BIO Web of Conferences **117**, 01034 (2024) https://doi.org/10.1051/bioconf/202411701034
ICoLiST 2023

The effectiveness of the combination of *Dioscorea bulbifera* L. extract and leri water as a bio-insecticide

Ade Ayu Oksari[1*], *Devy* Susanty[2], *Fathan Hadyan* Rizki[3], *Irvan Fadli* Wanda[4], *Arinana* Arinana[5] and *Dadang* Dadang[6]

[1]Biology Department, Faculty of Mathematics and Natural Sciences, Nusa Bangsa University, 16166 Jl. K.H. Sholeh Iskandar Km 4, Bogor, Indonesia
[2]Chemistry Department, Faculty of Mathematics and Natural Sciences, Nusa Bangsa University, 16166 Jl. K.H. Sholeh Iskandar Km 4, Bogor, Indonesia
[3]Agrotechnology Department, Faculty of Agriculture, Nusa Bangsa University, 16166 Jl. K.H. Sholeh Iskandar Km 4, Bogor, Indonesia
[4]Research Center for Biosystematics and Evolution, National Research and Innovation Agency (BRIN), Jl. Raya Jakarta-Bogor No.Km.46, Cibinong, Kec. Cibinong, Kab. Bogor, West Java, 16911, Bogor, Indonesia
[5]Department of Forest Products, Faculty of Forestry and Environment, IPB University, 16680 Jl. Ulin, Kampus IPB Dramaga, Bogor, Indonesia
[6]Department of Plant Protection, Faculty of Agriculture, IPB University, 16680 Jl. Kamper, Kampus IPB Darmaga, Bogor, Indonesia

Abstract. *Dioscorea bulbifera* L. and leri water have the potential to control dry wood termites because they contain several compounds (flavonoids, alkaloids, chlorine, and tannins) that can eradicate termites and damage insect body cells. This study aims to determine the effectiveness of the combination of *D. bulbifera* extract and leri water against *Cryptotermes cynocephalus* Light. The completely randomized design investigation employed three replications and nine treatments. In this study, only one test, namely the contact poison test, was applied. A variety of concentrations, a *D. bulbifera* extract source, and leri water were used as the treatment in this investigation. Termite mortality, test weight reduction, and the degree of damage were the parameters that were measured. The treatment significantly decreased the test's weight and the degree of damage. Still, it had no statistically significant impact on mortality, according to the DMRT test, at a substantial level of 5%. The results showed that the best mortality, test weight reduction, and degree of damage were found in the combination of stem (50%): leri water (50%), which were 62.22% (equal to corrected mortality of 45.16%), 8.34%, 16.47%, respectively. The combination of these extracts efficiently inhibits dry wood termites, according to this result.

* Corresponding author: adeayuoksari@gmail.com

1 Introduction

Synthetic insecticides are a serious environmental hazard, particularly ground and surface waterways and living things. In the past, termite infestations were typically prevented for extended periods by synthetic insecticides like DDT, aldrin, BHC, and dieldrin. Because of the effects caused by pesticides, their use is prohibited in many countries [1]. Due to its high toxicity and poor biodegradability (including soil contamination, water, crops, and people), pest management practices based on excessive pesticide use have resulted in several environmental issues and financial losses [2]. Indonesia employs synthetic pesticides to control termites, but their composition puts humans at risk, and their cost is high [3]. Due to human activities, including diet (food, drinking water), environmental exposure, and human vocations, people and wildlife are constantly exposed to various pesticides (surface water, groundwater, soil, air). Pesticide residues are known to harm human health. The effects of pesticides are neurologic toxicity, chronic neurodevelopment damage, potential immunological, reproductive, or cancer system malfunction, and many other harmful effects [4]. So, creating an environmentally friendly termite control innovation in Indonesia must use readily available, reasonably priced ingredients and safe for people. Therefore, various extracts, fractions, essential oils, wood vinegar, and single compounds from plants are used as alternative materials to replace synthetic materials containing dyes [5]. Innovations that can be developed include making insecticides with short and non-persistent properties and environmental hazards to support the application and application of a green economy [6]. One is using vegetable insecticides that contain active compounds in secondary plants.

Dioscorea bulbifera L. (Dioscoreaceae), one plant with the potential to be a bio-insecticide, is one such species. On ruined terrain, *D. bulbifera* can be quickly grown without any assistance. As a result, it might function as a bio-insecticide [7]. Due to the presence of secondary metabolites with allelopathic action, *D. bulbifera* is one of the invasive species included in the Global Compendium of Weeds and one of those that harm the ecosystem in many countries [8-10]. The tubers and leaves of *D. bulbifera* include flavonoids, alkaloids, saponins, and tannins that are known to be termititoxic [9, 10, 11]. Additionally, research using isolated compounds on *D. bulbifera*'s tubers, leaves, and stalks showed that each of these parts could function as a bio-insecticide in the control of dry wood termites (*Cryptothermes cynocephalus* Light) [8]. *Aedes aegypti* larvae [9]; *Spodoptera litura* F. [10]; *Nillavarpata lugens* Stall [11], and the walang sangit pest [12] have all been targets of the insecticidal potential of a different Dioscorea species, *Dioscorea hispida* Denst. The dry wood termite *Cryptotermes cynocephalus* Ligh has never been subject to reports of control employing a mixture of *D. bulbifera* plant parts as a bio-insecticide.

