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SHORT COMMUNICATION

Evaluation of visual encounter surveys of the noble crayfish, *Astacus astacus*, and the spiny-cheek crayfish, *Orconectes limosus*

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Abstract. Several methods of sampling are commonly used to detect freshwater crayfish (Decapoda: Malacostraca). Many of them are laborious, time-consuming, and require dedicated equipment. The aims of this contribution are i) to compare visual encounter surveys and baited trap success in the detection of the noble crayfish, *Astacus astacus* (L.), which is endangered in Poland, and ii) to assess the time needed to detect the invasive spiny-cheek crayfish, *Orconectes limosus* (Raf.). The study is based on data collected between 2016–2018 in various habitats of *Astacus astacus* and *Orconectes limosus* in Poland. Visual encounter surveys are at least as effective in assessing the presence of *A. astacus* as the trapping method. The modal value for the detection time of *O. limosus* at all sites and all surveys was two minutes. Sample rarefaction showed that one survey covered 11.33 (SD = 0.43) of a maximum of 12 detections per survey. This suggests that, despite some limitations, visual detection might be an efficient method for determining crayfish presence/absence for a wide range of applications.

Keywords: crayfish sampling, watercourses, water reservoirs, lakes, baited traps

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Introduction

Several sampling methods are commonly used to detect freshwater crayfish (Decapoda: Malacostraca). These include baited minnow or eel traps, light attraction, electrofishing, kick sampling, seining, snorkeling, and artificial refuge traps (Rabeni et al. 1997, Alonso 2001, Pilotto et al. 2008, Price and Welch 2009, Ahmadi 2016, Green et al. 2018). These methods usually provide an indirect population assessment, but they can be used to assess total population abundance when applied with capture-mark-recapture methods (Nowicki et al. 2008). Comparisons of some of these methods were conducted to determine the best sampling methods for specific habitats and species (Dorn et al. 2005, Price and Welch 2009). However, these methods are laborious, time consuming, and require dedicated equipment. For example, baited traps should be exposed at night for at least several hours (Holdich and Black 2007, Strużyński 2015). These can negatively affect efficiency, because of the reduced number of sites that can be studied within a given time unit. Simple methods providing presence/absence data are also useful for determining crayfish distribution and, to some extent, to study their ecology. Potentially, the simplest presence/absence method is wading in the shallow water and actively, visually searching for crayfish in the beam of a flashlight. The aims of this contribution are i) to compare visual encounter surveys and baited trap success in the detection of the noble crayfish, *Astacus astacus* (L.), which is endangered in Poland, and ii) to assess the time needed to detect the invasive spiny-cheek crayfish, *Orconectes limosus* (Raf.).

Methods

Astacus astacus

Data were obtained from national monitoring of the noble crayfish in Poland in which the authors of this paper were the main field workers. The detailed sampling protocol is described in a methodological guide book (Strużyński 2015). The method is based on sampling river sections of 1 km or parts of the shoreline in stagnant waters. In each section, ten baited traps are placed in a way that maximizes crayfish detection (i.e., upstream sites providing shelter). Trap exposition time was eight hours per night. Data were obtained from summer to fall in 2016–2017. Simultaneously, during trap placing and monitoring, visual encounter surveys were conducted with flashlights. These surveys were limited to places with visible shelters or burrows and on stream/reservoir bottoms. Visual surveys were conducted by one or two people. Further, the success of visual encounter surveys and the trapping approach was compared. Additionally, the overlap between visual encounters and trapping was assessed, i.e., the number of instances when trapping and visual inspection detected the species and cases when the results of these two methods differed were compared.

Orconectes limosus

In summer and fall 2018, stagnant waterbodies including natural, postglacial lakes (north-central Poland) and artificial reservoirs (south-central and central Poland), were studied (see Table 2 for locations). The sites were inspected after sunset in the shallow parts of each reservoir. The surveys were concluded after 30 minutes or when we detected the first spiny-cheek crayfish. Each of the three visits targeted easily accessible sites (parts of the shoreline with non-vegetated bottoms and surfaces), but when these areas were small, the reed-covered parts of the shoreline were also assessed.

Results

Astacus astacus trapping and visual encounter surveys

In total, 27 sites were inspected (Table 1). The ratio of detection to non-detection was 0.5 for the trapping method and 0.8 for visual observation. The slightly higher effectiveness of the visual encounters was insignificant (Fisher's exact two tailed probability test: $P = 0.58$). In most cases (24 sites), the results for trapping and visual search were the same (presence vs. presence or absence vs. absence).

