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Article

Evaluating the filtration efficiency and water quality impact of *Corbicula javanicus*

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SUMMARY
Freshwater ecosystems are vital to both ecological health and human well-being, yet they face significant degradation due to water contamination and loss of biodiversity. Bivalves, a class of aquatic mollusks with a hinged pair of shells, have been found to feed on plant detritus, algae, and other particles, making them a significant contributor to natural water filtration. Their feeding behavior not only removes suspended particles but can also help control algal blooms in nutrient-rich waters. In this study, we investigated the water filtration capabilities of *Corbicula javanicus*, a freshwater bivalve, to assess its potential in improving water quality. We hypothesized that *C. javanicus* would improve water clarity in nutrient-rich freshwater environments. To test this, we introduced juvenile clams to experimental tanks containing pond water with high levels of algae, while control tanks remained clam-free. Over a three-day period, we measured water clarity and pH levels. The results demonstrated that *C. javanicus* improved water clarity, increasing from 25% to 90% in one trial, whereas control tanks remained stagnant. Each clam filtered approximately 0.33 gallons of water per day, based on visual clarity changes assessed in this experiment. These findings align with prior research on filter-feeding organisms and highlight the potential of bivalves in not only saltwater ecosystems, but freshwater environments as well. The use of freshwater bivalves such as *C. javanicus* offers a promising, sustainable solution for enhancing water quality, benefiting both ecological stability and human communities dependent on these resources.

INTRODUCTION
The quality of water in freshwater ecosystems is a cornerstone of ecological health, directly influencing the organisms that inhabit these environments, the stability of the ecosystem, and human health. Poor water quality can disrupt ecological balances, leading to a decline in biodiversity and, in extreme cases, the extinction of species (1). For humans, the stakes are equally high—contaminated water serves as a vector for severe health risks, including cholera, dysentery, and other waterborne diseases (1). Moreover, industries such as agriculture, fisheries, and tourism heavily rely on freshwater resources, making water quality a critical factor for economic sustainability.

The degradation of freshwater ecosystems has profound implications for human health through both direct and indirect pathways. Directly, polluted water can lead to acute and chronic health issues. Chemical pollutants, including pesticides, polycyclic aromatic hydrocarbons (PAHs), and brominated flame retardants, pose serious risks, contaminating drinking water and causing conditions such as cancer and endocrine disruption (2,3). Pathogens present in polluted water further exacerbate these risks, as evidenced in mountain regions where declining water quality facilitates the spread of harmful microorganisms to new environments, endangering both aquatic species and human populations (4)

Indirectly, biodiversity loss in freshwater ecosystems undermines essential ecosystem services like water purification, flood regulation, and food provision, which are vital for human well-being (5,6). Healthy ecosystems offer services such as clean water, food sources, and recreational opportunities, but these are increasingly threatened by pollution, climate change, and unsustainable human activities (7-9). For instance, industrial waste, agricultural runoff, and urbanization introduce harmful substances that deteriorate water quality and ecosystem resilience (2,3,10). Climate change further exacerbates these challenges by altering water availability and quality (4,6).

Among the many organisms contributing to water quality in ecosystems, invertebrates like bivalves play a critical role. In marine ecosystems, bivalves, such as clams, are vital to maintaining ecological balance. By filtering seawater, they help sustain water clarity, regulate nutrient loads, and provide stable habitats for a variety of organisms, from seagrasses to fish (11). However, oceanic bivalve populations are increasingly threatened by overfishing, coastal development, pollution, and climate change (11). Ocean warming and acidification impair shell formation and reduce survival rates, making clams more vulnerable to population decline (11). Because of their importance in sustaining healthy oceans, protecting clam populations is critical to preserving biodiversity and the natural processes that keep marine environments resilient (11).

Freshwater bivalves are natural water filters, removing phytoplankton, algae, sediments, bacteria, toxins, and excess nitrogen from water (12). As filter feeders, clams utilize cilia on their gills to create water currents, capturing suspended particles for ingestion and releasing cleaner water through their excurrent siphon (12). These filtration activities not only enhance water clarity but also help regulate nutrient cycles, as nitrogen incorporated into their shells is effectively removed from the water when clams are harvested (12).

