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Toxicological Exploration of Tapak Dara *Catharanthus roseus* as Bioinsecticide

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ABSTRACT

Mosquito control efforts have been done physically, chemically, and through environmental management. However, the use of synthetic chemical insecticides has various negative impacts. Therefore, plant-based alternatives are a solution that needs to be developed. This study explores the toxicological potential of *Catharanthus roseus* as a botanical bioinsecticide. This systematic review study takes data from the literature in the form of published articles obtained via the internet from Google Scholar, Semantic Scholar, Garuda, PubMed, and Science Direct databases. The subjects of the study were 12 articles that focused on using *Catharanthus roseus* as a larvicide. The selected journals were eligible based on the study of LC50, zero value, and No Observed Adverse (NOA) of Catharanthus roseus plant extract against mosquito larvae. The data are presented in tabular form. Several studies provided different results regarding LC50 and zero value, but only 1 study reported on NOA. Further research is needed to improve data consistency, especially on LC50 values and control effects, including against non-target organisms.

INTRODUCTION

Mosquitoes are a deadly threat in the world. Various diseases have caused millions of human deaths each year because they are transmitted by mosquitoes, such as dengue fever, chikungunya, malaria, and others. Control efforts have been carried out physically, chemically, and through environmental management. Using synthetic chemical insecticides in pest control has caused various negative impacts, such as insect resistance, bioaccumulation, and environmental damage. Therefore, plant-based alternatives are a solution that needs to be developed. Efforts can be made using natural chemicals (phytochemicals). Phytochemicals are biological agents that may be able to control pests that are harmful to human and animal health and plants (Najukha et al., 2024; Putri & Pandapotan Nasution, 2022). Plants contain a variety of potential phytochemicals that are target-specific, rapidly biodegradable, and environmentally friendly. The diversity of phytochemicals found in ornamental plants has promising larvicidal activity and is a safe and effective alternative to chemical insecticides and biotechnology (Kumar et al., 2012).

C. roseus is an upright, bushy, perennial plant from the Apocynaceae family that grows up to 75 cm in height, becomes woody at the base, and branches heavily, the stems contain little milky latex; the leaves are in opposite pairs, smooth, oblong-oval, blunt, or rounded at the apex, 2.5 to 9 cm long and 1.5 to 4cm wide, with short stalks. Flowers grow all year round in the upper leaf axils, are tubular, 1.5 to 4cm long, 5-lobed, widening to 5cm wide; the color can be white with a yellow eye, white with a dark red eye, or lavender pink with a dark red eye tua (Novitasari et al., 2021; Ulpa et al., 2022).

One of the plants with bioinsecticide potential is tapak dara (*Catharanthus roseus*), which is known to have various bioactive compounds. *C. roseus*, or tapak dara, is a tropical plant famous for its alkaloid compound content. However, the use of this plant is not free from the risk of toxicity due to its bioactive components. Understanding the toxicological aspects is important to support the safe use of this plant, both in medical contexts and other applications, such as botanical pesticides. This study explores the toxicological potential of *C. roseus* as a botanical bioinsecticide, focusing on toxicity to *Aedes aegypti* mosquito larvae, one of the main vectors of dengue fever.

METHOD

This study is a systematic review. The data sources for this study come from published articles obtained via the internet from Google Scholar, Semantic Sholar, Garuda, PubMed, and Science Direct databases. The subjects of the study were articles that focused on the use of *C. roseus* as a larvicide from 2012 to 2024. The selected journals were eligible based on the study of LC50, zero value, and No Observed Adverse (NOA) of *C. roseus* plant simplex extract against mosquito larvae. The results of data screening were obtained from 12 journals. The data are presented in tabular form. The selected journals were strengthened and elaborated with explanations from other journal article sources.

RESULTS

Several studies gave different results regarding LC50 and zero value, but only 1 study reported on NOA (Table 1).