Orconectes limosus detection time

The spiny-cheek crayfish was detected in 12 of the 17 investigated waterbodies (Table 2). It took from 1 to 22 min to detect the crayfish. The modal value for detection time at all sites and all sampling dates was 2 min. In some cases (approx. 11%), crayfish were detected in the first minute of the survey (Table 2) (Fig. 1). The mean (and median) time of detection lengthened gradually from the first to the third survey

Table 1
Presence (1) and absence (0) data for trapping and active visual observation of the noble crayfish, *Astacus astacus*. Catch per unit effort (CPUE) for trapping is shown. Exact location is not given to mitigate potential poaching (locations are available from the Chief Inspectorate of Environmental Protection)

Site id.	CPUE	Traps	Visual Sampling
1 – river	0	0	0
2 – river	0	0	0
3 – stream	0	0	0
4 – stream	0	0	0
5- stream	0	0	0
6 – stream	0	0	0
7- stream	0	0	0
8 – stream	0	0	0
9 – stream	0	0	0
10 – stream	0	0	0
11- quarry	0	0	0
12 – excavation	0	0	0
13 – quarry	>1	1	1
14 – stream	1.6	1	1
15 – stream	4.2	1	1
16 – stream	0.1	1	1
17 – stream	0	0	1
18 – river	0	0	1
19 – stream	>0.5	1	1
20 – river	0.6	1	1
21 – stream	>1	1	1
22 – stream	0	0	1
23 – stream	0	0	0
24 – lake	4.2	1	1
25 – stream	1.2	1	1
26 – stream	0	0	0
27 – excavation	0	0	0
Sum of ‘presence’ observations		9	12

(Table 2, Fig. 1); however, the differences were insignificant (Kruskal-Wallis test: χ^2 = 1.87, df = 2, P = 0.39). In terms of presence/absence, there was 100% agreement between the first and second survey. During the third survey, crayfish were not detected at two sites (12%) despite being detected on two previous occasions. The absence of crayfish in five waterbodies was confirmed in all three consecutive surveys. Sample rarefaction showed that one survey covered 11.33 (SD = 0.43) of a maximum of 12 detections per survey.

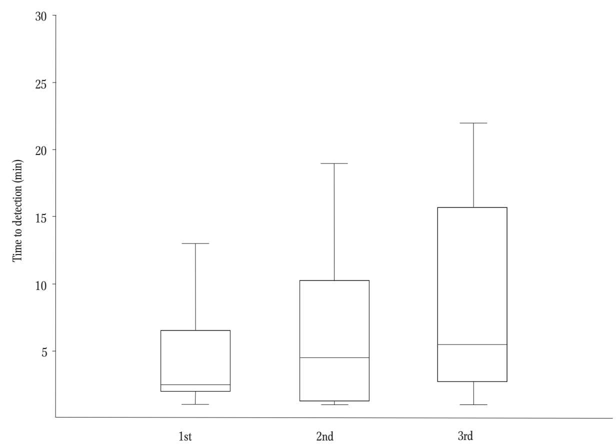

Figure 1. Median time until the first detection of *O. limosus* during three surveys. Boxes show standard errors and whiskers show the time range.

Discussion

The effectiveness of crayfish visual encounter surveys vs. other methods have not been compared to date. Reynolds et al. (2010) compared the practical advantages of visual encounter surveys with other commonly used methods of crayfish sampling.

Table 2
Presence (1) and absence (0) data, date, and time (min) until the detection of the first *Orconectes limosus* individual in stagnant waters, and waterbody characteristics. Area is in hectares

