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Development of Chalk from Selected Herbs as Cockroach (*Periplaneta americana*) Repellents

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ABSTRACT

The World Health Organization (WHO) estimates that there are 3 million cases of pesticide poisoning each year and up to 220,000 deaths primarily in developing countries. Commercial repellents and pesticides, aside from being expensive, also contain chemicals that, when ingested, may pose further threats to the health of humans. The study aims to determine which plant preparation (bay leaf, garlic, peppermint, eucalyptus at 25%, 50% and 75% each) were able to form chalk and can repel the *P. americana*. Endemic and accessible plants namely, eucalyptus (*Eucalyptus globulus*), garlic (*Allium sativum*), peppermint (*Mentha piperita*), bay leaf (*Laurus nobilis*) were used in this study as *Periplaneta americana* repellent in the form of chalk. Using a Completely Randomized Design, results revealed that the type of plant preparation and chalk formation are independent. All plant preparations repelled the *P. americana*. Based on the means of distances (cm) of repulsions, it was revealed that 75% Peppermint preparation has the highest repulsion mean of 80.67cm based on three trials. Hence, it is highly suggested that 75% and 50% *Mentha piperita,* as well as 75% *Eucalyptus globulus,* should be manufactured for commercial production based on the results of this study.

Keywords **—** Agriculture and Forestry, *Periplaneta americana* repellent, experimental design, Philippines/Southeast Asia

INTRODUCTION

Commercial repellents and pesticides, aside from being expensive, also contain chemicals that, when ingested, may pose further threats to the health of humans. These chemicals do more harm than good to the human body. Most of the preparations of these commercial repellents are in the form of spray, lotion and even in a solid cube. Households with children, especially infants and toddlers may accidentally ingest these repellents and instead of repelling the noxious arthropods, the children may be hospitalized.

The World Health Organization (WHO) in 2001 estimated that out of three million cases of pesticide poisoning, 220,000 ended to mortality of patients in developing countries (Sarwar, 2015). The pesticide is oftentimes improperly applied, and unintentional exposures occur to other animals in the vicinity where pesticides are used. The kids and also other young pets are principally vulnerable to the negative effects of pesticides and repellents alike. Exposure to these chemicals during early childhood development may cause adverse health problems.

Exposure to pesticides can lead to a number of neurological health effects such as loss of memory, uncoordinated body movements, slow response to stimuli, problems with vision, mood and behavioral alterations, and reduced motor skills. These warning signs are often very subtle and may not be easily diagnosed as a clinical problem. Further, possible health problems include asthma and other allergic reactions. Pesticide exposure can also lead to carcinoma, hormonal disorders, and reproductive and obstetrical problems (Sarwar, 2015).

Roaches were already living on the earth for at least two hundred million years before the first *Homo sapiens* wandered the surface of the earth. Cockroaches evolution is fascinating and complex when the researcher studies are surviving species comparative to the recorded fossil (Dominguez, 2005). Cockroaches, since time immemorial, have been a vector—a harbinger of diseases. Cockroach infestation is a major domestic problem. Cockroaches can pick up disease-causing bacteria such as salmonella, on their legs and later deposit them on foods and cause food infections or poisoning (Jacobs, 2013). The adults, being active and can easily be seen roaming around, must be controlled as they serve as a reservoir of diseases. House dust containing cockroach feces and body parts can

trigger allergic reactions and asthma in certain individuals. Studies show that the bacterium *Pseudomonas aeruginosa* can reproduce massively in guts of these arthropods. The said bacterium can cause a lot of diseases like urinary tract infections, gastrointestinal problems, and septicemia. The odorous secretions produced by American cockroaches (*Periplaneta americana*) can alter the flavor of food. Moreover, if populations of cockroaches are high, a strong concentration of this odorous secretion can be present. To top all these facts, cockroaches multiply at an exponential level.

With these cited threats, it is really a necessity to repel these organisms from our houses that is if drastic measures such as complete eradication of these arthropods, is not an option. Since more than a quarter of the Philippines population is below the Poverty Line, it would be hard for these individuals to allow budget on some of their basic needs, and these needs include health-promoting toiletries in the form of insect repellents. Organic preparation of repellents, aside from being environmentally friendly, can be reproduced cheaply.

