

Effectiveness Test of Combined Extract Concentrations from Mature and Immature Physic Nut Seeds (*Jatropha curcas*) on the Mortality of Golden Apple Snail (*Pomacea canaliculata* Lamarck)

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Abstract. The golden apple snail (*Pomacea canaliculata*) is a major pest causing significant damage to rice plants, particularly at the early vegetative stage. The use of chemical pesticides for its control poses negative environmental impacts, thus environmentally friendly alternatives such as botanical pesticides are needed. Physic nut (*Jatropha curcas*) seeds contain bioactive compounds with pesticidal properties. This study aimed to evaluate the effectiveness of combined mature and immature physic nut seed extract on snail mortality, weight loss, and morphological changes, and to determine the most effective concentration. The experiment used a Completely Randomized Design (CRD) with five treatments: control (0 g/L), 5 g/L, 10 g/L, 15 g/L, and 20 g/L, each with three replications. The results showed that the extract significantly affected all observed parameters. The highest mortality (93%) and weight loss (28.04%) were observed at 20 g/L. Morphological changes included reduced activity, slower response, operculum opening, and eventual body extrusion from the shell leading to death. Higher extract concentrations resulted in greater mortality, weight reduction, and morphological damage. Physic nut seed extract has strong potential as an effective and environmentally friendly botanical pesticide.

Keywords: botanical pesticide, golden apple snail, *Jatropha curcas*, mortality, morphology

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops in Indonesia and plays a strategic role in supporting national food security. However, rice productivity is frequently constrained by pest infestations, particularly the golden apple snail (*Pomacea canaliculata*), which is recognized as one of the major pests in irrigated rice ecosystems. This pest attacks young rice seedlings by cutting and consuming plant tissues, resulting in reduced plant populations and significant yield losses during the vegetative growth stage. The rapid reproductive capacity and high adaptability of *P. canaliculata* enable this pest to spread rapidly and become difficult to control in rice cultivation areas (Hutasoit et al., 2021).

Management of golden apple snail infestations is commonly conducted through manual collection and the application of synthetic molluscicides. Although chemical pesticides are considered effective in suppressing pest

populations, their continuous and excessive use may lead to environmental pollution, pest resistance, destruction of non-target organisms, and potential risks to human health. Therefore, the development of environmentally friendly pest management strategies has become increasingly important in sustainable agricultural systems. Botanical pesticides derived from plant materials are considered promising alternatives because they are biodegradable, relatively safe for the environment, and contain bioactive compounds capable of controlling agricultural pests (Isman, 2020).

One plant species with potential as a botanical molluscicide is physic nut (*Jatropha curcas* L.), a member of the Euphorbiaceae family. Physic nut seeds contain various secondary metabolites, including alkaloids, flavonoids, tannins, saponins, curcin, and phorbol esters, which exhibit toxic activity against insects and mollusks (Devappa et al., 2010). These compounds may interfere with feeding behavior, respiration, metabolic activity, and nervous system function in pests.

Previous studies reported that *Jatropha curcas* seed extract effectively increased the mortality of golden apple snails and reduced their activity in rice fields (Widawati et al., 2022).

The toxicity of physic nut seed extract is influenced by seed maturity level. Mature seeds generally contain higher concentrations of toxic compounds, whereas immature seeds are more abundant and still possess pesticidal properties. The combination of mature and immature physic nut seeds is expected to optimize the utilization of plant materials and potentially enhance the effectiveness of the extract against golden apple snails. However, studies regarding the combined use of mature and immature *Jatropha curcas* seed extracts against *Pomacea canaliculata* are still limited.

Therefore, this study aimed to evaluate the effectiveness of combined extract concentrations of mature and immature physic nut seeds (*Jatropha curcas* L.) on the mortality of golden apple snail (*Pomacea canaliculata*). The results of this study are expected to provide scientific information regarding the potential use of physic nut seed extract as an environmentally friendly botanical molluscicide for sustainable rice cultivation systems.

MATERIALS AND METHODS

Time and Location

This study was conducted from February to April 2026 in Sindangkarya Village, Anyar District, Serang Regency, Banten, Indonesia.

Tools and Materials

The materials used in this study were mature and immature physic nut seeds (*Jatropha curcas* L.), juvenile golden apple snails (*Pomacea canaliculata*) measuring 0.5–1 cm, taro leaves, and distilled water. The equipment used included a blender, measuring cylinder, analytical balance,

filter cloth, plastic containers, labels, and stationery.

Research Method

The study employed an experimental method using a Completely Randomized Design (CRD) consisting of five treatments and three replications. The treatments included K = control (distilled water), M5 = 5 g/L extract concentration, M10 = 10 g/L extract concentration, M15 = 15 g/L extract concentration, and M20 = 20 g/L extract concentration. Each experimental unit contained five golden apple snails. The physic nut seed extract was prepared by combining mature and immature seeds at a ratio of 1:1, followed by blending and filtration to obtain a homogeneous extract solution. The extract was then applied according to the treatment concentrations. Observations were conducted daily to determine snail mortality and morphological changes after treatment application.

