

Leaf preference and choice of the macroinvertebrate shredder *Potomonautes emini* in Gombe Stream National Park, Tanzania.

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Introduction

Stream ecosystems rely heavily on the input of allochthonous organic matter, such as leaves, as a primary source of nutrients. Within the macroinvertebrate community, shredders are an essential component in the process of leaf litter breakdown in streams and are largely responsible for the conversion of coarse particulate organic matter (CPOM) into fine particulate organic matter (FPOM) (Rincon and Martinez 2006). Many other chemical and biological factors, including water temperature, nutrient concentrations in the leaf, and microbial activity, influence the rate at which particular leaf species break down in a stream (Peterson and Cummins 1972). Furthermore, these factors have a direct relationship to the subsequent colonization of leaf litter by macroinvertebrate shredders (Peterson and Cummins 1972). In particular, it has been observed that shredders feed preferentially on certain leaf species according to the microbial community established on a leaf (Peterson and Cummins 1972). The rate at which leaves are conditioned by microbes in a stream is dependent on the composition of different nutrients and compounds in the leaf (Rincon and Martinez 2006). In temperate streams, colonization of different leaf species by invertebrate shredders varies substantially, depending on the rate at which available leaves breakdown (Peterson and Cummins 1972). However, little experimental support exists for preferential feeding of different leaf species by the macroinvertebrate community in tropical stream ecosystems. Rincon and Martinez (2006), found that *Phylloicus sp.* larvae actively discriminate between various native leaf species differing in chemical composition in a second order stream located in northwestern Venezuela. *Phylloicus* larvae selected leaves with high N and P concentrations and low polyphenol and lignin concentrations, while rejecting leaves having low N and P levels and high amounts of polyphenols and lignin (Rincon and Martinez 2006).

The amount of research performed on leaf preference by shredding invertebrates in tropical streams is extremely limited (Rincon and Martinez 2006), and even more limited on the tropical streams of Africa. However, it has been observed that invertebrate shredders are found at significantly lower concentrations in tropical streams compared to the shredding community found in temperate streams (Dobson et al. 2003). Assuming allochthonous resources provide the primary input of energy in tropical streams (Benstead 1996) and that those resources vary substantially in nutrient and structural composition and microbial colonization, I predict that shredders will display a preference for certain leaf species while rejecting others. The watersheds comprising Gombe Stream National Park, Tanzania were used in this experiment to observe the significance of leaf preference among the invertebrate community. Very little is known about the behavior of macroinvertebrate shredders inhabiting these streams and their significance in the process of leaf litter breakdown. Specifically, the aim of this study was to observe the behavior of the crab *Potomonautes emini* in the laboratory to determine its ability to discriminate between provided leaf species. It is also assumed that selected leaves vary in nutrient composition and will therefore impact the microbial community and preference by shredders.

Methods and Materials

Field Experiment

Two small (*Monanthotaxis poggei* Eng. Diels & Species B) and two large (*Tabernaemontana pachysiphon* staph. & *Ficus vallis-choudae* Del) leaf species were selected by assessing the dominant vegetation in the riparian zone and the common leaf litter observed in three streams at Gombe Stream National Park, Tanzania. Leaves were picked directly from riparian trees at Mkenke and Rutanga streams to minimize variation in initial nutrient composition. Leaf decomposition bags were constructed from 210D/2 ply twine with one-inch mesh nylon fishing net and fishing line. Initial leaf bag mass differed between species and was approximately 3.00 g (*Monanthotaxis poggei* Eng. Diels), 5.00 g (spp. B), 30 g (*Tabernaemontana pachysiphon* staph.), and 10 g (*Ficus vallis-choudae* Del.). Four single species leaf bags were made and organized into replicates of four consisting of one leaf bag per

species. Sixteen identical leaf decomposition bags were made for each species to account for handling loss of the leaves.

Each replicate was tied to a fishing line and placed in the Rutanga stream on Day 0 (July 15, 2006). Replicates were anchored to existing vegetation along the bank of the stream and contact with the stream substrate was ensured by placing rocks on top of the fishing line. Four replicates were collected on the third, sixth, ninth, twelfth, fifteenth, eighteenth, and twenty-first day for a total of twenty-one days. Leaf bags were collected by placing a zip-lock bag over the leaf packs in the stream and cutting the attachment string. Leaf bags were transported back to the laboratory in stream water where they were subsequently washed with tap water for collection of macroinvertebrates. All macroinvertebrates were sorted and preserved in 70% ethanol and later identified to their highest possible taxonomic classification.