Intensive use of chemical insecticides affect not only the target species but also non-target species and environment. The present question about non-poisonous repellent has come to the researcher's mind. In this study, the researcher chose plants that are inexpensive, endemic and require simple methods of extraction. The study aims to determine if plants namely, garlic *(Allium sativum)*, bay leaf *(Laurus nobilis),* eucalyptus *(Eucalyptus globulus)* and peppermint *(Mentha piperita)* as repelling agents can be used as an effective, non-hazardous and budget-friendly roach repellent.

Chemical analysis from related literature in Botany and medicine revealed the following substances from the chosen plants:

Garlic (*Allium sativum*) - Garlic can be used to repel a variety of crawling and flying insects, including mosquitoes, according to Patrick Parker (2002). Garlic bulbs contain an amino acid that converts to a chemical called *allicin* after being blended, chopped, or crushed. The garlic in itself does not have the chemical allicin, however, when the garlic cloves are cut or crushed, two compounds inside it react to form the said substance. This is the reason why garlic will not smell until it is crushed. The typical smell released as a product of this procedure has powerful insect repellent properties. The chemical allicin has shown to have fungicidal, bactericidal, antiviral and anti-infective properties. Scientists believe that the substance may also help in preventing the occurrence of cancer. Oil from garlic has been used as a repellent against insects and may also be lethal to certain insect ova. Current studies showed results that garlic is not only

valuable as an herbal plant, as it can also be utilized as an insect repellent to some plant pests like cockroaches. Transgenic rice cultivars containing ASAL protein (A. sativum leaf lectin based) have been found to exhibit increased resistance against sap-sucking insects such as brown planthopper and green leafhopper (Meriga, Mapori, & Muralikrishna, 2012).

Bay leaf (*Laurus nobilis*) – It is a known fact that the *L. nobilis* leaves are a very popular component in pasta sauces and soups. However, only a few know that they can also be utilized as an eco-friendly insect repellent. When scattered around the home, dried bay leaves can be just as effective as most popular commercial pesticide sprays in repelling annoying insects, like ants, termites, cockroaches, and fleas. The fact that there are no toxins involved when using bay leaves instead of commercial insecticides makes it qualified research subject -- they are safe for use at houses where toddlers and domesticated pets exist. Essential oils in bay leaves contain lauric acid, which has insect repellent properties. The bay leaf from the *Laurus nobilis* 'bay laurel' tree along with regular sanitation practices can repel cockroaches, eliminating them from our personal spaces. Bay leaf oil and leaves can also be used in warding off moths, cockroaches, and other insects away from households without harming the children or family pets. The best way to do this is by placing dried bay leaves around moist spots, cabinets or at different corners of the house. This process leaves behind nice natural scent which also keeps insects repelled.

Eucalyptus (*Eucalyptus globulus*) - any insect such as ants and gnats will avoid its strong, sharp smells as potential hazards. Eucalyptus not only has a strong aroma—in most areas of the country, it is also something unfamiliar and instinctively will be perceived by roaches as possibly hazardous. There is evidence that components in eucalyptus oil (in particular the compounds p-menthane-3, 8-diol and eucamol) are as effective as DEET and in some cases more effective. Currently, it has been discovered that a lot of cooling agents also have potent insect repelling property and this includes the p-Menthane-3,8-diols (Leffingwel, 2001).

Peppermint (*Mentha piperita*) - Peppermint is an aromatic plant, created from the blending of watermint and spearmint. Peppermints have high menthol contents. The peppermint oil also has carboxyl esters and menthone, specifically methyl acetate. These compounds give the plant its strong minty aroma which the cockroaches dislike. The repellent action of Mentha oil was comparable to that of Mylol oil consisting of dibutyl and dimethyl phthalates. This was validated by the study conducted by Ansari, Vasudevan, Tandon, & Razdan (2000) where oil

of *Mentha piperita L.* (Peppermint oil), a widely used essential oil, was evaluated for larvicidal activity against different mosquito species.

The four plants above were chosen because these are indigent in the community. Garlic and Bayleaf are known to grow in various parts of Libacao and are considered as an indigenous plant of the Municipality. Peppermint and eucalyptus may not be grown commercially in Libacao, but it is widely used as ingredients in cooking.

