# The Effect of Light on Colonization Patterns of Aquatic Insects

**Bios 569 – Practicum in Aquatic Biology**

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## Abstract

Terrestrial insects have undergone evolution allowing them to inhabit aquatic environments. During this time there has been a substantial amount of diversification occurring over time that has lead to the great variety of aquatic insects that we find today. With only a finite number of resource space available on the planet, insects have to adapt to ecosystems that are capable of sustaining their life-history patterns. Insects have to take into account certain biotic (species presence) and abiotic (temperature, pH, photoperiod, and substrate type) factors that determine the relative fitness the species would entertain in a particular ecosystem. In attempt to determine what factors contribute to a species preference of habitat colonization, this project will test species preference for shaded (no sunlight) or non-shaded (sunlight available) modules that act as mini-habitats for a site-specific stream experiment. It was found that the majority of the fifteen species found preferred to colonize the non-shaded traps. *Hydropsyche* and *Simuliidae* were the most abundantly found species in all the traps combined. Furthermore, the insects that are considered collectors/scrapers clearly chose to live in the non-shaded traps and the predators showed a similar disposition to inhabiting the non-shaded traps. However, the filter-feeder insects showed no preference for the non-shaded traps and were actually more prevalent in the shaded traps.

## Introduction

Since the evolution of certain insects from a terrestrial lifestyle to one adapted to living in aquatic conditions, there has grown to be a substantial amount of variation in behavioral characteristics. These characteristics differ between the species for many reasons, a few of which are: modes of feeding (i.e. scrapers, predators, or filter feeders), habitat preferences, swimming mechanisms, and methods of oxygen uptake. Insects have evolved quite efficiently, allowing them to inhabit both lentic and lotic aquatic habitats. In lakes the insects feed primarily on plants that flourish in the limnetic zones. However, a few species are well adapted to deep-water habitats and, therefore, are able to feed on the profundal and benthic plants. Although it may seem that the currents of flowing water ecosystems such as streams would offer a poor habitat for insects to become firmly established, streams do in fact hold a flourishing abundance of many species of invertebrates. There are many niche spaces found in streams that offer a variety of resource zones that can be readily occupied by insects that are more adapted to living in a particular habitat. Certain species prefer shallow to deep water and vice versa, while some insects opt to live in a more slowly flowing current area of the stream. Each species realizes their particular niche based on their requirements and the degree to which the niche will satisfy these requirements. This is done to insure the survival of the respective species to the next generation. With nature working in such abstract ways certain questions seem to resurface such as: What drives these fundamental life history patterns of aquatic insects and why do certain species differ in their respective morphological, physiological, and behavioral characteristics? For instance, why does synchronous emergence occur in some aquatic insect populations and not others? (Butler 1978).

Clearly the possibilities for studying behavioral patterns for aquatic insects are numerous; therefore, this experiment will focus on the particular mechanisms that determine which habitats are preferred among certain species in the stream. Among the various aspects of nature, temperature, nutrition, and photoperiod are the most important environmental factors (Sweeney, 1984). To narrow the study more, this project will focus primarily on the effects of light on the habitat preferences of the invertebrates found in Tenderfoot Creek in Gogebic County on the University of Notre Dame's property near Land O'Lakes, Wisconsin. It is well known that insects are careful as to which habitats they choose to colonize and that these decisions are made based on feeding preference, morphological characteristics, and reproductive traits. To directly test the parameters of these choices the purpose of this project is to determine whether shaded or non-shaded habitats are preferred among the various aquatic insects native to the area. It is assumed that the factor determining colonization preferences will be based primarily on feeding mechanisms. For example, certain species will require a suitable substrate that offers a type of plant material growing on it that they are capable of scraping with their well-adapted mouthparts. In this instance, the plants in the habitat would require sunlight in order for photosynthesis to occur allowing for their growth and survival. Hypothetically, habitats that are devoid of light would also be without plant and algal growth and, therefore, absent of potential insect colonizers that require a productive substrate to live on.

This project will directly test the above hypothesis by placing both shaded and non-shaded modules (traps) in the stream that act as potential substrates or mini-ecosystem habitats for the insects to colonize. Since insects respond to very low light levels, light detection is a potential problem for them in most aquatic habitats (Sweeney, 1984). Therefore, the traps used in this experiment will be covered with a black weed cover, in attempt to shield all the sunlight from entering the module. Ideally, the shaded traps would have a significant enough portion of sunlight blocked from reaching inside them to prevent the growth of algae on the rocks found on the bottom of the traps. Thus, it is predicted that organisms categorized as scrapers would not be as concentrated in these traps because of the absence of a primary food source to sustain them. This is due to the optimal foraging theory in that the insects will tend to practice area-restricted searching by spending most of their time in high quality patches. The presence of shading in this project can be equated to natural blockades of the photoperiod found in aquatic habitats of nature, such as dissolved humic substances, suspended sediments, and ice or snow cover. Furthermore, in streams it is important to realize that there is no thermal stratification and that temperature remains relatively constant. Therefore, it seems that the photoperiod would be a more reliable and informative signal than temperature in studying the habitat preferences of aquatic insects.

