International Journal of Sustainability and Advanced Integrated Research
Volume 2, Issue 2 (April-June 2026) | ISSN: 3107-7854
DOI: https://doi.org/10.65339/ijsair.V2.I2.332

# Molluscicidal Potential of Tuba Root (*Derris elliptica*) Plant Extract on Golden Apple Snail (*Pomacea canaliculata*)

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Publication history: Received: April 13, 2026; Revised: April 19, 2026; Accepted: April 28, 2026
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## Abstract

A laboratory experiment on molluscicidal efficacy of Derris elliptica (tuba) root extracts was conducted from April to July 2025 at the Department of Agriculture, ATI RTC 02, San Mateo, Isabela. It aims to evaluate the potential efficacy of Derris elliptica against the golden apple snail *(Pomacea canaliculata)* and to compare its performance with a commercial molluscicide (Niclosanex). Crude extracts from the leaves, stems, and roots were prepared following the protocol of Guevarra et al. (2005) to determine the presence of flavonoids, saponins and tannins and tested at concentrations of 10, 20, 30, 40, and 50 ppm and commercial molluscicide as a positive control. The study was laid out following the Completely Randomized Design replicated three times. The observations were focused on behavioral changes, physiological responses, toxicity symptoms, mortality rates, internal organ damage, and phytochemical composition. Results showed that exposure to the root extract induced marked behavioral and physiological disturbances, including reduced mobility, initial hyperactivity followed by slow movement, excessive mucus secretion, floating behavior, and operculum detachment, with effects intensifying at higher concentrations. Internal examinations revealed tissue degeneration in vital organs, consistent with the action of bioactive compounds such as rotenone, flavonoids, tannins, and saponins. The mortality rates was significantly increased at 30, 40, and 50 ppm comparable to the effect of commercial molluscicide observed from 6 to 18 hours of exposure. The findings indicate that *Derris elliptica* root extract is a potential and effective molluscicide, particularly at concentrations of 30 ppm up to 50 ppm. Its bioactive constituents contribute to severe physiological disruption, leading to feeding inhibition, organ damage, and eventual mortality, highlighting its potential as an eco-friendly alternative for managing snail infestations in agricultural systems. Further, it is recommended that future research should focus on evaluating the efficacy and its minimum lethal concentration, and the quantitative phytochemical analysis of the plant extract.

**Keywords:** Botanical Insecticide, *Derris Elliptica Benth*, Golden Apple Snail, Molluscicidal Efficacy, Toxicity

## 1. Introduction

Rice production continues to face serious pest-related challenges, particularly from the golden apple snail *(Pomacea canaliculata)*, an invasive mollusk that damages young rice plants and contributes to yield loss in rice-growing areas. Conventional synthetic molluscicides are commonly used for rapid pest control, but their environmental toxicity, potential harm to non-target organisms, water contamination, and health risks have intensified the search for safer botanical alternatives. In this context, Derris elliptica, locally known as tuba or tubli, is considered a promising plant-based molluscicide because of its bioactive compounds, particularly rotenone, flavonoids, tannins, and saponins. This study therefore focuses on determining the molluscicidal potential of Derris elliptica plant extract against *Pomacea canaliculata* by identifying its phytochemical components, assessing snail mortality under different concentrations, and determining the plant part with the most effective molluscicidal action.