Cornstarch, being edible and even used in cooking, is a good choice in creating chalks which are non-poisonous to children. Aside from this, the mentioned website was able to provide easily understood steps in doing the process. According to eatbydate.com, cornstarch should be kept covered in a cool dark place (the pantry) away from moisture. The best way to store it is in its original container with the lid re-sealed. As long as it remains dry, it will remain safe to use since the shelf life of cornstarch is really indefinite

There is a need to create an economically-friendly, non-poisonous insect-repellant made from organic material. Another consideration of the researchers is that the said anti-roach should be handy and can be easily applied. There are plants endemic in the Philippines which have insect repellant properties. Four of these plants are as follows: Eucalyptus (*Eucalyptus globulus*), Garlic (*Allium sativum*), Peppermint (*Mentha piperita*), and Bay leaf (*Laurus nobilis*). The researchers believe that it is a necessity to pursue research on innovating these plants into a budget-friendly, purely organic and edible cockroach repellent in the form of chalk. These plants are easily accessible and are available in most household kitchens, thus, this study.

OBJECTIVES OF THE STUDY

Generally, this study aims to make an alternative hazard-free cockroach repellent which is budget friendly in the form of chalk. The study aims to determine if we can create a cockroach repellent from the powdered plants namely, garlic, bay leaf, peppermint and eucalyptus leaves. Specifically, it aims to answer the following questions: (1) which plant preparation will be able to form chalk? (2) Which plant repellent will be able to repel the *P. americana*? (3) What is the average distance the *P. americana* will be repelled from each of the plant preparations using 3 trials? (4) Is there a significant difference between the average distances of repulsion of *P. americana* in each plant preparation compared to the control? (5) What is the duration of the repellent effects of each plant preparations?

METHODOLOGY

Research Design

The study employed experimental research. Specifically, a *Completely Randomized Design* was used. Since it only uses two basic principles, randomization and replication, the completely randomized design (CRD) remains the simplest design for comparative experiments. I was initially developed for agricultural experiments (Salkind, 2010).

Research Site

The study was carried out at Libacao National Forestry Vocational High School, Poblacion, Libacao, Aklan. Commercially available and organically grown plants were used in the study. Organic fertilizers were used to grow said plants. No artificially created fertilizers and pesticides were used in growing the said plants.

Participants

Thirty-nine (39) students with informed consent were asked to assist in the application of the treatments and in documenting the testing process.

Instrumentation

The current study was conducted using the following steps:

A. Materials

The materials, tools, and equipment that were used in the conduct of this study are as follows:

Plant materials (garlic, bay leaf, eucalyptus, and peppermint)		
Cornstarch	Water	Wax paper
Masking tape	Cardboard	Weighing scale
Stirrer	Beaker	Knife
Oven	Mortar and pestle/coffee grinder	
Empty cartons	Android Phone	