Initially, this project had a broad reaching scope that sought to include a comparison between two different sites along Tenderfoot Creek. The differences between the two sites were that in one the water was more rapid flowing with a rocky bottom type and in the other the water flowed slower and had a sandy bottom. In this case stream velocity and bottom type would be the experimental variables and stream depth would serve as the control. The initial 24 traps were placed in the stream on June 11$^{th}$ with half of them placed at the gravel pit and the other half placed alongside the bridge on the north side of the road. Three weeks later, on July 10$^{th}$ a day before the traps were to be removed, a tremendous storm crashed its way through the area and washed the traps downstream. In a courageous effort, 20 of the 24 traps were recovered and of these 19 were still in operable condition. However, due to time constraints the project was narrowed to ten traps for a duration of only a week in just one location with half of the traps shaded and the other half non-shaded. The velocity and depth readings for each of the traps are shown in Figure 1. Fortunately, sufficient colonization occurred in this time frame to allow for some comprehension and data analysis.

Figure 1

| Trap Number | Shaded or Non | Depth | Velocity |
|---|---|---|---|
| #1 | Shaded | 43.5cm | 1.11 m/s |
| #2 | Non-shaded | 38.5cm | 1.02 m/s |
| #3 | Non-shaded | 34cm | 1.88 m/s |
| #4 | Non-shaded | 34.5cm | 1.42 m/s |
| #5 | Shaded | 31.5cm | 1.48 m/s |
| #6 | Non-shaded | 28.5cm | 1.09 m/s |
| #7 | Shaded | 35cm | 1.49 m/s |
| #8 | Non-shaded | 36.7 | 1.85 m/s |
| #9 | Shaded | 34cm | .42 m/s |
| #10 | Shaded | 33.5cm | 1.28 m/s |

Figure 1. The above table shows the values obtained for the depth and velocity of each trap.

## Materials and Methods

As mentioned in the introduction, 24 traps were initially constructed and the primary objective was to carry the experiment out at two sampling sites. However, the number of traps was scaled down to ten concerning time constraints.

- Construction

Twenty-four boxes were built in order to obtain significant statistical analysis results. Half of the traps were shaded using a black weed cover material called *Weed Ender Pro Landscape Fabric*. A staple gun was used to secure the material to all sides of the wooden traps to prevent as much sunlight as possible from entering the traps. However, some space (4-8") was left open at the bottom of the traps to allow for the current of the stream to pass through. The other twelve traps were left non-shaded with open tops to allow for maximum sunlight to penetrate to the bottoms of the submerged traps. The wooden traps were constructed out of 2" by 2" 's using 12" pieces to form the square bottoms and tops. Steel nails were used to secure the individual pieces forming the bottom and tops. The sides were constructed out of wooden 18" 2 by 2's and it took four of these attached to one bottom and one top to complete the trap. These 18" pieces were more firmly connected by using Stainless Steel *Square Drive Flathead Screws*. A 1' by 1' piece of hardware cloth was stapled to the bottom of each trap by using a hammer and *Grip-Rite Fasteners* steel staples.

- Substrate

Rocks of similar size and density were chosen for the substrate of the traps. These dry rocks, devoid of insect colonization, were extracted from a rock heap on the north side of the UNDERC property near the fish dump. The rocks ranged from 4-6" in diameter and were placed on the bottom of the traps on top of the hardware cloth. Enough rocks were placed in each trap so that there were no significant open spaces in between the rocks.

- Trap Placement

The boxes were placed in the middle of the stream in a staggered formation so as to allow water to flow through each of the traps equally. The placement was crucial because this project attempted to maintain depth and water velocity constant for each of the traps. To maximize insect colonization efficiency, the traps were placed on the bottom of the stream only after a 1' by 1' area was cleared of rocks and debris to allow for the trap to be placed flat on the real bottom of the stream. The ten traps were placed in Tenderfoot Creek near the gravel pit and Figure 1 details the depth and velocity for each of these traps. Five of the traps were shaded and five were non-shaded.

- Sampling Period

The sampling period for this project was narrowed from three weeks down to one week due to time constraints. The traps were placed in the stream on July 12$^{th}$ and removed on July 19$^{th}$. Even though the sampling period was only for a week, certain species were able to successfully colonize the traps. These species might be considered pioneer species, or the first to inhabit the area in a continuously changing process.

