The Molluscicidal Potential of Selected Plants against *Pomacea Canaliculata*

**Abstract:** This research determined the molluscicidal performance of selected plants namely, black pepper, garlic, and madre de cacao against the subject, *Pomacea canaliculata* or golden apple snails. This quantitative research utilized post-test only control group research design through the use of treatment and control group exposed to experimental subjects. The sample was randomly selected and has undergone acclimation process. The experimentations and observations done were based from the guidelines mandated by WHO and related studies. The potency of each treatment groups was observed through numbers or trials along with the comparison with the positive control, metaldehyde. The researchers desired to identify the significant different between each group and the control, supported by the outcome of the study, the results concluded that among the three samples, the black pepper showed no significant difference against the metaldehyde with the manifestation of the p-value which accepts the null hypothesis.

**Keywords:** molluscicide, golden apple snails, acclimatation, potency, agriculture.

**INTRODUCTION**

Invasive species is an organism which thrives extensively in an already balanced ecosystem with the increasing risk on the native species and since it is an alien species that is released to an existing ecosystem, this clearly suggests that it causes drastic disruption amongst other organisms. By nature, these species are often widespread because it typically rules out the native species. The Golden Apple Snails ( *Pomacea canaliculata* L.) was originally introduced to the Philippines as a new possible food source for the Filipinos as it is rich in protein. However, it became a major pest in the Philippine rice fields as it eats young rice seedlings (Joshi & Brito, 2016). This South American freshwater gastropod, largely affect the rice production of Asian countries shortly, after its introduction in Asia in the 1980s. It basically caused ecosystem changes upon the paddy fields that it invaded (Tamburi & Martin, 2016). It basically caused ecosystem changes upon the paddy fields that it invaded (Tamburi & Martin, 2016). Among the thousands of farmers that were affected here in the Philippines were the farmers in Paliparan I, City of Dasmariñas, Cavite and that exact problem was the root of fascination for the researchers.

The golden apple snails were brought to their community in the 1980s, when it was still promoted as a possible food source and according to the original inhibitors of some of the farmlands in the locale, the idea of culturing snails fascinated individuals. Yet, bringing an alien species without further knowledge about its capabilities and risks, the species escaped and extremely thrived on the paddy fields. Today, the prevalence of the golden apple snails in the remaining farmlands of Paliparan I, City of Dasmariñas, Cavite caused drastic changes in the ecosystem, wiping down the native species and pushing the farmers to resort on non-organic techniques to decimate the pest.

On the contrary, the molluscicidal property of commercially-bought molluscicide is manifested by looking for sufficient amounts of the active ingredient, metaldehyde and niclosamide (Li & Wang, 2017). These active ingredients are known to cause disruption in the whole ecosystem as it is highly corrosive and poisonous to other organisms, not just the snails. Today, the damage that the golden apple snails caused to the Philippine rice fields gravely affects the rice production which then cause large losses for the Filipino farmers. The use of commercial molluscicides is one of the major solutions that they use to decimate the snails, but the risk in their health since there are high concentrations of toxic chemicals in the molluscicide is extremely notable. In the midst of that, since the Philippines is home to a wide collection of flora and fauna, hundreds of plants possess molluscicidal properties similar to metaldehyde and niclosamide. With these presented findings, the researchers saw an opportunity to lessen the use of such synthetic chemicals. Among these...
plants were the seeds of *Piper nigrum* (black pepper) with 1,000-8,000 ppm and the roots of *Gliricidia sepium* (madre de cacao) with 500-8,000 ppm, where the said concentrations are said to efficiently decimate the mollusks (Rejesus & Punzalan, 2009). Moreover, a study by Picardal et al. (2018) revealed that aqueous extract of the *Allium sativum* (garlic) bulb can effectively kill snails at 7.5 – 10 ppm.

The molluscicidal potential of these Philippine plants may be the key to efficiently decrease the numbers of the *P. canaliculata*, *L.* In this study, the researchers aim to verify the molluscicidal potential of selected plants through comparing their crude extracts to a synthetic molluscicide. The verification of the molluscicidal potential of the selected plants could open the possibility to the development of plant derived molluscicide that would efficiently decimate the snails as well become a safer option for the farmers to use and for the ecosystem around it.

