Martinson, R.J., J.B. Sandberg, & B.C. Kondratieff. 2012. Life history and food habits of *Isoperla quinquepunctata* (Banks) (Plecoptera: Perlodidae) from a spring source and Willow Creek in the Piceance Basin, Colorado.
Illiesia, 8(12):125-133. Available online: http://www2.pms-lj.si/illiesia/papers/Illiesia08-12.pdf

LIFE HISTORY AND FOOD HABITS OF *ISOPERLA QUINQUEPUNCTATA* (BANKS) (PLECOPTERA: PERLODIDAE) FROM A SPRING SOURCE AND WILLOW CREEK IN THE PICEANCE BASIN, COLORADO

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ABSTRACT

Life history aspects of the perlodine stonefly *Isoperla quinquepunctata* (Banks) are reported from the Piceance Basin, Colorado. We wished to discover if the conditions of a spring source would affect the life cycle and relative food habits of *I. quinquepunctata* as compared to nearby Willow Creek, a typical region small stream site. It is often unusual to find stoneflies directly in a spring source in the southern Rocky Mountains, which had dissolved oxygen concentrations well below 5.2 mg/l (58% saturation), but with flowing water. *Isoperla quinquepunctata* exhibited a univoltine slow life cycle with extended hatching at both sites. At the spring, while the largest *I. quinquepunctata* nymphs ingested a variety of food types, they did not switch to carnivory as has usually been reported for *Isoperla*. Diatoms comprised the majority of the gut contents of nymphs from both the spring and Willow Creek sites, with detritus a more important component at the Willow Creek site.

Keywords: Life history, *Isoperla quinquepunctata*, food habits, drift, Colorado, Piceance Basin

INTRODUCTION

The perlodine stonefly *Isoperla quinquepunctata* (Banks) is a common species of *Isoperla* of medium and larger streams throughout the western United States and in relatively unpolluted remnant streams of the northern Great Plains (Szczytko and Stewart 1979a, Sandberg 2011b). This species appears to be eurythermic and emergence occurs from early May in southern populations and early July in northern populations (Szczytko and Stewart 1979a). Szczytko and Stewart (1979b) studied the drumming behavior of *I. quinquepunctata* from three western states where it exhibited the greatest variability of the four *Isoperla* species studied. Sandberg and Stewart (2001) reported on another Colorado population with monophasic and 2-way, interspersed exchanges. The most current study by Sandberg (2011a) examined a California population with varied beat-intervals and 2-way, interspersed exchanges. He also re-examined the data from Sandberg and Stewart (2001) and re-assigned the male call type to varied beat-interval.

The life history and food habits of *I. quinquepunctata* were elucidated as part of a larger study of macroinvertebrate communities of aquatic habitats of the Piceance Basin, in western Colorado. *Isoperla quinquepunctata* was found to be a major aquatic invertebrate predator in the Piceance Basin (Gray and Ward 1979). Little is known about the life history or general ecology of this species in Colorado other than that reported by DeWalt and Stewart (1995). The purpose of this paper is to provide information on the life history of a spring source and stream populations of *I. quinquepunctata* in northwestern Colorado.