## Results

When discussing the results of this project, the most important thing to remember is to keep shaded and non-shaded traps separate when analyzing the statistics for each type. Therefore, a breakdown has been done for each individual trap. This breakdown recognizes each trap as shaded or not and then accounts for all species present at the time the trap was extracted. There were fifteen species found amongst the ten traps with Hydropsychidae, Hydropsyche and Simuliidae being the two most abundantly found. Figure 2 gives the details of each trap's contents and Figure 3 shows the total number of organisms present in each trap. To gain a quantitative view of the complete project, Figure 4 shows the total number of each species found in all traps. However, it remains to be determined which habitats the individual species prefer; therefore, Figures 5-12 depict the preference (light or dark) each species had that were present in significant enough numbers. Clearly, it is shown that the majority of the species preferred to colonize the non-shaded traps, while the Bettningiidae, Dolania and the Ephemerellidae, Serratella were the only species to prefer the shaded traps. What determines which species colonize the shaded and which the non-shaded traps? To answer this question it is important to realize that there are three main types of feeding mechanisms practiced among the fifteen species found in the ten traps. These types range from collectors/scrapers, to predators (engulfers), to filter feeders. From this it can be predicted that the collectors/scrapers will be most abundant in traps that have algae or some other plant material growing on the rocks that is available for their consumption. These traps would most likely be those that were non-shaded and allowed sunlight to penetrate to the rocks and permit the growth of algae. The predators, however, would show a preference toward foraging in high quality patches. These patches would be those traps that had the most prey available for the predators to consume. Therefore, the tendency would be to forage in the traps most densely populated by their prey, which would be the non-shaded traps. Finally, since the filter feeders to not rely on the growth of algae or upon the presence of prey, they seemingly could be found in either shaded or non-shaded traps because the water flowing through each would be the same. However, a reasonable assumption is that the filter feeders would tend to favor the traps that contained the least number of predators to increase the chance of their survival. Figure 13 shows the actual findings of habitat preferences among the different feeding behaviors of the fifteen species found in the traps. The collectors/scrapers highly favor the non-shaded traps, while the predators show a tendency toward non-shaded traps as well. However, as mentioned above the filter feeders do not rely on light for their energy source and, therefore, favor the traps with the smaller abundance of predators.

## Figure 2. The Number of Individuals Found in each Trap For All Fifteen Species

| Organism | Trap #1 Dark | Organism | Trap #2 Light |
|---|---|---|---|
| Hydropsychidae, Hydropsyche | 33 | Hydropsychidae, Hydropsyche | 16 |
| Baetidae, Baetis | 1 | Baetidae, Baetis | 1 |
| Perlidae, Paragnetina | 1 | Perlidae, Paragnetina | 0 |
| Polycentropodidae | 2 | Polycentropodidae | 0 |
| Caedidae, Caenis | 2 | Caedidae, Caenis | 0 |
| Ephemerellidae, Serratella | 2 | Ephemerellidae, Serratella | 1 |
| Bettningiidae, Dolania | 0 | Bettningiidae, Dolania | 3 |
| Philopotamidae | 1 | Philopotamidae | 0 |
| Simuliidae | 20 | Simuliidae | 7 |
| Perlidae, Neoperla | 0 | Perlidae, Neoperla | 2 |
| Chironomidae | 0 | Chironomidae | 2 |
| Heptageniidae | 0 | Heptageniidae | 0 |
| Ephermerellidae, Drunella | 0 | Ephermerellidae, Drunella | 0 |
| Corydalidae, Corydalus | 0 | Corydalidae, Corydalus | 0 |
| Polycentropodidae, Polycentropus | 0 | Polycentropodidae, Polycentropus | 0 |

| Organism | Trap #3 Light | Organism | Trap #4 Light |
|---|---|---|---|
| Hydropsychidae, Hydropsyche | 26 | Hydropsychidae, Hydropsyche | 11 |
| Baetidae, Baetis | 5 | Baetidae, Baetis | 4 |
| Perlidae, Paragnetina | 0 | Perlidae, Paragnetina | 1 |
| Polycentropodidae | 0 | Polycentropodidae | 0 |
| Caedidae, Caenis | 2 | Caedidae, Caenis | 0 |
| Ephemerellidae, Serratella | 1 | Ephemerellidae, Serratella | 1 |
| Bettningiidae, Dolania | 0 | Bettningiidae, Dolania | 0 |
| Philopotamidae | 0 | Philopotamidae | 0 |
| Simuliidae | 67 | Simuliidae | 5 |
| Perlidae, Neoperla | 0 | Perlidae, Neoperla | 0 |
| Chironomidae | 0 | Chironomidae | 0 |
| Heptageniidae | 1 | Heptageniidae | 0 |
| Ephermerellidae, Drunella | 1 | Ephermerellidae, Drunella | 0 |
| Corydalidae, Corydalus | 0 | Corydalidae, Corydalus | 0 |
| Polycentropodidae, Polycentropus | 0 | Polycentropodidae, Polycentropus | 0 |

| Organism | Trap #5 Dark | Organism | Trap #6 Light |
|---|---|---|---|
| Hydropsychidae, Hydropsyche | 11 | Hydropsychidae, Hydropsyche | 73 |
| Baetidae, Baetis | 0 | Baetidae, Baetis | 1 |
| Perlidae, Paragnetina | 0 | Perlidae, Paragnetina | 0 |
| Polycentropodidae | 1 | Polycentropodidae | 13 |
| Caedidae, Caenis | 0 | Caedidae, Caenis | 0 |
| Ephemerellidae, Serratella | 0 | Ephemerellidae, Serratella | 9 |
| Bettningiidae, Dolania | 0 | Bettningiidae, Dolania | 0 |
| Philopotamidae | 0 | Philopotamidae | 0 |
| Simuliidae | 4 | Simuliidae | 1 |
| Perlidae, Neoperla | 0 | Perlidae, Neoperla | 0 |
| Chironomidae | 0 | Chironomidae | 5 |
| Heptageniidae | 0 | Heptageniidae | 5 |
| Ephermerellidae, Drunella | 0 | Ephermerellidae, Drunella | 0 |
| Corydalidae, Corydalus | 0 | Corydalidae, Corydalus | 1 |
| Polycentropodidae, Polycentropus | 0 | Polycentropodidae, Polycentropus | 0 |