Site name	Location	Origin	Area	Control date i	Control date ii	Control date iii	Presence absence i	Presence absence ii	Presence absence iii	Time i	Time ii	Time iii
Wikaryjskie Lake	52.604622°N 19.123320°E	natural	51.5	2018.06.03	2018.08.11	2018.11.01	1	1	0	3	12	na
Kryspinów	50.050837°N 19.788228°E	anthropogenic	40	2018.06.08	2018.07.20	2018.10.04	1	1*	0	2	5	na
Lubiechowskie Lake	52.547797°N 19.253799°E	natural	16	2018.06.03	2018.08.11	2018.11.01	1	1	1	1	3	12
Skrzynki Lake	52.524601°N 19.322297°E	natural	25	2018.06.03	2018.08.11	2018.11.01	1	1	1	2	19	4
Przylasek	50.048405°N 20.160138°E	anthropogenic	19	2018.06.07	2018.07.19	2018.10.04	1	1*	1	13	4	18
Wióry Reservoir	50.946181°N 21.169768°E	anthropogenic	300	2018.07.22	2018.09.26	2018.10.08	0	0	0	na	na	na
Borków Reservoir	50.775408°N 20.759704°E	anthropogenic	38	2018.06.16	2018.07.23	2018.10.08	1	1	1	2	5	1
Golejów	50.555175°N 21.217658°E	anthropogenic	5.5	2018.06.15	2018.07.23	2018.10.09	1	1	1	5	1	7
Połaniec	50.441505°N 21.262344°E	anthropogenic	3	2018.06.16	2018.09.27	2018.10.09	0	0	0	na	na	na
Skalbierz Reservoir	50.327400°N 20.397814°E	anthropogenic	8.5	2018.06.07	2018.07.19	2018.10.07	0	0*	0	na	na	na
Kazimierza Wielka Reservoir	50.263813°N 20.477810°E	anthropogenic	21.5	2018.07.19	2018.08.31	2018.10.07	0*	0*	0	na	na	na
Dąbie Pond	50.065248°N 19.986981°E	anthropogenic	2.5	2018.07.21	2018.09.06	2018.10.04	0	0	0	na	na	na
Borzymowskie Lake	52.488269°N 18.995411°E	natural	167.5	2018.06.03	2018.08.12	2018.11.01	1	1	1	5	5	22
Lubieńskie Lake	52.408212°N 19.170790°E	natural	88.5	2018.06.03	2018.08.11	2018.11.01	1	1	1	7	17	15
Łuba Lake	52.633494°N 19.010120°E	natural	11	2018.06.03	2018.07.07	2018.11.01	1	1	1	2	1	2
Mostki Reservoir	51.060458°N 20.909800°E	anthropogenic	22	2018.07.24	2018	2018.10.08	1	1	1	7	2	3
Cedzyna Reservoir	50.871865°N 20.725719°E	anthropogenic	54	2018.06.16	2018.07.22	2018.10.08	1	1	1	1	1	3
						Mean (SE)				4.2 (1.84)	6.3 (2.50)	8.7 (2.74)
						Modal value				2	5	3
						Median value				2.5	4.5	5.5

* Two persons participated in this survey

Moreover, they used night surveys to provide indirect (catch per unit effort; CPUE) abundance data, but they did not compare the efficiency of various methods. These studies were conducted for *Autropotamiobius paliipes* (Lereboullet) in Ireland. Marzec and Okrągła (2018) also found in their studies that night surveys were more effective than trapping (*Pacifastacus leniuscuslus* (Dana) and *O. limosus*) in postglacial lakes in Poland. However, since comparing these methods was not the target of the study, no information on the visual survey effort is provided. With *A. astacus*, which is surveyed mostly in watercourses, visual encounter surveys are at least as effective when assessing the presence of the species as is the trapping method. A slightly higher ratio of positive detections, although statistically insignificant, indicates that this method might outperform standard trapping. However, this requires further research.

Considering the costs, labor, and time needed to conduct crayfish detection using traps, visual encounter surveys are a better solution for studies requiring presence/absence data from numerous sites. In the authors' experience, a survey effort of several minutes is often enough to detect the first crayfish in small streams. Even 2 to 3 h of visual monitoring in a 1 km section of a stream is still much less than the eight hours or more required to conduct passive trapping (Strużyński 2015). On the other hand, traps can still be a better solution when abundance data are necessary. Crayfish are also much more difficult to detect in deeper and/or turbid waters; thus, the visual encounter method can be recommended mostly for shallow, relatively clear watercourses. This method is also probably more influenced by surveyor skills and experience. *O. limosus* can also be effectively sampled by visual encounters. According to the observations presented herein, one monitoring survey is usually sufficient to detect this species as it was typically detected after several minutes of inspection. However, fall water cooling can decrease the probability of detection because of declining crayfish activity as the temperature of the water drops and the season progresses; however, this does not stem from a decrease in the effectiveness of the detection method itself. According to the data presented, false absences were detected in fall at sites where the species had been recorded earlier in the season. The mean detection time tended to increase later in the season, but it was not significant. However, this could have resulted from random reasons because of the relatively small number of sites surveyed. Holdich and Black (2007) found that the most effective trapping period of *O. limosus* in the UK is late summer and fall. This could be caused by higher foraging and/or breeding activity and also higher detection probability with baited traps. Most probably, false non-detection in our study could have stemmed from local, short-term factors such as weather conditions.

Visual encounter surveys have many limitations (i.e., water depth and turbidity, surveyor skills). They also do not provide population size estimates at given sites. On the other hand, they may be less dependent on the foraging intensity of crayfish and much more useful for large scale inventories of both endangered *A. astacus*, invasive *O. limosus*, and also, most probably, other crayfish. Further studies on larger samples (both the number of sites and the number of surveys) that focus on the relationship between detection time and population abundance would verify whether this method is useful for population abundance estimations.

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