Leaf Preference Experiment

Leaf preference experiments were performed in nine circular plastic benthic macroinvertebrate stream chambers. Fine mesh screen was secured over all chambers and any areas where the crabs could trap themselves were covered. Approximately 700 milliliters of unfiltered stream water, collected from the same stream crabs were taken from, was added and aerated with aquarium pumps at a constant rate. Fresh stream water was collected at the beginning of each experiment. The same leaf species were used in the leaf preference experiment as in the field experiment. Leaves were also picked directly from living trees in the riparian zone of the streams. All species were then conditioned in the stream for approximately seventy-two hours and then transferred back to the lab in stream water. 10 cm² leaf discs from each of the four species were cut and placed individually over marked bent paperclips to anchor the leaves to the bottom of the chambers. All chambers contained one leaf disc of each species. Leaves were haphazardly placed in the chambers to avoid leaf preference based on accessibility. Initial wet and final dry mass of ten leaf discs of each species and initial wet and final dry mass of experimental leaves was taken to determine the mass loss (g) of each leaf disk after the leaf preference experiment. Leaves used for dry mass were placed outside to air dry until weight was stable.

Crabs were collected from Rutanga and Mkenke streams using a Surber sampler and transported back to the lab in stream water. Crabs were weighed, placed in a chamber, and allowed to feed for three days or until one leaf disk was completely shredded. One chamber during each experiment was designated as a control to account for decomposition by microbial factors and disturbances caused by the chambers/handling.

At the end of the experiment, leaf discs were carefully removed and placed on a sheet of plastic. Immediately following removal, all leaf discs were scanned into Adobe Photoshop 6.0 to be analyzed for surface area loss (cm²) using ImageJ software. Leaf discs were then placed back on aluminum foil in a tray and covered with fine mesh to be air dried for final dry mass (g).

Results

Within the four species of leaves, *Tabernaemontana pachysiphon* staph. was the only species to differ significantly from the others in all tests. The surface area loss (cm²) was found to be significantly greater in this species compared to the other three species of leaf (F=13.7769, p<0.0001). A comparison for all leaf species using Tukey-Kramer HSD also showed that only *T. pachysiphon* staph. differed substantially in surface area loss (Fig. 1). Percent surface area loss was also found to be greatest among *T. pachysiphon* staph. (F=13.0335, p<0.0001) and a Tukey-Kramer HSD supported the findings that *T. pachysiphon* was the only species to differ significantly from the others (Fig. 3).

Similarly, a comparison of mass loss (g) by leaf species showed a significant decrease in *T. pachysiphon* staph. (F=29.3555, p<0.0001), while *Ficus vallis-choudae* Del., *Monanthotaxis poggei* Engl. Diels, and Species B only decreased slightly in mass (Fig. 2). However, percent mass loss by leaf species, using Tukey-Kramer HSD, showed no significant difference between *T. pachysiphon* staph. and *F. vallis-choudae* Del. (Fig. 4). A considerable difference was observed in the percent mass loss when *T. pachysiphon* staph. and *F. vallis-choudae* Del. was compared with *Monanthotaxis poggei* Engl. Diels and Species B (Fig. 4)...

Discussion

Although leaf preference has been observed among shredding invertebrates extensively in temperate streams and some evidence found in the tropical streams of South America (Rincon & Martinez 2006), these findings have not yet been attributed to the tropical streams of Africa. Our data is the first to suggest preferential feeding of leaf detritus within the tropical shredder community of East Africa. Our results indicated that, when given a distinct choice, *Potomonautes emini* clearly discriminated between provided leaf species. For instance, in all cases, *P. emini* was observed to only select *T. pachysiphon* leaf disks while rejecting the three other leaf species. This

preference was clearly illustrated by the significant reduction in surface area of *T. pachysiphon* leaf disks accompanied by the minimal surface area loss seen in *F. vallis-choudae*, *M. poggei*, and Spp. B leaf disks. Furthermore, *T. pachysiphon* leaf disks also experienced substantial mass loss during experiments compared to the alternative leaf disk choices. However, mass loss was still significant even in the absence of *P. emini*, showing that other factors were responsible for much of the mass loss in leaf disks. Peterson and Cummins (1974) found that a large percentage of weight loss in leaves occurs by the leaching of nutrients into the stream. Based on observations of the leaves in the absence of *P. emini*, the drastic changes in *T. pachysiphon* from a thick, leathery leaf at the beginning to a very soft and fragile condition after the experiment may have made it more susceptible to shredding by *P. emini*. These physical changes seen in the leaf possibly signify greater microbial activity and therefore, higher nutrient concentrations.

