FISHERIES SCIENCE 2003; **69**: 154–160

Diel and seasonal abundance of fishes in the Platte River, Nebraska, USA

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ABSTRACT: The objective of the present study was to determine diel and seasonal patterns of fluvial fish composition and abundance. Electrofishing grids were used to collect fish in the Platte River at North Bend, Nebraska, USA. Sampling was started at 12.00 h and continued every 3 h for a 24-h period. More species were taken during the day than at night in the spring. In contrast, more species were taken at night than during the day in summer. In the fall, equal numbers of species were caught during the day and night. Comparisons of fish densities showed significant differences among the three seasons. Major taxa were significantly more abundant in spring, but river shiner *Notropis blennius* and western silvery minnow *Hybognathus argyritis* were more abundant in the fall. The greater nocturnal abundance of fish in summer and fall than in the spring may be due to changes in the physical and chemical characteristics during the study periods. The significance of seasonal difference in abundance of fish assemblages may indicate a response to changes in available habitats.

KEY WORDS: **diel difference, fish composition, fluvial fish, seasonal difference.**

INTRODUCTION

Diel cycles of activity have been documented for many fish species.[1] This activity can be recognized from changes in abundance between day and night. Variations in fish abundance have been investigated for different time scales. Long-term studies provide a database for broader issues, such as global temperature changes.[2] Short-term studies have been reported on day/night changes in abundance.[3–5] These diel differences can usually be attributed to behaviors of foraging patterns or a trade-off between food utilization and predator avoidance.[6,7] In addition to diel cycles, fish also display seasonal changes in abundance.[8–10] Changes in seasonal abundance may be related to environmental fluctuations that affect suitable habitats for fish spawning.

Most work on diel differences of fish abundance have been concentrated on lentic systems using passive techniques, such as gill nets or analyses of stomach contents.[3,8,11] The passive technique may affect the number caught because fish can see the gill net and avoid it.[12] Studies that combined seining with gill nets to increase their efficiency of catch showed no significant reduction in fish catch over 24-h periods.[4,13] Limited information has been collected in 24-h periods over long time scales on lotic systems using other active techniques.

The objectives of the present study were to: (i) describe diel differences of fluvial fish species composition and abundance; and (ii) examine seasonal shifts in the diel patterns of species composition and abundance.

MATERIALS AND METHODS

The study was conducted from 1987 to 1991 at North Bend in the Platte River, Nebraska, USA (Fig. 1). The Platte River in eastern and central Nebraska is wide, braided and shallow with sand and gravel substrate. Riparian areas are vegetated with trees. The area is defined as moist subhumid with areas of trees. Ninety-three percent of the drainage area of the lower Platte River is classified as agricultural land with the majority suitable for irrigation. Water depth at the study site ranged up to 105 cm and current velocity ranged from 0 to 100 cm/s.[14,15] Water temperature at the surface

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Received 13 September 2001. Accepted 10 September 2002.

ranged from 5 to 32.25°C during collections. Other chemical characteristics at the study site fell within ranges suitable for aquatic life. The dissolved oxygen values ranged from 7.1 to 13.8 mg/L, conductivity measurements ranged from 20.0 to 89.0 umhos/cm, pH readings ranged from 6.9 to 8.9, and mean suspended solids concentrations were generally below 500 mg/L. Sample dates included September, October 1987; July, October and November 1988; March, June, July, August, October and November 1989; March, May, June, July, August, September and October 1990; and July 1991. Sampling was started at 12.00 h and continued at 3-h intervals until 09.00 h the next day for a 24-h period. Monthly data were combined into three seasons: spring (March–May), summer (June–August) and Fall (September–November).

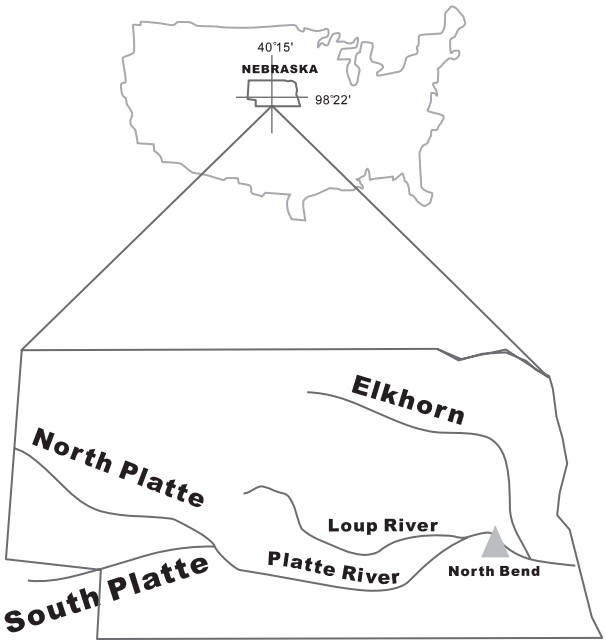

Fig. 1 The Platte River basin and the study site.