Data Collection Techniques

The study was initiated by preparing the experimental materials and equipment, followed by the collection and acclimatization of juvenile golden apple snails (*Pomacea canaliculata*) with shell sizes of 0.5–1 cm. The snails were maintained under laboratory conditions prior to treatment application to ensure uniformity of the test organisms. The physic nut seed extract was prepared by combining mature and immature seeds (*Jatropha curcas* L.) at a ratio of 1:1. The seeds were blended with distilled water according to the designated treatment concentrations and filtered to obtain a homogeneous extract solution.

Observed Variables

Each experimental unit consisted of five golden apple snails placed in plastic containers containing treatment solutions according to the experimental design. Taro leaves were provided as feed during the observation period. The treatments

consisted of control (distilled water), 5 g/L, 10 g/L, 15 g/L, and 20 g/L extract concentrations. Observations were conducted daily to determine snail mortality and morphological changes after treatment application.

Research Procedure

The observed morphological responses included movement activity, mucus production, body color changes, and response to external stimuli. The collected data were subsequently analyzed using Analysis of Variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at the 5% significance level.

RESULTS AND DISCUSSION

Mortality of Golden Apple Snail (*Pomacea canaliculata*) (%)

Mortality serves as a critical indicator reflecting the death rate of pest populations within a specific environment due to

various factors, including pesticide application. This parameter not only represents the number of individual pests that perish but also demonstrates the biological response of pests to applied treatments. Hasanah et al. (2016) explained that mortality constitutes one of the primary measures for evaluating the success of pest control methods.

Mortality data were obtained through periodic observations of the number of dead pests following treatment, which were subsequently compared with the initial population count. Higher mortality values indicate greater treatment efficacy in suppressing pest populations. Based on observational results, the application of combined physic nut (*Jatropha curcas*) seed extract demonstrated increased golden apple snail mortality corresponding to elevated treatment concentrations.

Table 1. Mortality of golden apple snail pest.

Concentration	Replicate			Mean (%)
	1	2	3	
				%
K	0	0	0	0a
M5	3	3	2	0,53b
M10	4	4	4	0,8c
M15	5	4	4	0,86c
M20	5	5	4	0,93c
Mean	3,4	3,2	2,8	0,62

Note: Values followed by the same letter within the same row and column indicate no significant difference based on Duncan's Multiple Range Test (DMRT) at 5% significance level.

Based on the observations presented in Table 1, the application of combined mature and immature physic nut seed extract exerted significant effects on golden apple snail mortality across all treatments compared to the control. The Duncan's Multiple Range Test (DMRT) at 5% significance level revealed that extract treatments produced significantly different effects on golden apple snail mortality, as indicated by distinct letter groupings among treatments. The highest mortality was recorded in treatment M20, with a mean

value of 0.93 (equivalent to 93%), whereas the lowest mortality among extract treatments occurred in M5, with a value of 0.53 (53%).

The progressive increase in golden apple snail mortality demonstrates that physic nut seed extract possesses toxic properties effective as a botanical pesticide. Elevated concentrations correspond to greater quantities of bioactive compounds entering the snail's body, consequently increasing mortality rates. Physiologically, golden apple snail mortality results from the

activity of secondary metabolites contained in physic nut seeds, including alkaloids, saponins, and curcumin. Margis and Juanda (2022) reported that alkaloid compounds function by disrupting the nervous system, while saponins damage cell membranes and increase cellular permeability, thereby causing metabolic disturbances and ultimately death. Furthermore, curcumin, a toxic protein, operates through mechanisms that inhibit protein synthesis within cells, rendering cells incapable of regeneration and disrupting normal cellular functions. This finding aligns with Nurhariyati (2025), who stated that toxins in poisonous plants can induce systemic damage in target organisms through enzymatic and metabolic disruption.

In the control treatment (K), no golden apple snail mortality was observed throughout the observation period, and this treatment was classified in letter group "a." The absence of mortality indicates that golden apple snails maintained normal physiological conditions and survived adequately without toxic stress from physic nut seed extract. This condition confirms that mortality in other treatments was entirely attributable to the toxic effects of the extract rather than environmental factors or natural stress.

In treatment M5 (5 g/L), golden apple snail mortality was recorded at 3, 3, and 2 individuals in replicates 1, 2, and 3, respectively, with a mean mortality of 0.53 (53%). This treatment was assigned to letter group "b," indicating significant differences compared to the control. These values demonstrate that at low concentrations, physic nut seed extract began exhibiting toxic effects, although not yet optimal for causing mortality. This phenomenon can be attributed to the limited quantities of bioactive compounds such as saponins, alkaloids, and curcumin, which only induced mild physiological disturbances. Under these conditions, golden apple snails retained the capacity for detoxification

processes mechanisms through which organisms neutralize, decompose, or eliminate toxic compounds from their bodies to prevent harm allowing some individuals to survive (Linda *et al.*, 2024). According to Maudodi *et al.* (2025), botanical pesticides at low concentrations tend to produce sublethal effects, including reduced activity and feeding disruption, prior to causing mortality.