The apparent preference observed for *T. pachysiphon* was likely induced by the specific characteristics of the organic matter in the leaf (Peterson and Cummins 1974) and by microbial conditioning (Triska 1970 and Mackay & Kalff 1973 as cited in Peterson and Cummins 1974). These studies both illustrated a preference by invertebrate shredders for leaves colonized by microbes as opposed to leaves lacking microbial activity. The differential rate of microbial colonization between species allows various leaf species to become available as a food source for shredders at distinct times in the stream (Peterson and Cummins 1974). The fast breakdown rate of *T. pachysiphon* relative to the other leaf species observed in the field (Forsyth Nyanza 2006) and in the laboratory was likely an indication of rapid microbial conditioning, which would have made it available as a resource to *P. emini* before any other leaf species. Provided sufficient time, *F. vallis-choudae*, *M. poggei*, and Spp. B may have become an acceptable food source after sufficient microbial conditioning has occurred. The fast microbial conditioning time associated with the rapid breakdown rate of *T. pachysiphon* indicates high leaf quality of the species, which further supports the preference of *P. emini* for this species.

These findings are consistent with the results of other leaf preference experiments, such as Rincon and Martinez (2006), in which tropical shredders were found to actively select for particular native leaf species. It has been suggested that *P. emini* was a dominant shredder in the stream systems of Lake Tanganyika, but very little was known about the actual behavior and role of this species. Through this research, it can be concluded that *P. emini* contributes significantly to the breakdown of leaf detritus and actively selects among available leaf species in Gombe Streams National Park. More research on *P. emini* needs to be conducted using different leaf species conditioned for varying lengths of time to determine other important components of their diet and the rate at which food resources become available to the system. Although this study indicates that discrimination among leaf species exists in the tropical shredders of East African streams, future research on how other invertebrate shredders function in these systems must be performed before this assumption can be applied to the shredding community as a whole.

Acknowledgments

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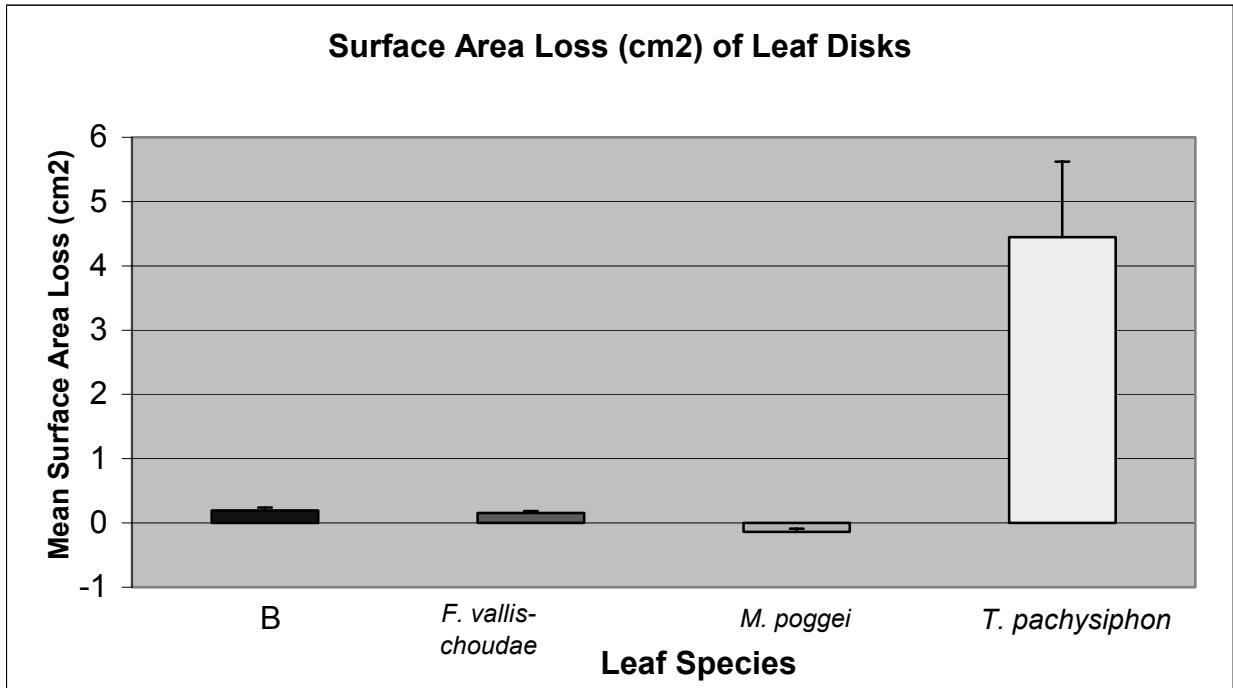


Figure 1. Surface area loss (cm²) of four leaf disk over a three-day period in the presence of a single crab.

