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Rapid Communication

Mortality estimate of Chinese mystery snail, *Bellamyia chinensis* (Reeve, 1863) in a Nebraska reservoir

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Abstract

The Chinese mystery snail (*Bellamyia chinensis*) is an aquatic invasive species found throughout the USA. Little is known about this species' life history or ecology, and only one population estimate has been published, for Wild Plum Lake in southeast Nebraska. A recent die-off event occurred at this same reservoir and we present a mortality estimate for this *B. chinensis* population using a quadrat approach. Assuming uniform distribution throughout the newly-exposed lake bed (20,900 m²), we estimate 42,845 individuals died during this event, amounting to approximately 17% of the previously-estimated population size of 253,570. Assuming uniform distribution throughout all previously-reported available habitat (48,525 m²), we estimate 99,476 individuals died, comprising 39% of the previously-reported adult population. The die-off occurred during an extreme drought event, which was coincident with abnormally hot weather. However, the exact reason of the die-off is still unclear. More monitoring of the population dynamics of *B. chinensis* is necessary to further our understanding of this species' ecology.

Key words: invasive snail; mortality estimate; freshwater ecosystem; population dynamics

Introduction

The Chinese mystery snail (*Bellamyia* [= *Cipangopaludina*] *chinensis* (Reeve, 1863)), is an aquatic invasive species found in more than 30 states in the USA (USGS 2012a). Originally from Southeast Asia, Japan, and Russia (Jokinen 1982), the species was transported for both food and the aquarium trade, first appearing in the western USA in the late 1800's (Wood 1892) and reported on the East coast as early as 1914 (Jokinen 1982).

The species is capable of reaching high densities after invasion (Johnson et al. 2009; Solomon et al. 2010), yet little is known about

the ecological effects of such large populations. It is the second largest snail reported in North America – and the largest snail present in most of its invasive range – reaching shell lengths upwards of 65 mm (Olden et al. 2009). Because our knowledge is limited (Solomon et al. 2010; Jokinen 1982; Johnson et al. 2009; Prezant et al. 2006), documenting changes in population density is crucial to increasing our understanding of this species' life-history and population dynamics in novel ecosystems. Additionally, we hope to improve knowledge on how invasive gastropod species, in general, distribute themselves in nature.

Bellamyia chinensis is found throughout Nebraska, though the first and only estimate for

the population of a reservoir, Wild Plum Lake, was conducted only recently (Chaine et al. 2012). To briefly summarize this manuscript, we used a mark-recapture technique of adult snails found submerged across a transect and found an average of 5.2 snails/m², or 52,280 snails/ha. Extrapolating out to the estimated available habitat in the lake (75% of lake) by using the Lincoln-Peterson estimation, we estimated an adult population size of 253,570 snails.

In 2012, Nebraska experienced low precipitation levels and limited lake recharge from surface water runoff and groundwater inputs (High Plains Regional Climate Center 2012). In addition, ambient temperatures in Lancaster County were approximately 0.5°C above the long-term average (High Plains Regional Climate Center 2012). During this same period, both an increased number of empty adult *B. chinensis* shells along the shoreline and decreased water levels were observed at Wild Plum reservoir, prompting an investigation and mortality estimate for the population.

Methods

Field sampling

Sampling occurred on 29 August 2012 at Wild Plum Lake (40-36'52"N, 096-54'09"W), Lancaster County, Nebraska, approximately 27 km southwest of Lincoln. Typically, the reservoir has an area of 64,700 m² and is relatively shallow (<5 m) (Nebraska Game and Parks Commission 2012). The number of recently deceased snails was estimated by walking the perimeter of the lake, and placing a 1 m² quadrat, with one edge adjacent to the water line, every 10 m. The number of adult (shell length > 11.2 mm) *B. chinensis* shells with an intact spire was counted within each quadrat and recorded. By counting only the shells including a complete spire, we prevented counting an individual more than once, as some of the shells were broken and in pieces. Only snails visible at the surface were counted; we did not dig for buried individuals (which may be an important distinction, as *B. chinensis* have been reported to bury in sediment) (Jokinen 1982). All individuals counted were adults (based on shell length); we did not note or count juveniles due to their small size and easy confusion with native species. Additionally, we did not collect any submerged snails out of the water, though dead snails were also found in the lake (personal observation).