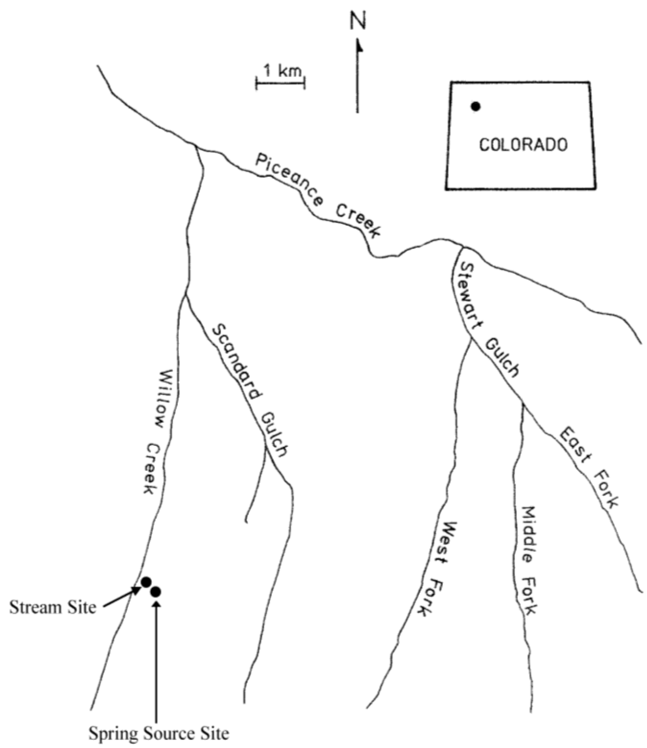

Fig. 1. Map indicating the spring source and stream sampling sites for Willow Creek in the Piceance Basin, Colorado.

Study Area

Both collection locations were in the Piceance Basin about 6.5 km upstream from Piceance Creek in the Willow Creek Valley, Rio Blanco County, in western Colorado and were separated by approximately 300 m in stream distance (Fig. 1). The Piceance Basin is characterized by hot, dry summers and cold winters often with high snow fall (Tiedeman and Terwilliger 1978). The spring source was located near the base of the eastern valley wall and flowed to an irrigation pond about 20 m downstream that usually overflowed a weir into Willow Creek, a small third order stream. The spring emerged in three areas that coalesced into one small channel about 1 m wide. Width near the spring emergence areas was approximately 5 m; depth varied from 1 to 5 cm and substrate was 2.4 to > 5.0 cm. Riparian vegetation of sagebrush (Asteraceae, *Artemisia* spp.) and various grasses was similar at both sites, but the emergent macrophyte

(Scrophulariaceae, *Veronica anagallis-aquatica* L.) became dense during the summer months at the spring source and died back from October-April. This plant was not present at the Willow Creek site. The Willow Creek stream site was approximately 1 m wide, 10 cm deep, and had a gravel-cobble substratum. The aquatic macrophyte (Zannichelliaceae, *Zannichellia* sp.) was sparse in riffle areas of Willow Creek. Table 1 presents the selected physico-chemical contrasts between the two sites. The methods for measuring the physico-chemical parameters can be found in Martinson et al. (1982).

Table 1. Selected physical-chemical data from a spring source and Willow Creek in the Piceance Basin, Colorado.

Variable	Sampling Locations	
	Spring Source	Willow Creek
Temperature range °C	6.0-9.0	6.0-19.0
pH range	7.2-7.3	7.1-8.0
Dissolved oxygen range (mg/l).	3.8-5.2	7.5-10.8

METHODS AND MATERIALS

Four replicate quantitative samples of *I. quinquepunctata* nymphs were collected every four weeks from July 22, 1978 to June 23, 1979 at the spring source and three were taken from the Willow Creek site using coring devices described by Martinson et al. (1982). Because of the four week schedule, two sets of samples were taken during April (April 1 and 28, 1979). Samples were preserved in 5% formalin and transported to the laboratory for analysis. Adults were collected with a sweep net and by turning over partially submerged rocks to note adult activity qualitatively. Head capsule widths of *I. quinquepunctata* nymphs were measured with an ocular micrometer and charted using fifty 0.06mm (0.024-3.18mm) divisions for frequency growth histograms. One hundred forty-seven nymphs were then divided into six size classes for food habits analysis: <0.36mm (N=6), 0.42-0.66mm (N=37), 0.72-0.96mm (N=40), 1.02-1.44mm (N=26), 1.50-1.98mm (N=27), and > 2.04mm (N=11). Food habits analysis followed techniques outlined by Gray and Ward (1979).

Dry weights were determined after drying to constant weight at 60°C. The weight of each *I. quinquepunctata* nymph could then be estimated from a regression equation relating head capsule width to dry weight ($y = 0.0007x^{3.48}$, $R^2 = 0.82$, N = 83) where x equals head capsule width and y equals dry weight.

