

Energy Fluxes of Terrestrial and Aquatic Invertebrates in the East River

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Abstract

Climate change is increasing temperatures globally including aquatic habitats like rivers, directly affecting the biology of many invertebrate species. In freshwater ecosystems, snow melt drives rivers in the Rocky Mountains of Colorado. Increasing river temperatures can result in increasing metabolism, and thus prey demand for riverine fishes. Climate change may also affect the temporal dynamics of prey availability by effects on aquatic insect development, which is accelerated under warm conditions, creating mismatching in prey demand and prey abundance. Trout may compensate by feeding on terrestrial prey. Energy flux change throughout the summer season in rivers the temporal dynamics of terrestrial invert fluxes to streams and comparing to the proportion of terrestrial inverts in trout diets. EPT (Ephemeroptera, Plecoptera, and Trichoptera) and Non-EPT (Coleoptera, Hymenoptera, Orthoptera ect.) had close measurements, potential conflicts were weather which was not to be expected. Benthic samples showed the opposite of what was expected because there was an increase over time due to diatom growth. The study is still in progress to become more knowledgeable on how energy fluxes can change River Food webs.

Intro

Climate change has altered environments in the Western United States by human influence (Harper and Peckarsky 2006). In the Rocky Mountains of Colorado, significant abiotic changes have caused enormous influences in biotic components. River ecosystems are impacted by air temperature and snowpack's which create precipitation. Over the past century snowpack density has decreased due to warmer air temperatures (Brown et al. 2007). This has caused shallow rivers, which increases sun absorption effecting river temperatures (Harper and Peckarsky 2006). Temperature and light changes with the seasons (Nakano et al 2001) and as temperatures rise, it offsets the seasons for many animal's, dependent on it.

Aquatic invertebrates that go through nymph stages depend on water temperatures for development (Briers et al. 2004). In the Rocky Mountains of Colorado, rising temperatures cause early development in insects such as Ephemeroptera, Coleoptera, and Diptera. Mayflies in the order of Ephemeroptera, larvae are influenced by spring temperatures, and when the seasons change from winter to spring, river temperatures rising causes the flies to develop faster and emerge into their adult terrestrial stages (Briers et al. 2004). Invertebrates emergence have been observed in early July, and in normal years' emergence happen during mid/late July (Harper and Peckarsky 2006). Larger mayflies (females) can carry more eggs, and females are attracted to larger males. This rapid development causes their metabolism to increase by a way of respiration and the energy used for growth is then used for maintenance, the lower the respiration the larger

the body mass changing their phenology (Vannote and Sweeney 1980). Hydrology influences aquatic communities and populations, fitness and fecundity is directly effected, causing it to increase or decrease (Harper and Peckarsky 2006). Rapid growth also causes other issues to arise because these invertebrates are dominant and serve ecological functions, such as filter feeding, and the consumption of algae and leaves which plays an importance on trophic structures (Vannote and Sweeney 1980).

Increasing growth rates don't only effect body mass, but cause nonsynchronous growth rates between female and male mayflies. This phenomenon effects reproduction success by lowering the population and can eventually lead to these animal's extinction (Vannote and Sweeney 1980).

Population dynamics are influenced with predator-prey interaction (Burgmer et al. 2007). This can cause a collapse in the ecosystem because less invertebrates in the water decreases prey and the consumption of algae (Harper and Peckarsky 2006). When habitats are not synchronized this can cause a shift with energy flux (Nakano and Murakami 2000), changing the energy budget for these species (Nakano and Murakami 2000), and can force some to change their behavior by a way of finding a new energy source. Other studies are being done by RMBL (Rocky Mountain Biological Laboratory) scientist studying how river flow and peaks effect animal abundance (Demi et al. in review). To start off, these research questions were asked; What are the temporal patterns of terrestrial insect input and benthic patterns in the East river? How does the energy flux change throughout the spring and summer seasons in rivers, in Gothic Colorado? I predict that during the early summer, aquatic insects are more abundant, and as the season progresses into late summer, the biomass in the river will empty out and more terrestrial insects will emerge

Methods

Data was obtained from the East River in Gothic, Colorado location center -106.994° 38.963° in Figure 1. Location point center (-106.994 38.963) shown in figure 1. To measure terrestrial energy input by way of invertebrates (fish prey), 20 plastic pan traps (36.195x20.955x12.395 cm) were mounted on metal rebar (figure 2), among five randomly selected transects in the East River., At each transect, 4 traps were deployed, 2 are at the stream edge and the other 2 placed in the middle of the stream (example on figure 1 and 3). Another set of 20 plastic pans where placed in the mounted tubs with 2-3cm of river water added. Next, 2-3 squirts of non-scented, colorless soap was added to all pan traps to break the water tension to prevent terrestrial invertebrates that got caught from escaping. To collect, 4 pan traps from each transect are pooled (5 samples), then trapped using a 250-micron sieve, and rinsed sieve contents will be put into a sample bottle and frozen/ refrigerated, depending on sample processing date. Samples are then frozen and will be identified under magnification glasses for 2 level identifications, aquatic (adults or juvenile) and terrestrial (adults). Invertebrates will be organized by order (i.e. Coleoptera, Diptera, etc...). Invertebrates will be put in a dry oven, then biomass will be measured 2-3 times a week.

