



International Journal of Mosquito Research

ISSN: 2348-5906

CODEN: IJMRK2

Impact Factor (RJIF): 5.82

IJMR 2025; 12(6): 13-21

© 2025 IJMR

<https://www.dipterajournal.com>

Received: 12-08-2025

Accepted: 17-09-2025

Archana Yadav

Department of Zoology, Kamla
Nehru Institute of Physical and
Social science, Sultanpur, Uttar
Pradesh, India

Neeraj Yadav

Department of Zoology, Kamla
Nehru Institute of Physical and
Social science, Sultanpur, Uttar
Pradesh, India

Sippy Singh

Department of Zoology, S S
Khanna Girls' Degree College,
Prayagraj, Uttar Pradesh, India

Alok Suman Sharma

Department of Public Health,
Tata Steel Utilities and
Infrastructure Services,
Jamshedpur, Jharkhand, India

Larvicidal action of Temephos and its environmental impact: A comprehensive review

Archana Yadav, Neeraj Yadav, Sippy Singh and Alok Suman Sharma

DOI: <https://www.doi.org/10.22271/23487941.2025.v12.i6a.865>

Abstract

Temephos, an organophosphate larvicide, is extensively employed in India for mosquito control, specifically targeting mosquito larvae in standing water. Mosquito-borne diseases such as dengue, malaria, and chikungunya pose substantial public health risks, Temephos application has become a crucial element of integrated vector management programs. The compound works by inhibiting the activity of cholinesterase, an essential enzyme in the nervous system of mosquito larvae, ultimately leading to their death. Studies conducted in various regions of India have shown its efficacy in reducing mosquito populations, particularly *Aedes*, *Anopheles* and *Culex* species, which are primary vectors for dengue, Chikungunya, malaria and Filariasis respectively. However, the overuse of Temephos raises concerns about the development of resistance among mosquito populations, necessitating regular monitoring and the implementation of rotation with other control agents to maintain its effectiveness and ensure long-term vector management in the country. In this article we trying to analyze the larvicidal action of Temephos and its impact on aquatic organisms including nontargeting species and other terrestrial organism and its long terms ecological effect.

Keywords: Temephos, larvicide, resistance, public health, vector control

1. Introduction

Mosquito-borne illnesses remain a considerable global public health concern, particularly in tropical and subtropical areas where warm, humid climates foster mosquito propagation^[1, 2, 3]. Diseases such as malaria, dengue fever, chikungunya, and lymphatic filariasis are spread by various mosquito species, including *Anopheles*, *Aedes*, and *Culex*. In context of the India, where mosquito-borne diseases are a significant public health concern, These vector-borne diseases result in millions of deaths each year and place a substantial socioeconomic burden on impacted populations, especially in countries where these illnesses are endemic^[4, 5, 6, 7].

To mitigate the spread of these diseases, various mosquito control strategies have been developed, one of the most effective of which is chemical control using insecticides and larvicides. Among the array of chemical agents, Temephos stands out as one of the most widely used larvicides for controlling mosquito larvae, playing a crucial role in integrated vector management programs in several countries, including India. Laboratory studies have established Temephos' effectiveness, showcasing its ability to deliver high mortality rates in numerous mosquito species, including *Aedes*, *Anopheles*, and *Culex*.^{8,9} Temephos has been crucial in managing populations of mosquitoes responsible for spreading serious illnesses such as malaria, dengue, and chikungunya^[10, 11].

2. History of Temephos

Temephos, known chemically as O,O,O',O'-tetramethyl O,O'-thiodi-p-phenylene bis (phosphorothioate), is a non-systemic organophosphorus (OP) pesticide commonly utilized to control mosquito outbreaks.¹² It was first synthesized in the 1950s by American Cyanamid Company^[13, 14]. The chemical belongs to the class of organophosphates, a group of compounds known for their potent insecticidal properties.