| Organism | Trap #7 Dark |
|---|---|
| Hydropsychidae, Hydropsyche | 34 |
| Baetidae, Baetis | 1 |
| Perlidae, Paragnetina | 1 |
| Polycentropodidae | 9 |
| Caedidae, Caenis | 0 |
| Ephemerellidae, Serratella | 1 |
| Bettningiidae, Dolania | 2 |
| Philopotamidae | 0 |
| Simuliidae | 11 |
| Perlidae, Neoperla | 0 |
| Chironomidae | 0 |
| Heptageniidae | 3 |
| Ephermerellidae, Drunella | 0 |
| Corydalidae, Corydalus | 0 |
| Polycentropodidae, Polycentropus | 0 |

| Organism | Trap #8 Light |
|---|---|
| Hydropsychidae, Hydropsyche | 20 |
| Baetidae, Baetis | 0 |
| Perlidae, Paragnetina | 4 |
| Polycentropodidae | 6 |
| Caedidae, Caenis | 0 |
| Ephemerellidae, Serratella | 1 |
| Bettningiidae, Dolania | 1 |
| Philopotamidae | 0 |
| Simuliidae | 0 |
| Perlidae, Neoperla | 0 |
| Chironomidae | 0 |
| Heptageniidae | 1 |
| Ephermerellidae, Drunella | 0 |
| Corydalidae, Corydalus | 0 |
| Polycentropodidae, Polycentropus | 1 |

| Organism | Trap #9 Dark | Organism | Trap #10 Dark |
|---|---|---|---|
| Hydropsychidae, Hydropsyche | 10 | Hydropsychidae, Hydropsyche | 28 |
| Baetidae, Baetis | 2 | Baetidae, Baetis | 2 |
| Perlidae, Paragnetina | 0 | Perlidae, Paragnetina | 2 |
| Polycentropodidae | 0 | Polycentropodidae | 1 |
| Caedidae, Caenis | 0 | Caedidae, Caenis | 0 |
| Ephemerellidae, Serratella | 4 | Ephemerellidae, Serratella | 3 |
| Bettningiidae, Dolania | 1 | Bettningiidae, Dolania | 2 |
| Philopotamidae | 0 | Philopotamidae | 0 |
| Simuliidae | 0 | Simuliidae | 2 |
| Perlidae, Neoperla | 0 | Perlidae, Neoperla | 0 |
| Chironomidae | 0 | Chironomidae | 0 |
| Heptageniidae | 0 | Heptageniidae | 0 |
| Ephermerellidae, Drunella | 0 | Ephermerellidae, Drunella | 0 |
| Corydalidae, Corydalus | 0 | Corydalidae, Corydalus | 0 |
| Polycentropodidae, Polycentropus | 0 | Polycentropodidae, Polycentropus | 0 |

Figure 2. The relative abundance of the fifteen species broken down by trap.

Figure 3. Total Number Of Organisms

| Light (L) or Dark (D) | Total Number for Replicate | |
|---|---|---|
| L | 33 | 1 |
| L | 103 | 2 |
| L | 22 | 3 |
| L | 107 | 4 |
| L | 34 | 5 |
| D | 62 | 1 |
| D | 16 | 2 |
| D | 63 | 3 |
| D | 17 | 4 |
| D | 40 | 5 |

Figure 3. The total number of organisms found in each trap taking into account whether the trap is shaded (D) or non-shaded (L).

Figure 4.

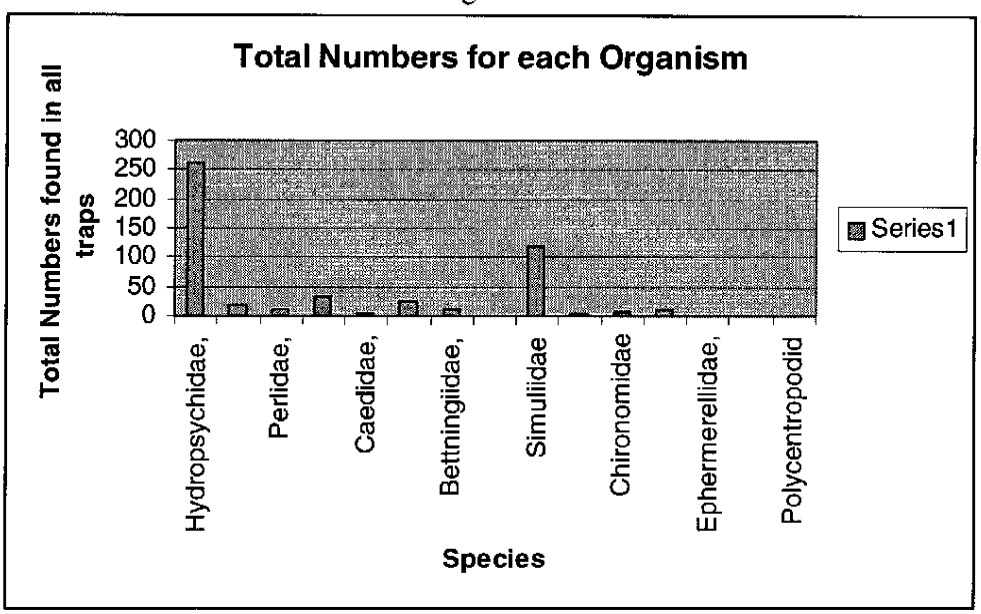



Figure 4. This graph shows the total number of organisms found summed from all the traps. Here, it is apparent that the Hydropsychidae, Hydropsyche and the Simuliidae are the most abundant.

