An Experimental Study of Invertebrate Predation in a Stream Environment

BIOS 560 - Practicum in Aquatic Biology

Angela T. Bednarek

327 Knott Hall

Dr. Gary Lamberti

1992

ABSTRACT

Previous studies on invertebrate predation in stream ecosystems have been limited. This investigation attempted to determine the effects of three predators, Claasenia wu stoneflies, Corydalus latreille dobsonflies, and Orconectes propinquus crayfish, on other benthic invertebrates in a riffle area of Tenderfoot Creek at UNDERC. Predator density was manipulated in 10 clear, butarate tubes (0.023 m^2 each) on the stream bed over a 10-day period.

The results indicated that only the crayfish Orconectes propinquus had a significant effect on the other invertebrates and in particular the Simuliidae. In addition, general predation exerted a significant effect on the invertebrate community in Tenderfoot Creek, probably due to the effects of Orconectes propinquus.

Invertebrate Predation in Tenderfoot Creek

INTRODUCTION

Several investigations have indicated that many aquatic communities are responsive to changes in predation (reviewed by Peckarsky 1982, Ward 1992). In fact, these studies have shown that vertebrate and invertebrate predation acts as a major force in structuring aquatic plant and animal communities. However, studies on the effects of predation, and especially invertebrate predation, in stream or other running water environments have been limited (reviewed by Allan 1983, Peckarsky 1982, New 1992). Often, the difficulty in obtaining accurate data on invertebrate predation is related to the interaction of environmental factors in the stream community (reviewed by New 1992). In this study, I explored the effects of three invertebrate predators on stream benthic invertebrates.

Some studies have suggested that the predators' lack of effect on the stream community may be related to (1) the lower tendency for one species to dominate an area of space in a stream, (2) the greater mobility and turnover of species in running water, and (3) the high heterogeneity of streambed sediments, which provide refuge for prey (reviewed by New 1992, Ward 1992). The manipulation of different species in one area of a stream frequently allows other species from other parts of the stream to reach the experimental area. Laboratory stream studies have shown stronger predation effects, probably because of the smaller area and greater control over the running water environment (reviewed by Allan 1983, Peckarsky 1981). In addition, predation may vary with depth in the stream (Ward 1992).

Studies involving invertebrate predators have also included investigations into the kinds of prey consumed by the predators, usually by studying the gut contents of the invertebrate predators (New 1991, Peckarsky 1982, Ward 1992). For two of the insect predator orders that were studied in my experiment, Plecoptera and Megaloptera, the prey consumed frequently varies. Plecopterans have been shown to mostly consume (in order of abundance): Chironomidae, Baetidae, Simuliidae, Heptageniidae, and Trichoptera. Megalopterans have been shown to consume Chironomidae and Ephemeroptera (reviewed by Allan 1983).

EXPERIMENTAL DESIGN

My experiment explored the direct effects of predatory insects on other invertebrates. The experiment involved experimental manipulations of predators to examine the effects on the prey populations in Tenderfoot Creek (Gogebic County, Michigan).

The experimental design for this project involved using ten, clear, butarate tubes. Two of the tubes were used as a control for the colonization period. The remaining eight tubes were divided into two sets of four. All ten tubes were used in a sequence of three successive experiments with three different predators. The first experiment was done with larval Plecopterans (Claasenia wu), the second experiment treatment involved larval Megalopterans (Corydalus latreille), and the third experiment used crayfish (Orconectes propinquus). In each experiment, four of the tubes were used as a control (no predators introduced) and the other four tubes contained introduced predators.

Each plastic tube was 22.86 cm long, 10.16 cm in diameter, and clear in order to allow light penetration. Both ends were covered with mosquito netting secured by rubber bands to allow water to flow through. Eight of the tubes were oriented in pairs along the stream margin, about 0.5 m separating each pair, and 10 cm between tubes. The remaining two tubes (the colonization/control tubes) were placed 1 m apart, about 20 cm from the other tubes. Each tube was held in place by small rocks from the stream bed piled around the sides. Each tube was filled with natural substrate to a depth of about 5 cm for a surface area of approximately 0.023 m^2.

SAMPLING APPROACH

The sampling approach included several different measurements. In order to test for effect of the invertebrate predators on other invertebrates, all ten tubes were allowed to colonize naturally for seven days. At the beginning of the experiment, the tubes were placed in the stream in pairs, without mosquito netting at the ends of the tube, and filled with natural substrate. Colonization was allowed to proceed for 7 days. During this time, the appropriate predators for that experiment were collected from various parts of Tenderfoot Creek. A study was done to estimate the density of predators in the stream. Three predators were used in each predatory tube. The average, individual size of Claasenia wu was 3 cm long, and the Corydalus latreille larvae were approximately 1.5-2 cm long. Orconectes propinquus crayfish were 6-7 cm long. At the end of the 7-day colonization period, the two tubes designated as the control/colonization tubes were removed and returned to the lab for analysis. For the remaining eight tubes, three individuals of the appropriate predator were placed in each of the four "predatory" tubes and mosquito netting was secured on both ends of the tube with rubber bands. The ends of "non-predatory" tubes were also covered with mosquito netting to control for changes in flow. These tubes were then left in the stream for three more days and removed at the end of a total of ten days. This procedure was then repeated for the second and third predation experiments.

Each tube was analyzed for invertebrate abundance and composition. The contents of each tubes, including the mosquito netting, was emptied into a pan, and the substrate was rinsed through a 250 μm screen. The interior of each tube and mosquito netting also were scraped (both sides of the mosquito netting were sampled because of the difficulty of obtaining only the contents of the inside of the netting). The material collected on the screen was then preserved in an appropriately labeled jar with 70% ethanol. This material was sorted and the invertebrates were counted and identified and placed into appropriate vials. Various statistical analysis were applied to the data to determine the invertebrate predators' effects on the populations of the other invertebrates.

RESULTS

Preliminary studies

The experiments were conducted in a riffle area in Tenderfoot Creek in the northern part of the UNDERC property. Because of the wet spring, the water level in Tenderfoot Creek was higher than normal for that time of the year (May 23-30, 1992). Near the center of the stream bed, the rocks were fairly large (approximately 5-12 cm in diameter) and judged too large for the tubes. Instead, the tubes were placed close to the stream banks and filled with the smaller, pebble substrate. In addition, the stream flow in the center of the stream was too fast and deep at this point in the summer to safely place the tubes there. The shallower area near the banks still contained swift water but the water depth was approximately 10-12 cm compared to 20-30 cm deep in the center.