In treatment M10 (10 g/L), mortality increased to 4, 4, and 4 individuals in replicates 1, 2, and 3, respectively, with a mean mortality of 0.80 (80%). This treatment was classified in letter group "c." These results indicate that M10 exerted substantially greater effects, differing significantly from both M5 and the control. This increase demonstrates that the extract concentration reached more effective levels for suppressing golden apple snail populations. Physiologically, the elevated mortality resulted from toxic compound accumulation within the snail's body exceeding tolerance thresholds. Chairudin *et al.* (2020) reported that compounds such as phorbol esters and curcumin begin inhibiting vital functions including cellular respiration and protein synthesis. Curcumin operates by inactivating ribosomes, thereby inhibiting the formation of proteins essential for cell survival, ultimately causing cells to fail in performing normal functions and resulting in death.

In treatment M15 (15 g/L), mortality reached 5, 4, and 4 individuals in replicates 1, 2, and 3, respectively, with a mean mortality of 0.86 (86%). This treatment was assigned to letter group "c" alongside M10. This classification indicates that M15 did not differ significantly from M10 statistically, despite numerical increases in mortality. These values represent an improvement over previous treatments, signifying intensified toxic effects of the extract. At this concentration, bioactive compounds functioned not only as contact poisons but also as stomach poisons

entering through the golden apple snail's digestive system. Saponins contribute to cell membrane destruction by increasing membrane permeability, causing ion leakage and cellular imbalance, while alkaloids act as nerve toxins disrupting neural impulse transmission (Nasution *et al.*, 2019).

In the highest concentration treatment (M20: 20 g/L), mortality reached 5, 5, and 4 individuals in replicates 1, 2, and 3, respectively, with a mean mortality of 0.93 (93%). This treatment was classified in letter group "c" together with M10 and M15. This grouping indicates that all three treatments showed no significant statistical differences, although M20 exhibited the highest numerical mortality value. The 20 g/L treatment represented the most effective dosage for inducing golden apple snail mortality. At this concentration, bioactive compound content reached maximum levels, causing rapid and irreversible physiological damage. Toxic compounds including phorbol esters, saponins, and curcumin operated synergistically to damage the metabolic system, nervous system, and cellular structures of golden apple snails. These findings correspond with Banjarnahor *et al.* (2016), who reported that physic nut seed extract at high concentrations can induce mortality approaching 100% within relatively short periods.

The DMRT results demonstrated that treatments M10, M15, and M20 belonged to the same letter group "c," indicating no significant statistical differences among these three treatments. Although mortality increased numerically from 80% to 86% and 93%, these increments were insufficient to demonstrate significant differences at the 5% significance level, suggesting that 10 g/L concentration likely achieved the optimum efficacy threshold of the extract for inducing golden apple snail mortality.

The lack of significant differences in mortality among 10 g/L, 15 g/L, and 20 g/L concentrations can be explained through both biological and statistical perspectives. Biologically, at 10 g/L concentration, the quantity of bioactive compounds contained in the extract was presumably sufficient to maximally disrupt the golden apple snail's metabolic system. Beyond a certain threshold, concentration increases do not always enhance efficacy linearly because the target organism's body has already sustained severe physiological damage. Souto *et al.* (2021) reported that botanical pesticide efficacy has specific biological response limits; therefore, dose increases above the toxic threshold do not consistently produce significant mortality increases.

Additionally, statistical factors influenced these results. The number of test organisms used in each experimental unit was relatively limited, comprising five golden apple snails per container. Mortality differences among treatments ranged only around one individual, causing inter-treatment data variation to remain homogeneous according to DMRT analysis. This condition resulted in numerical differences in mean mortality values being insufficiently substantial to generate statistically significant differences.

Botanical pesticide efficacy is strongly influenced by concentration, as elevated concentrations increase the quantity of bioactive compounds interacting with the organism's body, thereby accelerating mortality processes. The absence of mortality in the control treatment reinforces that golden apple snail death was entirely attributable to the toxic effects of the extract rather than environmental factors or natural stress.

Overall, the data demonstrate a pattern of increasing mortality corresponding to elevated extract concentrations, indicating a dose-response relationship. Higher extract concentrations

result in greater quantities of bioactive compounds entering the golden apple snail's body, consequently increasing physiological damage severity culminating in death. The mechanism of golden apple snail mortality occurs through combined nervous system disruption by alkaloids, cell membrane damage by saponins, and protein synthesis inhibition by curcumin. Hariyani and Maryani (2026) stated that botanical pesticides possess multi-target mechanisms of action capable of simultaneously attacking various biological systems of organisms, thereby enhancing control efficacy and reducing resistance risks.