**Figures 5-12. Species Preference for Colonization of Shaded vs. Non-shaded Traps**

**Figure 5**

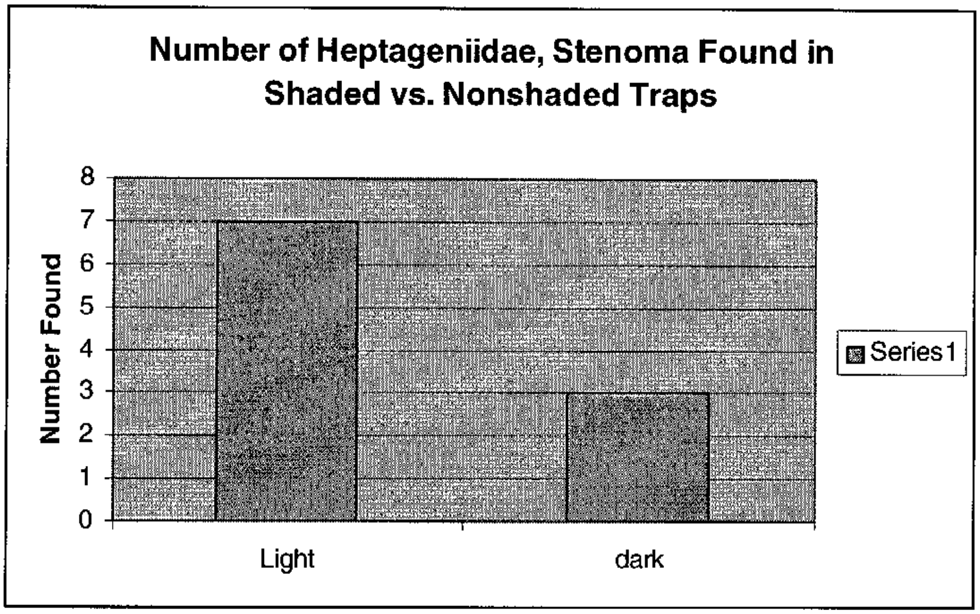



**Figure 6**

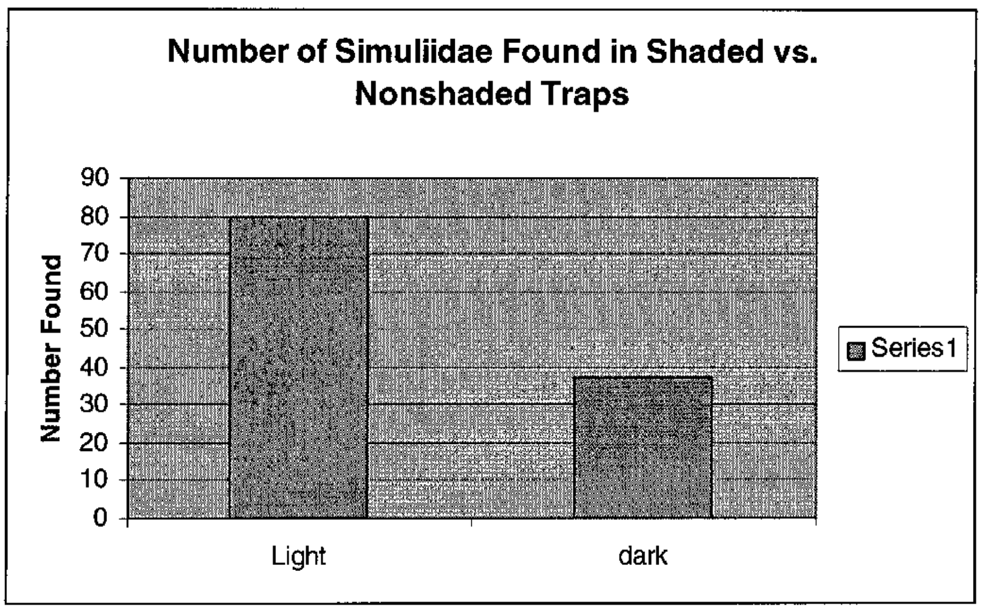


**Figure 7**

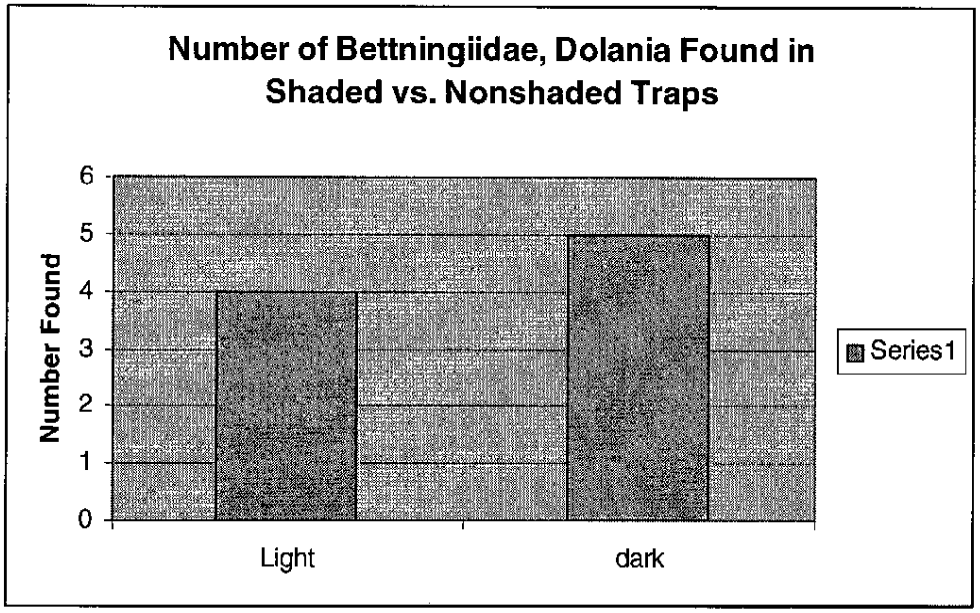