Another alternative that can be used besides *D. bulbifera* is leri water, commonly known as rice washing water. Rice is a staple food that is needed, especially by the community. The rice generally consumed is white rice with pigments or dyes belonging to the flavonoid group [13], which can be used to eradicate termites [14]. In addition, leri water also contains chlorine, which can damage insect body cells [15]. According to research by Miftah et al, the death rate of subterranean termites (Coptotermes sp.) might be increased by 66.7% by using leri water [14]. However, the best results from this study were in the combination treatment of 75% leri water and 25% betel leaf, with a mortality rate of 93.3%. Reflections on the combination of water leri and *D. bulbifera* have never been carried out, so it is necessary to see its potential as a bioinsecticide. The number and type of bioactive chemicals present in plants determine their ability to be insecticidal. Due to potential chemical interactions between the components of the various plants, it is possible that the combination of these botanicals could have either synergistic or antagonistic effects on their capacity to ward against insect pests. As a result, combining these three herbs may increase or decrease their efficacy as termiticides [16]. Thus, through this research, we hope to find compatibility between *D. bulbifera* and air leri to be effective in their use as bio-insecticides. This study aims to determine the effectiveness of the combination of *D. bulbifera* extract and leri water against *Cryptotermes cynocephalus* Light.

2 Experimental details

2.1 Place and time

The research was conducted at the Biology and Chemistry Laboratory, Nusa Bangsa University, Bogor, Indonesia. Collection of *Dioscorea bulbifera* L. at the Center Research on Plant Conservation and Botanical Gardens-BRIN and dry wood termites at the Central Laboratory for Standardization of Sustainable Forest Management Instruments, Ministry of Environment and Forestry, Bogor-The research was conducted from May to July 2023.

2.2 Materials and instruments

D. bulbifera (tuber, stems, and leaves), leri water, dry wood termites (*Cryptotermes cynocephalus* Ligh.), Whatman filter paper No. 41, and aquades were used as test papers. Among the tools utilized were a petri dish, a blender, a set of glasses, a water bath, a shaker, a separating sieve (60 mesh), an evaporating cup, and an oven. *D. bulbifera* leaf samples were taken and collected randomly from around the Center Research on Plant Conservation and Botanical Gardens-BRIN

2.3 Procedures

2.3.1 Providing test samples of D. bulbifera, dry wood termites, and filter paper

The title is set in bold 16-point Arial, justified. The first letter of the title should be capitalised with the rest in lower case. You should leave 22 mm of space above the title and 6 mm after the title The termites utilized for testing are dry wood termites Cryptotermes cynocephalus Light from the Bogor-based Central Laboratory for Standardization of Sustainable Forest Management Instruments of the Ministry of Environment and Forestry. A worker caste of 50 termites was utilized in each replication of all treatments. The termites chosen are still alive, in good health, and roughly the same size. *D. bulbifera* was purchased from the Bogor Botanic Gardens collection. The filter paper is produced as sheets, like squares with four cm-long sides.

2.3.2 Extraction of plant material and leri water preparation

D. bulbifera was adequately cleaned, diced, and dried in an oven for 24 to 72 hours at 60 °C. The powdered dry leaves were passed through a sieve with a mesh size of 60. 5 liters of distilled water were used to extract 1 kg of *D. bulbifera* powder over 24 hours. A thick extract is made from the concentrated filtrate that results [17]. While making the actual leri water requires washing rice up to 1 kg at a time in 5 L of water.

2.3.3 The impact of extraction on drywood termites

Testing is based on a modified version of Japan Wood Preserving Association, No. 11 (1) - 1992. The first step is to weigh the paper test sample before it has been impregnated with the extract, removed, drained, and dried by air. The container holding 15 healthy and active termites is then used to test and control samples, and the container is then kept in a dark room for four weeks. After four weeks, termite activity and mortality were tracked every day. Before being tested on termites, the paper is taken from the termites, thoroughly cleaned, and weighed at the same water content [18].

2.3.4 Observation parameter

The dry wood termite mortality, determined using the Equation (1), serves as the test parameter [18] :

$$TM = (\frac{D}{F}) \times 100 \quad (1)$$

Information :
TM = Termite mortality (%)
D = The amount of termites that have died
F = Amount of termites before feeding

The formula is used to compute weight loss (Equation 2).

$$WR = [\frac{W1-W2}{W1}] \times 100 \quad (2)$$

Information :
WR= Weight reduction (%)
W1 = Air dry weight of filter paper before feeding (g)
W2 = Air dry weight of filter paper after feeding (g)

The formula computes the degree of filter paper damage (Equation 3).

$$Dd = [\frac{RWa}{RBta}] \times 100 \quad (3)$$

Information :
Dd = Degree of damage (%)
RWa = The preserved test sample weighed less (%)
RWta = Loss of weight in the control or unpreserved test samples (%)

Table 1 equates to the degree of damage's value [18].

