Arch. Pol. Fish. (2011) 19: 175-182
DOI 10.2478/v10086-011-0022-7

RESEARCH ARTICLE

Comparison of seasonal activity of the lake minnow, *Eupallasella percnurus* (Pall.), and crucian carp, *Carassius carassius* (L.), in small water bodies in northern Poland

Received – 07 July 2011/Accepted – 31 August 2011. Published online: 01 September 2011; ©Inland Fisheries Institute in Olsztyn, Poland

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Abstract. This paper presents preliminary results of a comparison of the seasonal activity of lake minnows, *Eupallasella percnurus* (Pall.), and crucian carp, *Carassius carassius* (L.), in a few small water bodies. Field studies were conducted based on catches made with baited traps in periods without ice cover from April to December 2006. *E. percnurus* became active earlier than did *C. carassius* and their period of intense activity was longer. The first *E. percnurus* appeared in the traps in early April when the ice was still melting, and these fish were caught at a temperature range of 3.5-29.2°C. *C. carassius* were caught most abundantly in the beginning of May at temperatures from 15°C; this species was usually noted in traps at a narrower, but higher, temperature range in comparison with the *E. percnurus*. Additionally, the activity of both these species was similar with regard to weather conditions; both species were less active on cloudy days and when atmospheric pressure was increasing.

Keywords: fish trapping, small water bodies, fish activity, cyprinids

Introduction

Despite its wide geographical range and in contrast to the crucian carp, *Carassius carassius* (L.), the lake minnow, *Eupallasella percnurus* (Pall.), inhabits only a small area of western and central Europe and occurs in isolated populations (Kottelat and Freyhof 2007). In Poland, the majority of small water bodies inhabited by this species are located in the Kashubian Lakeland (Wolnicki and Radtke 2009). The lake minnow is a protected species in Poland and is designated as a priority species within the European Ecological Natura 2000 Network. The primary threats to the species in the north of Poland include habitat loss (drying up, draining, filling in, and transforming water bodies) and the stocking and expansion of other species. *E. percnurus* often co-inhabits water bodies with the *C. carassius*, which is subjected to the same threats.

E. percnurus was discovered in northern Poland relatively recently (end of the nineteenth century), and the first comprehensive investigations to discover its locations of occurrence were undertaken just a few years ago (Wolnicki and Radtke 2009, Radtke et al. 2011), which means that knowledge regarding the distribution and biology of this species is increasing. To date, a few investigations have been conducted on *E. percnurus* population growth and structure (Tandon 1979, Wolnicki et al. 2008) and also on reproduction and the impact of temperature under controlled conditions (Kamiński et al. 2004, 2006, Wolnicki et al. 2004).

Decidedly more work has been done on *C. carassius*, including investigations of the impact of

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Table 1
Characteristics of investigated water bodies (*E. p.* – *Eupallasella percnurus*, *C. c.* – *Carassius carassius*, *C. g.* – *Carassius gibelio*)

Name of water body and symbol	Latitude (N)	Longitude (E)	Surface area (m^2)	Maximum depth (m)	Maximum mud layer thickness (m)	Mean conductivity ($\mu S\ cm^{-1}$)	Plant cover (% of surface)	Adjacent area	Registred fish species	Range of *E. p.* length - TL (cm)
Mały Klincz (MK)	54°07'27"	18°04'09"	1400	2.50	1.0	43	30	cropland	*E. p., C. c., C. g.*	3.5-8.6
Rekownica 1 (RE1)	54°08'18"	18°07'11"	550	0.95	> 0.5	88	90	cropland	*E. p., C. c., C. g.*	2.6-12.0
Rekownica 2 (RE2)	54°08'15"	18°07'13"	190	0.90	> 0.5	118	80	cropland	*E. p., C. c.*	2.0-9.3
Zielona Wieś (ZW)	54°07'17"	18°12'33"	450	1.50	> 0.5	106	30	cropland, growe	*E. p., C. c., C. g.*	4.0-10.5
Guzy (GU)	54°08'44"	18°19'17"	2250	1.40	> 0.5	76	65	forest	*E. p., C. c., C. g.*	3.6-10.0
Lubieszynek1 (LU1)	54°06'39"	18°12'44"	1550	1.30	0.2	44	40	cropland	*E. p., C. c.*	3.9-11.1
Lubieszynek2 (LU2)	54°06'31"	18°12'35"	1200	1.55	0.5	50	50	cropland	*E. p., C. c.*	2.9-9.6
Skrzeszewo* (SK)	54°16'17"	18°21'11"	1910	1.45	> 0.5	291	90	forest	*C. c.*	-
Sobącz (SO)	54°04'34"	18°10'58"	1050	1.05	0.7	42	0	pasteuries	*C. c., C. g.*	-

