Acta Entomology and Zoology

E-ISSN: 2708-0021
P-ISSN: 2708-0013
www.actajournal.com
AEZ 2024; 5(2): 233-238
Received: 17-09-2024
Accepted: 24-10-2024

Ingle HD
P.G., Department of Zoology, Deogiri College, Chhatrapati Sambhajinagar, Maharashtra, India

Pardeshi AB
P.G., Department of Zoology, Deogiri College, Chhatrapati Sambhajinagar, Maharashtra, India

Corresponding Author:
Ingle HD
P.G., Department of Zoology, Deogiri College, Chhatrapati Sambhajinagar, Maharashtra, India

Bioefficacy of methanol and aqueous extract of *Ricinus communis* L. against Indian white termite, *Odontotermes obesus* (Isoptera: Termitidae)

Ingle HD and Pardeshi AB

DOI: https://doi.org/10.33545/27080013.2024.v5.i2c.177

Abstract
The Indian white termites are one of the most devastating insects and severely damage to agricultural crop and wooden structure. The chemical pesticides are not safe and crucial impact on environment. Therefore, the bio-efficacy of termiticidal potential of methanol and aqueous leaves extract of *Ricinus communis* Linn. Were studied against Indian white termites, *Odontotermes obesus.* The plant leaves were dried, powdered and extracted with methanol and aqueous solvent in soxhlet apparatus for 24 hrs. The 20 termites were exposed to various concentrations of methanol leaves extracts (7.5 8.0, 8.5, 9.0, and 9.5 mg/ml) and aqueous leaves extracts (10.0, 10.5, 11.0, 11.5, and 12.5 mg/ml) of *Ricinus communis* and percent mortality were recorded after 24 hrs.
The termiticidal activity of leaves extract of *Ricinus communis* were (LC_{10}= 7.5370 mg/ml, LD_{50}= 8.6238, LC_{90}=9.8679 mg/ml) in methanol and (LC_{10}= 10.016, LC_{50}= 11.355, LC_{90}=12.662 mg/ml) in aqueous solvent respectively. Results revealed that the mortality was increased with increasing in concentration of the plant extracts.
The methanol extract of *Ricinus communis* showed termiticidal potential against *Odontotermes obesus*, (LD_{50}: 8.6238 mg/ml). The statistical analysis, variance, 95% confidence intervals, and regression equations to support these findings.

Keywords: Termiticide, *Odontotermes obesus*, *Ricinus communis*

Introduction
The Indian white termite, *Odontotermes obesus Ramb*., is a highly destructive polyphagous pest that constructs large mounds and primarily consumes cellulose-based materials, including a wide variety of substances rich in carbohydrates.
This termite species inflicts significant economic damage to various materials, including commercial wood, cellulose fibers, paper products, textiles, and wooden construction materials. It also poses a threat to green foliage and stored grains in warehouses. Traditionally, chemical insecticides like chlorodane, cypermethrin, hydroquinone, and indoxacarb have been employed to manage termite populations. However, these chemicals often have long-lasting effects and can be harmful to the environment, humans, and beneficial organisms. Therefore, it is crucial to explore alternative control strategies, such as physical barriers, cultural practices, and the use of organic and eco-friendly substances for effective termite management.
As awareness of the risks linked to synthetic pesticides grows, there is an increasing demand for effective alternative methods for termite control. Farmers are turning to various plant materials to safeguard their crops from termite infestations. Natural products, whether in their raw form or as extracts, offer significant potential as termiticides. Plant-derived pesticides are environmentally friendly, pose minimal toxicity to non-target organisms, are biodegradable, and do not contribute to the development of pesticide resistance. (Liu *et al.*, 2000) [17].
Plants are rich sources of natural substances that can be utilized in the development of environmentally safe methods for insect control (Sadek, 2003) [34]. A broad range of plants are toxic, repellent, or have some antifeedant properties several of which were regarded as insecticides (Blaske and Hertel, 2001; Ganapaty *et al.*, 2004, Boulogne *et al.*, 2012; Raina *et al.*, 2012; Addisu *et al.*, 2014) [2, 6, 7, 13, 32]. Kasseney *et al.*, (2016) [16] studied the effect of plant extracts on the survival rate of termites, *Macrotermes subhyalinus* and *Trinervitermes*