RESULTS AND DISCUSSION

The abundance and biomass trends of *I. quinquepunctata* at the spring and Willow Creek sampling stations are presented in Figs. 2 and 3. The spring source abundance and biomass values differed from the Willow Creek and were low throughout fall and winter, and then increased during the spring months (Figs. 2, 3). The rapid vernal increase in abundance and biomass apparently was not due to recruitment (Figs. 2-5) as the individuals collected were large. Rather, it may be possible that small nymphs drifted or moved out of the immediate spring source during fall and winter and may have migrated upstream during the springtime. The nymphs, however, could only drift about 20m downstream due to an irrigation reservoir that blocked further movement to and from Willow Creek. Drift and upstream movement of immature aquatic insects, in streams including Plecoptera, has been documented (Neave 1930; Clifford 1978; Butler and Hobbs 1982, Stewart and Szczytko 1983, Bergey and Ward 1989). The drift and subsequent upstream movement phenomenon of the spring source was not detected in Willow Creek where nymphs were likely

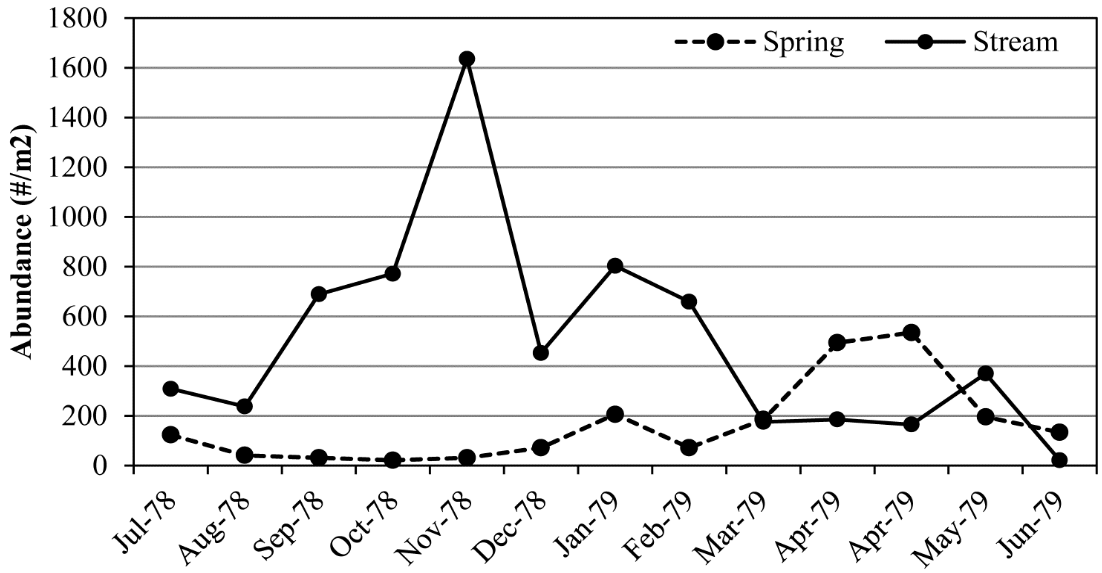

Fig. 2. Monthly abundance (no. larvae/m^2) from a spring source and Willow Creek in the Piceance Basin, Colorado.

