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Comparative Analysis of the Common Household Agents on *Aedes* and *Culex* Larval Development and Control

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Abstract

Mosquitoes are known for spreading dangerous diseases such as dengue, chikungunya, Zika, and filariasis. Although chemical and biological methods are commonly used to control mosquito populations, their drawbacks have sparked growing interest in alternative solutions that are effective, low-cost, and environmentally friendly. This study investigates the larvicidal effects of household items such as salt, liquid dishwashing detergent, and vinegar on *Aedes* and *Culex* mosquito larvae under laboratory conditions. Larvae were exposed to five concentrations of each substance, and lethal concentration (LC_{50}) values were determined using probit analysis. For *Aedes aegypti*, LC_{50} values were 1.152% for salt, 0.015% for dishwashing liquid, and 0.084% for vinegar. For *Aedes albopictus*, the values were 1.200%, 0.023%, and 0.118%, respectively. Meanwhile, *Culex quinquefasciatus* showed LC_{50} values of 1.335% (salt), 0.021% (dishwashing liquid), and 0.131% (vinegar). There were no significant differences in larval mortality among species treated with salt, (p = *.966*) and vinegar, (p = *.151*) although a slight difference was observed for dishwashing liquid (p = *.032*). All treatments caused clear behavioral and physical changes in the larvae. Larvae showed abnormal behaviours such as restless movement and self-biting, resulting in a curled “C-ring” shape. Darkening of body parts, especially the abdomen and anal papillae, was observed and is attributed to melanization resulting from tissue damage. These results suggest that common household products have potential as practical, sustainable tools for mosquito control at the community level.

1. Introduction

Mosquitoes, small flying insects classified under the order Diptera, are found across the globe from tropical and subtropical zones to temperate climates. To date, around 3,500 mosquito species have been identified. Among them, a few species within the subfamily Culicinae, particularly *Aedes aegypti, Aedes albopictus*, and *Culex quinquefasciatus*, have drawn widespread attention due to their role as vectors of several life-threatening diseases [1]. For example, *Ae. aegypti* and *Ae. albopictus* are responsible for spreading viruses such as dengue, Zika, chikungunya, and yellow fever [2]. Meanwhile, *Anopheles* mosquitoes transmit malaria, and *Cx. quinquefasciatus* is a known vector of Bancroftian filariasis.

Each mosquito species exhibits unique ecological preferences and behaviors. *Aedes* larvae typically develop in clean, stagnant water found in artificial containers like discarded tires or plastic bottles. In contrast, *Culex* species also utilize man-made habitats but prefer water rich in organic pollutants. These differences play an important role in determining the most effective methods for controlling their populations. Chemical insecticides have long been the primary tool for mosquito control. Commonly used compounds include dichlorodiphenyltrichloroethane (DDT), pyrethroids, pyrethrins, organophosphates, and temephos. These chemicals are often applied through fogging, ultra-low volume (ULV) spraying, or residual spraying. While effective, the widespread and repeated use of insecticides has led to growing resistance among mosquito populations. Resistance to DDT was first reported decades ago, followed by increasing resistance to other insecticides such as organophosphates and temephos [3]. Additionally, the environmental consequences of chemical use such as pollution and harm to non-target species have raised concerns about their sustainability.

To reduce reliance on chemical control, biological methods have been developed as more eco-friendly alternatives. Examples include the introduction of *Gambusia affinis* (mosquito fish) [4] to consume larvae and the implementation of *Wolbachia*-infected mosquito programs which interfere with mosquito reproduction [5]. Although these strategies have shown promise, they can be expensive and logistically challenging to scale up, particularly in resource-limited settings. Given these limitations, there is growing interest in identifying alternative control methods that are affordable, effective, and easy to implement especially at the household level. One such approach involves the use of everyday household substances, such as oil, salt, vinegar, and dishwashing liquid, to target mosquito larvae. Historically, oil has been used since the early 1900s to form a thin layer over water surfaces, suffocating larvae by blocking their access to oxygen [6]. More recent interest has turned to the larvicidal potential of common products like vinegar and dish soap, which may disrupt larval development or interfere with their respiratory functions [7]. While these household items are widely available and low-cost, their precise effects on mosquito larvae have not been thoroughly studied. The primary aim of this study is to investigate how common household items specifically salt (NaCl), liquid dishwashing detergent, and vinegar (acetic acid) affect the development and mortality of *Ae. aegypti*, *Ae. albopictus*, and *Cx. quinquefasciatus* mosquito larvae under controlled laboratory conditions.