**Statement of the Problem**

This study generally aimed to measure the molluscicidal potential of the selected plants against golden apple snails (*Pomacea canaliculata* *L.*). The study specifically aimed to answer the following questions:

1. What is the molluscicidal performance of the following selected plants:
   a. *Allium sativum* (garlic) bulb;
   b. *Piper nigrum* (black pepper) seeds; and
   c. *Gliricidia sepium* (madre de cacao) roots.

2. What is the significant difference between the performance of plant derived molluscicides and a synthetic molluscicide?

3. What is the significant difference among the performance of each plant-derived molluscicide?

**Significance of the Study**

The brief length of time that the golden apple snails (*Pomacea canaliculata, Lamarck.*) need to complete a life cycle resulted to a fast increase in numbers. The invasive species soon dominated the Philippine rice fields and became a prominent problem for the farmers to solve. It caused massive changes to the native species and to the surrounding ecosystem. These snails became uncontrollable and the effects worsen as they consume a large portion of seedlings which affects the totality of the harvest. The prevalence of this issue among rice farmers in Paliparan I, City of Dasmariñas, Cavite is the source of the snails to be used, the source of the selected plants. It also limits the snail species to be tested which is the golden apple snail (*Pomacea canaliculata* *L.*).

The molluscicidal potential of the selected plants against the golden apple snail (*Pomacea canaliculata L.*). The study was limited to the molluscicidal properties of certain parts of the selected plants. It also limits the research to the golden apple snail (*Pomacea canaliculata* *L.*). Along with its limitations was the source of the snails to be used, the source of the selected plants, and the area of its development which is situated in Paliparan 1, City of Dasmariñas, Province of Cavite, year 2019.

**Theoretical Framework**

The molluscicidal potential of selected plants namely, *Allium sativum* (garlic), *Piper nigrum* (black pepper), and *Gliricidia sepium* (madre de cacao) on GAS was evaluated through a series of biological tests involving the test subjects (*Pomacea canaliculata* L.) exposed to the different crude extracts of the selected plants. Using the WHO 2019 Guidelines for Laboratory and Field Testing of Molluscicides for Control of Schistosomiasis, Phase I was used since the researchers are conducting the study under laboratory conditions. Thus, the researchers would be using laboratory procedures to see the number of mortalities of GAS after snails are exposed to the crude extracts of the selected plants at different concentrations. One of the objectives of Phase 1 is to determine the lethal concentration (LC) for the snail species that would result to 50 percent (LC50) and 95 percent (LC95) mortality of adult snails. Another objective is to kill the invasive snails as well as protect them from harmful chemicals that would inflict their health.

**Nature.** The molluscicidal potential of the selected plants is being developed for the natural restoration and preservation of past ecosystems that may have been damaged or disrupted by the invasive snails. The verification of the molluscicidal properties of selected plants tries to address the increasing usage of commercial molluscicides which contain harmful concentrations of chemicals.

**Community.** Providing sufficient information for the community to seek, regarding the alternative molluscicides that may be produced if needed in certain quantities is deemed to be achieved at the end of this study.

**Future researchers.** This study is significant for future researchers as they could extend this research to develop a more efficient molluscicide made from rarely-notice and unusual plants. This research also suggests further exploration among plants which could be used for the decimation of invasive species. The study also provides reliable data which could be used for other researches with similar topics.

**Scope and Delimitations of the Study**

The study covers the determination of the molluscicidal performance of selected plants against the golden apple snail (*Pomacea canaliculata L.*). The study was limited to the molluscicidal properties of certain parts of the selected plants. It also limits the snail species to be tested which is the golden apple snail (*Pomacea canaliculata* L.). Along with its limitations was the source of the snails to be used, the source of the selected plants, and the area of its development which is situated in Paliparan 1, City of Dasmariñas, Province of Cavite, year 2019.

determine the minimum effective concentration that kills 100% of a snail species. In relation to these, the researchers decided to manifest (1) the goal to see the significant difference between each plant molluscicide and the significant difference between the plant molluscicides and synthetic molluscicides and (2) the goal to find the minimum effective concentration of the selected plants’ crude extracts. With these in mind, the experiments would result to the appropriate amount of plant-based molluscicides to be applied to the GAS, thus the performance and boundaries of the plant-based molluscicide would be identified.

