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Source: Folia Zoologica, 61(2) : 97-105

Published By: Institute of Vertebrate Biology, Czech Academy of Sciences

URL: https://doi.org/10.25225/fozo.v61.i2.a2.2012

Folia Zool. – 61 (2): 97–105 (2012)

Within year representativity of fish assemblage surveys in two small lowland streams

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Received 7 July 2011; Accepted 23 January 2012

Abstract. Although most monitoring protocols characterize fish assemblages based on one sampling occasion per year per site, it is largely unknown how well such snapshot samples characterize fish assemblages at the site and the stream levels. To address these issues, we conducted monthly samplings from March to November in 2009 in two wadeable lowland streams in the catchment area of Lake Balaton, Hungary. Five and seven sites were investigated in the two streams by electric fishing 150 m long sections. For a given sampling site, mean estimated species composition of a single survey showed on average 41 % and 35 % Jaccard index based similarity to the pooled annual samples of the site, and 90 % species representation could be reached using 5.2 and 6.4 sampling occasions on average. The representativeness of relative abundance data also varied considerably in time, showing on average 51 % and 67 % Bray-Curtis index based similarity to the pooled annual samples of the site, and reached 90 % similarity by taking 4.2 and 5.4 surveys on average per year per site. Stream level simulations of sample representativeness showed that a single survey reached on average 62.3 % and 66 % Jaccard similarity and 75.7 % and 74.8 % Bray-Curtis similarity to the whole year dataset. At the stream level, 90 % representativeness of both species composition data and relative abundance data was reached by pooling four surveys for both streams. These results indicate considerable within year variability in lowland stream fish assemblages, which should not be forgotten when evaluating monitoring data, which are based on a single survey per year.

Key words: electric fishing, wadeable streams, sample representativeness, stream fishes

Introduction

The ability of precisely estimating assemblage attributes (e.g. species richness, composition, relative abundance) has important implications for the management and conservation of ecological assemblages. Monitoring of fish assemblages in wadeable streams is principally based on electric fishing methods (Platts et al. 1983, Cowx & Lamarque 1990, Reynolds 1996, FAME Consortium 2004). Several studies have dealt with the representativeness of electric fishing in these type of streams, and especially with the determination of optimal reach length to sample with either single-pass or multi-pass removal methods for characterising fish assemblage structure (e.g. Lyons 1992, Angermeier & Smogor 1995, Cao et al. 2001, Reynolds et al. 2003, Penczak & Głowacki 2008, Holtrop et al. 2010, Van Liefferinge et al. 2010). In some cases the authors emphasize the

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necessity of the multi-pass sampling (Paller 1995, Kennard et al. 2006), contrary by others who argue that single-pass sampling of longer stream sections and a diverse array of habitats can be effectively used for monitoring purposes (Meador et al. 2003, Bateman et al. 2005, Reid et al. 2009, Sály et al. 2009).

Great differences can be found in the proposed reach length in sampling protocols as well. For example, in Europe the single-pass electric fishing of 10-20 times the wetted width, but a minimum of 100 m long sections was suggested by the FAME Consortium (2004). However, the optimal reach length depends highly on watershed- and habitat-level characteristics and it was found to vary from 14 to 286 times of the mean stream width (Holtrop et al. 2010, and references therein).

Although the above studies give information on the catching efficiency of electric fishing for a given time period, it is still largely unknown how sample representativeness varies on seasonal scale, and to what extent a single temporal survey represents the fish assemblage of a given stream section or the whole stream. This question is important because bioassessment programs and biodiversity surveys frequently use low intensity sampling on temporal scale with one sampling per year per site. However, representativeness of such surveys is supposed to be low if fish assemblages show significant short-term variation.

There are several mechanisms which may result considerable within year variations in stream fish assemblage structure, even on short time scale. Seasonal changes may occur in the fish assemblage due to migration (Bruylants et al. 1986, Pierce et al. 2001), the appearance and mortality of offspring (Gelwick 1990, Janáč & Jurajda 2005), or due to changes in environmental parameters such as water level, water chemistry, macrophyte cover and food availability (Moyle & Vondracek 1985, Taylor et al. 1996, Lusk et al. 2001, Taylor & Warren 2001, Erős & Grossman 2005a, Keaton et al. 2005). Seasonal or eventual changes in environmental parameters may also affect the efficiency of the electric fishing (e.g. water temperature, water depth, water transparency, and density of macrophytes) and can bias among site or among stream comparisons (Funk 1949, Pierce et al. 1985, Lamarque 1990, Hayes & Baird 1994).