The golden apple snail *(Pomacea canaliculata)* is recognized as one of the most destructive pests in rice ecosystems because it feeds on young rice plants and reduces crop productivity. Its high reproductive capacity, adaptability, and ability to spread through irrigation systems make it a persistent threat to rice-based farming systems (Wang et al., 2024). Golden apple snails also cause ecological disruptions by competing with native species and altering habitat dynamics (Martin et al. (2019). Under changing temperature conditions, invasive golden apple snails may exhibit increased survival, growth, and feeding rates, which can further aggravate rice crop damage (Panchot et al. (2025). Significant damage commonly occurs during the seedling stage, with yield reductions of more than 20 percent reported in heavily infested areas (Constantine et al. (2023). Beyond crop damage, high snail populations may reduce aquatic vegetation, increase water turbidity, and disturb ecosystem functions (Carlson et al. (2005), while the species may also serve as an intermediate host of Angiostrongylus cantonensis, which is associated with eosinophilic meningitis and related health concerns (Hochberg and Bhadelia (2015). Chemical molluscicides have been used to control golden apple snail populations; however, their long-term use is limited by toxicity to non-target organisms, ecological risks, cost, and sustainability issues. Chemical molluscicides may harm fish, beneficial invertebrates, and aquatic ecosystems (Danlami, 2025), while niclosamide formulations have been reported to show low selectivity and may affect other aquatic species (Gomes et al. (2025). Their high cost also limits accessibility among small-scale farmers (Samoo, 2026), and intensive pesticide use contributes to soil degradation, water contamination, and ecological imbalance (Abo-Elwfa et al. (2025). These concerns support the need for plant-based molluscicides that are effective, affordable, and environmentally safer.

The related literature emphasizes three major themes: the invasive nature of *Pomacea canaliculata*, the limitations of synthetic molluscicides, and the potential of botanical molluscicides. The life cycle of Pomacea canaliculata includes egg deposition, hatching, juvenile development, and rapid maturation, with eggs commonly deposited above water surfaces to increase survival (Andriani et al. (2023). Growth and reproduction are influenced by temperature, moisture, food availability, and environmental conditions (Memon et al., 2025). Higher temperatures increase feeding, movement, and growth, while lower temperatures cause inactivity and mud-burrowing behavior (Sulistiono (2007). The species may also enter dormancy during unfavorable conditions, allowing it to survive drought and later re-emerge when conditions improve (Chen et al. (2025). Its macrophytophagous feeding behavior enables it to consume large quantities of plant material, particularly rice seedlings and aquatic vegetation (Memon et al. (2025), thereby reducing plant density and disrupting freshwater ecosystem dynamics (Wang et al. (2024). Derris elliptica has been widely examined as a botanical pesticide because of its rotenone and other bioactive compounds. Synthetic molluscicides such as metaldehyde and niclosamide remain effective, but they pose risks to aquatic life, soil microorganisms, and human health (Horgan et al., 2021). Derris elliptica leaf extracts have been found to produce molluscicidal effects comparable to niclosamide while degrading more quickly and reducing environmental contamination risks (Rahman and Hashim (2019). Although botanical molluscicides may have higher initial costs, their long-term benefits include lower environmental cleanup costs and reduced risk of pesticide resistance (Castillo et al. (2022). Crude root extracts of *Derris elliptica* contain rotenone and related flavonoids that exhibit strong molluscicidal activity, with rotenoid compounds disrupting mitochondrial electron transport and causing paralysis and mortality in mollusks (Yamamoto and Lee (2021). Extracts containing flavonoids, tannins, and saponins may also produce significant mortality in Pomacea canaliculata through membrane disruption, oxidative stress, and inhibition of essential metabolic enzymes (Bamamoto, Lee, and Santos (2021); Bamamoto et al. (2021). Ethanolic extracts have been reported to produce stronger molluscicidal effects than aqueous extracts because of higher rotenone recovery (De Rivera and Tan (2020). The literature further highlights the environmental implications of botanical molluscicides. Derris elliptica extracts may be biodegradable, but excessive concentrations may still affect aquatic organisms (Torres et al. (2021). Rotenone application should therefore consider safe thresholds to avoid harming beneficial aquatic organisms (Martínez et al. (2020), and regulatory guidance is needed to prevent over-application and unintended ecological damage (Del Rosario et al., (2023). Plant-based molluscicides degrade more rapidly than synthetic agents, reducing risks of bioaccumulation and chronic toxicity (Villanueva and Ramos (2022). Compared with synthetic molluscicides that may cause long-lasting contamination and harm aquatic organisms, botanical extracts may offer lower toxicity to non-target species when applied at recommended concentrations (Cruz and Martinez (2019).