geminatus (Wasmann). Upadhyay *et al.*, (2010, 2012) [42, 43]. reported the efficacy of *Capparis deciduas* and its mixtures against *Odontotermes obesus*. Osipitan and Oseyemi (2012) [27]. have evaluated the insecticidal effect of three plant extracts including *Citrus sinensis*, *Theobroma cacao*, *Tithonia diversifolia* and *Anacardium occidentale*, against *Macrotermes bellicosus*. They found that the aqueous extract of these plants not only caused the mortality of tested termites, but also showed an important repellency to them. The repellent effect of extracts from few tropical plants on termite has also been reported (Maistrello *et al.*, 2011; Osipitan *et al.*, 2013 and Acda, (2014) [1, 19, 28,]. Patel and Narasimhacharya (2017) [30] examined the anti-termite potential of four plant species namely, *Achyranthes asapera*, *Sida acuta*, *Syzygium cumini* and *Terminalia arjuna* against *Odontotermes obesus.* Nagare and Pardeshi (2019a; 2019b) [23, 24]. studied the anti-termite potential of plant extracts of *Semicarpus anacardium* and *Argemone mexicana* against Indian white termite, *Odontotermes obesus.* Bio-termiticidal potential of *Jatropha gossypifolia* and *Datura metel* plant extracts was reported against *Odontotermes obesus* (Ingle and Pardeshi 2024; Shinde and Pardeshi 2024) [14, 39].

This paper presents the findings of the bioefficacy of methanol and aqueous extracts of *Ricinus communis* against Indian white termite, *Odontotermes obesus.*

Ricinus communis Linn. Belongs to family Euphorbiaceae. It is cultivated in tropical and subtropical regions worldwide. *Ricinus communis* is a well-known medicinal plant with wide range of pharmacological potential and useful in hepatoprotective, antifilarial, antioxidant, antiasthmatic and antimicrobial activities. Singh and Geetanjali, (2015) [33]. reviewed the phytochemical and pharmacological investigations of the plant, *Ricinus communis*. The family Euphorbiaceae is the largest family among the Angiosperms. Euphorbiaceae family is rich source of secondary metabolites such as alkaloids, cyanogenic glycosides, diterpenes, glucosinolates, tannins and triterpene. The leaf, root and seed oil of *Ricinus communis* were applied for the treatment of inflammation and liver disorders (Wedin, 1986) [46].

Kombieni *et al.*, (2023) [11]. evaluated the insecticidal activity of *Ricinus communis* L. seed extract against fall armyworm, *Spodoptera frugiperda* under laboratory and field conditions and 50% of maize plant infestation by *Spodoptera frugiperda* were reduced at 200 g/l and 250 g/l concentration of seed extracts.

Wale and Assegie (2015) [20]. recorded the biocidal activity of castor bean oil from *Ricinus communis L*. against *Sitophilus zeamais* and found 2 ml of castor bean oil was sufficient to destroy 50% of the weevils in 1 h after treatment.

Upasani *et al.*, (2003) [40]. showed the potential insecticidal, ovicidal and oviposition deterrent activities of flavonoid isolated from *Ricinus communis L*. against *Callosobruchus chinensis*.

Salem *et al.*, (2017) [26]. assessed the fumigant and repellent toxicities of *Ricinus communis* and *Mentha pulegium* essential oils against two major stored product beetles, *Tribolium castaneum* and *Lasioderma serricorne* and isolated the effective volatile compound 2, 4-bis (dimethylbenzyl)-6-t-butylphenol of castor essential oil.

Goyal *et al.*, (2005) [4]. showed the vapor toxicity and repellent activity of purified fractions and acetone leaves extracts of *Ricinus communis* against two pest of store product, *Callosobruchus chinensis* and *Tribolium castaneum* and 100% mortality found after 72 hours of treatment.

There are no reports available on the biological activities of *Ricinus communis* against Indian white termite, *Odontotermes obesus*.