I used a delta net and scuff net to sample the sediments for any predators or other invertebrates in this area of the stream. Individuals of Trichoptera, Ephemeroptera, and Odonata were found but no Plecoptera, Megaloptera, or Decapoda were found. The following day, a trial run of the experiment was performed. The tubes were placed in the water in pairs, marked with flags because of the tendency of the butarate plastic to become "invisible" under water, and secured with several large rocks. Natural stream substrate was placed in each tube. The following day, an additional riffle area of Tenderfoot Creek north of the UNDERC property was searched for predators. Numerous *Claasenia* stoneflies were found there, as well as two *Corydalus* hellgrammites. The tubes were checked daily to ensure that they were still secure and had begun to colonize.

Experimental Conditions

During the first experiment (June 11-20, 1992), the weather was sunny and warm (21-26°C) nearly every day. The stream level had declined since the beginning of the summer, and the experiment was run without complications. Three *Claasenia* stoneflies, from the north riffle of Tenderfoot Creek, were placed in the right-hand tube of each pair (for a total of 12 stoneflies). However, at the end of the 10-day period, three of the tubes contained freshly emerged, adult plecopterans, 1 from each of two tubes and two from a third tube. Either the stoneflies that were captured were ready to emerge or the conditions of the tube induced emergence. The tubes were placed in pans and taken back into the lab for analysis.

The second 10-day experiment was conducted from June 21-30, 1992, during which there were heavy rains. The air temperature was also colder, with temperatures of 4-10°C. Corydalus were collected from the original riffle of Tenderfoot Creek by using delta nets and scuff nets. The megalopterans were found in the center, deepest part of the stream. Megalopterans did not emerge within the tubes.

The third 10-day experiment was conducted with Orconectes crayfish from July 7-17, 1992. Days were sunny, with an approximate air temperature that varied from 16-26°C. The crayfish were captured using scuff nets and delta nets, and were approximately 6-7 cm in length. Many of them were found clustered in groups in the still, calm pools that are sometimes found at the edges of streams or created by debris in the stream. Three crayfish were placed in the right-handed member of each pair of tubes, for a total of 12 crayfish in the 4 enclosures.

Experimental results

Invertebrate data were later examined graphically and statistically, including total invertebrate density and densities of different groups of invertebrates. Some of the major types of invertebrates included larval Trichoptera (Brachycentridae and Hydropsychidae), larval Diptera (Simuliidae and Chironomidae), larval Ephemeroptera (Baetidae and Heptageniidae), and young stages of Plecoptera and Orconectes propinquus. In addition, bivalves and larval Lepidoptera were found.

Figure 1.1 shows the mean density and standard deviation of total invertebrates for (1) the colonization period of the Claasenia experiment (2) the predator treatment, and (3) the no predator control. The invertebrate density after the colonization period was relatively low, possibly related to the shorter time that those two tubes were colonized. The difference between invertebrate density in the tubes with and without Claasenia predators was not statistically significant (ANOVA p>0.05). Table 1 Fig 1.1

Figure 1.2 for the predator Corydalus suggests an increase in invertebrate density in enclosures with no predators. However, there was no statistical difference between the predator and no predator treatments (ANOVA p>0.05). Fig 1.2

Figure 1.3 shows results of the third predation experiment with Orconectes propinquus. Invertebrate density in the colonization tubes was intermediate between the two predator treatments. The tubes that contained no predators had higher mean invertebrate density than did the treatment with Orconectes crayfish (ANOVA p>0.05). Fig 1.3

Figure 1.4 shows the overall effects of predation, regardless of type of predator. The predation treatments significantly reduced total invertebrate density (ANOVA p=0.04). Thus, predation as a whole had a significant effect on benthic invertebrates in Tenderfoot Creek. Fig 1.4

I also examined the effects of the different predators on different groups of invertebrates (Figure 2.1). I determined the effects of predation on densities of Trichoptera, Diptera (mostly Simuliidae and Chironomidae), and Ephemeroptera. These insects were chosen because these were most abundant in the tubes. Trichoptera levels were fairly high during the 10-day experiment with Corydalus latreille, intermediate with the predator Claasenia wu, and extremely low for the final predator Orconectes propinquus. There was no statistical significant effect of any of the three predators on Trichoptera densities (ANOVA p>0.05). Fig 2.1

In the first two experiments (Claasenia and Corydalus) there were no significant differences in Dipteran densities across treatments (Figure 2.2). However, in the third experiment, Orconectes reduced mean dipteran densities, which was marginally significant (p=0.055). In general, the densities of Diptera larvae were higher in the crayfish experiment. Further, the crayfish seemed to exert a much greater influence over Dipteran densities than did the other two predators. Because of the apparent greater effect of Orconectes propinquus on the Dipteran densities, I also examined the responses in Simuliidae and Chironomidae densities (Figure 2.3). In the Plecoptera and Megaloptera experiments, the densities of Simuliidae were extremely low. However, in the Orconectes experiment, there were much higher densities of Simuliidae larvae, and crayfish had a greater effect on blackfly larvae. The effect of Orconectes predation on blackfly larvae was nearly significant (ANOVA p=0.058). Fig 2.2 & 2.3

Chironomidae were also abundant in the tubes (Figure 2.4). The overall densities of Chironomidae were higher in the first two experiments (Plecoptera and Megaloptera). There were no statistical differences in the Chironomidae densities for any predation treatment. Fig 2.4

The last relationship examines the responses in Ephemeroptera (Figure 2.5). In the first experiment (Plecoptera) mean Ephemeroptera densities were highest in the tubes with predators. However, there were no trends for the other two experiments. There were no statistical differences for any of the treatments (ANOVA p>0.05). Fig 2.5

DISCUSSION

Perhaps the experiment failed to show any significant difference between the invertebrate densities of the tubes containing no Claasenia versus tubes containing Claasenia because the experiment should have been designed to accommodate the faster, colder conditions needed by Plecopterans. The tubes were not sturdy or large enough to accommodate the natural substrate located in that stream area. Perhaps, the tube should have been enlarged to suit the conditions favorable for Plecopteran growth (allowing larger stones and deeper water). Since the tubes were placed towards the edge of the stream, the water was too slow moving and shallow, and the substrates found in the bottom of the tubes were too small. In addition, the mosquito netting attached on the ends of the tubes reduced stream flow.