Locally and nationally, the study is relevant to rice farming systems in the Philippines, where golden apple snail infestations threaten crop establishment, farmer income, and sustainable production. Derris elliptica, locally known as tubli or tuba, is an available botanical resource that may provide farmers with a practical and cost-effective alternative to commercial pesticides. The use of botanical pesticide inputs is particularly important for farmers who have limited capacity to purchase expensive commercial pesticides and who may benefit from locally available resources for sustainable agriculture (Wilcox, 2011; Sola et al., 2014). Tubli roots have also been reported to contain rotenone and related compounds with pesticidal properties, and local references describe the plant as poisonous and biologically active against insects and other pests (Philippine Medicinal Plants, 2010). Globally, the study contributes to ongoing research on botanical molluscicides and environmentally safer pest management. Plant-derived molluscicides such as Azadirachta indica, Jatropha curcas, Barringtonia asiatica, and Derris elliptica have been investigated because their phytochemicals can affect molluscan physiology while reducing long-term environmental residue (Singh et al. (2020). Jatropha curcas seed extracts contain phorbol esters that disrupt molluscan enzyme activity (Kumar & Devi (2019), while plant-derived compounds such as alkaloids, flavonoids, and tannins have been associated with molluscicidal activity and safer environmental profiles (Alam et al., (2021). Fish poison trees such as Barringtonia asiatica contain saponins that reduce oxygen absorption in aquatic organisms (Mangawang et al., 2020; Sankaran & Sachithanandam, 2015). Saponins may also affect snail membrane permeability and nervous system function (San Martin and Cruz (2013). The growing interest in biopesticides derived from natural compounds reflects the global need for organic and sustainable snail control strategies (Quijano et al., (2014).

The study is conceptually anchored on integrated pest management and phytochemical toxicity. Integrated pest management emphasizes environmentally benign and sustainable pest control practices that reduce dependence on synthetic chemicals (Pimentel & Burgess, 2021). Derris elliptica is considered within this framework because its extracts may offer broader ecological benefits, including reduced accumulation of synthetic chemical residues and support for soil health (Gopalakrishnan et al., 2020). The study also rests on the concept that plant-derived secondary metabolites can produce molluscicidal effects through multiple physiological pathways. Rotenone is the primary active compound associated with *Derris elliptica* toxicity. It disrupts mitochondrial electron transport and causes energy failure and death in target organisms (Wang et al. (2018). It may inhibit Complex I of the mitochondrial electron transport chain, leading to paralysis and energy metabolism failure in snails (Gutiérrez et al., (2017). Flavonoids and tannins may intensify toxicity by inducing oxidative stress and rupturing molluscan cell membranes (Chen et al., (2021). Rotenone content varies depending on geographical origin, plant maturity, environmental conditions, plant part, and extraction method, with roots generally showing higher rotenone levels (Chen et al. (2021); Sae-Yun et al., 2019). Extraction techniques also influence rotenone yield, with maceration producing moderate concentrations (Umaru et al. (2019) and pressurized liquid extraction improving rotenone recovery (Sae-Yun et al. (2019). Quantitative studies have reported rotenone in stem extracts (Phairoh et al. (2017), while total phenolic and flavonoid contents are commonly measured using standard spectrophotometric methods (Umaru et al. (2019); Wu et al., 2012). Solvent polarity also influences phytochemical yield, with methanolic leaf extracts showing higher phenolic concentrations than ethanol or hexane extracts (Zhang et al. (2023). The biological activity of Derris elliptica is also linked to its broader phytochemical profile. Rotenone and deguelin are associated with insecticidal activity (Sae-Yun et al. (2019), while botanical molluscicides from Derris elliptica show promise against golden apple snails (Chen et al. (2021). The plant contains rotenone in its roots (Li and Chen (2023), and rotenone levels vary according to plant age, tissue type, and environmental conditions (Phairoh et al. (2021). Other phytochemicals include deguelin, tephrosin, elliptone, flavonoids, tannins, saponins, alkaloids, steroids, and phenolic compounds (Rashed (2020), which may contribute to antibacterial, antifungal, insecticidal, and molluscicidal activities (Khan and Smith (2006). Crude root extracts have been found to cause high mortality in Pomacea canaliculata (Morallo-Rejesus and Punzalan (2014), and aqueous root extracts may immobilize and kill snails even at low concentrations (Maini (1993). Derris elliptica extracts have also shown toxicity to *Pomacea canaliculata* and other pest species (Ruamthum et al. (2010).

