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Bioactivity of the Leaf and Stem Bark Extracts of Siam Weed (*Chromolaena odorata*) L. on Cowpea seed pest, *Callosobruchus maculatus* Fabricius (Coleoptera: Bruchidae) in Storage

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Abstract: **The use of botanical insecticides as potent alternatives in the control of insect pests of agricultural products have been established. *Chromolaena odorata* is a plant which has both medicinal and insecticidal properties. The leaves and stem barks of this plant were extracted using different solvents namely, methanol, ethanol, water, acetone, pet-ether and n-hexane. The different extracts were evaluated on *C. maculatus* adults for their mortality, oviposition and adult emergence. The effect of the extracts on seed viability was also investigated. The leaves and stem barks were also analysed to know the phytochemicals present. The results obtained showed that the steam distillate of leaves and stem barks of *C. odorata* were most toxic to *C. maculatus* for causing 100 % and 95.75 % respectively within 96 h of exposure. The leaf and the stem bark extracts of the plant effectively reduced oviposition in *C. maculatus*. The percentage adult emergence in the untreated (control) cowpea seeds was significantly higher than emergence in the treated seeds. The Percentage germination of all treated seeds by the 7th day was generally high. The Phytochemical analysis of the leaf of *C. odorata* showed that Tannins, Terpenoid were present in large quantity. While alkaloid, flavonoids, saponins, cardiac glycosides and steroid were present. Phytochemical analysis of the stem bark extract of *C. odorata* showed that alkaloid, tannins, flavonoids, saponins, terpenoid, cardiac glycosides and steroids were present. The results obtained from this study revealed that the extract of *C. odorata* are effective in controlling cowpea storage weevils, *C. maculatus* and could serve as an alternative to synthetic insecticides for the protection of stored cowpeas against *C. maculatus*.**

Keywords: Chromolaena odorata*, *Callosobruchus maculatus **Oviposition, Adult emergence, viability and phytochemicals.**

1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp is a food and animal feed crop grown in semi-arid tropic, which comprises of Africa, Asia, Europe, United State, Central and South America. The high protein content (25%) of cowpea together with vitamins and mineral salts makes the crop an important economic crop in the Sub-Sahara regions like Nigeria. Cowpea is the most important food crop after cereal [1] It is an important staple food and cash crop of significant economic importance in Nigeria and some other countries of the world [2]. It is cheaper than other sources of protein such of protein, such as egg, fish, meet [[3, 4]. Apart from the seeds, the leaves of cowpea are consumed in green form as green vegetable in some Africa countries [5, 6]

Cowpea, being one of the major highly consumed cereal grains in every parts of the world has been suffering different attacks from different species of insects ranging from the beetles to weevils to moths [1, 7, 8]. Valuable grain crops that feeds more than 50% of the world total population annually is being attacked almost incessantly between harvest and consumption by insects such as *Ryzopertha dominica*, *Sitotroga cerealella* , *Sitophilus* oryzae L., *Sitophilus granarius*, as well as *Scirpophaga innotata*, *Callosobruchus maculatus* [10].

Cowpea weevil, *Callosobruchus maculatus* is very popular among other insects that attack cowpea seeds. In most developing countries including Nigeria where the level of literacy among the farmers is still low and government intervention in term of adequate storage facilities provision is minimal, the production and market price of this valuable cereal has dropped steadily over the years [11, 12].

C. maculatus is from the subfamily Bruchinae of beetles, now placed in the family Chrysomelidae. They are Granivores, and typically infest various kinds of seeds or beans, living most of their lives inside a single seed. The family includes about 1,350 species found worldwide. Cowpea weevils are generally compact and oval, with small heads somewhat bent under. Although their mandibles may be elongated, they do not have the long snouts characteristic of true weevils. Adults deposit eggs on seeds, then the larvae chew their way into the seed. When ready to pupate, the larvae typically cut an exit hole, and then return to their feeding chamber [13]. The adults do not require food or water and they spend their limited lifespan (one-two weeks) mating and laying eggs on beans.

