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Research Article

Effective Control of *Alphitobius diaperinus* Using Natural Bioinsecticides

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ABSTRACT

Pest insects known as darkling beetles (*Alphitobius diaperinus*) are common in poultry farms. These pests can develop into a variety of disease vectors, causing damage to chicken coops, decreased chick performance, and financial losses to farmers. In Indonesia, synthetic insecticides are still used for pest control, which is detrimental to non-target creatures and the environment. The purpose of this study is to analyze the effectiveness of biopesticides from cinnamon bark extract (*Cinnamomum aromaticum*), nutmeg seeds (*Myristica fragrans*), lavender flowers (*Lavandula angustifolia*), and lime peel (*Citrus aurantifolia*), as well as synthetic insecticides alpha-cypermethrin against *A. diaperinus* larvae and imago. Bioinsecticide levels are 2.5%, 5%, 7.5%, and 10%, while alpha-cypermethrin levels are 1%, 4%, 7%, and 10%, respectively, based on LC50 values. The analysis was repeated three times and the treatment was carried out every two days for a total of 14 days. The data were analyzed with paired sample t-tests to determine the average difference in each treatment when there was an average difference and calculated N-Gain score to determine the effectiveness of biopesticides and synthetic insecticides. The average value of N-Gain essential oil from cinnamon bark extract was successful in causing *A.diaperinus* death in the imago stage (81.14) and the highest larvae (80) of other test solutions. Cinnamon bark extract and nutmeg seed extract are effective in imago (95.14) and larvae (78.91), respectively, and can be used as a natural biopesticide to replace synthetic insecticides in the control of *A.diaperinus* in imago and larvae stages.

Keywords: Biological control, Biopesticides, Environmental management, Essential oils

Introduction

One of the most frequent forms of pest insects found in chicken farms around the world is *Alphitobius diaperinus*, sometimes known as frenki fleas. These insects are frequently found in livestock feed and manure. *A. diaperinus* larvae and imago serve as vectors for a variety of pathogens, including bacteria, viruses, and protozoa [2, 3]. Recent issues have been discovered in the poultry business in countries all over the world, especially on Korean broiler chicken farms. This insect damages chicken coops, reduces chick performance, and causes financial losses to poultry farmers [4].

Recently, synthetic insecticides are being used to combat *A. diaperinus*, which can be damaging to human health, the environment, and have toxic effects non-target creatures [5]. They are widely available at agricultural stores and internet retailers that sell several kinds of pyrethroid insecticides with the active component alpha cypermethrin. Pyrethroids are a potent contact poison that can harm both the central and peripheral nervous systems of insects [6]. Synthetic pesticides are used by farmers to control pests because they can eliminate pests rapidly, efficiently, and affordably.

The use of unsuitable synthetic insecticides by farmers or breeders, such as the use of inappropriate dosages, can have certain negative consequences. Impacting soil nitrogen cycles can harm soil micro flora, increase pest resistance, reduce the efficacy of synthetic insecticides, and lead to the establishment of new, more resistant species

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[7, 8]. As in some animal feed factories that use active alpha cypermethrin pesticides in their fumigation systems. The pest of *A. diaperinus* that survives after exposure to synthetic insecticides is still a product of fumigation of animal feed (pests become resistant). The community is subsequently given the fumigated animal feed to trade. Pests like *A. diaperinus*, which are still present in animal feed, will get carried away and breed in chicken farms, causing the population to explode.

Humans and the environment both require safe control measures. One of its methods is to extract acetone from cinnamon bark (*Cinnamomum aromaticum*), nutmeg seeds (*Myristica fragrans*), lavender flowers (*Lavandula angustifolia*), and lime peel (*Citrus aurantifolia*) and use them in natural pesticides [9, 10]. Essential oils are known to repel nuisance insects due to their aroma [11, 12]. These four plants include chemical compounds that act as repellents, limit insect growth at the egg [13], larval, pupae, and imago stages [14], and act as antifeedants [15], antioxidants, antimicrobials and antifungals [16, 17]. Essential oils' antifeedant qualities have little effect on the environment or non-target creatures [18]. Natural fumigants can eliminate insect pests without causing insects to develop immunity [19]. Experts proposed employing natural bioinsecticides as an alternative to biological controllers for disease vectors [20] and it is more environmentally friendly [21].