Table 1. Researchers, Research Title, LC50, Zero Value and NOA

No	Author	Title of Study	LC50 (ppm)	Zero value (ppm)	NOAs (ppm)
1	Kumar et al., 2012	Evaluation of 15 Indigenous plant species as larvicidal agents against Indian dengue mosquito strain, *Aedes aegypti* L. (Diptera: Culicidae)	250	100	50
2	Panneerselvam et al., 2013	Larvicidal Efficacy of *Catharanthus Roseus* and *Bacillus thuringiensis* Leaf Extracts	3.34-8.17 g/L (instar I-IV)	No mortality in control (water without acetone)	The authors only report that there were no negative effects in larvae exposed to water or control
3	Ekaputri et al., 2014	Larvicidal Effect of Vinca Fruit Extract (tapak dara) on Profile of Larvae and Secondary Metabolites	6,6mg/ml	Not mentioned	Not mentioned

No	Author	Title of Study	LC50 (ppm)	Zero value (ppm)	NOAs (ppm)
		of *Aedes aegypti* Based on Thin Layer Chromatography			
4	Chettiar Kamatchi & Maheswaran, 2016	Evaluation of Larval Toxicity of Lantana Camara L. and *Catharanthus Roseus L*. against Mosquito Larvae	26.64-72.89 ppm;	Zero mortality was observed in the control group	Not mentioned
5	Rajan & Varghese, 2017	Evaluation of Larvicidal Efficacy of Lantana Camara and *Catharanthus Roseus* Water Extracts	LC50 not explicitly reported; 100% mortality at 80 mg/10ml concentration	Zero mortality occurred at the lowest concentration (10mg/100ml).	Not available
6	Variavan et al., 2018	Larvicidal Efficacy of *Catharanthus roseus* Leaf Extract against Filaria Vectors *Culex quinquefasciatus* (Diptera: *Culicidae*)	150 ppm	There was no mortality in controls.	Not available
7	Tennyson et al., 2018	Bioeficacy of *Catharanthus roseus* (L.) G. Don (Apocyanaceae) and Hyptis suaveolens (L.) Poit (Lamiaceae) ethanol extract on instar larvae of dengue and chikungunya disease vector *Aedes aegypti Linnaeus* 1762 (Diptera: Culicidae)	22,91mg/L	Not mentioned	Not mentioned
8	Sari et al., 2022	Toxicity Test of Catharanthus roseus Flower Extract Using the Brine Shrimp Lethality Test Method	34.599µg/mL	Not mentioned	Not mentioned
9	Putri & Pandapotan Nasution, 2022	Phytochemical Screening and Cytotoxicity Test of Ethanol Extract of Tapak Dara Leaves (Catharanthus Roseus L.) Using the Brine Shrimp Lethality Test (BSLT) Method	305.140	Not mentioned	Not mentioned
10	Dewi et al., 2023	Toxicity Test of Tapak Dara Leaf Extract (*Catharantus roseus* L.) Using the BSLT Method With Variations of	Etanol: 154.886, n-heksan: 66.949	Not mentioned	Not mentioned

No	Author	Title of Study	LC50 (ppm)	Zero value (ppm)	NOAs (ppm)
		Different Extraction Solvents			
11	Najukha et al., 2025	Phytochemical Screening and Toxicity Test of Tapak Dara Flower Extract (Catharanthus roseus)	162.181 μg/mL	Not mentioned	Not mentioned
12	Hashim et al., 2024	Review on the efficacy of *Catharanthus roseus* Extract on Cd2+ toxicity: Implications for human health and remediation strategies	Not mentioned	Not mentioned	Not mentioned

DISCUSSION

Various studies have shown the toxicity effects of the *C. roseus* plant on *Aedes aegypti* mosquito larvae and other vectors such as *Culex quinquefasciatus*. LC50 of 250 ppm indicates a fairly strong larvicide potential. LC50 is measured in ppm and is the extract concentrate that kills 50% of larvae within a specific period of time. The larvicide effect with an LC50 of 150 ppm against *Culex quinquefasciatus* shows that *C. roseus* is also effective on filariasis vectors. LC50 of 22.91 mg/L indicates a very effective potential for *Aedes aegypti* larvae. Extract concentration greatly affects the mortality rate of mosquito larvae. Instar I-IV larvae require concentrations ranging from 3.34–8.17 g/L, more mature larvae require higher concentrations. Variations in solvents affect the LC50 results, with n-hexane (66,949 μg/mL) being more toxic than ethanol (154,886 μg/mL).

