INFRASTRUKTURA I EKOLOGIA TERENÓW WIEJSKICH
INFRASTRUCTURE AND ECOLOGY OF RURAL AREAS

Nr IV/3/2016, POLSKA AKADEMIA NAUK, Oddział w Krakowie, s. 1569–1580
Komisja Technicznej Infrastruktury Wsi

DOI: http://dx.medra.org/10.14597/infraeco.2016.4.3.117

COMPOSITION OF ICHTHYOFAUNA OF SMALL MID-FIELD PONDS IN RELATION TO THEIR ENVIRONMENTAL CONDITIONS AND THE POSSIBILITY OF ANGLING EXPLOITATION

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Abstract

One of the most intriguing and still rather mysterious water ecosystems are small mid-field ponds. Relatively little attention is devoted to representatives of ichthyofauna inhabiting them. The purpose of this work was the evaluation of the species and quantitative composition of the fish inhabiting several selected mid-field ponds (five), and the analysis of habitat conditions and the possibility of utilising small countryside ponds for angling purposes. Overall, 203 fish belonging to eight species were caught. The highest number was recorded in the pond No. 5 (84 specimens), and the lowest number was recorded in the pond No. 3 (18 specimens), where all the fish belonged to one species – Carassius auratus gibelio. No fish habitation was detected in the pond No. 1.

The highest dominance index (Di) was achieved by Perca fluviatilis (33.5%) and Carassius carassius (17.73%), whereas the lowest index belonged to Scardinius erythrophtalmus (2.46%) and Blicca bjoerkna (5.42%). The comparison of constancy index values (Ci) indicates that as many as six fish species out of eight demonstrated high constancy of 60%, whereas two fish species (Blicca bjoerkna and Scardinius erythrophtalmus) reached a low level of constancy amounting to 20%.

The studied ponds predominantly featured good or very good conditions for angling. In 2012, the presence of 28 anglers was noted with

regard to the studied ponds, therefore, it can be stipulated that small mid-field ponds contribute to the development of angling in Poland.

Keywords: pond, ichthyofauna, biodiversity, dominance index, constancy index

INTRODUCTION

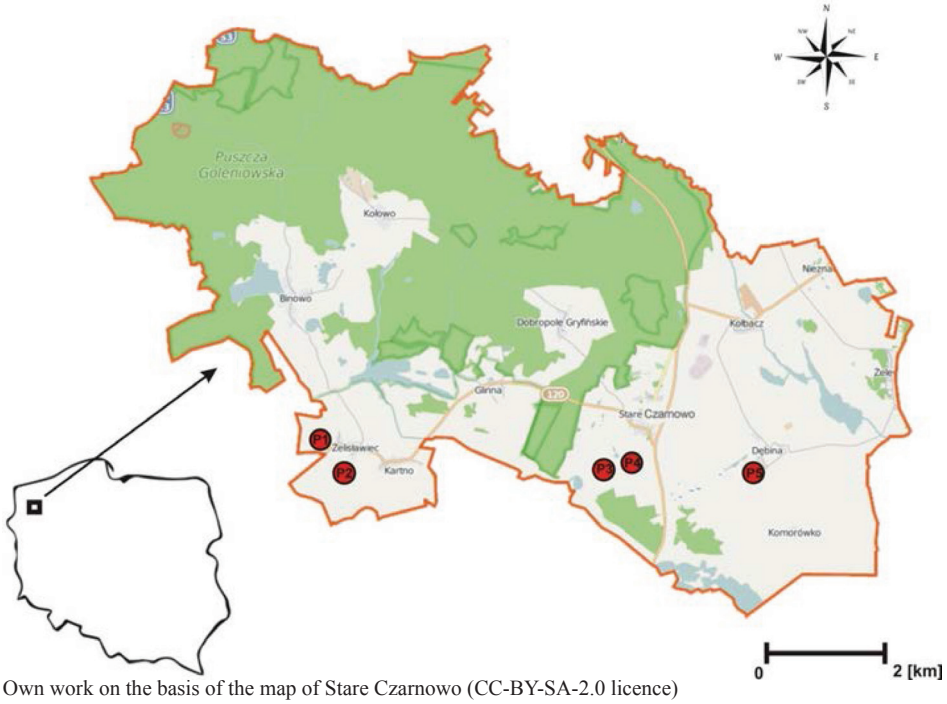
The agricultural landscape, particularly in the northern part of Poland, abounds in characteristic mid-field ponds with small surface areas. These remnants of the last glacial period are characterised by extreme biodiversity (Sayer *et al*., 2012). They are the habitat to many environmentally valuable plant and animal species, thus forming specific ecological corridors. They contribute to an increase in the local water retention, which is particularly important for rural areas (Szczykowska *et al*., 2015). Mid-field ponds are also a valuable component of the agricultural landscape as they form a micro-climate and a trap for nutrients flowing from agricultural fields (Kuczyńska-Kippen, 2014). Alas, these environmentally valuable water ecosystems are still in danger of extinction. Climatic change and human activity have contributed to an annual disappearance rate of 1% of those ponds from the map of Poland (Symonides, 2010). In the previous century, in Pomerania as many as 59% of small ponds disappeared, a vast majority began to dry out permanently and only 28% retained their open water surface (Pieńkowski, 2000). There is a lack of legal ways to protect them and a significant role of small mid-field ponds seems to be constantly underestimated.