*eastern basin

environmental conditions and predators have on their populations (e.g., Piironen and Holopainen 1986, 1988, Bronmark et al. 1995, Holopainen et al. 1997). However, data is lacking on the seasonal changes in activity of *E. percnurus* in natural conditions. Comparative data is also lacking on the impact of environmental conditions and weather on feeding intensity in these two species, as well as those that describe possible interspecies interaction. In view of the high conservation status of the *E. percnurus* and the range of threats to existence of both species, greater knowledge of the impact and dependencies of environmental factors on their populations is requisite. The aim of the current paper is to describe the seasonal activity of *E. percnurus* and *C. carassius* in small natural water bodies and the impact of selected environmental conditions on the activity of these co-inhabitants in their natural habitat.

Materials and methods

The study was conducted in nine small, natural, isolated water bodies located in the northern part of the Kashubian Lakeland in Pomerania between the cities of Gdańsk and Kościerzyna. Despite their small sizes, the basins studied differed regarding morphometry and water chemical properties (Table 1). Most of the sites were single reservoirs with distinctly oval basin shapes. Only the Skrzeszewo (SK) site comprised a few connected basins. *C. carassius* occurred at all of the sites studied, while *E. percnurus* only occurred in seven of them. Further, in three water bodies – Mały Klincz (MK), Rekownica 1 (RE1), and Zielona Wieś (ZW), single individuals of Prussian carp, *Carassius gibelio* (Bloch), were also noted.

Fish activity was studied using catches made with small folding traps. Since these are passive gear their catch yield can be considered as a measure of fish activity (He and Lodge 1990). However any impact of using bait in the catch yield of traps is debatable (Layman and Smith 2001), this method is regarded as a convenient and efficient way to catch small cyprinid fishes in small, overgrown water reservoirs (MacRae and Jackson 2006). Therefore it has been applied successfully in catches of *C. carassius* and *E. percnurus* (e.g. Piironen and Holopainen 1988, Wolnicki et. al. 2008). The traps measured 25×25×40 cm with a mesh bar length of 2 mm, two throats with 60 mm openings, and pocket for bait. The bait was wheat bread, and each portion was of the same size. The catches were made in the afternoons (14:00-18:00). One trap was deployed in the center of each water bodies always in the same, easily-accessible site at distances of 1.5-2.0 m from the pond edge at depths of 0.5-1.0 m. Each sample trapping session lasted for 15 minutes (CPUE).

Work was begun in early April 2006 when the ice cover was almost fully melted and was completed at the end of December 2006. Catches were made at the Lubieszynek 1 (LU1) and Lubieszynek 2 (LU2) sites in mid month. At the rest of the sites, the fish were caught at intervals of about two weeks. All of the fish caught were counted, measured, and then released back into the water. At the LU1 and LU2 sites, all of *E. percnurus* were measured, while at the other sites only individuals of extreme size were measured. The measure of activity was accepted as the number of fish caught. During the catches, surface water temperature and conductivity readings were taken. Additionally, the degree of cloud cover was noted on a simplified scale from 1 to 4: 1 – cloudless and sunny, 2 – scattered clouds, light clouds, 3 – mostly cloudy, 4 – overcast. Atmospheric pressure was also measured in the morning and evening on the days catches were made, and was categorized as 1 – decreasing, 2 – stable, 3 – increasing. Measurements of surface area, depth, and mud layer thickness were taken in the winter from the ice, while the degree of cover by floating-leaf vegetation, mainly *Potamogeton natans*, was determined in summer.