The application of biopesticides derived from cinnamon bark extract, nutmeg seeds, lavender flowers, and lime peel in *A. diaperinus* larvae and imago in Indonesia is the most recent study in this series. This endeavor also tries to disrupt *A. diaperinus*' life cycle, hence decreasing population growth. Because of the easy-to-obtain and environmentally acceptable ingredients, biopesticides are hoped to be a viable alternative for controlling *A. diaperinus* pests. This work may contribute further to the management of environmental contamination by presenting an alternative to the usage of natural insecticides.

Material and Methods

Alphitobius diaperinus sample preparation

A. diaperinus larvae and imago are placed in plastic containers with air vents containing husks as a medium for breeding and feeding chickens as food. Propagation is done by saving, fed by chickens as much as 30 gr per week, and given wet cotton wool to maintain temperature and humidity (28°C and 70%) for three months until it produces a second generation [22].

Acetone extraction

Acetone is extracted from the plant part of the stem bark of *C. aromaticum, M. fragrans* seeds, *L. angustifolia* flowers, and *C. aurantifolia* lime peel. The cinnamon bark is softened before being cut into small pieces and crushed into powder with a blender. The resulting powder is subsequently filtered using an 850 µm scarf [23]. For a month, the nutmeg seeds were separated from the dried fruit. The seeds are then mixed until they are completely smooth [24]. Lavender blossoms are cut into little pieces and soaked in acetone with interest the ratio of acetone is 1:5 [25]. Fresh lime juice peels blended until smooth [26]. Cinnamon powder, nutmeg seeds, lavender flowers, and lime peel were macerated in acetone at room temperature for three days, nutmeg seeds for two days, lavender flowers for seven days, and lime zest for 24 hours. The maceration results are filtered to obtain filtrate, which is then evaporated using a rotating vacuum evaporator and stored in an aluminum-foiled glass bottle.

Synthetic insecticide alpha cypermethrin

A pest control firm in Semarang provided the synthetic insecticide alpha-cypermethrin used in this investigation. The application's usage guidelines that are used in pest control companies are 0.2 mL/30 mL (solution / m^2). The LC50 range for this dosage was 6.67%.

Bioassay

Biopesticide activity was determined using acetone extracts of cinnamon stem bark, nutmeg seeds, lavender flowers, and lime peel at concentrations of 2.5%, 5%, 7.5%, and 10%, respectively, based on the different ratios between extract and methanol. Synthetic insecticides based on active alpha-cypermethrin with concentrations of 1%, 4%, 7%, and 10% based on LC_{50} range from 0.2 mL/30 mL or 6.67% Acetone is used to transport each pesticide. An acetone solution is used as a control treatment in research. There are two control treatments for each synthetic insecticide and biopesticide.

In vitro testing is performed in a 9-cm-diameter petri dish with an 8-cm-diameter filter paper coating. Each petri dish contains ten individual *A. diaperinus* larvae and ten individual *A. diaperinus* imagoes in separate petri dishes. A filter paper was used for dripping as much as 200 μl of test solution into the petri dish. Then the liquid was allowed to dry for 10 minutes before filling the petri dish with *A. diaperinus* larvae and imago and then closing the petri dish. Each treatment is repeated three times.

Data analysis

The average difference in each treatment in *A. diaperinus* larvae and imago was determined using a paired sample t-test with SPSS 26.0 to evaluate the data obtained in this study. The N-Gain score was also calculated when there was an average difference. The efficiency of bioinsecticides and synthetic insecticides in the larval and imago phases of *A. diaperinus* is determined by calculating the Gain score (N-Gain test) [27]. The formulas are as follows:

$$\text{N Gain} = (<\text{Post}> - <\text{Pre}>)/(100 - <\text{Pre}>)$$

Description:
The highest score that can be earned is known as the ideal score. Based on the percentage value, the category of earning an N-Gain score can be established (Table 1).

Table 1. The category of earning an N-Gain score [27]

Percentage (%)	Interpretation
< 40	Ineffective
40 – 55	Less effective
56 – 75	Quite effective
> 76	Effective

Results and Discussion

The results of this investigation revealed that synthetic insecticides made of active Alpha-cypermethrin differed from biopesticides in terms of effectiveness across all treatments (Tables 1 and 2). On the fourth day following treatment with nutmeg seed extract at concentrations of 7.5% and 10%, the mortality rate of *A. diaperinus* imago is the highest and fastest. On the fourth day following treatment with cinnamon bark extract at a concentration of 10%, the mortality rate of *A. diaperinus* larvae is the highest and fastest. The control treatment does not cause mortality in *A. diaperinus* imago or larvae until the 14th day following treatment.

