A COMPARATIVE STUDY ON THE DIRECT CONTACT AND FUMIGANT TOXICITY OF *Zingiber officinale* AND *Allium sativum* on *Culex pipiens quinquefasciatus*

by

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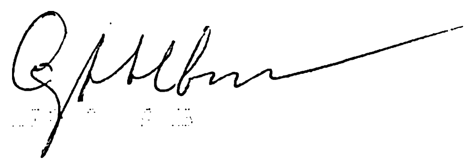

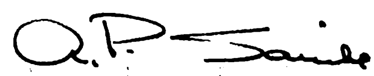

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ABSTRACT

Extracts were obtained from *Z. officinale* rhizomes and *A. sativum* cloves. Direct contact of both extracts was tested on *Culex pipiens quinquefasciatus* using 25%, 50%, and 75% concentrations, through spraying. Each treatment was conducted in triplicate. Mortality rates were compared with those obtained from control set-ups containing pure distilled water and subjected to the chi-square test. Results indicated that both extracts were toxic to the test insects, and that *Z. officinale* brought about quicker mortality than *A. sativum*. Mortality rates were also observed to increase with a corresponding increase in extract concentration (*Z. officinale* 75% 50% 25% ; *A. sativum* - 75% 50% > 25%). The order of degree of toxicity from the greatest to the least is as follows: 75% *Z. officinale* 75% *A. sativum* 50% *Z. officinale* 50% *A. satvum* 25% *Z. officinale* 25% *A. sativum*.

Fumigant toxicity was tested using concentrations proven to be most effective in the first part of the study and by placing a screen divider between the test insects and the extracts. Fumigant toxicity was proven positive for both, but to a lesser extent as compared to direct contact toxicity. Again, *Z. officinale* was proven to be more toxic than *A. sativum*.

It was therefore determined that *Z. officinale* was more effective than *A. sativum* in terms of both direct contact and fumigant toxicity.

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A COMPARATIVE STUDY ON THE DIRECT CONTACT AND FUMIGANT TOXICITY OF *Zingiber officinale* AND *Allium sativum* ON *Culex pipiens quinquefasciatus*

I. Introduction

The use of pesticides by man stems from two major problems encountered by him throughout history concerning pests. The first is concerned with the fact that pests pose a major threat to the sources of his food supply, and the second is that they are a direct danger to his life because of the diseases they transmit. This study will limit its scope to the latter.

Mosquitoes belong to the most medically significant taxonomic order (Order Diptera) among all arthropods. They are now known to be the vectors of a number of serious diseases such as malaria, filariasis, yellow fever, dengue fever, and others. They are also responsible for the transmission of many parasitic infections and arboviral (arthropod-borne viral) diseases. The prevalence of the above-mentioned diseases have been well-documented in recent years and it is the consensus of experts that these mosquito-borne diseases have become a significant problem to public health worldwide. These facts, thus, underscore the need for further research regarding this topic.

It has long been the practice of people all over the world to use conventional insecticides in mosquito eradiction efforts. Conventional or traditional insecticides are the ones which are chemically manufactured or, more specifically, synthetic in nature. Although the use of these insecticides have been relatively successful in the past, their employment in insect pest control poses a number of problems, the two major ones being: a) They are inherently toxic to man and other non-target organisms, thus they are detrimental to the ecological set-up of nature, and b) their manufacture in the Third World setting (such as in the Philippines) may not be viable either in the economic or technological sense.

It is in this light that this study will attempt to analyze the efficacy of extracts from plants readily available locally as insecticides and to determine the practicability of their use as a substitute for conventional insecticides.

Potentially, the use of plant extracts as insecticides pose a number of advantages not offered by conventional insecticides. First of all, since they are derived from plants, they are much less toxic. As a result, they are less hazardous to man and other non-target organisms. Also, since they are organic in nature, they are biodegradable, thus they do not endanger the ecological balance of nature. Secondly, the economical and technological problems encountered in the processing of conventional insecticides are not of particular consequence in the manufacture of plant extract insecticides. This is because the raw materials needed are available locally at minimal costs, and little technological know-how is needed in their production.

In summary, the use of plant extract insecticides, if proven to be effective, could be nothing but beneficial the average Filipino. By having at his disposal an insecticide with the above-mentioned potential, his efforts to rid himself of the pests which endanger both his subsistence and his life will be given a significant boost.

The objectives of this study are:

1. To analyze, determine and compare the efficacy of extracts of _Zingiber officinale_ and _Allium sativum_ as insecticidal agents on the common night-time mosquito, _Culex pipiens quinquefasciatus_.
2. To determine if they are indeed suitable substitutes to the more conventional insecticides presently being widely used.