2. Materials and Methods

2.1 Mosquito Rearing

A total of 1500 eggs each of *Ae. aegypti*, *Ae. albopictus*, and *Cx. quinquefasciatus* were sourced from the Vector Control Research Unit (VCRU), School of Biological Sciences, Universiti Sains Malaysia. These colonies are long-established laboratory strains that have never been exposed to insecticides and are therefore considered fully susceptible. The eggs were divided into batches of 500 and placed in transparent plastic containers filled with approximately 800 ml of distilled water. They were left submerged for 1–2 days until the larvae hatched. The larvae were fed every alternate day until they reached the late 3rd or early 4th instar stages at which point they were used for the assay.

2.2 Preparation of Stock Solutions

Serial dilutions were prepared by dissolving the appropriate amount of each household item (salt, liquid dishwash, and vinegar) into distilled water to produce 1000 mL of stock solution at the desired concentration. Prior to the final preparation, screenings were conducted to determine the suitable concentration range for each household item. This was done to assess the acute toxicity effects on mosquito larvae and to identify the most effective concentration ranges for the bioassay. For the salt (NaCl) solution, the concentration range used was 0.5%, 1.0%, 1.5%, 2.0%, and 2.5% (w/v). For the liquid dishwash (Joy®), the concentrations used were 0.01%, 0.02%, 0.03%, 0.04%, and 0.05% (v/v) with triclosan 0.10% as the active ingredient. For the vinegar (acetic acid) solution, the tested concentrations were 0.05%, 0.10%, 0.15%, 0.20%, and 0.25% (v/v). The desired volumes and concentrations of the stock solutions were calculated using the dilution formula:

$$M1V1 = M2V2 \tag{1}$$

Where,

M1 and V1 are the concentration and volume of the stock solution (initial),
M2 and V2 are the concentration and volume of the final diluted solution

After determining the appropriate concentration ranges, 1000 mL of each stock solution was prepared. The required volume or mass of each household item was measured precisely and thoroughly mixed with distilled water to ensure homogeneity. Each 1000 mL stock solution was then divided into three disposable plastic cups (each containing 200 mL). This procedure was repeated for each concentration level of each household item, with fresh dilutions prepared for each treatment to maintain consistency and minimize variability. Mosquito larvae were then introduced into each cup and monitored for mortality over a 24-hour period. Control groups were maintained using distilled water to confirm the baseline survival rate of the larvae.

2.3 Bioassay of Mosquito Larvae

Following the WHO larvicidal guidelines [8], the experiment was carried out using disposable plastic cups, each filled with 200 ml of the prepared stock solution. Into each cup, 25 mosquito larvae at the late 3rd or early 4th instar stage were introduced. Each concentration of the stock solution was prepared in four replicates. A control group containing only distilled water was added to monitor normal larval development without treatment. Observations were made at one hour and 24 hours after introducing the larvae to record any behavioural and physical changes. Both moribund and dead larvae were counted to calculate the percentage mortality. Larvae were considered dead if they showed no response to probing with a needle in either the siphon or cervical region.

2.4 Observation of Mosquito Larvae under Microscope

Mosquito larvae reared under normal conditions were briefly placed in a freezer to immobilize them. Both the untreated (control) larvae and those exposed to the stock solution were then examined under a stereo binocular microscope. The morphological features of the treated larvae were compared with those of the control group to identify any structural deformities. Images of the larvae were captured using an OLYMPUS SZX16 microscope equipped with OLYMPUS cellSens Standard software and subsequently transferred to a computer for analysis.

2.5 Data Analysis

The data obtained were analyzed using Statistical Package for the Social Sciences software v27 (SPSS). Percentage mortality and Lethal Concentration (LC_{50} and LC_{90}) were calculated using probit analysis to determine statistical significance.

3. Results and Discussion

The present study demonstrates that common household substances, such as salt solution, liquid dishwashing detergent, and vinegar can exert significant larvicidal effects on *Ae. aegypti*, *Ae. albopictus*, and *Cx. quinquefasciatus*. In all three assays, *Ae. aegypti* and *Ae. albopictus* were more susceptible to treatment than *Cx. quinquefasciatus*, although mortality in the latter species increased with higher concentrations. As shown in Figure 1, salt solution was found to be most effective at concentrations of 2% and above, producing nearly complete mortality in *Ae. aegypti* and *Ae. albopictus* larvae, while *Cx. quinquefasciatus* showed comparatively higher tolerance. The mechanism is likely related to osmotic stress, which disrupts larval homeostasis and can lead to dehydration and death [9]. The observed susceptibility of *Aedes* species aligns with previous findings that container-breeding mosquitoes are more sensitive to saline environments than floodwater or sewage-associated species [10].