Although many theses deal with biodiversity of small ponds in agricultural areas of Poland, relatively little attention is drawn to their ichthyofauna. There are no comprehensive monitoring studies of the condition of ichthyofauna in small mid-field ponds and the potential possibilities of utilising the resources for fishing and angling.

The purpose of this work was to analyse and evaluate the species and quantitative composition of fish residing in several selected mid-field ponds in the Stare Czarnowo Commune, in the West Pomerania Province. Moreover, habitat conditions of the ichthyofauna and the possibilities of utilising small ponds in agricultural areas for angling were analysed.

MATERIALS AND METHODS

The studies were conducted in the vegetation period from April to October 2012 in five mid-field ponds located in the Stare Czarnowo Commune (in the West Pomerania Province) (Fig. 1).



Own work on the basis of the map of Stare Czarnowo (CC-BY-SA-2.0 licence)

Figure 1. Study area with locations of studied mid-field ponds in the area of the Stare Czarnowo Commune (in the West Pomerania Province, Poland)

The studied ponds had areas ranging from 0.2 ha to 0.9 ha. They were partially covered with macrophytes and surrounded by arable land. The habitat conditions were evaluated through monthly measurements of the mean depths of the ponds, pH, electrolytic conductivity, temperature and the oxygenation of the water. Moreover, the numbers of anglers using the ponds and the presence or absence of access to fishing spots (fishing platforms) were also monitored. The types of bottoms of the ponds, expansion of rushes and weeds and the presence of avifauna were also studied (Table 1). The mean depth for each basin was measured at three selected points. The other measurements were performed at forenoon hours, using a multi-parameter Multi 3400 meter, manufactured by WTW, equipped with an oxygen probe Cellon 323.

In the spring of 2012, control fish harvests were conducted in the studied small ponds. The studies were conducted from dawn till late afternoon hours. The fish harvests were conducted using a selective set of gillnets (5 sets of nets) with various mesh lengths (12-45 m) and diameters (12-45 mm). The gillnets were placed in three different places of the pond perpendicularly to the shore,

each time changing the order of sections. Additionally, a classic IUP set for electro-fishing was used, especially in places where the use of nets was impossible due to the extensive overgrowth of water plants and in the case of the young specimens harvest. Depending on the depth of the selected point, fish were caught either by wading in the water or, in locations of greater depths, from a boat.

