5-5-2017

California Horn Snail exhibit a bimodal size distribution and size-associated dispersal patterns

Isai L. Lopez
Loyola Marymount University, isai-lopez@hotmail.com

LMU|LA
University Honors Program

California Horn Snail exhibit a bimodal size distribution and size-associated dispersal patterns

A thesis submitted in partial satisfaction

of the requirements of the University Honors Program

of Loyola Marymount University

by

Isai Lopez

5/5/17

California Horn Snail exhibit a bimodal size distribution and size-associated dispersal patterns

Isai Lopez, Colin Wikholm, Alex Napior, Shakeel Ahmad, and Víctor D. Carmona-Galindo*

Biology Department, Loyola Marymount University, Los Angeles, CA 90045

*Correspondence to: Víctor D. Carmona-Galindo, Department of Biology, Loyola Marymount University, 1 LMU Drive MS 8820, Los Angeles CA 90045; phone: (310) 338-1968; fax: (310) 338-4479; email: vcarmona@lmu.edu

Abstract The California Horn Snail (*Cerithideopsis californica*) is an important primary intermediate host in the life cycle of a variety of parasitic species that have extensive effects on ecological food webs. As such, parasite load in the California Horn Snail can serve as an important tool in assessing the effectiveness of restoration projects. The goal of the study was to investigate the population dynamics of the California Horn Snail in Ballona Wetlands, California, the only major coastal salt marsh in Los Angeles County. This study evaluated the spatial dispersion, size distribution, and density of *C. californica* collected from the Ballona Wetlands Ecological Preserve. The results showed that the population of *C. californica* in the preserve exhibited a bimodal distribution of size, with the large and small cohorts exhibiting significantly different patterns of dispersion. The study suggests that both bimodal size distribution and size-associated behavior of *C. californica* may be important for understanding this ecologically important snail.
Keywords: Population distribution, size-associated dispersal, *Cerithideopsis californica,* Ballona Wetlands, dispersion index

Introduction

The population structure of a species as well as the dispersal patterns within organisms of a community are both influenced by a variety of factors, including intraspecific competition (Crowe and Underwood, 1999), exploitative interactions (Mittlebach, 1988), and antagonistic interactions (Lafferty, 1993). Density dependent interactions as a result of crowding within populations can cause organisms to repel each other due to competitive exclusion (Roderick & Denno 1992). Population structure can serve as a measure of competitive interactions in some species, especially as it relates to temporal and spatial adaptation (Snell 1979). Organisms like the California Horn Snail, (*Cerithideopsis californica*) whose interspecific (Byers 2000) and intraspecific (Fenchel 1976) interactions play a large role in shaping community structure (Hawkins 1987), thus serve as excellent indicator species for monitoring changes in intertidal habitats (Hatcher & Dunn 2011).

In species where intraspecific competition is high at a young age, some have been observed to adapt their growth rates to escape and reach a less competitive size quickly (Arendt and Wilson 1997). Differences in resource use between age groups of a species are thought to impact niche width such that one age group can act as a biologically different species (Polis 1984). As such, studying differences in age groups within a study organism may give more specific information about how those groups interact with their environment. By assessing species dispersion by grouping the total species population within a habitat into cohorts we may be able to use size class to evaluate interactions and observe how intraspecific and interspecific interactions change as the snail develops.

The California Horn Snail is a common inhabitant of many salt marshes from Central California, USA to Baja California, Mexico (Lorda & Lafferty 2012). The snail plays a central role in ecological food webs in its habitat, and removal of the species would cause an extensive collapse of species-species food web links, primarily through interaction with a host of parasite species (Lafferty et al. 2006). The California Horn Snail lives between 6-10 years and serves as the first obligate host for larvae of at least 18 parasitic trematode species (Hechinger 2005). Other hosts of parasites that infect the California Horn Snail extend vastly in the food web (Lorda and Lafferty 2012). The California Horn Snail has shown to be a useful indicator for measuring the health of an ecosystem because of the extensive influence of trematodes and Horn snail on food web interactions (Hudson et al. 2006). Specifically, examining the population structure as well as the dispersal patterns of the California Horn Snail may be used to measure the health of the ecosystem, where a healthy ecosystem is defined as one with organization, vigor, and resilience that remains stable over time (Costanza 1999).

