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Diel and Seasonal Habitat Use by Red Shiner (*Cyprinella lutrensis*)

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Shyi-Liang Yu and Edward J. Peters (2002) Diel and seasonal habitat use by red shiner (*Cyprinella lutrensis*). *Zoological Studies* **41**(3): 229-235. Fish distribution and microhabitat use were quantified over a 24-h period 15 times from July 1988 to October 1990 at a site in the lower Platte River, Nebraska. The objectives of this study were to determine the effects of availability on habitat use by the red shiner (*Cyprinella lutrensis*) and to describe variations in red shiner use of depth, velocity, cover, and substrate by seasonal and diel periods. Day-night collections showed a difference in selection or avoidance of depths and substrates in summer. Red shiners selected depths of less than 30 cm during the night and fine substrate during the day in summer, and avoided depths from 30 to 60 cm during the night and coarse substrate during the day in summer. Red shiners consistently selected slow water (< 30 cm/s) and avoided fast currents (> 60 cm/s) during both day and night times in summer and fall. Results suggest that current velocity is a major factor affecting distributions of red shiner in the lower Platte River. http://www.sinica.edu.tw/zool/zoolstud/41.3/229.pdf

Key words: Microhabitat use, *Cyprinella lutrensis*, Current speed.

Changes in flow conditions in many streams and rivers are thought to be a major limitation to fish distribution (Bovee 1982 1986, Schlosser 1985, Nelson 1986, Wesche et al. 1987, Heggenes 1988), because flow fluctuations are usually associated with rapidly changing available depth, velocity, cover, and substrate in habitats. Available habitats fluctuate over diel and seasonal periods, which also can influence fish distribution and abundance (Neu et al. 1974, Campbell and Neuner 1985, Bovee 1986, Nelson 1986, Shuler et al. 1994). Peters et al. (1989) developed habitat suitability criteria for red shiner (*Cyprinella lutrensis*) and other fishes in the lower Platte River (Nebraska, USA) and noted that diel and seasonal changes of availability influence fish distribution. Many studies have shown differences in catches of species over 24-h periods or seasonal fluctuations in abundances (Hobson 1965, Mendelson 1975, Craig 1977, Kelso 1978, Helfman 1981a, Hubbs 1984, Matthews 1986a, Adams et al. 1988).

Matthews (1986a) suggested that knowledge of optimum collecting hours is essential for fishery studies as well as for seasonal comparisons. Despite the importance of diel and seasonal changes of habitat availability on fish distribution, few researchers have included these kinds of comparisons in their studies, or else have emphasized only game species such as trout (Campbell and Neuner 1985, Harris et al. 1992, Shuler et al. 1993).

The red shiner is one of the most abundant and widely distributed species in mid-western prairie streams of the US (Cross 1967, Pflieger 1975, Lee et al. 1980, Maret and Peters 1980). Matthews (1986b 1987) and Matthews and Hill (1979a 1979b) summarized its distribution, habitat use, and thermal tolerance. In this study, we examined changes in habitat availability for and use by red shiner across seasonal and diel periods. Our objectives were to (1) determine the effects of availability on habitat use by red shiner, and (2) describe variations in red shiner occurrence with respect to depth, velocity, cover, and substrate by seasonal and diel periods.

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MATERIALS AND METHODS

The study was conducted at North Bend (Dodge Co.) on the lower Platte River, Nebraska. The Platte River in eastern Nebraska is wide, braided, and shallow with sand and gravel substrates. Water at the study site was as deep as 105 cm, and current velocity ranged from 0 to 100 cm/s (Peters et al. 1989, Peters and Holland 1994). Surface water temperature ranged from 5 to 32.25 °C. Fish and habitat data were collected at North Bend on 15 occasions in July, October, and November 1988; June, July, August, October, and November 1989; and March, May, June, July, August, September, and October 1990. Sampling began at 1200 and continued every 3 h for a 24-h period. Samples correspond to seasonal phases: spring (March-May), summer (June-August), and fall (September-November).

Fish were collected using 2 x 4-m electrofishing grids (Bain et al. 1985, Peters et al. 1989). We measured depth, current velocity, cover, and substrate at the middle of each grid immediately after shocking because turbidity precluded observation of individual fish positions. To organize the measuring procedure at each site, we set up a 100-m transect perpendicular to the bank. The position for the 1st grid on the transect was randomly chosen in the first 10-m from 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-V, AC generator for 30 s. Fish were collected in a 6.35-mm (1/4") mesh bag-seine held downstream of the grid. Fish from each grid were identified and enumerated in the laboratory. A graduated wading rod equipped with a pygmy current meter was used to measure water depth (cm) and mean water column velocity (cm/s) at 0.6 of the depth. Cover types were determined visually and coded as none, instream, outstream, and combined cover. Substrate types were silt, sand, and gravel. We further reduced cover and substrate to 2 categories because some habitat types were not available in the data: cover (with cover, without cover), substrate (fine substrate, coarse substrate).