Although Derris elliptica is known for pesticidal and insecticidal properties, limited attention has been given to its molluscicidal activity in rice fields, particularly for managing Pomacea canaliculata populations that damage young rice plants. Existing studies suggest that roots, stems, and leaves differ in their phytochemical composition and toxicity, but further work is needed to clarify which plant part and concentration level provide the most effective molluscicidal response. Quantitative data on rotenone are more established than data on tannins and saponins, and further characterization is needed to fully understand the biochemical composition of Derris elliptica and its pest management applications (Yadav et al. (2023) and Phairoh et al. (2021). Leaf extracts have been reported to contain measurable flavonoids (Yadav and colleagues (2023); Yadav et al. (2023), while leaves and roots contain flavonoids, tannins, and saponins in different distributions (John et al. (2025). Rotenone in dried stem material has also been quantified through TLC-densitometry (Phairoh et al. (2021). The combined action of rotenone, flavonoids, tannins, and saponins may explain the observed toxicity, but the molluscicidal effect cannot be attributed to rotenone alone (John et al. (2025); Rashed (2020). The rationale for the present study is strengthened by prior bioassays showing that Derris elliptica extracts can produce high snail mortality. Root extracts reportedly killed 95% of *Pomacea canaliculata* within 24 hours at 50 ppm (Santos et al., (2019), while leaf extracts caused 80% mortality within 48 hours at 60 ppm (Liu & Tan (2020). Environmental conditions such as temperature, pH, and dissolved oxygen may influence toxicity (Rodríguez et al. 2021). Derris elliptica has also been used traditionally as a molluscicide, insecticide, and fish toxin (Dos Santos and Sant'Ana, 2000; Andrea et al., 2007; Lu et al., 2008), with additional reported antifungal and anticancer activities (Chun et al., 2003). It is mainly grown in tropical regions because its roots are a source of rotenone (Wu et al., 2012b). Lethal concentration studies further support its potential, with Derris elliptica leaf extracts having an LC50 of 30 ppm and root extracts having an LC50 of 18 ppm (Fernando et al. (2020). Compared with Jatropha curcas and Azadirachta indica, Derris elliptica showed strong molluscicidal effects at lower concentrations (Garcia et al. (2018). Prolonged exposure to sublethal doses may also reduce reproductive capacity in *Pomacea canaliculata* (Yamamoto & Lee (2021). These findings justify examining Derris elliptica as a sustainable, plant-based alternative to synthetic molluscicides.

This study aligns with SDG 2 – Zero Hunger because controlling golden apple snail infestation can help protect rice crops, reduce pest-related yield losses, and support food security. It also supports SDG 3 – Good Health and Well-Being by exploring a plant-based molluscicide that may reduce farmer and consumer exposure to synthetic chemical pesticides. The study contributes to SDG 12 – Responsible Consumption and Production by promoting sustainable pest management practices that reduce reliance on synthetic chemicals. It also supports SDG 15 – Life on Land because eco-friendly molluscicides may help protect biodiversity, reduce chemical contamination, and limit environmental degradation caused by synthetic pesticide use.