Synthetic insecticides are widely used [14] as the control agents of the weevils. Many problems have been faced as a result of the use of synthetic insecticides. Such problems as environmental pollution, ozone layer depletion potential, resistance of pest and affordability by poor-resource farmers. In Nigeria, inexperience and illiteracy have led to the abuse and misuse of these convectional insecticides and these have resulted to several repercussions, such as acute and chronic poisoning, sudden death, blindness, skin irritation and pest resurgence of man [15, 16]. The negative effects posed by the chemical insecticides have led to the need for cheap, effective, biodegradable organic pesticides [17-20].

The use of fumigants and conventional neurotoxic insecticides as grain protectants are unsuccessful in controlling store product pests because of environmental problems such as pollution and mammalian toxicity.

The use of botanical insecticides stand out as a promising alternative for the control of insect pest. This plants are usually affordable, biodegradable and ecologically friendly and readily available [21]. For instance, seeds treated with *Azadirachta indica*, *Vernonia amygdalina*, *Uvaria afzelli* and *Delonix regia* powders and extracts effected 100 % mortality of *C. maculatus* and *Sitophilus zeamais* during storage [22-24].

Chromolaena odorata is a medicinal plant whose insecticidal effect has been proved against *C. maculatus* infesting cowpea seeds [1]. This study, therefore, investigated the insecticidal effect of *C. odorata* against *C. maculatus.*

In Malaysia, where *C. odorata* is an invasive exotic, plant parts are used by traditional practitioners for the treatment of burns, wound healing, skin infections, post-natal wounds, and as an anti-malarial. It has also been reported to possess a,nti-inflammatory, astringent, diuretic, and hepatotropic activities [26]. Since the use of chemicals to control bean weevil and other grain pests have been abused causing possible chaos to humans, this study became important for the need for alternative biological pesticides using dried grinded and chopped *C. odorata* leaves and stems [13]

Plate 1: *Chromolaena odorata* plant

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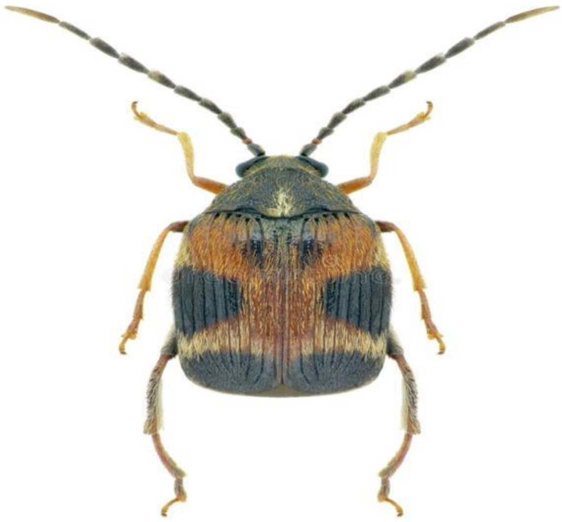

Plate 2: ***Callosobruchus maculatus***

2. MATERIALS AND METHODS

2.1 *Insect rearing*

The cowpea bruchid, *Callosobruchus maculatus* used to establish the insect culture was obtained from naturally infested cowpea seeds from a food store in Olorunsogo Community, Ado Ekiti, Nigeria. The insects were raised under laboratory conditions with a room temperature of 28ºC ± 2ºC and 70 % relative humidity in a transparent plastic container, covered with muslin cloth for six weeks using susceptible clean Ife brown cowpea seeds. The freshly emerged adult (0 - 24 hours old) *C. maculatus* were used for the experiments.

2.2 *Collection and preparation of plant materials*

Fresh leaves and stems of *Chromolaena odorata* were collected from Iworoko road, Ado Ekiti, Nigeria. The leaves and stems were washed in clean water. The water on the leaves and stems were allowed to drain off by placing them in a basket. The leaves and the stem barks were slices into pieces separately and air-dried for 15 and 21 days respectively in the laboratory. When the leaves and the stems were fully dried, they were separately pulverized into fine powders using an electric Binatone blender (Model BLG 400). They were stored in an airtight plastic containers for subsequent use.