Table 1. The degree of damage scale concerning control

Value-based weight loss (%) in comparison to the control	Attack class
0	No attack
≤ 10	Ligh
11-30	Currently
31-60	Heavy
≥ 60	Very heavy

2.4 Experiment method

The research design used was a factorial Completely Randomized Design (CRD) consisting of nine treatments with three replications. The treatment is a combination of concentration and source of extract. The extracts are from each part of the *Dioscorea bulbifera* L plant (leaves, stems, and tubers) and leri water. The combination of extract concentrations used is leaves: stems, leaves: tubers, leaves:leri water, tubers: stems, stems:leri water, and tubers:leri water of *D. bulbifera* with concentrations of 50: 50%, leri water with concentrations 50 and 100%.

2.5 Data analysis

The data was examined using a descriptive approach and a variance (F) test with a 5% significance threshold. If the F test revealed a significant effect, additional tests were conducted using Duncan's multiple distance test (Duncan Multiple Range Test/DMRT) at a 5% absolute level. Statistical Tool for Agricultural Research (STAR 2.0.1) and Microsoft Excel were used to analyze the data. It is required to modify it using the Abbott formula if mortality is discovered in the control group, which ranges from 5 to 20%.

3 Results and discussion

3.1 Effect of the combination of *Dioscorea bulbifera* L. extract and leri water as a bio-insecticide

Termites are the most crucial pest economically because they significantly destroy home and agricultural resources. We are looking for environmental safety because chemical termiticides are still being utilized. This research has demonstrated the effectiveness of combining Aquadest extracts from *D. bulbifera* and water leri as biocontrol agents (bio-insecticides) against dry wood termites. Analysis of variance results shows that dry wood termites' mortality, degree of damage, and weight loss (*Cryptotermes cyanocephalus* Light.) are significantly influenced by the dose and source combination of *D. bulbifera* extracts (Table 2). It was anticipated that the *D. bulbifera* and water leri aquadest extracts would have more phenolic, alkaloid, and flavonoid components [9, 10, 17]. These phytochemicals affect an insect's behavior and ability to feed, grow, molt, and reproduce [22-23]. Termites can die in large numbers from several plant chemicals. Their method of action on the insect nervous system is related to this condition [19]. Additionally, plant substances may behave neurotoxic (hyperactivity, seizures, and tremors) [20].

The mechanism of termite death is due to these extractive substances, which can kill flagellate protozoa, bacteria that live in the hindgut of termites. According to Sumartini et al., in the gut of the termite *Macrotermes* sp, there are *Enterobacter aerogens*, *Enterobacter cloacae*, *Serraisa bacteria*, Marcescens and *Paracoccus yeei*[21]. These bacteria are symbionts that produce cellulase enzymes that digest cellulose and convert it into simple sugars and acetic acid as an energy source for termites. As a result, the termites do not get food, and the termites die. In addition, the death of termites is thought to be due to the presence of alkaloid, phenolic, and steroid compounds. Phenolic contains a polyphenol structure, so the mechanism of action as an antibacterial is similar to the properties of phenol, which denatures proteins. Tannin compounds found in *D. bulbifera* [17] will react with proteins that cause inhibition of the work of protease enzymes so that they cannot dissolve in the air. This condition makes it more difficult for protein to be reached by digestive juices, so it affects the digestive system and can reduce growth rates, weight loss, and symptoms of impaired nutrient absorption [22].

In this regard, bioactive substances are a much safer alternative that can be used to control termites. Plant extracts are being researched for various purposes, such as insecticidal, repellant, and antifeedant qualities [23]. Since they drive away pests by awakening their sense organs before they attack the plants, plant-based repellents are predicted to have the least detrimental environmental effects. They are also swiftly and efficiently degraded [24]. These investigated plants' byproducts, notably *D. bulbifera*, can be effectively used to make phytochemicals that can be used to protect all nontarget creatures from insecticides. Complex combinations of secondary metabolites have been suggested to function as regulators of plant defense and provide a variety of methods of action; as a result, their use lessens the possibility that insects may develop resistance [30-31]. For the safety of human and animal health, numerous studies using plant extracts in farming and home pest management have produced encouraging findings [32-33]. As a result, switching to bio-pesticides in place of synthetic insecticides has become a widely recognized and effective strategy.

It is widely recognized as a biorational strategy to replace synthetic bio-rational insecticides. It is widely recognized as a bio-rational strategy to replace synthetic pesticides with bio-rational ones [23]. As insecticides, they can be effective against termites and other arthropods in managing and replacing the widespread use of insecticides in the environment [25]. Chemical defense in plants holds this promise. Rational botanical pesticides have recently gained popularity regarding their use and termite control.

Table 2. Recapitulation of the treatment's impacts on many variables, such as weight loss, the degree of the damage, and termite mortality

Treatment	Parameters		
	Weight loss	Degree of damage	Termite mortality
Combination of concentration and source of extract	*	*	ns

Note: * = significantly different (F 0.05) ns = not significantly different (F >0.05)

3.2 Termite mortality

A single treatment of 50% leri water showed the highest percentage of termite mortality, which was 75.56% (Table 3). This result is because the chlorine content contained in rice water is usually used as a germ killer and termite. Chlorine will react with water to form hypochlorous acid, whose reaction is known to damage the cells in the termite body and attack the intestines. Damaged termite intestines can result in termites dying [14]. In addition, the rice that is generally consumed is white rice, which has pigments or dyes belonging to the flavonoid group, which are commonly used to eradicate termites [13]