Since the sizes of the populations of both species differed in each of the ponds studied and could have impacted catch sizes, comparisons of the numbers of fish caught and the weather condition and water temperature data were standardized for each pond (Zar 1974) with the following formula:

$$Z = \frac{X_i - \mu}{\delta}$$

where:

Z – standardized value

X_i – initial value

μ – group mean

δ – standard deviation

Since no significant values were found between the mean number of *C. carassius* caught in the water bodies inhabited or not by *E. percnurus* (Student's t-test), all of the ponds inhabited by the former were treated equally in further comparisons. Only at the Mały Klincz site were *E. percnurus* not caught beginning in September; this could have indicated that this species had become extinct here because of the diametrical shift in conditions in this basin. Comparisons of optimal values of water temperature and atmospheric pressure for both species (for standardized catches above the mean) were performed with the Mann-Whitney U test. Differences in the activity of both species in the different cloud condition categories and with regard to changes in atmospheric pressure were analyzed with the non-parametric Kruskal-Wallis test.

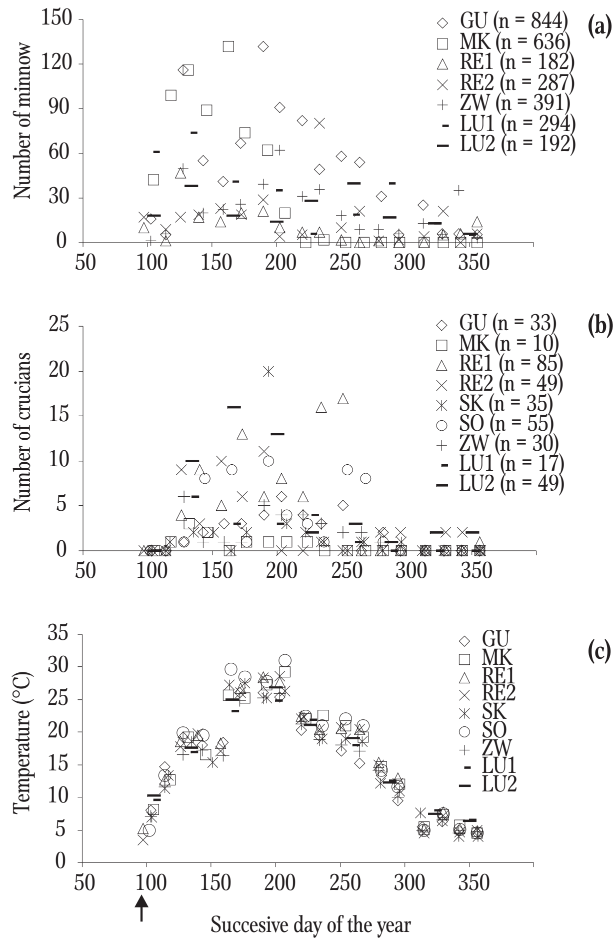

Figure 1. Number of *E. percnurus* (a) and *C. carassius* (b) caught and water temperature during the catches (c). Arrow indicates the end of the ice cover period.