Based on Table 2, revealed that C. *aromaticum* extract with 10% concentration for 4 days, 7.5% for 8 days and 5% for 10 days had the maximum mortality (100%) in the larvae phase, while 2.5% mortality was only 76.7%. Meanwhile, mortality was 100% in *M. fragrans* extract achieved at concentrations of 10% for 6 days, 7.5% for 10 days, 5% for 12 days, and 2.5% for 14 days. The control group, on the other hand, did not produce mortality until the 14th day of observation. Compared to nutmeg, lavender, and lime peel, the results showed that *C. aromaticum* extract was the most effective in regulating the larva phase of *A. diaperinus*.

The fastest 100% mortality value was attained in the treatment group given the synthetic insecticide alpha cypermethrin, which was given at a concentration of 10% for 10 days and a concentration of 7% for 12 days (Table 2). Meanwhile, the administration of *C. aromaticum* extracts resulted in 100% death at doses of 10%, 7.5 %t, and 5%, respectively, and for periods of 4, 8, and 12 days. Compared to the group given by the synthetic pesticide Alpha Cypermethrin, the bioinsecticide of *C. aromaticum* at a dosage of 10% was the most efficient dose for controlling the imago phase of *A. diaperinus* (Table 2).

The mortality of the imago larvae phase differed (Table 2) slightly from the larvae phase (Table 3). The *M. fragrans* extract treatment group had the fastest 100% mortality rate compared to the others. On day 4, a series of 10% concentrations resulted in 100% mortality. Therefore, Table 3 shows that administering a 10% concentration of *M. fragrans* extract for 14 days is the most effective for controlling the imago phase of *A. diaperinus*.

Based on Table 4 and Table 5, the N Gain score suggested effective categories on the types of extract solutions of *C. aromaticum* and *M. fragrans* with the highest average of other solutions extract. This implies that cinnamon bark and nutmeg seeds can suppress both the larval and imago stages of *A. diaperinus*. Table 4 and 5 show that *C. aurantifolia* has the lowest average as well. This means that lime peel extract was less efficient at suppressing *A. diaperinus* in both larval and imago stages. This study collected *A. diaperinus* larvae and imago that were still alive after 14 days of treatment to see how their life cycle developed. The first container held larvae and imago exposed to biopesticides, while the second held larvae and imago subjected to synthetic insecticides (alpha-cypermethrin). Because biopesticide exposure re-

Table 1. Mortality (%) biopesticides and synthetic Insecticides in larvae *Alphitobius diaperinus* on various treatment

Treatment	Concentrations test (%)	Mortality (Mean ± Sdev) in 2 days	4 days	6 days	8 days	10 days	12 days	14 days
Cinnamomum aromaticum	2.5	23.3 ± 25.16	36.67 ± 47.26	40 ± 43.59	50 ± 43.59	60 ± 34.64	73.3 ± 23.09	76.67 ± 20.82
	5	43.3 ± 30.55	50 ± 26.46	60 ± 26.46	83.3 ± 15.28	96.67 ± 5.77	100 ± 0	100 ± 0
	7.5	76.67 ± 15.16	80 ± 26.46	93.3 ± 11.55	100 ± 0	100 ± 0	100 ± 0	100 ± 0
	10	96.67 ± 5.77	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Myristica fragrans	2.5	23.3 ± 11.55	36.67 ± 11.55	50 ± 10	60 ± 10	76.67 ± 5.77	93.3 ± 11.55	100 ± 0
	5	20 ± 17.32	60 ± 10	73.3 ± 25.16	83.315.28	93.3 ± 5.77	100 ± 0	100 ± 0
	7.5	40 ± 17.32	60 ± 0	80 ± 17.32	93.311.55	100 ± 0	100 ± 0	100 ± 0
	10	70 ± 20	96.67 ± 5.77	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Lavandula angustifolia	2.5	16.67 ± 15.28	33.3 ± 15.28	60 ± 10	63.3 ± 11.55	66.67 ± 15.28	70 ± 17.32	70 ± 17.32
	5	10 ± 17.32	33.3 ± 15.28	53.3 ± 28.87	70 ± 10	70 ± 10	73.3 ± 11.55	73.3 ± 11.55
	7.5	13.3 ± 5.77	36.67 ± 5.77	56.67 ± 5.77	66.67 ± 5.77	76.67 ± 5.77	80 ± 10	80 ± 10
	10	20 ± 20	46.67 ± 15.28	60 ± 10	66.67 ± 11.55	76.67 ± 15.28	80 ± 10	86.67 ± 5.77
Citrus aurantifolia	2.5	13.3 ± 5.77	40 ± 0	40 ± 0	50 ± 17.32	53.3 ± 15.28	60 ± 10	70 ± 10
	5	16.67 ± 5.77	33.3 ± 11.55	46.67 ± 30.55	56.67 ± 20.82	63.3 ± 15.28	73.3 ± 15.28	76.67 ± 11.55
	7.5	16.67 ± 5.77	33.3 ± 11.55	50 ± 17.32	60 ± 10	63.3 ± 5.77	66.67 ± 5.77	76.67 ± 5.77
	10	13.3 ± 11.55	33.3 ± 35.12	53.3 ± 20.82	63.3 ± 11.55	70 ± 10	73.3 ± 5.77	83.3 ± 5.77
Alpha cypermethrin	1	26.67 ± 11.55	33.3 ± 15.28	40 ± 20	43.3 ± 15.28	50 ± 20	56.67 ± 20.82	70 ± 20
	4	40 ± 0	66.67 ± 5.77	70 ± 10	80 ± 10	86.67 ± 11.55	90 ± 10	93.3 ± 11.55
	7	50 ± 36.05	76.67 ± 20.82	83.3 ± 15.28	93.3 ± 11.55	93.3 ± 11.55	100 ± 0	100 ± 0
	10	86.67 ± 23.09	93.3 ± 11.55	96.67 ± 5.77	96.67 ± 5.77	100 ± 0	100 ± 0	100 ± 0