B. Methods

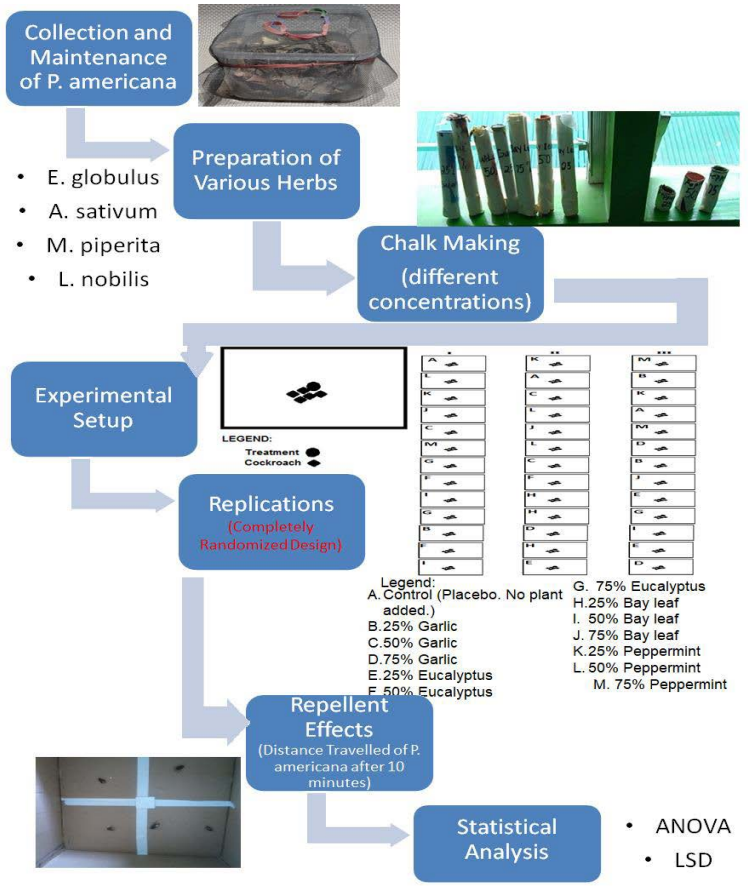

Figure 1. Process Flowchart

C. Collection and Maintenance of *P. americana*

For the present studies, *P. americana,* of both sexes were trapped and collected at work, at home, street, and other buildings. The male abdomen contains asymmetrical genitalia, epiprocts and cerci like the female, and below the cerci one or two thin appendages called styles that retain in adult from those found in the nymphal stages of both sexes; the female abdomen contains the small

ovipositor valves concealed beneath tergum 10 (the 10th dorsal segment) inside a genital atrium (Gullan, et al., 2005).

Picture 1 & 2. Identifying the adult male (Left) and female (Right) P. americana

Their habitat was created to simulate a favorable condition for them to thrive. They can be found in abundance in dark, damp areas. They need access to water and food. These were the criteria needed in making their container. In the habitat, the roaches were acclimatized in the container with dimensions 20×10×15 inches for 30 days before the start of the experiment. Food and water were provided ad libitum. Food consists of cracker, noodles, rice, water, and cabbages. After acclimatization, the healthy and mature roaches of both sexes were randomly selected by an entomologist from Aklan State University.

Cockroaches are hemimetabolous insects with three stages of development: egg, nymph, and adult. The egg stage for American cockroaches lasts about six to eight weeks, while Oriental cockroaches hatch in approximately 60 days (Brown, Merchant, & Gold 2012).

D. Preparation of Raw Materials

The plants were taken from a nursery at Libacao National Forestry Vocational High School. These were ensured that the plants are of the same age during the time of collection. Garlic cloves were peeled, sliced thinly and dried in an oven. The garlic was then turned into powder using a coffee grinder. The leaves of bay leaf, eucalyptus and peppermint were washed thoroughly and dried under the sun or in an oven. These were then pulverized using a coffee grinder and a mortar and pestle.

E. Chalk Making

Molds made from cardboard lined with the wax paper were used to contain the chalk. Equal amounts of cornstarch and water are mixed to create the chalk.

Each of the plants was prepared in three concentrations (25, 50, and 75%). That is, for 25% concentration, 25grams of the powdered plant is mixed in 75grams of the cornstarch-water mix. Pure chalk, made from just the cornstarch and water solution, was also created which served as the control in this study. A total of thirteen preparations were made.

F. Treatment

Three different concentrations of each plant, that is, 25, 50, and 75%, were tested against a placebo (chalk only). The placebo served as the control in this study. The plants used are bay leaf, garlic, eucalyptus, and peppermint. Five cockroaches were tested to each plant preparation and the control.

G. Experimental Setup

Thirty-nine (39) laboratory pens of size 100×100×40 cm were used in the experiment. Each pen was cleaned properly taking into consideration that no trace of any smell remains in them. The treatment was placed at the center of each pen. The cockroaches were placed in a receptacle just beside the treatment. A student was assigned to each pen. The student took a picture of the pen after 10 minutes to determine the distance traveled by the cockroaches. Here is the schematic diagram of the setup:

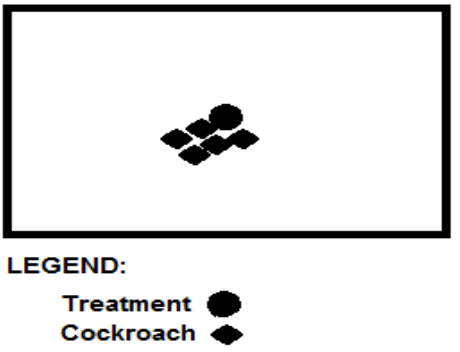

Figure 2. Schematic diagram of the experimental set-up.

H. Replications/Trials

Each treatment was collected in three trials. The experiment was done simultaneously in all 39 pens. Here is the laboratory layout of the experiment

arranged in a completely randomized design with thirteen (13) treatments and three (3) replications.