Therefore, the present study was undertaken to evaluate termiticidal potential of methanol and aqueous leaves extract of *Ricinus communis* Linn. Against Indian white termites, *Odontotermes obesus.*

Materials and Methods

Plant materials

The leaves of *Ricinus communis* were collected from the local area of Chhatrapati Sambhajinagar. The collected leaves were brought to the laboratory and washed three times in tap water and rinsed with distilled water, the excess water was soaked and leaves were separated and dried in shade. The dried leaves material was powdered in domestic grinder and stored in air tight container in refrigerator till further use. From the stock 50 g of powdered was extracted with 1000 ml of methanol and aqueous solvent using Soxhlet apparatus for 24 hrs separately.

Termites

Odontotermes obesus were collected from nearby farms of Chhatrapati Sambhajinagar and brought to the laboratory. Traps were maintained in plastic jar containing moist soil. Active and healthy termites were used for the study within four days after field collection.

Termiticidal bioassay

The termiticidal effects of the plant extracts were tested on termites by using a 'no-choice' feeding test. Various concentration (7.5 to 12.0 mg/mL) of methanol and aqueous solvent extract of *Ricinus communis* were applied to Whatman No. 1 filter papers and allowed to air dry completely and were placed in petri plates under laboratory conditions. These treated filter papers were given as feed and 20 active termites, *Odontotermes obesus* were released in each experimental and control petri plates. Three replications were conducted. The percent mortality was calculated after 24 h and the observed data was subjected to probit analysis (Finney, 1947; Busvine, 1971) [12]. Filter paper treated with solvent alone was used as a control.

Results

The toxic effect of leaf extract of *Ricinus communis* was evaluated against *Odontotermes obesus*. The numbers of dead *Odontotermes obesus* were counted after 24 at (7.5, 8.0, 8.5, 9.0, and 9.5 mg/ml) and (10.0, 10.5, 11.0, 11.5, and 12 mg/ml) doses of methanol and aqueous extract of *Ricinus communis* respectively. The total percent mortality was observed after 24 h, and then the corrected mortality was calculated using Abbott's formula and the results are presented. The results showed that, the mortality increases with increase in concentrations (Figure and Tables).

The results of probit analysis for the estimation of LD_{10}, LD_{50}, LD_{90}, variance, 95% confidence limits and regression equation at 24 h for the mortality of Indian white termite, *Odontotermes obesus* are presented in Table-2.

The termiticidal bioassay in methanol solvent extracts, LC_{10}= 7.5370 mg/ml, LD_{50}= 8.6238, LC_{90}=9.8679 mg/ml and in aqueous extract of *Ricinus communis* was, LC_{10}= 10.016,

LC_{50}= 11.355, LC_{90}=12.662 mg/ml respectively. Among the various estimate of regression based probit analysis, the $\chi 2$ values for the regression coefficients showed homogeneity to the data.

Table 1: Percent mortality of Indian white termite, *Odontotermes obesus* treated with methanol and aqueous leaf extracts of *Ricinus communis* after 24 h

Sr. No.	Dose in mg/ml	No. of insects used	% Mortality (Methanol)	% Mortality (Aqueous)
1.	Control	20	00	
2.	7.5	20	10	
3.	8.0	20	25	
4.	8.5	20	40	
5.	9.0	20	65	
6.	9.5	20	85	
7.	10.0	20	100	05
8.	10.5	20	-	15
9.	11.0	20	-	35
10.	11.5	20	-	55
11.	12.0	20	-	80
12.	12.5	20	-	100

Table 2: LD_{10}, LD_{50} and LD_{90} values with variance, 95% confidence limits and probit analysis parameters of Indian white termite, *Odontotermes obesus* after 24 h of treatment

Solvent	LD_{10}	LD_{50}	LD_{90}	Variance	95%CL		Regression equation	χ^2 (Degree of freedom)
					Lower	Upper		
Methanol	7.5370	8.6238	9.8673	0.002091	0.8462	1.0252	Y= 21.9105x-15.5026	0.2931
Aqueous	10.016	11.355	12.662	0.001470	0.9800	1.1303	Y= 27.0652x -23.5598	3.2158