sults in total mortality 28 days after exposure in imago, whereas synthetic insecticide exposure results in total mortality 30 days after exposure in imago, neither biopesticides nor synthetic insecticide exposure results in a new generation. Naturally, larvae exposed to biopesticides and synthetic insecticides become mature into pupae. However, pupae exposed to natural insecticides do not mature into imago beetles and die after 19 days.

The current study results align with Benbelkacema *et al.* [28]. Cinnamon extract has been shown to effectively kill *A. diaperinus* larvae and imago. Cinnamon extract has 89 components, the most important of which is e-cinnamaldehyde (94.67%), followed by coumarin (0.88%), cinnamyl acetate (0.74 %) and others [28]. Volpato *et al.* [28] used essential oils, nanoemulsions, and nanocapsules of *Cinnanomum zeylanicum* on *A. diaperinus* larvae and imago in a similar study. As a result, *A. diaperinus* larvae and imago die when exposed to essential oils at concentrations of 5% and 10%, nanoemulsions (1%), and nanocapsules (1%). The use of nanotechnology in pesticide delivery aims to limit the indiscriminate spraying of conventional pesticides while also ensuring their safety [30].

According to Rueda *et al.* [31], who tested grain beetles (*Sitophilus granarius*) with essential

Table 2. Mortality (%) biopesticides and Synthetic Insecticides in imago *Alphitobius diaperinus* on various treatment