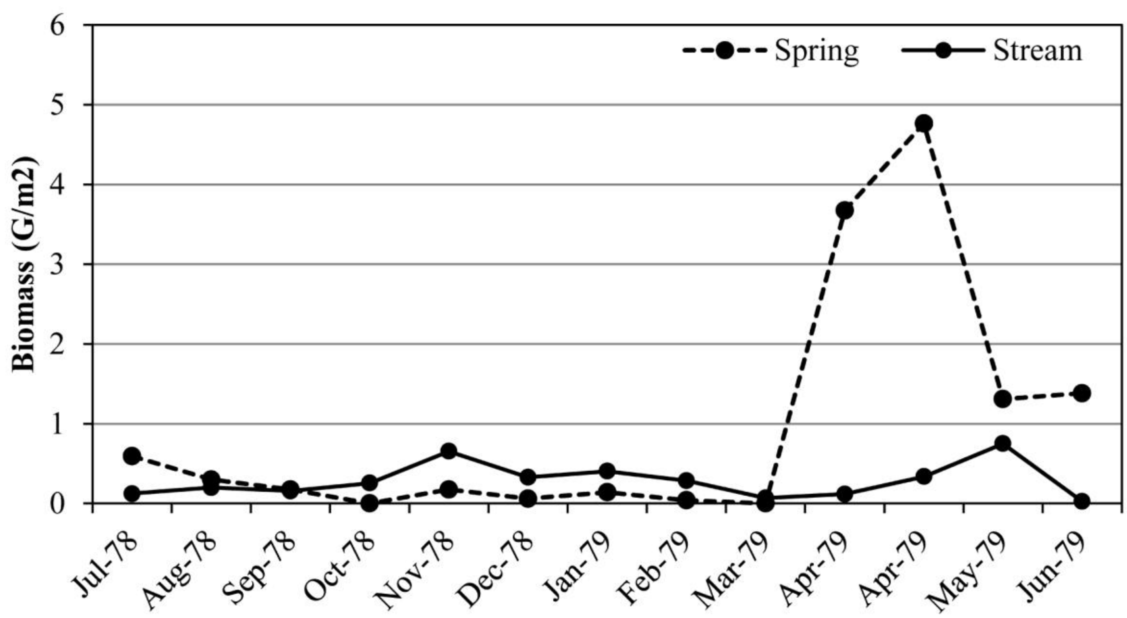

Fig. 3. Mean monthly biomass (g/m^2 dry weight) from a spring source and Willow Creek in the Piceance Basin, Colorado.

to have been replenished from upsteam and/or downstream areas.

Stewart and Stark (2002) noted a consistent pattern of univoltinism for the genus *Isoperla* and most subsequent studies seem to confirm this pattern. DeWalt and Stewart (1995) found that at a southern Colorado stream, *I. quinquepunctata* had a univoltine-fast growth pattern with recruitment in