The study is important to multidisciplinary sustainability because it connects agriculture, environmental science, pest management, public health, and community livelihood. From an agricultural sustainability perspective, it explores a practical botanical intervention for reducing golden apple snail damage in rice production. From an environmental and ecological sustainability perspective, it supports reduced dependence on synthetic molluscicides that may contaminate water bodies and affect non-target organisms. From a public health sustainability perspective, it may lessen exposure to chemical pesticides among farmers and consumers. From a socio-economic sustainability perspective, it offers possible support for small-scale farmers who need affordable and locally available pest control options. From a policy and governance sustainability perspective, the findings may provide baseline evidence for developing safer pest management guidelines and encouraging integrated pest management practices. Overall, the study advances the use of natural plant-based resources as part of a more sustainable, safer, and ecologically responsible approach to rice pest management.

## 2. Material and methods

### 2.1 Research Design

The study employed an experimental research design using a Completely Randomized Design (CRD). Different concentrations of Tuba (Derris elliptica) plant extract were tested against golden apple snails to determine mortality rate, elapsed time to mortality, phytochemical constituents, and observable internal changes after exposure. Six treatments were used: 10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm per liter of water, and a commercially available molluscicide, Niclosanex, as the positive control. Each treatment was replicated three times.

### 2.2 Locale of the Study

The study was conducted from April 2025 to July 2025 at the greenhouse and laboratory of the Department of Agriculture–Agricultural Training Institute–Regional Training Center 02, Malasin, San Mateo, Isabela. The Tuba (Derris elliptica) plant samples were collected from Diffun, Quirino, while extraction and phytochemical analysis were conducted through the Department of Science and Technology Region 2 laboratory.

### 2.3 Respondents of the Study

The study did not involve human respondents. The test organisms were golden apple snails (Pomacea canaliculata), which were used to determine the molluscicidal activity of Tuba (Derris elliptica) plant extract. Mature golden apple snails were exposed to different extract concentrations and observed for mortality, behavioral changes, and internal organ changes.

### 2.4 Sample and Sampling Procedure

Whole plant parts of Tuba *(Derris elliptica),* including leaves, stems, and roots, were collected at the mature stage of development, approximately 10–12 months after planting. The maturity of the plant was identified through fully expanded dark green leaves, woody and thickened roots, and well-developed climbing stems. Golden apple snail eggs were handpicked from rice fields, transported to the laboratory, and reared in plastic containers until they reached the adult stage. Ten mature golden apple snails were placed in each treatment, with three replications per treatment.

### 2.5 Research Instrument

The study used laboratory-based bioassay procedures, phytochemical screening, and mortality observation as the main research instruments. Plant extracts were analyzed for phytochemical constituents following the procedure of Guevarra et al. (2005). The bioassay measured snail mortality at 6, 12, 18, and 24 hours after exposure. Mortality was confirmed through absence of heartbeat and lack of response to stimuli. The study also observed behavioral and internal organ changes, including mucus secretion, shell color changes, failure of the soft body to retract into the shell, collapsed lungs, inflamed intestines, and perforations in the female reproductive organs. These observations were associated with the findings of Musman (2010) regarding the effect of saponins on the breathing process of golden apple snails.

### 2.6 Data Gathering Procedure

The collected Tuba plant parts were washed, air-dried, dried at room temperature until constant dry weight was achieved, cut into smaller pieces, and ground into powder using a laboratory blender. Approximately one kilogram each of powdered leaves, stems, and roots was prepared, properly labeled, and submitted to the Department of Science and Technology Region 2 for extraction and analysis. The plant samples were soaked in 70% ethyl alcohol for 72 hours at room temperature with occasional shaking, filtered using muslin cloth and Whatman filter paper, and concentrated using a rotary evaporator at 40 ± 5 °C until crude extracts were obtained. A separate cold ethanolic extraction of leaf samples was also performed using the same procedure described by Guevarra et al. (2005). The crude extracts were prepared into concentrations of 10 ppm, 20 ppm, 30 ppm, 40 ppm, and 50 ppm per liter of water. A positive control was prepared using approximately one gram of commercial molluscicide powder, Niclosanex, dissolved in 75 ml of water and divided into three replicates. Before treatment application, ten snails were placed in containers with one liter of paddy field water for 30 minutes. The snails were then exposed to the prepared treatments and observed every 6, 12, 18, and 24 hours. After exposure, they were transferred to fresh, dechlorinated, and deionized water for further observation. One snail from each treatment was dissected at the end of the study to observe possible internal organ changes.