II. Review of Literature

In recent years, the problems concerned with the relationship of a number of diseases and their respective insect carriers have been put into sharp focus. Of particular interest is the group of insects belonging to the order Diptera (Yap, 1989). Included in this order are flies and mosquitoes. The diseases transmitted by those insects are considered to be the more serious ones, thus their significance public health cannot be over emphasized.

A mosquito is an insect classified under the family Culicidae. The most widely known characteristic of mosquitoes is their habit of sucking blood from either man or animals both. It is through this feeding habit of the mosquito that it is able to contract and transmit the diseases which they are known to carry (Yap, 1989).

As mentioned earlier, mosquitoes belong to the order Diptera meaning having "two wings". Insects belonging to this order actually have four wings but the hind wings are greatly reduced forming halteres which are slender knoblike organs for balancing (Salazar, 1979). The head of the mosquito is roughly spherical and it is almost entirely covered by a pair of compound eyes that nearly meet at the center. The mouth parts are composed of the following: labrum epipharynx, mandibles, maxillae, hypopharynx, labium, and labellum. Skin penetration during feeding is accomplished by the mandibles and maxillae. Actual bloodsucking is performed by the labrum epipharynx and the hypopharynx. The two mandibles, maxillae, hypopharynx, and labrum epipharynx are loosely ensheathed in the elongated labium which has a lobe-like tip called the labella. The thorax is of particular taxonomic importance since the scutellum is used to distinguish between the Subfamilies Culicidae (Aedes and Culex) and Anophelidae

(Anopheles). The abdomen consists of ten segments although only the last two segments become externally visible. The ninth and tenth segments are modified to become external reproductive organs; in males, upom hatching from the pupa, the segments undergo a 180 degree rotation to become claspers. Culicine mosquitoes have abdomens that contain many bristles, hairs, or scales; while Anophelines are either bare or possess very few bristles , hairs, or scales. The thread-like antennae of males have generally more bristles as compared to that of females (Yap, 1989).

Adult mosquitoes (both male and female) feed on nectar and fruit juices (Salazar, 1979). It is only the females which suck blood from man and other animals since blood induces the formation of gonadotrophic hormones which trigger ovulation, thus blood is essential to mosquito reproduction (Yap, 1989). Biting activity varies according to the age of the mosquito (mature ones bite more often), the time of day depending on the preference of the mosquito, and environment (they bite more often during the rainy season). Mosquitoes which bite during day-time (Aedes) are different from those which do during night-time (Culex and Anopheles). Certain mosquito species prefer human blood (they are termed anthrophilic) while others prefer animal blood (zoophilic) (Yap, 1989).

Mosquitoes undergo holometabulous development meaning they pass through four stages in their life cycle: egg, larva, pupa, and adult. Larval and pupal stages develop only in water or in rafts of eggs on water (Yap, 1989)

There are three main groups of diseases transmitted by mosquitoes. These are malaria, filariasis , and arboviral diseases. Malaria is carried only by Anopheles mosquitoes, and the [illegible] stage of _Plasmodium_, sporogony, occurs in the mosquito. Filariasis is transmitted either by _Culex_, _Aedes_ or _Anopheles_. The first larval stage of the filarial worm is taken by the mosquito through the blood where it develops [illegible] the third stage larva which is infective to man. Arboviral diseases are classified into three groups namely Systemic Febrile diseases, hemorrhagic fevers, and Encephalatides. Of 181 arboviral diseases analyzed, 131 have been recovered from mosquitoes (WHO, 1967) (Yap, 1959).

The most common mosquito found in the tropical and subtropical regions of the world is _Culex pipiens quinquefasciatus_ (_Culex fatigans_). It is of particular medical importance since it is a probable vector of filariasis and viral encephalitis in the Philippines and other nearby countries. It has a brownish color with uniformly pale wings and basally banded abdominal tergites. It prefers to seek blood at night and it [illegible] anthropophilic. It is domesticated with regards to its reproductive habits since it breeds in any place where there is water like canals and ditches. Their eggs are laid in rafts and are st[illegible] together (Salazar, 1979).

The larvae possess spiracles on the eight abdominal segment which also has siphons which function for respiration, and they lie diagonal or oblique to the water surface. The pupae have long trumpets (also for respiration) and their abdomens are not curved so closely towards the cephalothorax as compared to other species. In the adults, the proboscis and the body form an angle while feeding meaning that the head is bent forward. The maxillary palps of females are one-fifth to one-half times the length of the proboscis (Yap, 1989).

<u>Culex pipiens quinquefasciatus</u> will be the test insect to be used in this study because first of all, they are readily available in large numbers (<u>C. pipiens quinquefasciatus</u> is the common night-time mosquito found all over Metro Manila).