Changes in Golden Apple Snail Weight (%)

In addition to the mortality parameter, changes in the body weight of golden apple snails were also used as an indicator to

evaluate the physiological effects of *Jatropha curcas* seed extract on the tested pest. Observation of weight changes was conducted to determine the extent of disruption to feeding activity, growth, and metabolic processes of the golden apple snails after treatment application. A decrease in body weight may indicate the toxic effects of active compounds contained in *Jatropha curcas* seed extract on the physiological condition of the snails. Furthermore, body weight changes may reflect the level of stress experienced by organisms due to exposure to bioactive compounds present in the extract treatment. Weight change data can also serve as supporting information in evaluating the effectiveness of botanical pesticides against golden apple snails (Yana, 2019).

Table 2. Changes in the body weight of golden apple snails

Concentration	Replicate			Mean (%)
	1	2	3	
		%		
K	-1,38	-0,41	-0,51	-5,23c
M5	1,34	0,76	0,63	6,61b
M10	1,5	1,77	2,13	12,95b
M15	2,8	2,85	2,99	21,52a
M20	3,98	4,69	3,45	28,04a
Mean	1,64	1,93	1,73	12,78

Note: Values followed by the same letter within the same row and column indicate no significant difference based on Duncan's Multiple Range Test (DMRT) at 5% significance level.

Based on the results presented in Table 2, the changes in golden apple snail body weight exhibited a pattern consistent with increasing concentrations of *Jatropha curcas* seed extract. The Duncan's Multiple Range Test (DMRT) at the 5% significance level demonstrated that the extract treatments significantly affected the body weight changes of golden apple snails. These differences were indicated by the variation in letter groupings among treatments.

In the control treatment (K), the body weight change value was -5.23% and classified into group c. The negative value in the weight change parameter indicates an increase in body weight during the

observation period, since the calculation was based on the difference between initial and final body weight ($W_0 - W_t$). This finding suggests that the golden apple snails in the control treatment remained under normal physiological conditions, actively consumed food, and continued to grow. The absence of toxic compound exposure allowed metabolic processes to function optimally, enabling the snails to utilize feed efficiently for body weight gain. This condition further confirms that the weight changes observed in the extract treatments were genuinely caused by the toxic effects of *Jatropha curcas* seed extract rather than environmental factors or natural stress. These findings indicate that, without extract

application, golden apple snails were able to utilize feed optimally to support body growth. In contrast, the extract-treated groups experienced significant weight reduction, indicating that *Jatropha curcas* seed extract not only caused mortality but also inhibited feeding activity prior to death (Sumiana et al., 2025).

At the 5 g/L treatment (M5), body weight decreased by 6.61% and was categorized into group b. This reduction indicates that *Jatropha curcas* seed extract had begun to inhibit the feeding activity of golden apple snails. Active compounds such as flavonoids and tannins likely reduced feed palatability, resulting in lower feeding activity. In addition, saponins may have started to interfere with the basic physiological functions of the organism. According to Fitriana (2023), secondary metabolites contained in botanical pesticides can function as antifeedants that suppress the feeding activity of target organisms.

In the 10 g/L treatment (M10), body weight reduction increased to 12.95% and remained within group b, indicating no statistically significant difference from treatment M5. Nevertheless, numerically, the degree of weight loss was higher than that observed in the previous treatment. This suggests that feeding inhibition became more pronounced as extract concentration increased. Besides the antifeedant effect, metabolic disturbances likely began to occur due to greater exposure to toxic compounds. Energy that would normally be allocated for growth was instead diverted toward detoxification processes, resulting in body weight reduction (Shofa, 2021). The absence of statistical differences between M5 and M10 may indicate that the physiological responses of golden apple snails at both concentrations were still within a relatively similar biological tolerance range.

In the 15 g/L treatment (M15), body weight change reached 21.52% and was

classified into group a. These results indicate that M15 exerted a significantly greater effect compared to M5 and M10. At this concentration, golden apple snails experienced more severe physiological disturbances, characterized by reduced feeding activity, impaired energy metabolism, and weakened body condition. According to Wulansari (2022), significant body weight reduction indicates that organisms experience physiological stress due to the accumulation of toxic compounds within the body. Active compounds such as saponins and alkaloids were presumed to act more effectively in disrupting the digestive system and metabolic balance of the organism.

At the highest concentration treatment, M20, body weight reduction reached 28.04% and was grouped together with M15 in group a. This result indicates that the two treatments were not significantly different statistically, although numerically M20 produced the highest weight loss value. The substantial reduction in body weight under M20 treatment suggests that the golden apple snails experienced physiological starvation due to severe disruption of feeding activity and metabolism. According to Ngegba et al. (2022), exposure to botanical pesticides at high concentrations may induce metabolic stress that significantly reduces body weight before eventually causing mortality. The lack of significant difference between M15 and M20 may indicate that the toxic effect of the extract had reached its optimal threshold at 15 g/L in inhibiting the physiological activity of golden apple snails, such that increasing the concentration to 20 g/L no longer produced a significantly greater effect.