2.3 *Preparation of C. odorata leaves and stem barks extracts*

The extractions were carried out separately with the following solvents: methanol, ethanol, water, acetone, pet-ether and n-hexane. Fifty grams (50 g) of the pulverised plant materials were measured separately into beakers and packed in a thimble using muslin cloth and extracted with 250 mL of solvents in a Soxhlet apparatus. In each case, the extraction was carried out within the temperature range of 40–60°C. The steam distillate was obtained by steam distillation method. Excess solvent was recovered using the rotary evaporator vacuum. The resulting extract was concentrated by air-drying to remove traces of the solvent. The extracts were then labelled and stored as stock solution until needed.

2.4 *Effects of C. odorata Leaves and stem barks extract on the mortality of adult C. maculatus*

One millilitre (1.0 mL) of each of the methanol extracts of *C. odorata* leaves and stem barks methanol extract was mixed with 20 g of clean cowpea seeds in a Petri dish. The cowpea seeds were air-dried for 1 h to remove traces of solvents. Afterwards, 20 teneral adult *C. maculatus* were introduced into each Petri dish containing the treated grains. Untreated cowpea seeds were also included in the set up as controls. Similar preparation was set up for *C. odorata* Leaves and stem barks extract extracted with ethanol, water, acetone, pet-ether and n-hexane. Each treatment was replicated four times. Weevil mortalities were observed daily for 4 days at 24 h interval. After every 24 h, the number of dead beetles were counted and recorded. The beetles were confirmed dead when there was no response to probing with sharp pin at the abdomen.

2.5 *Effects of C. odorata leaves and stem barks extract on oviposition and adult emergence of C. maculatus.*

C. odorata leaves and stem barks extract was mixed with 20 g of clean un-infested cowpea seeds at dosage 1.0 mL. The cowpea seeds and extract were thoroughly mixed with a glass rod to ensure uniform coating of the extract and the seeds. The seeds were air-dried for 1 h after which a pair of newly emerged (0-24 h old) adult *C. maculatus* were introduced. A control experiment comprising untreated seeds was also set up. The Petri dishes were covered with Petri plates and left on the shelf for 7 days or until after the death of the insects. The same experiment was repeated using *C. odorata* leaves and stem barks extracted with ethanol, water, acetone, pet-ether and n-hexane. The total number of eggs laid were counted and recorded. The experiment was kept inside the wooden cage for another 35 days to allow for the emergence of the first filial (F1) generation. The number of adults that emerged from each replicate were counted and recorded. The percentage adult emergence was calculated thus: -

$$\text{Percentage adult emergence} = \frac{\text{No of emerged adults x 100}}{\text{Total no of eggs laid}}$$

2.6 *Effect of C. odorata leaves and stem barks extract on the germination of cowpea seeds*

Clean pristine cowpea seeds were first sorted out and disinfested by putting them in a deep freezer for 72 h. The seeds were then removed and air-dried for 1 h in the laboratory, in order to prevent mouldiness. Then, 20 g of the cowpea grains were weighed into transparent plastic containers and 1.0 mL of each of *C. odorata* leaves and stem barks extract was added to the cowpea in each Petri dish and thoroughly mixed with the aid of a glass rod in order to enhance uniform coating. They were left for 1 h to air dry and then covered with muslin clothes to prevent weevil infestation and allow for ventilation. There were four replicates for each solvent extract. The control experiment consisted of samples that were not treated with any of the extracts. Both the treatments and control set up were left in a wooden cage in the laboratory for 60 days. After seven days of germination, the number of germinated seeds in each Petri dish were counted and recorded.

