FEEDING SELECTIVITY IN STREAM INSECTS AND ITS EFFECT ON THE COMMUNITY OF A RIFFLE AREA

Kathleen McTigue
UNDERC Research Project
December 5, 1988

Hellenthal

ABSTRACT

Comparison of the available food of the environment with that ingested by the insects *Serratella* sp. (Ephemerellidae), *Perlesta placida* (Perlidae) and *Chimarra obscura* (Philopotamidae) over a seven week sampling period, through identification of the insects and algae of the habitat, and gut analyses, suggests that these three insects do follow the feeding regime predicted from their body structures. The insects did show some selectivity in their food. The preferred food choices differed over the summer as varying amounts of algae and insects inhabited the riffle area. Apparently, grazing had an important regulatory effect on the algal population, as seen by chlorophyll levels determined by fluorimetry.

In addition to abundance and quality of food, the grazer comunity was probably regulated by abiotic factors such as light, temperature, and current. However, biotic factors such as predation and competition seemed to be the major factor influencing insects. Fluctuating biomass and species composition of insects both appeared to be directly related to the population of the dominant predator in the habitat.

INTRODUCTION

The feeding method, choice of food, and abundance of resources in a stream can have a major effect on the growth and survival of the insects in that environment. Stream insects are traditionally divided into feeding groups according to their structural differences (Cummins 1973, Cummins and Klug 1979). These groups include shredders, filter feeders, scrapers, and deposit-collectors. Shredders, with characteristic small cutting jaws, are expected to break down terrestrial leaves into fine detritus. The filter feeders spin nets or use bodily filtering apparatus to strain fine organic matter from the water. Scrapers are grouped together because of the elaborate structures they possess to scrape algae and detritus from solid surfaces. Deposit-collectors generally have reduced mouthparts, and are expected to feed on the algae and fine organic matter of the sediments. Organisms from all of these feeding categories were abundant in the riffle area sampled.

Because these classifications are based on structural, not behavioral characteristics, the actual feeding categories may not be so distinct. This study examined whether insects within a category would choose to eat a wide variety of foods, thereby using food sources typically assigned to another functional feeding group. An insect may feed as a generalist; eating whatever is available (Vaughn 1986). Conversely, insects may be selective in choosing their food. (Calow 1973). In addition, as the insects develop and the food sources vary, patterns of feeding may change.

Epilithic algae are a major food source for herbivorous insects in streams. The overall abundance, as well as the species composition, of the periphyton, can have an impoprtant impact on the stream insects. Both of these factors fluctuate with the normal algal lifecycles and the effects of grazing on the algal community. Some studies suggest that certain algal species are preferred food sources because of their high nutrition content (Moore 1975); others state that selected algae may just be those kinds that are easy to feed upon (Calow 1973, Moore 1975). Finally, some algae are reported to secrete toxins to avoid herbivore grazing (Hutchinson 1981). Even within a designated functional feeding routine, several of these factors may be involved in determining the food choice of grazers. In addition, grazing could effect algal populations; possibly decreasing or stimulating productivity (Lamberti et al 1987, Hill and Knight 1987, Gregory 1980). I attempted to see how the algal populations in the creek changed with changing insect species.

Grazing is not the only biotic factor regulating food supply and feeding processes in a stream. By expoiting grazing insects as a food source, carnivorous insects can have a big impact on the abundance and size of the grazers. As different insects develop, immigrate to and emmigrate from the system, they interact not only with their own food sources, but also with the organisms which prey on them. In this study, fluctuations in the numbers and kinds of predacious insects, along with the changing weights of all the stream insects sampled, showed predation to be a major consideration. In addition, competition between predators was seen to be a major regulating factor in this environment.

MATERIALS AND METHODS

Preliminary Sampling

Before begining this study, I used a dip net and examined overturned rocks to make a preliminary sample of the insects within the riffle area of Tenderfoot Creek on the Notre Dame Properties in the Michigan upper peninsula near Land O' Lakes, Wisconsin. The water of the sampling site ranged from 4-6 inches deep, and moved faster than the rest of the stream, but not quickly enough for any white water. From the insects present, I picked three key ones to study; one from each of three functional feeding groups: *Perlesta placida* (Plecoptera: Perlidae); *Serratella* sp. (Ephemeroptera: Ephemerellidae); and *Chimarra obscura* (Trichoptera: Philopotamidae). These insects were identified using keys in Merrit and Cummings (1984), and Hilsenhoff(1981). Merrit and Cummings classify the stonefly as a predator, the mayfly as a gatherer/scraper, and the caddisfly as a filterer in terms of functional feeding groups.