The DMRT analysis at the 5% significance level showed that treatments M5 and M10 belonged to the same letter group, namely b, indicating no significant statistical difference between the two treatments. Similarly, treatments M15 and

M20 were both classified into group a, suggesting no significant difference between them. Although numerically the degree of weight loss increased with higher extract concentrations, the increase was not sufficiently large to produce significant differences at the 5% significance level.

The similarity between treatments M5 and M10 indicates that concentrations ranging from 5 g/L to 10 g/L were already capable of inhibiting feeding activity and disrupting metabolic processes, although the physiological stress generated remained within a relatively similar biological response range. At both concentrations, the golden apple snails presumably still retained adaptive and detoxification capabilities against the toxic compounds, so the increase in concentration did not produce markedly different responses. In addition, the antifeedant effect induced by both treatments was likely still in the early phase of physiological inhibition.

Meanwhile, the absence of significant differences between treatments M15 and M20 indicates that a concentration of 15 g/L may have reached the optimal effectiveness threshold of the extract in inducing body weight reduction in golden apple snails. Under these conditions, the feeding activity and metabolism of the organism had already been severely disrupted, such that increasing the concentration to 20 g/L did not significantly enhance the effect. The golden apple snails were presumed to have experienced maximum physiological stress due to the accumulation of active compounds such as saponins, alkaloids, and curcumin, which interfere with the digestive system and energy metabolism. According to Souto et al. (2021), botanical pesticides possess a certain biological response threshold; therefore, increasing the dosage beyond the effective threshold does not always result in significantly greater toxic effects. In addition to biological factors, the relatively small number of test organisms in each experimental unit may also have

contributed to the homogeneity of data variation among treatments according to the DMRT analysis, causing numerical differences in mean values to remain statistically insignificant.

The reduction in golden apple snail body weight is closely associated with the antifeedant mechanism of botanical pesticides, which suppress feeding activity. Active compounds contained in the extract, particularly saponins and alkaloids, likely reduced appetite and disrupted digestive system functions, resulting in suboptimal nutrient intake. This condition caused the golden apple snails to experience energy deficiency, ultimately leading to physiological deterioration and death. Increasing extract concentration was proven to strengthen this effect, whereby higher concentrations resulted in stronger feeding inhibition and toxicity intensity (Setiakusuma et al., 2023). This phenomenon was clearly observed in the 20% concentration treatment, which produced the highest body weight reduction value of 28.04%.

These findings indicate that *Jatropha curcas* seed extract acts not only as a lethal agent causing direct mortality but also exerts sublethal effects in the form of feeding inhibition and metabolic disruption. The observed body weight reduction may therefore be considered an early indicator of physiological stress prior to mortality. Thus, the mechanism of action of the extract appears to occur gradually, beginning with reduced feeding activity, followed by metabolic and physiological disturbances, and ultimately leading to organism death (Handyta, 2024).

Morphological Changes of Golden Apple Snails

Morphological observations were conducted visually every 24 hours for seven days to evaluate the physical changes of golden apple snails following the application of *Jatropha curcas* seed extract. The observed parameters included

movement activity, body condition, operculum position (shell cover), body coloration, and response to external stimuli. These observations were essential to complement mortality and body weight

reduction data, as morphological alterations may indicate early symptoms of toxicity before mortality occurs.

Table 3. Morphological changes in golden apple snails

D A A	Extract Concentration				
	Control (0 g/L)	M5 (5 g/L)	M10 (10 g/L)	M15 (15 g/L)	M20 (20 g/L)
1	Actively moving, rapid response, normal coloratio, operculum tightly closed	Active, no morphological changes observed	Active, no morphological changes observed	Active, no morphological changes observed	Active, no morphological changes observed
2	Normal, actively feeding, good response	Reduced activity, slightly slower response	Reduced activity, began remaining motionless more frequently	Slower movement, weakened response	Reduced activity, initial mortality observed, weak response
3	Normal, no visible changes	Limited activity, some individuals remained motionless	Some individuals inactive, response weakened	Most individuals inactive, operculum began to open	Inactive, mortality increased, body weakened
4	Active and normal	Very slow movement, body color became pale	Inactive, several individuals began to die	Many inactive individuals, some emerged from shells	High mortality, most individuals dead, tissue deterioration initiated
5	Normal, body weight increased	Some individuals weak, others still active	Most individuals dead, weakened body condition	High mortality, most individuals dead, bodies protruding from shells	Nearly all individuals dead, bodies protruding from shells
6	Normal	Several individuals dead, some still alive	Majority dead, only a few individuals survived	Majority dead	Nearly all individuals dead
7	Remained normal	Some individuals survived in weak condition	Most individuals dead, surviving individuals severely weakened	Most individuals dead	Highest mortality observed, majority dead

Based on the morphological observations presented in Table 3, physical changes in golden apple snails occurred progressively in line with increasing extract concentrations and longer exposure duration. On the first day after application, neither the control nor extract treatments (M5, M10, M15, and M20) exhibited morphological alterations or mortality. Snails in all treatments remained actively

mobile, responsive to stimuli, and maintained normal body conditions with tightly closed opercula. These findings indicate that the active compounds in the extract were still in the early phase of penetration into the snail body and had not yet produced evident toxic effects. This condition also suggests the absence of an immediate knockdown effect following application, indicating instead the presence

of a latent phase before biological responses became apparent (Witri, 2024).