On the other hand, liquid dishwashing solution exhibited potent larvicidal activity even at very low concentrations (≥0.03%), achieving almost complete mortality in *Aedes* species at 0.04%–0.05% (Figure 2). Detergents act as surfactants, reducing water surface tension and impairing the ability of larvae to breathe at the air water interface, in addition to potential toxicity from chemical components [11]. The high efficacy at low doses suggests a practical advantage for household vector control, as minimal amounts may be sufficient to target breeding sites without substantial cost or environmental residue. Similarly, vinegar solutions induced high mortality in *Aedes* larvae at concentrations as low as 0.2%, with *Cx. quinquefasciatus* again showing greater tolerance (Figure 3). The acidic environment created by acetic acid likely disrupts cellular processes and interferes with larval development [12]. The effectiveness of vinegar as a low-cost and widely available control agent is consistent with its reported antimicrobial and insecticidal properties [13].

This indicates that simple household substances like salt, dishwashing detergent, and vinegar do not act equally against mosquito larvae, and their effectiveness varies not only by the substance but also by the mosquito species tested. Detergent stood out as the most powerful, working at very small amounts to kill nearly all larvae, with a statistically significant effect ($p < .05; p = .032$), while vinegar was effective at slightly higher doses but did not show a significant effect, ($p > .05; p = .151$) and salt solution needed much stronger concentrations before showing similar results and was also not statistically significant ($p > .05; p = .966$). Interestingly, *Ae. aegypti* and *Ae. albopictus* were much easier to control than *Cx. quinquefasciatus*, which was more resistant and survived at doses that were fatal to the *Aedes* larvae. This difference is likely tied to how each species has adapted to its environment, with *Aedes* mosquitoes being more sensitive to changes in water chemistry than the more tolerant *Culex* [14]. This suggests that everyday, low-cost products already present in most households could offer practical options for managing mosquito breeding in small water containers.

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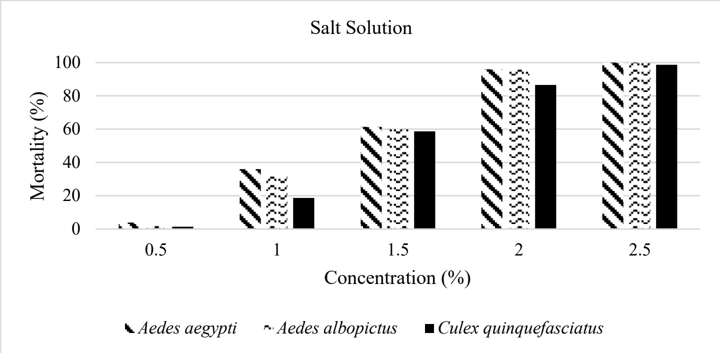

