GROWTH RATE OF *NORRISIA NORRISI* IN A KELP FOREST AT SANTA CATALINA ISLAND

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ABSTRACT

This is the first field study of growth rates for Norris' top snail (*Norrisia norrisi*) in a kelp forest community. *Norrisia* is a common inhabitant of kelp forests near the Wrigley Institute for Environmental Studies on Santa Catalina Island, California. As part of a study on the diel vertical migration of *Norrisia* on the giant kelp *Macrocystis pyrifera* (Lonhart 1996), growth of the snails was measured in the field for 10 mo on the leeward side of Santa Catalina Island at Pumpernickel Reef (33°26.53´N, 118°28.35´W), a shallow (1 to 12 m) subtidal cove. Since growth rates for subtidal trochid snails in the field are not known (Morris et al. 1980), this study represents the first measurements of snail growth under natural rather than laboratory conditions.

Growth was measured along the greatest dimension of the shell (body whorl diameter) in situ using calipers precise to one mm. Individual snail sizes were scratched into the periostracum of the shell with the metal shaft of the caliper. This method was easy to use underwater and marks generally lasted three to six mo. *Norrisia* on tagged *Macrocystis* were initially measured and marked in August 1992. During subsequent surveys (Sept., Oct., Dec. 1992, Feb., Mar./Apr., May 1993), the current size was marked anterior to the previous size. Unmarked snails naturally occurring on the tagged kelp (emigrants) were added to the study on subsequent surveys. During the 10 mo study, 1602 observations were recorded of snails that ranged in size from 4 to 51 mm (mean = 23.6 mm, SD = 10.2). For all calculations, only *Norrisia* identified with certainty were used (n = 67). Individuals were identified by unique shell characteristics and unique size markings. Time between mark and recapture ranged from 21 to 345 d. Increases in shell diameter were standardized to 30 d.

Growth rates significantly varied with time of year (ANOVA, P <0.001). Growth was highest from August to September (2.97 mm/mo; Student-Newman-Keuls test, P <0.01), followed by September to October (1.97 mm/mo; SNK test, P <0.01). The remaining survey intervals did not differ significantly (0.78 to 1.20 mm/mo; SNK test, P >0.05). Sample sizes for monthly rates ranged from 2 to 15. The decline in growth rates was mirrored by a decline in water temperature. Water temperature at a depth of seven m was measured during each survey. Mean water temperature at the site was warmest from August to October, ranging from 20.8 to 22.1°C, then dropped significantly during the rest of the study, ranging from 15.6 to 17.2°C.

Norrisia ≤17 mm grew an average of 1.7 mm/mo (±0.21 SE; n = 18), which was significantly higher (ANOVA P =0.003; SNK tests, P<0.01) than snails 18 to 29 mm (1.2 mm/mo ±0.10; n = 40) and snails 30 to 41 mm (0.8 mm/mo ±0.11; n = 9). Snails ≥ 42 mm were rarely recaptured, and those that were recaptured had not measurably increased in size. Using conservative but realistic monthly growth rates, I propose snails ≤ 17 mm include new recruits and young of the year. Snails 18 to 29 mm are one to two yr old, and snails 30 to 41 mm are two to four yr old.

I also used the data in a Walford plot (size at marking vs. size at recapture) to estimate the von Bertalanffy growth curve parameters K (growth rate constant/30 d) and S (asymptotic size). The coefficients of the least-squares linear regression equation from a Walford plot were used to calculate growth parameters. Despite the linear distribution of data points in the Walford plot and the highly significant regression equation ($y = 0.9553x + 2.2667$; P<0.001; r^2 = 0.987), the estimates of K = 0.048 and S = 48.5 mm are too conservative. *Norrisia* on Santa Catalina Island rarely reach 50 mm, but snails on the mainland of California often reach 60 mm, with some individuals reaching 70 mm.

Growth rates for *Norrisia norrisi* measured in the field varied as a function of season and snail size. At the end of summer, when kelp beds were healthy and dense, and water temperature was high, young snails grew between two to three mm/mo. During winter and early spring, when kelp beds thinned and deteriorated, snail growth dropped to about one mm/mo. It was also during the winter that water temperatures were lowest. Lowered water temperature increases calcium carbonate solubility and reduces metabolic activity, and it has been hypothesized that both contribute to increased energetic costs of shell production, resulting in lower growth rates during cold water months. Seasonal growth in this system is presumably strongly influenced by a combination of food supplies, water temperature, and availability of calcium carbonate.

LITERATURE CITED

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