Sampling

Each week, three replicate samples of insects were collected using a Surber sampler. Each one square foot sample site was chosen randomly by tossing a small rock over my shoulder. To sample, the Surber was positioned on the bottom, with the current runnning into the net. Any rocks overlapping on the back and left hand side of the sample were included in the sample, while those overlapping on the right side or front were removed. Macrophytes within the sample site were gently uprooted and any insects on them collected. The plants were then discarded outside the net to avoid a tangle of roots and stems in the sample. Next, each large rock within the sample was picked up. Any mayflies on it were removed with forceps to prevent damage to their gills, and preserved in 70% alcohol. Everything else on the rock was gently rubbed off in the current, which carried it into the net. Once all large rocks were examined and discarded, the sediment was stirred to collect any shallowly buried invertebrates. Then, for each site, the contents of the Surber net were placed in a jar of 70% alcohol.

On each sample date between June 26-July 24, I also collected 5 algae samples from random rocks in the riffle area using a brushing procedure similar to that of Loeb (1981).

Separation of Insect Samples

I picked through each sample of insects in the lab, using a dissecting microscope. A small amount of the sample was placed in a petri dish with a 10% sugar, 90% alcohol solution. Rocks and detritus settled to the bottom, and most of the insects floated due to density differences. This method worked well except in samples with large amounts of vegetative matter. This tended to entangle the insects, making them difficult to locate and remove from the sample. I found that it was easiest to identify the key insects as I picked, and to place them immediately in separate vials of 70% alcohol. In addition, all the non-key insects were preserved. The number of the key insects from each replicate was noted.

Treatment of Algae Samples

Immediately after returning to the lab, each algae sample was diluted with tap water to 100ml; 20 ml of which were set aside in a scintillation vial with a few drops of Lugols solution as a preservative. These subsamples were later used for algal identification. The remaining 80 ml of algae and water were filtered by vaccuum, the filter papers frozen in plastic bags, and later analyzed by fluorometer for chlorophyll a and phaeophyton using procedures described by Marker et al. (1980) and Strickland and Parsons (1968).

Gut Analyses

Gut analyses were performed on one or more of each key insect, as well as on the caddisfly *Hydropsyche* sp. (Hydropsychidae) from every sampling date. Under the dissecting scope, an insect was grasped by the head and by the thorax with two pairs of fine tipped forceps. The head was gently removed from the body; the gut of *P. placida* easily came out with the removal of the head, but in the case of *C. obscura* or *Seratella* sp., I usually had to then pull the gut from the body using forceps or a fine probe. The membrane around the digestive tract was carefully removed, and the contents viewed under the dissecting scope. If the insect was predacious, I tried to identify its prey. If the gut contents appeared to be algae and detritus, I put some, with alcohol, on a slide and identified the algae using a compound microscope and 400x magnification.

Insect Weights

For each sample date, the average weight of each key insect was determined. Replicates were combined to get as many insects for each day as possible. Up to ten individuals were weighed together on a tared weighing boat. The value obtained was divided by the number of specimens to determine average individual weight. The total weight of the non-key insects for each sampling date was also determined.

Algae Identification

One slide was viewed from each sample; an eyedropper was filled at the bottom of the vial of preserved algae and water, and emptied onto the slide for viewing at 400X magnification. Identifications were based on a pictoral key to common species of algae provided by Jane Aloi.

RESULTS

Insects Sampled

Over the sampling dates, I saw a marked change in the insect compostition of the stream. Changes took place at the species level as well as the trophic level. On the earliest sampling dates *P. placida,* one of the key insects, was abundant: a dominant organism in the riffle area (figure 1). In the first week of sampling, two cohorts of *P. placida* appeared to be present; the larger individuals were not included as key organisms, and were not found after this sampling date. Numerous excuvie from *P. placida* were found on June 26; after this time, the species dropped rapidly in abundance.

The other two key insects did not show such regular distribution over time. After an initial increase, the average number of *Serratella* sp. in a square foot sample remained high throughout the middle sampling weeks (figure 1). A number of exuviae from this species were found in the sample on July 17; fewer nymphs and exuviae were collected later. *C. obscura* was initially present in low numbers, then increased in abundance in the weeks in which *Serratella* sp. was also common (figure 1). However, *C. obscura* showed another increase in number.