Another problem might have been that the Plecoptera that were introduced from the north riffle area of Tenderfoot Creek were not able to adapt to the slightly new conditions of the riffle area in Notre Dame property. Therefore, these Plecopterans may not have been able to exert a strong predatory influence.

Some of the larval Plecopterans had emerged into adults during the 3-day predation period in the tubes. The closed conditions of the tube may have been conducive to emergence or the Plecopterans may have been close to emergence. This pre-emergence period may be a time in which the larvae do not exert much of a predation effect.

The species of invertebrates most consumed by the Claasenia may not have been present in great enough numbers in the Claasenia experiment. For example, Simuliidae larvae begin to develop in large populations during July, and are not as abundant in late May and June. Claasenia may have exerted a greater influence over invertebrates such as Simuliidae if more blackflies were present.

On the other hand, the small, closed, tube design of the experiment may have contributed to the predation effect exerted by Claasenia and Corydalus. For example, the other invertebrates in the tubes were not able to escape from them.

The crayfish used, Orconectes propinquus, seemed to exert the greatest predation effect. The crayfish had a number of favorable conditions. The water conditions of the tubes were suitable for the crayfish. The crayfish were found in slow moving parts of the stream towards the stream banks where the tubes were placed. The mosquito netting attached on the ends of the tubes also cut down on stream flow. In addition, the crayfish were larger than the other two predators. The large Orconectes propinquus may have been more mobile and able to consume more invertebrates. The size of the tube may have been appropriate for that size of crayfish needed to exert a significant predation effect.

In addition, July seemed to contain a "population explosion" of several kinds of larval invertebrates, such as larval Simuliidae. The significant consumption of Diptera by the crayfish is mostly due to the Simuliidae populations and not to the Chironomidae populations. Populations of larval Chironomidae decreased as the summer. However, these particular predators may also simply prefer the larval Simuliidae to the larval Chironomidae.

Another large constituent of the invertebrate population of the tubes were the Trichoptera. The larval Trichopterans increased slightly in June and then declined in July. However, the numbers of Trichoptera decreased so much in July that it was difficult to determine whether any of the predators "preferred" or exerted a significant effect on Trichoptera.

Ephemeroptera responses indicated that the tubes that contained predators had greater numbers of Ephemeroptera than the non-predator tubes. Perhaps the Ephemeroptera were not affected by these particular predators. However, in the Megalopteran experiment, many of the Ephemeropterans that were examined appeared to be torn into pieces. Another possibility is that these remains were the cast skins of Ephemeropterans. Perhaps Megalopterans did feed on the Ephemeropterans or perhaps the Ephemeropterans had simply emerged and the cast skins had accumulated in the tubes. Ephemeropterans also seemed to be most abundant in late May and June. During July, when the Orconectes propinquus were introduced, there were not enough larval Ephemeroptera to show a significant change.

The populations of the other invertebrates in the tubes were small. Therefore, it was difficult to determine whether predation exerted any effect on the other invertebrates.

A final statistical analysis was done for predation as a whole for the experiment. Predation, without any specificity of predator, had a significant effect on the total invertebrate community.

CONCLUSION:

I studied the effects of three different types of predators, Claasenia wu stoneflies, Corydalus latreille dobsonflies, and Orconectes propinquus crayfish, on the abundances of other benthic, invertebrates in a riffle area in Tenderfoot Creek at UNDERC. A wide variety of factors affected the predation by each predator species. Overall, the crayfish Orconectes propinquus exerted the greatest effect on invertebrates in the tubes. However, the results obtained from the experiment may not be representative because of the wide range of variable conditions, such as the choice of tube size, the placement of the tubes, the time period of the experiment, the choice of the predators themselves, as well as the measurement errors when working with such large numbers of invertebrates. This study was a satisfactory introduction for predatory invertebrates; however, for accuracy, the procedure should be improved.

This study suggested that predation influences benthic invertebrates in Tenderfoot Creek. Additional studies need to be conducted to determine the importance of predation in stream ecosystems. The loss of predators due to the increased pollution of streams and rivers could prove to be detrimental to stream and river ecosystems.

ACKNOWLEDGEMENTS:

I would like to thank Dr. Gary Lamberti for all of his assistance, time, and patience with my project. I would also like to thank Dr. George B. Craig Jr. for encouraging me to apply and attend UNDERC. In addition, I thank all of the UNDERC professors, especially Dr. Martin Berg, for providing such an interesting summer program for undergraduate students at Notre Dame. I would like to thank the other UNDERC students for all of the field assistance and support they provided. I would also like to thank The Bernard J. Hank Endowment for providing the funds for students to attend the UNDERC program.

LITERATURE CITED

Allan, J.D. 1983. Predator-Prey Relationships in Streams. pp. 191-221 in Barnes, J.R. and Minshall, G.W. (eds.) Stream Ecology: Application and Testing of General Ecological Theory. Plenum Press, New York.

Claassen, P. 1931. Plecoptera Nymphs of America (North of Mexico). Thomas Say Foundation by Charles C. Thomas Publisher, Baltimore Maryland.

Cummings, K.W. Merritt, R.W. 1984. An Introduction to the Aquatic Insects of North America-Second Edition. Kendall/Hunt Publishing Co. Dubuque, IA.

Lamberti, G.A. and Moore J.W. 1984. Aquatic Insects as Primary Consumers. pp. 164-195 in Resh, V.H. and Rosenberg, D.M. (eds.) The Ecology of Aquatic Insects. Praeger, New York.

McCafferty, P.W. 1981. Aquatic Entomology. Science Books International, Boston.

New, T.R. 1991. Insects as Predators. New South Wales University Press, New South Wales, Australia.

Peckarsky, B. 1981. Use of Behavorial Experiments to Test Ecological Theory in Streams. pp. 79-97 in Barnes, J.R. and Minshall, G.W. (eds.) Stream Ecology: Application and Testing of General Ecological Theory. Plenum Press, New York.

Peckarsky, B. 1982. Predator-Prey Interactions Among Aquatic Insects. pp.196-254 in Resh, V.H. and Rosenberg, D.M. (eds.) The Ecology of Aquatic Insects. Praeger, New York.

Resh, V.H. and Rosenberg, D.M. (eds.). 1984. The Ecology of Aquatic Insects. Praeger, New York.

Slobodkin, L.B. 1961. Growth and Regulation of Animal Populations. Holt, Rinehart, & Winston, New York.

