Behavioral Responses of Two Populations of Hydropsyche Morosa (Trichoptera: Hydropsychidae) to Suspended Sediment Loads: Rock Substrate

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Abstract:

One of the primary hazards to North American stream ecosystem integrity today is the transport of suspended and bedload sediments. Suspended sediments have a substantial effect on stream organisms and are considered a form of stream pollution.. Most vulnerable to the effects of increasing and accumulating suspended sediments are the filter- feeding stream inhabitants, in the case of this experimental study *Hydropsyche morosa* (Trichoptera: Hydropsychidae). Individuals exhibited three net tending behaviors when subjected to the addition of leaf particles of varying sizes to artificial streams. This study examined the differing behavioral responses of *H. morosa* to induced suspended sediment loads. The results of this experiment indicate a significant trend of increasing net modification with increasing load in both Tenderfoot Creek and Trout Creek *H. morosa* individuals for all particle sizes. Also observed was a significant difference in the net tending behaviors of the *H. morosa* individuals from the two creeks. Two different rates of response to sediment addition were observed., however both insect groups show a general maximum rate of net modification.

Introduction:

One of the primary hazards to North American stream ecosystem integrity today is the transport of suspended and bedload sediments (Waters 1995). Suspended sediments are a major form of stream pollution and are ranked seventh on the list of most hazardous stream pollutants along with bedload sediment. Thus suspended sediment would have a substantial effect on stream organisms. Most vulnerable to the effects of increasing and accumulating suspended sediments are the filter- feeding stream inhabitants. Transported sediment will greatly interfere with food gathering and respiration a well as deplete resources, smother surfaces and cause sedimentation of interstitial spaces (Culp 1986, Edwards 1969, Graham 1990, Jones 1949, Nuttal and Bielby 1973, Resh and Rosenberg 1984).

Three orders of filter feeding aquatic larvae dominate in North American streams: Ephemeroptera, Diptera, and Trichoptera (Wallace 1980). The hydropsychidae family of Trichoptera are the most important in stream ecology due to their abundant numbers and contribution to secondary production in streams (Wallace 1980, Wiggins 1996). Runde (1999) found that *Hydropsyche morosa* exhibited three behaviors when subjected to the addition of leaf particles of varying sizes to artificial streams: no net modification, full net removal, or creating a hole in the filtering surface. Runde found that with increasing particle size there was a corresponding increase in net modification.

This study seeks to examine the differing behavioral responses of *H. morosa* to induced suspended sediment loads. In the field, the influence of increased transport of suspended sediment is quite difficult to measure, especially due to the impact of outside variables such as bedload sediment. Therefore laboratory artificial streams were utilized in order to more closely observe the effect of suspended sediments on *H. morosa* obtained from two separate streams and thus differing habitats, specifically fifth instar *H. morosa* . Only fifth instar insects were chosen for the experiment since differences in net architecture, preferred food, and microhabitat choices occur among varying sizes of Trichoptera (Culp 1986, Gore 1990, Reice 1990, Schlosser 1990). Sequential applications of leaf particles ranging from 0 to 1000 μm in size were added to the artificial chambers in order to determine the effects of particle size and load on the net-tending behavioral response of *H. morosa* and to compare these effects between the two stream habitats.

Materials and Methods:

For these experiments, Instar V of the *Hydropsyche morosa* larvae were collected from both Trout Creek (Vilas County, Wisconsin) and Tenderfoot Creek (Gogebic County, Michigan). The stream bottom of Tenderfoot Creek is almost completely composed of a large rocky substrate with almost no smaller sediment while Trout Creek is composed of both coarse and fine particular sediment. The artificial stream chambers were prepared as described by Runde (1999). Before the addition of insects the bed of each chamber was covered with small pebbles. Five to six insects were placed in each replicate stream and the chambers were filled with water from the same creek as the insects. Six replicate streams were used in this experiment. Insects were fed 20 mg of finely ground Tetra-Flakes and feeding was kept to a regularly scheduled time every other day. Water velocity and temperature were held constant at 23 cm/sec and 23°C, respectively.

For each round of sediment addition, *H. morosa* were given 2 days to construct their nets. After that the locations of all insects were mapped within the artificial chambers. Insects that had died or had failed to construct nets were removed from the experiment. Once insect mapping was completed, varying sizes of ground leaves (varying per round of experimentation) were added to the artificial stream chambers. Varying sizes of leaf particles were classified into five size ranges: <64 μm, 64-125 μm, 125-250 μm, 250-500 μm, and 500-1000 μm. Leaves were sifted into these size ranges using sieves with 64 μm, 125 μm, 250 μm, 500 μm, 1000 μm and 2000 μm mesh.

Twenty-four hours after sediment addition, the insects were observed to determine their reactions to suspended sediments. The responses of *H. morosa* larvae to the varying sizes of leave particles and load size were observed and classified into four different behaviors: no reaction/cleaning of net, drift, manipulation or death. All types of manipulation were grouped under one heading, however three types of active net manipulation were observed: cutting a hole in the surface of the net, detaching one side or total removal of the net. After daily observations an initial 0.1 grams and then 0.2 grams for each subsequent addition of the same size leave material were added to each chamber per day with the total amount of sediment added to each chamber being 0.9 grams. Insects that demonstrated active net manipulation as opposed to simple cleaning procedures were removed from the chambers and preserved in 70% EtOH.

Results:

Leaf particles <64 μm typically did not clog the nets of *H. morosa* from either Tenderfoot Creek (TFC) or Trout Creek (TC) except in limited cases. A significant difference was noticed between sites as TC insects demonstrated more drift and manipulation that TFC insects. However the difference was contributed by relatively small percentage of the total population of insects (Figures 1-3). No death occurred in this potion of the experiment.

