International Seminar on Plant Protection
Faculty of Agriculture, University of Bengkulu
Departement of Plant Protection, Faculty of Agriculture, University of Bengkulu, Indonesia

Volume 1, No. 1, june. 2025

Comparison of Growth Rate and Density of Gastropoda in the Intertidal Zone

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Abstract

The intertidal zone, the smallest area in the ocean located between high and low tides, exhibits the greatest variation in environmental factors. Seagrass ecosystems influence biological and physical processes in coastal areas. Gastropods are among the biota found in seagrass areas, both on the surface and within sediments. This review employs a literature study technique, compiling articles from international journals over the past decade on the growth rate and population density of gastropods, using the ScienceDirect database with relevant keywords. Articles were analyzed based on inclusion and exclusion criteria. The maximum body size and density of gastropods from three populations were measured using a digital caliper with an accuracy of 0.01 mm and converted to density per square meter. Growth rate testing was conducted through mark-recapture methods every two months over a year. Three populations of *Nerita japonica* showed significant variation in maximum body size and density. The S3U population ceased growth at a small size, S3I at a medium size, and R1 at a large size. The density of *N. japonica* was lower on open rocky shores compared to sheltered shores, similar to the pattern observed in *Nerita atramentosa*. This study demonstrates that the growth rate of *N. japonica* can vary even over small geographic distances, reflecting differences in maximum body size and the diversity of fundamental species characteristics that influence their way of life.

Keywords: *density, gastropods, growth rate,*

Introduction

The intertidal zone, the smallest area in the world's oceans, lies between high and low tides. This region exhibits the greatest variation in environmental factors despite its limited size. Gastropods are among the larger life forms inhabiting this zone. Some members of the gastropod class can thrive in intertidal waters by tightly closing their shells to prevent water loss.

One of the coastal ecosystems along the bay waters of West Sumatra is seagrass, which contributes to productive waters. Seagrass ecosystems significantly influence biological and physical processes in coastal areas. Seagrasses can live permanently below the sea surface, forming ecosystems dominated by vegetation (Umar 2010). Seagrass ecosystems serve as habitats for shelter, feeding, mating, spawning, and rearing offspring (Priosambodo 2016). Gastropods are among the biota found in seagrass areas, emerging from the surface or burrowing into sediments. Gastropods are relatively sedentary, often remaining in one area for extended periods (Putri, 2012; Wahyuni et al., 2017) and are sensitive to changes in water quality. Exposure to pollution can kill gastropods, disrupting community structure and species diversity

(Odum, 1993). Therefore, gastropods are often used as indicators to assess water pollution.

Gastropods play a crucial role in aquatic ecosystems by aiding the mechanical decomposition of organic material through their feeding activities. They also hold importance in education, economy, and ecology.

The gastropod Monetaria annulus inhabits coral reefs and seagrass beds (Katoh 1989, Irie 2006). Ecologically, gastropods contribute to the food chain as detritivores and prey for aquatic biota (Wendri et al., 2019). Economically, they support human livelihoods as food sources, industrial materials, and jewelry (Wendri et al., 2019). Research shows that M. annulus is harvested for various economic purposes worldwide (Newton et al., 1993; Poutiers, 1998; Kusnadi et al., 2008; Laimeheriwa, 2017), leading to population declines (Newton et al., 1993).

Research Method

In compiling this review, the technique used is a literature study, where several reference articles or primary data from international journals from the last 10 years relevant to the growth rate and population density of gastropods were collected. The article search was conducted using the ScienceDirect database with the keywords "growth rate," "population density," and "gastropod." The collected articles were then analyzed and selected based on predefined inclusion and exclusion criteria.

The inclusion criteria encompass articles that specifically discuss the growth rate of gastropods. The journals used in this study include both open-access and subscribed journals to ensure broad and comprehensive coverage. The selected articles were analyzed descriptively to provide an in-depth and thorough overview of the topic. This approach allows researchers to identify patterns and trends in the growth rate and population density of gastropods based on the latest available empirical data in scientific literature.

Results and Discussion

In 2022, Kusuma Novian P et al. studied the abundance and growth patterns of gastropods (Telescopium telescopium and Cerithidea obtusa) and their relationship with the mangrove ecosystem at Bee Jay Bakau Resort, Probolinggo, East Java. They found that gastropod abundance ranged from 9 to 84 individuals per square meter, with a negative allometric growth pattern, where length increased faster than weight.

In 2021, Jean Beguinot examined intra-specific variability in the growth rate of whorls in terrestrial gastropods with conispiral shell shapes. The study revealed significant differences in the amplitude of intra-specific variability in whorl growth rates among species, with no significant correlation between intra-specific variability and shell shape type.

In 2020, Patricio de los Ríos et al. investigated the age and growth of two populations of Pugilina cochlidium (Gastropoda: Melongenidae) from the Thondi-Palk Bay coast in Tamil Nadu, Southeast India. The results showed similar growth patterns between males and females. Age and growth estimates for both populations were determined using multiple methods, with FISAT 1 software as an analytical tool.