Ward, J.V. 1992. Aquatic Insect Ecology: I. Biology and Habitat. John Wiley & Sons, New York.

Table 1. Invertebrate abundances (mean+SD) in three predation experiments

	Exp. 1	Exp. 2	Exp. 3
Invertebrates			
colonization	24830	24491	46132
Predator	35774	34833	30171
No Predator	44400	39012	54954
Trichoptera			
colonization	3533	14997	4820
Predator	13855	22855	1355
No Predator	18736	21730	2374
Ephemeroptera			
colonization	87	390	174
Predator	1824	910	133
No Predator	1273	1112	183
Diptera			
colonization	13920	11745	41195
Predator	22754	16206	28846
No Predator	19237	17808	52440

Simuliidae			
colonization	1088	2436	36061
Predator	2556	2016	26013
No Predator	1778	2998	52601
Chironomidae			
colonization	12833	9788	5133
Predator	20251	12992	5502
No Predator	17631	15492	7920

FIG.1.1: PREDATION EXPERIMENT 1- *Claasenia wu*
JUNE 10-20, 1992 (MEAN +SD)

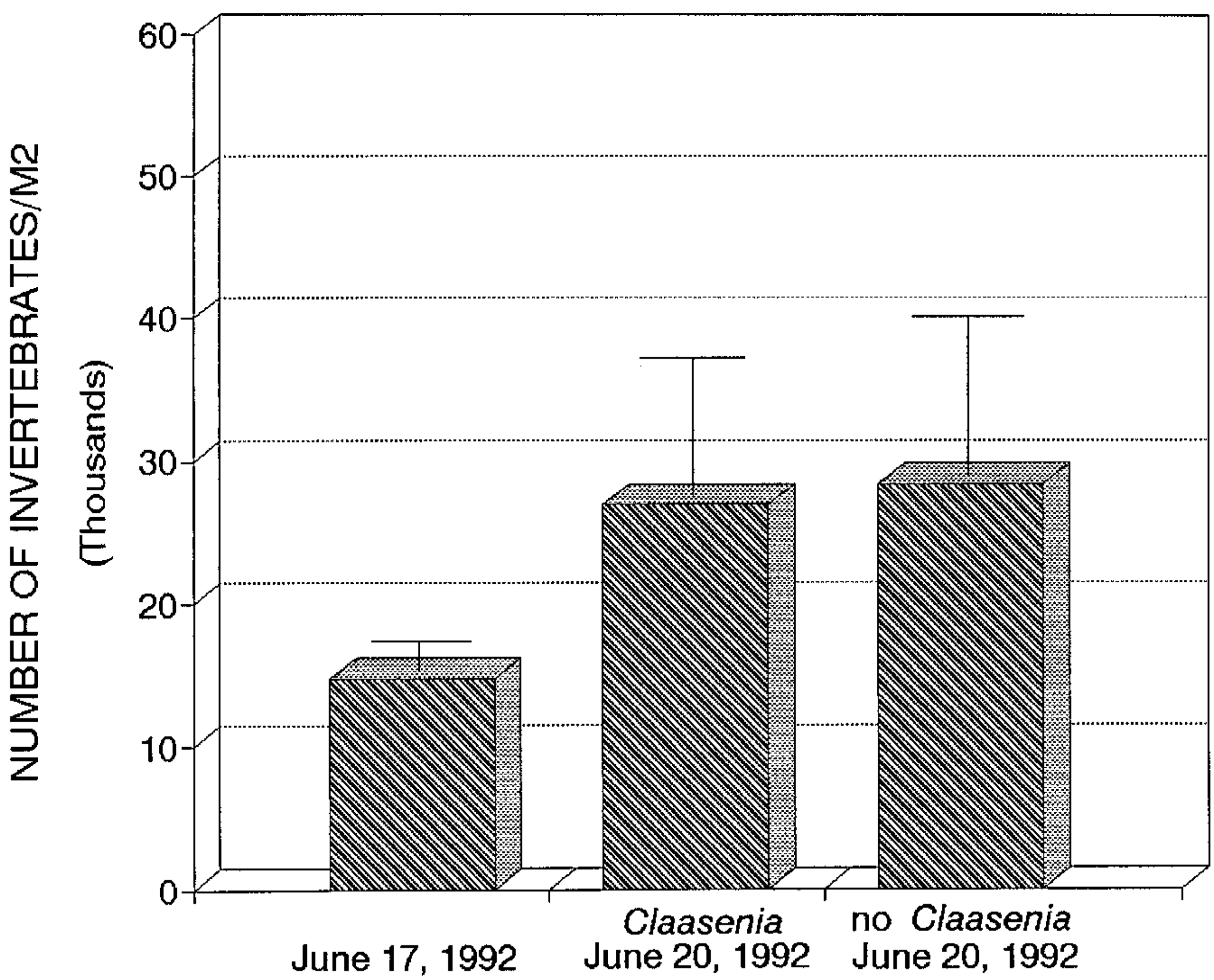

FIG. 1.2: PREDATION EXPERIMENT 2- *Corydalus latreille*
JUNE 20-30, 1992 (MEAN + SD)