The study conducted by Rawi, Al-Hazmi, and Al Nassr (2011) entitled, The Comparative Study of the Molluscicidal Activity of Some Plant Extracts on the Snail Vector of Schistosoma mansoni, Biomphalaria alexandrina was the basis on how the molluscicidal performance would be evaluated. The number of dead snails at certain time interval, the mortality count, the sum of the number of mortalities at a certain time interval, cumulative mortality rate of the snails, and the post-mortem observations would be the parameter in measuring the molluscicidal performance of the selected plants against the golden apple snail. The mortality count is measured using visual examination which is to be performed during and after the application of the said plant molluscicides. Subjects that exhibit immobility were then be subject for physical examination which includes tests related to their response. The use of a sharp metal pin to poke the snail to check muscle contractions was used. By poking, it revealed if the snail is still alive since a live snail should quickly respond and show muscle contractions. If the subject showed no signs of response, it was marked and isolated from the laboratory. The number of dead snails per 24 h intervals was recorded. The cumulative mortality was then obtained after the experiment was finished as the total number of dead snails were tallied. Along with the mortality rate and the cumulative mortality, post-mortem observations were simultaneously noted as it will reveal the reaction of the snails on each specific molluscide which was important in evaluating the results of the study. This also showed vital information as to what the mode of action does the plant molluscide act towards the target subjects.

In summary, to evaluate the molluscicidal performance of the plant-based molluscicides, the researchers would base on the mortality count, cumulative mortality count and post-mortem observations of the snails during and after the snails are exposed to the selected plant extracts, thus observing the lethal performance of the proven compounds present among the selected plants.

Conceptual Framework

This study is anchored in the concept of evaluating the mortality rate and post-mortem analysis of test subjects to compare the molluscicidal performance of plant extracts based on the study of Rawi, Al-Hazmi and Al Nassr (2011).

Figure 1. The Process of Determining Molluscicidal Performance

Figure 1 entails the flow of the study. The selected plants namely: seeds of *Piper nigrum* (black pepper), bulb of *Allium sativum* (garlic), and roots of *Gliricidia sepium* (madre de cacao) against golden apple snails will be the treatment group of the study. The parameters used to measure the molluscicidal performance of the plant-based molluscicide is the mortality rate, cumulative mortality rate and post-mortem observations of the *P. canaliculata, L* which is adapted from Rawi, Al-Hazmi and Al Nassr (2011). After harnessing the parameters of the dependent variable, the researchers then looked for the significant difference among the plant molluscicides and between the plant molluscide and synthetic molluscide.

**Hypothesis**

H₀: There is no significant difference between the plant-based molluscicides and the synthetic molluscicides against golden apple snails (*Pomacea canaliculata, Lamark*).

H₁: There is no significant difference among the different plant-based molluscicides with the following treatment groups against golden apple snails (*Pomacea canaliculata, Lamark*).
RESEARCH METHODOLOGY

This chapter vividly shows the discussion on the experimental design, the subjects of the study, sampling technique, research instruments, data gathering procedures and data analysis regarding the study about exploring the molluscicidal potential of garlic, black pepper and madre de cacao against *Pomacea canaliculata*, Lamarck.

**Experimental Design**

This study used true experimental design. The presences of control and manipulation group as well as the application of randomization made it ideal for the chosen design. The study focused on determining the molluscicidal potential of the selected herbs against the invasive species, *Pomacea canaliculata*, Lamarck. Specifically, the design used in the study was post-test only control group design. With this design, the effect of experimental treatment yielded the significant difference between the experimental group that is the three plant derived molluscicides namely: garlic (*Allium sativum*), black pepper (*Piper nigrum*), and Madre de Cacao (*Gliricidia sepium*) which were the treatment group and the synthetic molluscicide that is metaldehyde which was the positive control group in killing the golden apple snail (*Pomacea canaliculata*, L.).

**Subjects of the Study**

Minimum of 600 samples of *Pomacea canaliculata*, L. (green apple snails or GAS) were utilized in the study. The samples were gathered from rice fields where the said species are abundant. Upon collecting the GAS, random selection was done as these were exposed to the plant-derived molluscicides in order to determine it molluscicidal performance. This study used 58 sets of adult *Pomacea canaliculata*, L. samples, with each individual set including 10 snails as the subject of the study.

