

Larvicidal Action of Leaf and Seed of *Ricinus Communis* Against *Anopheles* Species

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ABSTRACT

Mosquito-borne diseases remain major public health challenges throughout the world, particularly in tropical and subtropical regions. Species of *Anopheles* mosquitoes act as principal vectors of malaria and contribute substantially to global morbidity and mortality. Continuous use of synthetic insecticides has resulted in environmental pollution, development of insect resistance, and adverse effects on non-target organisms. Therefore, there is increasing interest in identifying eco-friendly and plant-derived alternatives for mosquito control. The present study evaluated the larvicidal potential of leaf and seed extracts of *Ricinus communis* against *Anopheles* larvae. *R. communis* contains several biologically active compounds including alkaloids, flavonoids, ricinine, phenolic compounds, and toxic proteins that may exert insecticidal activity. Plant extracts were prepared from leaves and seeds using solvent extraction procedures and tested at varying concentrations against third and fourth instar *Anopheles* larvae under laboratory conditions. Mortality responses were recorded after 24 and 48 hours of exposure. Results demonstrated concentration-dependent larval mortality with seed extracts showing comparatively greater toxicity than leaf extracts. Increased mortality rates were observed at higher concentrations, suggesting the effectiveness of plant-derived compounds in disrupting larval physiological activities. The larvicidal activity may be associated with phytochemical constituents that interfere with metabolic and neurological functions in mosquito larvae. The findings indicate that *Ricinus communis* possesses promising larvicidal properties and may provide an environmentally sustainable alternative for mosquito vector management. Further studies involving isolation of active compounds, field trials, and evaluation of non-target effects are recommended before large-scale applications.

Keywords- *Ricinus communis*, Larvicidal activity, *Anopheles*, Mosquito control, Botanical insecticide, Vector management, Plant extract.

I. INTRODUCTION

Mosquitoes are among the most important vectors of human diseases and are responsible for transmitting numerous pathogens that affect millions of people worldwide. Mosquito-borne diseases such as malaria, dengue fever, filariasis, chikungunya, yellow fever, and Japanese encephalitis remain major public health challenges, particularly in tropical and subtropical regions (World Health Organization [WHO], 2023). Among mosquito genera, *Anopheles* species are considered medically significant because they act as principal vectors of malaria parasites belonging to the

genus *Plasmodium*. Malaria continues to be a major health burden in developing countries and contributes significantly to mortality and morbidity rates, especially among children and pregnant women (WHO, 2023). Control of mosquito populations remains one of the most effective approaches for preventing mosquito-borne disease transmission. Various vector control strategies have been implemented worldwide, including insecticide-treated bed nets, indoor residual spraying, environmental management, and chemical insecticides (Benelli & Mehlhorn, 2016). Conventional mosquito control programs primarily depend upon synthetic insecticides such as organophosphates, pyrethroids,