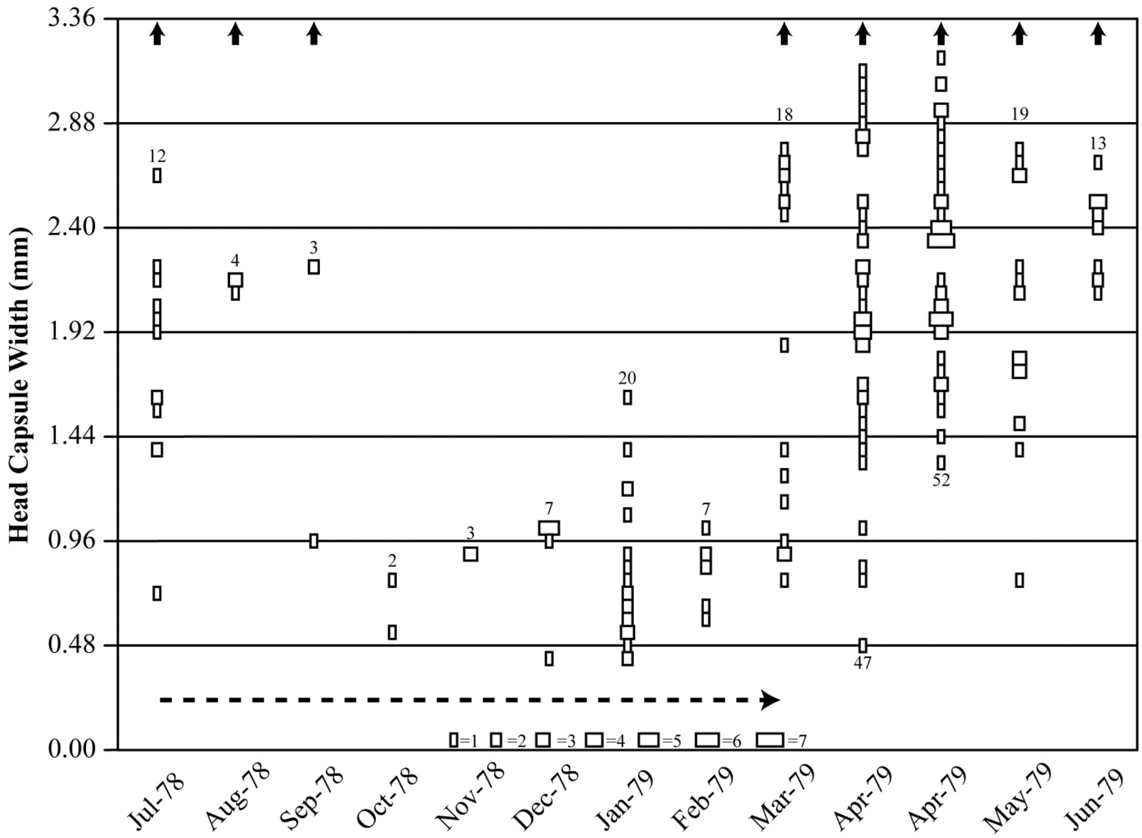

Fig. 4. Larval growth, adult presence, and possible extended egg hatching for the spring source near Willow Creek in the Piceance Basin, Colorado. Short vertical arrows indicate when adults were collected. Horizontal dashed arrow indicates suspected egg hatching. Larval sample size indicated by number above or below the monthly size-frequency histogram.

January-February and emergence in mid-June through July. Other congeners such as *I. fulva* Claassen from the same stream had a univoltine-slow growth pattern (DeWalt and Stewart 1995). In this study, the size class distribution of nymphs and the months when adults were present indicated an extended adult emergence from March-July continuing into September (Figs. 4, 5). Adult emergence at the spring source generally occurred one to two months behind the populations in Willow Creek (Figs. 4, 5).

Mature nymphs and adults of *I. quinquepunctata* in our study were collected from March to September at both sampling locations. They were always found on the underside of partly submerged rocks or clinging to the base of aquatic or riparian vegetation. Mating and egg laying were not observed. Dissected selected females contained approximately 25-35 nearly elliptical gold colored eggs, as described by Szczytko and Stewart (1979a).

There is substantial evidence that nymphs of *Isoperla* are carnivorous, especially in larger size classes (Percival and Whitehead 1929; Frison 1935; Jones 1950; Mackereth 1957; Malmqvuist et al. 1991; Minshall 1965; Minshall and Minshall 1966; Richardson and Gaufin 1971; Fahy 1972; Shapas and Hilsenhoff 1976; Fuller and Stewart 1977, 1979; Gray and Ward 1979; Feminella and Stewart 1986;). Jop and Szczytko (1984) found a switch to omnivory by later instars of *I. signata* (Banks). Reports of mainly algae and detritus consumption by larger size classes of *Isoperla* seem to be the exception (Jones 1950;