**Sampling Technique**

Probability sampling, specifically simple random sampling, was used in selecting the six hundred (600) samples of *Pomacea canaliculata*, Lamarck upon collecting it from the rice fields, wet lands, and some small bodies of water like swamps, lakes and ponds in Dasmariñas City. The samples underwent equal distribution when it came to exposing them to the treatments which are the plant-derived molluscicides and the control groups. This was done to determine if the selected plants have the potential molluscicidal property against the golden apple snail (*Pomacea canaliculata*, L.).

**Research Instrument**

The research instrument used in this study was a laboratory sheet that was checked by a validator to ensure that it can efficiently measure the parameters of the variables used in the study. In addition to the laboratory sheet were the laboratory materials used for the actual experimentation and storing of materials. Laboratory equipment and apparatus were used to extract and purify substances, measure quantities and concentration of substances and to identify the status of the subjects. Protective equipment such as face mask, surgical gloves, laboratory gown and laboratory goggles were also used to follow sanitary measures and safety precautions. The validated laboratory sheet and pencil were used to record the data that were obtained in the experiment. The mortality count after the treatment groups namely: garlic (*Allium sativum*) bulb, black pepper (*Piper nigrum*) seed, and Madre de Cacao (*Gliricidia sepium*) root extracts are applied, as well as the control groups namely: distilled water and metaldehyde was to be recorded in the laboratory sheet.

**Data Gathering Procedure**

Collection of plant materials. Among the many possible plant molluscicide was the plants that were chosen by the researchers which is garlic (*Allium sativum*), black pepper (*Piper nigrum*), and Madre de...
Cacao (*Gliricidia sepium*). The following plants were readily available around the locale of the study, that is why the plant materials needed were gathered individually, carefully inspecting the condition of the plant material used. The garlic and black pepper were purchased at a local market, and the roots of Madre de Cacao were collected from random trees around Dasmariñas City. The amount of the individual plant materials to be gathered is no less than 250 grams since sufficient amount of extract is needed for the experiments which is done in 3 replications for the range-finding test and 5 replications for the actual experimentation.

**Extraction.** The purchased and collected plant samples were taken to DOST Pharmaceuticals Section, Chemicals and Energy Division wherein the plant samples were subjected for crude extraction. It was recommended by one of the researchers’ colleagues and since they found it convenient and more accurate, they went in and proceeded. In terms of steps however, it was found similar by the researchers since they also followed the same procedure wherein the plant samples underwent microwave drying, pulverizing and crushing, maceration, and rotary evaporation. It was also noted that the solvent used was ethanol. Thus, resulting to an ethanolic extract.

**Preparation of snails.** The subjects, *Pomacea canaliculata, Lamarck*, used were randomly collected around Dasmariñas City. The snails collected however, were adult snails, with shell diameter of 25 mm ± 35 mm and a weight requirement of ≥5 grams. Prior to the application of treatment, the snails were checked, ensuring they were all alive and moving. After collecting the snails, quarantine and acclimation was done to ensure that the test subjects were able to adapt to such laboratory condition wherein the continuation of the experiment is anchored. During the acclimation process, the snails are allowed to adapt in a controlled environment. This is to ensure that the snails have enough time to adapt on the newly-introduced environment. The acclimation process is adapted from the methods of Joshi et al. (2005) wherein 10 snails were placed in 500 ml containers, specifically transparent containers. Each container was filled with 350 mL dechlorinated water at 26°C (Dai et al., 2011; He et al., 2017). The acclimatization process lasted for 24 hours. The snails then had a three-day quarantine period where they were exposed to the typical fresh water for two days and to the negative control, dechlorinated water, for one day. The snails were fed as well since it could affect the data gathered in this study. Additionally, only the ones that passed the height and weight requirements and was actively moving (i.e. rasping using the radula, movement of inhalant siphon, tentacles and visceral foot outside the lip) were the ones that proceeded in the actual experiment. The snails that didn’t show active state or/and didn’t pass the shell diameter and weight requirement were separated, crushed and disposed as instructed by the standard protocol for disposing gastropods (WHO, 1983).

**Preparation of equipment and tools.** Since the experiment was conducted under laboratory conditions, laboratory tools and equipment are used. Volumetric flask, 100 mL to 500 mL beakers, and other tools must be sanitized before usage. Distilled water is used to rinse the tools and equipment to lessen the presence of contaminants, thus deducting other factors that could affect the experiment. It is also a necessary precaution to ensure the accurateness of data to be collected.