The ecological and economic value of bivalves is substantial. Studies have demonstrated that shellfish provide critical ecosystem services, with aquaculture operations removing significant amounts of nitrogen from coastal

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waters, valued at $2.8–5.8 million annually in regions like Greenwich, Connecticut (13). Such findings highlight the potential of freshwater clams as keystone species, crucial for environmental stability and human industries.

Freshwater clams exhibit remarkable capabilities in improving water quality. For instance, species like *Corbicula fluminea* can reduce metal concentrations in water by over 70% and entirely remove certain pollutants such as chromium (Cr) and PAHs (NAP, PHE) (12). Additionally, they act as bioindicators for microplastic pollution, accumulating microplastics in their tissues and signaling environmental contamination levels (14).

Despite their demonstrated benefits, research on freshwater bivalves, particularly clams, remains limited compared to their marine counterparts. *Corbicula javanicus* – a freshwater clam native to Asia - is of particular interest because it is readily available for aquaculture and aquarium trade. It is smaller than many unionid mussels but still plays a vital role in biofiltration by consuming algae, detritus, and other suspended matter (4). Studying this species helps address the knowledge gap in freshwater filtration and offers insights into how clam populations may be used in ecosystem restoration.

By actively filtering out excess nutrients, such as nitrogen and phosphorus, which contribute to algal blooms, *C. javanicus* can help restore ecological balance. This reduction in algae allows aquatic plants to access essential nutrients, preventing them from being outcompeted by excessive algae, and promoting greater biodiversity (15). Additionally, the filtration abilities of *C. javanicus* can also play a crucial role in addressing man-made pollution. Freshwater bodies are increasingly affected by agricultural runoff, industrial waste, and urban pollution, which introduces harmful contaminants such as heavy metals, microplastics, and chemical pollutants (6). By removing suspended particles, bacteria, and organic matter from the water, these clams can help combat the effects of pollution, making freshwater environments more hospitable for native species (5,16,17). Ultimately, utilizing *C. javanicus* as a natural water filtration method presents a promising idea for improving the health and sustainability of freshwater ecosystems, offering a sustainable approach to combat not only algal blooms, but also the increasing issue of man-made pollution that contaminates water sources. Integrating these filter-feeding bivalves into conservation and water management strategies could provide an eco-friendly alternative to traditional, chemical-based water treatment methods (12,15).

This study aims to investigate the filtration capabilities of freshwater clams, specifically those of *C. javanicus*. We sought to quantify their filtration rates and examine changes in water quality parameters, such as pH, during the filtration process. We hypothesized that the introduction of *C. javanicus* would result in increased water clarity by reducing particulate matter and filtering nutrients from the water. To test this, we conducted a tank experiment with control and experimental groups, tracked water clarity and pH changes, and compared our findings to previous literature. Our results show that *C. javanicus* improved water clarity, suggesting potential applications for its use in freshwater biofiltration in ecosystem management.

RESULTS

To evaluate the filtration capabilities of *C. javanicus*, we prepared two 5-gallon for each trial: one control tank without clams and one experimental tank containing five juvenile clams. Both tanks were filled with nutrient-rich pond water containing high algae levels. Over three days, we measured pH and water clarity to track changes in water quality as the clams filtered the tank water. The pond water's pH provided insight into chemical changes in the system, since biological processes such as algal growth and respiration can change acidity (1). Water clarity referred to how clear or turbid the water appeared, which reflects the amount of suspended particles, like algae and organic matter, present (1).

Over the course of three days, the water filtration rate of *C. javanicus* clams was estimated at approximately 0.33 gallons of freshwater per clam per day, based on clarity improvements observed in experimental tanks. We estimated clarity from photographs and assigned percentages based on how much light passed through the water under consistent environmental lighting conditions. On day 0, the water in all the tanks was extremely opaque and full of algae, resulting in only 20%-25% water clarity.