Initially, Temephos was developed as a broad-spectrum insecticide targeting various agricultural pests, but it quickly gained recognition for its efficacy against mosquito larvae.

Corresponding Author:**Archana Yadav**

Department of Zoology, Kamla
Nehru Institute of Physical and
Social science, Sultanpur, Uttar
Pradesh, India

The U.S. Environmental Protection Agency (EPA) registered Temephos as a larvicide in 1965^[10, 15]. After which it was adopted by several countries, including India, for use in mosquito control programs. Its specific action on mosquito larvae in water bodies made it a preferred choice for combating mosquito populations before they could mature into adults, thereby reducing the incidence of mosquito-borne diseases.

3. Mechanism of Action

Temephos primarily functions by impeding cholinesterase, an essential enzyme for appropriate neurological function in insects. By disrupting cholinesterase, temephos interferes with standard nerve impulse transmission, culminating in paralysis and subsequent mortality in mosquito larvae^[16, 17, 18].

It acts as a neurotoxin by impeding acetylcholinesterase, which is responsible for breaking down acetylcholine, a neurotransmitter crucial for relaying signals across the synaptic gap between nerve cells^[19, 20]. In normal circumstances, acetylcholinesterase breaks down acetylcholine after it has transmitted a nerve signal, ensuring that the signal is short-lived and does not over-stimulate the nerve. However, in the presence of Temephos, the breakdown of acetylcholine is blocked, leading to the continuous transmission of nerve signals. This overstimulation results in paralysis and ultimately the death of the mosquito larvae. Recent histopathological studies on *Aedes aegypti* have also indicated that Temephos acts as a stomach poison, causing harm to the midgut of the larvae^[15, 21].

4. Application and Efficacy of Temephos

Temephos is typically utilized as granules or an emulsifiable concentrate, applied directly to bodies of water where mosquito larvae are found. These habitats include stagnant ponds, pools, ditches, and containers that serve as breeding sites for mosquitoes. In context of the India, where mosquito-borne diseases are a significant public health concern, Temephos has played a vital role in vector control strategies. India has one of the highest burdens of mosquito-borne diseases in the world, with recurring outbreaks of malaria, dengue fever, and chikungunya affecting millions of people each year. The use of Temephos in India is part of an integrated pest management approach, combining chemical, biological, and environmental interventions to control mosquito populations. *Aedes aegypti* is a significant vector for dengue and chikungunya in India, breeding in domestic water storage containers. Numerous studies demonstrated the effectiveness of Temephos against *Aedes aegypti* larvae. Several studies have highlighted the effectiveness of Temephos against *Aedes aegypti* larvae. In Delhi, Temephos achieved 100% mortality at concentrations as low as 0.02 mg/L within 24 hours, underscoring its high larvicidal potency at minimal doses. Reported LC₅₀ values for *Aedes aegypti* larvae^[23] in Tamil Nadu ranged between 0.012 and 0.017 mg/L. *Anopheles stephensi*, a vector of urban malaria, has also been extensively studied for Temephos susceptibility. Laboratory and field investigations throughout India have indicated high *Anopheles stephensi* larvae sensitivity to temephos, with LC₅₀ values spanning from 0.01 to 0.02 mg/L^[24]. *Culex quinquefasciatus*, the vector of lymphatic filariasis, is one of the most common mosquito species in India. Temephos has been found to be highly effective in controlling *Culex* larvae. Studies in Kolkata and southern India reported

LC₅₀ values of around 0.012 mg/Which indicating high larvicidal efficacy^[25].

Field investigations have substantiated temephos' capacity to diminish mosquito populations across diverse Indian states. Integrated vector management (IVM) has progressively become a thorough methodology for mosquito control, amalgamating various strategies to sustainably manage mosquito populations. IVM involves a combination of chemical, biological, and environmental methods to minimize the reliance on any single control measure, thereby reducing the likelihood of resistance development and environmental harm^[26, 27]. Temephos has been a key component of IVM programs, particularly in regions where chemical control is necessary due to high mosquito populations and disease outbreaks.