carbamates, and organochlorines because of their rapid action and effectiveness against mosquito vectors (Pavela, 2015). However, excessive and continuous use of these synthetic compounds has created several ecological and health-related concerns. One of the major limitations of chemical insecticides is the development of insect resistance in mosquito populations. Repeated exposure to synthetic insecticides has enabled mosquito species to develop resistance mechanisms, thereby reducing the effectiveness of control programs (Hemingway et al., 2016). In addition, synthetic insecticides can accumulate in the environment and adversely affect non-target organisms including aquatic animals, beneficial insects, birds, and humans (Benelli et al., 2017). Environmental contamination and ecological imbalance caused by prolonged insecticide application have encouraged researchers to explore alternative mosquito control methods that are effective, economical, and environmentally safe. In recent years, plant-derived insecticides have gained considerable attention because of their eco-friendly nature and biological effectiveness against mosquito vectors. Botanical insecticides are obtained from plant materials containing naturally occurring bioactive compounds that possess insecticidal, larvicidal, repellent, and growth-regulating properties (Pavela, 2015). Plant secondary metabolites such as alkaloids, flavonoids, tannins, terpenoids, saponins, steroids, and phenolic compounds are known to interfere with various physiological processes in insects, leading to mortality or inhibition of growth and reproduction (Mossa, 2016). Larval control is considered an important component of mosquito management because mosquito larvae inhabit confined aquatic habitats where they are easier to target than adult mosquitoes (Benelli & Mehlhorn, 2016). Larvicidal compounds act by disrupting metabolic processes, respiratory functions, nervous activity, and feeding behavior in larvae, thereby preventing the emergence of adult mosquitoes (Govindarajan et al., 2013). Plant-based larvicides offer several advantages including biodegradability, reduced toxicity to non-target species, lower environmental persistence, and minimal resistance development. *Ricinus communis* L., commonly known as castor plant, belongs to the family Euphorbiaceae and is widely distributed in tropical and subtropical regions of the world. The plant has considerable medicinal, agricultural, and industrial importance and is widely cultivated for castor oil production (Ross et al., 2017). Different parts of the plant, including leaves, roots, stems, and seeds, contain numerous biologically active compounds with pharmacological and insecticidal properties. Important phytochemical constituents of *Ricinus communis* include ricin, ricinine, flavonoids, alkaloids, saponins, tannins, and phenolic compounds (Scarpa & Guerci, 2019). Previous studies have reported that extracts from *Ricinus communis* exhibit antimicrobial, antioxidant, antifungal, anti-inflammatory, and insecticidal activities (Mansour et al., 2020). The

seed extracts of *Ricinus communis* are particularly rich in toxic proteins and secondary metabolites that may interfere with insect physiology and survival mechanisms. The larvicidal effects of plant extracts may occur through inhibition of digestive enzymes, disruption of neuromuscular functions, interference with hormonal regulation, and impairment of respiratory processes (Govindarajan et al., 2013). Several investigations have demonstrated the effectiveness of plant extracts against different mosquito species, including *Aedes*, *Culex*, and *Anopheles* mosquitoes (Benelli et al., 2017). However, comparative information regarding the larvicidal efficacy of leaf and seed extracts of *Ricinus communis* against *Anopheles* species remains limited. Therefore, the present study was designed to evaluate the larvicidal action of leaf and seed extracts of *Ricinus communis* against *Anopheles* larvae and to assess their potential application as eco-friendly botanical larvicides for mosquito vector control.

II. REVIEW OF LITERATURE

Mosquitoes are among the most important vectors of human diseases and continue to pose significant public health challenges worldwide. The transmission of malaria, dengue, filariasis, chikungunya, and other vector-borne diseases is directly associated with mosquito population density and distribution (World Health Organization [WHO], 2023). Among mosquito genera, *Anopheles* species are of particular concern because they act as vectors of *Plasmodium* parasites responsible for malaria transmission. Effective mosquito control programs therefore remain essential for reducing disease prevalence and improving public health outcomes. Traditionally, mosquito control programs have relied heavily on synthetic insecticides for vector management. Chemical compounds such as organophosphates, pyrethroids, carbamates, and organochlorines have been widely used due to their rapid insecticidal effects and broad-spectrum activity (Hemingway et al., 2016, Kamalesh Kumar 2025). Although these compounds initially demonstrated considerable success, their prolonged use has created several ecological and biological challenges. Repeated exposure of mosquito populations to synthetic insecticides has resulted in the development of insecticide resistance, reducing the effectiveness of conventional control programs (Ranson & Lissenden, 2016). Furthermore, chemical residues can persist in ecosystems and negatively affect non-target organisms, including aquatic fauna, beneficial insects, birds, and mammals (Benelli et al., 2017). The growing concern regarding environmental contamination and insecticide resistance has stimulated interest in alternative and environmentally sustainable mosquito control approaches. Plant-derived insecticides have gained increasing attention because of their natural origin, biodegradability, reduced environmental persistence, and