Table 1. General description of the studied ponds

	Pond 1	**Pond 2**	**Pond 3**	**Pond 4**	**Pond 5**
Location (geographical coordinate)	Żelisławiec (53°16'16"N 14°39'30"E)	Żelisławiec (53°16'10"N 14°40'00"E)	Stare Czarnowo (53°16'04"N 14°46'06"E)	Stare Czarnowo (53°16'07"N 14°46'34"E)	Dębina (53°16'20"N 14°48'48"E)
Surface [ha]	0.2	0.9	0.8	0.9	0.8
Average depth [m]	0.4	0.8	0.8	0.9	1.5
Characteristics of the bottom*	m.	s. m.	s. m.	s. m.	s. m. g.
Macrophytes	miserly	affluent	very affluent	affluent	affluent
Avifauna	Lack	very often	often	often	poor
Availability for fisheries (footbridges for fishing)	very good (no footbridges)	very good (3 footbridges)	limited by rushes (no footbridges)	good (no footbridges)	very good (2 footbridges)
The number of anglers	0	8	4	5	11

* m. – muddy, s – silty, g – gravel

The collected fish were classified according to their species (Brylińska, 2000) and counted. Each particular fish was measured (total length *lt.* and body length *lc.*) using a measuring tape with an accuracy of 1 mm and weighed using the AXIS electronic scales with an accuracy of 1 g. After the measurements were performed, the fish were released into the ponds at the harvest points.

Constancy indices for fish species (*Ci*) and species dominance indices (*Di*) were calculated on the basis of the results.

Constancy index was calculated according to the following equation:

$$Ci = 100 \times si / S,$$

where: *si* – the number of harvest points at which the species was present and S – the number of all harvest points.

Dominance index was calculated according to the following equation:

$$Di = 100 \times ni / N,$$

where: *ni* – the number of specimens of one species and *N* – the number of all collected specimens.

RESULTS AND DISCUSSION

The control fish harvests in the five mid-field ponds indicated great species and quantitative diversity in the composition of the inhabiting ichthyofauna. Overall, 203 specimens belonging to eight species were caught. The highest number was recorded in the pond No. 5 (84 specimens) and the fish caught there belonged to all the eight fish species. Also, big numbers of fish were observed in the pond No. 4 (61 specimens) and the pond No. 2 (40 specimens) and the fish caught there belonged to six species (Table 2).

Table 2. The number of fish caught in the studied ponds in 2012

Species	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
Blicca bjoerkna (L. 1758)	0	0	0	0	11
Carassius auratus gibelio (Bloch, 1782)	0	1	18	0	5
Carassius carassius (L. 1758)	0	4	0	15	17
Esox lucius (L. 1758)	0	3	0	2	12
Perca fluviatilis(L. 1758)	0	26	0	26	16
Rutilus rutilus(L. 1758)	0	3	0	12	8
Scardinius erythrophthalmus (L. 1758)	0	0	0	0	5
Tinca tinca (L. 1758)	0	3	0	6	10

The lowest number of fish was recorded in the pond No. 3 (18 specimens) and all the fish caught there belonged to one foreign fish species – *Carassius auratus gibelio*. Foreign species are often observed in mid-field ponds, presumably because of anglers releasing them into the waters (Kolejko and Demetraki-Paleolog, 2014). The presence of fish was not detected in the pond No. 1 (Table 2).

Of the ponds analysed in this work, two (the pond No. 2 and the pond No. 3) were subjected to ichthyofauna studies in the years 2010-2011 (Brysiewicz *et al.,* 2012). The comparison of the results of the ichthyofauna studies of the pond No. 2 from 2012 with the previous two-year period, demonstrated a similar number of harvested fish belonging to the same six species. The pond No. 3 demonstrated a significantly higher decrease in the number of fish. In the years

2010-2011, overall, the presence of 48 specimens of two species (*Carassius auratus gibelio* and *Carassius carassius*) was observed. In 2012, only the presence of one species, *Carassius auratis gibelio,* in the number of 18 specimens was observed. The decrease can probably be justified with annual decrease in the water level in the two studied ponds and the reduction in the content of oxygen in the water (Brysiewicz *et al.,* 2012). At the beginning of 2012, dead fish were observed on the surface of the pond No. 3.

The fish harvested from all the ponds were subjected to measurements of length and biomass (Table 3).

