

Research Insight

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Effects of Stocking Density on Yield and Quality of Hard Clams

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Abstract Stocking density is one of the most critical management factors influencing the productivity, profitability, and sustainability of Manila clam (*Ruditapes philippinarum*) aquaculture. Appropriate stocking densities can enhance resource utilization efficiency and maximize yield, whereas excessively high or low densities may adversely affect growth performance, survival, product quality, and environmental conditions. This review summarizes the current understanding of the effects of stocking density on Manila clam culture, with particular emphasis on growth characteristics, biomass production, quality attributes, and environmental impacts. The underlying mechanisms through which density influences food availability, competition, physiological performance, and carrying capacity are discussed. Furthermore, the interactions between stocking density and environmental factors, including water quality, sediment conditions, and disease occurrence, are examined. Recent advances in density optimization strategies, such as stage-specific stocking management, graded culture practices, and precision aquaculture technologies, are also reviewed. Representative case studies from different aquaculture systems are presented to highlight practical approaches for balancing production efficiency and product quality. Finally, future research directions are proposed, focusing on multi-factor interactions, intelligent farming systems, and sustainable aquaculture development. This review provides a comprehensive reference for optimizing stocking density and promoting the sustainable growth of the Manila clam industry.

Keywords Manila clam; Stocking density; Growth performance; Yield; Product quality

1 Introduction

Manila clam, *Ruditapes philippinarum*, is one of the most commercially important cultured bivalves worldwide, contributing about 24%-25% of global mollusc aquaculture production in recent years (Johnson et al., 2025). Its annual global market value has exceeded US\$6 billion, and the species now has a cosmopolitan aquaculture distribution following transfers far beyond its native temperate East Asian range. China remains the leading producer, with production exceeding 2 million tons annually along the Yellow Sea, Bohai Sea, and East China Sea coasts, while Italy is the second-largest producer globally and the dominant producer in Europe. In Italy alone, Manila clam aquaculture generated 23 thousand tons valued at €212 million in 2021, underscoring the species' importance not only to seafood supply but also to regional employment and coastal economies (Martini et al., 2024). At the European scale, clam fisheries and aquaculture have substantial economic value, and production has become strongly dominated by the introduced Manila clam as native clam landings have declined because of overfishing, recruitment failure, abiotic stress, and disease. The expansion of the industry has also been supported by production-system diversification, including integrated culture with shrimp, fish, and crab in China and the extension of farming grounds from intertidal areas into shallow subtidal waters, where longer immersion and higher phytoplankton availability can improve growth opportunities. Beyond direct harvest value, Manila clam farming provides ecosystem services that further strengthen its economic relevance: farm production in Puget Sound has been modeled at 32-45 t per year with additional nutrient credit value exceeding US\$41,000 annually, while life-cycle studies in Italy indicate that clam farming can function as a net carbon sink because shell formation offsets operational emissions. These advantages help explain why Manila clam aquaculture is often regarded as one of the more environmentally favorable forms of animal food production, with relatively low climate impacts and measurable nutrient-removal functions.