Benthic sample were collected with a drift net, in the same location as the invertebrate input samples randomly. Samples were then put into ethanol to preserve, then taken to the lab and rinsed with water in a 250-micron sieve to remove rocks, to leave organic matter. The sample was then separated under a 0.63x magnification from invertebrates and CPOM (coarse

particulate organic matter). Invertebrates are put into a glass vile filled with ethanol, and counted.



Figure 1

East River at Rocky Mountain Biological Laboratory, Gothic Mt, Gunnison County, Colorado, USA

Results

Statistical data was done in ANOVA and graphs were calculated in excel and “R” program. In figure 2 there was significance in the comparison to EPT and Non-EPT invertebrates inputs in the East River. EPT (pvalue = 0.0434; F value= 4.411; Mean sum= 2.0308×10^{-4}) and Non-EPT (pvalue = 9.73×10^{-5} ; F value= 19.64; Mean sum= 9.297×10^{-4}) were measured in grams per day. Weather patterns created conflicts on days of heavy rain which effected the input from the East River.

In graph 3 an ANOVA test was ran through the program “R” (pvalue= 0.00174) for the graph divided by Order, and it showed differences amongst the groups. The order was grouped over the span of the experiment, and “R” showed that Diptera and Trichoptera were the most abundant for insect input.

Benthic samples which measured larval aquatic insects had no ANOVA test done because there were only 2-4 samples processed, and a single sample processed around July 15th date. This created fewer replicates of the data. The high spike at the end of the graph represents the single sample with very dense Didymo and increased invertebrate counts.

Discussion

The temporal patterns between EPT and Non-EPT were similar and unexpected. The study had potential conflict due to the Monsoon which is a natural annual occurrence in the Rocky Mountains of Colorado, but 2021 brought abnormal weather patterns, with heavy rains that lasted for 2-3 days at a time. In figure 2 the weather patterns can be seen and the dips in the graph around July 12th, July 19th and into August. The rain decreased the input of flying invertebrates in the East River. As the season progressed EPT invertebrates decreased as the summer season progressed which was expected. What was not expected was the Non-EPT decreased over time due to the EPT invertebrates becoming terrestrial increasing the input. Invertebrate input in the East River is still being researched.

The ANOVA test concluded that there was significance in the difference of Order input seen in the bar graph in figure 3. Diptera and Trichoptera were the most abundant input amongst all the orders. However, Ephemeroptera came in third, and I think that is due to body mass being less dense than Trichoptera. This graph also shows the variety of orders input into the East River, but, Orthoptera (grasshoppers) were at a very low input which was surprising due to their abundance onsite at RMBL. We think that the traps themselves may be too tall, and that they should be more leveled with the river's surface to get a better input of all the orders.

For Benthic samples in graph 4 did the complete opposite of what was to be expected. Since a lot of invertebrates in the river are aquatic during their juvenile stage and adults during aquatic stages, I expected for them to taper out like the EPT line on graph 2. The Benthic sample had no ANOVA test run on them because there were not enough replicates of data collection. Samples were between 2-4 collections and around July 15th where there is a high spike on the graph, was a single sample. What made this single sample different from the others, was the amount of *Didymo* (diatom), found in the East river later in the summer, and it had attracted a large population of midges which took over most of the total insects per meter². An emptying out effect was expected in this graph.

In other studies, *Baetis bicaudatus* development was monitored in warmer versus ambient waters, and found out that warmer waters speed up metamorphosis (Harper and Peckarsky 2006) which would speed up the "emptying out effect" previously mentioned in the paper. A significant higher mortality rate was also observed in warmer waters over time, decreasing the population density of the *Baetis* (Harper and Peckarsky 2006). In comparison to this paper, if benthic invertebrates particularly mayflies are decreasing, metamorphosis stages are speeding up due to warmer waters, which is created from climate change, their predator's trout will have to increase their terrestrial food source to keep up the population. If the trout can not keep up with increasing their food source to terrestrial invertebrates, their population will start to decrease, and can be endangered to extinction. Snow packs decreasing density, causing altering river temperatures over time, and can be changing phenology in the River food webs.