lower toxicity toward non-target species (Pavela, 2015). Botanical insecticides contain diverse secondary metabolites that exhibit insecticidal, repellent, ovicidal, and larvicidal properties against mosquito vectors. Plants synthesize a wide variety of bioactive compounds as defense mechanisms against herbivorous insects and microbial pathogens. Secondary metabolites such as alkaloids, terpenoids, flavonoids, tannins, phenolic compounds, steroids, and saponins have demonstrated significant insecticidal activity against various insect species (Mossa, 2016). These compounds interfere with physiological functions including feeding behavior, digestive processes, nervous system activity, hormonal regulation, and respiration in insect pests. Several researchers have investigated the larvicidal activity of medicinal plants against mosquito vectors. Govindarajan et al. (2013) reported that extracts obtained from medicinal plants showed significant toxicity against larvae of *Anopheles*, *Aedes*, and *Culex* mosquitoes. The study suggested that plant-derived compounds may serve as effective alternatives to synthetic insecticides for vector control programs. Pavela (2015) extensively reviewed plant essential oils and phytochemicals with insecticidal properties and observed that many plant species possess strong larvicidal potential against mosquitoes. According to the study, botanical insecticides provide multiple modes of action that reduce the likelihood of resistance development among insect populations. Benelli and Mehlhorn (2016) highlighted the importance of botanical products in integrated mosquito management strategies. The authors reported that plant extracts containing terpenoids and phenolic compounds effectively disrupted mosquito larval development and adult emergence. Furthermore, plant-based larvicides were found to be environmentally safer compared to synthetic chemical agents. Larval stages represent an important target in mosquito control programs because larvae inhabit restricted aquatic environments where interventions can be implemented efficiently. Larvicidal agents act by affecting larval physiological activities and preventing successful development into adult mosquitoes (Benelli et al., 2017). Control of larval populations ultimately contributes to reductions in adult mosquito abundance and disease transmission.

Among medicinal plants, *Ricinus communis* L., commonly known as castor plant, has attracted considerable scientific interest because of its diverse biological properties. The plant belongs to the family Euphorbiaceae and is widely distributed throughout tropical and subtropical regions. Different plant parts including seeds, leaves, stems, and roots contain numerous phytochemical constituents with medicinal and insecticidal activities (Ross, 2017). The seeds of *Ricinus communis* contain castor oil and biologically active compounds such as ricin, ricinine, flavonoids, alkaloids, tannins, and phenolic substances (Scarpa & Guerci, 2019). Ricin and ricinine are particularly

important because of their toxic effects on insects and other organisms. Several investigations have suggested that these compounds interfere with insect metabolism, protein synthesis, and nervous system functions, leading to mortality. Mansour et al. (2020) reported that *Ricinus communis* extracts exhibited significant antimicrobial, antioxidant, and insecticidal activities. The biological activity of the plant was attributed primarily to its phytochemical composition. Similarly, previous investigations demonstrated that extracts prepared from *Ricinus communis* leaves and seeds showed toxicity against agricultural pests and mosquito larvae. Kumar et al. (2012) observed that plant extracts from medicinal species including *Ricinus communis* produced concentration-dependent larvicidal effects against mosquito vectors. Higher extract concentrations resulted in greater mortality rates due to increased availability of active compounds. Similar observations have been reported by other researchers investigating botanical larvicides. Research conducted by Govindarajan and Sivakumar (2012) and Kumar 2026 suggested that plant extracts may affect mosquito larvae through multiple mechanisms including disruption of respiratory pathways, inhibition of digestive enzymes, and interference with hormonal regulation during larval development. Such multi-target activity may reduce the probability of resistance development. Plant seed extracts frequently demonstrate stronger insecticidal effects compared to leaf extracts because seeds often contain higher concentrations of bioactive compounds. Several studies have reported that seed oils and seed-derived phytochemicals possess stronger larvicidal activity against mosquito species (Benelli et al., 2017, Indu 2021). The enhanced toxicity of seed extracts may be associated with the presence of concentrated secondary metabolites and toxic proteins. Recent studies have also explored combinations of plant-derived compounds with nanotechnology and bioformulations for improving larvicidal efficacy and prolonging biological activity. Nano-encapsulation of botanical compounds has shown promising results in controlled release and enhanced mosquito toxicity (Benelli, 2018). Such developments may further increase the practical applicability of botanical larvicides in mosquito management programs. Despite extensive studies on plant-derived larvicides, information regarding comparative evaluation of leaf and seed extracts of *Ricinus communis* against *Anopheles* species remains limited. Most available studies have focused on general insecticidal properties rather than detailed assessments of mosquito larval mortality and concentration-dependent responses. Therefore, the present study aims to investigate and compare the larvicidal action of leaf and seed extracts of *Ricinus communis* against *Anopheles* species under controlled laboratory conditions and assess their potential application as environmentally sustainable alternatives for mosquito vector management.