Table 3 shows that the highest proportion of mortality was in the tuber: leaf treatment (1:1), which was 77.8%, based on the results of termite mortality. The content of secondary metabolites found in tubers and leaves is suspected to influence termite mortality strongly [9-10]. The single treatment results conducted by Oksari et al. show that tubers provide the smallest percentage of mortality compared to leaves[8]. However, combining these parts has a significant effect compared to when applied in a single treatment. This result can also be seen from the results obtained; termite mortality in single extracts of *D. bulbifera* stems is lower than when combined with leri water. The combination effect with leri water gives the highest percentage in the stem: water leri treatment (1:1), equal to 62.22%. In addition, several single treatments carried out by [8]showed that at the same concentration (50%) showed low mortality compared to the combination of *D. bulbifera* and *D. bulbifera* sections with leri water . These findings also align with research on *A. sativum* treatments alone, which have been shown to be more toxic than other treatments alone at both dosage rates. The effectiveness of botanical pesticide combinations has been the subject of certain investigations. It would be difficult for pests to develop resistance to more than two botanical combinations. This finding is consistent with Cynthia et al. research; which demonstrated that *M. bellicocus* may be controlled using any plant extract that was tested for termiticidal activity [26]. Based on the experiment results, it was found that the combination of *Z. officinale* + *A. sativum* was the most efficient (biopotential) extract at a 10–30% concentration test after 24–72 hours and effectively repelled most insects. When compared to the mortality brought on by diazinon, the mixture of *Z. officinale* + *A. sativum* produced the most deaths. In contrast, *D tripetala* was found to have the lowest fatality rate when used alone.

Bio-insecticides from *D. bulbifera* and water leri are thought to contain contact and stomach poison. Insecticides classified as contact poisons will enter the body of the target insect through the skin (cuticle), trachea, sensory glands, and other organs associated with the cuticle. The active compounds in vegetable insecticides will dissolve the fat or wax coating on the cuticle, causing the active ingredients to penetrate the insect's body. Poisoning symptoms arise due to the accumulation of acetylcholine, characterized by the emergence of disorders of the motor nervous system, seizures, and respiratory paralysis to cause death. Insecticides that work as stomach poisons kill target insects if ingested and enter the digestive organs. Insecticides will be absorbed by the walls of the food digestive tract and then carried by body fluids to target organs such as the insect's central nervous system, respiratory organs, stomach, and so on [27].

The least harmful impacts on the environment are anticipated from plant-based repellents since they deter pests by awakening their sensory systems before attacking the plants and are quickly degraded [29, 37]. Because they drive pests by stimulating their sense organs before the damage is done to plants, plants with repellent effects have little to no adverse environmental effects when employed for pest management. These plant extracts are biodegradable, affordable, and simple to prepare, making them potential replacements for synthetic insecticides in termite management techniques. The water extract may have an effect by contacting the insects' body walls. These substances may enter the insect's body system and obstruct average growth, leading to termite mortality. The results of [28], who assessed the antifeedant, toxicant, and growth-regulating effects of acetone leaf extracts of *Curcuma longa* and *A. sativum* against adults of *T. castaneum*, also agree with this conclusion.

According to Cynthia et al, African agriculture has long used plant parts and derivatives to control insect pests of stored goods, vegetables, soil, and human properties [26]. This result suggests that naturally occurring anti-termite compounds extracted from locally accessible plants have the potential to control the population of termites. The results of numerous studies on the use of plant extracts for agricultural and domestic pest management are encouraging for the preservation of both human and animal health [32, 33, 39]. Therefore, switching to bio-pesticides instead of synthetic insecticides has become a widely accepted and sensible strategy and is recommended.

Table 3. Test of the impact of treatment recapitulation on termite mortality

Treatment	**Termite Mortality (%)** **F= 0.99; p=0.4732**
Control	31.11 ± 21.44
Water Leri 50%	75.56 ± 21.44
Water Leri 100%	68.89 ± 21.44
Leave : Water Leri (1:1)	57.78 ± 21.44
Leave : Stems (1:1)	53.33 ± 21.44
Stems : Water Leri (1:1)	62.22 ± 21.44
Tubers : Water Leri (1:1)	42.22 ± 21.44
Tubers : Leaves (1:1)	77.78 ± 21.44
Tubers : Stems (1:1)	57.78 ± 21.44

Note: There is no statistical difference between numbers separated by the same letter at $p < 0.05$ using DMRT

3.3 Degree of damage

Based on the results that can be seen in Table 4, a single treatment of leri water at 50% and 100%, respectively, showed the highest degree of damage, namely 104.01% and 110.96%. Meanwhile, the combination treatment between stem: water leri offered the lowest level of damage, which was 16.47%. Furthermore, the lowest damage level was found in tuber: stems (1:1), which was 13.88%. Meanwhile, the single blow done by [8] showed a high level of damage, namely 54.82% -94.07%. The results obtained are likely caused by the content of metabolites produced in each of these treatments. Insects will face two things to start their feeding activity, namely 1) first, there is a stimulus to initiate feeding activity (feeding stimulant), and 2) detection of the presence of foreign compounds (foreign compounds) that can inhibit feeding activity so that it can shorten or even stop feeding activity. Anti-feeding compounds are substances that, when tested on insects, will temporarily or permanently stop feeding activity depending on the potency of the essence. Compounds that act as anti-food are primarily found in the secondary metabolites of alkaloids, terpenoids, and phenolics [29], and these compounds are found in *D. bulbifera* L. [30]. This result causes the several treatments in this study to obtain low and high levels of damage.