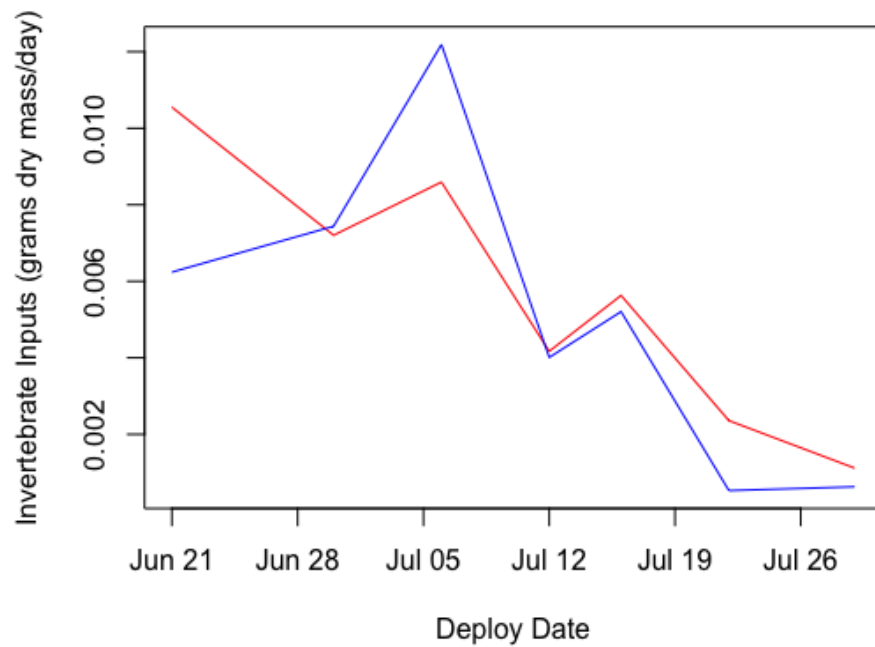


Figure 2

EPT and Non-EPT input by dry mass over a time span with flux changes over time. The input was measured by grams per day over an 8-week span during the months of June and July.

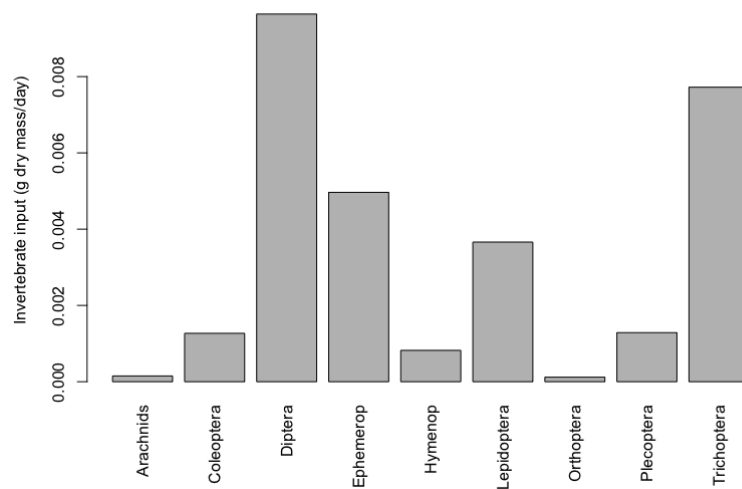


Figure 3

Order of Invertebrate input in the East River calculated by grams in dry mass per day. Diptera and Trichoptera are the most abundant inputs in this study.

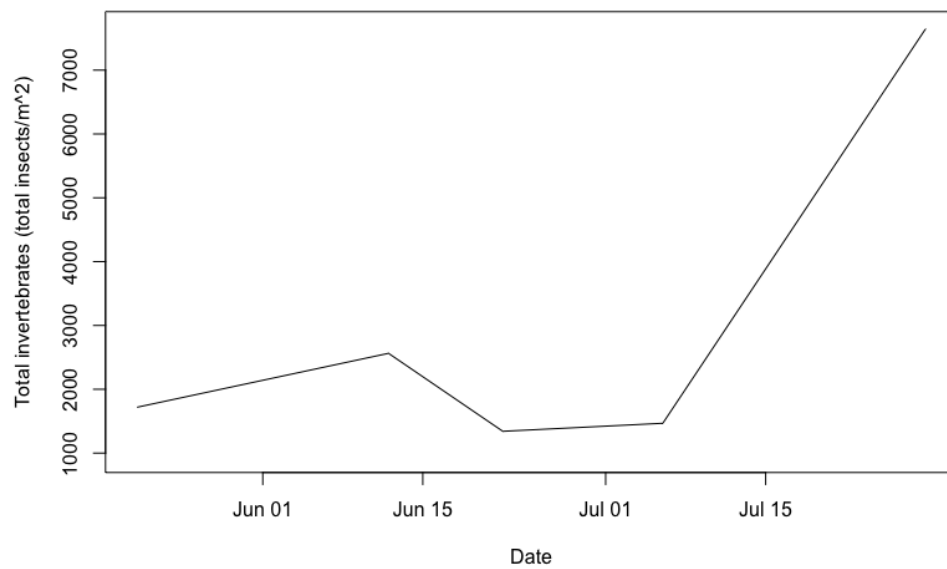


Figure 4

Benthic/Larval invertebrate sample total, measured per meter square. Samples of 2-4 were taken and on the last sample around July 15th one sample was taken, and the spike is due to a large density of Didymo.

Acknowledgements

NSF REU, RMBL, etc. NSF DEB grant #

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