To organize the measuring procedure at each site, we set a 100 m transect perpendicular to the bank. The position for the first grid on the transect was randomly chosen in the first 10 m at shore. Subsequent grids were positioned (long axis parallel to flow) at 10 m intervals along the transect line. After at least 30 min, each grid was shocked with a 120-volt AC generator for 30 s. Fish were collected in a 6.35-mm mesh bag-seine held downstream of the grid. Fish from each grid were identified and enumerated in the laboratory. Density was calculated for each grid sample. We used the Mann–Whitney *U*-test and the Kruskal–Wallis test to analyze differences of fish abundance between day and night and among seasons, because data were not normally distributed and were not transformed. All the analyses were performed in SAS.[16]

RESULTS

Species composition and abundance

From 1987 to 1991, 12 species were caught in spring samples (Table 1), 23 species in the summer (Table 2) and 19 species in the fall (Table 3). In

Table 1 Numbers of individual fish collected in the spring (March of 1989 and March and May of 1990) in electrofishing grids at 3-h intervals in the Platte River[†]

	Day			Night			Day			
Species	12.00 h (21)	15.00 h (25)	18.00 h (24)	21.00 h (13)	24.00 h (14)	03.00 h (7)	06.00 h (14)	09.00 h (24)	Day (108)	Night (34)
Cyprinella lutrensis	105	43	1	1	2		30	11	190	3
Hybognathus argyritis		2						1	3	
Hybognathus placitus	23	65	117	10	10	1	8	9	222	21
Macrhybopsis aestivalis		1	3	4	3	1	1	2	7	8
Notropis atherinoides			1				4	2	7	
Notropis blennius	39	37	16	19	8	2	23	22	137	29
Notropis dorsalis		12			4		4	1	17	4
Notropis stramineus	24	63	40	19	16	5	19	17	163	40
Carpiodes carpio	1	10	1	2	1		1	1	14	3
Carpiodes cyrinus		7	3	3	2	1		2	12	6
Ictalurus punctatus		1	3	4	2		2	1	7	6
Fundulus zebrinus		1					1		2	
Density (no. fish/m^2)	1.15	1.25	1.21	0.60	0.47	0.20	1.04	0.36	0.99	0.46

[†]Number of grids sampled at each interval are in parentheses.

Table 2 Numbers of individual fish collected in the summer (June–August of 1989 and 1990 and July of 1991) in electrofishing grids at 3-h intervals in the Platte River[†]

	Day			Night			Day			
Species	12.00 h (87)	15.00 h (87)	18.00 h (87)	21.00 h (84)	24.00 h (78)	03.00 h (74)	06.00 h (81)	09.00 h (63)	Day (405)	Night (236)
Scaphirhynchus platorynchus				1						1
Lepisosteus osseus	1	1							2	
Hiodon alosoides				1						1
Dorosoma cepedianum	2	1		2	4	2		1	4	8
Cyprinella lutrensis	34	12	23	123	106	118	145	18	232	347
Hybognathus argyritis		2	5	1			1		8	1
Hybognathus placitus	7	6	9	4	15	21	29	12	63	40
Macrhybopsis aestivalis	3		3	5	8	3	4		10	16
Macrhybopsis storeriana				2	1	4	1	1	2	7
Notropis atherinoides				1	3	3				7
Notropis blennius	18	29	29	18	49	23	45	12	133	90
Notropis dorsalis						4		1	1	4
Notropis stramineus	111	13	25	92	32	37	46	25	220	161
Pimephales promelas	1		9	1		1			10	2
Platygobio gracilis	4			1	1		3	2	9	2
Carpiodes carpio	2	2	15	1	1		3	2	24	2
Carpiodes cyprinus	11	9	8	5	5	3	4	5	97	3
Catostomus commersoni			1						1	
Moxostoma macrolepidotum					1					1
Ictalurus punctatus	15	14	14	32	28	29	11	8	62	89
Pylodictis olivaris				1	1		1		1	2
Fundulus zebrinus				1						1
Aplodinotus grunniens	9	5	1	8	13	5	9	5	29	26
Density (no. fish/m^2)	0.31	0.14	0.28	0.45	0.43	0.44	0.49	0.19	0.28	0.44