The species composition of the other insects in the stream varied conspicuously with time. The collection of non-key insects from the earliest sampling date was dominated by chironomids, especially small case dwelling species. Whenever *P. placida* was found, few other predators were present; only several gomphids werewere collected between June 8 and June 26, and a few smaller dragonflies were found. Later in the summer, after *P. placida* emerged, large Odonata species were consistently found, and two individuals of a different Plecoptera species were seen.

The average number of each key insect species on each sampling date, and the variability among replicates within each date, were also noted. As seen by the standard deviations of each sampling date (table 1), the distribution of the insect species was not even throughout the stream. Even between two very similar sampling sites on the same day, there were often quite different numbers of species present. In general, insects appeared in greater numbers in the shallower water closer to the shore than at sampling sites in the deeper middle water.

Gut Analyses

The guts of *P. placida* contained animal matter. In some, the undigested food could be easily identified as chironomids. Other times, only head capsules remained; these also appeared to be of chironomids. Gut contents included as much as three whole chironomids or seven head capsules. Also, two individuals were examined with empty guts; both of these were found near the time of emergence; June 26 and July 3.

Serratella sp. contained a large variety of material. Sand, algae and detritus were combined in their guts. Much of the algae was diatoms; some were recognizable as Navicula, but others had fractured frustules so could not be identified any further. Some mayflies also contained fragments of filamentous algae, usually unidentifiable due to the small size of the pieces. Different individuals from the same sampling date often had quite different gut contents. One speciman from June 18 contained mosty filamentous algae, and only a few diatoms, while another had no filaments and was dominated by diatoms. Likewise, there seems to be little relationship between the dominant algae in the riffle and what was found in individual guts.

C. obscura guts also indicated a hebivorous diet, but held much more material than those of *Serratella* sp.. The algae found in *C. obscura* corresponded much more with the algae dominant in the stream at the time. Diatoms, especially *Navicula* sp., and a few fragments of unbranched filaments were found in the earlier specimens. While diatoms, such as species of *Navicula, Cymbella, Synedra*, and *Fragellaria* remained common in *C. obscura* guts throughout the study, the branched filaments *Cladophora* sp. were also seen in insects from July 3 and July 10, over a week before it was identified as an abundant algae of the riffle. After July 10, although *Cladophora* sp. was plentiful in the riffle, its presence was not seen in philopotamids examined.

The gut analyses of *Hydropsyche* sp. revealed similar contents to *C. obscura.* The diet of this insect was entirely herbivorous during the sampling period.

Changes in Insect Weights

P. *placida* showed a steady increase in average individual body weight with time until its emergence in early July. *Serratella* sp. exhibited a similar trend, but dropped slightly in average body weight with the last sample. The weights of *C. obscura*, the third of the key insects, fluctuated greatly over the sampling time. The original *C. obscura* weight data was so irregular that the samples were re-examined and found to contain two species: *C. obscura* and *C. feria*.. In addition, numerous instars, probably from both species, were present. However, even with this additional identification information, the average weight data of *C. obscura* remains erratic.

When all the insects sampled, grouped according to feeding regime as predator or grazer, were weighed for each sample date, similar patterns in total weight were noted for the two trophic groups (figure 3). Predator biomass was constantly much smaller than that of the grazers. In addition, as the total biomass of predators in the environment rose and fell, similar changes were observed in the weight of grazing species present. The initial decrease in predator biomass corresponds with the emergence of *P. placida*.

Algae Samples

A visual change in the algae of the stream was noted throughout the summer. In mid-June, the rocks were heavily coated with periphyton, and showed a few scattered patches of green filamentous algae. The preservative alcohol in the sample jars turned a golden brown color. However, starting on June 26, the samples stained the alcohol bright green almost immediately. Also, in non-riffle areas of the stream, algae became increasingly visible over the summer. Algae mats had formed by July 3, and covered most of the open water by the end of the month.

Identification of algal samples showed that diatoms were abundant in the riffle throughout the sampling dates (table 2). The filament algae *Mougotia* sp. was also an abundant genus according to estimated biomass for the weeks of June 27 and July 3. *Cladophora* sp. was common in the samples during the last two weeks of the study. As abundance is assigned according to estimated biomass, it should be noted that the filamentous algae never dominated the samples in number. However, as each strand is much larger than individual diatoms, only a few filaments are necessary to make up the 20% algal biomass used to assess abundance.