Log-linear tests of independence were performed among habitat use, seasonal, and diel periods. The SAS (SAS 1985) PROC CATMOD was used for computations. Chi-square goodness-of-fit analyses were used to test null hypotheses that habitat use was in proportion to availability (Neu et al. 1974, Miller 1981, Byers et al. 1984). If a significant difference was found between utilization and availability, then 95% Bonferroni confidence intervals were computed to determine which specific habitat types were used more or less frequently than expected use. To calculate confidence intervals, we used the formula:

$$Pi - Z(\alpha/2k)[Pi(1 - Pi)/n]^{0.5} \leqq Pi \leqq Pi + Z(\alpha/2k)[Pi(1 - Pi)/n]^{0.5}$$ (Neu et al. 1974)

where

Pi = actual proportion use of the ith specific category,

Z(α/2k) = the table value corresponding to a probability tail area of α /2k,

α = 0.05 in our calculations,

k = the number of categories, and

n = total use.

Habitat selection (+) was used to indicate that habitat use was proportionally greater than availability. Habitat avoidance (-) was used to indicate that habitat use was proportionally less than availability (Neu et al. 1974).

RESULTS

Log-linear tests of depth use by red shiners indicated differences by diel (χ^2 = 4.96, p < 0.05) periods, but not with season (χ^2 = 2.81, p > 0.05). Depth use by red shiners showed no selection or avoidance in spring because Bonferroni procedures require count data to be greater than 0 in more than 1 habitat type (Byers et al. 1984). Deep water (> 60 cm) was not available in spring, presumably due to high flows in spring or low sampling efforts because only 1 set of samples was collected each in March and May. Red shiners selected shallow water (< 30 cm) and avoided depths of from 30 to 60 cm during the night in summer (Fig. 1). In summer, red shiners were more frequently in shallow water at night than in the day, and were less frequently at depths of from 30 to 60 cm at night than in the day.

Velocity in habitats used by red shiners was independent of seasonal (χ^2 = 2.12, p = 0.55) or diel (χ^2 = 2.13, p = 0.34) periods, but different patterns of velocity use occurred in summer and fall. Velocity in habitats used by red shiners was proportional to availability in spring (Fig. 2). Red shiners selected slow water (< 30 cm/s) and avoided fast water (> 60 cm/s) during both day and night in summer and fall (Fig. 2). Additionally, red shiners avoided moderate water speeds (30-60 cm/s) during the day in fall. We did not perform Bonferroni tests for night times in spring because only 1 habitat type appeared in the data.

Cover use by red shiners was independent of seasonal (χ^2 = 3.60, p = 0.16) and diel (χ^2 = 1.02, p = 0.31) periods, but cover use differed in fall. Cover use by red shiners showed no selection or avoidance during either day or night times in spring and summer except 0 counts for night times in summer precluded any Bonferroni tests (Fig. 3). Red shiners selected habitats with cover and avoided habitats without cover during both day and night in fall.

Substrate use by red shiners was independent of seasonal (χ^2 = 2.25, p = 0.32) and diel (χ^2 = 1.51, p = 0.22) periods. Substrate use by red shiners was proportional to availability in spring and fall (Fig. 4). Red shiners selected fine silt and avoided coarse substrate during the day in summer. Bonferroni tests showed no selection or avoidance in day times in spring because only 1 habitat type appeared in the data.

DISCUSSION

Habitat selection tests which account for availability showed that red shiners selected