One of the key advantages of Temephos is its relative safety for non-target organisms, particularly when compared to other insecticides^[28, 29, 30]. Temephos is specifically formulated for application in water bodies, where mosquito larvae develop, and has low toxicity to fish, birds, and mammals at recommended dosages. This makes it an attractive option for use in areas where human and animal populations coexist with mosquito breeding habitats.

5. Challenges of Resistance

While Temephos has been widely used for decades, the extensive and prolonged application of this insecticide has raised concerns about the development of resistance in mosquito populations. Insecticide resistance occurs when mosquitoes evolve mechanisms to survive from exposure to insecticides that would normally be lethal. larval susceptibility / resistance to Temephos (Table: 1) and other organophosphates has been documented in various parts of the world, including India.

Several studies conducted in India have reported resistance to Temephos among mosquito populations, particularly *Aedes aegypti*. In Tamil Nadu, researchers have observed reduced susceptibility to Temephos in *Culex quinquefasciatus*, with LC₅₀ values increasing to 0.04 mg/l^[31]. In some regions, the emergence of resistance has been linked to continuous, year-round application of Temephos, leading to the selection of resistant mosquito populations.

Some worker studied in West Bengal and revealed that the some *Aedes aegypti* populations exhibited partial resistance to Temephos, requiring higher concentrations for effective larval control^[32]. These findings suggest that the overuse of Temephos could reduce its long-term efficacy and underline the need for resistance management strategies, including the rotation of larvicides and integration of non-chemical control measures. The mechanisms of resistance to Temephos in mosquitoes include genetic mutations that alter the target site of the insecticide (cholinesterase), as well as enhanced metabolic detoxification that breaks down the insecticide before it can act. As per Pungasem Paeporn *et al*, 2003, *Ae. aegypti* populations may develop temephos resistance under selective pressure, primarily through esterase detoxification. Resistance can markedly diminish mosquito control program effectiveness, resulting in elevated mosquito populations and heightened disease transmission^[33]. Resistance can significantly reduce the effectiveness of mosquito control programs.

Resistance monitoring is critical to ensure the continued effectiveness of Temephos. To address the issue of resistance,

vector control programs often rotate Temephos with other insecticides or combine it with biological control methods,²⁶ such as the introduction of larvivorous fish or bacterial agents like *Bacillus thuringiensis israelensis* (Bti), to target mosquito larvae.

6. Environmental and Public Health Concerns

Despite its widespread use and relative safety, there are environmental and public health concerns associated with the use of Temephos. As with all chemical insecticides, the improper application or overuse of Temephos can lead to unintended environmental consequences. Runoff from treated water bodies can introduce Temephos into ecosystems where it may affect non-target species, particularly aquatic organisms like crustaceans and insects.

In addition, the long-term exposure of human populations to Temephos in treated water bodies has raised concerns about potential health risks. Although Temephos is considered to have low toxicity to humans at the concentrations used for mosquito control, chronic exposure to even low levels may be associated with neurological and developmental effects. Therefore, it is essential that Temephos be used in accordance with safety guidelines and that alternative mosquito control measures are explored to reduce reliance on chemical agents. On the basis of Studies many workers had been reported that the temephos has cytostatic and genotoxic effects^[34, 35].

7.1 Toxicity of Temephos on Non-Targeted Fauna and Flora: While Temephos is highly effective as a mosquito larvicide, its use raises concerns about its impact on non-target organisms in aquatic bodies^[36] and surrounding environments³⁷. The chemical's toxicity can vary significantly between different species, ecosystems, and environmental conditions. This section will focus on the effects of Temephos on non-targeted fauna and flora, including aquatic organisms, terrestrial animals, and potential implications for human health.