Evaluation of environmental status is of particular concern in Southern California, where anthropogenic causes have reduced wetland habitats in Los Angeles County by 98% of their original size (ballona.org). The California Horn Snail can be used as a tool for measurement of the effectiveness of a habitat restoration project. Due to the California Horn Snail's role as an obligate host in the life cycle of parasitic trematodes, a successful restoration of estuarine habitat should be accompanied by an increase in species richness as well as a higher prevalence of parasites (Huspeni and Lafferty 2004).

The objective of our research was to evaluate dispersal patterns in terms of changes in age structure of the California Horn Snail. We were also interested in comparing population density to a sample taken from a previous year to evaluate how density has changed over time (Johnston 2012). We hypothesized that dispersion index values would vary with respect to size class.

Materials and Methods

Ballona Wetlands

California Horn Snails were collected during low tides from channels connected to Ballona Creek in the Ballona Wetlands Ecological Reserve, a managed salt and freshwater marsh in Los Angeles, CA during November 2015. The approximately 2.4 square kilometer reserve is composed of three sites, A, B, and C. Site A, west of Lincoln Boulevard and north of Ballona Creek, is a primarily saltwater marsh cut off from tidal influence, completely dependent on rainfall for water (Ballona Friends). Site B is located west of Lincoln Boulevard and south of Ballona creek, and is divided into a mostly freshwater marsh on the east and an estuarine marsh in the west. This estuarine marsh, the site of our study, is tidally influenced, although influence is considered muted (Johnston 2015). Site C is located east of Lincoln Boulevard and north of Ballona Creek, and is made up of uplands, an important refuge for migrating birds (Ballona Friends) Over half of Ballona is covered in non-native plants that are poor refuges for the native wildlife. The dominant plant growing in the Ballona Wetlands is the *Salicornia virginia* (Ballona Friends).

Measuring structure and dispersion

A 0.5 m x 0.5 m quadrat was used to sample snail sites. Snails were measured lengthwise (cm) using a Vernier caliper. Snail length measurements were taken from 5 quadrats (1.25 m^2 total). The distribution of size abundance was evaluated using a histogram.

Thirteen quadrats (3.25 m^2) were digitally photographed for dispersion pattern analysis. Dispersion pattern was measured using nearest neighbor calculation of large and small size cohorts. Large and small snails were assigned to cohorts based on cohort distribution minimum binned snail length that partitioned the population structure curve into two groups, >17.7 mm and < 17.7 mm (Figure 1). Population densities were also calculated to compare to values from a baseline assessment from 2010 (Johnston 2012).

Data Analysis

The nearest neighbor of each snail was calculated using SigmaScan Pro. Snails that were at and above a cutoff length of 17.7 mm were designated as large while those below that length were designated small. These size cohorts were marked on the image and were then used to calculate the dispersion index (R) for both sizes of snail at each measurement using the Clark-Evans method (Clark & Evans 1954). C-values were calculated for each R-value ($\overline{r}_A$ / $\overline{r}_E$ where $\overline{r}_A$ is the mean distance between neighbors and $\overline{r}_E$ is the distance expected in a population of uniformly dispersed individuals) to determine if the value was further from 1 than expected by chance. Dispersion indices were tested for normality using the Shapiro-Wilks test. We compared dispersion indices of the two size cohorts using a Mann-Whitney U test. The population density of our measurements was compared to the snail density from baseline survey of Ballona Wetlands 5 years prior (Johnston 2012) by testing for normality using the Shapiro-Wilks tests, and then using a t-test for independent variables.

Results

The size distribution of the California Horn Snails exhibited a mean of 19.3 ± .211 mm (n=746). The two most abundant size cohorts were at 14.1 mm and 21.4 mm (Figure 1). A trough in the middle separated snail population into small (<17.7 mm) and large (>17.7 mm) size classes.

The R-values for both small and large size classes were not normally distributed (W=0.82015, p = 0.02545). The small cohort had a dispersion index that was significantly smaller than the large cohort (p=0.047). Three out of the 10 dispersion indices had a c-value that indicated that the observed R-values were further from 1 than would be expected by chance.