The results of body length and weight measurements in each basin indicate the diversity of the studied ponds. In the cases of *Carassius auratus gibelio* and *Carassius carassius* inhabiting four ponds, the measurements were similar, except for the pond No. 3. In 2010-2011, the fish in this basin had the mean body length ranging from 10.8 –to 19.6 cm (Brysiewicz *et al.,* 2012). In the fish harvests from 2012, only young specimens were obtained (Table 3), which probably resulted from the mass fish die-off at the beginning of 2012. In the case of *Esox lucius*, the specimens with the greatest length and biomass were observed in the pond No. 4. In the other ponds inhabited by the species, the measurements were similar (Table 3).

Table 3. Description of ichthyofauna of the mid-field ponds, taking mean total lengths, body lengths and biomass into consideration

		Blicca bjoerkna	*Carassius auratus gibelio*	*Carassius carassius*	*Esox lucius*	*Perca fluviatilis*	*Rutilus rutilus*	*Scardinius erythrophtal-mus*	*Tinca tinca*
Pond 1	*Lt. [cm]*	–	–	–	–	–	–	–	–
	Lc. [cm]	–	–	–	–	–	–	–	–
	B. [g]	–	–	–	–	–	–	–	–
Pond 2	*Lt. [cm]*	–	**28.1** (28.1)	**23.8** (22.0-27.9)	**27.5** (12.0-38.2)	**22.6** (14.0-25.0)	**27.5** (25.0-32.2)	–	**30.5** (28.1-33.4)
	Lc. [cm]	–	**23.5** (23.5)	**19.7** (18.5-22.5)	**18.0** (10.5-33.5)	**19.6** (12.0-21.0)	**24.1** (21.0-30.2)	–	**25.8** (23.3-28.5)
	B. [g]	–	**360** (360)	**286** (250-360)	**185** (10-330)	**158** (30-195)	**240** (195-325)	–	**445** (315-580)

		Blicca bjoerkna	*Carassius auratus gibelio*	*Carassius carassius*	*Esox lucius*	*Perca fluviatilis*	*Rutilus rutilus*	*Scardinius erythrophtalmus*	*Tinca tinca*
Pond 3	*Lt. [cm]*	–	**4.6** (2.4-7.8)	–	–	–	–	–	–
	Lc. [cm]	–	**3.7** (2.0-6.5)	–	–	–	–	–	–
	B. [g]	–	**2** (1-10)	–	–	–	–	–	–
Pond 4	*Lt. [cm]*	–	–	**20.7** (15.5-24.5)	**36.3** (30.5-42.1)	**17.6** (6.0-36.9)	**25.3** (18.5-21.9)	–	**30.2** (25.5-35.5)
	Lc. [cm]	–	–	**16.4** (12.8-20.1)	**31.8** (25.1-38.5)	**14.1** (4.2-32.3)	**21.1** (14.1-26.5)	–	**25.3** (20.0-30.3)
	B. [g]	–	–	**200** (150-260)	**338** (290-385)	**97** (95-715)	**221** (100-300)	–	**450** (290-600)
Pond 5	*Lt. [cm]*	**17.7** (10.3-19.5)	**22.9** (15.8-28.5)	**19.4** (10.8-23.4)	**25.4** (11.5-39.0)	**22.4** (12.1-28.9)	**26.8** (19.5-31.5)	**11.2** (7.7-15.4)	**25.2** (18.7-35.1)
	Lc [cm]	**14.5** (7.6-17.5)	**18.3** (10.4-24.0)	**15.7** (8.1-19.9)	**21.3** (11.3-34.5)	**18.8** (8.9-25.8)	**23.0** (17.4-27.1)	**8.9** (6.6-11.4)	**21.0** (13.4-29.8)
	B. [g]	**41** (5-60)	**284** (205-360)	**204** (100-280)	**169** (35-270)	**146** (40-210)	**224** (155-255)	**9** (5-15)	**275** (135-490)

Lt. – longitudo totalis (total length), Lc. – longitudo corporis (body length), B – biomass

