NO NEED FOR SPEED: A STUDY OF THE EFFECTS OF WATER VELOCITY ON *NERITINA LATISSIMA* DISTRIBUTION IN A TROPICAL STREAM

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Abstract: The *Neritina latissima* snail population in the Rio Claro in Corcovado National Park, Costa Rica is found across microhabitats of varying water velocities. We studied the effects of water velocity on *N. latissima*'s distribution within the stream. In an observational study, we measured snail density, size, and location on rocks in various water velocity sites. We found that at higher velocity sites, snail density was lower, smaller snails were present, and snails tended to be at the base of rocks. In a reciprocal transplant experiment, we moved snails from a low water velocity site to a high velocity site and vice versa. When transferred from the low velocity site to the high velocity site, snails either moved to the base of the rocks or fell off. When transferred from the high velocity site to the low velocity site, almost all snails moved to the top of the rocks. Our results suggest that snails seek shelter from strong currents at the base of rocks.

Key Words: snail distribution, Corcovado, snail density, population dynamics

INTRODUCTION

Variation in environmental conditions drives spatial heterogeneity in stream organisms (Cooper et al. 1997). Water velocity is one environmental factor that may influence aquatic populations. Within a stream, velocity is affected by many characteristics such as slope, stream width, and stream depth, and corresponding habitats can be categorized as riffle, run, or pool. A riffle is a part of the stream where water flows rapidly over rocky substrates causing high turbulence. A run is an area of stream with moderate to high water velocity, but water flow is smooth with low turbulence. A pool is an area where the water is still or at a low velocity and has no turbulence.

The Rio Claro in Corcovado National Park, Costa Rica is a large freshwater stream, which contains microhabitats of different water velocities. While some of Rio Claro's organisms are found in riffles and runs, others are found in pools. One population present in all three microhabitats is *Neritina latissima* snails. Due to the snails' prominence within the stream, we wished to understand how water velocity may impact the snails' distribution. We hypothesized that at different water velocities, snail densities would differ, different sized snails would be present, and snail location on its rock would vary. We predicted that snail density would be lower at

higher velocity sites because snails in these environments may have to expend more energy to remain attached to their substrate. We also predicted that smaller snails would be present at higher water velocity sites because they may be better equipped to hold onto rocks due to less force per unit area on their smaller shells (Moore 1964). Lastly, we predicted that in areas with low water velocity, snails would be located on the top of rocks to forage on the area of greater algal growth; and in areas with high water velocity, snails would tend to be at the base of the rocks to seek protection from the strong current.

METHODS

Observational Study. On 4 February 2007, we observed the snail population in the Rio Claro located in Corcovado National Park, Costa Rica. We chose four sites with varying water velocities within a reach of the stream: a separated pool, a pool connected to the stream, a run, and a riffle. In each of the four site-types, we used randomly generated numbers to lay five 1m x 1m quadrats. We measured velocity in each quadrat by dropping a piece of wood on top of the water and timing its movement along the length of the quadrat (1m). We averaged the velocity of the quadrats per site and found a velocity of 0 m/s for the separated pool, 0.1 ± 0.97 m/s (mean ± SD) for the connect pool, 0.69 ± 0.37 m/s for the run, and 1.91 ± 0.43 m/s for the riffle.

In each quadrat, we estimated the percentage of different substrates: ledge (exposed bedrock), boulder (> 25cm), cobble (5-25cm), pebble (1-5cm), and sand (< 1cm). We sampled three rocks from each quarter of the quadrat that were representative of the relative natural abundances of rock sizes in the quadrat. We measured length and width of approximately rectangular rocks and the diameter of approximately circular rocks, and used these metrics to calculate the top surface area of the rock, as an index of rock size. We counted the number of snails on each rock, measured their size from the apex of the shell to the front of the aperture, and noted if each snail was located on the top or base of the rock. We defined the top of the rock as the part that could be seen from above and defined the base as the remainder of the rock. We calculated snail density as total number of snails per rock surface area (cm^2) and calculated an average snail density for each quadrat (n=12 rocks per quadrat).