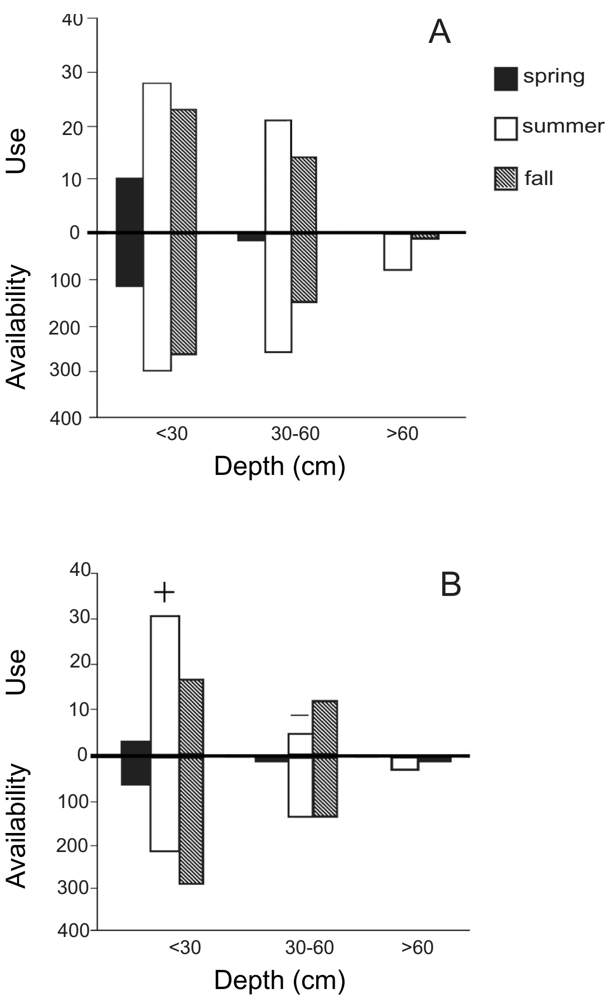

Fig. 1. Depth availability and use by red shiners during day (A) and night (B) times in spring (March-May), summer (June-August), and fall (September-November) of 1988-1990 at 3-h intervals in the Platte River, NE, collected from pre-positioned electrofishing grids. Night time periods began from 2100 to 0300 in spring and summer, but extended to 0600 in fall. Day or night differences between habitat availability and use are indicated by + (habitat selection) or - (habitat avoidance).

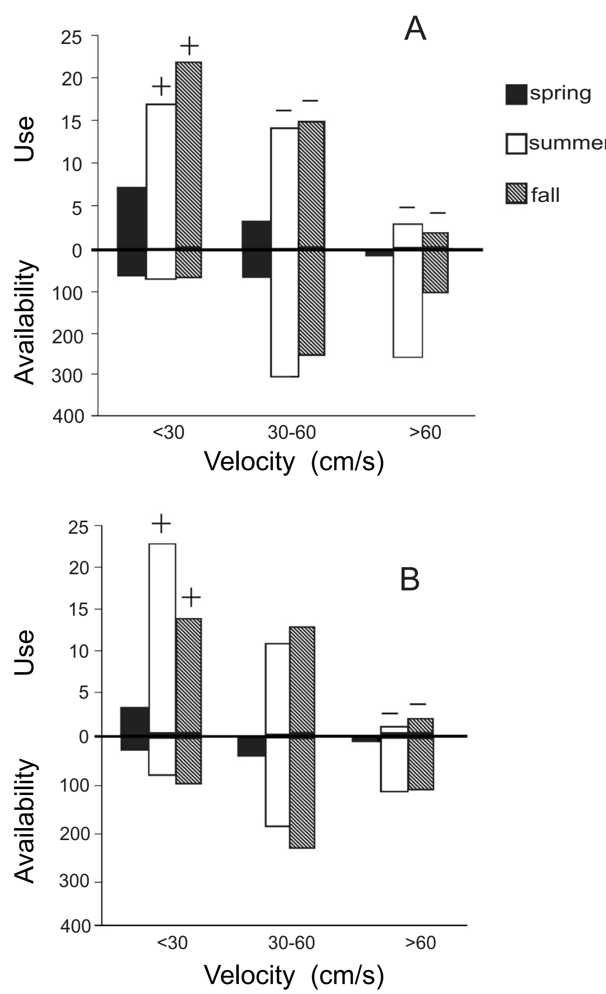

Fig. 2. Velocity availability and use by red shiners during day (A) and night (B) times in spring (March-May), summer (June-August), and fall (September-November) of 1988-1990 at 3-h intervals in the Platte River, NE, collected from pre-positioned electrofishing grids. Night time periods began from 2100 to 0300 in spring and summer, but extended to 0600 in fall. Day or night differences between habitat availability and use are indicated by + (habitat selection) or - (habitat avoidance).

depths of less than 30 cm, velocities of less than 30 cm/s, and silt substrate with cover seasonally and diurnally (Figs. 1-4). Increased use of shallow water (< 30 cm), slow velocities (< 30 cm/s), and silt substrate in summer suggests the importance of these habitats for red shiners in summer relative to other seasons. Although we did not examine food habits or temperature tolerance of red shiners, we speculate that red shiners use these habitats in summer because of their forage values or to avoid high temperatures. Peters et al. (1989) found that maximum water temperatures of 32 °C were recorded during 1986 and 1987 in the Platte River. Because the number of potential prey in the drift decline seasonally, especially through the summer, fish need to increase their activity in these habitats to exploit decreasing levels of prey in the drift (Griffith 1974, Gibson and Galbraith 1975, Allan 1981).