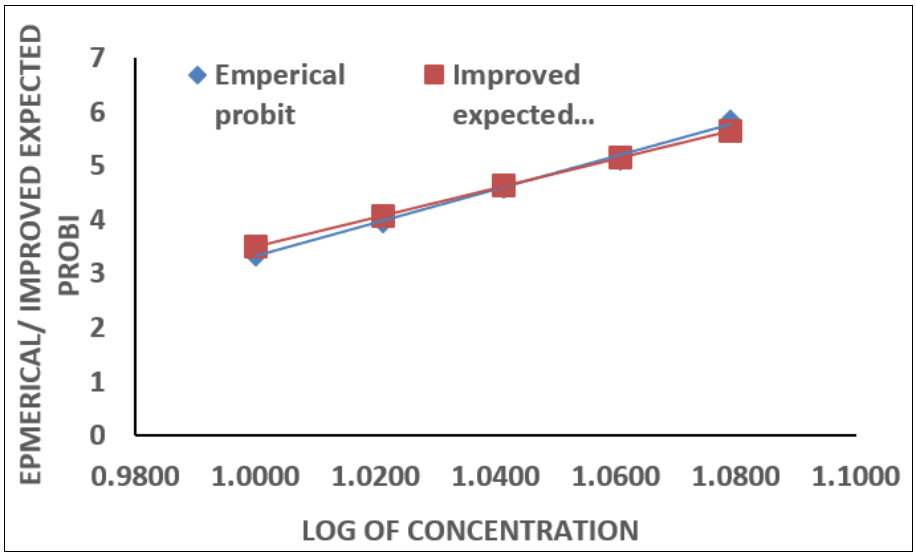

Fig 1: Regression and provisional lines for *Odontotermes obesus* exposed to methanol leaf extract of *Ricinus communis* after 24 h

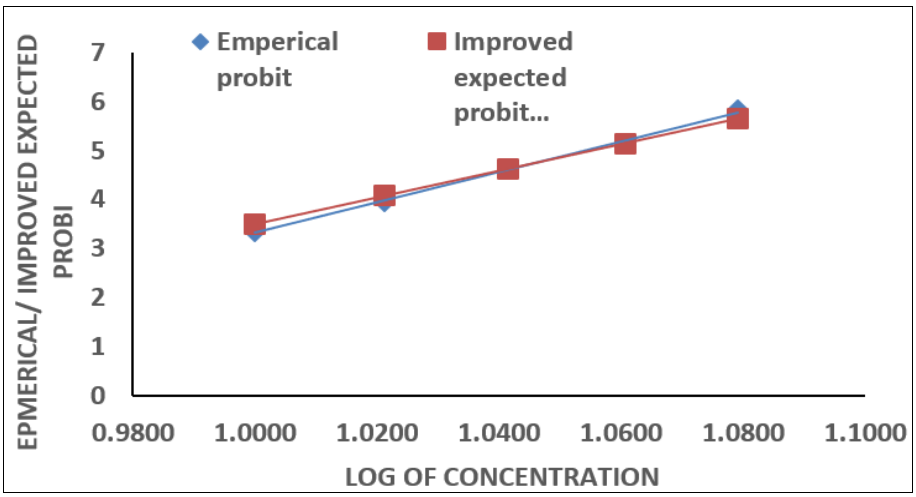

Fig 2: Regression and provisional lines for Indian white termite, *Odontotermes obesus* exposed to aqueous leaf extract of *Ricinus communis* after 24 h

Discussion

The Indian white termite, *Odontotermes obesus*, is a highly destructive pest that inflicts significant economic losses on commercial wood, fibers, paper products, textiles, woolens, and mats. Additionally, it poses a serious threat to agricultural crops and forest resources.

In the present study, we have tried to control termite infestation in the farm ecofriendly by applying methanol and aqueous plant extract of *Ricinus communis*. Our results show that *Ricinus communis* possess bio-termiticide potential.

In insect-plant interactions, insects often have unique adaptation to their host plants in locating and selecting the plants by the use of chemical, visual and mechanical cues (Schoonhoven *et. al*., 1998) [36]. According to Mustaparta (2002) [21]. unsuitable plants are avoided by detection of other chemical cues; such chemical substances may have repellent or toxic properties against insects. In line with this principle, botanical pesticides have been developed and employed for the management of insect pests. The finding showed the crude extracts from the leaves, stems, roots, and seeds of various plant species exhibit antifeedant, insecticidal, and growth-inhibitory properties. (Ekesi 2000) [9].