**Mortality count.** The minimum LC (lethal concentration) at 99 percent was prepared and based off partial experimentation (3 replicates per treatment) that was done prior to the actual experimentation. There were three concentrations per plant molluscicide (1000 ppm, 500 ppm, & 250 ppm) tested and the minimum lethal concentration of 99 percent was noted and applied for the actual experimentation. There was also a total of 330 GAS samples used for the partial experiment. For the actual experiment, 25 transparent containers (5 replicates per treatment) were labeled (e.g. T1 GCE = treatment 1 (250 ppm) GCE (garlic crude extract), trial 1). Ten golden apple snails were distributed randomly to every container, with a total of 250 golden apple snails used during the actual experimentation. The mortality of the snails was continuously observed for the succeeding 72 hours. The test subjects were first exposed to the negative control, dechlorinated water. The treatment groups namely, treatment 1 (garlic crude extract), treatment 2 (black pepper crude extract), and treatment 3 (Madre de cacao crude extract) were applied to the snails by preparing a uniform amount of plant extract solution (250 mL of 100% stock solution with the minimum LC99) using a 500 mL beaker. The positive control, metacide, was also prepared to its designated sample with the same concentration as the plant molluscicides. Following the first 24 hours of application of the treatments, the mortality of snails was checked through the use of a metal needle. By poking, it will reveal if the snail is still alive since a live snail should quickly respond and show muscle contractions. The number of confirmed mortalities were removed and recorded on the laboratory sheet. Once the number of mortalities were recorded, the dead snails will be separated, crushed and disposed as instructed by the standard protocol for disposing gastropods (WHO, 1983). The data gathering was repeated in 24 h intervals.

**Data Analysis**

To analyze the gathered data, the statistical mean of the collected data after five trials were computed. This is to ensure the reliability and accuracy of the data gathered. From that, mean percentage reduction was computed. Additionally, statistical treatments under inferential statistics were used. T-test was used to statistically examine the data between two
variables since the study aimed to prove the significant difference between the control group and the treatment group. Analysis of Variance (ANOVA) was also used to statistically examine the data for the multiple experimental groups since the study aimed to determine if there is a significant difference between the different treatment groups.

RESULTS AND DISCUSSION
This chapter presents the following results from the data collected to answer the previously presented research questions.

Molluscicidal Performance of the Treatments against Pomacea canaliculata L.

As scientists discover the detrimental effects of invasive species specifically mollusks such as the golden apple snails, thousands of plant samples became subjected for further research since synthetic chemicals used to eradicate the pests have such fair share of negative effects in humans and even in the ecosystem. Prior to the experimentation, each plant sample was said to possess molluscidal potential against the target organism, golden apple snail (P. canaliculata L.) that is why the researchers conducted a molluscicide evaluation in a laboratory setup which took place on the 4th of February 2020 until the 14th of February 2020. The negative control used in the following experiments was distilled water while the positive control used in the following experiments was 1000 ppm aqueous solution of Bayonet™ pellets. For the final experimentation, the final concentrations are 250 ppm for garlic crude extract, 500 ppm for black pepper crude extract and 1000 ppm for madre de cacao crude extract.

Table 1. The mean and standard deviation of the mortality count of P. canaliculata L.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Percentage Reduction</th>
<th>Standard Deviation</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic</td>
<td>82</td>
<td>0.84</td>
<td>Toxic</td>
</tr>
<tr>
<td>Black Pepper</td>
<td>96</td>
<td>0.55</td>
<td>Highly Toxic</td>
</tr>
<tr>
<td>Madre de Cacao</td>
<td>80</td>
<td>1.00</td>
<td>Toxic</td>
</tr>
<tr>
<td>Metaldehyde</td>
<td>100</td>
<td>0.00</td>
<td>Highly Toxic</td>
</tr>
</tbody>
</table>

<50%: Non-Toxic; 50-79%: Partially Toxic; 80-94%: Toxic; 95-100%: Highly Toxic; >100%: Very Highly Toxic (Rejesus & Punzalan, 2012)

