An experimental test of the effects of sedimentation on Lake Tanganyika rocky shore gastropod survivorship

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Introduction

Sediment erosion from land and transport and deposition on littoral habitats has been identified as a form of pollution threatening the biodiversity of Lake Tanganyika (Cohen et al., 1993, 1996; Alin et al. 1999; Donoghue & Irvine, 2003; McIntrye et al. submitted). This anthropogenic sediment can alter the native aquatic habitat by blocking light when it is in suspension, affecting water chemistry and changing the substrate where it is deposited. Effects are most severe in rocky habitats, which in their pristine states have specialized endemic faunas and florae that are tightly co-evolved to clear water physical surroundings. Allochthonous sediment in suspension decreases light quantity and quality, reducing algal growth and potentially changing algal composition. When sediments settle out of the water onto the rock surface, the particles may interfere directly with algal growth and also survivorship of the fauna that lives on the algae. Sediment may coat the rock surfaces interfering with grazing and digestion for a very diverse fauna of herbivores (e.g. see Gilbert, this volume). For the truly benthic animals such as gastropods, shrimp, and ostracods, sediment also interferes with movement and many more physiological processes such as respiration and reproduction. Finally, if the sediment blanket on the habitat becomes great enough, it may decrease the entire available habitat by filling cracks between rocks and successively covering the entire rocky habitat. Various stages of this process have been documented throughout Lake Tanganyika. Anthropogenic sedimentation on a large scale is evident along the Burundi shoreline and is correlated with significantly depauperate diversity (Cohen et al., 1993). Areas of sedimentation, in some cases severe, although generally patchy, have been documented around Kigoma. This has allowed local comparisons of field patterns through a number of Nyanza research projects (France & McIntyre, 1998; Sekendende, 1999; Menone, 2000; Mulongaibalu 2000; Rivers, 2001; Solomon, 2001; Sapp, 2002; Faloon, 2002; Gilber, 2003). Sedimentation has been found to correlate with altered species assemblages, changing population sizes, decreases in predation and parasites and smaller adult sizes in fish and gastropods. However, direct testing of the effects of sediment on the animals themselves has been lacking.

I set up a series of laboratory experiments to test the effects of sediment on gastropods from the rocky areas around Kigoma. My work was modeled on experiments by Donoghue & Irvine, 2003 that subjected Reymondia horei to inundation with sediment of various size classes in replicated experimental containers and record the time until death. This was essentially an LD₅₀ experiment. The Donoghue & Irvine (2003) experiment had two major flaws that I attempted to redress in this study. First, they used a gastropod species that does not occur on rock surfaces, rather it is generally lives on vertical surfaces and under overhangs or in very deep water, thus is not generally exposed to sedimentation of any kind in its natural environment (Powers, 2002). Their experiment covered the snails with a heavy sediment load, thus their results might not be relevant to the real life, where Reymondia are unlikely to experience sedimentation at all. I used snail species that naturally occur on upward-facing rock surfaces and do directly experience sedimentation when it occurs in their natural habitat. Second, Donoghue & Irvine (2003) used sediment that was not very close to the naturally deposited sediment on three criteria: 1) they use terrestrial sediment (dirt), 2) they separated it into three separate, single grain-size distributions and 3) they sterilized all the experimental sediment, removing organics. We could see no reason for these deviations from natural conditions except to create artifacts. I used sediment that had been deposited in the lake and retained a natural range of grain sizes. Sediment with a range of grain sizes is likely to have more natural interstitial space. As I was interested in comparing my results to the Donoghue & Irvine (2003) results, I used both sterilized and native sediment.

Material and methods

To determine the effects of deposited sediments on rock dwelling endemic snails, I conducted three different experiments:
**Experiment 1**

This experiment tested six species and two sediment particle sizes plus a control, replicated eight times for each treatment for a total of 24 experimental units. I used 2 liter round chambers (approx. 20cm diameter, 10 cm height), each with 1500ml of lake water and a small, flattish cobble from the lake of essentially similar sizes of 10cm diameter. The cobbles came from 3-5m depth at Kalalangabo 3, a pristine area with high snail diversity and also the source of most of the tested snails (see map in Berrett et al, this volume).

Two sediment particle size treatments from lake were used in this experiment, with grain size determined by sieving representative samples from the bulk lot. These were:
- **Fine sediment** which ranged from 500µm to 2mm collected from approximately 5m water depth inside Nondwa Point
- **Very fine sediment** which ranged from 63µm to 250µm collected from the east of Hilltop point, near Kigoma prison. The sediments were not sterilized, thus had a natural complement of organic matter and lake bacteria.