Ajedani (2023) [8] evaluated the termiticidal activity of *Allium sativum, Syzygium aromaticum, Lavandula latifolia, Cinnamomum verum* and *Origanum vulgare* against the termites, *Reticulitermes* spp. and the corresponding LC_{50} values were 17.274, 17.84, 18.823, 23.706, and 25.483 µL/L. Recorded $\chi 2$ values were 0.0322, 0.4688, 0.5364, 0.7074, and 1.54, respectively. Sharma *et al.*, (1990) [37]. examined the insecticidal value of castor oil plant, *Ricinus communis* for controlling the termites and their damage wood of *Mangifera indica* and *Pinus longifolia*.

Sharma *et al.*, (2011) [35]. evaluated the termiticidal potential of non-edible seedcakes of Jatropha, Karanja, Neem and Mahua plant and their active omponents, phorbol esters, karanjin, saponins and azadirachtin in *vitro* and in *vivo*. Patel and Narasimhacharya (2017and 2024) [30, 31]. reported the anti-termite potential of four plant species, *Achyranthes aspera, Sida acuta, Syzygium cumini* and *Terminalia Arjuna* also isolated the termiticidal compounds from *Lantana camara L*. against *Odontotermes obesus*. The anti-termite potential of each extract revealed that among the plants examined, *T. arjuna* stem methanol extract exhibited the highest termiticidal potential (74.67%) followed by *S. cumini* leaf and stem methanolic extracts (70%, 67% respectively). Aqueous extract of *A. Aspera* was found effective against termites and exhibited 56% mortality over a period of 48hrs. The hexane dried leaf extracts of *Tagetes erecta* and the hexane extracts of *Flourensia cernua* were reported to possess termiticidal activity against Formosan subterranean termite, *Coptotermes formosanus* and *Reticulitermes sp*. (Elango *et al.*, 2012; Tellez *et al.*, 2001) [10, 41]. Pal *et al.*, (2013) [29]. tested antitermite responses of leaves of *Cordia dichotoma* extracted with methanol and fractionated with different solvents at different dilutions i.e. (0.5%, 1%, and 2%) against *Odontotermes obesus*. The 2% ethyl acetate extract possesses highest antitermite potential. Ethanol extract of Sappan (*Caesalpinia sappan*) has a significant potential in the control of termites at 30% concentration (Acero *et al*., 2018) [18]. Nisar *et al*., (2020) [21]. determined the comparative effect of termiticides and plant extracts on mortality and tunnel formation of *Odontotermes obesus* results showed that Bifenthrin as most effective treatment among chemicals while among plant extracts *Dodonaea viscosa* was found most effective having lower LT_{50} values.

Vasanthi *et al.*, (2016) [3]. evaluated the termiticidal and antifeedant activity of tree seed oils, *Azadirachta indica, Pongamia glabra L., Madhuca longifolia L, Ricinus communis L., Hydnocarpus pentandra* and *Calophyllum inophyllum L*. against *Odontotermes wallonensis* (Wasmann) in laboratory conditions. All the tree seed oils exhibited significant antitermitic activity ($p<0.05$) compared to control at 48 hours after treatment.

Aouinty *et al.*, (2018) [5]. reported the toxic action of *Ricinus communis* on the larvae of *Culex pipiens* and showed severe damage in the middle intestine, including hypertrophy and lysis of the epithelial cells, indicating the toxic action of the ingested toxic substances of plant extract.

Islam *et al.*, (2018) [15]. investigated the in-vitro efficacy of aqueous, methanolic, and ethanolic extracts of *Ricinus communis* against tick infestations as alternative acaricide.

Khalil *et al.*, (2010) [25]. evaluated the biocidal potential of hexane, acetonitrile, and methanol.extract of *Ricinus communis* against the infestation of whitefly *Bemisia tabaci.*

Verma *et al.*, (2016) [45]. investigated the termiticidal effect of *Tagetes erecta* and *Citrus sinensis* oil against termite, *Odontotermes obesus*. The plants reviewed show good insecticidal properties against termites Verma *et al.*, (2009) [44]. Shiberu *et al.*, (2014) [38] resulted seven botanical were antitermite property in Ethiopia. Aqueous extracts of tobacco leaves, *Nicotiana tabacum*, Birbira seeds, *Militia ferruginea* and Endod leaves, *Phytolacca dodecandra* were achieved 100% mortality after 24 hours.