Analysis of the algal samples for chlorophyll showed an initial decrease in chlorophyll levels, followed by a gradual increase begining on July 10. (figure 4) Although there are large significant differences for these data, the replicates appear to show a trend towards high algal populations in early and late summer, with decreased levels throughout July (figure 5, table 3).

DISCUSSION

The results of this study suggest that in the summer months in Tenderfoot Creek, *P. placida*, *Serratella* sp. and *C. obscura* follow the functional feeding regimes to which they are assigned. Because the gut contents of *C. obscura* are completely vegetable matter, these insects probably did feed only on the various algae and detritus which were swept into their nets by the current. Likewise, the algal food of *Serratella* sp. corresponds to the expected diet of a gatherer and scraper. The carnivorous diet of a predator is seen in the gut contents of *P. placida*. Although some algae was found in several of these stoneflies, the quantities were extremely low, suggesting accidental ingestion.

While the standard feeding categories were followed, there was still some selectivity in food choice. The appearance of *Cladophora sp.* in the *C. obscura* for the weeks of July 3 and July 10 probably reflects the beginning of *Cladophora* sp. abundance in the stream. Although this green alga was not yet evident in the riffle, filamentous algae was already forming blooms in deeper non-rocky portions of the stream. Because *C. obscura* feed from particulate matter carried by the current, the *Cladophora* sp. in the guts probably originally grew upstream. Once *Cladophora* sp. became abundant in the riffle, it no longer appeared in the guts of the *C. obscura* individuals, indicating that these insects may use some selectivity in feeding. This supports the previous findings that *Cladophora* sp. may be a poor food source. The delay of *C. obscura* in selecting against the green algae could be the result of a threshold abundance of *Cladophora* sp. being reached before selective foraging takes place.

Selective feeding appeared to take place in the *Serratella* sp.. The dominance of their gut contents by diatoms or filamentous algae with no apparent relationship to the abundant algae of the environment suggests that they did not eat randomly on the algae of the environment. No *Cladophora* sp. was identified in the *Serratella* sp. guts. However, most of the filamentous fragments were very small, so the characteristic branching of *Cladophora* sp. filaments could have been unidentifiable. In addition, most of the *Serratella* sp. had emerged before *Cladophora* sp. was abundant in the riffle area.

In the predacious feeding group, *P. placida* did show selectivity in feeding. The prey in all the individuals examined were chironomids, although many other potential prey insects, such as mayflies, were present in the riffle. *P. placida's* preference for the chironomids could be due to the great abundance of these insects during the early summer. The ease with which they can be caught and consumed, or their value as a nutrition source compared to other prey may also make midges a selected food type.

My results were not conclusive in showing which food sources are most beneficial for the three key species of this study. The decrease in average *Serratella* sp. weight in the last week of sampling, after a steady increase throughout the study, could be due to the increasing abundance of *Cladophora* sp. in the riffle, indicating a possible decrease in desirable food resources. It should also be noted that many of the *Serratella* sp. emerged during the week of the average weight peak; those left as larvae on the next sampling date were probably less healthy individuals, with lower body weights. The steady growth rate of *Serratella* sp. throughout the summer, although there was changing food available, makes sense if the individuals of*Serratella* sp. do feed with the foraging behavior predicted by gut analyses. Feeding from a random assortment of diatoms and green filaments, with no major changes in the overall algal species would produce a steady overall growth rate in the population.

No effect of food quality can be seen from the *P. placida* weights. This species used one consistant food source. Also, because it emerged so early in the summer, the indirect effects of changing algal community, the food source of the stonefly's prey, cannot be seen.

Similarly, the effects of varying food supply cannot be seen in *C. obscura*. The weight data are too inconsistant to analize. Difficulty in distinguishing between multiple species and cohorts are probably the cause of these results.

Besides looking at the effects of the quality changes in algae present in the riffle, the quantity of this food source can be reflected in the growth of the aquatic insects. The greatest average weight gains of *Serratella* sp. took place between the weeks of June 12 and June 18, corresponding with the greatest decrease in chlorophyll a, and suggesting that the high algal levels provided good growing conditions for the mayflies. Conversely, for such increased growth of grazers, a big effect is seen on the algal populaton.

