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SOME FACTORS INFLUENCING THE DISTRIBUTION OF THE SNAIL *Neritina reclivata*

The gastropod Family Neritidae contains over 200 living species, most of which inhabit intertidal zones in tropical and temperate climates. The olive nerite, *Neritina reclivata* Say, is irregularly distributed along coastal regions of the Gulf of Mexico and the Caribbean Sea from 10 to 30 degrees N latitude. Its distribution ends in the north at Jacksonville, Florida on the Atlantic Ocean and in the south at Trinidad (Russell, 1941). Most records of *N. reclivata* are from coastal regions of the Gulf of Mexico, but this may be due to the paucity of faunal surveys elsewhere in its range.

Despite the common occurrence of *N. reclivata,* it remains virtually unstudied. Russell (1941) reported that *N. reclivata* inhabits brackish and freshwater, and is absent from many small islands in the Antilles that do not support permanent freshwater rivers. According to this author, *N. reclivata* is found on solid substrates in the water, but not on mud. *N. reclivata* crawls using monotaxic retrograde waves, a type of locomotion often found in species living on solid substrate (Gainey, 1976). Pilsbry (1931) noted the snail's presence on reeds and other aquatic plants near drainage canals and suggested that algae may comprise the food of the snail.

We have collected *N. reclivata* from hard substrates (e.g., plants, stumps, rocks) at locations between 5 km up the Escambia River and the western tip of the Gulf Breeze peninsula, Santa Rosa County, Florida. These locations correspond to a salinity range of 1 to 19 ppt (U.S. Environmental Protection Agency, 1975). Because our preliminary observations suggested an affinity of *Neritina* for solid substrates, we investigated this

relationship to determine its ecological basis.

MATERIALS AND METHODS

Grass Bed Population

Neritina reclivata were found on the plants *Ruppia maritima, Spartina alterniflora* and *Vallisneria americana,* with the submerged seagrass *Ruppia* being the primary natural substrate. A homogeneous area covered by *Ruppia* was studied in detail to determine if a correlation existed between snail and seagrass density. A square having 4 m sides was delineated in water 0.75 to 1.5 m deep. At 1 m intervals throughout the sample area, a core (182 cm^2 diameter, 10 cm deep) of grass and substrate was removed and sifted with a 1 mm^2 sieve. For each of these 25 cores, the dry weight of the entire plants was measured after exposure to 100° C for 24 hours, and the shell lengths of all snails were measured.

Food Analysis

An experiment was conducted in the laboratory to determine whether epiphytic algae, bottom detritus, *Vallisneria* detritus, and sand were ingested by *Neritina reclivata.* These materials were considered to be the primary potential foods either attached to or settling on surfaces inhabited by the snail.

The epiphytic unicellular algae were collected by scraping leaves of living *Vallisneria americana* in ambient seawater. Algae were concentrated by allowing the suspension to settle in a 1 liter flask for 24 hours. Bottom detritus was scraped from the surface of the substrate and consisted of macrophytic plant cells, organic material in various stages of decomposition, unicellular algae and sand grains. *Vallisneria* detritus floated on the surface of the intertidal zone; it consisted of *Vallisneria* plant cells, unicellular algae and decomposing organic material. Both the bottom detritus and the *Vallisneria* detritus were concentrated and homogenized before use. Sand was collected from the top 5 cm of the upper intertidal zone, dried and passed through a 250-μm sieve before use.

Food consumption was measured by two methods. First, the amount of a potential food material remaining on a test surface after being browsed upon by snails was compared to a control surface lacking snails. This method permitted determining the amount of material removed by the snails. Second, the amount of feces produced by snails after browsing on a test surface possessing the potential food material was compared to the amount produced by snails browsing on a control surface lacking this material. This method permitted determining if the snails were actually ingesting the material. Both methods were accomplished simultaneously by including test surfaces containing the potential food and snails, containing food only, and containing snails only, in the same aquaria.