We conducted two independent trials and averaged the estimated water clarities from both trials (**Figure 1**). In Trial 1, after the introduction of five *C. javanicus* clams into the experimental tank, we observed a clear improvement in water clarity by day 3. Based on blind assessment of photographs, the water clarity increased to about 90%, with a visible reduction in algae and particulate matter. By contrast, the control tank, which did not contain clams, remained at around 25% clarity throughout the experiment. By day 3, the clarity in the control tank dropped even further to 20% (**Figure 2**).

The two trials differed slightly in initial tank conditions, including small variations in algal density and environmental

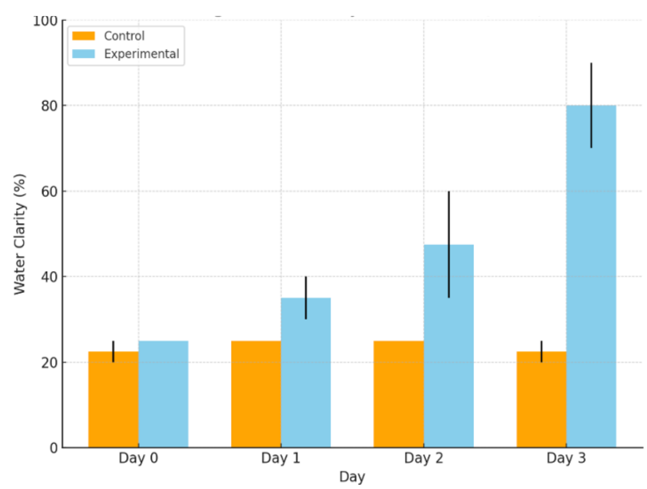

Figure 1: Water clarity over time in tanks with C. javanicus (experimental) vs. tanks without clams (control). Bar graph illustrating the changes in water visibility over time between the control and experimental groups in both trials. Bars represent the mean water clarity (%) across two independent trials, assessed using a blind evaluation method. Error bars indicate negative or positive standard deviation (*n*=2). Control tanks remained relatively unchanged across days, whereas experimental tanks showed a consistent increase in water clarity, reaching the highest levels by day 3.

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factors such as lighting. Despite these differences, both trials showed the same expected results: tanks containing *C. javanicus* became clearer over time, while the control tanks remained opaque. In Trial 2, the improvement in water clarity was more gradual. The experimental tank exhibited a steady increase in clarity over the three-day period, reaching approximately 70% clarity by day 3 (**Figure 2**). This difference in magnitude compared to Trial 1 could be attributed to variation in initial water quality or minor inconsistencies in clam health. The control tank showed little to no change in water clarity, maintaining approximately 25% throughout the experiment.

For insight into the impact of the clams on algal biological activity, we monitored pH levels in both the experimental and control tanks over the three-day period; however, the changes in pH were inconsistent between the two trials. In Trial 1, both control and experimental tanks started at pH 7.6, with the experimental tank increasing slightly to pH 7.8 by day 3. In contrast, in Trial 2, both control and experimental tanks started at pH 8.0, with the experimental tank decreasing slightly to pH 7.8 (**Table 1**).

DISCUSSION

This study aimed to determine whether *C. javanicus* could improve water clarity in nutrient-rich freshwater environments. We hypothesized that the clams' filter-feeding activity would reduce algae and suspended particles, resulting in clearer water. The results of this experiment were generally consistent with the hypothesized outcomes and aligned with findings from previous studies on the water filtration abilities of bivalves. Like other studies, the clams' filter feeding abilities showed visible results, with the experimental tank becoming clearer over time compared to the control. These findings suggest that *C. javanicus* and other freshwater clams may play a role in enhancing water quality in freshwater ecosystems. The filtration process, where the clams removed phytoplankton, bacteria, and excess nitrogen, was particularly effective in reducing the turbidity caused by algae. This is in line with previous studies that have shown the capacity of bivalves to improve water clarity in aquatic systems (12,13,16).