Fig. 1 *Percentage mortality of mosquito larvae in salt solution*

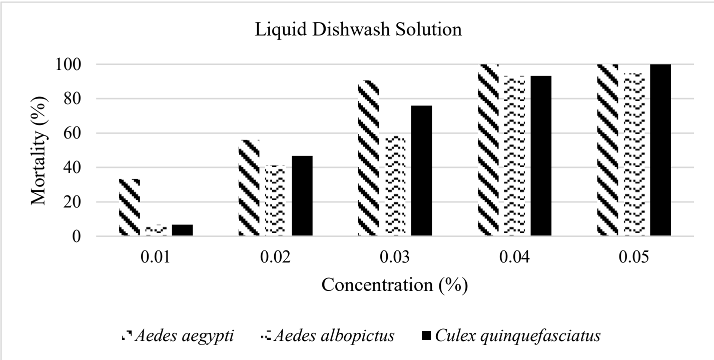

Fig. 2 *Percentage mortality of mosquito larvae in liquid dishwash solution*

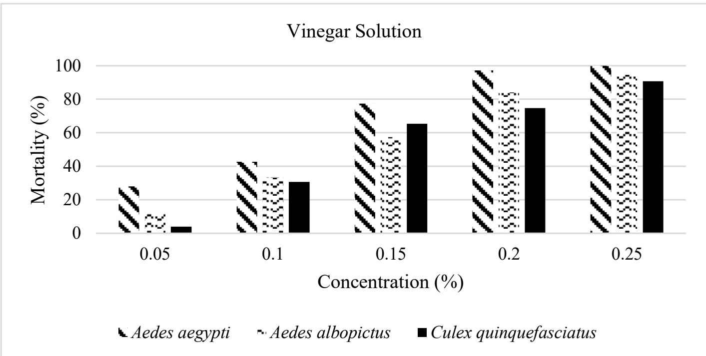

Fig. 3 *Percentage mortality of mosquito larvae in vinegar solution*

3.1 Toxicity Threshold (LC_{50} and LC_{90})

Table 1 presents the LC_{50} and LC_{90} values of salt solution, liquid dishwashing detergent, and vinegar against *Ae. aegypti, Ae. albopictus*, and *Cx. quinquefasciatus*, highlighting clear differences in susceptibility between species and treatments. Liquid dishwashing detergent proved to be the most effective, with LC_{50} values of 0.015% for *Ae. aegypti*, 0.023% for *Ae. albopictus*, and 0.021% for *Cx. quinquefasciatus.* The corresponding LC_{90} values ranged from 0.030% to 0.044%, indicating that near-complete mortality was achieved with only slightly higher concentrations than the median lethal dose. This narrow range underscores the strong killing potential of detergent at minimal concentrations reinforcing detergent's role as a reliable larvicide. Its efficacy at such low doses highlights its practicality for household mosquito control, as even small amounts can substantially reduce larval populations without significant cost or environmental burden.

Table 1 *Toxicity threshold of treatments against mosquito larvae*

Treatment	Species	Lethal Concentration (95% Confidence Interval) LC_{50} (%)	LC_{90} (%)	Slope ± S.D
Salt solution				
	Ae. aegypti	1.152 (0.830 - 1.443)	1.923 (1.522 - 3.367)	5.75 ± 0.50
	Ae. albopictus	1.200 (0.860 - 1.500)	1.936 (1.541 - 3.485)	6.17 ± 0.55
	Cx. quinquefasciatus	1.335 (1.247 - 1.420)	2.111 (1.949 - 2.343)	6.44 ± 0.59
Liquid dishwash (Joy®)				
	Ae. aegypti	0.015 (0.006 - 0.021)	0.030 (0.021 - 0.093)	4.10 ± 0.40
	Ae. albopictus	0.023 (0.017 - 0.028)	0.044 (0.034 - 0.075)	4.54 ± 0.40
	Cx. quinquefasciatus	0.021 (0.019 - 0.022)	0.036 (0.033 - 0.041)	5.18 + 0.42
Vinegar				
	Ae. aegypti	0.084 (0.017 - 0.135)	0.187 (0.120 - 3.163)	3.65 ± 0.35
	Ae. albopictus	0.118 (0.086 - 0.150)	0.252 (0.189 - 0.491)	3.87 ± 0.35
	Cx. quinquefasciatus	0.131 (0.120 - 0.142)	0.267 (0.236 - 0.316)	4.13 ± 0.37

Vinegar (acetic acid) showed moderate effectiveness, with LC_{50} values of 0.084% for *Ae. aegypti*, 0.118% for *Ae. albopictus*, and 0.131% for *Cx. quinquefasciatus* (Table 1). The LC_{90} values were correspondingly higher, at 0.187%, 0.252%, and 0.267% suggesting that larger doses are required to achieve widespread larval mortality compared with detergent. As observed with salt and detergent, *Aedes* species were more susceptible than *Culex,* reflecting differences in ecological adaptation. El Sayed et al. [15] investigated the effect of vinegar on *Culex pipiens* and reported 100% larval mortality when exposed to a 7.5% vinegar solution. They suggested that acetic acid damages and disintegrates larval cells and tissues, ultimately leading to death. Compared with those findings, the present study demonstrates lethal effects at much lower concentrations, highlighting vinegar's potential as a readily available larvicide. However, its reduced effectiveness against *Culex* compared with *Aedes* species suggests that while vinegar may be useful in small breeding habitats where higher doses can be easily applied, its broader application may be limited.

Salt solution, in contrast, was the least effective larvicide, with LC_{50} values of 1.152% for *Ae. aegypti*, 1.200% for *Ae. albopictus*, and 1.335% for *Cx. quinquefasciatus* (Table 1). The LC_{90} values of 1.923%, 1.936%, and 2.111% indicate that much stronger concentrations were required to achieve high mortality compared with detergent and vinegar. These findings align with Sandhu & Singh [16], who reported an LC_{50} of 1.322% for *Ae. aegypti*. While salt can kill mosquito larvae by interfering with their osmoregulation, the relatively high concentrations required to achieve significant mortality limit its practicality as a control measure compared with other agents. Notably, *Cx. quinquefasciatus* again displayed the greatest tolerance, underscoring the role of species-specific adaptations in shaping susceptibility.