[†]Number of grids sampled at each interval are in parentheses.

spring, most minnow species are usually more abundant during the day than at night. In contrast, most of the species were captured more often at night than during the day in summer and fall. There was no significant difference between the number of species during the day and at night in the spring (Fisher's exact test, $P > 0.05$) (Table 1). More species were taken during the day than at night in spring; however, densities of catch were not different between day and night ($U = 2.0$, d.f. = 1, $P > 0.05$). In contrast, more species were taken at night than during the day in summer (Table 2). There was no significant difference between the number of species during the day and at night (Fisher's exact test, $P > 0.05$). No significant difference of catch was observed between the day and night ($U = 3.0$, d.f. = 1, $P > 0.05$). In the fall, equal numbers of species were caught during the day and at night (Table 3). Densities of fish were not different ($U = 4.0$, d.f. = 1, $P > 0.05$) between day and night. Dominant taxa, in decreasing order of abundance, were red shiner *Cyprinella lutrensis*, river shiner *Notropis blennius*, sand shiner *Notropis stramineus* and plains minnow *Hybognathus placitus* in all years and western silvery minnow *Hybognathus argyritis* was only abundant in the fall. These five species are the typical fish species in the study area and regularly make over 80% of the species present (Tables 1–3). In spring, red shiner and river shiner showed peak abundance at 12.00 h, sand shiner at 15.00 h and plains minnow at 18.00 h in the day (Fig. 2). In summer, the highest abundance was at 06.00 h (day) for red shiner and plains minnow, at 24.00 h (night) for river shiner and at 12.00 h (day) for sand shiner (Fig. 3). In fall, the dominant species showed the highest abundance at night, with red shiner, plains minnow and river shiner at 03.00 h and sand shiner at 21.00 h and western silvery minnow at 24.00 h (Fig. 4). Channel catfish *Ictalurus punctatus* was more abundant at night than during the day during three seasons (U-test, $P < 0.05$), but no major changes of abundance in spring (U-test, $P > 0.05$) (Tables 1–3). No gizzard shad *Dorosoma cepedianum* was

Table 3 Numbers of individual fish collected in the fall (September and October of 1987 and 1990 and October and November of 1988 and 1989) in electrofishing grids at 3-h intervals in the Platte River†

	Day			Night				Day		
Species	12.00 h (47)	15.00 h (67)	18.00 h (57)	21.00 h (74)	24.00 h (58)	03.00 h (76)	06.00 h (63)	09.00 h (66)	Day (237)	Night (271)
Lepisosteus osseus								1	1	
Dorosoma cepedianum						4				4
Cyprinella lutrensis	42	44	43	107	17	116	64	64	193	304
Hybognathus argyritis	73	37	33	95	171	152	69	24	167	487
Hybognathus placitus	14	12	5	38	14	248	31	5	36	331
Macrhybopsis aestivalis	1	3	10	12	9	6	7	2	16	34
Macrhybopsis storeriana				3	3		3	1	1	9
Notropis atherinoides	1	2		1	3	4	4	1	4	12
Notropis blennius	44	54	46	185	63	205	104	65	209	557
Notropis dorsalis			2	2	2	4			2	8
Notropis stramineus	28	33	36	116	23	96	37	41	138	272
Pimephales promelas								1	1	
Platygobio gracilis		1	1	16	3	97	6		2	122
Carpiodes carpio	8			3	1	4	5	2	10	13
Catostomus commersoni			2	1		2	5	1	3	8
Ictalurus punctatus	3	9	6	14	5	15	3		18	37
Fundulus zebrinus		2	1		1			1	4	1
Stizostedion canadense						1				1
Aplodinotus grunniens			1	1	1	9		2	3	11
Density (no. fish/m^2)	0.57	0.37	0.41	1.39	0.73	1.60	0.67	0.41	0.43	1.14

†Number of grids sampled at each interval are in parentheses.