Experimental Study. On 5 February 2007, we performed a reciprocal transplant experiment in the Rio Claro to test snail behavioral response to changes in water velocity. We chose the two sites with the largest contrast in water velocity,

the separated pool and the riffle sites. We transplanted snails of a range of sizes from the separated pool site to the riffle site, and vice versa. We controlled for rock size by choosing small, medium, and large sized rocks from each site. In each trial, we placed one snail on one of the three rocks from the snail's original habitat, waited for its foot to fully attach to its new rock, and then placed the rock in the other habitat (n = 5 snails per rock size per treatment). Since our observational study showed that snails are generally found on top of the rock in the separated pool and at the base of the rock in the riffle, we placed snails on the top of the rock in the pool-to-riffle transplant and at the base of the rock in the riffle-to-pool transplant. For both treatments, we recorded whether the snail fell off the rock, moved to a new location on the rock, or stayed where it was originally placed on the rock, at the end of a five minute period.

Statistical Analysis. We used a MANOVA to determine whether there were differences in snail density [square-root transformed (cm^{-2})], snail size [log- transformed (mm)], and percent of snails at the base (arcsine square-root transformed) among the four sites. We used separate one-way ANOVAs to determine if snail density, size and location on rocks (transformed as above) varied among sites. To determine differences of snail density, size and location on rocks among sites, we used a Student's t-test. We used a Chi-squared analysis to determine whether the reciprocally transplanted snails moved non-randomly.

RESULTS

Overall, at higher velocity sites, snail density was lower, snail size was smaller and snail location was on top of their rocks. We found that there were differences in snail density, size, and percent of snails at the base among the four sites (Wilks' Lamba = 0.16, $F_{9,34}$ = 4.33, P = 0.0008). We found that snail density was four times higher at the separated pool and the connected pool sites than at the run and the riffle sites ($F_{3,18}$=6.72, P=0.0038, Figure 1). We found that snail size was 54% smaller at the run and the riffle sites than at the separated pool and the connected pool sites ($F_{3,18}$=18.92, P <0.0001, Figure 2). We found that the percentage of snails at the base of rocks in the run and the riffle was twice as great as that of the separated pool and the connected pool ($F_{3,18}$ = 6.36, P = 0.0054, Figure 3).

In our transplant experiment, we found that when moved from the separated pool to the riffle, 60% of the snails moved to the bottom and 40% fell off the rock. When moved from the riffle to the separated pool, 20% stayed on the bottom, 80% moved to the top, and none fell off

($\chi^2_{2,28}$= 21.00, P = 0.0001).

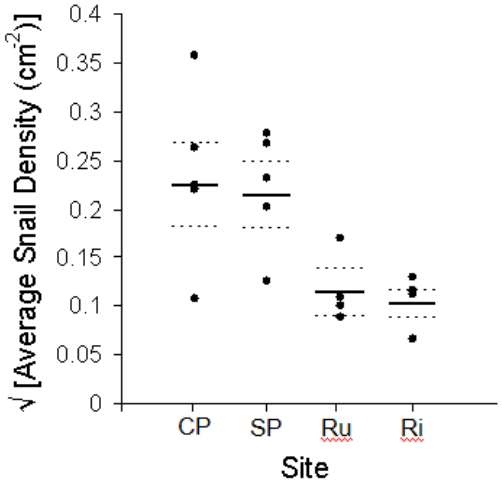

Figure 1. Density of snails (square-root transformed) in the connected pool (CP), separated pool (SP), run (Ru), and riffle (Ri) along the Rio Claro in Corcovado National Park, Costa Rica. Each point represents a quadrat. (n=5 per site).