The finding of the present investigation revealed that, the leaves extract of *Ricinus communis* possesses remarkable termiticidal activity against *Odontotermes obesus*. The LC_{10}= 7.5370 mg/ml, LD_{50}= 8.6238, LC_{90}=9.8679 mg/ml in methanol and LC_{10}= 10.016, LC_{50}= 11.355, LC_{90}=12.662 mg/ml in aqueous leaf extract of *Ricinus communis* are recorded whereas methanol solvent extract was more effective than aqueous extract of *Ricinus communis*. The study needs further investigation to find out active ingredients responsible for termiticidal properties of *Ricinus communis* and to reach any final recommendations.

Conclusion

The study demonstrated that Ricinus communis leaf extracts exhibit significant termiticidal potential against Indian white termites, *Odontotermes obesus*. Methanol extracts were more effective than aqueous extracts, with lower LD10, LD50, and LD90 values. These findings suggest that *Ricinus communis* could be an eco-friendly alternative to chemical pesticides for termite management. Further research is required to isolate and identify the active compounds responsible for its termiticidal properties, paving the way for sustainable pest control solutions.

Acknowledgments

Authors are thankful to the MAHAJYOTI and Principal, Deogiri College, Chhatrapati Sambhajinagar for his encouragement and providing facilities.

References

1. Acda MN. Repellent effects of *Annona* crude extract on the Asian subterranean termite *Coptotermes gestroi*

Wasman (Isoptera: Rhinotermitidae). Sociobiology. 2014;61(3):322-337.
2. Addisu S, Mohamed D, Waktole S. Efficacy of botanical extracts against termites, *Macrotermes* spp. (Isoptera: Termitidae) under laboratory conditions. Int J Agric Res. 2014;9(2):60-73.
3. Adlin Pricilla V, Jeyarajannelson S, Muthukrishnan N, Ramanathan A, Uma D. Termiticidal and antifeedant activity of tree seed oils against *Odontotermes wallonensis* Wasmann (Termitidae: Isoptera). Life Sciences Leaflets. 2016. p. 66-74.
4. Aneesh Goyal P, Usha Rani P, Devanand. Vapor toxicity and repellent activity of some purified fractions and acetone extracts of *Ricinus communis* Linn. leaves against two pests of stored products. J Appl Zool. 2005;16(2):198-202.
5. Aouinty B, Chennaoui M, Mahari S, Rihane A, Mellouki F. Larvicidal effects of aqueous extract from *Ricinus communis* L. leaves against mosquito *Culex pipiens*: Mortality and histopathology of treated larvae. J Mater Environ Sci. 2018;9(2):619-623.
6. Blaske VU, Hertel H. Repellent and toxic effects of plant extracts on subterranean termites. J Econ Entomol. 2001;94(5):1200-1208.
7. Boulogne I, Petit P, Ozier-Lafontaine H, Desfontaines L, Loranger-Merciris G. Insecticidal and antifungal chemicals produced by plants: A review. Environ Chem Lett. 2012;10(4):325-347.
8. Dalal M. Evaluation of some plant extracts effectiveness on the termites *Reticulitermes* spp. (Isoptera: Rhinotermitidae). Polish Journal of Environmental Studies. 2023;32:3015-3024.
9. Ekesi S. Effect of volatiles and crude extracts of different plant materials on egg viability of *Maruca vitrata* and *Clavigralla tomentosicollis*. Phytoparasite. 2000;28:305-310.
10. Elango G, Rahuman AA, Bagavan KC, Zahir AA, Santhoshkumar T, Marimuthu S, *et al*. Efficacy of medicinal plant extracts against Formosan subterranean termite, *Coptotermes formosanus*. Industrial Crops and Products. 2012;36(1):524-530.
11. Emmanuel K, Atti T, Nazer FS, Abouwaliou NN, Oyetounde D, Agnassim B, *et al*. Insecticidal activity of *Ricinus communis* L. seed extract against *Spodoptera frugiperda* J.E. Smith under laboratory and field conditions. Int J Biol Chem Sci. 2023;17(3):760-772.
12. Finney DJ. Probit analysis. Cambridge University. 1947;2nd edn:318.