III. MATERIALS AND METHODS

3.1 Study Area

The present experimental study was conducted under controlled laboratory conditions in the Department of Zoology, N.R.E.C. College, laboratory during 2025–2026. Environmental conditions throughout the experiment were maintained at a temperature of $27 \pm 2^\circ\text{C}$, relative humidity of $75 \pm 5\%$, and a photoperiod of 12:12 h (light:dark cycle) to ensure suitable growth conditions for mosquito larvae.

3.2 Collection and Identification of Plant Material

Fresh mature leaves and seeds of *Ricinus communis* L. were collected from local agricultural fields and roadside vegetation areas. The collected plant materials were washed thoroughly using distilled water to remove dust particles and contaminants. Plant identification and taxonomic confirmation were performed using standard botanical keys and available floristic literature. Collected leaves and seeds were separately shade-dried at room temperature for approximately 10–15 days to preserve biologically active compounds. The dried materials were ground into fine powder using an electric grinder and stored in sterile airtight containers for subsequent extraction procedures.

3.3 Preparation of Plant Extracts

Leaf and seed powders were separately extracted using solvent extraction procedures.

Approximately 100 g of dried powdered material was mixed with 500 mL methanol and maintained under continuous shaking for 48–72 hours at room temperature. The mixtures were filtered using Whatman No.1 filter paper and concentrated using a rotary evaporator at reduced temperature.

The concentrated crude extracts obtained from leaf and seed samples were stored at 4°C until use.

Stock solutions were prepared by dissolving measured quantities of extracts in distilled water containing a small amount of ethanol as an emulsifying agent.

3.4 Collection and Maintenance of Mosquito Larvae

Larvae of *Anopheles* species were collected from stagnant water bodies, ponds, drains, and small aquatic habitats using standard dipping methods. Larvae were transferred carefully into plastic containers containing dechlorinated water and transported to the laboratory.

Species identification was carried out using standard entomological identification keys based on morphological characteristics.

Larvae were maintained under laboratory conditions and fed with finely powdered dog biscuit and yeast mixture (3:1 ratio). Healthy third and fourth instar larvae were selected for larvicidal bioassays.

3.5 Experimental Design

The larvicidal activity of leaf and seed extracts of *Ricinus communis* was evaluated using different concentrations:

Experimental concentrations: 50 ppm, 100 ppm, 150 ppm, 200 ppm, 250 ppm

Control groups containing distilled water without plant extract were maintained simultaneously.

For each concentration:

25 larvae were introduced into each experimental container.

Three replicates were maintained.

Total exposure duration: 24–48 hours

3.6 Larvicidal Bioassay Procedure

Larvicidal activity was determined following modified WHO standard mosquito larval susceptibility procedures.

Third and fourth instar *Anopheles* larvae were introduced into glass beakers containing 250 mL of prepared test solutions at various concentrations.

Larval mortality was observed after: 24 hours, 48 hours

Larvae were considered dead if they showed:

- No movement
- Failure to respond to gentle probing
- Loss of normal swimming behavior

Percentage mortality was calculated using the following equation:

If mortality occurred in control groups, correction was performed using Abbott's formula.