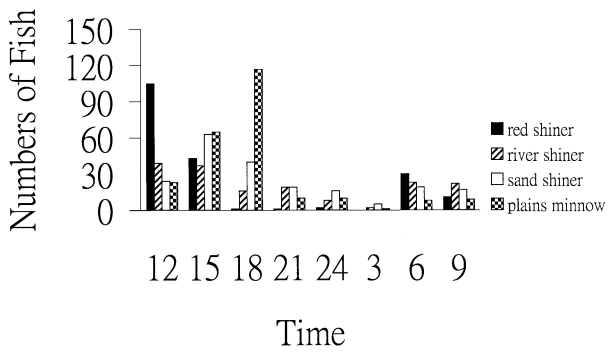

Fig. 2 Numbers of the dominant species collected in the spring (March of 1989 and March and May of 1990) at 3-h intervals in the Platte River.

caught in the spring and three river carpsucker *Carpiodes carpio* were collected in spring during the night (Table 1). Gizzard shad showed strong night abundance in summer and fall. River carpsucker are more abundant in the day in spring and summer and almost equal numbers of fish were caught by grids in the fall. Only one shovelnose sturgeon *Scaphirhynchus platorynchus*, one goldeye *Hiodon alosoides*, and one shorthead redhorse *Moxostoma macrolepidotum* were collected in summer during the night and one white sucker *Catostomus commersoni* was collected during the day (Table 2). One sauger *Stizostedion canadense* was caught in the fall at night (Table 3).

Diel and seasonal variation

Comparisons of the total densities of fish showed differences ($H = 16.56$, d.f. = 2, $P < 0.001$) among spring (0.86/m^2), summer (0.34/m^2) and fall (0.81/m^2) (Tables 1–3). All major taxa (red shiner, sand shiner, plains minnow) were more abundant (*H*-test, $P < 0.05$) in spring, except river shiner and western silvery minnow, which were more abundant in fall.

Because of the low frequency of capture (Table 1), statistical tests were not performed for spring collections. Distinct trends in diel abundance of some dominant species were present in summer (Table 2). Abundance of red shiner was higher ($U = 3.0$ d.f. = 1, $P > 0.05$) at night than during the day. No differences (*U*-test, $P > 0.05$) in diel abundance of the dominant species were found in the fall (Table 3). However, day/night changes in total density (0.43/m^2 *vs* 1.14/m^2) were evident.

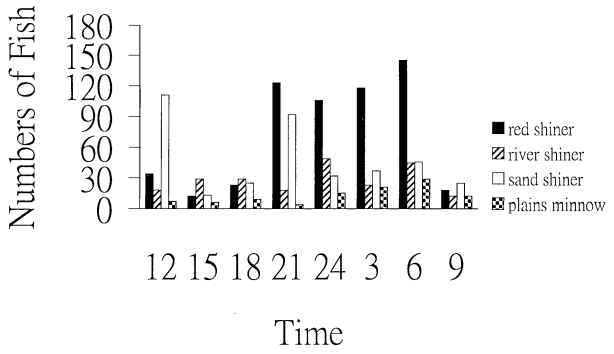

Fig. 3 Numbers of the dominant species collected in the summer (June–August of 1989 and 1990 and July of 1991) at 3-h intervals in the Platte River.

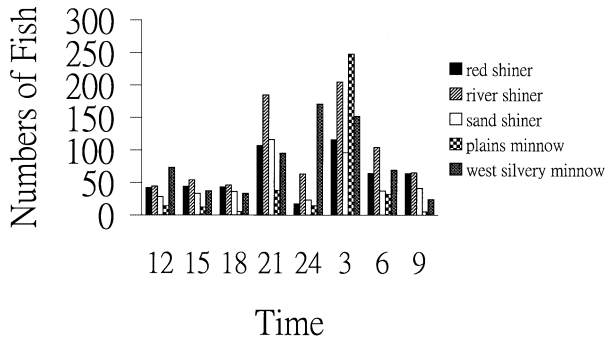

Fig. 4 Numbers of the dominant species collected in the fall (September and October of 1987 and 1990 and October and November of 1988 and 1989) at 3-h intervals in the Platte River.