By the second day, early symptoms of morphological changes began to appear and varied among extract concentrations. In the control treatment, golden apple snails continued to exhibit normal conditions without visible alterations. At the low concentration of 5 g/L (M5), locomotor activity decreased and responses became slightly slower, although no mortality was recorded. In the intermediate concentrations (M10 and M15), the reduction in activity became more evident, characterized by an increased tendency to remain motionless and weakened responses to stimuli. In contrast, the highest concentration treatment, 20 g/L (M20), resulted in the initial mortality of one individual accompanied by a more pronounced decline in activity compared to other treatments. These findings indicate that higher extract concentrations accelerated the toxic effects on the physiological systems of the organism.

From the third to the fifth day, morphological alterations became increasingly evident and severe. In the control treatment, the snails remained active and showed no visible morphological changes. At 5 g/L (M5), the observed effects were still relatively mild, characterized by limited movement, paler body coloration, and progressively reduced responses, although some individuals remained alive. At 10 g/L (M10), several snails became inactive, exhibited extremely weak responses to external stimuli, and mortality began to occur. In the 15 g/L treatment (M15), most snails displayed no movement, the operculum began to open, body condition weakened substantially, and several individuals partially emerged from their shells, indicating conditions approaching death. Meanwhile, at the highest concentration of 20 g/L (M20), mortality increased markedly, with most individuals dying more rapidly and

displaying severe morphological damage, including protrusion of body tissues from the shell and initial tissue degradation. These observations demonstrate a strong relationship between extract concentration and the severity of physiological damage experienced by the golden apple snails.

By the sixth and seventh days, differences among treatments became increasingly distinct. In the control treatment, the snails maintained normal conditions without any morphological abnormalities. At the low concentration (M5), approximately three individuals remained alive, although in weakened condition, characterized by very limited movement, reduced body strength, and almost complete loss of responsiveness. This finding suggests that at lower concentrations the extract exerted sublethal rather than fully lethal effects (Witri, 2024). At 10 g/L (M10), most snails had died, while the surviving individuals were in extremely weak condition. At 15 g/L (M15), mortality was higher than in M10, with the majority of individuals dead and displaying more pronounced tissue damage. At the highest concentration, 20 g/L (M20), mortality was the most dominant among all treatments and was accompanied by severe morphological deterioration, including bodies protruding from the shell, decomposition of soft tissues, darkened body coloration, and floating shells caused by gas accumulation during decomposition processes (Fatmawati et al., 2025).

The results indicate that *Jatropha curcas* seed extract acts progressively and its effects are concentration-dependent. At lower concentrations, the extract produced sublethal effects that still allowed some organisms to survive, whereas at higher concentrations, toxic effects occurred more rapidly and lethally. The observed morphological changes further support the mortality and body weight reduction data, demonstrating that the mechanism of action of the extract occurs gradually, beginning

with behavioral disturbances, followed by physiological damage, and ultimately leading to death (Handyta, 2024).

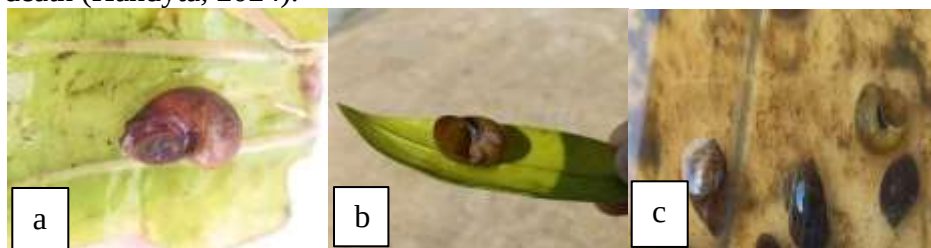


Figure 7. Morphology of golden apple snails after application of *Jatropha curcas* seed extract: (a) opened operculum; (b) body protruding from the shell; (c) dead snails floating on the water surface.

The observed morphological alterations are closely associated with the mechanism of action of active compounds contained in *Jatropha curcas* seed extract. According to Saenong (2017) cited in Nasution et al. (2019), compounds such as saponins can damage cell membranes and disrupt ionic balance, alkaloids interfere with the nervous system, while toxic compounds including phorbol esters and curcumin inhibit enzymatic activity and protein synthesis. Disruption of these vital systems leads to decreased activity, loss of muscular control as indicated by operculum opening, tissue damage, and eventually mortality. The reduction in locomotor activity observed during the early stages is also consistent with the findings of Dewi et al. (2024), who stated that behavioral alterations represent an early indicator of physiological disturbances caused by exposure to toxic compounds.