The combination of these treatments increases the effectiveness of the two active substances in controlling *C. cynocephalus*, one of which may be to suppress the condition of the target termites. Economically, the combination treatment can increase the efficiency of termite control because it takes a smaller quantity to get the same control effect. Thus, vegetable insecticides can also be used as an alternative for controlling *C. cynocephalus*, where the application is combined by mixing. This condition is presumably because *D. bulbifera* contains several active ingredients, such as alkaloids capable of providing toxic properties to termites by inhibiting eating [31]. Alkaloids can be an antibacterial by interfering with the constituent components of peptidoglycan in bacterial cells so that the cell wall layer is not formed entirely and causes cell death. In addition, *D. bulbifera* aquadest extract and leri water also contain phenolic and steroid compounds. Phenol, triterpenoid, alkaloid, and steroid compounds are active ingredients as pest control agents. These compounds cause biological activities such as toxic food inhibition, antiparasitic, and pesticides. These active chemicals harm the termites' symbiotic system by eradicating bacteria and flagellate protozoa in termite intestines [21].

Botanicals are non-toxic, safe for the environment, renewable, and biodegradable, albeit some are not as effective as chemicals. However, the extensive use of chemical insecticides frequently results in hazards of insect resistance development and residues that harm both people and the environment. Consequently, botanical insecticides, based on natural plant components, will become a potential use. These products are selective, effective, and toxicologically safe. Many reports have demonstrated the effectiveness of natural chemicals against insects [32].

Table 4. Recapitulation test measuring the degree of damage and the impact of treatment

Treatment	Degree of damage (%) (F= 21.96; p=0.0000)
Control	$100.00^{abc} \pm 11.87$
Water Leri 50%	$104.01^{ab} \pm 11.87$
Water Leri 100%	$110.96^{a} \pm 11.87$
Leave : Water Leri (1:1)	$61.04^{cd} \pm 11.87$
Leave : Stems (1:1)	$14.58^{e} \pm 11.87$
Stems : Water Leri (1:1)	$16.47^{e} \pm 11.87$
Tubers : Water Leri (1:1)	$66.74^{bcd} \pm 11.87$
Tubers : Leaves (1:1)	$49.52^{de} \pm 11.87$
Tubers : Stems (1:1)	$13.88^{e} \pm 11.87$

Note: There is no statistical difference between numbers separated by the same letter at $p < 0.05$ using DMRT

3.4 Test weight loss

The single treatment of leri water at 50% and 100%, respectively, showed the highest test weight reduction, 52.82%, and 56.38%. Meanwhile, the combination treatment between stem: water leri offered the lowest test weight reduction, 8.34%. Furthermore, the lowest test weight loss was found in tuber: stems (1:1), which was 6.87% (Table 5). Meanwhile, the single treatment carried out by Oksari et al showed a high reduction in test weight, which was 29.73% - 47.95% [8]. The compound content contained in the treatment provides a feeding inhibition for termites, thereby affecting termite feeding activity. Low weight loss of the bait medium indicates a high level of feeding activity inhibition. At first, termites will adapt to the living environment, so termite feeding activity is still low. If forced, termites will eat the food provided. If termites cannot adjust to the live environment provided, the termites will die. Termites that can adapt to the living environment provided will carry out feeding activities.

The amount of media weight loss at the feeding is used as an indicator to see the toxicity of *D. bulbifera* and water leri. The value of the feed media's ability to promote weight reduction decreases as *D. bulbifera* extract and leri water are added in more significant quantities. Compared to bait media that didn't receive the extract (the control), this result demonstrates that the rate of termite ingestion of the provided bait media is low. This circumstance fits the research findings [33]. The treatment of the highest loss of media feed weight was in the combination of control and sawdust, with an average loss of 28.76%, while the treatment of the lowest weight loss of feed media was in the powder treatment. 4 g of soursop leaves and 10 g of sawdust, with an average weight loss of 9.99% of the feed medium. This result indicates that it is suspected that there is a compound that inhibits dry wood termites from eating the bait. Some plants can repel insects by making them avoid the crops because of their taste or fragrance, while others influence insects' oviposition behavior by preventing them from laying eggs [1]. The plants may also reduce calling behavior and growth by acting as antifeedants and inhibitors. The most crucial factor in the search for novel and safer pest control techniques is feeding inhibition in insect pests [34].

The scale of damage severity concerning control (Table 1), the findings of this study were categorized as belonging to the mild to severe attack category. This result appears to be because the compounds used in each treatment differ, changing how termites are attacked. According to many authors, an antifeedant is anything that stops an insect from consuming as much. Antifeedants were categorized as behavior-modifying compounds by Isman et al. due to their direct impact on insect taste organs [35]. This definition excludes toxins that are toxic to insects at levels below lethal or compounds that prevent an insect from feeding by disrupting its nervous system.