The observed densities of snails from our study and the densities observed in the 2010 baseline survey were both normally distributed (W=0.8535, p=0.110). The densities of California Horn Snail observed during the two years were not significantly different (p=0.2078).

Discussion

The difference in distribution indices suggests that the distribution pattern of the California Horn Snail population varies with the size of individuals. The population structure of the California Horn Snail exhibited a bimodal pattern, suggesting that the middle size group is being selected against by environmental forces (Warwick 1984). A similar bimodal distribution has been observed in freshwater snail populations, suggesting that the predation selected for snails that grow faster through this dangerous size range (Reed and Janzen 1999). Previous studies have found that depending on the predator species, certain size groups of California Horn Snail are targeted more frequently, with the middle and larger groups being the most vulnerable (Sousa 1993).

The difference in dispersal indices for the two size classes suggests intraspecific competition within the smaller group of snails (Snell 1979). The larger snails exhibit a random dispersal, suggesting a balance between repelling and attracting forces. The dispersal pattern indicates interspecific competition, either with a different species of snails (Fenchel & Kofoed 1976) or a predatory species (Crowl & Covich 1990). The similarities observed between population densities of California Horn Snail in this and the 2010 study of greater Ballona Wetlands suggest that the population from our study is representative of the greater salt marsh.

Several tools and strategies for measuring ecosystem health have been proposed including soil metal content (Peakall & Burger 2003), parasite community structure (Bongers & Ferris 1999), and carefully chosen indicator species (Hewitt et al. 2005). The indicator species in particular are useful in that they concentrate information about how nutrients, pathogens, and pollutants move throughout the habitat (Stewart et al. 2008). The variance in dispersal seen in the California Horn Snail is therefore an important tool in analyzing interspecific interactions due to the snail's extensive connection with other members of the food web (Lafferty 2008).

In a food web, parasite-host interactions are more common than predator-prey interactions (Lafferty 2006). Their life-cycle consists of various stages within multiple hosts, resulting in a greater degree of rooting within the food web (Marcogliese & Cone 1997). Parasites are also known to alter the behavior of their host, modifying interactions with other species and increasing predation (Lafferty et al. 2008, Moore 2002). The emergence of different dispersal patterns in California Horn Snail at Ballona is consistent with previous studies showing differences in behavior between parasite infected adults and juveniles (Levri & Lively 1996). The bimodal population distribution discussed earlier may also be explained by parasite behavior influence, as parasites have been shown to cause both gigantism (Hechinger 2010) and dwarfism (Lafferty 1993) in host species.

The California Horn Snail stands as an important indicator species in examining intraspecific as well as interspecific interactions, including those with its parasites. Across size cohorts, we see differences in the way the California Horn Snail disperses itself. The underlying causes for the difference in dispersal is not clear however, and should be a focus for future research. The size distribution displays a bimodal trend, which suggests some advantage to growing to those lengths. Parasite composition has shown to have both attracting and repelling effects on host population depending on the species of parasite (Kuris & Lafferty 1994), so an examination of parasite diversity in addition to predation rates among size cohorts may provide further knowledge as to the strength of interactions between food web links in the Ballona Wetlands

References

Arendt, J. D., & Wilson, D. S. (1997). Optimistic growth: competition and an ontogenetic niche-shift select for rapid growth in pumpkinseed sunfish (Lepomis gibbosus). Evolution, 1946-1954.

Bongers, T., & Ferris, H. (1999). Nematode community structure as a bioindicator in environmental monitoring. Trends in Ecology & Evolution, 14(6), 224-228.

Byers, James E. "Competition between two estuarine snails: implications for invasions of exotic species." Ecology 81.5 (2000): 1225-1239.

Clark, P. J., & Evans, F. C. (1954). Distance to nearest neighbor as a measure of spatial relationships in populations. Ecology, 35(4), 445-453.

Costanza, R., & Mageau, M. (1999). What is a healthy ecosystem?. Aquatic ecology, 33(1), 105-115.

Crowl, T. A., & Covich, A. P. (1990). Predator-Induced Life-History Shifts in a Freshwater Snail. *Science*, *247*(4945), 949–951.

Denno, Robert F., and George K. Roderick. "Density-related dispersal in planthoppers: effects of interspecific crowding." Ecology 73.4 (1992): 1323-1334.