CONCLUSION

Based on the results and discussion, it can be concluded that the combined extract of *Jatropha curcas* seeds was effective in increasing the mortality of golden apple snails, as demonstrated by the analysis of variance, which revealed highly significant effects on both mortality and body weight reduction parameters. Increasing extract concentration significantly enhanced the mortality rate of golden apple snails. Among all treatments,

the concentration of 20 g/L was identified as the most effective treatment, producing the highest mortality rate of 93% along with the greatest reduction in body weight. These findings indicate that the extract at this concentration was capable of exerting maximum toxic effects through mechanisms involving nervous system disruption, cell membrane damage, and metabolic inhibition.

Further studies are recommended to evaluate the effectiveness of *Jatropha curcas* seed extract under field-scale conditions with more complex environmental factors, including temperature, water pH, and interactions with other organisms. In addition, further research on extract formulation and stability is necessary to improve its durability, stability, and practical applicability for farmers. Quantitative analysis of the active compounds should also be conducted by identifying and measuring the concentrations of bioactive substances such as saponins, alkaloids, and curcumin in order to better understand the relationship between compound composition and toxicity levels.

REFERENCES

- Badan Pusat Statistik. 2019. *Konsumsi Bahan Pokok 2019*. Jakarta: Badan Pusat Statistik.
- Banjarnahor, I., Wibowo, L., Hariri, A.M. 2016. Pengaruh pemberian ekstrak biji jarak pagar (*Jatropha curcas* L.)

- terhadap mortalitas keong mas (*Pomacea* sp.) di rumah kaca. *Jurnal Agrotek Tropika*. 4(2): 145–151.
- Chairudin, C., Lizmah, S.F., Mahdi, R. 2020. Efikasi ekstrak biji jarak pagar terhadap mortalitas larva penggulung daun (*Lamprosema indicata*) pada tanaman kedelai (*Glycine max*). *Jurnal Agrotek Lestari*. 6(1): 40–45.
- Devappa, R.K., Makkar, H.P.S., Becker, K. 2010. *Jatropha* toxicity—A review. *Journal of Toxicology and Environmental Health Sciences*. 2(3): 47–55.
<https://doi.org/10.1080/10937404.2010.499736>
- Dewi, V.K., Fitrianti, N., Puspasari, L.T. 2024. Daya makan dan mobilitas keong mas (*Pomacea canaliculata* L.) pada tanaman padi hitam (*Oryza sativa* L.) berpupuk ampas bungkil nimba dengan kedalaman air berbeda. *Jurnal Agrikultura*. 35(1): 180–187.
- Fatmawati, P.R., Yanuarti, R., Hasibuan, Z.H., et al. 2025. *Mollusca: Biologi, Keanekaragaman, dan Aplikasi*. Kamiya Jaya Aquatic.
- Fitriana, A. 2023. Inventarisasi jenis tumbuhan di Taman Singha Merjosari Kecamatan Lowokwaru Kota Malang yang berpotensi sebagai pestisida nabati. Skripsi. Universitas Islam Negeri Maulana Malik Ibrahim.
- Gamarra, M., Giraud-Billoud, M., Castro-Vazquez, A. 2013. Reproductive organogenesis in the apple snail *Pomacea canaliculata*. *Journal of Molluscan Studies*. 79(2): 147–162.
<https://doi.org/10.1093/mollus/eyt004>
- Glasheen, P.M., Calvo, C., Meerhoff, M., Hayes, K.A., Burks, R.L. 2017. Survival, recovery, and reproduction of apple snails (*Pomacea* spp.) following exposure to drought conditions. *Freshwater Science*. 36(2): 316–324.
<https://doi.org/10.1086/692241>
- Hakim, L. 2019. Uji bioaktif ekstrak biji jarak pagar terhadap keong mas (*Pomacea canaliculata* L.) di laboratorium. Skripsi.
- Halwart, M. 1994. The golden apple snail *Pomacea canaliculata* in Asian rice farming systems: Present impact and future threat. *International Journal of Pest Management*. 40(2): 199–206.
<https://doi.org/10.1080/09670879409371882>
- Handyta, B.P. 2024. Uji toksisitas ekstrak etanol daun jarak pagar (*Jatropha curcas*) sebagai insektisida nabati terhadap mortalitas hama kutu putih (*Planococcus citri*) pada tanaman kopi robusta (*Coffea canephora*). Skripsi.
- Hasanah, E., Sari, W., Amelia, K., Putri, S.D. 2026. Uji efektivitas beberapa pestisida nabati untuk mortalitas keong mas (*Pomacea canaliculata* L.) pada varietas padi Sambutan. *Jurnal Agrium*. 66–83.
- Hasanah, J. 2024. Teknik pengendalian keong mas (*Pomacea canaliculata*) pada tanaman padi di Gapoktan Sulek Raya wilayah kerja BPP Maskuning Kabupaten Bondowoso. Skripsi.
- Hutasoit, R.T., Sembiring, M., Simanjuntak, R. 2021. Dinamika populasi dan intensitas serangan keong mas (*Pomacea canaliculata*) pada pertanaman padi. *Jurnal Hama dan Penyakit Tumbuhan Tropika*. 21(2): 112–120.
- Isman, M.B. 2020. Botanical insecticides in the twenty-first century—Fulfilling their promise? *Annual Review of Entomology*. 65: 233–249.
<https://doi.org/10.1146/annurev-ento-011019-025010>
- Kementerian Pertanian Republik Indonesia. 2019. *Peraturan Menteri Pertanian Nomor 43 Tahun 2019 tentang Pendaftaran Pestisida*. Jakarta.
- Putra, S.R., Hasjim, S. 2019. Efektivitas moluskisida berbahan aktif