The food analysis experiments were prepared by placing 15 liters of 5-μm filtered seawater (20° C, 12 ppt) into a 75.5 liter aquarium. The aquarium was aerated and placed in a dark box fitted with a fluorescent light operating on a 14L:10D regime. Bottoms of 10-cm diameter petri dishes served as test surfaces. Dishes requiring a potential food material were placed on the bottom of the aquarium and a standard amount of the material was suspended in the aquarium and allowed to settle evenly. The standard amounts were 150 ml of epiphytic algae, 50 ml of bottom detritus, 150 ml of *Vallisneria* detritus, and 2 gm of sand. Once the material settled, dishes to be tested without a potential food were added to the aquarium. One snail was placed on each appropriate dish. Nitex screen covers

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were placed on all dishes to confine each snail's movements to its own dish. After 48 hours, snails were removed and placed in individual net bags in 100-ml test tubes to collect their feces. The petri dishes were carefully removed by hand and any food remaining on them was collected by rinsing and filtering. The residue was dried for 24 hours and weighed. The snails in the test tubes were allowed to pass feces for 48 hours before the feces were collected, dried and weighed. Weights were measured with a Mettler H20 balance to the nearest 10 μg.

Sixteen replicates were performed for each of the four potential foods. Student's t-test was used to compare means for the food removal data because variances were not significantly different in all four cases. The less powerful Mann-Whitney U-test was used to analyze the feces production data because variances were significantly different in three of four cases. The total organic carbon content of each potential food was determined by the combustion method described by Byers *et al.* (1978).

Effects of *Neritina* on Submerged Vegetation

To examine the effects of *N. reclivata* on epiphytes attached to the seagrass, *Ruppia maritima,* ten 1.9-liter glass jars were supplied with 300 ml of sand-mud substrate, 1300 ml of 1-μm filtered seawater (19-23° C, 7-11 ppt) and equal amounts of seagrass having attached epiphytes. Equal amounts of seagrass were obtained by counting the number of leaves and nodes and by measuring plant length. Ten adult snails of about equal length were placed in each of five of the culture jars; the remaining five jars lacked snails. An overhead fluorescent light operated on a 14L:10D regime. Light levels were 150 and 400 ft-c in tests A and B, respectively.

Epiphyte density was measured by carefully scraping the leaves of a seagrass sample and rinsing the epiphytes into 20 ml of 1-μm filtered seawater. After the solution of seawater and epiphytes was thoroughly mixed, the epiphyte concentration was estimated by counting three separate aliquots using a hemocytometer. Each week for five weeks, we measured the epiphyte concentration in one jar containing snails and in one jar lacking snails. For each week, Student's t-test was used to determine if snails significantly reduced epiphyte populations by comparing the three concentration estimates obtained for each of the two jars.

RESULTS

Grass Bed Population

The data from the 25 core samples are summarized in Figure 1. The density of snails was positively correlated to the amount of vegetation present in the area ($r = 0.785$, $P < 0.01$). For this study site, 1 gm dry weight of *Ruppia* supported 3.97 snails. In the 25 cores, a total of 66 snails were collected, with a mean shell length of 5.1 mm (s.d. = 1.7).

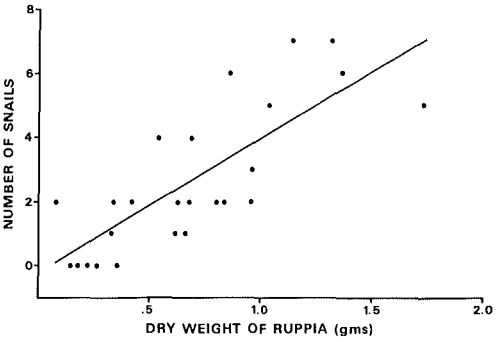

Figure 1. Relationship between the amount of *Ruppia maritima* and the number of snails present in 25 core samples ($y = 4.21x - .24$).

Food Analysis

Because of the observed positive cor-

relation between snail and *Ruppia* density, a study was conducted to determine if the basis for the relationship was nutritional. Consumption of a food was measured by examining both the amount of food removed from a test surface and the amount of feces produced in order to insure that the food's absence from the test surface resulted from ingestion by the snail.