Ebert, D., Joachim Carius, H., Little, T., & Decaestecker, E. (2004). The Evolution of Virulence When Parasites Cause Host Castration and Gigantism. *The American Naturalist*, *164*(S5), S19–S32.

Fenchel, T., and L. H. Kofoed. "Evidence for exploitative interspecific competition in mud snails (Hydrobiidae)." Oikos (1976): 367-376.

Hatcher, M. J., & Dunn, A. M. (2011). Parasites in ecological communities: From interactions to ecosystems. Cambridge, UK: Cambridge University Press.

Hawkins, Charles P., and Joseph K. Furnish. "Are snails important competitors in stream ecosystems?." Oikos (1987): 209-220.

Hechinger, R. F. (2010). Mortality affects adaptive allocation to growth and reproduction: field evidence from a guild of body snatchers. *BMC Evolutionary Biology*, *10*(1), 136.

Hechinger, R. F., & Lafferty, K. D. (2005). Host diversity begets parasite diversity: bird final hosts and trematodes in snail intermediate hosts. *Proceedings of the Royal Society of London B: Biological Sciences*, *272*(1567), 1059–1066.

Hechinger, R. F., Lafferty, K. D., Iii, F. T. M., Warner, R. R., & Kuris, A. M. (2008). How large is the hand in the puppet? Ecological and evolutionary factors affecting body mass of 15 trematode parasitic castrators in their snail host. *Evolutionary Ecology*, *23*(5), 651–667.

Hewitt, J. E., Anderson, M. J., & Thrush, S. F. (2005). Assessing and monitoring ecological community health in marine systems. Ecological Applications, 15(3), 942-953.

Hudson, P. J., Dobson, A. P., & Lafferty, K. D. (2006). Is a healthy ecosystem one that is rich in parasites? *Trends in Ecology & Evolution*, *21*(7), 381–385.

Huspeni, T. C., & Lafferty, K. D. (2004). Using larval trematodes that parasitize snails to evaluate a saltmarsh restoration project. *Ecological Applications*, *14*(3), 795–804.

Johnston, Karina. (2012). The Ballona Wetlands Ecological Reserve Baseline Assessment Program 2010-2011 Final Report.

Johnston, Karina. (2015). "Technical Memorandum: Condition Assessment of the Wetland Habitats in the Ballona Wetlands Ecological Reserve, Los Angeles, CA" Prepared for California State Coastal Conservancy and California Department of Fish and Wildlife.

Kuris, A. M., & Lafferty, K. D. (1994). Community Structure: Larval Trematodes in Snail Hosts. *Annual Review of Ecology and Systematics*, *25*, 189–217.

Lafferty, K. D. (1993). The Marine Snail, Cerithidea californica, Matures at Smaller Sizes Where Parasitism Is High. *Oikos*, *68*(1), 3–11.

Lafferty, K. D., Dobson, A. P., & Kuris, A. M. (2006). Parasites dominate food web links. *Proceedings of the National Academy of Sciences*, *103*(30), 11211–11216.

Lafferty, K. D., Allesina, S., Arim, M., Briggs, C. J., De Leo, G., Dobson, A. P., … Thieltges, D. W. (2008). Parasites in food webs: the ultimate missing links. *Ecology Letters*, *11*(6), 533–546.

Levri, E. P., & Lively, C. M. (1996). The effects of size, reproductive condition, and parasitism on foraging behaviour in a freshwater snail, Potamopyrgus antipodarum. *Animal Behaviour*, *51*(4), 891–901.

Lorda, J., & Lafferty, K. D. (2012). Shading decreases the abundance of the herbivorous California horn snail, Cerithidea californica. *Journal of Experimental Marine Biology and Ecology*, *432*, 148–155.

Marcogliese, D. J., & Cone, D. K. (1997). Food webs: a plea for parasites. Trends in Ecology & Evolution, 12(8), 320-325.

Minchella, D. J. (1985). Host life-history variation in response to parasitism. *Parasitology*, *90*(01), 205–216.

Moore, J. (2002). Parasites and the Behavior of Animals. Oxford University Press, Oxford.