The fact that it is the mosquito which bites people in Metro Manila more frequently makes its study of particular significance

The degree of importance by which insects affect public health is illustrated by the fact that four of the six quarantinable diseases recognized internationally are insect transmitted (Salazar, 1979). The vast number of people being afflicted anually by insect-borne diseases gives an indication as to how seriously insect-pest control programs should be given attention. It is in this light that the importance of insecticides to modern man is clearly shown.

A pesticide is defined officially by Presidential Decree 1144 promulgated on May 30, 1977 as "any substance or product, or mixture thereof, including active ingredients , adjuvants, and pesticide formulations intended to control, prevent, destroy, repel or mitigate, directly or indirectly, any pest". This term includes insecticides, fungicides, herbicides, rodenticides, nematocides, molluscicides, and a host of other materials directed against insect pests (Magallona, 1980).

Organochlorine insecticides constitute the more commonly used insecticides being utilized worldwide. Representatives of this group include DDT, chlordane, aldrin, endosulfan, and heptachlor (Vettorazzi, 1979). Their characteristics include a high stability as compared to other insecticides, lower water solubility, and a wider spectrum of insecticidal activity.

Organophosphate insecticides are esters of phosphoric acid and phosphorothioic acid. They constitute the largest group of insecticides at present. They show a diversity of biological activity and stability (Vettorazzi, 1979). Some of them are highly toxic like parathion which could be fatal even if only a few drops are ingested (Hayes, 1982), while some are relatively very weakly toxic like malathion. They are not as stable as the organochlorines and they are comparatively highly reactive (Vettorazzi, 1979).

The above-mentioned insecticide groups constitute the more traditional or conventional insecticides being used in the country. As mentioned earlier, these conventional insecticides are synthetic compounds which are chemically manufactured.

Despite its advantages, the use of conventional insecticides brings with a number of drawbacks, a fact which has made their use controversial in the ecological sense in recent years. These include the inherent toxicity of insecticides to man and other non-target organisms, and its potential to create negative ecological repercussions (Magallona, 1981).

Ideally, an insecticide should be toxic only to a particular insect pest against which it is directed. This is not the case however since all insecticides are toxic to all animals including man. Unfortunately, in one way or another, the use of insecticides necessarily means that they come into contact with or are handled by people. There have been a number of cases reported wherein people involved in the manufacture or handling of insecticides developed disorders due to their contact with these toxic chemicals (Hayes, 1982). The other important drawback of conventional insecticide use is that it has the potential to bring about ecologic disruption. This is defined by Magallona (1981) as the destruction or disturbance, usually permanent or for a considerable time, of the checks and balances in an ecosystem. Among the ecologically disruptive side-effects of conventional insecticides are pest-succession, effects on non-target organisms and the development of resistance of pests to the broad acting insecticides. Pest succession occurs when a formerly minor pest becomes a major pest due to insecticide use. The effects on non-target organisms could be expected since, as mentioned earlier, insecticides are not only to a particular group of target pests, but to animals it which comes into contact with as well. The World Health Organization Expert Committee on Vector Biology (1979) has defined the term "resistance" as "the ability of a strain to tolerate doses of a toxicant which prove lethal to the majority of individuals in a normal population of the same species".

In view of the above, the aim of present day researches regarding insecticides is to minimize if not totally eliminate the above-mentioned problems. It is in observance of this fact that this study will attempt to determine the viability of using extracts from two plants available in the country as substitutes for conventional insecticides.

A number of studies and experiments have already been made concerning insecticidal properties of different plants such as the one involving the insecticidal activities of Philippine plants (Alberto, 1953). In the investigation, ten local plants were analyzed for their insecticidal properties using different methods. It was found out that a number of the plants showed exhibited promising toxic properties. Other studies were also made with <u>Derris philippinensis</u> (Magsanoy, 1975) and with aromatic anise (Marcus, 1979). Both yielded significant results in which the plants' extracts [illegible] highly [illegible] to insect species used. In the latter, the type of action used [illegible] contact poisoning and fumigant toxicity. Contact poisons are applied directly to the insects and fumigants are applied as gases or in a form which rapi[illegible] gas to be inhaled by the insect. The inherent advantage of insecticides derived from plants is that they are significantly less toxic to non-target organisms as compared to other insecticide types. Since they are not so toxic to man and other vertebrates, then it follows that their application or use is not limited by the toxicity problem. A predicament presently being encountered by insecticide manufacturers is the fact that present day insecticides are gradually becoming less and less effecti[illegible] due to the development of resistance of the target insects to the said insecticides. Thus there is a need to develop new insecticide formulations, but then the costs of research are quite steep. Plant extract insecticides could prove [illegible] to useful with regards to this since little technological know-how is needed in extracting and testing these insecticides. Since plant extract insecticides are considerably less expensive than conventional ones and are more readily available, then their use will prove to be beneficial to the ordinary Filipino since disease prevention efforts will be enhanced.