Taken together, the findings highlight the potential of salt solution, dishwashing detergent, and vinegar as practical household agents for routine mosquito larval control. Their demonstrated efficacy at relatively low concentrations, coupled with affordability and widespread availability, makes them attractive alternatives or supplements to conventional larvicides [17]. Application of these substances in domestic breeding habitats could serve as a sustainable community-based intervention, reducing dependence on costly chemical insecticides and minimizing the need for specialized operational efforts by vector control programs [17]. Moreover, such approaches may contribute to integrated vector management strategies by empowering households to participate actively in source reduction while mitigating the ecological and health risks associated with repeated use of synthetic chemicals [18].

3.2 Impact on Morphology and Behaviour

Changes in larval morphology and behaviour often provide early indications of stress or toxicity, reflecting the disruptive impact of exposure. In this study, the larvae were frequently observed curling into a C-shaped ring as a result of self-biting (Figure 4 (a)), a response that coincided with periods of intense restlessness and erratic movement during the first hours of treatment, as in Figure 4 (b). In addition, signs of melanization were evident, with darkened regions developing on the abdominal segments (Figure 4(c)) and anal papillae (Figure 4(d)) of larvae treated with household solutions.

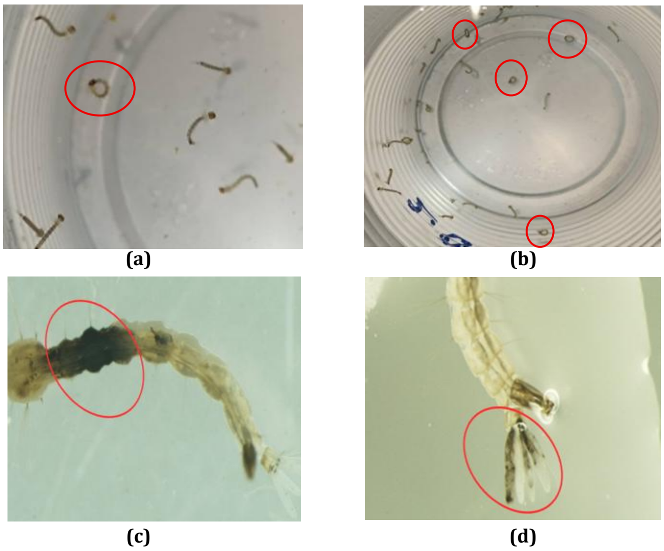

Fig. 4 *(a) Self biting behaviour; (b) Formation of C-shaped ring; (c) Melanization at the body segments (d) Melanization at the anal papillae*

These manifestations are not merely superficial changes but reflect deeper disruptions to larval physiology. Excessive movement and self-biting behaviors are consistent with neurotoxic stress, where interference with neuromuscular regulation alters normal activity patterns [19]. Melanization, by contrast, is widely recognized as part of the insect immune defense, typically arising in response to tissue damage or chemical insult [19] [20]. Similar observations have been reported in larvae exposed to both synthetic larvicides and plant-derived compounds, suggesting that such responses represent a general stress pathway rather than an agent-specific effect [21]. Overall, the observations suggest that exposure to household substances, even at non-lethal concentrations, can trigger substantial morphological and behavioral disruptions in mosquito larvae, potentially impairing their development and reducing their chances of survival.

4. Conclusion

In conclusion, this study demonstrate that common household substances such as salt, vinegar, and especially dishwashing detergent can serve as effective, low-cost options for mosquito larval control. Their varying but significant efficacy, particularly the potent action of detergent and vinegar at low concentrations, demonstrates practical potential for reducing mosquito populations, especially in domestic settings where traditional interventions may be limited. The observed species-specific responses, with *Cx. quinquefasciatus* showing greater resistance than *Aedes* species, highlight the need for targeted strategies that account for ecological and physiological variability. Given their accessibility and safety, these agents offer a practical complement to conventional methods, supporting sustainable, community-based approaches to vector control.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Azlinda Abu Bakar;* ***data collection:*** *Voo Qun Yun;* ***analysis and interpretation of results:*** *Voo Qun Yun, Azlinda Abu Bakar;* ***draft manuscript preparation:*** *Azlinda Abu Bakar. All authors reviewed the results and approved the final version of the manuscript.*

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