Red shiners are important forage fish for larger fish species and avian predators in the Platte River because of their abundance and size (Peters et al. 1989). Despite its ecological importance, little is known about the nocturnal activity of red shiner among different seasons. Most nocturnal studies have either emphasized 24-h studies in a

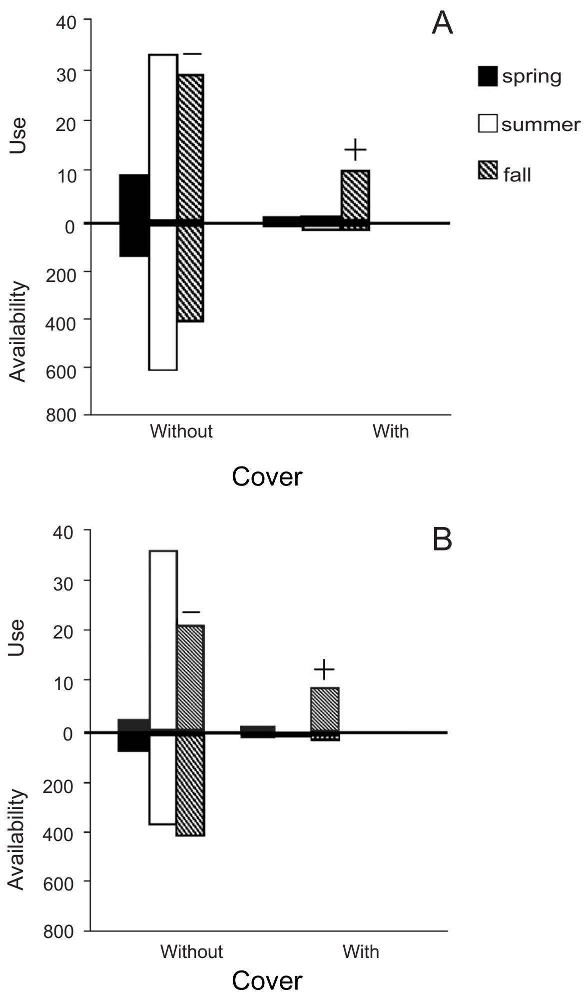

Fig. 3. Cover availability and use by red shiners during day (A) and night (B) times in spring (March-May), summer (June-August), and fall (September-November) of 1988-1990 at 3-h intervals in the Platte River, NE, collected from pre-positioned electrofishing grids. Night time periods began from 2100 to 0300 in spring and summer, but extended to 0600 in fall. Day or night differences between habitat availability and use are indicated by + (habitat selection) or - (habitat avoidance).