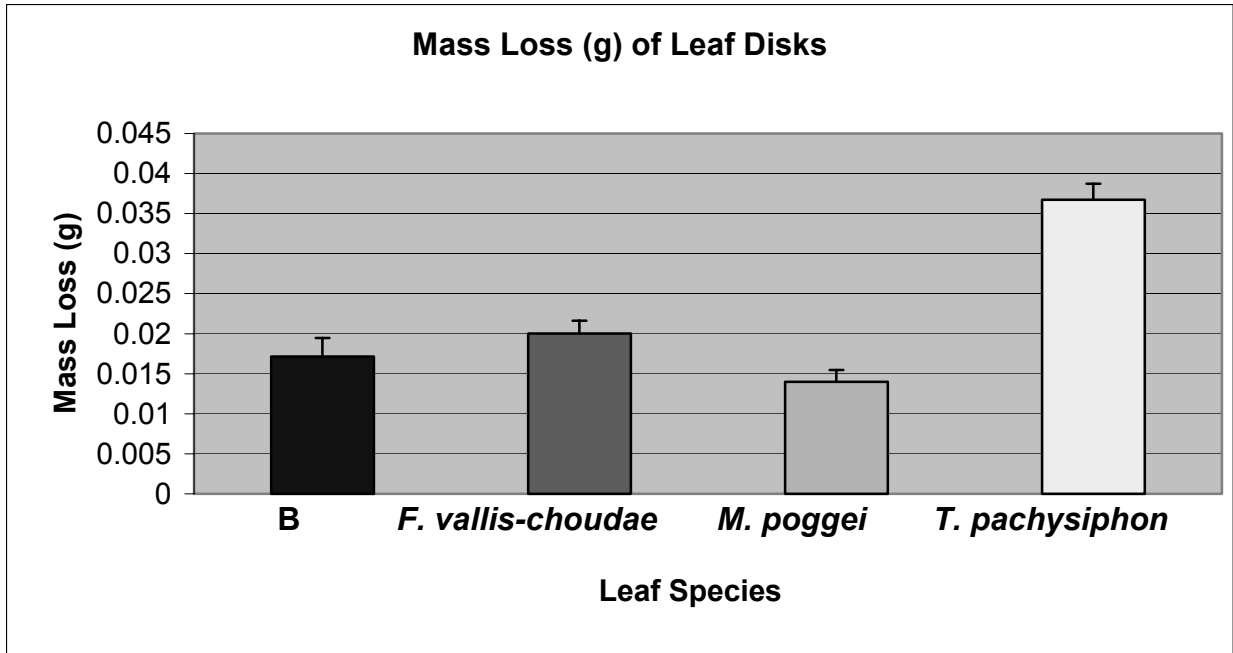


Figure 2. Mass loss (g) of four leaf disks over a three-day period in the presence of a single crab.