The impact of the insects on the algae populations, can be further seen in the amounts of chlorophyll a present over the summer. High grazing of insect herbivores probably caused the initial decrease in the algal population. This is reflected by the chlorophyll a level. While grazing initially greatly reduced the chlorophyll a levels, a relatively constant amount was reached for the middle weeks of sampling. This could reflect a state at which steady agal production equals insect consumption. However, if the low chlorophyll a levels represent a simple equilibrium between steady algal production and fluctuating levels of grazing, days with low chlorophyll a should have high grazer populations and ones with high cholorophyll should show few grazers. However, the decrease in grazer biomass corresponding with a large decrease in chlorophyll between June 26 and July 3, and the slight decrease in algae with a huge increase in grazer biomass the next week do not fit this pattern. The herbivores did appear to decrease the algal population. However, these data do not show if productivity of the algae was increased during this time as grazers removed cells, providing more light and space for survivors. Due to huge fluctuations in phaeophyton values, comparison between the amounts of chlorophyl and its breakdown product are not helpful. The increase in chlorophyll a at the end of the summer is probably due to a combination of decreased grazing (enough of a reduction to overcome any stimulatory effect of grazing just discussed) with an increase of the filamentous *Cladophora* sp. in the environment.

While the interactions between grazers and the algal community may affect the insect community of the stream, a much stronger relationship was seen between insects of different trophic levels. When separated into predators and herbivores, biomass data indicate strong correlations between the two groups. The large increase in herbivore biomass between the weeks of June 12 and June 18 may be related to an increase in both herbivore size and diversity. Many non-predacious insects, especially mayflies and caddisfies, hatched or migrated into the area at this time. This increase in available prey corresponds with an increase in total predator biomass.

The dominant predator in the early summer was the stonefly *P. placida*. Its population's continuous growth is reflected in the decrease of herbivore biomass over the next few weeks. Following the emergence of *P.*

placida between July 3 and July 10, the sharp increase in herbivore biomass indicates that they may be experiencing lower rates of predation. The subsequent decrease in total harbivore weight corresponding with an increase in predator biomass suggests that new predators were beginning to influence the insect community of the riffle. This idea is upheld by the increase in abundance of large aeschnid dragonflies and the appearance of a new stonefly species. These insects immigrated to the area, or became better able to prosper there with the emergence of*P. placida*. They may have been unable to compete against *P. placida* for food, but became dominant once the key stonefly emerged. Under the influence of these new predators, both predator and herbivore biomass values returned to levels very close to the stable ones seen when *P. placida* was abundant. The last sampling day shows a second marked decrease in predator biomass which may be due to an absence of large dragonfly nymphs, possibly due to emergence. Because the study ended, the effects of this decrease in predation can not be seen, but another surge in herbivorous biomass could be expected.

From these data it is obvious that there are many factors regulating the growth of insects within a community. The availability and quality of algae had some effect on those animals relying on it for a food source. In the presence of abundant food, insects such as *P. placida* steadily increased in weight and were able to emerge. However, abiotic and biotic factors other than food supply were also important in determining the survival and growth of stream insects. The purely herbivorous behavior of *Hydropsyche* sp., *C. obscura* and *Serratella* sp. suggests that if conditions are favorable, gathering of food according to the specialized features of their bodies is most advantageous to insects. The assortment of current speeds, water depths and light levels in the riffle area, should have allowed the insects to live in optimal habitats. However, changes in light, current, food supply, or competition levels could possibly lead to differential feeding to occur. Overall, the most important considerations found determining populations were the biotic interactions of competition and predation. The influence of species on the food available for other species strongly altered the feeding regime and possible the ability of the other insects to survive in the habitat. Predation had a major effect not only directly on the predator and prey, but also on the food sources for other potential predators, and the level of competition among herbivores.

Some parameters of trophic activity in the stream combine both abiotic and biotic effects, such as the effects of the position of the sample site within the stream. Different species were more abundant in diffferent areas; caseless caddisflies were especially common in the deeper water of the center of the stream. Because the water was deeper, there was probably less light for photosynthesis of algae, but also release from most predation, as stonflies and dragonflies were more abundant near the shore. The food availability, selective feeding and the effects of feeding behavior on insect growth involves many factors which may change in importance or in the way they interact over a summer.