Results

Pronounced differentiation in seasonal fish catches was noted in basins inhabited by both species as well as in those inhabited only by *C. carassius*. There were also significant differences in the quantity of fish caught (Fig. 1). In 144 catches, 2826 *E. percnurus* and 363 *C. carassius* were caught. The most *E. percnurus* were caught at the GU site, while the most *C. carassius* were caught at the RE1 site (Fig. 1). The former appeared in the traps as early as the beginning of April when ice cover was still melting (Fig. 1a). The highest number of *E. percnurus* was noted in most of the basins they inhabited in early May. The next increase in the number of *E. percnurus* caught was observed in some basins in the summer months; however, fish activity collapsed in almost all the basins after the thermal maximum was reached. The greatest decrease in catches was observed at the MK and RE1 sites, in which the maximum surface water temperature recorded was above 28°C, while at the MK site the *E. percnurus* disappeared after the temperature exceeded 29°C. Only slightly lower numbers of *E. percnurus* were caught at the GU and ZW sites, where the maximum recorded temperature was about 26°C. The length of the fish throughout the season ranged from 2.0 to 12.0 cm (Table 1).

C. carassius appeared in the traps later than *E. percnurus* (Fig. 1b). Mainly, they were noted since May when the water temperatures exceed 15°C (Fig. 1c). *C. carassius* were caught most abundantly in the

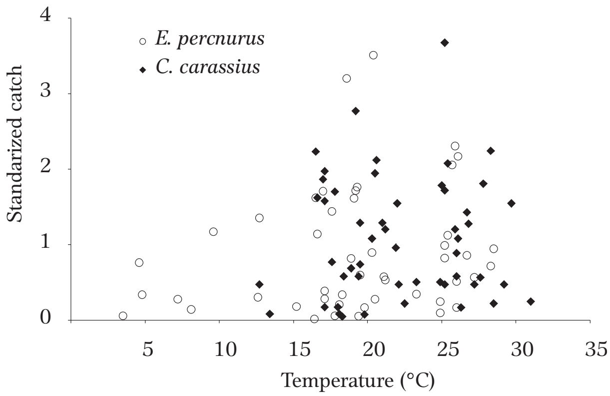

Figure 2. Relation of fish numbers (standardized catch) to water temperature.

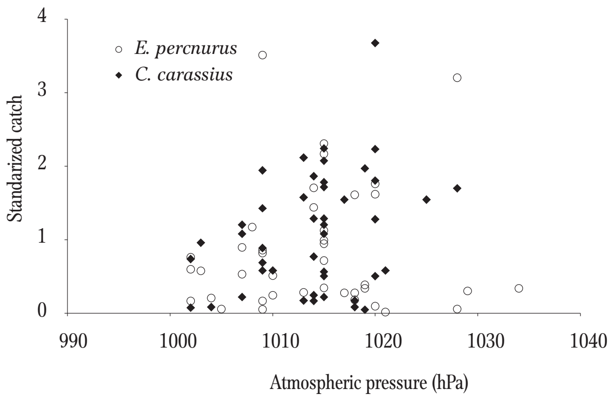

Figure 3. Relation of fish numbers (standardized catch) to atmospheric pressure.

majority of basins during the summer months, and their activity decreased as water temperatures downing in autumn. However, because of the atypically high temperatures in 2006 that persisted until the end of December, single specimens were still being caught at the end of the year. This warming also affected the activity of *E. percnurus*.

The range of water temperatures at which *E. percnurus* were caught (for standardized catches above the mean) was significantly higher than that of *C. carassius* (Fig. 2). It was also confirmed that