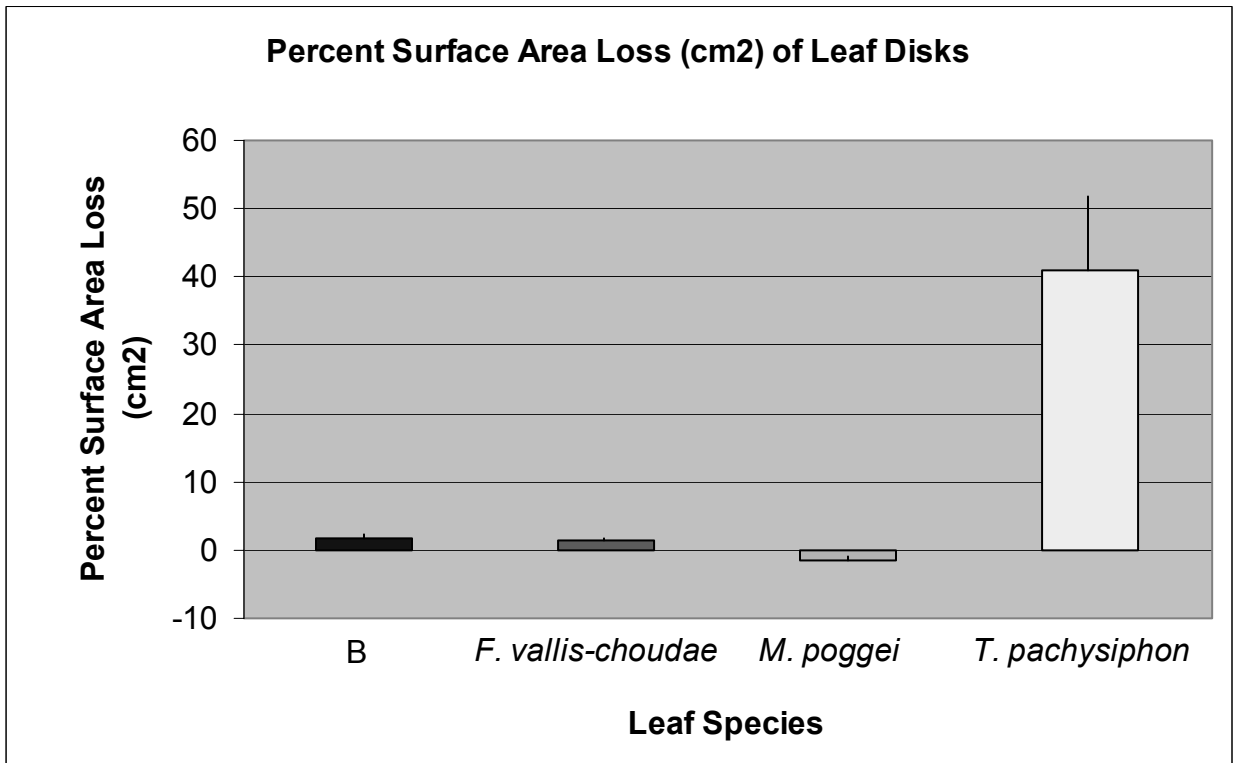


Figure 3. Percent surface area loss (cm²) of leaf disks over a three-day period in the presence of *P. emini*.

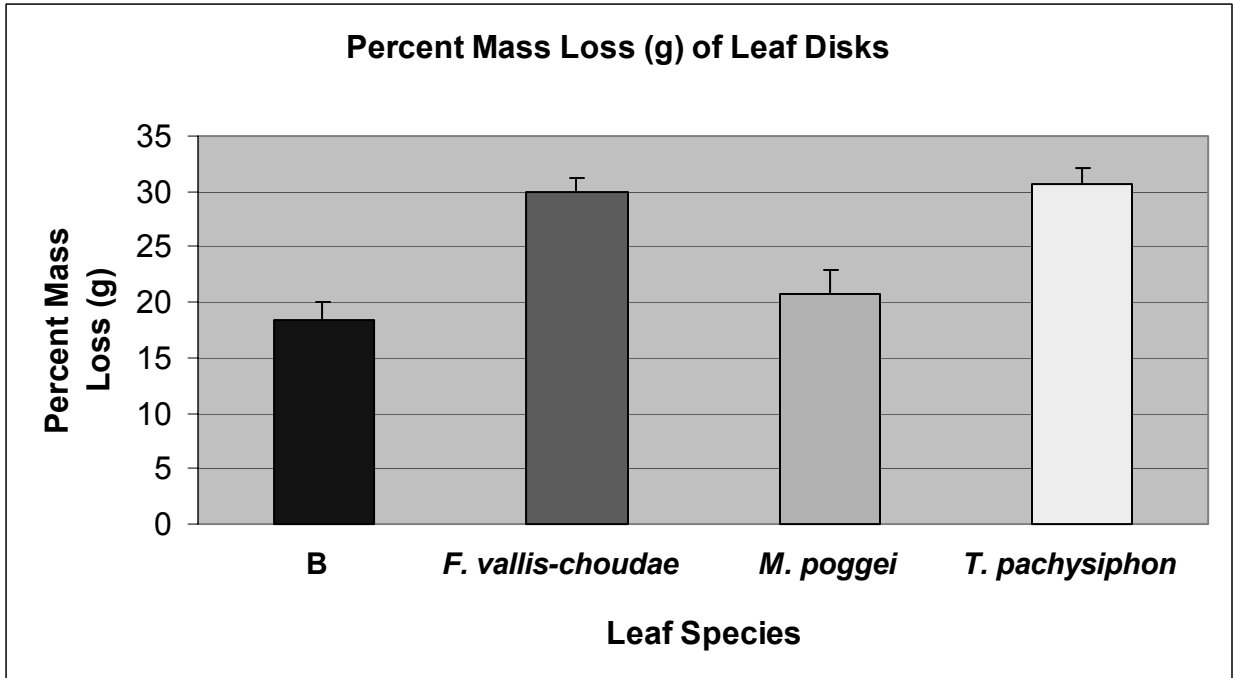


Figure 4. Percent mass loss (g) of leaf disks over a three-day period in the presence of *P. emini*.