DISCUSSION

The 24 fish species that were collected at North Bend during the study periods commonly occur in the Platte River.[14,15] From 1987 to 1991, red shiner, river shiner, sand shiner, plains minnow and western silvery minnow contributed approximately 85% to the total collections. Abundance of these species varied among seasons suggesting a temporal distribution. Relations between seasonal patterns of abundance and threshold temperature have been shown by Matthews *et al.*[10] The highest temperature in our study site reached 32.25°C in the summer. It is possible that catches of these species decreased in summer because some fish species reached their threshold temperatures during the day. Overall, densities of the fish species were highly variable with relatively low mean densities.

Analyses of the species caught in the study revealed a difference of diel patterns in each season. In spring, most minnow species are usually more abundant in the day than at night, which agrees with Matthews' results for three cyprinids (*Notropis atherinoides, Notropis lutrensis, Notropis venustus*) in winter at Lake Texoma.[4] In contrast, most of the species were captured more often at night than in the day in summer and fall, which disagrees with Matthews' results for the three cyprinids in mid-summer.[4] Although total numbers were small, gizzard shad showed a strong night abundance in summer and fall. This result conflicts with findings by Matthews that gizzard shad are less abundant at night than in the day.[4] River carpsucker are more abundant in the day in spring and summer, and almost equal numbers of fish were caught by grids in the fall. This also differs with Matthews' results that river carpsucker were collected during darkness. The large amount of temporal variation of fish species in the study area is expected, given the fluctuations in the physical and chemical characteristics in the Platte River.[14,15] Changes in flow conditions in many streams and rivers is thought to be the major reason to limit fish distribution because of flow fluctuations usually associated with rapidly changing available habitats such as depth, velocity, cover and substrate.[17–19] Fish distribution is influenced by water temperature, dissolved oxygen, salinity and many other factors.[20] Silt substrate and habitats with cover can usually be found in the Platte River where water is shallow and slow. In contrast, sand bottoms generally appear in parts of the river with fast currents. Water temperature at the surface ranged from 5 to 32.25°C during collections. High summer temperature may exceed tolerance levels of some species, causing fish kills in the Platte River owing to a lack of forestry canopy cover. This may contribute to the lower densities of catch in daytime in summer (Table 2).

The greater nocturnal abundance of fish in summer and fall (Tables 2,3) than in spring (Table 1) may be due to the changes in physical and chemical characteristics during the study periods. Peters *et al.* showed that sand shiners, red shiner and river shiner prefer shallow water, slow velocity and moderate temperature in the Platte River.[14] In summer and fall, lower depth, velocity and water temperature appeared at night because of environmental conditions and flow regulation for irrigation. Most of the drainage area of the Platte River is classified as agricultural land with the majority suitable for irrigation.[14] In contrast, higher depth, velocity and water temperature were found in spring during the night. Furthermore, available food resources, such as higher drift rates of invertebrates in the evening, may also contribute to the fish abundance at night in summer and fall.[21] Fish selected habitats with cover and avoided habitats without cover during the day in summer and fall. Our data showed that the most abundant predator is the channel catfish

and this species is more abundant at night than in the day during the study periods. Pflieger indicated that channel catfish are more active to feed in shallow water at night.[22] However, this pattern of abundance is not consistent with the previous results that minnows showed seasonal variations in abundance between day and night. Sand shiner and river shiner spawn from June to August and red shiner spawn from May to September with the peak in June and July.[22–25] Seasonal fluctuations in minnow abundance appear closely associated with their life-history features of recruitment.

Differences in river flow between sampling times can have a substantial effect on fish distributions and their abundance.[26] Lower mean abundance was associated with high flow regime.[14] Especially at the Platte River subbasin, which is delineated by its confluence with the Loup River near Columbus, Nebraska, mean fish abundance declined from greater than nine fish per grid in 1992 to less than one fish per grid in 1993.[15] This is similar to the study by Moyle and Baltz in a California stream where temporal variation resulted in a 7–21-fold increase in numbers and a 5–12-fold increase in biomass.[27] Flow fluctuations are usually associated with rapid changes in habitats.[17–19] Significance of seasonal difference in abundance of fish assemblages in the present study may indicate a response to changes in available habitats.

ACKNOWLEDGMENTS

The study was supported by the Nebraska Game and Parks Commission (Federal Aid in Fish Restoration, Project F-78-R) and the Agricultural Research Division of the University of Nebraska. We thank R Holland, W Stroup and several anonymous reviewers for their valuable comments and suggestions. B Chapman and many others helped with field work. The National Science Council, Taiwan, ROC (Project 90–2415-H-346–001-SSS) provided additional funding for preparation of the manuscript.

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