In this study we examined the representativeness of electric fishing samples in two wadeable lowland streams in the catchment area of Lake Balaton, Hungary. Specifically, we evaluated how the representativeness of species composition and relative abundance data change with sampling effort in a short time scale, that is with the number of sampling occasions within a year. We made our comparisons at both site and stream levels.

Material and Methods

Study area and field sampling

For this study two lowland streams, the Egervíz- (E) and the Marótvölgyi-streams (M) were selected in the catchment area of Lake Balaton, Hungary. Egervíz-stream (length = 48.9 km; catchment area = 369 km^2; Q_{av}= 0.31 m^3 s^{-1}; av. slope = 3.57 ‰); is the largest northern inflow of Lake Balaton while the Marótvölgyi-stream (length = 28.8 km; catchment area = 177 km^2; Q_{av}= 0.50 m^3 s^{-1}; av. slope = 1.11 ‰) is a characteristic southern stream of the lake. Mean width and depth of the studied stream sections were 4.78 ± 2.3 m and 0.58 ± 0.3 m and 2.88 ± 1.0 m and 0.46 ± 0.2 m for the Marótvölgyi and Egervíz streams, respectively.

Like the majority of lowland streams in Europe, these streams are canalized and run through a predominantly agricultural landscape between dikes, which allow little meandering. Their substrate is a mixture of silt and sand with varying portions of gravel and artificial materials (i.e. concrete, stone and rock) used to fix stream channel and stream bank. Similarly to most streams in this region, fish ponds were built on both watercourses, one on the Egervíz-stream above the E3 site and one on the Marótvölgyi-stream above the M2 site. Beside the weirs of the fish ponds there is no considerable object restricting longitudinal connectivity in these streams.

Seven and five sites were investigated monthly between March and November in 2009 (i.e. nine surveys per site) in the Egervíz- and the Marótvölgyi-streams, respectively. Sampling sites were selected so as to represent the heterogeneity of habitats in these streams. A previous methodical study on this drainage area proved that single-pass sampling of 100-200 m long stream sections gives relatively representative information about the species composition and the relative abundance of the fish assemblage (Sály et al. 2009). Therefore, to optimize the sampling effort, 150 m long sections were surveyed at each sampling site at each sampling occasion, using a Hans-Grassl IG 200/2B backpack electric fishing machine (max. 10 kW PDC; Hans Grassl GmbH, Germany). Pulsating direct current with a frequency of 75-100 Hz and a voltage of 200-300 V was used. The 2 m long catcher rod had a ring shaped anode with a diameter of 30 cm and equipped with a net (mesh size 6 mm).

Table 1. *Cumulated catches for the sampling sites. Sampling sites are indicated by letters representing streams (E: Egervíz-stream, M: Marótvölgyi-stream) and by numbers representing their order in downstream direction. Abbreviations: Dist. – Distance from the mouth in km.*