Further investigations could explore the differences in importance of the various factors of the shallow edges of the riffle and the deeper, faster moving middle water. The importance of the dragonfly nymphs in regulating the abundance of food and levels of insect populations in the stream could also prove significant. Likewise, the regulatory effect that *limnephilid* caddisflies; a large and abundant herbivore, may have on the algal populations, could be examined. It would also be interesting to compare the feeding dynamics seen in this study with those of nearby streams, or of the same creek at a different time of year.

Acknowlegements

I would like to thank the Bernard J. Hank family for the funding of the UNDERC course which enabled this project to be carried out. In addition, special thanks to Dr. Ronald Hellenthal for his help in planning this project and interpreting the data and to Dr. Jane Aloi for her assistance and advice for examining the periphyton community. Finally, thanks to Marty Berg for his help in insect identifications and advice on sampling techniques, and to Neil MacKay and Joanna Guiltinan for their help in carrying out the field work of this study.

REFERENCES

Calow, P. 1973. Field observations and laboratory experiments on the general food requirements of two species of freshwater snail, *Planorbis conturtus* (Linn.) and *Ancylus fluviatilis* Mull. Proc. malac. Soc. Lond. 40:483-389.

Cummins, K.W. 1973. Trophic relations of aquatic insects. Ann. Rev. Ent. 18:183-206.

Cummins, K.W. and M. L. Klug. 1979. Feeding ecology of stream invertebrates. Ann. Rev. Ecol. Syst. 10:147-172.

Gregory, S.V. 1980. Effects of light, nutrients, and grazing on periphyton communities in streams. Unpublished Ph.D. Dissertation. Oregon State University, Corvallis, Oregon. 154 p.

Hill, Walter R. and A. W. Knight. 1987. Experimental analysis of hte grazing interaction between a mayfly and stream algae. Ecology. 68(6): 1955-1965.

Hilsenhoff, W.L. undated. Auatic insects of Wisconsin. 2nd ed. Publication of the Natural History Council. University of Wisconsin, Madison.

Hutchinson, G.E. 1981. Thoughts on aquatic insects. BioScience 31:495-500.

Lamberti, G.A., L. R. Ashenas, and S. V. Gregory. 1987. Effects of three herbivores on periphyton communities in laboratory streams. N. Am. Benthol Soc. 6(2):92-104.

Loeb, F.L. 1981. An in situ method for measuring the primary productivity and standing crop of the epilithic periphyton community in lentic system. Limnol. Oceangr 26:394-399.

Marker, A.F.H., C.A. Crowther, and R.J.M. Gunn. 1980. Methanol and acetone as solvents for estimating chlorophyll a and phaeopigments by spectrophotometry. Arch. Hydrobiol. Beih. Ergebn. Limnol. 14:52-69.

Merritt R.W. and K. W. Cummins 1984. An introduction to the Aquatic Insects of North America. 2nd edition. Kendall/Hunt Publishing Company. Dubuque, Iowa.

Moore, J.W. 1975. The role of algae in the diet of *Asellus aquaticus* L. and *Gammarus pulex* L. Ecology 44:719-730.

Strickland, J.H. and T.R. Parsons. 1968. A practical handbook of seawater analysis. Fish. Res. Brd. Bulletin 167. pp201-206.

Vaughn, Caryn C. 1986. The role of periphyton abundance and quality in the microdistribution of a stream grazer, *Helicopsyche borealis* (Trichoptera: Helicopsychidae). Freshwater Biology. 16: 485-493.

Figure 1. Average Number of Key Insects

Mean number of each key insect per replicate for each sampling date.