Treatment	Concentrations test (%)	Mortality (Mean ± Sdev) in						
		2 days	4 days	6 days	8 days	10 days	12 days	14 days
Cinnamomum aromaticum	2.5	40 ± 26.46	40 ± 26.46	46.67 ± 37.86	56.67 ± 28.87	70 ± 26.46	73.3 ± 25.16	83.3 ± 15.28
	5	56.67 ± 11.55	70 ± 10	70 ± 10	76.67 ± 5.77	86.67 ± 5.77	100 ± 0	100 ± 0
	7.5	70 ± 26.46	76.67 ± 32.14	90 ± 17.32	96.67 ± 5.77	100 ± 0	100 ± 0	100 ± 0
	10	83.3 ± 11.55	90 ± 0	93.3 ± 5.77	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Myristica fragrans	2.5	63.3 ± 20.81	63.3 ± 20.81	80 ± 17.32	93.3 ± 11.55	100 ± 0	100 ± 0	100 ± 0
	5	83.3 ± 15.28	93.3 ± 11.55	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0
	7.5	93.3 ± 11.55	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0
	10	96.67 ± 5.77	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0	100 ± 0
Lavandula angustifolia	2.5	40 ± 30	46.67 ± 25.16	56.67 ± 15.28	63.3 ± 5.77	66.67 ± 5.77	70 ± 0	73.3 ± 5.77
	5	40 ± 52.9	43.3 ± 51.3	56.67 ± 37.86	60 ± 34.64	76.67 ± 20.8	80 ± 17.32	83.3 ± 15.28
	7.5	83.3 ± 15.28	83.3 ± 15.28	86.67 ± 11.55	90 ± 10	90 ± 10	90 ± 10	90 ± 10
	10	90 ± 10	90 ± 10	93.3 ± 11.55	93.3 ± 11.55	93.3 ± 11.55	96.67 ± 5.77	100 ± 0
Citrus aurantifolia	2.5	0 ± 0	3.3 ± 5.77	23.3 ± 5.77	26.67 ± 5.77	30 ± 10	46.67 ± 5.77	60 ± 10
	5	3.3 ± 5.77	20 ± 10	50 ± 17.32	53.3 ± 23.09	53.3 ± 23.09	63.3 ± 15.28	80 ± 10
	7.5	6.67 ± 5.77	20 ± 10	46.67 ± 5.77	50 ± 0	53.3 ± 5.77	60 ± 0	70 ± 10
	10	20 ± 17.32	26.67 ± 15.28	36.67 ± 15.28	63.3 ± 5.77	76.67 ± 5.77	83.3 ± 5.77	90 ± 10
Alpha cypermethrin	1	0 ± 0	0 ± 0	3.3 ± 5.77	13.3 ± 5.77	13.3 ± 5.77	26.67 ± 5.77	36.67 ± 5.77
	4	3.3 ± 5.77	20 ± 26.46	36.67 ± 30.55	50 ± 30	56.67 ± 35.11	66.67 ± 35.12	73.3 ± 30.55
	7	23.3 ± 20.81	40 ± 45.82	56.67 ± 28.87	66.67 ± 20.81	76.67 ± 20.81	83.3 ± 15.28	90 ± 10
	10	76.67 ± 5.77	83.3 ± 5.77	90 ± 10	93.3 ± 11.55	93.3 ± 11.55	96.67 ± 5.77	100 ± 0

oil (*Cinnamomum* sp.), insects that have been exposed to the content of terpenoid compounds will diminish their respiration rate and mobility on terpenoid compound-exposed surfaces. This physiological function affects the rate of breathing, which is required for insects to build a self-defense mechanism against insecticides. Cinnamon (*Cinnamomum* sp.) essential oils have been shown to inhibit and prevent the development of insect resistance. Nutmeg seed extract (*M. fragrans*) has the content of α-pinene, sabinene, β-pinene, (S)-limonene, γ-terpinene, terpinene-4-ol, methyl eugenol, myristicin, and elemicin [32]. A-pinene and β-pinene are pinene-type monoterpene hydrocarbons engaged in membrane and lipophilic compounds and have antimicrobial activity [33]. This extract has a toxic effect and can inhibit the activity of the enzyme acetylcholinesterase (AChE) at IC50 = 4510 μg mL^{-1} and butyrylcholinesterase (BChE) at IC50 = 4130 μg mL^{-1} against larvae and imago *A. aegypti* [34, 20] AChE is an enzyme that can hydrolyze the neurotransmitter acetylcholine. AChE, which impairs nerve impulse transmission, can elevate acetylcholine levels in insect neuro-

Table 3. Calculation results from N Gain score larvae *Alphitobius diaperinus*

No.	Solution Type	Minimum	Maximum	Mean	Category
1	*Cinnamomum aromaticum*	60	94.2	80	Effective
2	*Myristica fragrans*	38.3	100	78.91	Effective
3	*Lavandula agustifolia*	15	77.5	57.5	Quite Effective
4	*Citrus aurantifolia*	15	76.7	51.78	Less effective
5	Alpha cypermethrin	50.8	90.8	75.58	Quite Effective

Table 4. Calculation results from N Gain score imago *Alphitobius diaperinus*

No.	Solution Type	Minimum	Maximum	Mean	Category
1	*Cinnamomum aromaticum*	63	96	81.14	Effective
2	*Myristica fragrans*	84	100	95.14	Effective
3	*Lavandula agustifolia*	63	87	76	Quite Effective
4	*Citrus aurantifolia*	8	75	43.14	Less effective
5	Alpha cypermethrin	26	75	52.57	Less effective

muscular tissues and causes death [35]. Immune insects will develop mutations on the active side of AChE. It will make pesticides unable to bind to enzymes and prevent AChE inactivation, decreasing the sensitivity of insecticides [36].