№	Species name – Dist. (km)	M1 20.8	M2 16.3	M3 11.9	M4 7.1	M5 1.9	∑M	E1 30.4	E2 20.0	E3 17.2	E4 13.8	E5 10.6	E6 5.5	E7 1.8	∑E
1.	*Abramis brama*	0	0	0	2	0	2	0	0	0	0	2	2	4	8
2.	*Alburnus alburnus*	0	0	0	3	1	4	0	0	0	0	0	0	22	65
3.	*Ameiurus melas*	0	0	0	0	0	0	0	0	6	1	0	0	2	12
4.	*Anguilla anguilla*	0	0	0	0	0	0	0	0	0	0	0	0	1	1
5.	*Barbatula barbatula*	6	1	5	0	0	12	17	2	0	3	0	12	0	36
6.	*Blicca bjoerkna*	0	0	0	28	0	28	0	0	0	0	3	2	18	23
7.	*Carassius carassius*	0	0	0	0	0	0	0	0	0	0	0	0	1	1
8.	*Carassius gibelio*	0	0	17	2	1	20	0	0	56	6	0	0	12	79
9.	*Cobitis elongatoides*	19	42	5	15	5	86	0	36	21	7	4	0	0	85
10.	*Cyprinus carpio*	2	0	0	0	0	2	0	0	1	0	0	0	1	2
11.	*Esox lucius*	2	0	2	42	13	59	0	23	1	0	4	8	34	70
12.	*Gobio gobio*	184	95	38	0	0	317	0	0	26	62	76	19	0	205
13.	*Gymnocephalus cernuus*	0	0	0	0	0	0	0	12	3	0	0	0	2	106
14.	*Lepomis gibbosus*	4	164	23	44	2	237	0	0	58	1	1	1	1	66
15.	*Leucaspius delineatus*	2	0	34	46	7	89	0	0	0	0	0	0	0	0
16.	*Misgurnus fossilis*	0	15	11	10	36	72	0	1	16	2	1	1	4	31
17.	*Oncorhynchus mykiss*	0	0	0	0	0	0	0	1	0	0	0	0	0	1
18.	*Perca fluviatilis*	0	0	5	3	0	8	0	4029	126	7	42	79	66	4439
19.	*Perccottus glenii*	0	0	0	7	4	11	0	0	0	0	0	0	0	0
20.	*Proterorhinus marmoratus*	0	0	1	1	0	2	0	0	0	0	0	0	0	0
21.	*Pseudorasbora parva*	187	755	247	26	3	1218	0	46	0	0	0	0	0	48
22.	*Rhodeus sericeus*	3	165	373	120	2	663	0	0	711	7	23	28	328	1194
23.	*Rutilus rutilus*	1	0	24	197	20	242	1	5250	253	7	23	68	492	6697
24.	*Sander lucioperca*	0	0	0	0	0	0	0	3	0	0	1	0	0	4
25.	*Scardinius erythrophthalmus*	16	0	0	35	33	84	4	0	42	4	0	0	13	68
26.	*Squalius cephalus*	0	40	10	3	0	53	0	0	0	0	0	1	2	4
27.	*Tinca tinca*	1	0	1	3	1	6	0	0	1	0	0	0	5	7
28.	*Umbra krameri*	0	0	391	815	1820	3026	0	0	0	0	0	0	0	0
	Species number	12	8	16	19	14	22	3	11	14	12	15	11	19	24
	Number of individuals	427	1277	1187	1402	1948	6241	24	9836	1623	195	203	225	1146	13252

Table 2. *Mean (± SD) within site temporal sample similarity for species composition (BIN) and relative abundance data (%) for the Marótvölgyi- (M) and Egervíz-streams (E). The numbers of sites represent their order in downstream direction.*

	M1	M2	M3	M4	M5		
BIN	0.51 ± 0.15	0.61 ± 0.19	0.40 ± 0.13	0.40 ± 0.17	0.39 ± 0.13		
%	0.52 ± 0.16	0.64 ± 0.17	0.48 ± 0.16	0.47 ± 0.18	0.48 ± 0.14		
	E1	E2	E3	E4	E5	E6	E7
BIN	0.85 ± 0.28	0.54 ± 0.17	0.63 ± 0.13	0.34 ± 0.17	0.33 ± 0.20	0.28 ± 0.21	0.39 ± 0.15
%	0.81 ± 0.35	0.63 ± 0.23	0.68 ± 0.12	0.48 ± 0.20	0.46 ± 0.21	0.34 ± 0.25	0.45 ± 0.23

The sampling crew consisted of two people: the electric fisher operator who effectively caught the fish and handled the machine, and a netter who helped to catch escaping or unseen fish. To eliminate the bias due to the environmental changes (e.g. changes in the flow regime) all the sampling sites assigned on one stream were assessed on the same day. Samplings were carried out daytime, usually between 9 am and 18 pm, starting at the uppermost sites and proceeding downstream.

Data analysis
Data analyses were carried out at both (1) the site and (2) the stream levels.
(1) To assess within site temporal variability in species composition (i.e. presence/absence) and relative abundance (%) data, similarity values between all monthly data pairs were first calculated for each sampling site. We used Jaccard index for the binary and Bray-Curtis index for the relative abundance data to express similarity (Legendre & Legendre 1983). Within site level temporal variability was then characterized by the mean and the standard deviation of these similarity values. We used Spearman rank correlation (R_S) to test the relationship between temporal variability (i.e. mean similarity) of fish assemblages and spatial position of the sites along the longitudinal profile of the stream.
A randomization procedure was applied to evaluate the effect of timely sampling effort on sample representativeness at the site level. In this procedure, i = 1,…,9 sampling units (i.e. monthly fishing data from a given site) were chosen randomly without replacement and pooled to form a sample, then compositional similarity between the sample and the site reference was computed. Compositional similarity was measured by the Jaccard index for the species composition data and the Bray-Curtis index for relative abundance data. Reference communities were established by pooling all monthly samples for a given sampling site. The randomization procedure was iterated 1000 times, and a mean similarity value and its standard deviation were computed for each sampling effort level (i.e. for each i).
(2) To assess temporal variability at the stream level, catches for all sampling sites were pooled by sampling occasions (months) for each stream separately. To evaluate the effect of timely sampling effort at the stream level a similar randomization procedure was applied to the site level analysis both for species composition and relative abundance data.
Reference communities for these analyses were established by merging all the data collected at all sites of a given stream. All analyses were performed with the R statistical program package (R Development Core Team 2009).