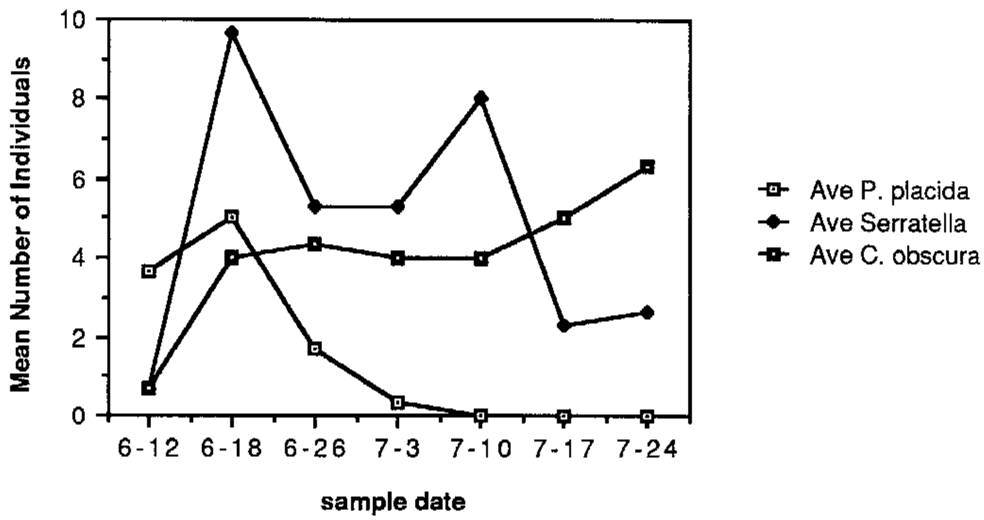


Table 1: Standard Deviations in Insect Number

Sample Date	P. placida	C. obscura	Serratella
6/12	1.155	1.155	.500
6/18	5.568	6.928	12.42
6/26	1.528	1.528	.577
7/3	0	1.000	4.163
7/10		3.512	8.185
7/17		6.083	1.155
7/24		6.282	3.786

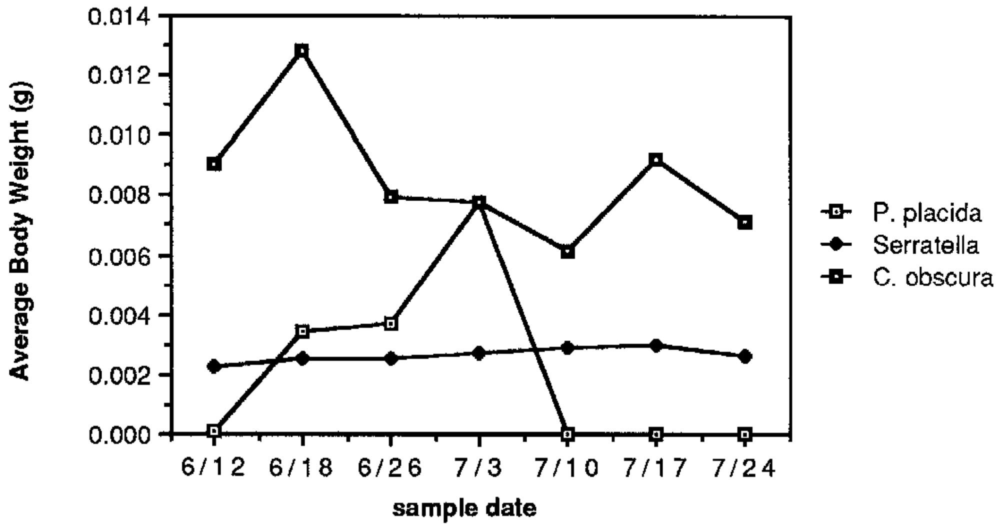
Table 2. Changing Composition of Algae Community in Tenderfoot Creek
Algae identification is based on periphyton samples brushed from rocks of the riffle area. Abundance assigned according to estimated biomass.

	6/27					7/3					7/10					7/17					7/24				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
DIATOMS																									
Achnanthes		░		░			░											▓							
Cocconeis																						░			
Cymbella	░	▓	▓	▓	▓		▒	▓	▓			▒	▓		░	░	░	▓	▓	░	▓	▒	▓	▓	░
Eunotia																						░			
Fragiliaria	░	░		▒	░		▒	▒	▒		░								░				░		
Gomphonema									░													▒			
Navicula	▓	▓	▒	▓	░	░	░	▓	░	░	▒	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓
Nitzschia		░	▒	░		░	░																	▒	
Pinnularia	░	░	░	░				▒					░									░	▒	░	░
Synedra		▓	▒	▒	░	░	░	▒	▒	░	░		░	░	░		▓	░	▒		▒		▒	░	
Tabellaria	░																								
GREEN ALGAE																									
Cladophora																		░	▒	▓			▓	░	
Coelastrum					░													░			▒		░	░	
Mougeotia	░	▓	▒	▓	▓	░	▓	▓	▓	▓						░			▒	░				▓	
Oedogonium		░		░	░	▓	▓	░			▓			░	░		▒				░	▒	░	░	
Scenedesmus	░	░																					░		
irogyra		░										▒													
CHAROPHYTES																									
Closterium				▒	░		▒	░	▒		░							░					▒	░	
Cosmarium		░	░																		░		░		
Staurastrum																		░							

▓ =abundant genus (>20% estimated biomass)
▒ =common genus (5-20%)
░ =uncommon genus (1-5%)

Figure 2. Changes in Mean Body Weight

Average weight of individuals from the three key insects over the course of the study.