However, there are several limitations to this study. The water clarity values were assigned using a blind assessment, meaning the evaluator did not know which tank contained clams. This reduced bias in the visual scoring process. However, this method is still inherently subjective, and future studies would benefit from more objective measurements such as digital image analysis or spectrophotometer readings of optical density. Another limitation is that only two experimental trials were conducted. Replication is important in ecological experiments because water quality and clam activity can vary. While both trials showed the same trend of increasing clarity in the experimental tank, future experiments should incorporate additional replicates to strengthen confidence in the findings.

Furthermore, the pH measurements were inconclusive and showed inconsistent results across trials. While clams may influence water chemistry by reducing algal biomass and organic matter – which can alter carbon dioxide levels and thus affect pH – the short duration of the experiment and the small size of the juvenile clams may have been insufficient to produce a measurable change. Additional factors, such as instrumental limitations, spatial variation within the tanks, or differences in initial water chemistry, may also have contributed to the variability. Despite these limitations, understanding how clams affect pH is ecologically important, as even small shifts in acidity can influence nutrient availability, microbial activity, and overall ecosystem health (8).

Additionally, the *C. javanicus* clams were juveniles and only around 1 inch wide, significantly smaller in size than the average adult clam, which would typically have a higher filtration capacity due to its larger size and greater gill surface area. For example, a single adult littleneck clam can filter 4.5 gallons of seawater per day (16). Therefore, the filtration rate of 2.88 gal/day observed in this study is lower than those of other experiments and may underestimate the potential of mature *C. javanicus*. The use of juvenile clams presents an important limitation in terms of the scale of filtration, especially when considering large populations of these bivalves in nature. Future research should compare juvenile and adult filtration rates across multiple trials.

Finally, this study only measured pH and visual clarity. While the results suggest reduced turbidity, we did not directly measure algae concentrations, nutrient levels, or other components of water quality. However, our findings indicate that *C. javanicus* could contribute to clearer water, which is associated with improved water quality (1,22,18).

This study focused on *C. javanicus*, a fully freshwater species, in contrast to many studies that typically examine the

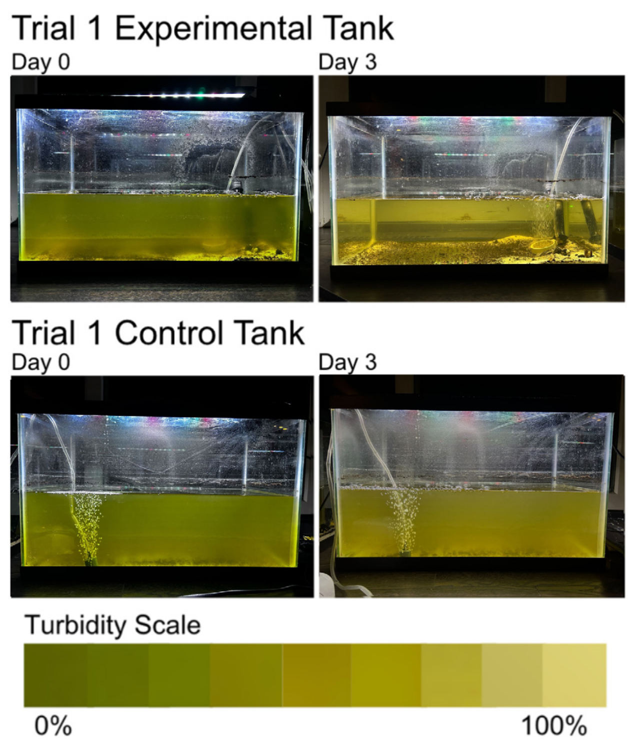

Figure 2: Visual comparison of water visibility over time. A visual comparison of water clarity in both the experimental (clam containing) and control (without clams) tanks across Trial 1. The left panels show water on day 0, and the right panels show water on day 3. In the experimental tank, water clarity visibly improved over three days, with reduced turbidity as indicated by the turbidity scale. In contrast, the control tank shows minimal change in water visibility over the same period.