Figure 2 shows that snails significantly

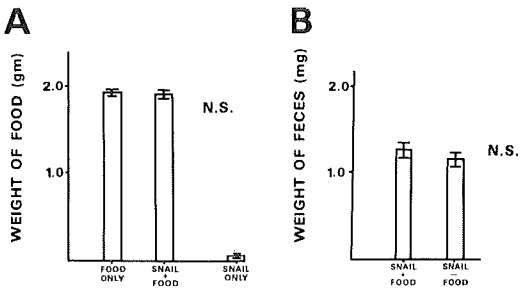

Figure 2. (A) Mean and standard deviation for the amount of *Vallisneria* detritus present on petri dishes after 48 hours. Sixteen dishes had only this potential food present, 16 had this food and one snail present, and 16 had only the single snail present on the surface. (B) Mean and standard deviation for the amount of feces produced by the same snails used in part A, during the 48 hours immediately following removal from their respective petri dishes.

reduced (P <0.005) the amount of *Vallisneria* detritus on the test surface but did not produce significantly more feces than unfed snails. Figure 3 shows that snails

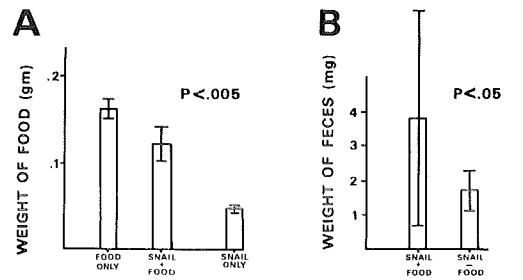

Figure 3. Same as for Figure 2 except for bottom detritus as the potential food.

did not remove a significant amount of bottom detritus from the test surface but did produce significantly more feces (P<0.05). Figure 4 shows that epiphytes

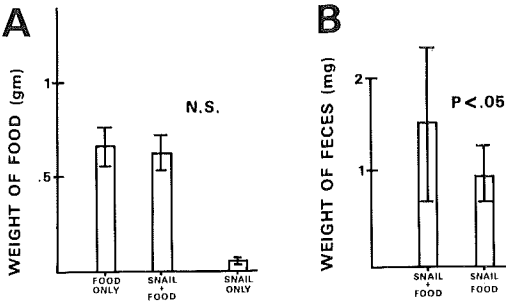

Figure 4. Same as for Figure 2 except for epiphytes as the potential food.

were significantly reduced (P<0.005) from the test surfaces by snails, and also that snails feeding on epiphytes produced significantly more feces (P<0.05) than unfed snails. Figure 5 shows that no

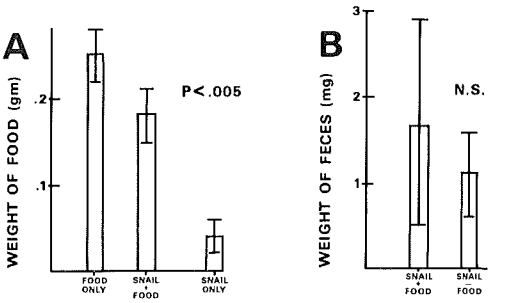

Figure 5. Same as for Figure 2 except for sand as the potential food.

significant differences existed in either of the two measures when sand was supplied as the potential food. *Vallisneria* detritus had the most organic content by weight, 69.4%; epiphytic algae had 36.8%, bottom detritus had 5.8% and sand had 1.0%.

Effects of *Neritina* on Submerged Vegetation

In each culture jar containing both snails and *Ruppia*, the concentration of algal epiphytes was significantly less than (P<0.025 or better) that in the corresponding jar containing only *Ruppia* (Figure 6).