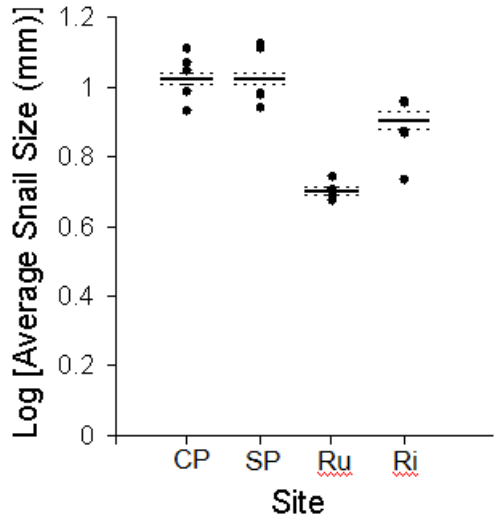

Figure 2. Size of snails (log-transformed) in the connected pool (CP), separated pool (SP), run (Ru), and riffle (Ri) along the Rio Claro in Corcovado National Park, Costa Rica. Each point represents a quadrat (n=5 per site).

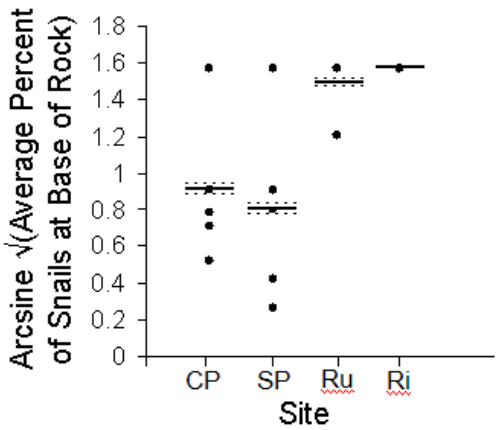

Figure 3. Percent of snails at the base of the rock (arcsine square-root transformed) in the connected pool (CP), separated pool (SP), run (Ru), and riffle (Ri) along the Rio Claro in Corcovado National Park, Costa Rica. Each point represents a quadrat (n=5 per site).

DISCUSSION

We focused on the effect of water velocity on snail density, presence of different sized snails, and location of snails on rocks in a neotropical stream. In our observational study, our first prediction, that snail density would be lower at higher water velocity sites was supported: snail density was lower in the riffle and the run sites than the separated pool and connected pool sites. It is possible that snails are more abundant in the lower velocity sites because they do not have to expend energy to remain attached to the rock in a strong current. Instead they are able to allocate their energy to activities such as foraging.

Our second prediction, that there would be more small snails at

higher water velocity sites was supported: snails at the riffle and run sites were smaller than snails at the separated pool and connected pool sites. Smaller sized snails may be more prevalent in high velocity waters because they experience less force per unit area on their shells, affording them a better hold on rocks (Moore 1964).

Our third prediction, that snails would be located on the top of rocks in areas with low water velocity and at the base of rocks in areas with high water velocity was also supported: snails in the separated pool and connected pool were found on the top of their rocks, and snails in the riffle and the run were found at the base. It is possible that snails in high velocity waters seek shelter from the current by hiding at the base of the rocks where water velocity is lower and where the rock impedes the current. In the higher velocity sites, the location preference of the snails could have negative effects on their foraging success: we observed less algae, presumably the main food for the Rio Claro snails, at the base of the rocks.

Our experiment further confirmed the results of our third observational prediction: the position of snails on rocks depended on water velocity. We found that 80% of snails transplanted from the riffle to the pool moved to the top of the rocks, while 20% remained on the bottom. On the other hand, 60% of the snails transplanted from the pool to the riffle moved to the bottom of the rocks, and the other 40% fell off the rocks. The large proportion of the pool-to-riffle snails that could not remain attached suggests that fewer snails are capable of remaining attached in these environments, which would lead to decreased snail density.

Future studies could replicate our transplant experiment using a range of snail sizes to test for an interaction between the effects of snail size and water velocity, i.e. are larger snails more likely to be detached from rocks in high currents? Another study could evaluate differences in snail foraging success on the tops and bases of rocks. We have shown that snails preferentially remain on certain parts of rocks depending on the water velocity of their environment and that within environments with higher water velocity, there tends to be a lower snail density and smaller snails. These population distribution patterns contribute to a better understanding of population dynamics of this prominent species in the Rio Claro.

LITERATURE CITED

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