This study will attempt to determine and analyze the potential insecticidal properties of extracts of two of the most plants being used as spices in the country. These are _Zingiber officinale_; or what is commonly known as ginger or luya, and _Allium sativum_ otherwise known as garlic bawang.

Z. officinale is an erect, smooth plant rising from thickened, very aromatic rootstocks. The leafy stems are 0.4 to meter high, the leaves are distichous, lanceolate, to linear lanceolate, 12 to 25 centimeters long, and covered distant, imbricate bracts. The bracts are ovate, cuspidate, about 2.5 centimeters long, and pale-green. The calyx is centimeter long or less, the corolla is greenish yellow, and its tube is less than 2 centimeters long while the lip is oblong-obovate and slightly purplish (Quisumbing, 1978).

Nadkarni states that ginger extract has the following constituents: an aromatic, volatile oil (0.25-3%) containing camphene, phellandrene, zingiberene, cineol, and borneol; gingerol, a yellow, pungent body; an oleoresin, gingerin, other resins; and starch. Read also mentions the presence of singerine, zingiberol, citral, linalool, geraniol, chevicol, vanillyl alcohol, caprylic acid, methyl heptenon, pelargon aldehyde and malate (Quisumbing, 1978).

Allium sativum is an herb measuring 30 to 60 centimeters high and the true stems are greatly reduced. The bulbs are broadly ovoid, 2 to 4 centimeters in diameter and consist of [illegible] densely crowded, angular, truncated tubers. The leaves [illegible] and flat and the umbels are globose, nearly [illegible] bul[illegible] and with many flowers. The sepals are [illegible], greenish-white, or more or less tinged with purple. The stamens are not exerted from the perianth (Quisumbing, 1978).

These two plants were chosen as subjects for this study mainly because of the fact that they are readily available locally and they are relatively inexpensive. This is in keeping with another objective of this study which is to find a cheaper, safer, and more practical alternative to the use of conventional insecticides.

III. Methodology

A. Preparation of ginger and garlic extract

The ginger and garlic extract used in this study were prepared in the same manner. In the case of ginger [illegible] was the crushed rhizomes of the plant which were processed. The pure extract was prepared by first slicing the ginger [illegible] into small cubes which were then put in an osterize for around two minutes. The resulting crushed ginger rhizomes were strained through a fine-meshed stocking and the resulting fluid extract collected in a flask. Solutions 25%, 50%, 75% ginger extract solution were then made by combining the 100% ginger extract with the corresponding amount of distilled water. In the case of garlic, the cloves of the bulb were utilized. The cloves were macerated as was done of the ginger rhizomes. The various concentrations of garlic extract (25%, 50%, 75%) were prepared in the same way the ginger extracts were processed.

B. Cultivation/rearing of test insects

The *Culex* mosquitoes used in this study were obtained from the Parasitology Department of the College of Public Health. Eggs, larvae, and pupae of the mosquitoes were collected from a swampy area inside the Philippine General Hospital compound. The test insects were grown to maturity inside a 40x 40 x 40 centimeter breeding cage with an opening on one side. The mosquitoes were fed by means of a wad of cotton soaked in 5% sucrose solution.

C. Screening for insecticidal activity.

1. Direct (contact) toxicity

a. This part of the study tested the direct contact insecticidal activity of the various concentrations (25%, 50%, 75%) of both ginger and garlic. The test was conducted in triplicate for each concentration of each of the plant extract. Thus 10 identical set-ups were prepared. Each set-up was composed of an 8 ounce plastic cup covered with fine-meshed stocking material. The mosquitoes were then allowed to enter each cup.

b. Three additional set-ups were prepared to serve as con[illegible] these set-ups, pure distilled water was used.

[illegible] concentrations of each of the extract and [illegible] water were applied by means of a fine mist [illegible]. The solutions were sprayed three times directly [illegible] the plastic cup set-ups.

d. The rate of mortality was determined by counting the number [illegible] mosquitoes dead at 15 minute intervals for 2 hours. The mortality rates exhibited during that range in time were tabulated. Being independent variables, the mortality rates were expected to be similar for each concentration of plant extracts since the conditions under which the mosquitoes were subjected were identical.

e. All these were done in the same location and at the same time so as to avoid or minimize variations between the extraneous variables.