Philip R. Hollyman (2018) estimated the age and growth rate of the commercially fished gastropod *Buccinum undatum*. Using oxygen isotope analysis on shells, they determined the age of several individuals from each location to test the accuracy of statolith and operculum age estimates. The statolith was considered a reliable improvement over the operculum for fisheries monitoring and management purposes.

In 2016, Saleky Dandi et al. studied the length-weight relationship and genetic diversity of two marine gastropod species (*Turbo sparverius* and *Turbo bruneus*) in the Bird's Head Seascape, Papua, Indonesia. They found that both species exhibited negative allometric growth patterns, where weight gain was slower than length increase. Haplotype diversity was high, with values ranging from 0.657–0.705 for *T. sparverius* and 0.739–0.816 for *T. bruneus*.

Carolus Paulus Paruntu (2011) investigated intraspecific variation in growth rates among three populations of the intertidal gastropod *Nerita japonica* (Dunker). The study found that the rocky shore population exhibited faster growth compared to the other two populations. Peak growth periods occurred between May–July for the R1 population and July–September for S3U and S3I.

Lastly, in 2009, Stella C. and Raghunathan C. examined the age and growth of Muricid gastropods *Chicoreus virgineus* and *Muricanthus virgineus* from Thondi Coast, Palk Bay, Bay of Bengal. Probability plot methods revealed that *C. virgineus* males reached a maximum shell length of 8.55 cm and females 10.35 cm by the fourth year, while *M. virgineus* males reached 9.4 cm and females 11.00 cm in the same time span.

The abundance of gastropods based on the number of individuals per unit area is calculated using the formula proposed by Odum (1993) as follows:

$$K = \frac{N}{A}$$

which:
K= species abundance (individuals/m²)
N = total number of individuals captured within area A (individuals)
A = plot area (m^2)

Maximum Body Size and Density

At least 125 individuals were collected from each of the three populations (R1, S3u, and S3l) using a quadrat. The size of each individual was measured using a digital caliper with an accuracy of 0.01 mm. Large individuals, representing 8% of the total population (with at least 10 large individuals from each population), were used for analysis. The data were then converted into density per square meter for further analysis.

Growth Rate

A mark-and-recapture experiment was conducted every two months during the growth period over the course of one year to estimate the individual growth rates among three populations (R1, S3u, and S3l). A total of approximately 1,897 individuals from R1, 2,432 from S3l, and 2,281 from S3u were collected (including snails that were re-tagged upon each recapture), all within a shell length range of more than 4 mm. After

the shells were dried, a small waterproof paper label (2 x 2 mm) with a number written in Chinese ink was attached using fast-drying epoxy resin.

The shell length of each individual was measured using a digital electronic caliper with an accuracy of 0.01 mm and then released back at the collection site. The snails were recaptured by hand or with tongs at approximately 8-week intervals over one year. After each measurement and tag correction, all snails were released within 72 hours.

The additional individuals, especially those that are small and difficult to recapture, are released in the same manner depending on the overall recapture rate during each sampling. The growth rate is calculated for each individual using the formula:

$$r = \frac{lnLt - lnLo}{T}$$

Where r is the growth rate, Lo and Lt are the shell lengths (mm) at times 0 and t, respectively, and t is the time in days.

Three populations of Nerita japonica differ significantly in many measured population variables. The maximum body size of the snails varies between populations, with snails from the S3U population stopping growth at a small size, snails from the S3l population stopping growth at a medium size, and snails from the R1 population stopping growth at a large size. The size differences may be caused by several factors. The maximum body size of N. japonica may be related to density, but not to tidal height, indicating that food availability might be a limiting factor affecting growth as density increases. The very low density of N. japonica on open rocky shores compared to moderately open rocky shores aligns with the pattern observed in Nerita atramentosa, whose density is very low on open shores compared to sheltered shores (Underwood, 1975b). Underwood (1975b) suggested that differences in density across shores for N. atramentosa primarily reflect the influence of wave exposure.

The growth rate of N. japonica differs across the three populations, similar to what was found for N. atramentosa by Underwood (1984). Growth rate differences among populations of several other grazing gastropods have been investigated by Paine (1969), Sutherland (1970), Lewis and Bowman (1975), Creese (1980), McCormack (1982), Fletcher (1984b), Jardines (1985), and Takada (1995). The growth rate differences between N. japonica populations in this study reflect the differences in the maximum body size of individuals from each of the three populations.

The growth of N. japonica may not be related to tidal height, but it is related to the density of snails at a given location, suggesting that food availability might be a limiting factor affecting growth as density increases. This study shows that even with small geographical distances, the growth rates of Nerita japonica can vary. It is clear that the variability in the fundamental characteristics of a species influences how it lives. Furthermore, this research highlights potential differences in the growth of Nerita japonica across populations. Future studies should determine whether the differences among populations are due to environmental differences between habitats, genetic differences between populations, or a combination of both.

Conclusion

This study demonstrates that the growth rate of N. japonica can vary even over small geographic distances, reflecting differences in maximum body size and the diversity of fundamental species characteristics that influence their way of life.

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