2.7 *Phytochemical Analysis of Chromoleana odorata*

The analysis of the alkaloids, tannins, flavonoids, saponins, terpenoids, and the cardiac glycosides present in the leaves and stem barks of the plant was carried out according to standard methods of [27, 28]

2.7.1 *Alkaloid*

Five millilitres (5 mL) of *C. odorata* leaf powder was measured with a weighing balance and and put in test tubes and two drops of Mayer's reagent were added along the side of the tubes. Then, 1.0 mL portion of the mixture was treated similarly with Dragenduff's reagent. The appearance of a creamy precipitate was an indication of the presence of alkaloids. The same procedure was carried out on the stem bark

2.7.2 *Tannins*

One gram (1.0g) of powdered sample of the *C. odorata* leaf extract was measured and put in a test tube boiled in 20 mL of distilled water in the test tube and filtered. Then, 0.1% FeCL3 was added to the filtered sample and observed for brownish green or a blue-black colouration which shows the presence of tannins

2.7.3 *Flavonoids*

Five grams (5 g) of *C. odorata* leaf extract was measured and put in test tubes and 1 mL of distilled water was used to dissolve in the extracts. Then, 0.5mL of dilute ammonia solution was added to it and concentrated sulphuric acid was added later. A yellow colour indicating the presence of flavonoids was observed. The yellow colour disappeared when the solution was allowed to stand.

2.7.4 *Saponins*

Two grams (2 g) each of *C. odorata* leaf powder was measured and put in test tubes, boiled together with 20 mL of distilled water in a water bath and filtered. Then, 10 mL of the filtered sample was mixed with 5 mL of distilled water in test tubes and this was followed by vigorously shaken to obtain a stable and persistent forth. The frothing was then mixed with 3 drops of olive oil. The formation of emulsion which indicated the presence of saponins was observed.

2.7.5 *Terpenoids*

Twenty milligram (20 mg) of *C. odorata* leaf powder was measured and put in test tubes, dissolved in 1mL of chloroform and 1mL of concentrated sulphuric acid was added to it. A reddish-brown discoloration at the interface showed the presence of terpenoids.

2.7.6 *Steriods*

Twenty millilitres (20 mL) of *C. odorata* leaf powder was dissolved in 1mL of acetic acid following Liberman Burchard and Salkowkiss procedures. A brownish colour and red colour at interference indicated the presence of steroids.

2.7.7 *Cardiac Glycosides*

Twenty millilitres (20 mL) of *C. odorata* leaf powder was measured and in test tubes, dissolved in 1mL of glacial acetic acid and 1-2 drops of ferric chloride solution were added. Then, 0.5 mL of concentrated sulphuric acid was slowly added along the side of the test tube. A brown ring at the interface indicated a deoxy-sugar characteristic of cardiac glycoside constituents.

2. 8 *Data Analysis*

The data obtained was subjected to one-way analysis of variance (ANOVA) at 0.05 significant levels, treatment means were separated by new Duncan`s Multiple Range Test

3. RESULTS

3.1 *Effect of C. odorata leaf extracts on mortality of adult C. maculatus*

Weevil mortality in cowpea seeds treated with the leaves extracts of *C. odorata* differed significantly ($P \leq 0.05$) as shown in Table 1. All extracts showed weevil mortality ranging from 82.5%– 100% within the 96 h of exposure. Adult mortality increased with length of exposure. *C. odorata* leaf extract of steam distillate and ethanol were the most effective against *C. maculatus* achieving 100% and 95.25 % mortality, respectively, after 96 h of exposure. Acetone extract was the least toxic causing 82.19 % weevil mortality after 96 h of exposure.

3.2 *Effects of C. odorata stem bark extracts on mortality of adult C. maculatus*

Weevil mortality in cowpea seeds treated with the stem bark extract of *C. odorata* differed significantly ($P \leq 0.05$) as shown in Table 2. All extracts showed weevil mortality ranging from 75.30 % to 92.18%. Adult mortality increased with length of exposure. None of the extracts was able to achieve 100 % weevil mortaliy. *C. odorata* stem bark extract of steam distillate and ethanol were the most effective against *C. maculatus* achieving 95.75 % and 92.18 % mortality, respectively, after 96 h of exposure. N-hexane extract was the least toxic, causing 75.30 % weevil mortality after 96 h of exposure.