### 2.7 Data Analysis Techniques

The data gathered were analyzed using Analysis of Variance (ANOVA) through the STAR Package to determine significant differences among treatments. Tukey's Honestly Significant Difference (HSD) test was used for post-hoc pairwise comparisons. Mortality rate was computed by dividing the number of dead golden apple snails by the total number of golden apple snails and multiplying the result by 100.

## 3. Results and Discussion

### 3.1 Molluscicidal Effects of Tuba (Derris elliptica) Extract

#### 3.1.1 Behavioral and Physical Responses of Golden Apple Snails

Snails exposed to lower concentrations of 10 ppm and 20 ppm showed reduced crawling activity, sluggishness, and delayed movement within the first 12 hours. At higher concentrations of 30 ppm to 50 ppm, the responses became more severe, including loss of coordinated movement, prolonged immobility, excessive mucus secretion, and failure to retract fully into the shell. Snails exposed to 40 ppm and 50 ppm refused feeding and became fully unresponsive after 18 to 24 hours. Other toxicity symptoms included floating behavior, shell tilting, impaired equilibrium, partial body extension from the shell aperture, weakened surface adhesion, and partial detachment of the operculum. These behavioral and physical changes indicate that the Tuba (Derris elliptica) extract caused progressive physiological stress in the golden apple snails. The stronger reactions observed at higher concentrations suggest that the toxic effect of the extract increased as concentration increased. The observed mucus secretion, immobility, feeding refusal, and operculum detachment reflect severe muscular and physiological impairment associated with molluscicidal action.

#### 3.1.2 Phytochemical Constituents of Tuba Plant Parts

The phytochemical screening confirmed that the leaves, stems, and roots of Tuba (Derris elliptica) were all positive for flavonoids, tannins, and saponins. This indicates that all examined plant parts possess bioactive compounds that may contribute to the molluscicidal activity of the extract against golden apple snails. The presence of flavonoids, tannins, and saponins supports the potential of Tuba as a plant-based molluscicide. According to Campos et al. (2019), flavonoids are associated with biological activities such as antioxidant, antimicrobial, and toxic effects on invertebrates, which may lead to reduced survival and behavioral abnormalities. Tannins may reduce feeding efficiency and nutrient absorption by binding proteins and inhibiting digestive enzymes. Saponins, on the other hand, may disrupt cell membranes and cause permeability changes, cell lysis, and tissue damage such as swelling and collapse of mollusk tissues (Ayoub and Yankov, 2008). The combined presence of these compounds suggests a synergistic mode of action, as supported by Upadhyay and Singh (2011), Makkar et al. (2007), and Wink (2012). Phytochemical screenings under Philippine conditions also confirmed that Derris elliptica contains flavonoids, tannins, and saponins across different plant parts (Madjos and Ramos, 2021; Nuneza et al., 2021).

#### 3.1.3 Internal Organ Changes After Treatment

Internal examination showed that snails exposed to 30 ppm, 40 ppm, and 50 ppm, as well as those exposed to the commercial molluscicide, exhibited collapsed and swollen lungs, collapsed and swollen intestines, and perforated reproductive organs. Snails exposed to lower concentrations of 10 ppm and 20 ppm showed no observable structural changes in the lungs, intestine, and reproductive organs during the observation period. These findings suggest that higher concentrations of Tuba extract were sufficient to cause internal tissue damage in golden apple snails. The collapse of respiratory and digestive structures may indicate impaired oxygen exchange and nutrient absorption, while reproductive organ perforation suggests irreversible damage that may affect reproductive viability and population sustainability (Kruatrachue et al. 2011). Mucus secretion, shell color change, failure of the flesh portion to withdraw into the shell, and the body hanging out of the shell were also observed as signs of snail mortality (Musman, 2010).