Each replicate was filled with a constant amount of sediments forming a layer of 1.5cm thick on the container bottom and covering, but not hiding, the cobble. No sediments were added to control replicates.

Six species of rock-dwelling gastropods were used; these were *Lavigeria coronata*, *L. grandis*, *L. nassa*, *Lavigeria* new species W, *Vinundu guillemei* and *Reymondia horei*. Taxa follow names in Michel et al. (2003, in press) and West et al. (2003). Two individuals from each species were placed in each jar after addition of sediments and water. All treatments were aerated using diaphragm pumps, air stones. Fresh lake water was replaced every second day. Behavior was noted and the number of live individuals of each species in each replicate was recorded daily to produce survivorship curves.

**Experiment 2**

This experiment used a wider range of different grain sizes and sources of sediments and only one species of snail, *Reymondia horei*, in an attempt to test results from Donoghue & Irvine (2003). The sediments were:
- fine sediments from lake
- very fine sediments from lake
- fine sediments from land
- very fine sediments from land

Fine sediments ranged from 500µm to 2mm and very fine sediments ranged from 63µm to 250µm that burned in muffle furnace at 550°C for one hour to remove organic matter. There were eight replicates per each treatment, and each replicate contained a small rock and filled with 2cm of sediments and 500ml of lake water in a 1 liter container (beaker-like cut “MajiPoa” bottle). No sediments were added to control replicates.

Eight individuals of herbivorous rock-dwelling gastropod *Reymondia horei* were placed in each jar after settling of sediments and water. Treatments were not aerated but fresh sediments and fresh lake water were replaced for every second day. The numbers of live individuals in each replicate were recorded daily.

**Experiment 3**

This experiment used the range of sediments as in experiment 2, but with a selection of species similar to experiment 1. This was run at the end of the program to test whether the results that were evident from experiment 1 were due to the species and lack of sterilized sediments or the experimental set up from experiment 2. Five species of rock-dwelling gastropods were used, these were *Lavigeria coronata*, *L. grandis*, *L. nassa*, *Reymondia horei* and *Vinundu guillemei*. There were eight replicates per each sediment treatments and each replicate filled with 2cm thickness of sediments and 500ml of lake water. No sediments were added to control replicates. One individual from each species was placed in each jar after addition of sediments and water. Treatments were not aerated but fresh sediments and fresh lake water were replaced every second day. The number of surviving individuals (for each species) in each replicate was recorded daily.

**Results and Discussion**

*Experiment 1* had continuous survivorship for almost all individuals of all species near the end of the research period – 18 days! Only at the end did snails begin to die. This indicates that natural lake
Sediments, if well aerated and not sterilized, are not immediately deadly to rock dwelling snails. It challenges the generality of results from Donoghue & Irvine (2003). These results could be consistent with previous field results showing decreased sizes of individuals at sedimented sites, as the snails were likely not to be thriving under sedimented conditions and could be growing more slowly. 

Experiment 2 had essentially immediate death of all test individuals in 4 days (Figure 1). This indicates that sterilized sediments are immediately deadly to rock dwelling snails (if not aerated). It also suggests that Donoghue & Irvine (2003) should not have sterilized their sediments, as sterile sediments are not found in the natural world. Control snails lived somewhat longer, but also all died within 8 days. Thus aeration is critical for snail survival.

Experiment 3 had rapid death of all treatment gastropods with no recoverable pattern by sediment grain size. However, some species appeared to be more robust, as was also shown in survivorship of control groups (Figure 2).

Conclusions

- Sediment has different effects based on size fractions (as shown by Donoghue & Irvine, 2003).
- Sterilizing sediments is not an appropriate methodology.
- Aeration changes the effects of sedimentation – lots of aeration allows snails to survive sedimentation.
- Snails from different species respond differently to sediments.
- Sedimentation into the lake affects benthic communities. It can lead to the extinction of benthic species, especially rock-dwelling populations, as it changes the substrate, light penetration and alters the algae.

Future research

I suggest that this work should essentially be redone with tests using more aeration on multiple sediment types. It will be very useful to compare results of species survivorship with field results of snail distributions such as Benthic Survey Team, Nyanza 2003. Finally the critical tests will include exploring physiological mechanisms of snail death: suffocation by sediment, interference with digestion, growth, reproduction.

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References


Sediment Impact on *Reymondia*
Not aerated lake & terrestrial seds., 8 reps e. tmt.

Figure 1. Results from Experiment 2

Figure 2: Survivorship of control group in experiment 3.