Related investigations demonstrated that botanical powder treatment served as an oviposition-deterrent, prevented oviposition, and decreased egg production by weakening adult bruchids, killing the hatchling larvae [34]. In a related study, several investigations showed the ability of botanical insecticides to lower the production of F1 progeny in various insects. However, a botanical combination that works synergistically to control insects has not yet been thoroughly investigated [36]. The toxicity of phytochemical compounds or plant crude extracts against insects manifests itself in several ways, including altering behavior, acting as a repellent substance, preventing growth, preventing oviposition, preventing eating, reducing fecundity and fertility, engaging in fumigation activity, and forming a mulch barrier [37]. Various formulations of organochlorines and organophosphates, as well as other synthetic insecticides with long environmental retention times, are the mainstays of termite control. As a result, it's essential to look for sensible termite control methods, including botanical extracts, which can be both secure and kind to the environment. Insecticidal, repellant, or antifeedant properties have been reported for various plant-based chemicals against termites and other insect pests [38]. It is possible to utilize single or combined botanical pesticides. Vegetable insecticide action has a more significant anti-pest effect due to its synergistic potential in hybrid form. The two main objectives are using less insecticide and making it difficult for resistance to develop [39].

Table 5. Recapitulation test of the therapy's effect on weight loss

Treatment	Weight loss (%) F= 12.93; p=0.0000
Control	51.67 ± 7.90^{ab}
Water Leri 50%	52.82 ± 7.90^{ab}
Water Leri 100%	56.38 ± 7.90^{a}
Leave : Water Leri (1:1)	32.48 ± 7.90^{abcd}
Leave : Stems (1:1)	7.89 ± 7.90^{d}
Stems : Water Leri (1:1)	8.34 ± 7.90^{cd}
Tubers : Water Leri (1:1)	35.76 ± 7.90^{abc}
Tubers : Leaves (1:1)	26.10 ± 7.90^{bcd}
Tubers : Stems (1:1)	6.87 ± 7.90^{d}

Note: There is no statistical difference between numbers separated by the same letter at $p < 0.05$ using DMRT.

4 Summary

The findings revealed that the combination had the best mortality, test weight reduction, and degree of damage found in the variety of stem (50%): leri water (50%), which were 62.22% (equal to corrected mortality of 45.16%), 8.34%, 16.47%, respectively. The combination of these extracts efficiently inhibits dry wood termites, according to this result.

The study was supported by the Indonesian Ministry of Education, Culture, Research, and Technology under grant number 074/E5/PG.02.00.PL/2023 for Penelitian Kerjasama Antar Perguruan Tinggi (PKPT).

References

1. N. H. Bakaruddin, H. Dieng, S. F. Sulaiman, & A. H. Ab Majid, Evaluation of the toxicity and repellency of tropical plant extract against subterranean termites, Globitermes sulphureus and Coptotermes gestroi. *Information Processing in Agriculture*, **5** (2018) 298–307. https://doi.org/10.1016/j.inpa.2018.03.004.
2. J. K. A. Lima, E. L. D. Albuquerque, A. C. C. Santos, A. P. Oliveira, A. P. A. Araújo, A. F. Blank, M. de F. Arrigoni-Blank, P. B. Alves, D. de A. Santos, & L. Bacci, Biotoxicity of some plant essential oils against the termite Nasutitermes corniger (Isoptera: Termitidae). *Industrial Crops and Products*, **47** (2013) 246–251. https://doi.org/10.1016/j.indcrop.2013.03.018.
3. N. Subekti, P. Widiyaningrum, I. Nurvaizah, & R. Mar'ah, Effective Control of Subterranean Termite Coptotermes curvignathus Using n-Hexane and Ethyl Acetate From Gaharu. *Systematic Reviews in Pharmacy*, **10** (2019) 31–33.
4. E. Matisová & S. Hrouzková, *Analysis of endocrine disrupting pesticides by capillary GC with mass spectrometric detection* (2012). https://doi.org/10.3390/ijerph9093166.
5. A. I. Giraldo-Rivera & G.-E. Guerrero-Alvarez, Botanical biopesticides: research and development trends, a focus on the Annonaceae family. *Revista Colombiana de Ciencias Hortícolas*, **13** (2019) 371–383. https://doi.org/10.17584/rcch.2019v13i3.9489.