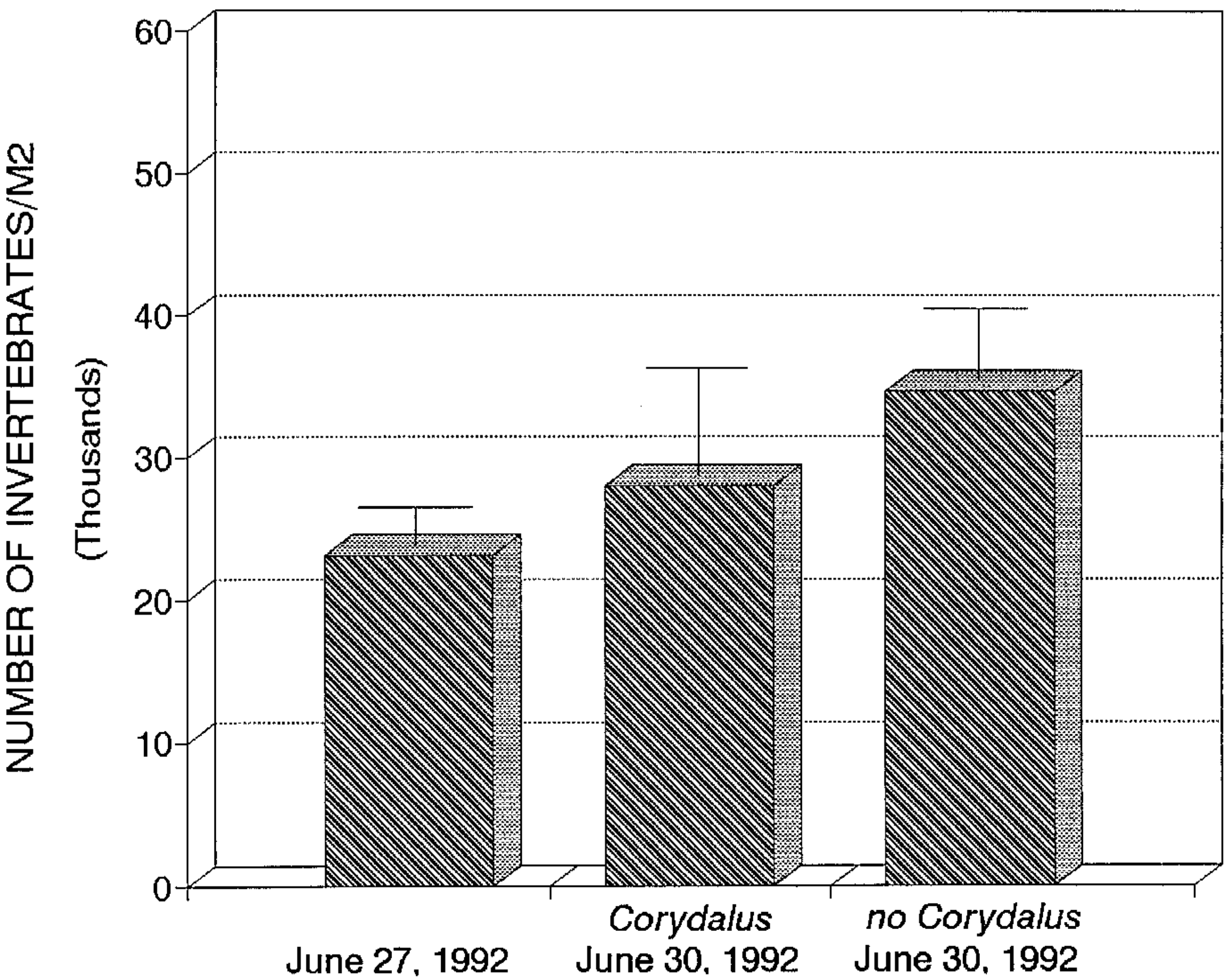

FIG 1.3: PREDATION EXPERIMENT 3- *Orconectes propinquus*
JULY 7-17, 1992 (MEAN + SD)

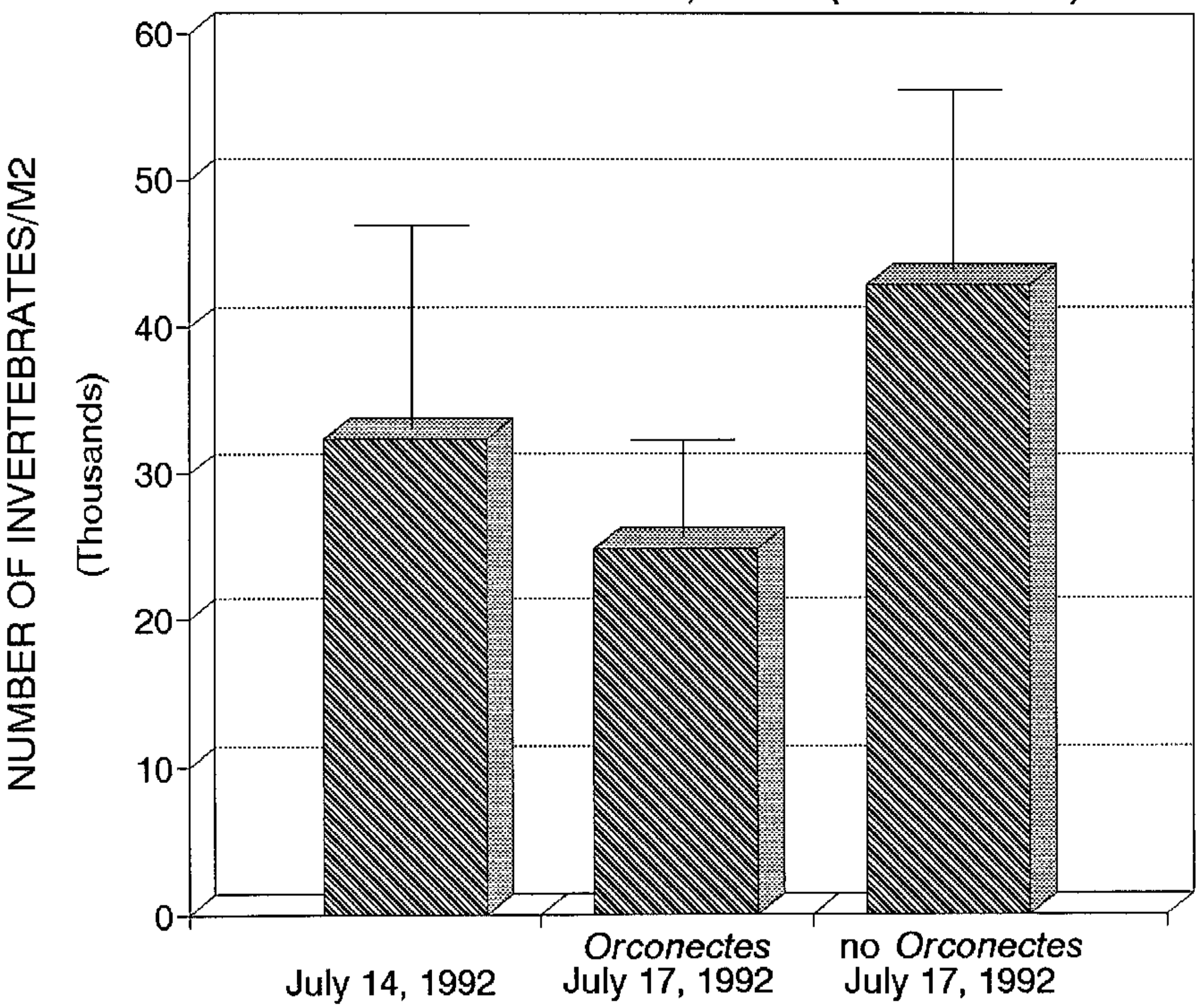

FIG. 1.4: GENERAL PREDATION
(MEAN + SD)