The researchers used two data gathering procedures to ensure that they could capture important details during the experiment. First, mortality count was recorded and second, post-mortem observations were noted. As the experiment was being conducted, post-mortem observations through visual observations reveal that there is a distinct quality observed within the fluid wherein the golden apple snails were submerged. Their feces looked like small grains, similar to termite droppings and there is also some stringy mucus suspended in the fluid. This might indicate that the snails could have died due to excessive production of mucus when the snail encounters the toxin (Labe et al., 2012). Proceeding to the mortality count, after the numerical data were gathered, statistical analysis was conducted wherein the mean and standard deviation were computed. Table 1 entails the mean percentage reduction and the standard deviation of the treatment groups which determine the molluscicidal performance of a plant-based molluscicide. The positive control, metaldehyde, got the highest mean percentage reduction of 100 percent and is interpreted as highly toxic. In comparison, black pepper extract follows with the highest mean percentage reduction of 96 percent and the lowest standard deviation value of 84 hundredths. The high mean percentage reduction was interpreted as highly toxic based on a toxicity range adapted from Rejesus and Punzalan (2012) and the low value of SD suggests that the values gathered were not widely distributed which means they had minimal variance in the results, between the 5 replications done during the experiment. This poses a positive result since the most potential plant sample was close to the positive control. The finding was then supported by a study conducted by Srivastava, Kumar, Singh and Singh (2009), wherein it is stated that piperine, the active component of black pepper is indeed a potent plant molluscicide compared to other plant molluscicides.

On the contrary, madre de cacao extract shows the lowest mean percentage reduction of 80 percent and highest standard deviation of 1. The low mean percentage reduction was interpreted as toxic based on a toxicity range adapted from Rejesus and Punzalan (2012) which is still a positive result since it is again toxic to snails, however, the researchers can say that it is not the best. Additionally, the higher value of SD contrasted with the rest implies that there is higher variance among the results between the 5 replications done during the experiment. The value of 1 SD however, means that it is actually neither low or high variance instead, it was seen as normal distribution. In addition, although it was mentioned on the study conducted by Akharaiyi, Boboye and Adetuyi (2012), that madre de cacao is indeed a possible molluscicide, it must have been a weak molluscicide when compared with the other two plant samples since it got the lowest values. In the midst of this, not all are lost as various experiments among the plant are yet to be tested out.
In summary, the molluscicidal performance of the Treatment groups were proved to kill the target organism, golden apple snails. Nevertheless, the potency of the treatment groups differed as the toxicity of one treatment almost reached the control while the other two treatments have a slightly lower toxicity than the other treatment.

Table 2. Significant Difference between the Treatment groups and positive control (Bayonet™)

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>p-VALUE*</th>
<th>DECISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic</td>
<td>0.0086</td>
<td>Reject H₀</td>
</tr>
<tr>
<td>Black Pepper</td>
<td>0.1778</td>
<td>Accept H₀</td>
</tr>
<tr>
<td>Madre de Cacao</td>
<td>0.0111</td>
<td>Reject H₀</td>
</tr>
</tbody>
</table>

*significant at <0.05

Table 2 reveals that all of the three treatment groups showed significant difference between the positive control, metaldehyde. Based on the result shown, among all the three treatment groups, black pepper manifests no significant difference from the positive control. Black pepper got the highest p-value of 1778 ten thousandths and while madre de cacao got the lowest p-value of 111 ten thousandths. Beforehand, in Table 1, it was stated how the treatment groups are toxic based on the experiment and observations undergone by the researchers. It was then found that the toxicity of black pepper has almost reached the positive control. In connection, this was even more justified on Table 2, which implies that black pepper is not significantly different from the positive control when it comes to their molluscicidal performance.

The interpretation was further supported by the study conducted by Srivastava, Kumar, Singh and Singh (2009) about the molluscicidal activity of the black pepper. It was revealed on the study that the molluscicidal performance of black pepper was even higher compared to other synthetic molluscicides like metaldehyde and to other plant derived molluscicides. With this study, the researchers were able to establish the most effective among the treatments based on their toxicity.

To sum up, on the manifestation of the black pepper where it got the highest p-value, it can be concluded that it almost reached the performance of the metaldehyde on the molluscicidal effect against the test subject, golden apple snails. By this, it was justified that the acceptance of the null hypothesis is an astonishingly positive finding for the study. The interpretation on the finding that black pepper has no significant difference with the positive control suggests that they are comparable to each other which give a positive implication to the whole research.