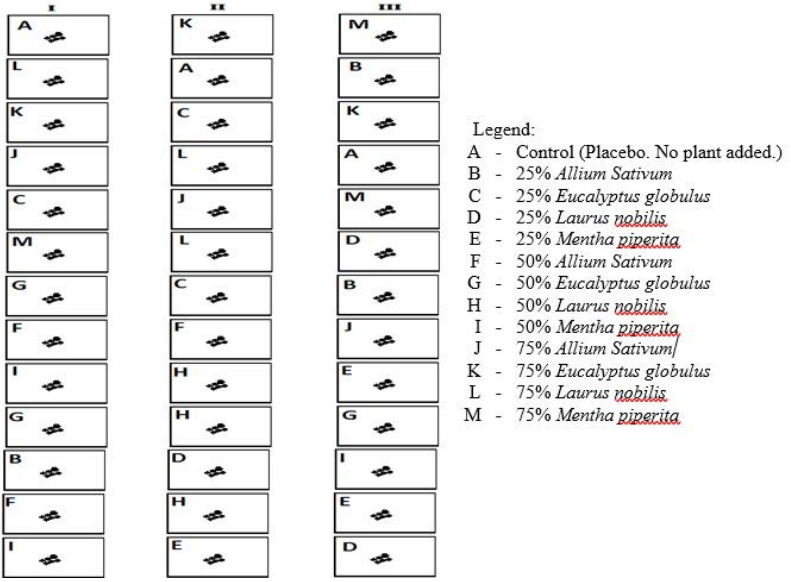

Figure 3. Replications.

Research Ethics Protocol

Intel ISEF (Intel International Science and Engineering Fair) Forms were prepared prior to the conduct of the study. An entomologist guided the selection process of the target insect. A chemist helped in the formulation of the plant-based repellents.

Data Collection

Repellent effect of the plants was assessed based on the distance traveled by the cockroaches from the chalk as well as the duration of its repulsion. The distance was measured in centimeters after 10 minutes of exposure to repellents. The mean of the distances traveled by all cockroaches will be taken in every pen Qualitative observation was to be noted each day to determine the duration of repellent effects to cockroaches. Once the repellents are already observed with cockroaches crawling on it, then that will be the basis of the researchers that the repellents have fully exhausted its effects.

Statistical Techniques

Values were determined and analyzed through One-Way ANOVA (Analysis of Variance). One-way ANOVA is a technique that generalizes the two-sample t-test to three or more samples (Heiberger & Neuwirth, 2009). The Analysis of Variance is a statistical tool which assesses significant differences in a scale-level dependent variable by a nominal-level variable with two or more categories. In this study, the independent variables are the plant preparations while the dependent variable is the distance traveled by the cockroaches after 10 minutes. After yielding a significant difference in the results, a post hoc test, Fisher's least significant difference (LSD) method for multiple comparisons was used to determine which pair of values have significant differences.

RESULTS AND DISCUSSION

Chalk Formation

Upon finishing the chalk making procedures, the researcher was able to confirm that all the plants (bay leaf, garlic, peppermint, eucalyptus) and their concentrations (25%, 50%, 75%) formed a functional chalk—that is, the chalk is solid enough to hold on to and is able to write on surfaces. The chalk's consistency and stability are highly dependent on the balance between the amount of solute (plant powder and cornstarch) and solvent (water). Mixing also affects the products' consistency and appearance. These considerations were taken into account when creating the products to ensure the proper distribution of the plant materials in the chalk solution. Using trial and error, a total of thirteen chalks, including the control, were created.

Picture 3. Drying of the chalk repellents.

Picture 4. A sample of the finished product.

Repellent Effect

As observed during the experiment, all preparations, except the control were able to repel the cockroaches using three trials.

Picture 5. Cockroaches are repelled by a sample treatment.

The distance of Repulsion in All Chalk Repellents

Table 1. Mean Distance (cm) of Repulsion Traveled by the *P. Americana* After 10 Minutes as Applied with Treatments.