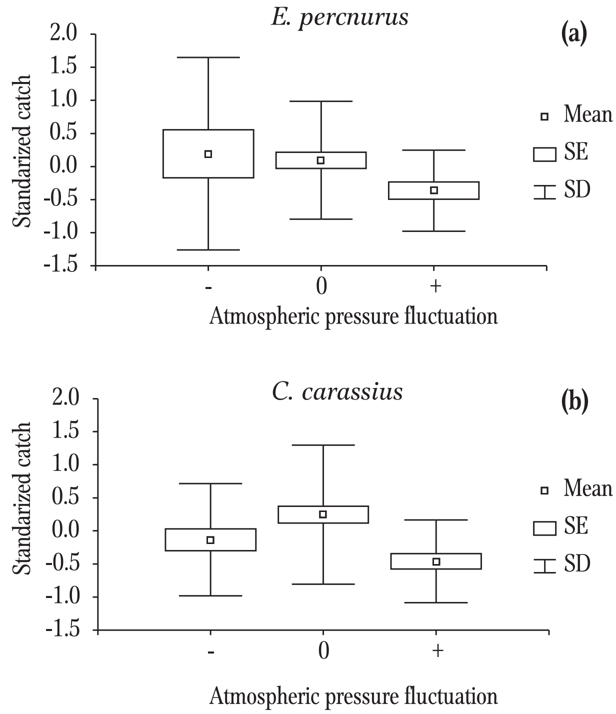

Figure 4. Mean number of fish caught (standardized catch ± SE, SD) in different pressure fluctuation classes ((-) – decreasing, (0) – stable, (+) – increasing).

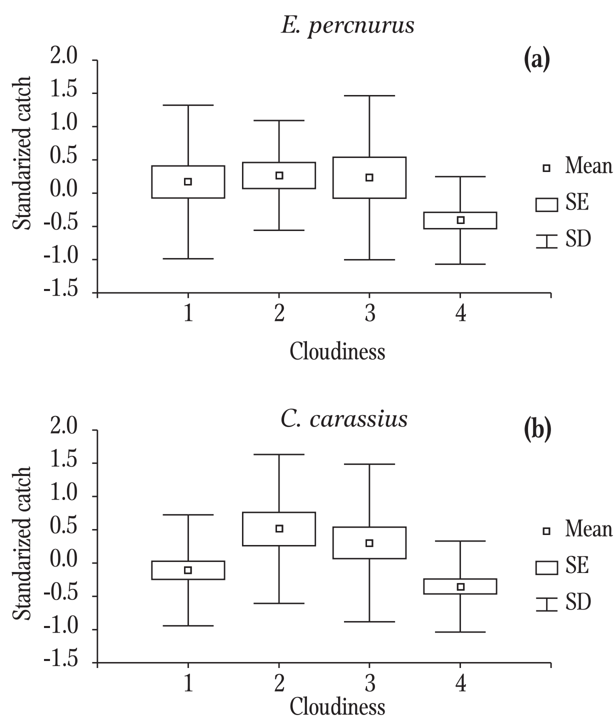

Figure 5. Mean number of fish caught (standardized catch ± SE, SD) in different cloud cover categories (1 – cloudless and sunny, 2 – scattered clouds, light clouds, 3 – mostly cloudy, 4 – overcast).

C. carassius preferred higher water temperatures (Mann-Whitney U test, Z = -2.33, P = 0.019). No significant differences were noted in the activity of either species with regard to atmospheric pressure (Fig. 3; Mann-Whitney U test, Z = -0.09, P = 0.925). However, differences in fish activity were dependent on changes in pressure (Fig. 4). Both species entered traps less intensively when pressure was increasing, but *C. carassius* distinctly preferred stable pressure, and these differences were sifnificant (Kruskal-Wallis test, H = 14.77, P < 0.001). Both species were caught in the greatest numbers when there was partial cloud cover, while they were caught less frequently on overcast days (Fig. 5), and the differences were significant for both species (Kruskal-Wallis test, for *E. percnurus*: H = 8.56, P = 0.036; for *C. carassius*: H = 11.08, P = 0.011).

Discussion

The habitats of very small water bodies offer extreme living conditions and the animals inhabiting them are considered to be exceptionally tolerant of periodic oxygen deficits and the persistence of high water temperatures in summer (Rahel and Nutzman 1994, Sondergaard et al. 2005, Danylchuk and Tonn 2006). An example of this is *C. carassius*, which is resistant to oxygen deficits of several months (Piironen i Holopainen 1986), and can also survive within a temperature range of 0-38°C, at an optimum of 27°C (Holopainen et al. 1997).

Since *E. percnurus* inhabit similar habitats to *C. carassius*, or co-inhabit the same sites, they are exposed to the same environmental conditions. The optimum temperature for juvenile *E. percnurus* growth and survival noted in laboratory experiments was 25°C, and values of these two parameters were distinctly lower at a temperature of 28°C (Wolnicki et al. 2004). In the current study, *E. percnurus* were more willing to enter traps at lower temperatures than were *C. carassius*; however, at temperatures exceeding 26°C, its activity decreased in contrast to that of the latter.