3.3 *Effects of C. odotata leaf extract on oviposition and adult emergence of C. maculatus*

The *C. odorata* extracts effectively reduced oviposition by *C. maculatus* (Table 3). Oviposition by *C. maculatus* on treated cowpea seeds was significantly lowered ($P \leq 0.05$) than oviposition on untreated (control) seeds. There were significant differences ($P \leq 0.05$) in the mean number of eggs laid on the treated seeds of different extracts (Table 3). The percentage adult emergence in the untreated cowpea seeds was significantly higher than the percentage emergence in the treated seeds. No adult emerged in cowpea seeds treated with *C. odorata* leaf extract of leaf distillate and ethanol extract.

3.4 *Effects of C. odotata stem bark extract on oviposition and adult emergence of C. maculatus*

The *C. odorata* stem bark extracts effectively reduced oviposition by *C. maculatus* (Table 4). Oviposition by *C. maculatus* on treated cowpea seeds was significantly lowered ($P \leq 0.05$) than oviposition on untreated (control) seeds. There were significant differences ($P \leq 0.05$) in the mean number of eggs laid on the treated seeds of different extracts (Table 4). The percentage adult emergence in the untreated cowpea seeds was significantly higher than emergence in the treated seeds. The percentage adult emergence was significantly lower in the treated cowpea seeds. The most effective extract were steam distillate, methanol with 5.0 %, 7.10 % and 6.25 % which are not significantly different ($P \leq 0.05$)

3.5 *Effects of C. odorata leaf extracts on grain viability*

Percentage germination of all treated seeds after 7th day was generally high (Table 5). Almost all the treated seeds germinated as germination was between 85.15 % and 90.75 %. The untreated cowpea seeds had the highest germination of 100%, followed by seeds treated with ethanol, ethanol, acetone, n-hexane, pet-ether extracts and steam distillate in that order. Seed treated with the steam distillate and pet-ether had the lowest percentage germination of 85.50% and 85.15 % which are not significantly different ($P \leq 0.05$).

3.6 *Effects of C. odorata stem bark extracts on grain viability*

Percentage germination of all treated seeds after 7th day of treatment was generally high (Table 5). Almost all the treated seeds germinated as germination was between 95.75 % and 100 %. The untreated cowpea seeds also had germination of 100%, followed by seeds treated with n-hexane, methanol, pet-ether, ethanol and steam distillate respectively Seed treated with acetone and steam distillate had the lowest percentage germination of 85.25% and 80.15 %.

3.7 *Phytochemical composition of leaf and stem bark extracts of C. odorata*

The phytochemical composition of the leaves and stem barks of *C. odorata* is shown in Table 7. Phytochemical analysis of the leaf of *C. odorata* showed that Tannins, Terpenoid were present in large quantity. While Alkaloid, Flavonoids, saponins, cardiac glycosides and Steroid were present. Phytochemical analysis of the stem bark extract of *C. odorata* showed that Alkaloid, Tannins, Flavonoids, saponins Terpenoid, cardiac glycosides and steroids were present.

Table 1: Mortality of adult *Callosobruchus maculatus* in cowpea seeds treated with different solvent extracts of *C. odorata* leaf

	Percentage	Mortality at hours	post-treatment	
Leaf extracts	24	48	72	96
Untreated (control)	0.00 ± 0.00e	0.00 ± 0.00e	0.00 ± 0.00f	0.00 ± 0.00f
n-hexane	18.10 ± 2.13cd	42.25 ± 2.26cd	75.50 ± 3.72b	88.20 ± 4.36d
Pet-ether	19.25 ± 1.21c	43.30 ± 2.32cd	64.50 ± 3.33e	87.25 ± 4.10d
Acetone	17.50 ± 1.15d	36.30± 2.18bc	58.25 ± 3.15bc	82.19 ± 3.27e
Steam distillate	29.35 ± 2.35b	65.25 ± 2.18a	87.40 ± 4.23a	100.00 ± 0.00a
Methanol	34.30± 1.41a	53.10 ± 2.22b	68.20 ± 3.35d	90.55 ± 3.16c
Ethanol	35.65 ± 1.20a	48.25 ± 2.76c	72.25 ± 3.24bc	95.25 ± 4.19b

Means within the same column followed by the same letter(s) are not significantly different ($P \leq 0.05$) using New Duncan`s Multiple Range Test.