Peakall, D., & Burger, J. (2003). Methodologies for assessing exposure to metals: speciation, bioavailability of metals, and ecological host factors. Ecotoxicology and Environmental Safety, 56(1), 110-121.

Polis, Gary A. "Age Structure Component of Niche Width and Intraspecific Resource Partitioning: Can Age Groups Function as Ecological Species?". The American Naturalist 123.4 (1984): 541–564.

Reed, W. L., & Janzen, F. J. (1999). Natural selection by avian predators on size and colour of a freshwater snail (Pomacea flagellata). *Biological Journal of the Linnean Society*, *67*(3), 331–342.

Seppälä, O., Karvonen, A., & Tellervo Valtonen, E. (2004). Parasite-induced change in host behaviour and susceptibility to predation in an eye fluke–fish interaction. *Animal Behaviour*, *68*(2), 257–263.

Snell, Terry W.. "Intraspecific Competition and Population Structure in Rotifers". Ecology 60.3 (1979): 494–502.

Sorensen, R. E., & Minchella, D. J. (2001). Snail-trematode life history interactions: past trends and future directions. *Parasitology*, *123*(07),

Sousa, W. P. (1993). Size-dependent predation on the salt-marsh snail Cerithidea californica Haldeman. *Journal of Experimental Marine Biology and Ecology*, *166*(1), 19–37.

Stewart, J. R., Gast, R. J., Fujioka, R. S., Solo-Gabriele, H. M., Meschke, J. S., Amaral-Zettler, L. A., ... & Sinigalliano, C. D. (2008). The coastal environment and human health: microbial indicators, pathogens, sentinels and reservoirs. Environmental Health, 7(2), 1.

Torchin, M. E., Miura, O., & Hechinger, R. F. (2015). Parasite species richness and intensity of interspecific interactions increase with latitude in two wide-ranging hosts. *Ecology*, *96*(11), 3033–3042.

Warwick, R. (1984). Species Size Distributions in Marine Benthic Communities. Oecologia, 61(1), 32-41. Retrieved from http://www.jstor.org/stable/4217200

Zimmer, R. K., Fingerut, J. T., & Zimmer, C. A. (2009). Dispersal pathways, seed rains, and the dynamics of larval behavior. *Ecology*, *90*(7), 1933–1947.

"How The Wetlands Affect Us - Ballona Wetlands Land Trust." Ballona Wetlands Land Trust. Web. 19 Apr. 2016.

Friends of Ballona Wetlands. http://www.ballonafriends.org/habitat.html, 16 Dec 2016