Several studies did not include complete data on mortality control, zero values, or differences in larval instars. The Zero Value is also measured in ppm. This value is the toxic effect that begins to be observed at the lowest concentration. NOA is the level of adverse effects without being observed, the highest concentration without adverse effects.

The significant larvicidal effect at low concentrations, as conducted by Tennyson, shows the potential of *C. roseus* as an effective bioinsecticide. The alkaloid and flavonoid content are thought to be the main compounds responsible for this toxicity. Alkaloid and flavonoid content are thought to be the main compounds responsible for this toxicity. The mechanism of action involves the disruption of the insect's nervous system function and the denaturation of important proteins (Ahyanti & Yushananta, 2022). The advantages of this botanical bioinsecticide include environmentally friendly properties, safety for humans, and high biodegradability compared to synthetic insecticides. However, further research is needed to determine field applications, formulation stability, and effects on non-target organisms.

Vinca alkaloids, such as vinblastine and vincristine, work by disrupting microtubule formation during mitosis, which can then trigger the apoptosis pathway. The exact mechanism of apoptosis induction by Vinca alkaloids is not fully understood, but studies suggest that they can interact with various regulatory proteins and cellular pathways, allowing apoptosis terminals to be activated (Ekaputri et al., 2014). Vinca alkaloids are a group of active chemical compounds derived from plants of the genus Catharanthus, especially Catharanthus. These compounds are classified as indole alkaloids, which contain an indole ring in their chemical structure and have very strong biological activity.

Mosquitoes play a significant role in transmitting several life-threatening diseases to human populations worldwide. They are the primary vectors of many infectious diseases affecting humans and animals, as well as disorders. In this study, the results revealed that *C. roseus* leaf extract has the potential to be a larvicide. The mode of action and larvicide efficacy of this plant leaf extract under field conditions should be studied and determined. In addition, further investigations into the effects on non-target organisms and synergism with biocides are essential. As the plant of this study is widely distributed, its commercial exploitation could provide an important step in developing new botanical insecticides as one of the expensive and environmentally friendly alternatives to hazardous chemical insecticides.

The success of mosquito control programs largely depends on the effectiveness of the insecticide after application, namely, its residual toxicity. In general, the efficacy of larvicides can be influenced by a series of environmental factors such as temperature, sunlight, aquatic organic matter, aquatic vegetation, and rain (Devillers, 2020; Sakka et al., 2023). At the same time, the selected active ingredients must comply with certain regulatory restrictions, such as areas included in the protected aquatic ecosystem category, where most conventional compounds cannot be applied (Sakka et al., 2023).

Using periwinkle extract as a bioinsecticide can affect non-target organisms, such as pollinating insects and fish, especially in aquatic ecosystems. Alkaloid compounds tend to have low bioaccumulation levels but can cause toxic residue effects in soil and water. Therefore, risk mitigation is needed for its use. Mitigating toxicity risks in 3 ways: dose standardization, environmental management, and effect monitoring. Dose standardization with the use of periwinkle plants must go through a safe dose study based on toxicology data. Ecological management with applications such as bioinsecticides must consider the impact on the ecosystem and environmental sustainability. Side Effect: Monitoring side effects on human users and the environment is necessary to reduce the risk of toxicity.

CONCLUSION

Catharanthus roseus is a plant with great potential in medicine and other applications. However, its use must be accompanied by an in-depth toxicology study to prevent the risk of toxicity to humans and the environment. A better understanding of safe doses and toxicity mechanisms will support the use of this plant more responsibly. Further research is needed to improve data consistency, especially on LC50 values and control effects, including on non-target organisms.

AUTHOR'S DECLARATION

Authors' contributions and responsibilities

The author conducted a literature study and drafted the manuscript, visualization, and conceptualization. Furthermore, I validated the data and reviewed and edited the work.

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Availability of data and materials

All data are available from the author. The author declares no conflict of interest in writing this article.

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