The pond No. 4 contained the smallest specimens of *Perca fluviatilis* (Table 3), which were as numerous as those inhabiting the pond No. 2 (Table 2). As opposed to the pond No. 2, the pond No. 4 featured a wider range of lengths of the harvested fish, i.e. *lt.* from 6.0 to 36.9 cm and *lc.* from 4.2 to 32.3 cm (Table 3). This also translated into the mean biomass which was the smallest for the analysed species in the pond No. 4 – 97 g (Table 3). Relatively small were the specimens of *Scardinius erythrophtalmus* in comparison to other fish. This species, belonging to the the family of *cyprinids*, reached the mean total length of 11.2 cm, with the biggest specimens reached the length of 15.4 cm. The minimum take able size for the species in question is 15 cm in Poland (The Regulation of the Minister of Agriculture and Rural Development, 2001). The species *Tinca tinca* inhabiting three ponds had similar mean lengths and biomass (Table 3).

Changes in the composition and structure of ichthyofauna observed in each mid-field basin indicate diversity of the studied ponds. The highest dominance index (Di) was achieved by *Perca fluviatilis* (33.5%) and *Carassius carassius*

(17.73%), whereas the lowest index belonged to *Scardinius erythrophthalmus* (2.46%) and *Blicca bjoerkna* (5.42%), (Table 4). The comparison of constancy indices indicates that as many as six out of eight fish species featured a high constancy of 60% (Table 4). Two fish species (*Blicca bjoerkna* and *Scardinius erythrophthalmus*) reached low constancy indices (20%).

Table 4. Comparison of constancy indices and dominance indices for each fish species

Species	Constancy index (*Ci*) (%)	Dominance index (*Di*) (%)
Blicca bjoerkna	20	5.42
Carassius auratus gibelio	60	11.82
Carassius carassius	60	17.73
Esox Lucius	60	8.37
Perca fluviatilis	60	33.50
Rutilus rutilus	60	11.33
Scardinius erythrophthalmus	20	2.46
Tinca tinca	60	9.36

The monitoring of the environment and measurements of water parameters in the studied mid-field ponds indicated great differences in the results, which translated into the condition of their ichthyofauna. The greatest diversity was observed in the values of water oxygenation and electrolytic conductivity (Table 5). The lowest values of oxygen dissolved in water were observed in the pond No. 1 and amounted to the mean of 1.77 mg O_2 dm^{-3}. This was presumably associated with the low water level, drying of the basin, a small area and a lack of water mixing. The low oxygenation level was also observed in the pond No. 3, where extensive overgrowth of macrophytes and large deposits of sludge on the bottom were observed. The highest oxygenation was observed in the pond No. 5 which was characterised by a relatively great depth (intensive water mixing). The mean oxygen content in this basin was 6.14 mg$O_2$$dm^{-3}$. Water birds, whose presence often significantly affects the condition of ichthyofauna, were not observed in great numbers (Kłosowski 2011).

The lowest values of electrolytic conductivity were observed in two ponds located in the area of the village of Żelisławiec (the ponds No. 1 and 2). Higher diversity of the values was recorded in the pond No. 2, which is indicated by a higher value of standard deviation (Table 5). The highest values of electrolytic conductivity were observed in ponds No. 3 and 4, where the former was characterised by higher diversity of values within a year (*SD*±102.28).

The highest mean water temperatures were recorded in the pond No. 5 and amounted to 16.83ºC, and the lowest values in the pond No. 3 – 13.77ºC

(Table 5). Also, in the case of the reaction of the water, the highest values were recorded in the pond No. 5 and the lowest ones in the pond No. 2. Mean pH in all the ponds fell within the range of 6.67 to 7.38. Therefore, it can be stated that pH of the water in the studied ponds was neutral (Table 5).