Results
Altogether 19493 individuals of 28 species were collected of which 24 and 22 species occurred in the Egervíz- and Marótvölgyi-streams, respectively. The number of shared species was 18 (64 % of the whole species pool) (Table 1).

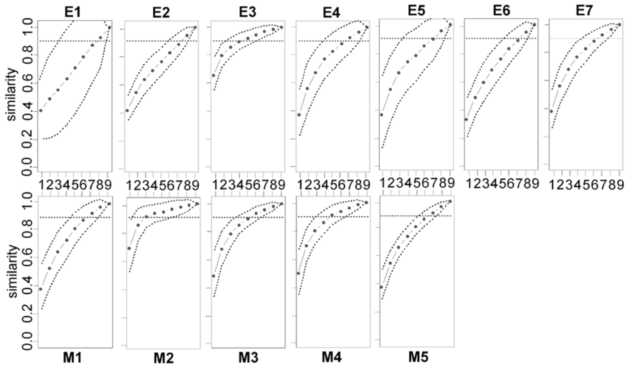

Fig. 1. *Site level similarity curves of species composition data of the studied sampling sites. Horizontal axis: number of surveys pooled. Circle: mean, dotted line: ± SD, horizontal dotted line: 90 % of similarity to the total catch. Sampling sites are indicated by letters representing streams (E: Egervíz-stream, M: Marótvölgyi-stream) and by numbers representing their order in downstream direction.*

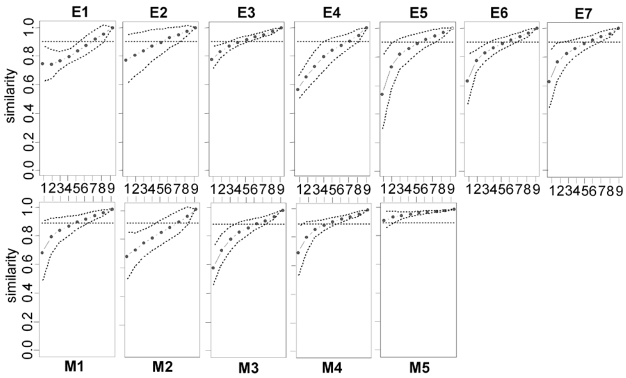

Fig. 2. *Site level similarity curves of relative abundance data of the studied sampling sites. Horizontal axis: number of surveys pooled. Circle: mean, dotted line: ± SD, horizontal dotted line: 90 % of similarity to the total catch. Sampling sites are indicated by letters representing streams (E: Egervíz-stream, M: Marótvölgyi-stream) and by numbers representing their order in downstream direction.*

Site level assemblage variability
Mean similarity values, used for characterizing the within year variability of fish assemblages, varied between 0.39 and 0.61 for species composition and between 0.47 and 0.64 for relative abundance data for the Marótvölgyi-stream. Corresponding values for the Egervíz-stream ranged between 0.28 and 0.85, and between 0.34 and 0.81 for species composition and relative abundance, respectively (Table 2). Mean similarity values of species composition and relative abundance data varied together from site to site for