13. Ganapaty S, Thomas PS, Fotso S, Laatsch H. Antitermitic quinones from *Diospyros sylvatica*. Phytochem. 2004;65(9):1265-1271.
14. Ingle HD, Pardeshi AB. Biotermiticidal activity of *Jatropha gossypifolia* Linn. plant extract against *Odontotermes obesus* (Isoptera: Termitidae). International Journal for Research in Applied Science & Engineering Technology. 2024;12:3880-3884.
15. Islam S, Talukder S, Ferdous J, Hasan M, Sarker YA, Sachi S, *et al*. In-vitro efficacy of *verenda (Ricinus communis)* leaves extract against ticks in cattle. J Vet Med. 2018;16(1):81-86.
16. Kasseney BD, Wolali SN, Abla DM, Guillaume KK, Isabelle AG. Termiticidal activities of few plant extracts against *Macrotermes subhyalinus* Smeathman and *Trinervitermes geminatus* Wasmann (Isoptera: Termitidae) survival. African Journal of Agricultural Research. 2016;11(28):2475-2480.
17. Liu SQ, Shi JJ, Cao H, Jia FB, Liu XQ, Shi GL, *et al*. Survey of pesticidal components in plants. In: Entomology in China in 21st Century, Proceedings of Conference of Chinese Entomological Society (Ed: Dianmo) Li Beijing, China. Science & Technique Press. 2000. p. 1098-1104.
18. Liwayway H, Acero ME, Pulumbarit Cruz F, Tuy FS. Termiticidal potential of *Sappan (Caesalpinia sappan)* seeds. International Journal of Chemical Engineering and Applications. 2018;9(6):216-220.
19. Maistrello L, Martin L, Macías-Pavon I, Bortolini S, Marchrttini N. Evaluation of polyphenols-rich natural compounds as treatments to prevent attacks by subterranean and dry wood termites: Preliminary results. J Entomol Acarol. 2011;43(2):261-267.
20. Melaku W, Habtamu A. Efficacy of castor bean oil (*Ricinus communis* L.) against maize weevils (*Sitophilus zeamais* Mots.) in northwestern Ethiopia. Journal of Stored Products Research. 2015. Available from: http://dx.doi.org/10.1016/j.jspr.2015.05.006.
21. Muhammad SN, Bashir MA, Naz H, Ahmed S. Comparative effect of termiticides and plant extracts on mortality and tunnel formation of *Odontotermes obesus*. 2020;9(3):1903-1910.
22. Mustaparta H. Encoding of plant odour information in insects: Peripheral and central mechanisms. Entomologia Experimentalis et Applicata. 2002;104:1-5.
23. Nagare G, Pardeshi AB. Anti-termite efficacy of *Argemone mexicana* L. for the control of Indian white termite, *Odontotermes obesus* (Ramb.). International Journal of Recent Scientific Research. 2019b;10(7I):33875-33879.
24. Nagare G, Pardeshi AB. Efficacy of plant extracts of *Semicarpus anacardium* against Indian white termite, *Odontotermes obesus* under laboratory conditions (Isoptera: Termitidae). International Journal of Current Agricultural Sciences. 2019a;9(6A):412-415.
25. Nasr S, Khalil H, Elseedi MR, Saleh MA, Salama MS, Hamed MS. Biocidal activity of some castor extracts against the whitefly *Bemisia tabaci* (Genn) (Homoptera: Aleyrpdidae). J Biolog Sci. 2010;2(1):31-38.
26. Nidhal S, Bachrouch O, Sriti J, Msaada K, Khammassi S, Hammami M, *et al*. Fumigant and repellent potentials of *Ricinus communis* and *Mentha pulegium* essential oils against *Tribolium castaneum* and *Lasioderma serricorne*. International Journal of Food Properties. 2017;20(S3):S2899-S2913.
27. Osipitan AA, Jegede TO, Adekanmbi DI, Ogunbanwo IA. Assessment of *Datura metel*, local soap, and garlic (*Allium sativum*) in the management of termites (Termitidae: Isoptera). Mun Ent Zool. 2013;8(1):407-414.
28. Osipitan AA, Oseyemi AE. Evaluation of the bio-insecticidal potential of some tropical plant extracts against termites (Termitidae: Isoptera) in Ogun State, Nigeria. J Ent. 2012;9(5):257-265.
29. Pal M, Tripti M, Ranjeet K, Tewari K. Antitermite activity of *Cordia dichotoma*. International Journal of Scientific and Innovative Research. 2013;1(2):57-61.
30. Patel K, Narasimhacharya. Anti-termite activity of