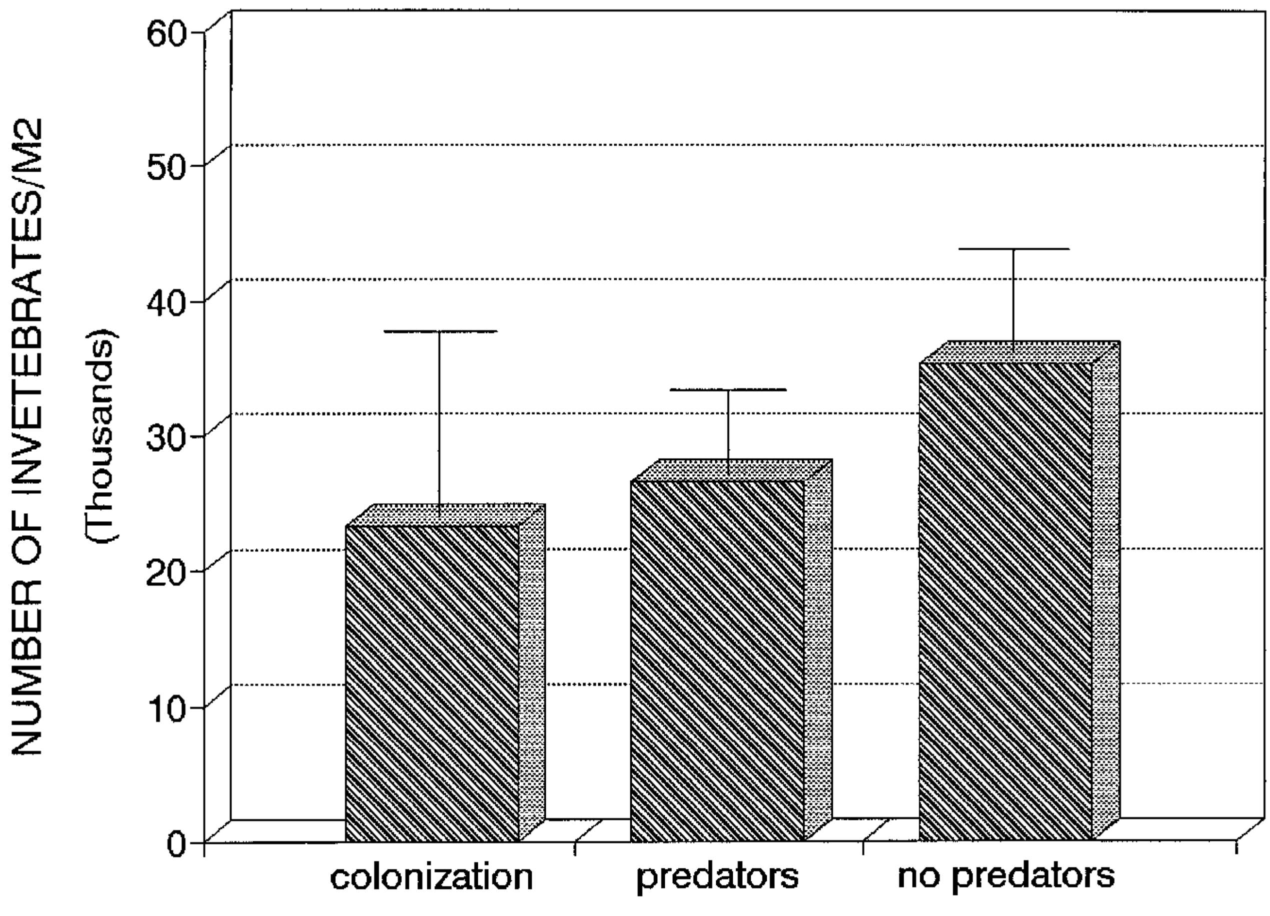

FIG. 2.1: Comparison of Trichoptera densities across experiments (Mean+SD)