Table 2: Mortality of adult *C. maculatus* in cowpea seeds treated with different solvent extracts of *C. odorata* stem bark

	Percentage	Mortality at hours	post-treatment	
Stem bark extracts	24	48	72	96
Untreated	0.00 ± 0.00d	0.00 ± 0.00e	0.00 ± 0.00f	0.00 ± 0.00f
n-hexane	15.20 ± 1.15c	37.30 ± 2.18c	55.75 ± 3.50e	75.30 ± 3.28e
Pet-ether	17.50 ± 1.45b	45.25 ± 2.66b	69.15±3.25bc	88.15 ± 3.46c
Acetone	15.75 ± 1.24cd	38.50 ± 2.17c	65.25 ± 2.24d	85.45 ± 4.33d
Steam distillate	32.25 ± 2.39a	65.25 ± 3.66a	86.20 ± 4.12a	95.75 ± 4.23a
Methanol	17.28 ± 1.31b	33.50 ± 2.30d	67.55 ± 1.25c	88.25 ± 3.15c
Ethanol	16.60 ± 1.19bc	36.20 ± 1.71cd	72.50 ± 3.14b	92..18 ± 3.31b

Means within the same column followed by the same letter(s) are not significantly different ($P \leq 0.05$) using New Duncan`s Multiple Range Test.

Table 3: Effects of *C. odorata* leaf extracts on oviposition and adult emergence of *Callosobruchus maculatus*

Leaf extracts	No. of eggs	% adult emergence
Untreated	34.20 ± 1.22a	82.25 ± 3.17a
Pet-ether	16.20 ± 1.33c	10.15 ± 1.04b
Acetone	18.25 ± 1.51b	12.50 ± 0.72b
Steam distillate	12.75 ± 0.81d	0.00 ± 0.00d
Methanol	17.30 ± 0.75b	6.25 ± 0.57c
Ethanol	10.45 ± 2.53e	0.00 ± 0.00d

Means within the same column followed by the same letter(s) are not significantly different (P ≤ 0.05) using New Duncan`s Multiple Range Test.

Table 4: **Effects of *C. odorata* stem barks extracts on oviposition and adult emergence of *Callosobruchus maculatus***

Stem bark extracts	No. of eggs	% adult emergence
Untreated	34.20 ± 1.22a	82.25 ± 3.17a
Pet-ether	22.35 ± 1.47b	13.50 ± 0.72c
Acetone	23.50 ± 1.31b	17.75 ± 0.74b
Steam distillate	13.25 ± 0.65d	5.60 ± 0.29e
Methanol	16.50 ± 0.77c	7.10 ± 0.53d
Ethanol	14.75 ± 0.83d	6.25 ± 0.43d

Means within the same column followed by the same letter(s) are not significantly different (P ≤ 0.05) using New Duncan`s Multiple Range Test.

Table 5: Percentage germination cowpea seeds that were previously protected for 60 days with 0.5 mL *C. odorata* leaf extracts

Leaf extracts	Mean percentage germination
Untreated	100.00 ± 0.00a
n-hexane	90.00 ± 3.14b
Pet-ether	85.50 ± 4.15c
Acetone	90.25 ± 3.50b
Steam distillate	85.15 ± 2.78c
Methanol	90.25 ± 3.28b
Ethanol	90.75 ± 4.63b

Means within the same column followed by the same letter(s) are not significantly different (P ≤ 0.05) using New Duncan`s Multiple Range Test.