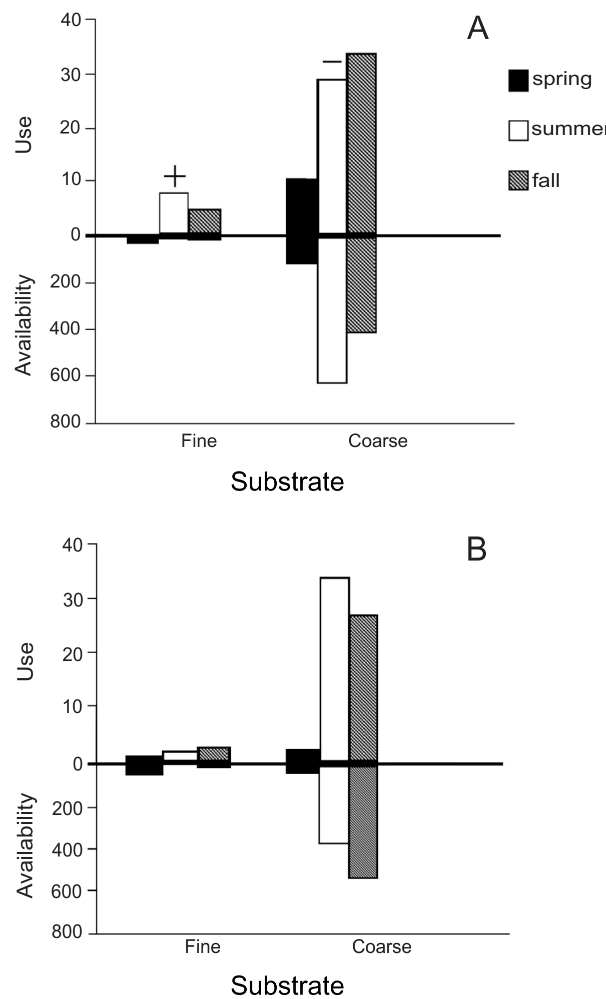

Fig. 4. Substrate availability and use by red shiners during day (A) and night (B) times in spring (March-May), summer (June-August), and fall (September-November) of 1988-1990 at 3-h intervals in the Platte River, NE, collected from pre-positioned electrofishing grids. Night time periods began from 2100 to 0300 in spring and summer, but extended to 0600 in fall. Day or night differences between habitat availability and use are indicated by + (habitat selection) or - (habitat avoidance).

single season (Hubbs 1984, Matthews 1986) or game species such as salmonids (Campbell and Neuner 1985, Hillman et al. 1988, Harris et al. 1992, Shuler et al. 1994). Day-night collections showed a difference in selection or avoidance of depths (Fig. 1) and substrate (Fig. 4) in summer. Red shiners selected depths of less than 30 cm during the night and fine substrate during the day in summer, and avoided depths of 30 to 60 cm during the night and coarse substrate during the day in summer.

Water depth, velocity, cover, and substrate are important factors affecting habitat choice by fish (Schuck 1943, Lewis 1969, Bovee 1982, Shirvell and Dungey 1983, Morantz et al. 1987, Wesche et al. 1987, Heggenes 1988, Shuler et al. 1994). Red shiners avoided velocities above 60 cm/s during the day in summer and fall, habitats without cover during the day in fall, and coarse substrate during the day in summer. Our results show that red shiners avoided fast currents in the Platte River in summer and fall. This is consistent with other studies of habitat use by red shiners, but Matthews and Hill (1979a) reported that they showed substantial use of deeper pools at the river's edge.

This study indicates the importance of water depth, velocity, cover, and substrate for red shiners seasonally and diurnally in their natural environments. Current velocity is a major factor affecting distributions of red shiners in the Platte River. Red shiners consistently selected slow water and avoided fast currents during both day and night in summer and fall (Fig. 2). Matthews (1985) and Matthews and Hill (1979a) considered red shiner a habitat generalist that avoided swift, turbulent flow. This is generally consistent with our analyses of velocity that red shiners avoid fast currents of greater than 60 cm/s, except in collections in spring (Fig. 2). Shallow water was only selected by red shiners at night in summer, possibly due to thermal stress during day times or to avoid visual predators in the river. Matthews (1979a) stated that shallow water avoidance by red shiner was probably related to thermal instability or exposure to predators. Power (1984) showed that predators influence patterns of habitat use by fish. Red shiners selected habitats with cover, and avoided habitats without cover during both day and night times in fall. This may reflect the fact that they avoided other kinds of predators (e.g., birds) by feeding during safe periods and responded to attack by moving into refuges (Helfman 1981b, Fraser et al. 1987). Red shiners selected fine silt and avoided coarse substrate in the day in summer. 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.

The influence of availability on habitat use depends on seasonal and diel periods. Fish habitat use can change seasonally and diurnally largely depending on flow conditions in the river. Our results indicate that depth, velocity, cover, and substrate are important factors for habitat use by red shiners in fluctuating environments such as the Platte River, particularly current velocity, which is a dominant factor in determining the habitat use by red shiners.

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紅銀小魚四季及日夜棲地使用的差異

于錫亮[1]　Edward J. Peters[2]

本研究從1988年七月至1990年十月利用24小時實驗在內布拉斯加州布萊德河下游一處採樣點，採樣15次，調查魚類在河川中的分布及其微棲地的利用，本實驗的目的在於決定河川中可利用的棲地，是否會對紅銀小魚於四季及日夜上利用水深、流速、遮蔽、底質造成差異，結果發現紅銀小魚夏季在水深和底質顯示出日夜選擇或躲避的差異，紅銀小魚在夏季夜晚選擇棲地水深< 30 cm躲避棲地水深30-60 cm的區域，在夏季白天選擇棲地底質為細石躲避棲地底質為粗石的區域，紅銀小魚在夏、秋兩季不分日夜均會選擇棲地為緩水的區域(< 30 cm/s)，躲避棲地為急水的區域(> 60 cm/s)，此項研究結果建議流速是影響紅銀小魚在布萊德河下游分布最重要的因子。

關鍵詞：微棲地使用，魚類分布，流速。

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