In other investigations, six active chemical compounds in nutmeg seed extract, each of which is extracted by fractionation, were used to assess the efficacy of insecticides and repellents against tobacco beetles (*Lasioderma serricorne*). The chemical compounds of eugenol, methyl eugenol, elemicin, and myristicin have the highest contact toxicity, having an LD50 of 9.8 g / imago [37]. The results of a recent study conducted by Abdelgaleil *et al.* [38] and Subekti and Indrawati [13] with nutmeg seed extract at a dose of 40 µl/g can control warehouse pests (*Sitophilus oryzae*) imago as well.

The results of the lavender flower extract treatment showed a 100% death rate solely in imago at a concentration of 10% for 336 hours (day 14) following treatment. Larvae do not have a 100% death rate. According to Martynov *et al.* [39], lavender extract can be used as a repellent against *T. confusum*. Kheloul *et al.* [40] conducted another investigation with different lavender species (*Lavandula spica*), which exhibited mortality results in early larvae (L1) more efficiently than older larvae (L8) after 24 hours of treatment, with LC50 = 19,535 ml/L. *L. spica* oil is more toxic in the *T. confusum* phase of the pupae, which causes not only mortality but malformations or imago abnormalities that hatch from the pupa. Similar research conducted by Theou *et al.* [41] tested *Lavandula hybrida* against the beetle *T. confusum* phase of larvae aged 10 days, 25 days, and 31 days, pupae aged 2 days, known to have strong toxicity. Larvae aged 10 days are most susceptible and larvae aged 31 days are most tolerant, with values LC50 1.8 and 109 µl / L. Meanwhile, pupae that have been exposed to essential oil vapor indicate inhibition of morphogenesis. Ebadollahi *et al.* [42] using *Lavandula stoechas* which has a primary content of 1.8-cineole (10.10%), can cause larvae and eggs to be more susceptible than pupae and imago to *T. castaneum* during 24 hours of exposure by fumigation method. Mortality increases with the time of exposure and dosage given.

The major constituents of *C. aurantifolia* are limonene (77.5%), linalool (20.1%), citronellal (14.5%), and citronellol (14.2%) [42]. According to the findings, there was no 100% death in either imago or larvae. After 336 hours (day 14) of therapy, the maximum rate of imago death is 90% at a concentration of 10%. Larvae with the highest mortality percentage of 83.3% at a concentration of 10% after 336 hours (day 14) of treatment. Compared to the other pesticides utilized, lime peel extract (*C. aurantifolia*) had a lower mortality effect.

The synthetic insecticide used in this study is made of active alpha-cypermethrin 30 g/L and an EC (Emulsifiable Concentrate) code is on the packaging. EC is a concentrated formulation that can be emulsified. The content of the active ingredients contained in it can be easily soluble in water and oil. Easy application, no need to stir often because it is easy to mix with solvents. Generally, the method of use of this type of insecticide is using spraying, but it can also be done by fogging, dipping, and drenching. The advantage of the EC formulation is that its use requires only a small stirring when buying a high concentration which means the price per unit of the weight of the active ingredient becomes cheaper, and the final result does not leave "visible residue" [44]. During the observation, synthetic insecticides made of active alpha-cypermethrin are not seen to leave residue on the provided petri.

A. pyrethroid pesticide known as alpha-cypermethrin is utilized in both the household and agricultural industries. This pesticide may have unfavorable consequences, polluting the environment [45] and being toxic for humans [46]. According to Hocine *et al*. [47], pregnant mice and their offspring were tested. The finding is attributable to alpha-cypermethrin exposure at a level of 0.02 mg/kg/day, which causes metabolic alterations in the parent and fetal changes. Increased activity of aminotransferase, alanine aminotransferase, alkaline phosphatase, and a rise in glucose in the blood. According to Ghazouani *et al*. [48], alpha-cypermethrin can enhance oxidative stress in the heart. Male mice were administered an alpha-cypermethrin dose of 8 mg/kg, which resulted in a considerable increase in cholesterol (42%) and triglycerides (75%). The *A. diaperinus* imago mortality symptoms seen are the same as those reported, namely shrinking body, inverted body, and slow movement [49]. The body blackens, shrinks, and its straight shape is not curled in *A. diaperinus* larvae that die.

Conclusion

The stem bark extract of *C. aromaticum* gave the best results with a concentration of 10% and a duration of 4 days in controlling *A. diaperinus* larvae compared to the others treatment. Meanwhile, the 10% concentration of *M. fragrans* extract for 4 days was the most effective in controlling *A. diaperinus* imago. The findings of this study can be used as an alternate management guideline for natural bioinsecticide-based pest control that is environmentally acceptable.

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