Table 3. Significant Difference among the Treatment Groups: Garlic, Black Pepper, Madre de Cacao

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean Percentage Reduction</th>
<th>P-Value*</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Pepper</td>
<td>96</td>
<td>0.018</td>
<td>Reject H₀</td>
</tr>
<tr>
<td>Madre de Cacao</td>
<td>80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significant at <0.05

Table 3 entails the results of one-way ANOVA conducted between the treatment groups. After the statistical treatment was applied, the researchers came up with the p-value of 18 thousandths. Since it is below 5 hundredths, the decision was to reject the null hypothesis. Thus, it can be assumed that there is a notable difference between the following treatment groups as supported by the results shown in Table 3. Also, it is mentioned in a study about a wide range of plant materials and their mode of actions, that plants have varying active compounds with varying concentration as well (Abubakar, Bala and Singh, 2017). Hence, it proves the finding presented above.

To look closely on the significant differences between the treatments, t-Test was performed wherein the treatment groups will be compared against each other to see where exactly is the significant difference between the treatments.
Table 4. Post-hoc analysis for The Treatment Groups

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>MEAN PERCENTAGE REDUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garlic</td>
<td>82&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Black Pepper</td>
<td>96&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Madre de Cacao</td>
<td>80&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Table 4 shows the mean percentage reduction of each treatment. It was then assigned with letters a and b wherein a corresponds to the superior plant-based molluscicide which is the black pepper while letter b corresponds to the other two plant-based molluscide (garlic and madre de cacao) which had lower molluscidial performance. The letters a and b also signified that garlic and madre de cacao have no significant difference with the p-value at 78 hundredths, black pepper and garlic and black pepper and madre de cacao have significant difference with the p-value of 52 thousandths and 28 ten thousandths. This suggests that the following treatment groups became significantly different between black pepper and the two treatments, garlic and madre de cacao.

**CONCLUSIONS**

The following conclusions were confirmed by the researchers to serve as answers to the experimental research conducted regarding the molluscisodial performance of selected plants against *Pomacea canaliculata* L. based on their toxicity and their significant differences in mortality count:

After all the experimentation and data analysis, the researchers came up with astounding discoveries. The black pepper crude extract has the highest molluscisodial performance among the three selected plants that were subjected for evaluation in laboratory conditions. On the contrary, madre de cacao crude extract has the lowest molluscisodial performance but is still a toxic plant derived molluscicide for the golden apple snail.

In addition, further data analysis led to results concerning their significant difference among the mortality count of each selected plant extract. The researchers found out that one plant derived molluscide, black pepper crude extract, have no significant difference from the positive control while the other two, garlic crude extract and madre de cacao crude extract have significant difference from the positive control. This only suggests that the black pepper crude extract has almost similar molluscisodial performance with the positive control while the garlic crude extract and madre de cacao crude extract has lower molluscisodial performance with the positive control.

Lastly, as the findings suggests sufficient toxicity between treatments, the researchers seek to find if there is significant difference between the treatment groups. It was then revealed that there is significant difference between the three treatment groups and that between black pepper and garlic and black pepper and madre de cacao was the point where they became significantly different.

**RECOMMENDATIONS**

The following are the recommendations and suggestions of the researchers:

It is recommended for the future researchers to search for more alternative plants which are low in concentration, but attains high mortality count. It is also noted that plants which are not expensive and is highly convenient to avail be tested with utmost priority.

Additionally, as used in the study conducted, different parts of the plants could have varying toxicity. Thus, further experimentation among plant parts could be noted for further researches.

The researchers also encourage to venture and try different solvents like water, acetone, and methanol for the extraction of chosen plant samples. It is also notable that instead of relying on laboratories, the extraction process could be done at home or local laboratories wherein a more hands-on yet challenging work is done. On the contrary, phytochemical analysis could be added to further explore the molluscisodial potential of the plant.

Meanwhile, when it comes to the gathering of test organisms, it was preferred that it be done between the land preparation and the rice planting season as the snail population were highest during these times. When it comes to the actual experiments, however, stricter laboratory setup is a must as it will ensure accuracy and precision.

Lastly, the researchers recommend to conduct a study focusing on black pepper. If given the opportunity, further progress which includes field setup will be very much appreciated. A highly in-depth study is also recommended as it will show more specific interpretation to the plant derived molluscicides used in this study.

**REFERENCES**

Gliricidia sepium and Spathodea campanulata. *World Applied Sciences Journal*, 16 (4), 523-530