For leaf particles 64-125 μm, there was definitely a significant difference in behaviors between the TFC and TC insects. Significant difference for all values was determined from the P values from two way ANOVAs for site, load and interaction (Nothing and Manipulation P values for site and load were all <0.001; Table 1). While drift and mortality were not significantly difference between the creeks, an increase in net modification was observed in the TC insects over increasing load and thus a correlative decrease in nothing/net cleaning behavior (Figures 4-7). For leaf particles 125-250 μm, there was also a significant difference in behaviors between TFC and TC (Nothing and Manipulation P values for site and load were all ≤0.001; Table 1). Again drift and mortality did not contribute significantly to the variance between sites. As with the 64-125 μm results, TC insects exposed to sediment additions of 125-250 demonstrated greater tendency to modify net structures with increasing load than did the TFC insects (Figures 8-11).

For leaf particles 250-500 μm in size, an increase in drift was noticed although there was no significant difference in amount between the two creeks. With this sediment addition, there was a loss of significant difference in net modifying behaviors between the two sites (Nothing: S= 0.632, L= <0.001 and Manipulation: S= 0.948, L= <0.001; Table 1). Both TFC and TC demonstrated about the same rate of net modification with increasing load (Figures 12-15). For leaf particles 500-1000 μm, neither drift nor mortality caused significant variation in observations. There was also no significant difference in net modifying behaviors between TFC and TC (Nothing: S= 0.213, L= <0.001 and Manipulation: S= 0.632, L= <0.001; Table 1). Significant difference still remains between load size however (Figures 16-19).

Discussion:

Unlike previous experimentation (Eschmann 2000), a significant difference in net manipulation was observed with an increase in load. For all sediment sizes excluding 0-64 μm and both sites, the P values determined from ANOVA analysis were <0.001, thus indicating that there was a very obvious correlation between *H. morosa* net modifying behavior with increasing load size. While only a small amount of sediment may be required to clog the net (Eschmann 2000), insects will tend to modify their net if the sediment addition is constant every 24 hours. In other words after a single addition of sediment the insects may clean a portion of the net and be content to wait and see if the suspended sediment transport continues. It may be proposed that *H. morosa* instinctively hesitates to modify their net in case the increased sediment transport and thus net clogging is only a temporary event. Eventual net manipulation due to increasing load size may also occur because constant particle addition will ultimately inundate the insect's home.

Both Tenderfoot Creek and Trout Creek demonstrated an increase in particle size generally lead to an increased in net manipulation. Drift and mortality, while important to note, did not demonstrate any significant trends between sites or over increasing load size. While a small amount of net modification was demonstrated at 0-63 μm for the Trout Creek insects, a threshold for net modification in Trout Creek insects was observed with particles greater that 64 μm in size. Addition of 64-125 μm particles caused an increase in net modification by 0.9 g load from 3.3% to 57.3%, an over 17-fold difference. This sharp change in insect response may be due to the size of net's mesh. Perhaps the nets spun by the Trout Creek insects contains holes of widths in the range of 64-125 μm. Mesh of this size would allow for smaller (0-64 μm) particles to flow through while larger particles would become trapped causing a response from the *H. morosa*. More experimentation is required to determine the actual size of the mesh as it is unknown at the present, however it can be hypothesized that the size of the mesh may be closer to the 64 μm end of the range due to the observed slight manipulation in the 0-64 μm experiments.

The net modification threshold for Tenderfoot Creek insects was slightly greater than in Trout Creek. A gradual increase in net manipulation occurred from 125-1000 μm (high manipulation was observed in the later sediment additions of 64-125 μm, but this is most likely due to load size and not particle size) These observed reactions to increasing particle size do not mimic the threshold-type response seen in Trout Creek insects, however a threshold can be determined to some extent by examining the data for 0.1g additions between particle size. Between 125-250 μm and 250-500 μm there is an increase in net modification from 3.3% to

19.7%, a 6-fold difference. Thus it can be inferred that the threshold for net manipulation may occur somewhere around 250 μm . However it may also be hypothesized that there is no particular threshold for Tenderfoot Creek insects. Insects in Tenderfoot Creek are accustomed to higher sediment loads as well as limited materials with which to build homes than Trout Creek insects. Therefore Tenderfoot Creek insects may be more adapted to constructing smaller and more poorly built nets that can be modified or removed in the event that accumulation occurs. A gradual increase in net modification would then be observed with increasing load and increasing particle size. Despite this gradual versus sharp threshold net modification observed between Tenderfoot Creek and Trout Creek, both groups of insects demonstrated the same rate of net modification in the upper particle sizes (250-1000 μm). Thus there must be a maximum rate of modification amongst all *H. morosa*.

In summary the results of this experiment indicate a significant trend of increasing net modification with increasing load in both Tenderfoot Creek and Trout Creek *H. morosa* individuals for all particle sizes. Also observed was a significant difference in the net tending behaviors of the *H. morosa* individuals from the two creeks. The insects in Trout Creek demonstrated net modifying behavior with additions of particle sizes from 64-1000 μm. The sharp threshold between nothing/net cleaning behavior and net modification is probably due to the size of the mesh in the insects' nets with the threshold being somewhere around 64 μm. Tenderfoot Creek insects did not demonstrate significant net modifying behaviors until 125-1000 μm and through that range there was a gradual increase in net modification probably due to greater inherent tendency to modify their nets. However both insect groups show a general maximum rate of net modification. While the results of this experiment are a good first step, more experimentation is necessary in order to determine why exactly manipulation of net structures occurs in these two insect groups.

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