Table 5. Comparison of parameters of water quality in the studied ponds

	pH	EC	Temperature[°C]	Oxygen [mg O_2 dm^{-3}]
Pond 1	7.03 ±0.26	111 ±7.02	16.39 ±6,11	1.77 ±0,64
Pond 2	6.67 ±0.68	105 ±26.06	15.58 ±5.63	4.38 ±1.63
Pond 3	7.06 ±0.59	439 ±102.28	13.77 ±4.79	2.17 ±1.91
Pond 4	7.25 ±0.30	436 ±26.26	14.22 ±4.30	4.87 ±1.10
Pond 5	7.38 ±0.20	163 ±35.53	16.83 ±3.50	6.14 ±0.87

The summary of the results of the studies of ichthyofauna structure with regard to environmental conditions indicates certain diversification. The basin which boasted the best habitat conditions for fish (the pond No. 5) was not only characterised by the biggest number of harvested fish, but also by the highest species biodiversity. The basin in question not only features a relatively large area, but also the greatest depth. Intensive water mixing was conducive to a high content of oxygen and the high annual water temperature (the mean value of 16.83ºC) allowed the fish to overwinter and reproduce. Of the studied ponds, only one exhibited no ichthyofauna habitation. During the monitoring, the water level in the pond No. 1 was very low (the mean annual depth 40 cm). Low levels of oxygenation and a very small area of the basin (0.2 ha) were not conducive to good conditions for ichthyofauna habitation. However, it cannot be excluded that in the past it may have been inhabited by cyprinids.

The studied ponds in the Stare Czarnowo Commune predominantly featured good or very good conditions for angling. Only one of the studied ponds had limited access due to extensive overgrowth of rushes. Two of the studied ponds had fishing platforms (Table 1).

The environmental conditions and access to fishing spots indicated the number of anglers using the ponds (Table 1). Owners of small mid-field ponds see the potential and possibilities of using them for agricultural tourism, including angling (Juszczak and Kędziora, 2003). The legal status of small post-glacial

ponds is not fully regulated. In many cases, these are highly neglected ponds unprotected by any legal regulations, which is conducive to and accelerates their biodegradation. However, there are also ponds that set an example with regards to their environmental condition, leading to the improvement of the biodiversity. No fishing or angling regulations regarding the ponds are in place. Slight private fry-stocking and bio-manipulation (transfer of more valuable fish species from larger lakes) were observed in the studied ponds. Although anglers use the ponds, there are no angling registers concerning the ponds.

In small ponds, one may occasionally encounter valuable and protected fish species, often even endangered ones, e.g. *Eupallasella pereburus*, which are sometimes the only representative of inhabiting ichthyofauna (Kamiński *et al.,* 2011). Their presence was not observed in the studied basin in the Stare Czarnowo Commune. Absence of *Eupallasella perenurus* confirms the view that the species does not occur in the north-western part of Poland (Wolnicki *et al.,* 2011). However, it is worth conducting monitoring studies of small mid-field ponds, as they might constitute a valuable habitat for representatives of ichthyofauna. Ecologically, they can be a valuable ecosystem constituting a habitat for protected species and, from the point of view of angling, they can be a perfect place for amateur fishing.

CONCLUSIONS

1. The presence of eight fish species belonging to three families were observed in the studied mid-field ponds: *cyprinids*, *percids* and *esocids*, but the pond No. 1 contained no ichthyofauna.
2. The dominant species was a representative of the predator fish *Perca fluviatilis* and occurred with a total number of 68 specimens. The species *Scardinius erythrophthalmus* was characterised by the lowest number of representatives – only five specimens.
3. The results of the environmental conditions study in three of the analysed ponds can be considered to be good, whereas in the ponds No. 1 and 3 low oxygenation and periodic drying were observed, resulting in the low number or absence of inhabiting fish.
4. Out of the five studied mid-field ponds, three were characterised by very good access to fishing grounds, whereas in the case of the remaining ones the conditions were assessed to be good or limited due to the overgrowth of rushes.
5. In 2012, the presence of 28 anglers was noted in four of the studied ponds, therefore, it can be stipulated that small mid-field ponds contribute to the development of angling in Poland.

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Received: 18.10.2016
Accepted: 09.11.2016