2 Fumigant activity

The set-up prepared for this part of the study were identical to those in the first part. The plant ext[illegible] solutions however, were not sprayed directly at the mosquitoes. Instead, the various plant extract concentrations were placed in a plastic cup and the set-ups containing the mosquitoes were put directly on top in an inverted position so [illegible] to allow the fumes originating from the extracts to reach the mosquitoes without the two coming into contact with each other. [illegible] this way, the fumigant toxicity of the samples were [illegible] ed. The concentrations used in this test were [illegible] ed to [illegible] the ones which proved to be the most effective among the concentrations for each type tested in the first [illegible] of the study. Again, the test was conducted in triplicate and a control set-up containing pure distilled water was prepared also in triplicate.

D. Statistical analysis

The chi square test was applied in this study for determining the significance of the mortalities obtained in both the direct contact and fumigant activity tests. The mean of each of the triplicates was obtained and these were designated the observed values. The mortalities in the control set-ups were designated the expected results. The null hypothesis formulated was that there was no significant difference between the observed and the expected mortalities.

IV. Results

<u>Zingiber officinale</u>, after being osterized, and the resulting pulp pressed, yielded a golden brown translucent liquid with an aromatic odor. <u>Allium sativum</u>, after being subjected to the same procedure, yielded a more opaque, light

yellow liquid markedly more viscous than the *Z. officinale* extract.

The data gathered in determining direct contact toxicity indicated that all the concentrations of both *Z. officinale* and *A. sativum* exhibited positive insecticidal properties and the [illegible] rates obtained for these were significantly greater than the ones observed in the control [illegible]. It was also noted that the mortality rates brought about by the *Z. officinale* extracts were more rapid than those resulting from the *A. sativum* extracts. It could also be observed that the mortality rates proceeded at a faster rate with an increase in concentration of both *Z. officinale* and *A sativum* extracts. (see Table I and 2 for mortality data) In the determination of the fumigant toxicity of both *Z. officinale* and *A. sativum*, positive results were again obtained. The resulting mortality rates caused by both extracts were again significantly greater than those brought about by the distilled water set-ups used as control. However, the differences were not as great as those observed in the direct contact toxicity test. (see Table 3 for mortality data).

The treated mosquitoes exhibited initial hyperactivity followed by convulsive and uncoordinated movements. Paralysis and death ensued afterwards.

Statistical analysis using the chi-square test showed that the computed chi-square values at 0.05 level are [illegible] and as the degree of freedom for all of the [illegible] were still higher than the tabulated value of [illegible] leading to the conclusion that the null hypothesis that there is [illegible] significant difference between the [illegible] expected mortalities should be rejected (refer Appendix A [illegible] statistical computations).

V. Discussion

As [illegible] by the results gathered from the study [illegible] both *Z. officinale* and *A. sativum* possess inherent [illegible] properties which point out that they do indeed have potential as insecticides. It was also gathered that *Z. officinale* had a greater effectivity as an insecticide as [illegible] to *A. sativum* [illegible] terms of the amount of time it took for [illegible] test insect mortality to be reached. Faster mortality rates were observed in the *Z. officinale* set-ups as compared to those of the *A. sativum* set-ups.

A conclusion which is indicated by the data gathered [illegible] this study is that both *Z. officinale* and *A. sativum* contain amounts of certain insecticidal reagents. The isolation and identification of these specific substances were not carried out in this study, however [illegible] is merely [illegible] establish the fact that both *Z. officinale* and *A. sativum* have potentials as insecticides, and [illegible]

[illegible] effectivity with each other. Also, such isolations and identifications of the said active constituents entail [illegible] not possessed by the author and also the use of apparatus which are not readily available, thus it was not feasible to do such.

An important factor which was given due significance before treatment of the test insects was the state of the [illegible] extracts. It was assumed beforehand that the plant extracts are not so chemically stable and certain [illegible] factors (such as sunlight, temperature, etc.) [illegible] cause alterations in their chemical composition. As such [illegible] precautionary measures were taken so as to ensure that the extracts remained fresh. They were stored in bottles tightly covered with tin foil and kept in refrigerator so as to maintain a constant temperature. It was also ensured that the extracts used in the treatment of the test insects did not stand for longer than 24 hours.

Due care was also taken in the transfer of the mosquitoes from the culture cage to the plastic cup set-ups since they are quite sensitive to improper handling. By ensuring that the test insects used in the study are injury-free, the risks of external factors affecting the resulting mortality rate was reduced.

Dilutions of the extracts applied to the test insects were randomly chosen to be 25%, 50%, and 75% solutions of the extracts. The highest concentration used was 75% because [illegible] the fact that higher concentrations of the extracts were too viscous, thus they could not be applied by means of spraying [illegible] finemist atomizer.