Table 6: Percentage germination cowpea seeds that were previously protected for 60 days with 0.5 mL *C. odorata* stem bark extracts

Stem bark extracts	Mean percentage germination
Untreated	100.00 ± 0.00a
n-hexane	100.00 ± 0.00a
Pet-ether	90.50 ± 3.54c
Acetone	85.25 ± 4.36bd
Steam distillate	80.15 ± 3.19e
Methanol	95.75 ± 4.08b
Ethanol	90.00 ± 3.53c

Means within the same column followed by the same letter(s) are not significantly different (P ≤ 0.05) using New Duncan`s Multiple Range Test.

Table 7: Phytochemical composition of *C. Odorata* Leaf and stem bark

Parameters	Leaf	Stem bark
Alkaloids	+	+
Tannins	++	+
Flavonoids	+	+
Saponins	+	+
Terpenoid	++	+
Cardiac glycosides	+	+
Steroids	+	+

Key:

++ = Present in large quantity

+ = Present

4. DISCUSSION

The results obtained from this study showed that Leaves and stem barks extracts of *Chromolaena odorata* caused high mortality of adult *C. maculatus* in treated cowpea seeds with steam distillate being the most toxic of the extracts tested. It has been established by some researchers that the use of botanical insecticides, such as extracts and oils as grain protectants had found to be effective against storage beetles [25,12]. The results from this investigation are similar to the observations of [12], who obtained 100% mortality of adult *C. maculatus* in cowpea seeds treated with steam distillate of cashew nut kernel at the rate of 5 ml and 6 ml of oil kg–1. Also, the result obtained in this research compared with the findings of [25,9] as well as [9] in which N. *laevis* was able to cause high mortality of *C. maculatus*, *Sitophilus oryza* and *S. zeamais*. Also, the result obtained tallies with the research of [28] as well as [8] in which plant materials were found to cause high mortality of *S. cerealella*.

In this study, the lethal effect of *C. odorata* extracts on the weevils could be as a result of contact toxicity. Most insects breathe by means of trachea which usually opens at the surface of the body through spiracles. These spiracles might have been blocked by the oil extract thereby leading to suffocation [12].

The extracts significantly ($P \leq 0.05$) reduced oviposition and adult emergence in *C. maculatus* when compared with their oviposition and adult emergence in the untreated cowpea seed. The ability of these plant parts extracts to reduce or prevent the emergence of the adult insect could be due to inability of the insect eggs to develop because botanical extracts have been noticed to block the chorion which is the breathing channel of eggs [11, 12]. Also, the early stage death of the insect larvae which was unable to fully cast off their old exoskeleton which typically remained linked to the posterior part of the abdomen [26]. Also, the extracts inhibits locomotion; hence, the beetles were unable to move freely thereby affecting mating activities. The inability of the egg to stick to the cowpea seeds due to the presence of the extract also reduced adult emergence arising from egg mortality.

Alkaloids, tannins, flavonoids, saponins, cardian glycosides, terpenoid and steroids were the phytochemicals present in *C. odorata* extracts. These chemicals are capable of disrupting growth and reduced larva survival as well as disruption of life cycle of insects [30]. Therefore, the presence of these chemicals could be the reason for the low or no adult emergence of *C. maculatus*

There were no marked differences between the percentage germination in treated cowpea seeds compared with the untreated (control). This shows that plant extracts have no adverse effect on germination.

The results obtained from this study confirmed that *C. odorata* extracts, most especially that of the steam distillate could serve as a better alternative to synthetic insecticides.

5. CONCLUSIONS

Results from this study have proved that *C. odorata* leaf and stem bark extracts were potent against *C. maculatus.* Its protectant properties were observed from the mortality caused and reduction in oviposition, and adult emergence. Also, these botanical extracts are cheap, readily available and ecologically friendly. Hence, can serve as alternative to the poisonous conventional chemical insecticides.

AUTHORS' CONTRIBUTIONS

Author***1** Designed the experiments, prepared the plant extracts and carried out the experiment on insect mortality, oviposition and adult emergence. Author[1] carried out the experiment on effect of different extracts on seed viability. Author[2] carried out the data analysis and the phytochemical analysis on the plant used. All authors read and approved the final manuscript

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