6. A. Hutama S, Y. Pangestiningsih, & L. Lisnawita, Pengaruh Beberapa Jenis Termitisida Dalam Mengendalikan Rayap (Captotermes Curvignathus Holmgren) Di Laboratorium. *Agroekoteknologi*, **3** (2015) 876–882.
7. P. Purnomo, B. S. Daryono, R. Rugayah, & I. Sumardi, Studi Etnobotani Dioscorea spp. (Dioscoreaceae) dan Kearifan Budaya Lokal Masyarakat di Sekitar Hutan Wonosadi Gunung Kidul Yogyakarta. *Jurnal Natur Indonesia*, **14** (2013) 191. https://doi.org/10.31258/jnat.14.3.191-198.
8. A. A. Oksari, D. Susanty, F. H. Rizki, I. F. Wanda, Arinana, & Dadang, Potential of Dioscorea bulbifera L. as a bioinsecticide in controlling dry wood termites (Cryptotermes cynocephalus Ligh.). *International Conference on Modern and Sustainable Agriculture (ICOMSA)*, (2023). https://doi.org/10.1088/1755-1315/1133/1/012046.
9. S. W. Handayani, H. Boesri, & H. Priyanto, Potensi Umbi Gadung (Dioscorea hispida) dan Daun Zodia (Euodia suaveolens) sebagai Insektisida Nabati. *Media Litbang Kesehatan*, **27** (2017) 49–56.
10. I. W. Darmanto, D. Supriyatdi, & A. Sudirman, Pengendalian Ulat grayak (Spodoptera litura F .) dengan Ekstrak Ubi Gadung dan Ekstrak Buah Maja (Armyworm [Spodoptera litura F .] Management using Dioscorea Tuber and Aegle Fruit Extract). *Jurnal Agro Industri Perkebunan*, **7** (2019) 23–30.
11. Muhidin, R. Muchtar, & Hasnelly, Pengaruh Insektisida Nabati Umbi Gadung terhadap Wereng Batang Cokelat (Nillavarpata lugens Stall) Pada Tanaman Padi. *Jurnal Ilmiah Respati*, **11** (2020) 62–68.
12. M. Hasanah, I. M. Tangkas, & J. Sakung, Daya Insektisida Alami Kombinasi Perasan Umbi Gadung (Dioscorea hispida Dennst) dan Ekstrak Tembakau (Nicotiana tabacum L). *Jurnal Akademika Kimia*, **1** (2012) 166–173.
13. J. Mangiri, N. Mayulu, & S. E. S. Kawengian, Gambaran Kandungan Zat Gizi Pada Beras Hitam (Oryza sativa L.) Kultivar Pare Ambo Sulawesi Selatan. *Jurnal eBiomedik*, **4** (2016) 2–6. https://doi.org/10.35790/ebm.v4i1.11050.
14. F. A. M. Miftah, A. N. Khalisah, Hamia, Masita, & U. Chalsum, Efektivitas Daun Sirih (Piper betle L.) dan Air Leri terhadap Mortalitas Rayap Tanah (Coptotermes sp.). *Indonesian Journal of Fundamental Sciences (IJFS)*, **5** (2019) 67–72.
15. A. M. Ulfa, Penetapan Kadar klorin (Cl2) Pada Beras Menggunakan Metode Iodometri. *Jurnal Kesehatan Holistik*, **9** (2015) 197–200.
16. O. E. Oladipo-nee Ajayi, E. A. Oyeniyi, & O. A. Elijah, Synergism of three botanical termiticides as wood protectants against subterranean termites, Macrotermes subhyalinus (Rambur, 1842). *The Journal of Basic and Applied Zoology*, **81** (2020). https://doi.org/10.1186/s41936-020-00149-z.
17. A. A. Oksari, I. F. Wanda, G. Ayu, & P. Kusumah, Alelopati Tumbuhan Invasif Dioscorea bulbifera L. Dan Pengaruhnya Terhadap Perkecambahan Biji Shorea selanica (Lam.) Blume. **14** (2021) 101–114.
18. A. Azis, T. A. Prayitno, S. A. Hadikusumo, & M. Santoso, UJI EKSTRAK ETANOL KUMIS KUCING (Orthosiphon sp.) SEBAGAI PENGAWET ALAMI KAYU. *Jurnal Ilmu Kehutanan*, **8** (2013) 48–56.
19. L. S. A. Mayra, S. O. Angelica, A. R. Allane, S. C. Gabriel, B. S. Luciana, H. G. L. Joatildeo, & E. C. Fabiana, Antitermitic activity of plant essential oils and their major constituentsagainst termite Heterotermes sulcatus (Isoptera: Rhinotermitidae). *Journal of Medicinal Plants Research*, **9** (2015) 97–103. https://doi.org/10.5897/jmpr2014.5695.

