Catches made with traps provide a good picture of the so-called catchable population comprised mainly of larger individuals, and which, through food competition, distances smaller individuals from the bait in the traps. The parameters determined included mean total length (TL) and population density (the mean catch efficiency expressed as the number of crayfish caught per trap per hour). Statistica 7.1 was used to analyze the data collected. The means from the length (TL) measurements of females and males were compared with analysis of variance and Tukey's test at a level of significance of $P < 0.05$. Only data from 1991 and 2007 were analyzed since the sample sizes were similar.

The raised water level and the resulting changes in environmental conditions did not have a significant impact on the sex ratio in the population, which was similar in 1996 and 2007 (Table 1). However, the length (TL) measurement data collected from the catchable population indicated that there was an increase in mean length from 10.5 cm in 1991 to 12.7 cm in 2007 ($P < 0.05$; Table 1).

The data also showed that there was a tendency toward a greater share of larger individuals in the population. This was distinctly notable in the size distribution of the catchable population in 1991 and 2007 (Fig. 1). The share of individuals exceeding 10 cm in TL increased from 76% in 1991 to 95% in 2007. In Lake Łoby, where conditions are advantageous for the

Table 1
Abundance, total length (mean ± SD), sex ratio, and catch yield of the catchable population of narrow-clawed crayfish from Lake Oświn before (1991) and after the water level increase (1996 and 2007)

Year	Sex	N	Total length (cm)	Sex ratio	Catch effectiveness (indiv. trap^{-1} h^{-1})
	males	24	10.9^{a}±1.67	0.92	0.021
1991	females	26	10.2^{a}±1.36		
	males	6	11.3±1.51	1.50	0.030
1996	females	4	11.6±1.48		
	males	27	12.6^{b}±1.65	0.92	0.053
2007	females	28	12.9^{b}±1.41		

Means with the same superscript letter index do not differ significantly statistically (ANOVA, Tukey's post hoc test, $P < 0.05$).

narrow-clawed crayfish population, the corresponding result was 91% (Kossakowski 1964). In Lake Oświn in 1991, the catches were dominated by the group of crayfish measuring 10-12 cm, which comprised 56% of the catchable population. However, in 2007 they were dominated by the group of crayfish measuring from 13-14 cm, which comprised 31% of the catchable population as opposed to just 6% in 1991. Thus, there was an increase in older individuals (by 2-3 years) in comparison to the previous sampling. This means that over the sixteen-year study period (1991-2007), the life span of the dominant crayfish age group in this lake increased. Undoubtedly, this was thanks to the improved habitat conditions in Lake Oświn following the rise in water level. Thanks to this, the narrow-clawed crayfish from Lake Oświn attained body sizes comparable to those in lakes with advantageous environmental conditions (Kossakowski 1964, 1966).

According to mean catch efficiency figures, after the water level was increased the population density also increased (Table 1). In 1991 it was 0.021 indiv. trap^{-1} h^{-1}, while over the sixteen years of the experiment it increased to 0.053 indiv. trap^{-1} h^{-1}, or by 252%. However, despite growth, this is still twentyfold lower than that in lakes with high catch

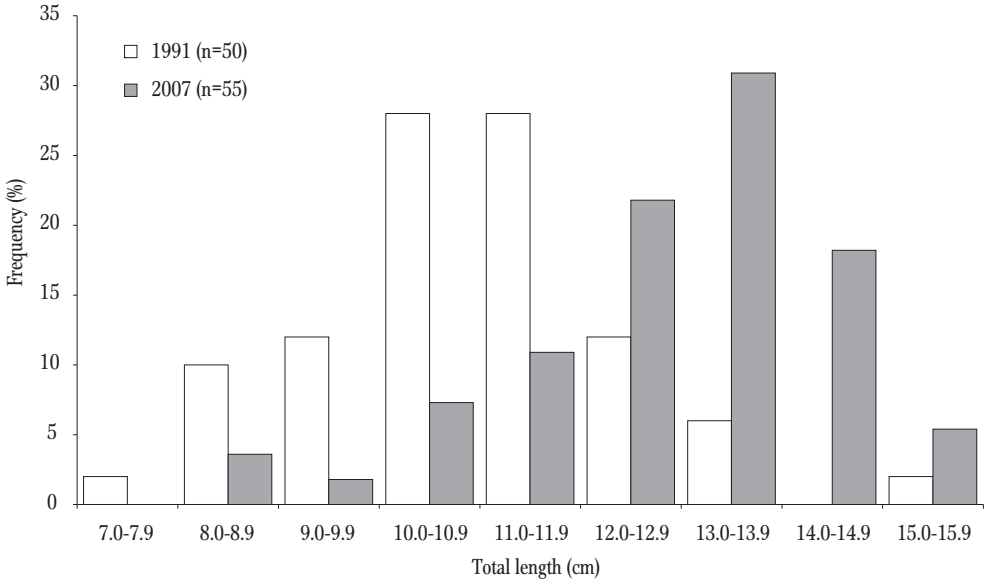

Figure 1. Distribution of total length (TL) of the catchable population of narrow-clawed crayfish from Lake Oświn before (1991) and after (2007) the water level was raised.