**Figure 8**

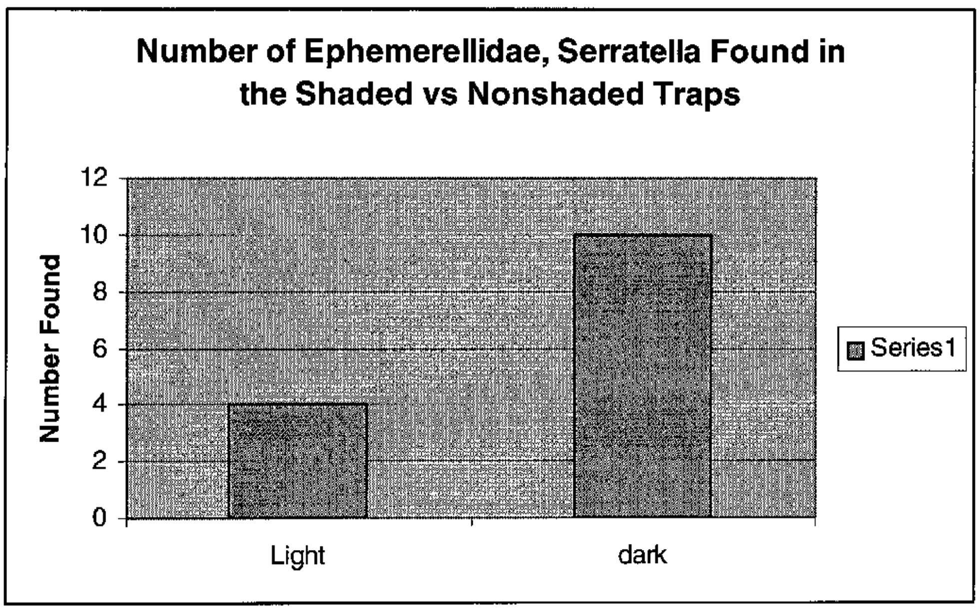


Figure 9

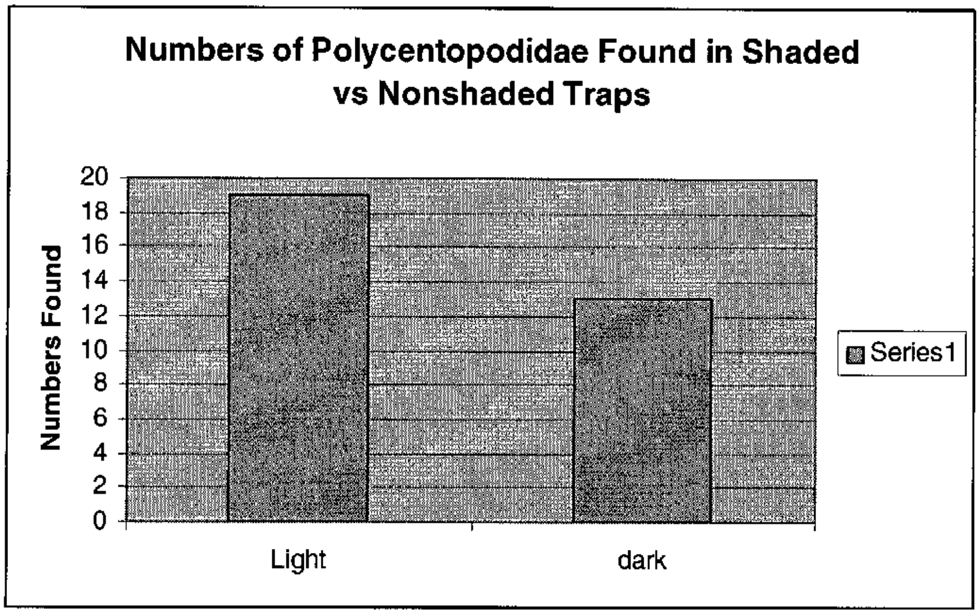



Figure 10

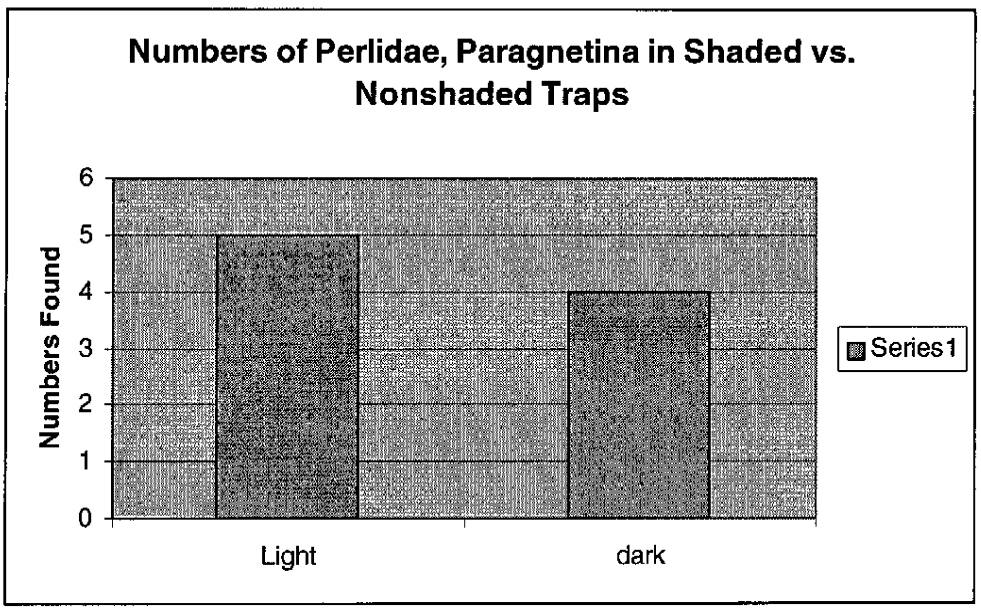


**Figure 11**

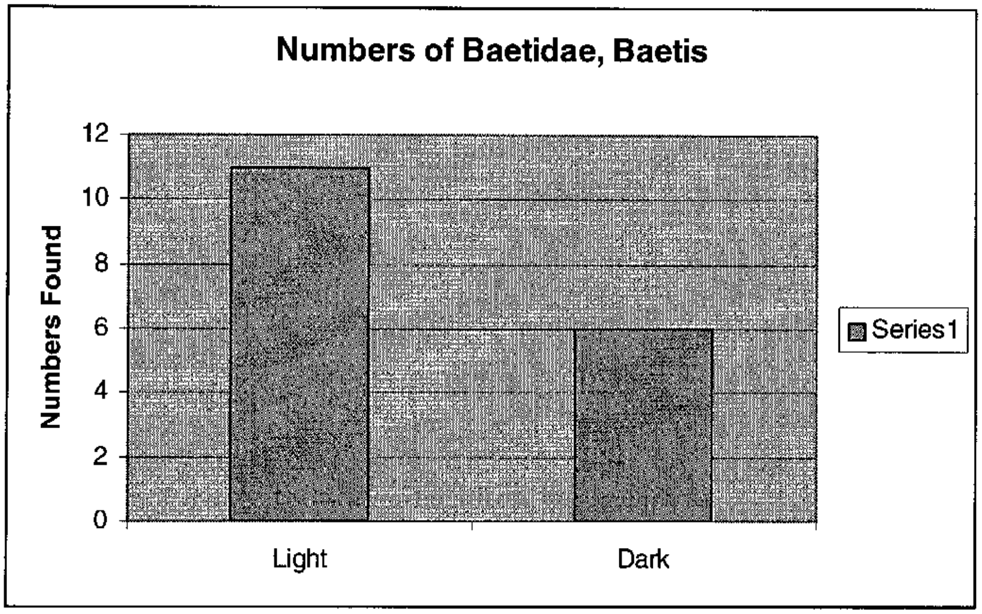
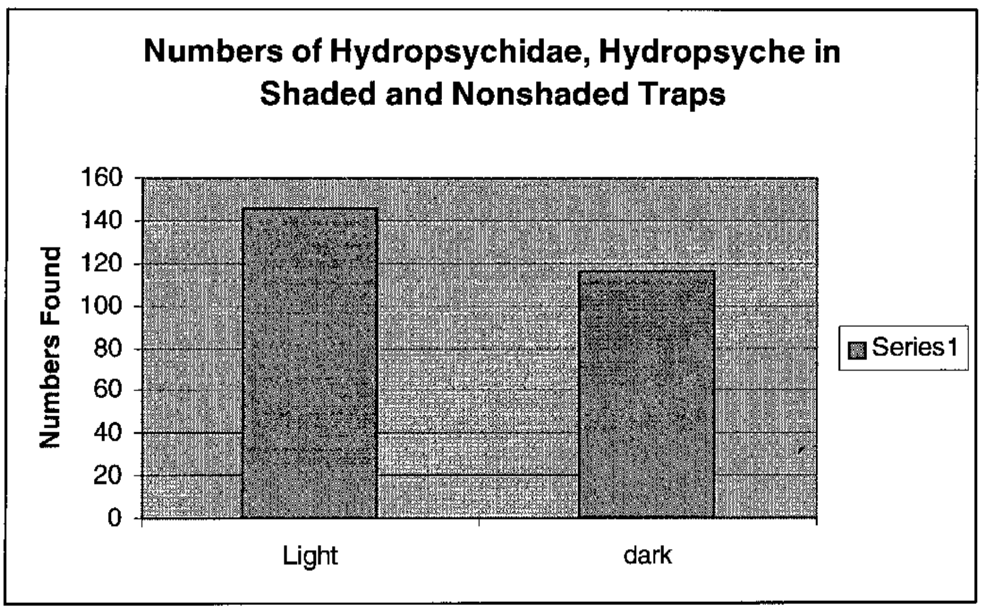



**Figure 12**




Figures 5-12. These figures show the habitat preference of pioneer species in the aquatic environment of a Wisconsin stream. Clearly, most of the species found in significant numbers chose to colonize the traps that experienced sunlight penetration.