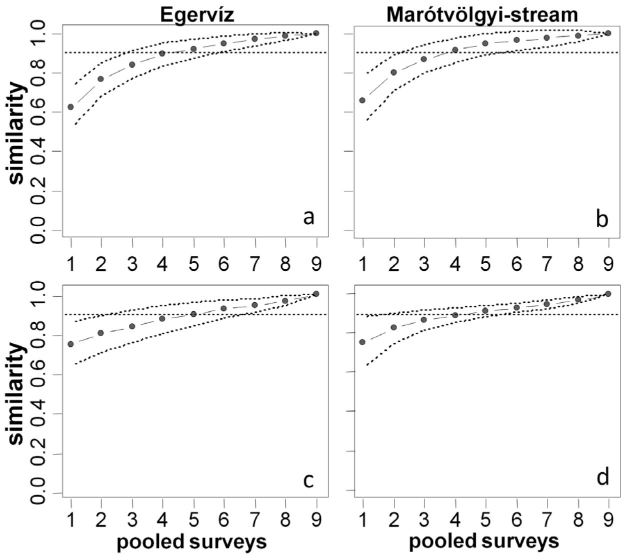

Fig. 3. Stream level similarity curves of the cumulated species composition (a and b) and relative abundance data (c and d). Circle: mean, dotted line: ± SD, horizontal dotted line: 90 % of similarity to the total catch.

both the Marótvölgyi-stream (R_S = 0.763, P = 0.133) and the Egervíz-stream (R_S = 0.893, P = 0.007), but this relationship was significant only for the latter stream. Temporal variability of assemblages tended to increase downstream, although only one of these relationships was significant and two of them were marginally significant (Marótvölgyi-stream: species composition R_S = 0.872, P = 0.054, relative abundance R_S = 0.718, P = 0.172; and Egervíz-stream: species composition R_S = 0.750, P = 0.052, relative abundance R_S = 0.929, P = 0.003).

Site level simulations showed that a single survey represented on average 48 % ± 12 % (± SD) and 41 % ± 11 % of the species composition information of the reference data for the Marótvölgyi- and Egervíz-streams, respectively (Fig. 1). At this level, 90 % representativeness of species composition was reached by pooling on average 5.2 ± 1.48 and 6.43 ± 1.27 sampling occasions for the Marótvölgyi- and Egervíz-streams, respectively. Representativeness of single survey data was higher for the relative

Table 3. Similarities between the species composition (presence-absence data) and relative abundance (%) data, and the whole year reference datasets at the stream and the site levels. Highest values are highlighted in bold.

			MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Marótvölgyi-stream	Species composition – stream level		0.55	0.55	0.77	0.68	0.73	0.73	**0.86**	0.55	0.50
	Species composition – site level	M1	0.33	0.17	0.33	0.33	**0.67**	0.50	0.58	0.33	0.17
		M2	0.63	0.63	0.88	0.88	**1.00**	0.63	0.50	0.38	0.63
		M3	0.25	0.19	0.63	0.63	**0.69**	0.63	0.44	0.50	0.38
		M4	0.26	0.32	0.63	0.58	0.58	0.63	**0.68**	0.32	0.32
		M5	0.43	**0.50**	0.43	0.21	**0.50**	0.36	**0.50**	0.36	0.21
	Relative abundance data – stream level		0.62	0.87	0.45	0.79	0.84	**0.88**	0.81	0.83	0.72
	Relative abundance data – site level	M1	0.62	0.65	0.50	0.23	**0.93**	0.76	0.78	0.66	0.87
		M2	0.79	0.68	0.43	0.43	0.91	**0.92**	0.53	0.64	0.63
		M3	0.37	0.44	0.46	**0.76**	0.70	0.66	0.71	0.74	0.49
		M4	0.48	0.69	0.30	**0.87**	0.75	0.86	0.83	0.79	0.68
		M5	0.93	**0.97**	0.86	0.94	0.77	**0.97**	0.96	0.96	0.95
Egervíz-stream	Species composition – stream level		0.54	0.50	0.58	**0.88**	0.71	0.63	0.63	0.58	0.54
	Relative abundance data – site level	E1	0.33	0.33	**1.00**	0.33	0.33	0.33	0.33	0.33	0.33
		E2	0.27	0.36	0.36	**0.55**	**0.55**	0.45	0.36	0.36	0.36
		E3	**0.79**	0.57	0.50	0.71	0.64	0.71	0.43	**0.79**	0.71
		E4	0.58	0.25	0.33	0.50	**0.67**	0.33	0.17	0.25	0.25
		E5	0.33	0.33	0.27	0.47	**0.53**	0.33	0.40	0.07	0.13
		E6	0.09	0.09	0.27	0.55	**0.91**	0.55	0.27	0.36	0.09
		E7	0.16	0.42	0.47	**0.58**	0.26	0.53	0.42	0.42	0.21
	Relative abundance data – stream level		0.73	0.74	0.77	0.53	0.75	0.69	**0.92**	0.91	0.70
	Relative abundance data – site level	E1	**0.79**	**0.79**	0.38	**0.79**	**0.79**	**0.79**	**0.79**	**0.79**	**0.79**
		E2	0.61	0.71	0.63	0.47	0.97	0.87	0.94	**0.99**	0.72
		E3	0.60	0.75	0.76	0.80	**0.89**	0.88	0.72	0.77	0.84
		E4	0.59	0.57	0.49	0.56	0.64	0.64	0.42	0.53	**0.67**
		E5	0.80	0.51	0.70	0.73	**0.82**	0.76	0.64	0.43	0.25
		E6	0.31	0.36	0.68	0.70	0.79	**0.92**	0.48	0.55	0.04
		E7	0.60	0.34	**0.91**	0.74	0.79	0.76	0.75	0.34	0.37