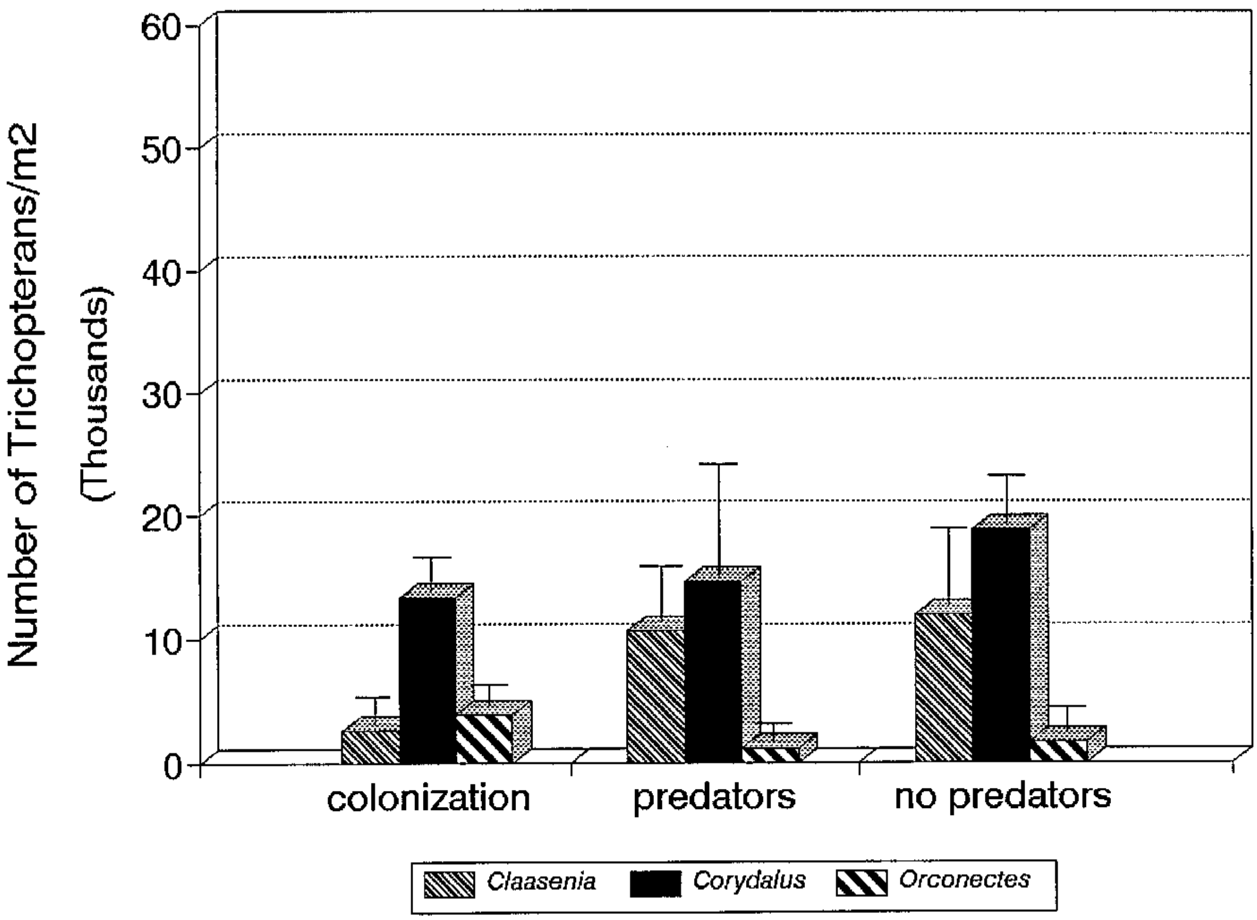

FIG. 2.2: Comparison of Diptera densities across experiments (Mean+SD)

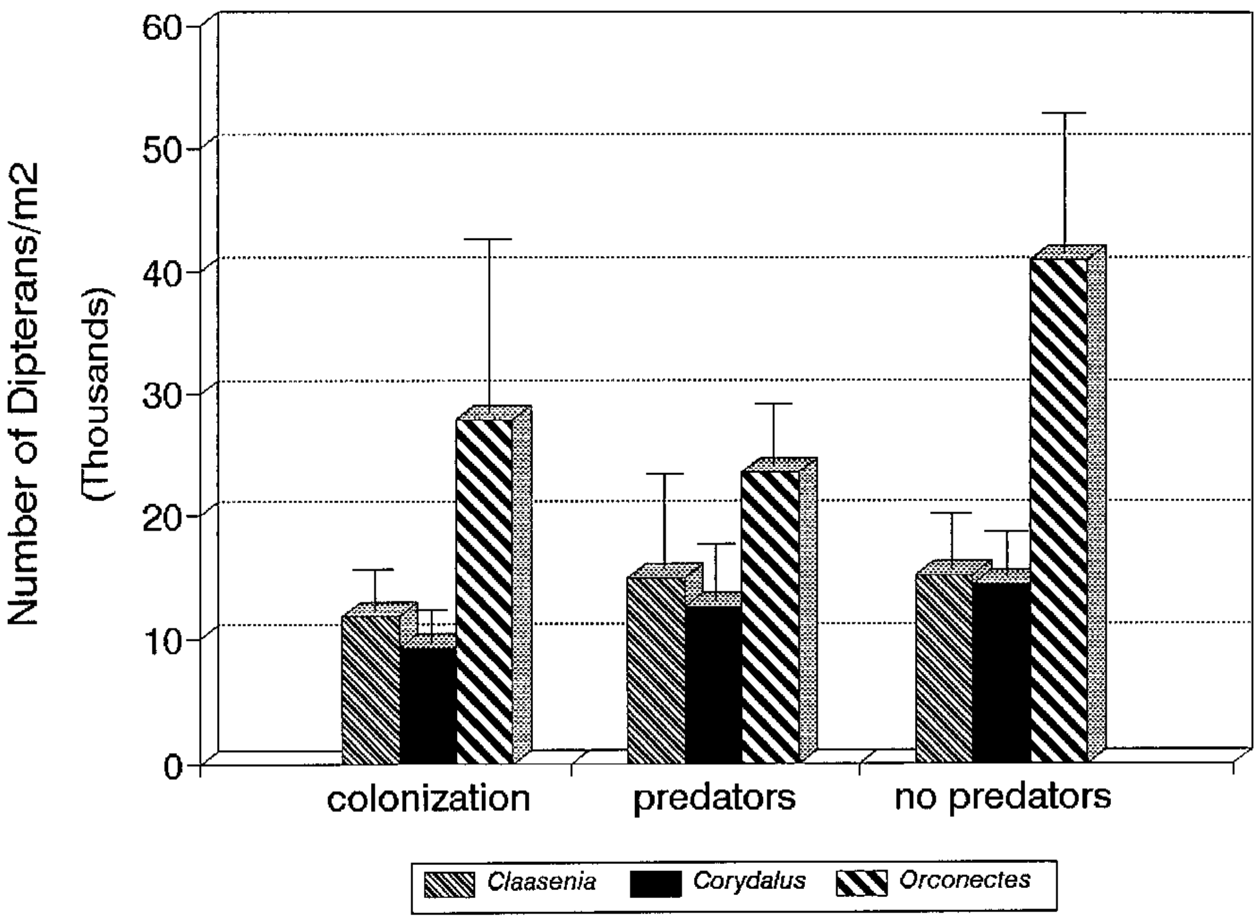

FIG. 2.3: Comparison of Simuliidae densities across experiments (Mean+SD)