Along with the wider optimal thermal spectrum, the period of activity in *E. percnurus* was longer than that of *C. carassius* and was noted throughout the study period when there was no ice cover from early April to the end of December. The greatest feeding activity of *C. carassius* occurs in summer (Prejs 1973, Penttinen and Holopainen 1992), while in winter when the ponds freeze, this species enters into a phase of anabiosis by radically altering its metabolism. While no studies have been performed yet on this aspect of *E. percnurus* biology, in the course of other studies this species has been observed in traps deployed under full ice cover in March (G. Radtke, unpubl. data). Partial corroboration of the theory that *E. percnurus* feed beneath the ice might be the fact that they were caught fairly abundantly in early April when the ice cover was melting.

The life cycle of *E. percnurus* is short (Tandon 1979, Wolnicki et al. 2008). The youngest fish at age 0+ initially hide in shallow, overgrown waters (Sikorska et al. 2011), and with the catch method used in the current study were practically not caught at all. This behaviour might indicate strong intraspecific pressure in *E. percnurus*. Distinct intraspecific competition and pressure on the youngest fish, including cannibalism, is observed among *C. carassius* (Paszkowski et al. 1990, Tonn et al. 1994, Holopainen et al. 1997). Considering the greater activity of *E. percnurus*, one can postulate that competition within this species is even stronger.

The initial evaluation of the activity of both species studied indicates substantial differences in their preferences especially during periods of extreme conditions, and further study is necessary to gain a fuller understanding of their environmental requirements. The study also indicated that there were substantial similarities in the two species' activity with regard to weather factors. The results of the current study provide only an outline of seasonal changes in the activity of *E. percnurus* and *C. carassius* in small water bodies in northern Poland. The imprecise methods used in the current study combined with the dearth of information on the some aspects of the biology of *E. percnurus*, particularly its activity in the winter period, it would be valuable to conduct further investigations into this topic. Many of the water bodies in the Kashubian Lakeland inhabited by *E. percnurus* are also inhabited by *C. carassius*, and the differences observed in the activity of these species suggest there is a low level of competition between them, but a precise evaluation of the interaction between these two species requires further study.

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Streszczenie

Porównanie sezonowej aktywności strzebli błotnej, *Eupallasella percnurus* i karasia *Carassius carassius*, w małych zbiornikach wodnych w północnej Polsce

Sezonową aktywność strzebli błotnej *Eupallasella percnurus* i karasia *Carassius carassius* badano w kilku niewielkich naturalnych zbiornikach wodnych na Pojezierzu Kaszubskim. Badania prowadzono od początku kwietnia do końca grudnia 2006 r. za pomocą pułapek zaopatrzonych w przynętę. Jako miarę aktywności ryb przyjęto liczbę złowionych osobników. Osobniki strzebli błotnej pojawiały się w pułapkach już w kwietniu, w trakcie topnienia pokrywy lodowej. W większości zbiorników zasiedlonych przez ten gatunek pierwszy szczyt aktywności pojawiał się w maju, przed tarłem. W niektórych zbiornikach kolejny wzrost liczby poławianych osobników strzebli błotnej następował w miesiącach letnich, przy czym we wszystkich zbiornikach wodnych wyraźny spadek połowów następował po osiągnięciu maksimum termicznego. Karaś pojawiał się głównie od maja, gdy temperatura wody przekraczała 15°C, a w większości zbiorników najwięcej osobników tego gatunku poławiano w miesiącach letnich. Generalnie okres intensywnej aktywności karasia był krótszy niż strzebli błotnej. Ponadto karaś pojawiał się w wyższych temperaturach. Oba gatunki były mniej aktywne w dni pochmurne oraz przy wzroście ciśnienia atmosferycznego.