[illegible] number of insects are more susceptible to insecticides [illegible] [illegible] time of day. To prevent this factor from affecting the mortality rates obtained, application of the test [illegible] [illegible] were done at approximately the same time.

Development of insect resistance to a particular insecticide may also be a factor which could affect the subsequent results. Thus, mosquitoes originating from an area where it is exposed to a greater extent to a particular insecticide may be more resistant to that insecticide than those living in another area. This is not a particular problem, however, in this study, since all the test insects utilized were taken from the same source.

As mentioned earlier, the insecticidal properties of both _Z. officinale_ and _A. sativum_ have been established [illegible] this study. The results showed that the mortality rates in all the garlic and ginger set-ups were significantly greater that those in the control set-ups, thus indicating that [illegible] extracts of both plants are indeed toxic to the test [illegible] It could also be seen that the efficacy of _Z. officinale_ was greater than that of _A. sativum_ if the amount [illegible] time for mortality to be achieved is taken into consideration. A number of factors could be responsible for this differential [illegible] rates.

The possible factor why the _Z. officinale_ extract brought about [illegible] mortality rates is that they were noted [illegible] cantly less viscous than the _A. sativum_ extracts. A [illegible] implication of this fact is that since the ginger extracts were more fluid, then their rates of diffusion and subsequent penetration through the exoskeleton [illegible] the layers of the integument of the test insects were significantly faster than that of the garlic extracts. As a result, [illegible] active constituents of the _Z. officinale_ extracts were able to reach the target organs in a shorter span of time thus inducing death at [illegible] faster rate.

[illegible] factor which could have been a marked influence in the [illegible] that the _Z. officinale_ extracts induced [illegible] the test insects as compared to the _A. sativum_ extracts is that the active components of the former may be significantly more toxic to the mosquitoes than those found in the latter. This fact could not be [illegible] verified [illegible] thoroughly however, since, as mentioned earlier, the identification of these active constituents is beyond the scope of this study.

With regards to the fumigant activity of the two types of extracts, the data gathered showed positive results [illegible] since that the mortalities observed were significantly higher than those of the control set-ups. This indicates that the [illegible] of both extracts are volatile [illegible] significant extent so as to bring about death in the test insects. It should be noted, though, that the number of deaths were lower and the mortality rate was slower if compared [illegible] the results of the first part of the study wherein the [illegible] [illegible] concentrations of the extracts were directly applied through spraying. This could be explained by [illegible] fact that less amounts of the toxic constituents of the [illegible] [illegible] [illegible] able to reach the test insects.

[illegible] noted that there was a difference in the [illegible] [illegible] brought about by the Z. officinale and the A. sativum [illegible] extracts, with the former being higher. A possible [illegible] [illegible] this result is that, since Z. officinale is less viscous, then [illegible] follows that it has a higher vapor pressure, a characteristic which enables it [illegible] diffuse through air [illegible] a quicker pace. Thus more amounts of the active constituents of the ginger extract were able to reach the mosquitoes tested in a shorter span of time.

A significant observation is that although the two types of extracts tested may not be too effective for [illegible] as fumigant type of insecticides, they may possess [illegible] properties. It was noted that the mosquitoes tested [illegible] such [illegible] way that they avoided the source of the fumigant [illegible] this case were the ginger and garlic extracts.

VI. Summary and Conclusion

Various dilutions of _Z. officinale_ and _A. sativum_ extracts were tested with regards to their insecticidal potentials using _Culex pipiens quinquefasciatus_ as the test garden. Two types of tests were conducted namely direct contact toxicity of the extracts and their fumiganSt action. [illegible] results indicate that both extracts indeed have [illegible] properties with the degree of toxicity [illegible] a corresponding increase in the extract concentration. Furthermore, it was determined that _Z. officinale_ has a higher degree of toxicity than _A. sativum_ since its extracts were able to bring about faster mortality in the insects.

It could therefore be concluded that the objective this study to prove that _Z. officinale_ and _A. sativum_ could be feasibly utilized as direct contact toxicants and fumigants on mosquitoes was achieved as proven by the data gathered.

VII. Recommendations

These further studies are suggested:

1. isolation and identification of the active components of _Zingiber officinale_ and _Allium sativum_ extracts.
2. testing of _Zingiber officinale_ and _Allium sativum_ extracts

other insects of medical and economic importance to man.

3. A more direct investigation of the mode of action of the active components of the two extracts with regards to insecticidal applications.

[illegible] [illegible]icidal action of *Z. officinale* and *Allium sativum* extracts on *Culex pipiens quinquefasciatus*, it is [illegible] suggested that a study be made on their economic [illegible] their use on a wider scale. Also, investigation should also be made on the insect repellent properties on both extracts.