abundance, and on average it was 72 % ± 12 % for the Marótvölgyi- and 67 % ± 10 % for the Egervíz-streams. To achieve 90 % representativeness 4.2 ± 2.1 and 5.4 ± 1.1 sampling occasions were needed for the Marótvölgyi- and Egervíz-streams, respectively (Fig. 2).

Stream level assemblage variability

At the stream level, mean similarity values of the cumulated monthly survey data were 0.65 ± 0.08 (± SD) for the species composition and 0.71 ± 0.09 for the relative abundance in the Marótvölgyi-stream, and 0.62 ± 0.08 (± SD) for the species composition and 0.62 ± 0.15 for the relative abundance in the Egervíz-stream, respectively.

Stream level simulations showed that a single survey (the cumulated catch of all sites in a certain month) represented on average 66 % ± 12 % (± SD) and 62.3 % ± 10 % of the species composition information of the reference data for the Marótvölgyi- and Egervíz-streams, respectively (Fig. 3a, b). At the stream level, 90 % representativeness of species composition was reached by pooling four surveys for both the Marótvölgyi- and Egervíz-streams. Representativeness of single survey data was higher for the relative abundance, and on average it was 75.7 % ± 13 % and 74.8 % ± 11 % for the Marótvölgyi- and Egervíz-streams, respectively (Fig. 3c, d). Again, to achieve 90 % representativeness four sampling occasions were needed in both streams (Fig. 3). Monthly detailed data of site and stream level similarities to the reference data set are shown in Table 3.

Discussion

Understanding the organization of stream fish assemblages, and establishing management and conservation options require representative assemblage structure data at a variety of spatial and temporal scales. Accordingly, a huge amount of studies dealt with the optimal reach length, the number of sites and the method of sampling (i.e. single- or multi-pass fishing) needed to describe spatial and long-term (i.e. year to year) variations in stream fish assemblages with electric fishing (e.g. Kennard et al. 2006, Fischer & Paukert 2009, Sály et al. 2009, Holtrop et al. 2010). As fish assemblages of the two studied streams showed high seasonal variability at both the site and the stream levels, we argue that within year assemblage level sample variability also needs more attention.

Previous studies on the same drainage area, including also the Marótvölgyi- and Egervíz-streams, showed that single-pass electric fishing of 150 m long stream sections gives representative information on instantaneous species richness and relative abundance of fish assemblage characteristic for a given stream reach (Sály et al. 2009). Present results suggest that snapshot yearly surveys may be inefficient to estimate the annual average assemblage characteristics of stream fish assemblages. Assemblage attribute estimates varied substantially within a year for both species richness and relative abundance data in both streams and at both site and stream levels. Compared to the yearly cumulated data, the representativeness of a single survey was generally less than 50 % for species richness and less than 75 % for the relative abundance data at site level in both streams. Data simulations showed that to achieve 90 % representativeness four to five sampling occasions per year are needed for these human modified lowland streams.

Concordant with the results of North American studies (Angermeier & Smogor 1995, Lohr & Fausch 1997), representativeness of a single survey was higher for the relative abundance data than for the species composition data. This is not surprising because species richness estimates (based on presence/absence data) are very sensitive for the presence of rare species unlike the Bray-Curtis index which was used to evaluate variances in the relative abundance data and which is determined mostly by the ratio of the dominant species (c.f. Angermeier & Smogor 1995).