Repellents	Mean Distance of Repulsion *
(M) 75% *Mentha piperita*	80.67[a]
(I) 50% *Menthapiperita*	68.17[ab]
(K) 75% *Eucalyptusglobulus*	54.00[abc]
(G) 50% *Eucalyptusglobulus*	44.65[bc]
(L) 75% *Laurusnobilis*	34.33[cd]
(H) 50% *Laurusnobilis*	31.50[cde]
(J) 75% *AlliumSativum*)	17.50[def]
(D) 25% *Laurusnobilis*	15.50[def]
(F) 50% *AlliumSativum*	14.67[def]
(C) 25% *Eucalyptusglobulus*	14.33[def]
(E) 25% *Menthapiperita*	13.00[def]
(B) 25% *AlliumSativum*	6.83[ef]
(A) Control (Placebo)	2.33[f]

**significant at 5% level; p-value=0.000; LSD=27.35*
***Means with common letters are not significantly different at 5% level by LSD: M vs L = not significant; M vs A = significant*

The analysis of variance showed that means are significantly different at 5% level which can be interpreted that the distance of repulsion of cockroaches after 10 minutes of exposure to plant repellents are comparable to each other as well as to the control. The 75% *Mentha piperita* has the highest distance of *P. americana* repulsion. It is closely followed by the 50% *Mentha piperita* and 75% *Eucalyptus globulus.* These three repellents have no significant difference in terms of distance of repulsion. We can see that the control has the lowest distance of repulsion, but that is expected as it doesn't contain any plant repellent. Thus, the plant repellent with the lowest distance of repulsion is the 25% *Allium sativum.*

Based on this result, we can see that 75 percent of *Mentha piperita* preparation has the highest repulsion mean based on three trials. This plant repellent has no significant difference against the 50% *Mentha piperita* and 75% *Eucalyptus globulus.*

It is noted that all the subject plants have similar particular characteristic—all of them have an aromatic smell. The chemical analysis of the active ingredients of these plant repellents responsible for their aromatic smell revealed the following results. The *E. globulus* has high components of compounds p-menthane-3, 8-diol and eucamol which are perceived by *P. americana* as hazardous. A study conducted by Thomas (2011) stated that this component might also be at par with the n-n-diethyl netatoluamide (DEET)—the active ingredient of commercially prepared repellents. The *M. piperita,* on the other hand, has a high menthol content. This plant also contains menthone and carboxyl esters, particularly methyl acetate which give the plant its strong minty aroma which the cockroaches dislike. The *L. nobilis* contains lauric acid, which gives off its strong aroma that has repellent properties. Lastly, the *A. sativum* contains protein molecules that transforms into a chemical called *allicin* after being chopped, crushed or blended. The distinctive smell that is released as a product of this method has a powerful repellent property. Although inconclusive, the garlic preparation may have affected its efficacy since the preparation of the *A. sativum* involves drying of the cloves which diminishes its aromatic smell.

Duration of Repellent Efficacy

All plant preparations repelled the cockroaches as stated in the previous data. A sample pen of each plant preparations were left untouched until such time that cockroaches will crawl naturally over the chalk. The chalk was left overnight. *Most cockroaches have died on the second day*. Those who survived were able to crawl naturally on the plant preparations.

In a study conducted by Bessette, Lindsay & Enan (2003), "insecticidal composition in the control of cockroaches and ants is comprised of a mixture of selected herb essential oils which include 40% benzyl alcohol and 40% peppermint oil with a fit solvent in a solution showed that it is highly effective, as results exhibited fast knockdown and mortality against cockroaches. Thus, although inconclusive, *M. piperita* could also be used as a pesticide aside from being a repellent.

CONCLUSIONS

Pests affect the health and the economy of the country. In household situations, insects act as carriers for allergens and diseases. In this research, the target organisms are the *P. Americana* who are not only scavengers of human food

but also harbingers of diseases. Although commercial pesticides can act as control measures for these arthropods, we can't risk the lives of humans from the side effects of these pesticides. Hence, this study, which is focused on the creation of a handy, economical and edible repellent solves the problem.

From the results above, it is highly recommended that the 75% *Mentha piperita,* 50% *Mentha piperita* and 75% *Eucalyptus globulus* should be used in mass production for plant-based chalk cockroach repellents. It is also noted that the type of plant preparation and chalk formation are independent. The type of plant repellents and its ability to repel *P. americana* have significant relationships. A significant difference was noted between the average distances of repulsion of cockroaches in each plant preparation and the control. Lastly, it is observed that the effects of the repellents vanish on the second day from the time of application.

TRANSLATIONAL RESEARCH

The chalks developed from the research were already undergoing a patenting process. Requirements for Intellectual Property were already being prepared. It is highly suggested that 75% and 50% *Mentha piperita,* as well as 75% *Eucalyptus globulus* should be manufactured for commercial production based on the results of this study. A brochure on the creation process and effects of the repellents are also underway and will be recommended to DOH, DENR, and DA for mass production.

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