- niklosamida terhadap hama keong mas (*Pomacea canaliculata* L.) pada tanaman padi. *Journal of Bioindustry*. 1(2): 98–109.
- Putra, S., Zein, S. 2016. Pengaruh variasi konsentrasi ekstrak serai (*Andropogon nardus*) terhadap mortalitas hama keong mas (*Pomacea canaliculata* L.). Skripsi.
- Raven, P.H., Johnson, G.B. 2001. *Biology*. 6th Edition. Boston: McGraw-Hill.
- Saenong, M.S. 2017. Tumbuhan Indonesia potensial sebagai insektisida nabati untuk mengendalikan hama kumbang bubuk jagung (*Sitophilus* spp.). *Jurnal Penelitian dan Pengembangan Pertanian*. 35(3): 131–142.
- Savira, A., Tambunan, A., Purba, D.A.B., Rahman, A.A., Widarto, T.H. 2024. Perilaku harian keong mas *Pomacea canaliculata* (Gastropoda: Ampullariidae). *Jurnal Sumberdaya Hayati*. 10(2): 114–121.
- Setiakusuma, N.P.M., Afifah, L., Sugiarto, S., Yustiano, A. 2023. Uji efektivitas ekstrak daun kipahit (*Tithonia diversifolia*) terhadap mortalitas dan intensitas serangan keong mas (*Pomacea canaliculata* L.) pada tanaman padi (*Oryza sativa* L.) varietas Inpari 32. *Jurnal Agroplasma*. 10(2): 682–688.
- Souto, A.L., Sylvestre, M., Tölke, E.D., et al. 2021. Plant-derived pesticides as an alternative to pest management and sustainable agricultural production: Prospects, applications and challenges. *Molecules*. 26(16): 4835. <https://doi.org/10.3390/molecules26164835>
- Sumiana, I.K., Takwin, B.A., Fahtuhrohman, A.B., Suleman, G.A. 2025. Potensi biji dan daun jarak pagar (*Jatropha curcas*) sebagai sumber protein alternatif dan imunostimulan dalam mendukung akuakultur berkelanjutan: Kajian pustaka. *Jurnal Riset Akuakultur*. 20(2): 195–228.
- Titalianingtyas, E., Ratnasari, E. 2023. Aktivitas biofungisida ekstrak daun jarak pagar (*Jatropha curcas* L.) terhadap pertumbuhan *Fusarium* sp. secara *in vitro*.
- Widawati, L., Permatasari, A., Yuliana, N. 2022. Efektivitas ekstrak biji jarak pagar (*Jatropha curcas*) terhadap mortalitas keong mas (*Pomacea canaliculata*). *Jurnal Agroteknologi Tropika*. 11(3): 145–153.
- Witri, U. 2024. Uji efektivitas kombinasi ekstrak biji jarak pagar (*Jatropha curcas* L.) dan ekstrak daun belimbing wuluh (*Averrhoa bilimbi* L.) sebagai insektisida alami pembasmi rayap tanah (*Coptotermes gestroi*). Skripsi. UIN Raden Intan Lampung.
- Wulansari, R. 2022. Analisis senyawa metabolit sekunder dan uji aktivitas larvasida alami pada ekstrak etanol daun bidara (*Ziziphus mauritiana* Lamk.) terhadap larva *Aedes aegypti*. Skripsi. Universitas Islam Negeri Maulana Malik Ibrahim.
- Yoshida, K., Hoshikawa, K., Wada, T., Yusa, Y. 2009. Life cycle of the apple snail *Pomacea canaliculata* inhabiting Japanese paddy fields. *Applied Entomology and Zoology*. 44(3): 465–474. <https://doi.org/10.1303/aez.2009.465>
- Zhang, C., Guo, J., Saveanu, L., Martín, P.R., Shi, Z., Zhang, J. 2023. Invasiveness of *Pomacea canaliculata*: The differences in life history traits of snail populations from invaded and native areas. *Agronomy*. 13(5): 1259. <https://doi.org/10.3390/agronomy13051259>