Similarly, higher representativeness at the stream level compared to the site level is a common pattern in many streams (Ross et al. 1985, Matthews et al. 1988, Lohr & Fausch 1997). The main reason is that sampling unit related data variability generally strongly correlates with the detectability of rare species (Lohr & Fausch 1997, Reynolds et al. 2003, Fischer & Paukert 2009). Thus, site level representativeness is more strongly affected by the sporadic occurrence of rare species since overall sampling effort is higher at the stream level. Accordingly, with only one survey per sampling period false conclusions may arise about the persistency of rare species at site level. On the other hand, based on variations of the relative abundance data, it is obvious that observed within year variations in the two streams were not just the result of the sporadic occurrence of rare species, but they represent real assemblage level changes and/or variations in sampling efficiency.

Many mechanisms can cause short-term changes in fish assemblages. These mechanisms include natural processes, changes due to human activities, inappropriate sampling effort and changes in the catching efficiency. One of the most important natural sources of temporal variations in stream assemblages could be related to seasonal dynamics of reproduction and recruitment of fish. For example, Gelwick (1990) found that most of the variances characterised the riffle assemblages of Northeastern Oklahoma Ozark streams derived from the seasonal dynamics of juvenile fish. The studied streams flow to Lake Balaton, from which several fish species migrates to spawn to the inflowing streams. Migration between the lake and its inflowing streams may also occur when environmental circumstances become suboptimal in either habitat (Bíró et al. 2003). Migration processes affect mainly the downstream sections in small streams from recipient larger streams and their significance is likely to decrease upstream (Erős & Schmera 2010). This may explain why within year variability of assemblage data tended to increase downstream in both streams. Moreover, fish assemblages of downstream sections may also vary due to eventual drifting of fish species from headwater sections by floods.

Human activities on the tributary may also considerably alter stream fish assemblages and their variability in time. On a short-term scale, such an important influence is the eventual escape of fish from fish ponds operating on the drainage area. Fish ponds can be found in the drainage area of both Egervíz- and Marótvölgyi-streams. Fish escapes, mainly during floods and discharging of ponds, are probably the primary sources of recruitment of some non-native fish species (e.g. *Carassius gibelio*, *Pseudorasbora parva*, *Lepomis gibbosus*, *Ameiurus melas*), which otherwise could not permanently exist in these streams. However, fish ponds are also partly responsible for seasonal variations in abundance of some native fish species (e.g. *Rutilus rutilus*, *Blicca bjoerkna*, *Scardinius erythrophthalmus*), which can effectively recruit in lowland streams.

Temporal variations in assemblage data may also be related to changes in electric fishing efficiency. Such changes are very likely to occur if there are obvious variations in habitat structure, water temperature or water chemistry. Although, the studied streams are canalized and thus have more or less homogenous habitat structure, significant seasonal changes occur in relation to the development of the macrovegetation. During the summer month (typically from the beginning of June) macrophyte cover increases substantially in the middle and lower sections of the Egervíz- and Marótvölgyi-streams, and this structural heterogeneity decrease electric fishing efficiency. Moreover, since our study covered the whole vegetation period (i.e. March to November), water temperature also significantly varied over the survey, and thus probably affected the sampling efficiency.

The surveys conducted in the middle of the vegetation period showed higher similarities to the whole year dataset both at the stream and the site levels (see Table 3). These results may indicate that the summer – early autumn period is the most applicable for monitoring purposes, at least compared with samples collected in early spring or late autumn. However, our data also showed that it is really hard to make generalizations, since the most representative month varied between relative abundance and species composition data and also showed differentiation among sites and between streams as well. Nevertheless, these data support the suggestions of monitoring protocols, which suggest the late summer and early autumn period for assessing stream fish assemblages.

In general, different sampling efforts are needed to ensure the same level of representativeness between sampling periods within a year, which is difficult to achieve in fish assemblage monitoring. However, in sampling surveys including many sampling sites over different streams and lasting for several days or weeks, it is unpractical to vary the sampling effort from site to site in time. Instead, the entire sampling schedule should be adjusted to attain the optimal overall sampling precision.

In conclusion, fish assemblages showed considerable within year variation in these two lowland streams. Our results may indicate that multiple surveys are needed annually in streams where temporal variations occur in fish assemblages or the sampling efficiency must be increased (e.g. longer stream section need to be sampled) during the regular monitoring period. Further studies are required however, how such short-term assemblage or sampling efficiency variations may effect the conclusions of fish assessment evaluation over wider spatial and temporal scales.

Acknowledgements

This study was supported by the OTKA K69033 research fund. T. Erős was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences and the OTKA PD77684 research fund.

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