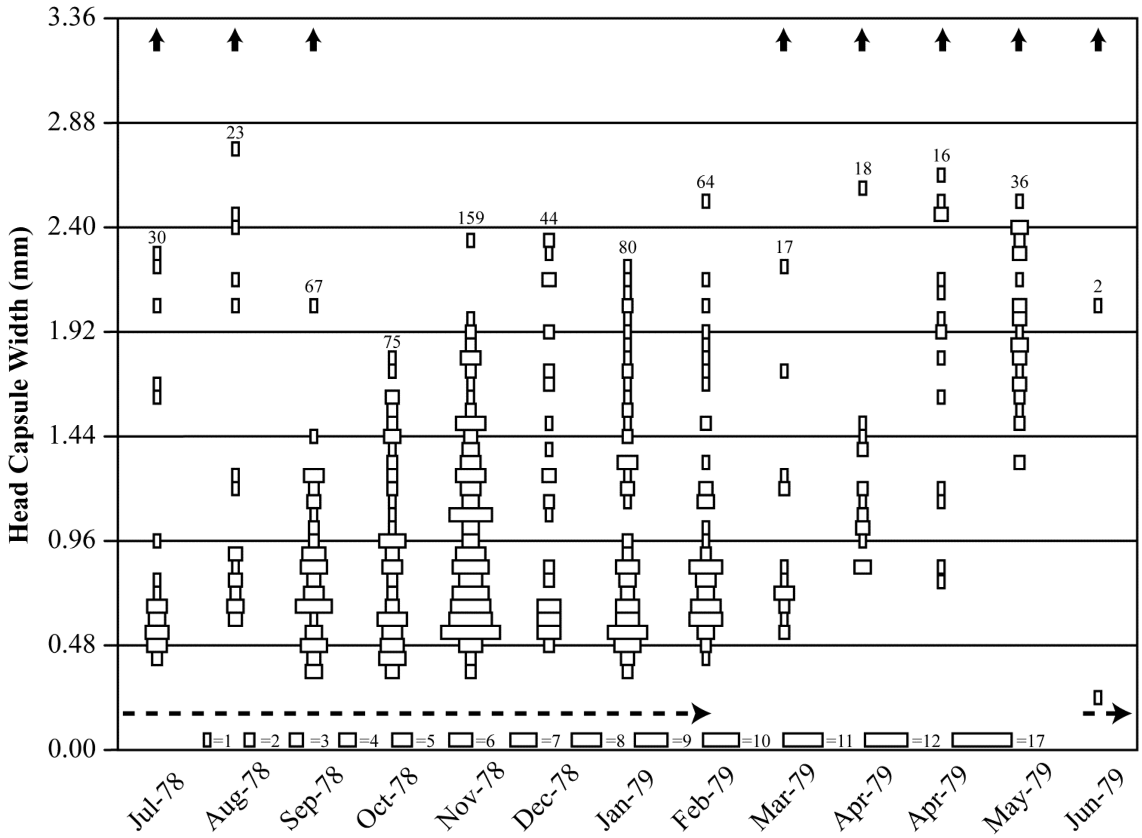

Fig. 5. Larval growth, adult presence, and possible extended egg hatching for Willow Creek in the Piceance Basin, Colorado. Short vertical arrows indicate when adults were collected. Horizontal dashed arrow indicates suspected egg hatching. Larval sample size indicated by number above the monthly size-frequency histogram.

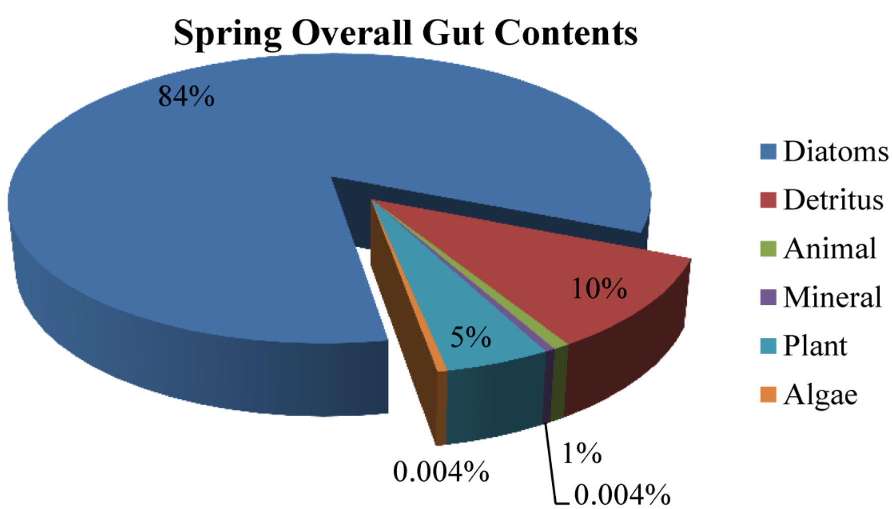

Fig. 6. Total mean percent composition of gut contents from *I. quinquepunctata* from the spring source in the Piceance Basin, Colorado.

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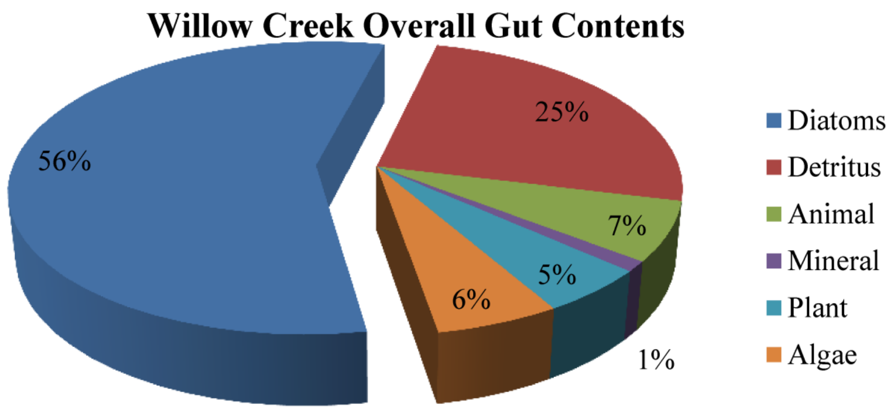

Fig. 7. Total mean percent composition of gut contents from *I. quinquepunctata* from Willow Creek in the Piceance Basin, Colorado.