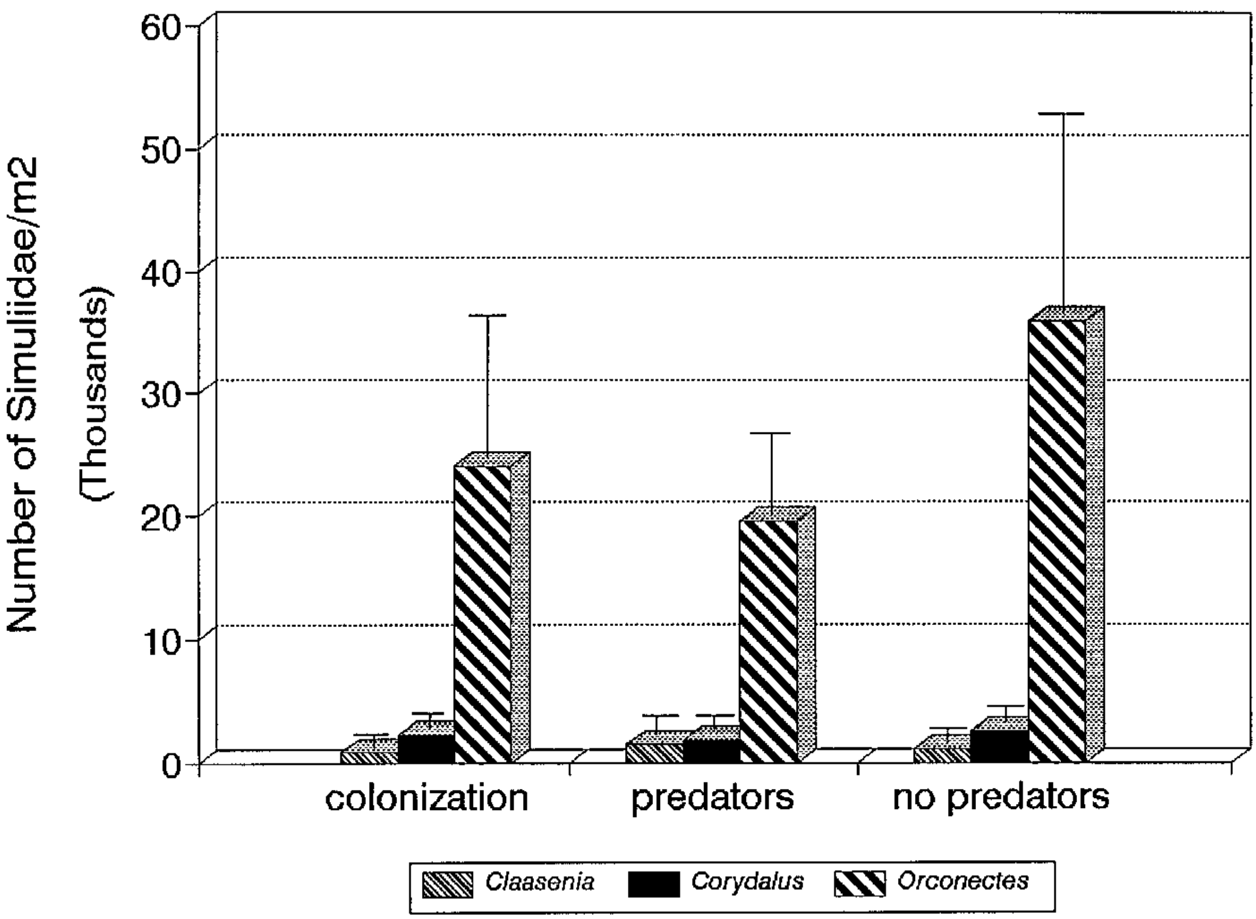

FIG. 2.4: Comparison of Chironomidae densities across experiments (Mean+SD)

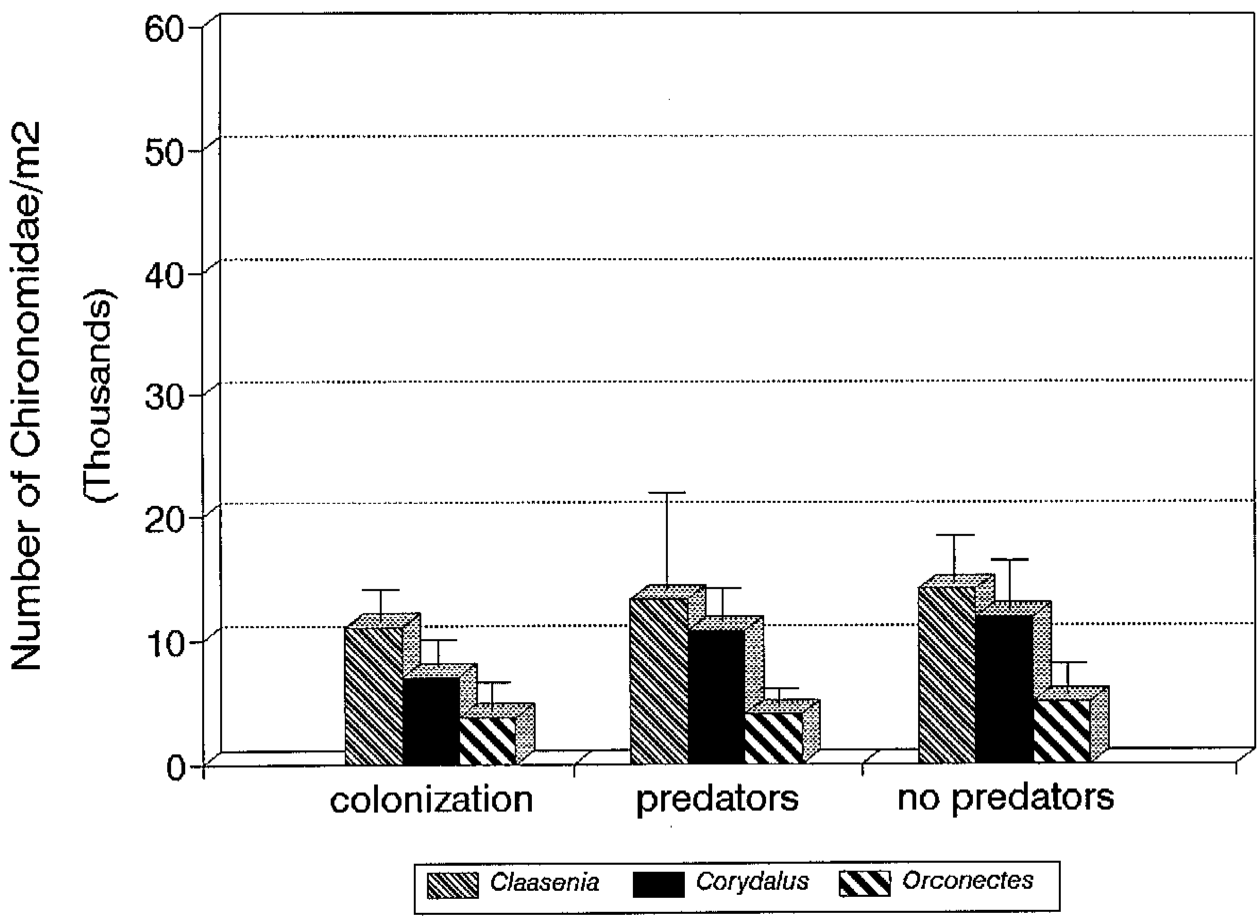

FIG. 2.5: Comparison of Ephemeroptera densities across experiments (Mean+SD)