certain plants against *Odontotermes obesus*. J Biopest. 2017;10(2):120-129.
31. Patel K, Narasimhacharya. Phenol 2, 4 di-tert butyl, phenol 3, 5 di-tert butyl and isoaromadendrane epoxide: Termiticidal compounds isolated from *Lantana camara* L. Journal of Natural Pesticide Research. 2024;100071:1-13.
32. Raina A, Bedoukian R, Florane C, Lax A. Potential of natural products and their derivatives to control Formosan subterranean termites (Isoptera: Rhinotermitidae). J Econ Entomol. 2012;105:1746-1750.
33. Ram S, Geetanjali. Phytochemical and pharmacological investigations of *Ricinus communis* Linn. Algerian Journal of Natural Products. 2015;3(1):120-129.
34. Sadek MM. Antifeedant and toxic activity of *Adhatoda vasica* leaf extract against *Spodoptera littoralis* (Lep. Noctuidae). J Appl Entomol. 2003;127:396-404.
35. Sharma S, Verma M, Prasad R, Yadav D. Efficacy of non-edible oil seedcakes against termites (*Odontotermes obesus*). Journal of Scientific & Industrial Research. 2011;70:1037-1041.
36. Schoonhoven LM, Jermy T, van Loon JJA. Insect-plant biology from physiology to evolution. Chapman & Hall, London. 1998, 409. ISBN 0-412-58700-9.
37. Sharma S, Vasudevan P, Madan M. Insecticidal value of castor (*Ricinus communis*) against termites. International Biodeterioration. 1990;27:249-254.
38. Shiberu G, Michael GP, Savarimuthu I, Naif AA. Bioefficacy of seed extracts of *Strychnos nux-vomica* and *Semicarpus anacardium* against *Helicoverpa armigera* (Hubnar) (Lepidoptera: Noctuidae). International Journal of Agricultural and Food Science. 2014;4(2):73-77.
39. Shinde RR, Pardeshi AB. Evaluation of bio-termiticidal potential of *Datura metel* L. plant extracts against *Odontotermes obesus* (Isoptera: Termitidae). International Journal of Innovative Research in Technology. 2024;11(4):2349-6002.
40. Shripad MU, Kotkar HM, Mendki PS, Maheshwari VL. Partial characterization and insecticidal properties of *Ricinus communis* L. foliage flavonoids. Pest Management Science. 2003;59:1349-1354.
41. Tellez M, Estell R, Fredrickson E, Powell J, Wedge D, Schrader K, *et al*. Extracts of *Flourensia cernua* (L): Volatile constituents and antifungal, antialgal, and antitermite bioactivities. Journal of Chemical Ecology. 2001;27(11):2263-2273.
42. Upadhyay RK, Gayatri J, Shoeb A. Anti-termite efficacy of *Capparis decidua* and its combinatorial mixtures for the control of Indian white termite *Odontotermes obesus* (Isoptera: Odontotermitidae) in Indian soil. J Appl Sci Environ Manage. 2010;14(3):101-105.
43. Upadhyay RK, Gayatri J, Shoeb A, Leena K, Subhash C. Antitermite activities of *C. decidua* extracts and pure compounds against Indian white termite *Odontotermes obesus* (Isoptera: Odontotermitidae). Article ID 820245. 2012;10:1155/820245:9.
44. Verma M, Sharma S, Prasad R. Biological alternatives for termite control: A review. International Biodeterioration & Biodegradation. 2009;63:959-972.
45. Verma S, Sharma S, Anushree M. Termiticidal and repellency efficacy of botanicals against *Odontotermes obesus*. International Journal of Research in Biosciences. 2016. p. 52-59.
46. Wedin GP, Neal JS, Everson GW, Krenzelok EP. Castor bean poisoning. Am Journal of Emergency Medicine. 1986;4:259-261.