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filtration capacities of marine or brackish bivalves, such as *Mytilus edulis* or *Crassostrea virginica* (19,20). This aspect is significant because it demonstrates the ability of filter feeders to improve not only saltwater habitats but also freshwater lakes and ponds, which serve as crucial water sources for many human communities. Understanding the filtration potential of freshwater bivalves broadens the scope of conservation and water management efforts, showing that these species could be used as natural biofilters to enhance water quality. Future research could explore the long-term effects of freshwater bivalve filtration on aquatic ecosystems, as well as the potential of using *C. javanicus* in water purification efforts. Further studies incorporating larger, mature clams and assessing their filtration rates in diverse environmental conditions would provide more insight into their ecological contributions.

The overall improvement in water clarity observed in this study highlights the ecological benefits of introducing *C. javanicus* and similar freshwater clams into aquatic environments, including lakes, ponds, and other water bodies that support both wildlife and human populations. Further efforts could explore the long-term viability of using freshwater clams to enhance water quality, support biodiversity, and mitigate the threats of pollution and habitat degradation in freshwater ecosystems (24,25). However, it is important to note that adding new species to an ecosystem may have risks, such as potentially outcompeting native species for resources or introducing new diseases.

MATERIALS AND METHODS

In April 2024, *C. javanicus* clams were purchased from an online vendor. Upon arrival, the clams were drip-acclimated and placed in a controlled environment to reduce stress and ensure health and suitability for the experimental setup. They were housed in hospital tanks for one week, where they were observed for signs of disease or malnutrition. All clams used in this study were juveniles, each approximately 1 inch in size. After the acclimation period, the experimental procedures began.

For the experimental setup, pond water was sourced from a local habitat in Millburn, New Jersey with high levels of algae, providing a natural environment suitable for clam filtration. Approximately 5 gallons of collected pond water were poured into both the experimental and control tanks. The pond was selected because of its visibly green and turbid appearance, and the presence of filamentous algae confirmed that the water was algae rich. To maintain clam health, ammonia and nitrite concentrations were kept low by using an aeration system with small air pumps. This replicates natural pond environments, as ammonia and nitrate are scarce in a functioning freshwater ecosystem. The water used in both experimental and control tanks was murky, nutrient rich, and full of detritus, confirmed visually by particulate matter settling on the bottom of the tanks.

Days	Trial 1 Control pH	Trial 1 Experimental pH	Trial 2 Control pH	Trial 2 Experimental pH
0 Days	7.6	7.6	8.0	8.0
1 Days	7.6	7.6	7.8	8.0
2 Days	7.4	7.8	7.8	7.8
3 Days	7.6	7.8	7.8	7.8

Table 1: Measured pH values across treatments. pH levels measured in both control and experimental tanks over the course of 3 days in Trials 1 and 2 (*n*=2). Measurements were taken at the start of the experiment (Day 0) and at daily intervals (Days 1-3). The values indicate stable pH conditions across treatments.

Two trials were conducted, and each trial consisted of one experimental tank and one control tank. In the experimental tanks, five juvenile clams were introduced, while the control tanks contained only pond water. For Trial 2, new pond water was collected from the same site as in Trial 1, and the experiment was repeated.

The experiment ran for three consecutive days per trial. Daily measurements of pH and water clarity were taken at 9:00 PM for both tanks. The pH levels were measured using the API Freshwater Master Test Kit, following the manufacturer's colorimetric protocol, in which 5 mL of tank water was removed and tested in a vial with indicator solution. Water clarity was assessed by photographing the water in each tank under consistent lighting and assigning a clarity value between 0-100%. A value of 0% indicated highly opaque conditions with poor visibility, while 100% represented completely clear water with maximum visibility. To minimize experimenter bias, clarity values were determined through a blind assessment by a reviewer who did not know which tanks contained clams. These clarity values should be considered approximate indicators of relative clarity, rather than precise measurements. Assuming the experimental tanks were fully filtered by the clams, the total tank volume (5 gallons) was divided by the number of clams (5) to estimate the volume filtered per clam. This value was then divided by the three-day duration of the experiment to obtain an average filtration rate of 0.33 gallons per day. Because water clarity was used as an indirect and approximate measure of filtration, this value should be considered an estimation rather than a precise filtration rate.

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