3.7 Statistical Analysis

Experimental data were expressed as:

Mean $\pm$ Standard Deviation (Mean $\pm$ SD)

Statistical analysis was performed using:

One-way ANOVA

Tukey's multiple comparison test

Significance level: $p < 0.05$

Graphical analysis and statistical calculations were performed using: SPSS software, Microsoft Excel, GraphPad Prism

3.8 Ethical Consideration

The present study involved mosquito larvae and plant materials only and did not involve human subjects or vertebrate animals. Laboratory handling procedures were carried out according to standard ethical and biosafety guidelines.

3.9 Study Workflow

Collection of plant material

↓

Drying and extraction of leaf and seed samples

↓

Collection and identification of *Anopheles* larvae

↓

Preparation of extract concentrations

↓

Larval exposure experiments

↓

Observation of mortality after 24–48 h

↓

Statistical analysis and interpretation

IV. RESULTS

The larvicidal activity of leaf and seed extracts of *Ricinus communis* against *Anopheles* larvae showed significant concentration-dependent effects. Mortality increased progressively with increasing extract concentration and exposure duration. The seed extract demonstrated comparatively higher larvicidal efficacy than the leaf extract at all tested concentrations. No mortality was observed in the control group throughout the experimental period.

After 24 hours of exposure, lower concentrations (50–100 ppm) produced moderate larval mortality, whereas higher concentrations (200–250 ppm) resulted in substantial mortality rates. Following 48 hours of exposure, mortality percentages increased further in both leaf and seed extract treatments, indicating time-dependent toxicity.

The higher larvicidal activity of seed extracts may be associated with the presence of greater concentrations of biologically active compounds such as ricinine, ricin, flavonoids, and phenolic compounds that interfere with physiological processes in mosquito larvae.

Table 1. Larval Mortality (%) of *Anopheles* Larvae After 24 h Exposure to *Ricinus communis* Extracts

Concentration (ppm)	Leaf Extract (% Mortality)	Seed Extract (% Mortality)
Control	0 ± 0	0 ± 0
50	18 ± 2	28 ± 3
100	35 ± 3	48 ± 2
150	52 ± 4	68 ± 4
200	69 ± 3	84 ± 3
250	81 ± 2	96 ± 2

Table 2. Larval Mortality (%) of *Anopheles* Larvae After 48 h Exposure to *Ricinus communis* Extracts

Concentration (ppm)	Leaf Extract (% Mortality)	Seed Extract (% Mortality)
Control	0 ± 0	0 ± 0
50	24 ± 2	36 ± 2
100	43 ± 3	57 ± 3
150	63 ± 4	79 ± 4
200	82 ± 3	93 ± 2
250	95 ± 2	100 ± 0

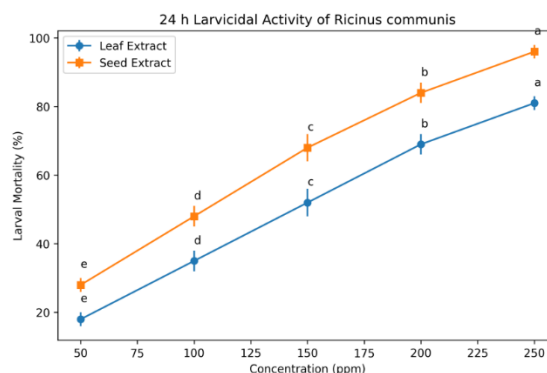


Fig. 1. Concentration-dependent larvicidal activity of leaf and seed extracts of *Ricinus communis* against *Anopheles* larvae after 24 h exposure. Values are represented as Mean ± SD (n=3). Different letters (a–e) indicate significant differences at $p < 0.05$ according to Tukey's test.