Mortality estimate

The total number of dead adult individuals is estimated by dividing the total study area (*A*), by the area of the quadrat (*a*) and multiplying this value by the mean number of organisms per quadrat (*n*). Total study area is defined as the newly-exposed shoreline that was previously submerged lake bed, and this was estimated using the bathymetric map provided by the Nebraska Game and Parks Commission (2012). We estimated the water levels had receded to the previously-reported 1.2 m contour line, which is approximately a 20% decline in whole-lake surface area. This method assumes the snails were uniformly distributed throughout this shoreline region. All values are reported as mean ± 1 standard error (SE).

$$N = (A/a) \times n$$

where: *N* = estimated number of dead individuals, *A* = total study area, *a* = area of quadrat, *n* = mean number of organisms per quadrat.

To provide a reasonable range of possible mortality, we include both a conservative and a liberal estimation, applying different assumptions.

Results and discussion

One hundred eighty one adult individuals were found within 88 m², with a mean of 2.05 ± 0.5 dead snails per m² (*n*). The total area of newly-exposed dry lake bed used in calculations was estimated at 20,900 m² (*A*). The estimated mortality in this newly-exposed area is 42,845 ± 10459 (*N*) individuals.

Comparing to the population estimate reported by Chaine et al. (2012), 42,845 adult snails comprise 17% of the total adult population. In the current investigation, approximately 10% of this exposed shoreline was assessed for dead individuals. The area sampled constituted a small percentage of the available *B. chinensis* habitat of the entire lake. Using this method, it was assumed that the number of dead adult individuals was uniformly distributed throughout this newly-exposed shoreline that was previously submerged at the time of the population estimate. Based on our previous field experience, snails were prevalent in the portion that was newly exposed, and, using similar search methods, we found few individuals still submerged in water. Only individuals visible on the surface were counted. The substrate was dry and cracked, making it difficult for snails to burrow.

If we assume that mortality was even throughout the lake area of suitable habitat, rather than just throughout the newly-exposed lake bed, and use a total study area (A) of 48,525 m² (75% of the total lake area of 64,700 m²) the mortality estimate (N) rises to 99,476 ± 24,263 adult snails. This liberal estimation comprises 39% of the previously-reported population density of adult snails in Wild Plum.

During the period of 8 June 2012 to 5 September 2012, Crete, Nebraska (8 kilometers to the west of Wild Plum) received 0.08 cm of precipitation (USGS 2012b); the average precipitation is 29.1 cm for this same time period (High Plains Regional Climate Center 2012). Reduced precipitation, combined with higher-than-average air temperatures, caused decreased water levels and increased water temperatures. Both factors may affect habitat requirements of *Bellamya chinensis*. Wild Plum Lake is a stream-fed reservoir, and the streams that usually feed the lake were dry at the time of the investigation (personal observation). It is suspected that this dry weather and high temperatures resulted in a die-off event not witnessed during sampling around the same time the previous year (in contrast, 2011 was a wetter-than-average year).

Population estimates should be repeated on a regular basis to monitor the Wild Plum *B. chinensis* population, and to improve our understanding of invasive freshwater snail species. Additional work can include juveniles, though our current methods did not result in a high juvenile collection rate. Other environmental variables, including dissolved oxygen concentrations and predator activity, should be investigated in the future, as they likely impact snail population dynamics. Additionally, snails may be fed on after becoming exposed as the water recedes, if they do not retreat quickly enough. The current results will serve as a reference for future investigations, and will improve understanding if the cause of die-off was due to climate and/or natural population fluctuations.

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