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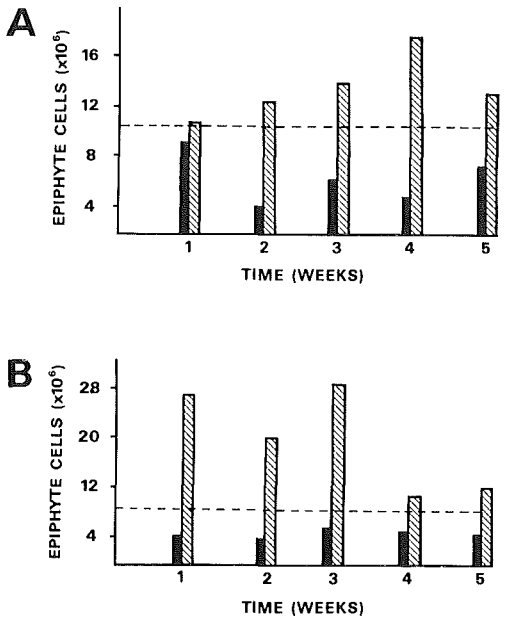

Figure 6. Concentrations of algal epiphyte cells present on *Ruppia* over a 5 week period, with and without *Neritina* present in the culture jars. Tests A and B were conducted in 150 and 400 ft-c of light, respectively. The dashed lines indicate the estimated concentrations of epiphytes present in all jars at the beginning of the tests. Solid bars indicate epiphytes in jars containing *Ruppia* and snails while striped bars indicate epiphytes in jars containing *Ruppia* only.

The results at both light levels clearly indicate that *Neritina* significantly reduced the number of epiphytes attached to the *Ruppia*. Throughout each test, *Ruppia* leaves were carefully examined for damage by the snails. No damage was observed.

DISCUSSION

Because *Ruppia maritima* density was positively correlated with snail density (Figure 1), the surface area of *Ruppia* was considered to be the critical factor influencing snail density. The hypothesis that seagrass simply comprises space for snail attachment is essentially untestable because of the difficulty of excluding potential food materials from a surface. The basis for the relationship between plant and snail density could be that more plant surface area supports more of a potential food such as epiphytes.

Food analysis studies (Figures 2 to 5) showed that *N. reclivata* ingested epiphytic algae and did not ingest sand. It was unclear from these data if *N. reclivata* ingested bottom detritus and *Vallisneria* detritus. *N. reclivata* could be expected to consume epiphytic algae because it is a naturally occurring food source attached to the plants and has a high organic carbon content. The fact that sand was present in bottom detritus but not *Vallisneria* detritus may have been responsible for the differences in removal of these two materials from the test surfaces. The fact that the low-organic content sand was not removed from the test surfaces validates this procedure for measuring food consumption by *Neritina*. The fact that no significant differences existed between the pairs of variances for the food removal data suggests that all snails tested with a given food removed that food at an approximately equal rate. The significant differences that existed between pairs of variances for the feces production data (for all foods except sand) may reflect variation in the rate of movement of food through the gut.

The food analysis study indicates that *N. reclivata* selectively ingest food. Because radula structure is related to the type of food ingested by molluscs, the spacing and shape of the radular teeth may influence the size of particles ingested by *N. reclivata*. Thus the basis for the preferred selectivity of epiphytic algae may have been its smaller particle size as compared to the other three potential food materials tested.

Epiphytic algae were determined to be the major natural food source for *N. reclivata*. In the culture jar experiments (Figure 6), snails significantly reduced the epiphytes attached to *Ruppia* but did

not damage the *Ruppia* itself. In these experiments, the reduction of epiphytes could have resulted from snails detaching them from the plants with the foot. However, because the food analysis tests showed that *N. reclivata* ingested epiphytes, we conclude that the reduction of epiphytes on the *Ruppia* in the jars containing snails resulted from the snails actually ingesting the epiphytes.

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ERRATA, Vol. 3, No. 2:

P. 57-58 in the key to species of *Leptocaris,* the indicated couplets should read as follows.

couplet 1. . . . Exp. P_2 and P_3 with 3 setae
couplet 2. . . . *L. armatus* Lang
couplet 7. . . . *L. pori* Lang
couplet 9. . . . *L. doughertyi* Lang
couplet 13. . . . *L. minutus* T. Scott

P. 104. Senior author is Martin F. Gomon

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