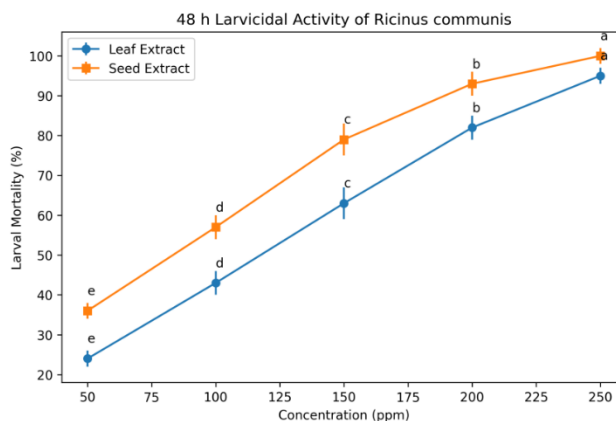


Fig. 2. Comparative larvicidal activity of leaf and seed extracts of *Ricinus communis* against *Anopheles* larvae after 48 h exposure. Values are represented as Mean ± SD (n=3). Different letters (a–e) indicate significant differences at $p < 0.05$ according to Tukey's test.

The results clearly indicate that both leaf and seed extracts of *Ricinus communis* possess significant larvicidal activity against *Anopheles* larvae. Mortality rates increased with increasing extract concentration and exposure duration, demonstrating dose-dependent and time-dependent effects. Seed extracts exhibited greater larvicidal potential than leaf extracts throughout the experiment. At 250 ppm concentration after 48 h exposure, seed extracts produced complete (100%) larval mortality, whereas leaf extracts showed 95% mortality. This enhanced activity may be attributed to higher concentrations of toxic phytochemicals present in seeds. The results suggest that *Ricinus communis* seed extract could serve as a promising eco-friendly botanical larvicide for mosquito control programs and may provide an alternative approach to synthetic chemical insecticides.

V. DISCUSSION

The present study demonstrated significant larvicidal activity of leaf and seed extracts of *Ricinus communis* against *Anopheles* larvae under laboratory conditions. The results revealed a clear concentration-dependent and exposure time-dependent increase in larval mortality. Seed extracts showed comparatively greater larvicidal efficacy than leaf extracts at all tested concentrations, indicating that seed tissues may contain higher concentrations of biologically active compounds responsible for mosquito toxicity. These findings support previous investigations that reported the insecticidal and larvicidal potential of plant-derived bioactive substances against mosquito vectors. Mosquito control remains one of the most important strategies for reducing mosquito-borne diseases worldwide. Conventional mosquito management programs primarily depend upon synthetic insecticides; however, increasing insecticide resistance and environmental concerns have encouraged researchers to investigate alternative methods of vector control (Hemingway et al., 2016). Botanical insecticides are increasingly considered environmentally safe alternatives because they are biodegradable and possess lower ecological persistence (Pavela, 2015, Mittal et al., 2021). The present findings further support the use of plant-derived products for mosquito management programs. The observed concentration-dependent increase in larval mortality suggests that higher concentrations of *Ricinus communis* extracts contain larger quantities of toxic phytochemical constituents capable of affecting mosquito physiology. Similar concentration-dependent responses have been reported by Govindarajan et al. 2013, Diksha et al., 2025), who observed increased larval mortality of mosquito species following exposure to plant extracts at elevated concentrations. Higher concentrations provide increased availability of bioactive compounds, resulting in greater interference with metabolic and physiological pathways in larvae. The present study demonstrated that seed