**Figure 13**

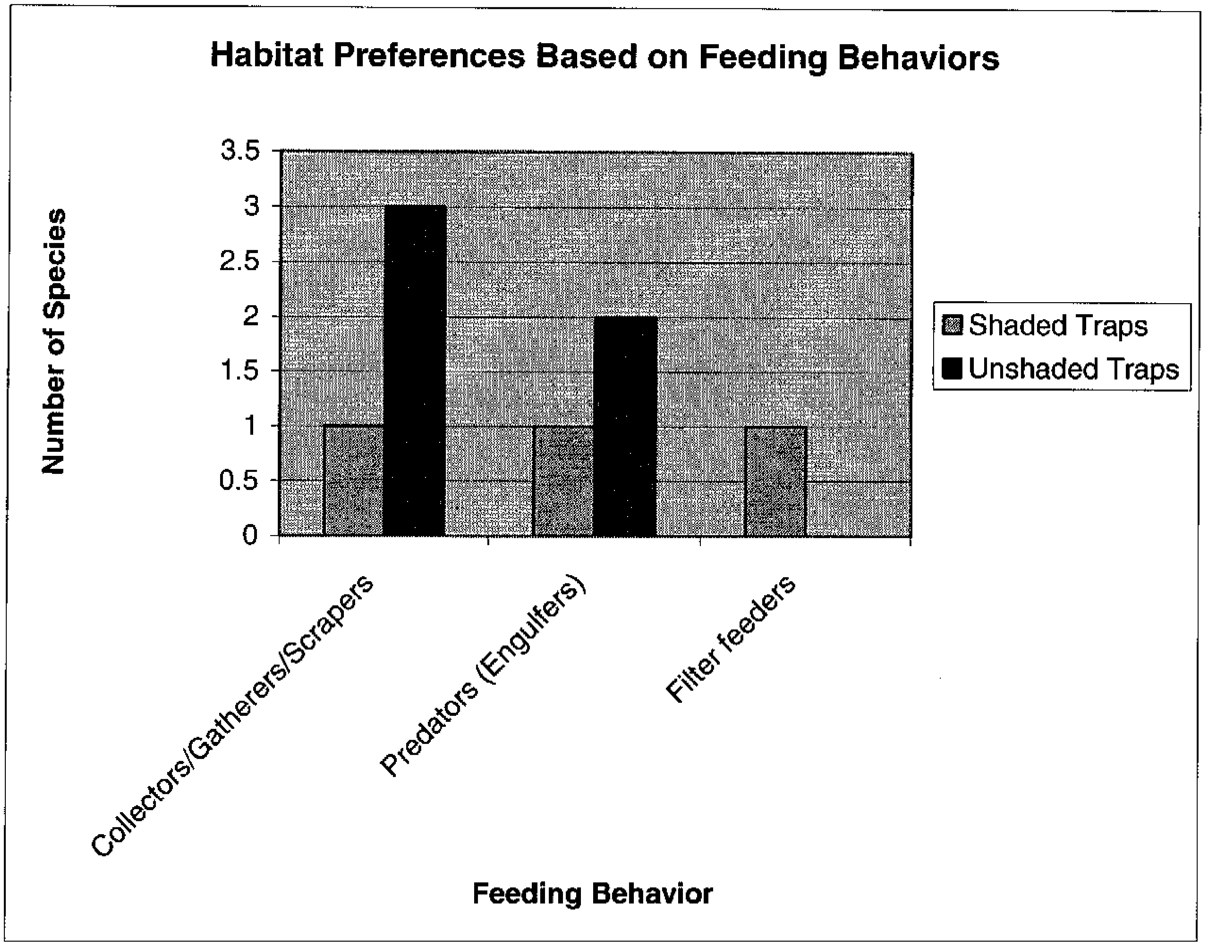



Figure 13. A comparison in the number of species of each feeding type that prefer foraging in shaded or non-shaded traps. Clearly, the collectors/scrapers prefer to live in the non-shaded traps, as did the predators. However, the filter feeders seem to prefer the shaded traps.

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## References Cited

1. Butler, Malcom. 1978. Life Histories of Aquatic Insects. Praeger Publishers. New New York, New York. 24-48.

2. Peckarsky, Barbara. 1980. Predator-Prey Interactions Among Aquatic Insects. Praeger Publishers. New York, New York. 196-220.

3. Resh, V.H. and D.M. Rosenberg. 1984. The Ecology of Aquatic Insects. Praeger Publishers. New York, New York. 9-14.

4. Sweeney, Bernard. 1984. Factors Influencing Life-History Patterns of Aquatic Insects. Praeger Publishers. New York, New York. 56-82.