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TABLE 1: *Allium sativum* Direct Contact Toxicity

(%)		time(min) 15	30	45	60	75	90	105	120
25	(t1)	2	2	3	3	3	3	5	5
	(t2)	2	2	3	3	4	4	4	4
	(t3)	3	3	4	4	4	4	4	4
50	(t1)	2	[illegible]	4	4	4	5	5	6
	(t2)	4	4	5	5	6	7	8	8
	(t3)	2	2	3	3	5	6	7	7
75	(t1)	3	5	6	6	8	8	8	9
	(t2)	3	4	4	4	7	7	7	8
	(t3)	4	6	6	8	8	9	10	10

TABLE 2: *Zingiber officinale* Direct Contact Toxicity
Mortality Rate

Conc. (%)		time(min) 15	30	45	60	75	90	105	120
25	(t1)	3	4	5	5	5	5	5	6
	(t2)	1	2	2	2	2	2	4	5
	(t3)	2	3	3	3	3	4	5	[illegible]
50	(t1)	3	4	5	6	7	7	7	8
	(t2)	2	6	6	7	7	9	9	9
	(t3)	3	4	6	6	7	7	[illegible]	7
75	(t1)	2	3	4	6	8	9	10	10
	(t2)	2	4	5	5	6	8	8	9
	(t3)	4	5	5	5	5	7	9	10

TABLE 3: Fumigant Activity

A. 75% *Zingiber officinale*

Trials	time(min) 15	30	45	60	75	90	105	120
1	2	3	3	5	6	7	7	7
2	2	2	2	4	6	6	6	6
3	3	3	3	3	4	6	6	6

75% *Allium sativum*

Trials	time(min) 15	30	45	60	75	90	105	120
1	2	2	3	4	5	5	5	5
2	2	3	3	3	5	5	6	6
3	2	2	3	3	4	4	4	4

TABLE 4: Distilled Water Control Set-up Mortality Rates

A. Direct Contact through Spraying

Trials	time(min) 15	30	45	60	75	90	105	120
1	0	0	0	1	1	1	2	2
2	0	1	1	1	1	1	1	[illegible]
3	1	1	1	1	1	2	2	2

B Fumigant Action (indirect exposure)

Trials	time(min) 15	30	45	60	75	90	105	120
1	0	0	0	1	1	2	2	2
2	0	1	1	1	1	1	1	1
3	0	0	0	0	0	0	1	1

APPENDIX [illegible] square test computations

[illegible] Toxicity

[illegible]

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
[illegible]		[illegible]7	3.64	13.4	[illegible]
[illegible]		5.[illegible]	3.66	13.4	1.[illegible]
					χ^2 = [illegible]

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
[illegible]	3	1.67	[illegible]33	40.0[illegible]	[illegible].9[illegible]
[illegible]	2	5.33	6.33	40.0[illegible]	20.[illegible]
					χ^2 = 43.77

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
[illegible]		.67	8	64	38.3[illegible]
[illegible]		5.37	8	64	7.[illegible]8
					χ^2 = 46

[illegible]

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
25% dead	3[illegible]	.67	2.66	7.08	2[illegible]
alive	5.47	.37	2.66	7.08	[illegible]
					χ^2 = [illegible]

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
50% dead	7	.67	5.33	28.41	[illegible]7
alive	[illegible]	8.33	5.33	28.41	[illegible]
					χ^2 = [illegible]

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
75% dead	7	1.67	7.33	[illegible]	[illegible]
alive	[illegible]	8.33	7.33	[illegible]	[illegible]
					χ^2 = [illegible]

B. Fumigant Toxicity

1. 75% *Zingiber officinale*

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
dead	6.33	1.33	5	25	18.8
alive	3.67	8.67	5	25	2.9
					$x^2 = 21.7$

2. 75% *Allium sativum*

	O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
dead	5	1.33	3.67	13.47	10.13
alive	5	8.67	3.67	13.47	1.55
					$x^2 = 11.68$

NOTE: The x^2 values computed above were compared with the tabulated chi-square value of 3.84 at .05 level of significance and 1 as the degree of freedom.