#### 3.1.4 Mortality Rate After 6 Hours of Exposure

After 6 hours, the mortality rate increased as extract concentration increased. The lower concentrations recorded lower mortality rates, with 33.33% at 10 ppm, 43.33% at 20 ppm, and 46.67% at 30 ppm. Higher mortality was observed at 40 ppm and 50 ppm, with 63.33% and 70.00%, respectively. The commercial molluscicide produced the highest mortality rate at 76.67%, but the 40 ppm and 50 ppm treatments were comparable to the positive control. The results indicate that Tuba leaf extract has concentration-dependent molluscicidal activity. The lower treatments were below the effective toxic threshold, while 40 ppm appeared to be an effective dose for rapid control of golden apple snails (Usman et al., 2023). The increase in mortality may be attributed to rotenone, tannins, flavonoids, and saponins, consistent with De Rivera and Tan (2020), who reported stronger molluscicidal activity as rotenone concentration increased. Similar findings were cited by Doncillo and Mejos (2025); Alforte et al. (2025), who associated the pesticidal activity of tuba (Derris elliptica) leaf extracts with rotenone as a naturally occurring toxic compound. The dose-dependent response also supports Usman et al. (2023), who noted that toxicity increases with concentration.

#### 3.1.5 Mortality Rate After 12 Hours of Exposure

After 12 hours, the same increasing pattern was observed, with higher concentrations producing greater mortality. The 40 ppm and 50 ppm treatments recorded 100% mortality, which was comparable to the commercial molluscicide control.

Lower concentrations produced partial mortality, showing that 10 ppm and 20 ppm were less effective than the higher concentrations. The 12-hour result further confirms that the molluscicidal activity of Tuba leaf extract depends on concentration and exposure duration. The high mortality at 40 ppm and 50 ppm may be due to the combined effects of saponins, flavonoids, and tannins. This supports Rug and Ruppel (2000), who cited that these bioactive compounds are capable of controlling both intermediate hosts and larval stages in schistosomes. Plant extracts containing flavonoids may influence feeding, motility, and reproduction in snails, contributing to molluscicidal activity (Lucero et al. 2020). Saponins may disrupt cellular membranes and cause leakage of intracellular contents, while saponin-rich extracts have shown strong toxicity against *Pomacea canaliculata* (Huang et al., 2003). Tannins may also affect snail survival, behavior, and physiology by inhibiting feeding activity, leading to mortality (Vehovszky et al., 2019). The partial mortality at lower concentrations supports the dose-dependent effect of the extract (Upadhyay et al., 2020).

#### 3.1.6 Mortality Response After 18 Hours of Exposure

After 18 hours, the data were subjected to square root transformation to reduce variance before analysis. The transformed data showed that total mortality was achieved among the remaining golden apple snails after prolonged exposure to the Tuba leaf extract. This indicates that extended exposure increased the toxic effect of the extract, even at lower concentrations. This result suggests that Tuba leaf extract has a strong molluscicidal effect under the conditions of the study. The finding agrees with Kumar et al. (2023), who reported that plant extracts with high concentrations of bioactive compounds can achieve 100% mortality in *Pomacea canaliculata* within 12–24 hours of exposure. The prolonged exposure period likely allowed greater absorption of toxic compounds, resulting in physiological failure and eventual death. The effectiveness of 40 ppm and 50 ppm was comparable to the rapid action of the commercial molluscicide, supporting Cruz and Martinez (2019), who reported that plant-derived molluscicides applied at sufficiently high concentrations can demonstrate efficacy comparable to synthetic compounds.