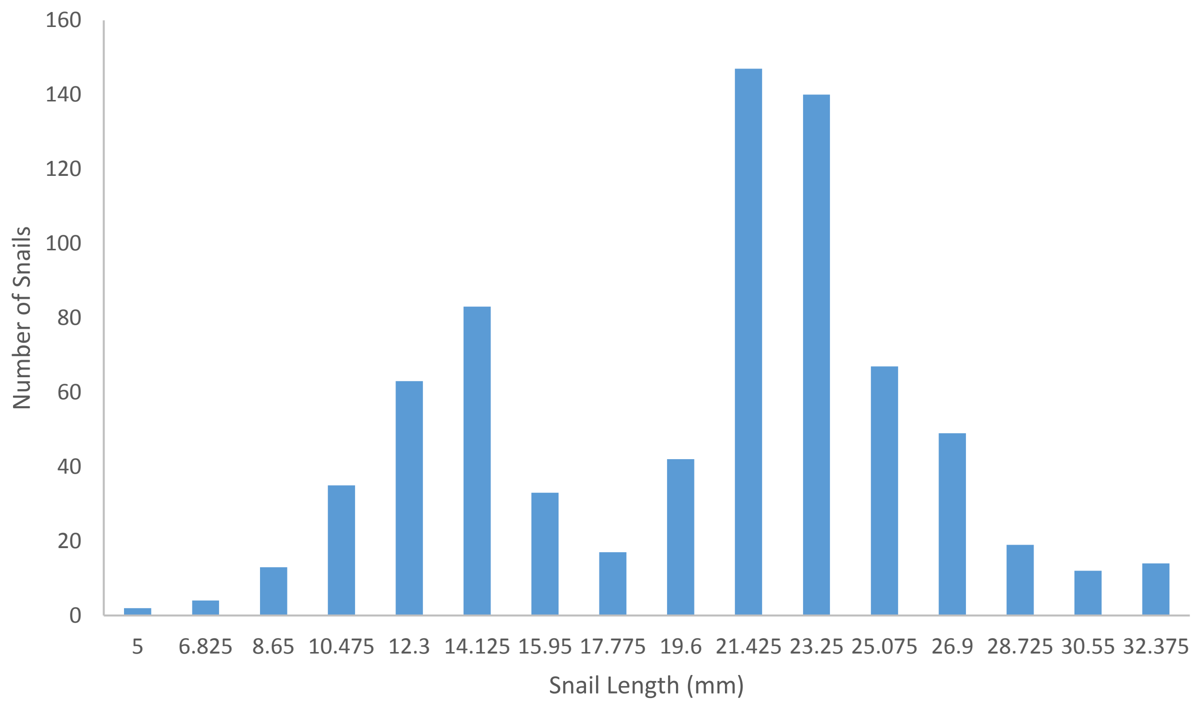

Figure 1: Population distribution curve showing numbers of snails measured by length

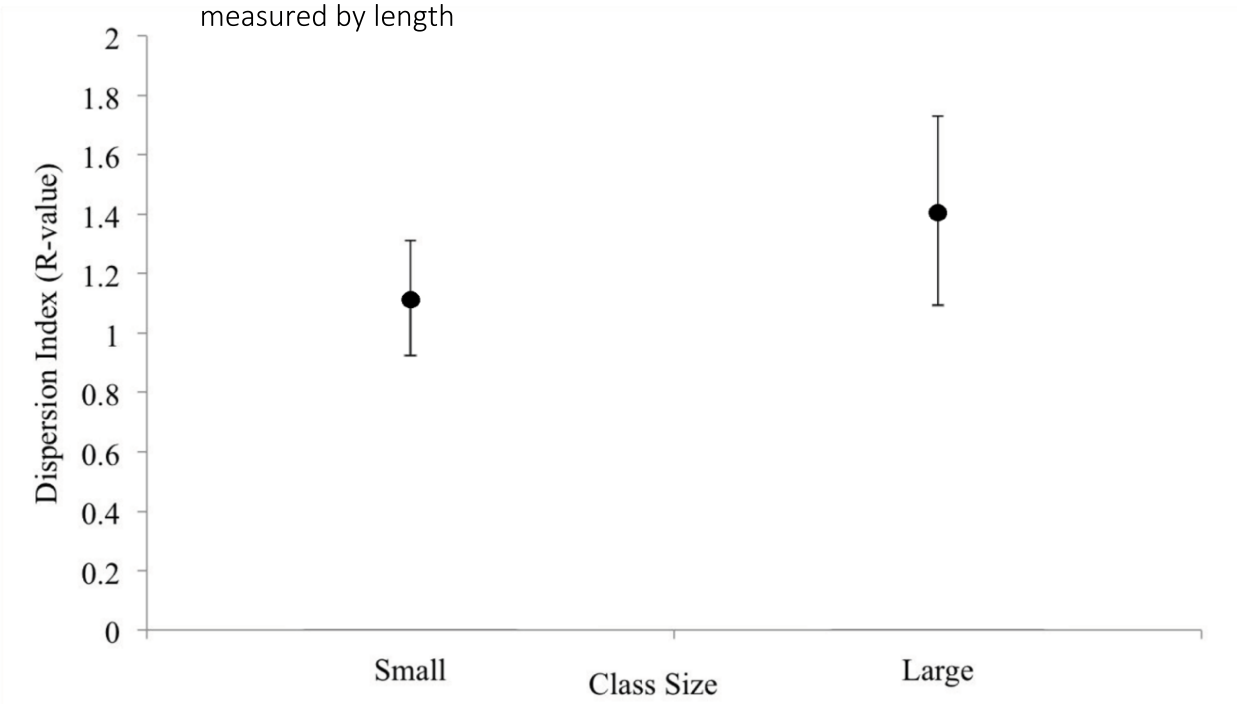

Figure 2: Comparison of dispersion indices for both small and large class sizes. Error bars denote one standard deviation unit.