Legend:

O = observed mortalities
E = expected mortalities

Plate 1: _Culex_ culture cage

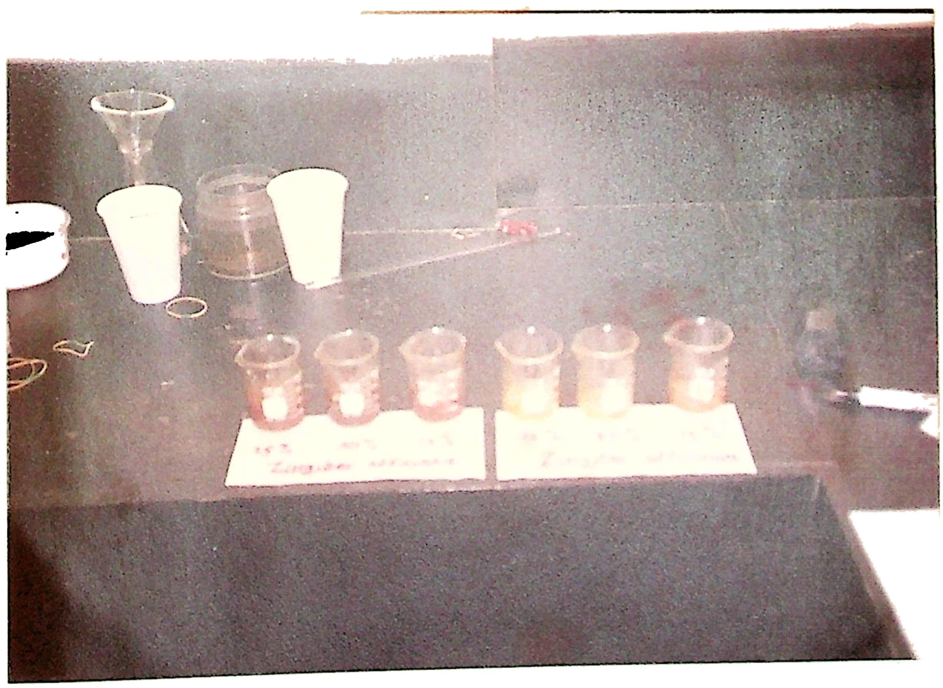

Plate 2: _Zingiber_ _officinale_ and _Allium_ _sativum_ pure extracts

Plate Transferring of test insects from cage to plastic cup set-ups.

Plate 4: Direct contact toxicity test set-up for *Zingiber officinale*

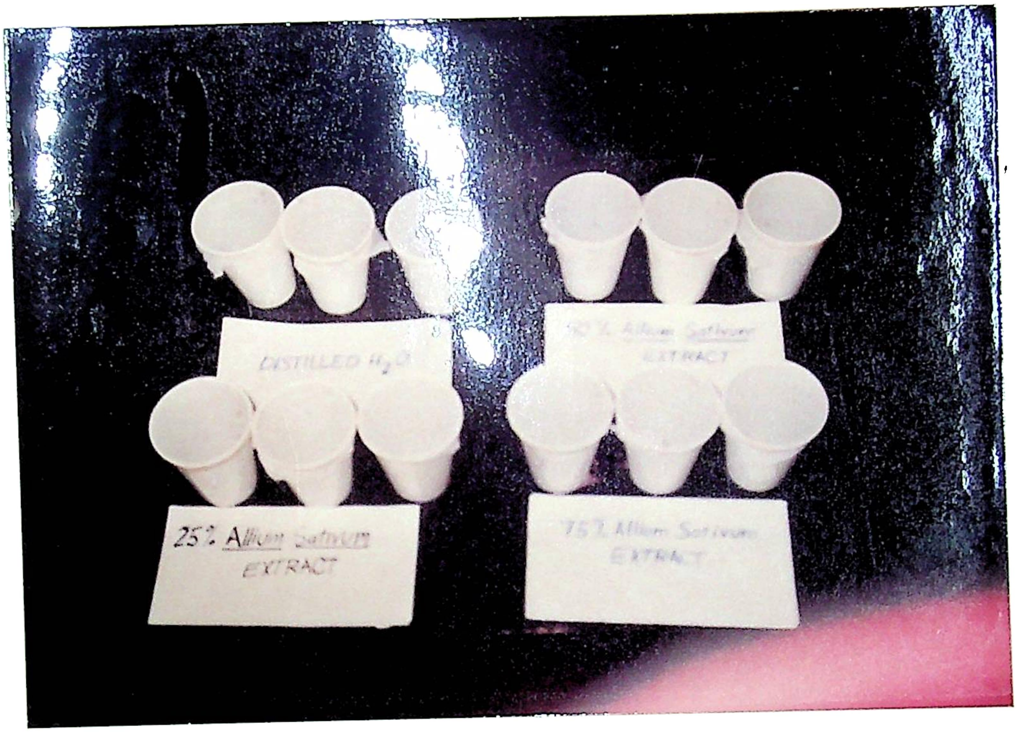

Plate 5: Direct contact toxicity test set-up for *Allium sativum* and distilled water control set-ups

Plate 6: Application of plant extracts for direct contact toxicity test