efficiency, where, according to the Cukerzis scale (1970), it is 1 indiv. trap^{-1} h^{-1}. This is why Lake Oświn is in the lowest category on this scale (i.e., low catch efficiency under 0.25 indiv. trap^{-1} h^{-1}). The low catch efficiency was doubtlessly influenced by the substantially silty bottom sediments of Lake Oświn (Gromadzki and Wiśniewski 2005), which makes it difficult for the crayfish to penetrate many sections of the lake. This is especially so in areas where there is a lack of aquatic vegetation, which makes movement easier for the crayfish. Hydrophytes also provide shelter and nutrition for the crayfish, which is why the increased bottom area covered by aquatic vegetation following the raised water level in Lake Oświn has had a positive impact on the crayfish population inhabiting the lake.

References

Białokoz W., Chybowski L., Krzywosz T. 1996 – Endangered crayfish species in the Suwałki District – Zool. Pol. 41 (Suppl. 1): 87-91 (in Polish).

Bryliński E., Zdanowski B., Krzywosz T., Białokoz W. 1986 – Limnological fisheries study of Lake Oświn including an attempt to evaluate the anticipated effects of water level increase – Manuscript IFI, Olsztyn-Giżycko, 46 p. (in Polish).

Cukerzis J. 1970 – Biology of the crayfish – Mintis, Vilnius, 208 p. (in Russian).

Gromadzki M., Wiśniewski R.J. 2005 – Lake Oświn and surroundings. Natural history and cultiral monograph – Bogucki Wydawnictwo Naukowe, Poznań, 448 p. (in Polish).

Holdich D.M. 2002 – Biology of freshwater crayfish – Blackwell Science, Oxford, 682 p.

Kondracki J., Szostak M. 1960 – Geomorphological and hydrographic outline of the lakes near Węgorzewo – Roczn. Nauk Roln. B-77: 7-59 (in Polish).

Kossakowski J. 1964 – Co-occurrence of the crayfish *Astacus astacus* (L.) and *Astacus leptodactylus* (Esch.) in Lake Łoby – Roczn. Nauk Roln. B-84: 431-455 (in Polish).

Kossakowski J. 1966 – Crayfish – PWRiL Warszawa, 292 p. (in Polish).

Machino V., Holdich D.M. 2006 – Distribution of crayfish in Europe and adjacent countries: updates and comments – Freshwat. Crayfish 15: 292-323.

Patalas K. 1960 – Relationship between thermal and oxygen conditions in relation to water transparency in 44 lakes near Węgorzewo – Roczn. Nauk Roln. B-77: 105-222 (in Polish).

Souty-Grosset C., Holdich D.M., Noël P.Y., Reynolds J.D., Haffner P. 2006 – Atlas of crayfish in Europe – Muséum National d'Histoire Naturelle, Paris, 187 p.

Strużyński W., Kulesh W., Alechnovich A. 2001 – The occurrence and habitat preferences of the noble crayfish (*Astacus astacus* L.) and the narrow-clawed crayfish (*Astacus leptodactylus* Esch.) in freshwaters of Belarus and Poland – Ann. Warsaw Agricult. Univ. – SGGW. Anim. Sci. 38: 27-31.

Streszczenie

Wpływ spiętrzenia wody w jeziorze przyduchowym na populację raka błotnego *Astacus leptodactylus* (Esch.)

Celem pracy było określenie wpływu spiętrzenia wody, w przyduchowym jeziorze Oświn, na populację raka błotnego zasiedlającą ten zbiornik. Spiętrzenie (o 0,8 m) spowodowało wzrost powierzchni jeziora z 360 ha do 900 ha i poprawę warunków bytowych. Zwiększyła się różnorodność gatunkowa roślin i powierzchnia dna przez nie zajmowana z 22 do 51%. Zmniejszyła się groźba wystąpienia przyduchy zimowej. Spiętrzenie wody jeziora oraz zmiana warunków środowiska nie miała istotnego wpływu na zmianę stosunku płci w populacji (tab. 1). Natomiast wpłynęła korzystnie na wzrost zagęszczenia populacji wyrażonego średnią wydajnością połowową, które wzrosło o 252%. Udział osobników o długości ciała powyżej 10 cm wzrósł z 76% przed spiętrzeniem wody, do 95% po 14 latach od spiętrzenia wody. W tym samym czasie średnia długość ciała TL raków wzrosła istotnie z 10,5 cm do 12,7 cm ($P < 0,05$). W jeziorze Oświn przed spiętrzeniem wody w połowach zdecydowanie dominowała grupa raków o długości ciała w przedziałach 10-11 cm i 11-12 cm, na które przypadało po 28% populacji łownej. Natomiast 14 lat po spiętrzeniu wody w połowach dominowała grupa raków o długości ciała w przedziale 13-14 cm, na którą przypadało 31% populacji łownej wobec tylko 6% udziału tej grupy wielkościowej w populacji przed spiętrzeniem wody jeziora (rys. 1). Oznacza to, że w badanym okresie szesnastu lat (1991-2007) wydłużył się okres życia (o 2-3 lata) dominującej w jeziorze grupy wiekowej raków.