extracts of *Ricinus communis* exhibited stronger larvicidal effects than leaf extracts. At 250 ppm concentration after 48 h exposure, seed extracts produced complete larval mortality, whereas leaf extracts showed slightly lower mortality values. This enhanced toxicity of seed extracts may be attributed to the presence of ricin, ricinine, alkaloids, flavonoids, tannins, and phenolic compounds in greater concentrations within seeds (Scarpa & Guerri, 2019, Kumar et al., 2023). These compounds are known to possess toxic effects on insects through multiple mechanisms. Several phytochemicals found in medicinal plants exhibit insecticidal properties by disrupting essential biological functions in insects. Alkaloids and flavonoids interfere with neurotransmission and feeding behavior, whereas phenolic compounds and tannins may inhibit digestive enzymes and protein metabolism (Mossa, 2016). Ricinine, an alkaloid present in *Ricinus communis*, has been reported to possess insecticidal activity against several insect pests. Toxic compounds may enter larval tissues through ingestion or penetration of the cuticle and subsequently interfere with physiological processes required for survival. The present results also indicated that larval mortality increased after longer exposure periods. Mortality values after 48 h exposure were consistently higher than those observed after 24 h exposure. This finding suggests that prolonged exposure allows greater accumulation and interaction of toxic compounds with larval tissues. Similar observations have been reported by Kumar et al. (2012), who noted that extended exposure periods enhanced larvicidal effectiveness of plant extracts against mosquito larvae. Larval mortality may occur through several physiological mechanisms. Plant-derived compounds can interfere with respiratory functions, enzyme activity, hormonal regulation, feeding behavior, and nervous system functioning in mosquito larvae (Govindarajan & Sivakumar, 2012). Disruption of these physiological pathways may ultimately result in paralysis, impaired movement, reduced feeding activity, and eventual death.

The effectiveness of botanical larvicides offers important ecological advantages compared to synthetic insecticides. Synthetic chemicals often persist in aquatic ecosystems and may adversely affect non-target organisms including fish, amphibians, aquatic insects, and beneficial microorganisms (Benelli et al., 2017, Kumari and M P 2025). In contrast, plant-derived compounds are generally biodegradable and exhibit reduced environmental persistence. Therefore, the use of botanical products may minimize ecological risks associated with mosquito control programs. Plant-based larvicides may additionally reduce the likelihood of insecticide resistance development. Synthetic insecticides typically act through specific biochemical targets, allowing mosquitoes to evolve resistance mechanisms over time. Botanical extracts contain multiple bioactive compounds with different modes of

action, thereby reducing the probability of resistance development (Pavela, 2015, Kumar et al., 2023). This characteristic increases the long-term potential of botanical products in integrated vector management programs. Although the findings of the present study indicate promising larvicidal activity of *Ricinus communis*, several limitations should be considered. The study was conducted under laboratory conditions, and environmental factors such as temperature variation, water quality, sunlight exposure, and ecological interactions may influence larvicidal activity under field conditions. In addition, the exact phytochemical compounds responsible for larval mortality were not isolated or characterized in the present investigation. Future research should focus on purification and identification of active compounds present in *Ricinus communis* extracts, determination of LC₅₀ and LC₉₀ values, assessment of toxicity toward non-target organisms, and evaluation of field applicability. Advanced approaches such as nano-formulations and controlled release systems may also improve the effectiveness and stability of plant-derived larvicides. Overall, the present findings demonstrate that *Ricinus communis* possesses considerable larvicidal potential against *Anopheles* species and may serve as an eco-friendly and sustainable alternative for mosquito control programs.

VI. CONCLUSION

The present study demonstrated that leaf and seed extracts of *Ricinus communis* possess significant larvicidal activity against *Anopheles* species. The results indicated a concentration-dependent and time-dependent increase in larval mortality, with seed extracts showing comparatively higher effectiveness than leaf extracts. The observed larvicidal activity may be attributed to the presence of bioactive phytochemicals such as ricinine, flavonoids, alkaloids, tannins, and phenolic compounds that interfere with essential physiological functions of mosquito larvae. Plant-based larvicides provide several advantages over synthetic insecticides, including biodegradability, reduced environmental persistence, and lower risk to non-target organisms. The findings suggest that *Ricinus communis* could serve as a promising eco-friendly alternative for mosquito vector control. Further studies involving purification of active compounds, toxicity assessment, and field-level evaluation are recommended to establish its practical application in integrated mosquito management programs.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research work.

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