20. M. Z. M. Salem, M. F. Ali, M. M. A. Mansour, H. M. Ali, E. M. Abdel Moneim, & A. Abdel-Megeed, Anti-termitic activity of three plant extracts, chlorpyrifos, and a bioagent compound (Protecto) against termite Microcerotermes eugnathus silvestri (blattodea: Termitidae) in Egypt. *Insects*, **11** (2020) 1–15. https://doi.org/10.3390/insects11110756.
21. N. Sumartini, M. A. Wibowo, & A. Jayuska, Uji Bioaktivitas Ekstrak Daun Kesum (Polygonum minus Huds) Sebagai Biotermitisida Rayap Tanah Macrotermes sp. *Jkk*, **4** (2015) 26–29.
22. N. Liansyah, A. Rusdy, & Hasnah, Pengaruh Campuran Ekstrak Serai Wangi dan Kulit Bakau terhadap Mortalitas dan Perkembangan Crocidolomia pavonana (F .) Influence of mixture of Fragrant Lemongrass Extract and Mangrove Bark toward mortality and Developmental Crocidolomia pavonana (F .) P. *Jurnal Ilmiah Mahasiswa Pertanian Unsyiah*, **3** (2018) 1–9.
23. K. Z. Rasib, A. Arif, A. Aihetasham, & D. A. Alvi, Bioactivity of Some Plant Extracts Against Termite Odontotermes obesus (Rambur) (Blattodea: Termitidae). *Journal of Biodiversity, Bioprospecting and Development*, **04** (2017). https://doi.org/10.4172/2376-0214.1000167.
24. C. L. Céspedes, J. R. Salazar, A. Ariza-Castolo, L. Yamaguchi, J. G. Ávila, P. Aqueveque, I. Kubo, & J. Alarcón, Biopesticides from plants: Calceolaria integrifolia s.l. *Environmental Research*, **132** (2014) 391–406. https://doi.org/10.1016/j.envres.2014.04.003.
25. S. Ahmed & M. Qasim, Foraging and Chemical Control of Subterranean Termites in a Farm Building at Faisalabad, Pakistan. *Pakistan Journal of Life and Social Sciences*, **9** (2011) 58–62.
26. O. C. Cynthia, O. Precious, O. S. Lynda, & C. C. Ojianwuna Cynthia, The toxicity and repellency of some plant extracts applied as individual and mixed extracts against termites (Macrotermes bellicosus). *~ 406 ~ Journal of Entomology and Zoology Studies*, **4** (2016) 406–418.
27. M. Kamelia, S. Zein, F. Supriyadi, & D. N. Chomsyah, Kombinasi Ekstrak Cymbopogon nardus L. dan Nicotiana tabacum Sebagai Insektisida Nabati Helopeltis antonii Sign. *Agriprima : Journal of Applied Agricultural Sciences*, **4** (2020) 128–135. https://doi.org/10.25047/agriprima.v4i2.377.
28. S. Ali, M. Sagheer, M. ul Hassan, M. Abbas, F. Hafeez, M. Farooq, D. Hussain, M. Saleem, & A. Ghaffar, Insecticidal activity of turmeric (Curcuma longa) and garlic (Allium sativum) extracts against red flour beetle, Tribolium castaneum: A safe alternative to insecticides in stored commodities. *~ 201 ~ Journal of Entomology and Zoology Studies*, **2** (2014) 201–205.
29. R. E. Septian, Isnawati, & E. Ratnasari, Pengaruh Kombinasi Ekstrak Biji Mahoni dan Batang Brotowali terhadap Mortalitas dan Aktivitas Makan Ulat Grayak pada Tanaman Cabai Rawit. *Lentera Bio*, **2** (2013) 107–112.
30. A. A. Oksari, D. Susanty, & I. F. Wanda, Allelopathic effect of invasive species air potato (Dioscorea bulbifera) on seeds germination of Polyalthia littoralis. *Nusantara Bioscience*, **11** (2019) 63–70. https://doi.org/10.13057/nusbiosci/n110111.
31. Zulkahfi, S. Suparmin, S. Suparmin, & A. Arif, Pengendalian Serangan Rayap Tanah Coptotermes sp . Menggunakan Ekstrak Daun Belimbing Wuluh. *Hasanuddin Student Journal*, **1** (2017) 1–8.
32. G. Elango, A. Abdul Rahuman, C. Kamaraj, A. Bagavan, A. Abduz Zahir, T. Santhoshkumar, S. Marimuthu, K. Velayutham, C. Jayaseelan, A. V. Kirthi, & G.

Rajakumar, Efficacy of medicinal plant extracts against Formosan subterranean termite, Coptotermes formosanus. *Industrial Crops and Products*, **36** (2012) 524–530. https://doi.org/10.1016/j.indcrop.2011.10.032.

33. T. E. Sari, M. Turnip, F. Diba, P. S. Biology, F. Mipa, U. Tanjungpura, J. Prof, & H. H. Nawawi, Pemanfaatan Daun Sirsak (Annona muricata L .) pada Media Umpan sebagai Pengendali Rayap Tanah (Coptotermes curvignathus Holmgren). *Jurnal Protobiont*, **3** (2014) 71–74.
34. Tegegne B, Combination Effect of Different Insecticide Plants Against Acanthoscelides obtectus (Coleoptera: Bruchidea): Storage Pests of Common Bean (Phaseolus vulgaris). **8** (2017). https://doi.org/10.4172/2471-2728.1000192.
35. M. B. Isman, Isman1990. (1990) 1406–1411.
36. K. D. Ileke & M. O. Oni, Toxicity of some plant powders to maize weevil, Sitophilus zeamais (motschulsky) [Coleoptera: Curculiondae] on stored wheat grains (Triticum aestivum). *African Journal of Agricultural Research*, **6** (2011) 3043–3048. https://doi.org/10.5897/AJAR11.622.
37. S. Sudrajat, W. Kustiawan, D. Mardji, & I. W. Kusuma, Chemical Composition and Termicidal Activity of Scorodocarpus Borneensis Becc Bark Extracts. *Journal of Advanced Scientific Research*, **9** (2018) 24–30.
38. M. S. Akbar, M. Aslam, M. R. Khalid, S. Iqbal, M. Luqman, & M. Z. Majeed, Comparative Toxicity of Methanolic Extracts of some Indigenous and Exotic Flowers against Subterranean Termites Odontotermes obesus (Isoptera: Termitidae). *Pakistan Journal of Agricultural Research*, **32** (2019) 636–641. https://doi.org/10.17582/journal.pjar/2019/32.4.636.641.
39. R. Wulansari, Y. Hidayat, & D. Dono, Aktivitas Insektisida Campuran Minyak Mimba (Azadirachta indica) dan Minyak Jarak Kepyar (Ricinus communis) terhadap Spodoptera frugiperda. *Agrikultura*, **32** (2021) 207. https://doi.org/10.24198/agrikultura.v32i3.35174.