### 3.2 Overall Interpretation of the Findings

The overall findings show that Tuba (Derris elliptica) leaf extract caused behavioral disruption, physical deterioration, internal organ damage, and mortality in golden apple snails. The most effective concentrations were 40 ppm and 50 ppm, which produced mortality rates comparable to the commercial molluscicide. Lower concentrations also showed molluscicidal effects, but their action was slower and less complete during the early observation periods. These results support the potential of Derris elliptica as a botanical molluscicide for golden apple snail control. The presence of flavonoids, tannins, and saponins in the plant parts provides a phytochemical basis for its toxic effect, while the mortality pattern confirms that its efficacy increases with concentration and exposure time. The findings further suggest that Tuba extract may serve as an eco-friendly alternative to synthetic molluscicides, particularly when applied at effective concentrations of 40 ppm to 50 ppm.

## 4. Conclusion & Recommendations

The study concludes that Derris elliptica, locally known as tuba, demonstrated strong molluscicidal potential against golden apple snail *(Pomacea canaliculata),* particularly as the concentration and exposure period increased. The findings showed that the extract produced clear behavioral, physiological, and toxic responses, including reduced movement, hyperactivity followed by weakening, mucus hypersecretion, floating behavior, feeding cessation, operculum detachment, and eventual mortality. Phytochemical screening further confirmed the presence of flavonoids, tannins, and saponins in the leaves, stems, and roots, indicating that the plant contains bioactive compounds that may contribute to its molluscicidal activity. The mortality results showed that concentrations of 30 ppm and above produced notable effects, while 40 ppm and 50 ppm exhibited the strongest efficacy and were comparable to the commercial molluscicide. Internal examination also revealed structural deterioration in treated snails, particularly collapsed and swollen lungs and intestines and damage to reproductive tissues, suggesting that the extract affected critical biological functions necessary for survival. Overall, the study establishes Derris elliptica as a promising plant-based molluscicide and a potential alternative to synthetic chemical molluscicides for golden apple snail management in rice production systems.

Based on the findings, Derris elliptica extract at 40 ppm to 50 ppm is recommended as the most promising concentration range for the potential control of golden apple snails, especially in rice farming areas where infestation is common. However, before wider application, further studies should be conducted to determine the lethal concentration (LC50) and lethal dose (LD50) of the extract from different plant parts and to establish the safest and most effective dosage for practical use. Additional research should also examine its possible effects on humans, animals, non-target aquatic organisms, soil quality, and the surrounding environment to ensure that its use remains safe, sustainable, and ecologically responsible. Field-based validation is also recommended to confirm whether the laboratory results can be replicated under actual rice field conditions, particularly in relation to water depth, snail density, exposure time, and environmental factors. These follow-up studies may strengthen the scientific basis for using Derris elliptica as a botanical molluscicide and may support the development of safer pest management practices for farmers.

The study was limited to selected concentrations of Derris elliptica extract, specifically 10 ppm, 20 ppm, 30 ppm, 40 ppm, and 50 ppm, with Niclosanex used as the commercial positive control. It focused mainly on mortality rate, behavioral responses, visible physical symptoms, phytochemical presence, and internal organ changes among golden apple snails under controlled experimental conditions. Although the findings showed strong molluscicidal activity, the study did not yet determine the exact LC50 or LD50 values of the extract, nor did it fully assess long-term environmental safety, residue effects, field-level performance, or impacts on humans, animals, and non-target organisms. Therefore, the findings provide strong preliminary evidence on the molluscicidal potential of Derris elliptica, but further laboratory and field-based studies are still needed before recommending its broader agricultural application.

## Compliance with ethical standards

The study was conducted in accordance with institutional ethical standards and proper laboratory procedures. Since the research involved plant extracts and golden apple snails rather than human respondents, voluntary participation and informed consent were not applicable; however, confidentiality of research records and responsible handling of data were observed. The authors declare that there was no conflict of interest, all contributions were properly acknowledged, and copyright ownership and authorship responsibilities remain with the rightful authors of the study.

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