Table 2. Mean percentage composition of gut contents from *I. quinquepunctata* from a spring source and Willow Creek in the Piceance Basin, Colorado.

Spring Source	Food Type						
Size Class	Sample Size	a	b	c	d	e	f
1 (< 0.36mm)	3	89	2	0	0	9	0
2 (0.42-0.66 mm)	9	91.6	6	0	<1	2.6	0
3 (0.72-0.96 mm)	9	92	6.8	0	1	0	0
4 (1.02-1.44 mm)	9	89	9	.7	1.3	0	0
5 (1.50-1.98 mm)	15	85.4	11.4	.8	<1	2.3	0
6 (> 2.04 mm)	5	56.1	25	2.8	<1	13	2.6
Willow Creek	Food Type						
Size Class	Sample Size	a	b	c	d	e	f
1 (< 0.36mm)	3	82	18	0	0	0	0
2 (0.42-0.66 mm)	28	45	30.5	0.8	3.3	14	5.8
3 (0.72-0.96 mm)	31	69	14	4	1	6	6
4 (1.02-1.44 mm)	17	46.1	32.7	14	.8	4.1	2.3
5 (1.50-1.98 mm)	12	63.9	9.1	5.6	.7	1.2	19.6
6 (> 2.04 mm)	6	32.5	46	15	1	5	0.5

a=diatoms; b=detritus; c=animal; d=mineral; e=plant; f=filamentous algae

Shapas and Hilsenhoff 1976; Randrianandrasana 2007). Lancaster et al. (2005) reported that *I. grammatica* (Poda) were carnivorous but shifted toward algivory in later stages. Gut contents examined from the present study (Table 2, Figs. 6 and 7) show a tendency for the largest *I. quinquepunctata* nymphs to consume a variety of food types, but they did not switch to carnivory as was reported by Gray and Ward (1979). Cummins (1973) noted that trophic differences between populations of the same species from different locations can occur. Overall from both sites, diatoms and then detritus were usually the dominant food items found in the guts (Figs. 6 and 7) with a reduction in diatoms and an increase in detritus for the larger nymphs (Table 2). Chironomid midges comprised the only animal material found in the guts. The chironomids appear to be consumed incidentally as they were fairly abundant in the spring source and in Willow Creek (Martinson et al. 1982). Randrianandrasana (2007) cautions that some soft-bodied animals, particularly oligochaetes, could already be digested and thus skew the results of gut analyses. In the current study, oligochaetes were fairly abundant in the spring source, but they were uncommon at the Willow Creek location. At the spring source, except for the largest size class, diatoms always comprised over 80 percent of the gut contents (Table 2). Although diatoms were still an important diet component in Willow Creek, detritus in the guts was much more prevalent. Although detritus did not appear to be more available in Willow Creek, it may have been conditioned with fungi and bacteria or converted to feces not available at the spring source since there was no upstream source for the detritus at the spring source and thus the detritus in Willow Creek may have been of higher quality (Cummins and Klug 1979).

Conclusions

Although the life cycle of *I. quinquepunctata* in the spring source and Willow Creek is considered slow univoltine; adult emergence at the spring source generally occurred one to two months behind the population in Willow Creek. The lower range of water temperatures at the spring source (Table 1) and perhaps less animal matter along with less available detritus in the diet may have slowed development of the spring source population.

ACKNOWLEDGEMENTS

Thanks must go to Dr. James V. Ward who fostered study design and gave advice on methods under which the work was initially conducted. Also thanks to Bruce H. Baird who helped to reinvigorate activity on the manuscript after an extended quiescent period.

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Received 23 May 2012, Accepted 12 July 2011, Published 13 August 2012