* The zero values for P. placida indicate weeks in which that insect was not present.

Figure 3. Predator/Grazer Biomass Relationship

Total weight of predacious and herbivorous insects determined for each sampling date.

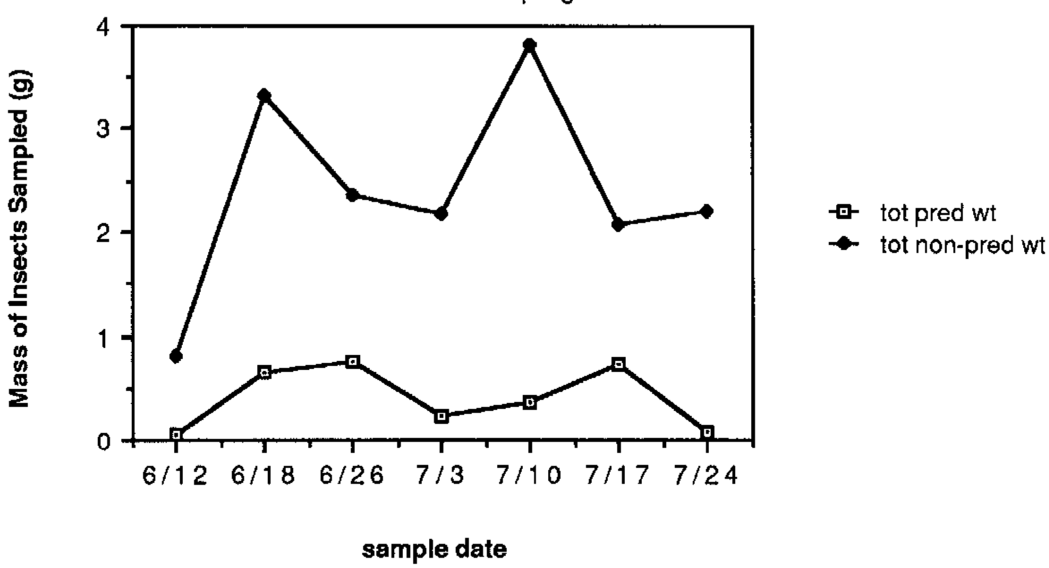


Figure 4. Mean Chlorophyll levels.

Average weekly values of Chlorophyll for a one square inch sampling area.

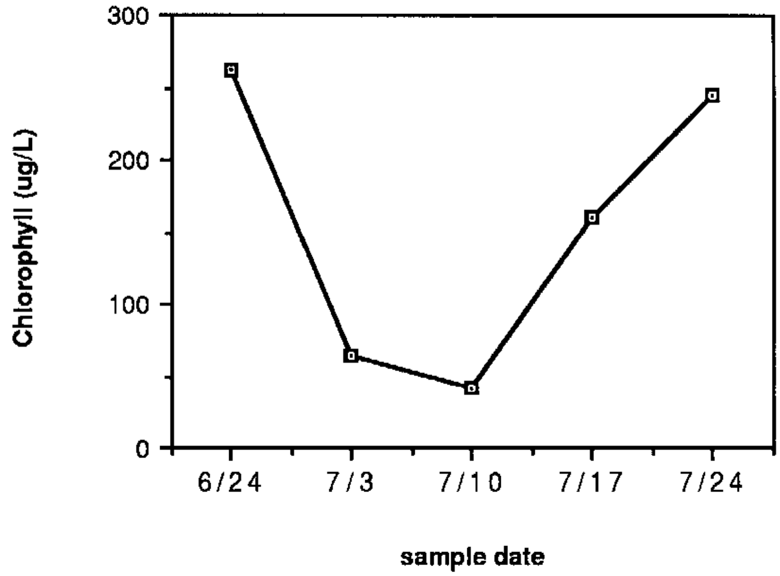


Table 3. Standard Deviations for Chlorophyll Data

Sample Date	Standard Deviation
6/24	206.002
7/3	35.547
7/10	22.35
7/17	115.807
7/24	115.944

Figure 5. Chlorophyll of all Replicates

Values of chlorophyll obtained from five square inch samples per sampling date.