7. Toxicity to Aquatic Organisms

7.1 Crustaceans and Insects

Temephos is particularly toxic to non-target aquatic invertebrates, such as crustaceans, which play vital roles in aquatic ecosystems as decomposers and as food sources for other species. Research has indicated that crustaceans like freshwater shrimp,^[38] crabs,^[39] and copepods^[40, 41] are highly sensitive to Temephos exposure, showing symptoms such as reduced mobility, reproductive issues, and death at concentrations like those used for mosquito control.

Several studies have demonstrated that Temephos can impact on growth and development of aquatic insects that are not vectors of disease. For instance, dragonflies^[36] and damselflies,^[36] which are predators of mosquitoes, can also be affected, leading to create potential imbalances in ecosystems where these species contribute to natural mosquito population control.

7.1.2 Fish: Fish species vary in their sensitivity to Temephos. While Temephos is considered to have low toxicity to most fish species when applied at recommended doses for mosquito control, some species of fish, particularly those in early developmental stages are more vulnerable. For example, studies on *Cyprinus carpio*^[42] and Tilapia species^[43] have shown adverse effects on behaviour, growth, and mortality at

elevated Temephos concentrations. Moreover, bioaccumulation of Temephos in fish tissue poses a risk to the food chain, potentially affecting predators that consume contaminated fish.

7.1.3 Amphibians: Amphibians, particularly tadpoles are another group of organisms that can be impacted by Temephos use. Tadpoles exposed to Temephos have shown developmental delays, reduced growth rates, and increased mortality. Amphibians are important bioindicators of ecosystem health, and their sensitivity to pesticides like Temephos may reflect broader environmental impacts. The loss or reduction of amphibian populations due to larvicide use could also disrupt food webs, as amphibians serve as both predators and prey within their ecosystems^[44].

7.2 Toxicity to Terrestrial Animals

While Temephos is mainly applied to aquatic habitats, there is a risk of contamination in surrounding terrestrial environments. Several terrestrial animals, including birds, mammals, and beneficial insects could be exposed to Temephos indirectly.

7.2.1 Birds

Temephos is considered to have low acute toxicity to birds, with studies indicating that birds such as ducks, quail, and chickens can tolerate exposure to the chemical at doses higher than those typically used for mosquito control. However, sublethal effects, such as reproductive impairments and behavioral changes, may occur at chronic exposure levels or in ecosystems where Temephos persists in the food chain. Birds that feed on aquatic invertebrates or fish in treated water bodies may also be indirectly affected by bioaccumulation of Temephos.

Available data indicates that the LD₅₀ of Temephos varies across avian species, ranging from 18.9 mg/kg in the California quail to 240 mg/kg in the chukar partridge^[45]. LD₅₀ values in other studied bird species, such as the Japanese quail, pheasant, and rock dove, fall between 35 mg/kg and 85 mg/kg^[45]. Mallards exposed to diets with moderate temephos concentrations exhibited no reproductive alterations, except for egg-laying frequency^[46].

7.2.2 Mammals

Mammals including humans are generally less susceptible to Temephos toxicity than invertebrates, but high levels of exposure can still be harmful. Temephos is an organophosphate, and like other chemicals in this class, it inhibits acetylcholinesterase, leading to overstimulation of the nervous system^[47].

Research suggests that prenatal exposure to Temephos can induce atypical behaviors and social interactions, including hyperactivity, repetitive behaviors, and impaired social skills in mice. Further studies have found that Temephos can cause lasting DNA damage in human HepG2 cells^[48]. Controlled-release formulations could help sustain effective pesticide levels, prolong pesticide residual activity, lower application rates and costs, decrease environmental pesticide levels, and reduce toxicity to mammals and non-target organisms^[49, 50].

7.3 Impact on Beneficial Insects

One of the significant concerns regarding Temephos use is its potential impact on beneficial insect populations, such as

pollinators and natural predators of mosquitoes. Insects like bees, butterflies, and predatory beetles play critical roles in ecosystems by pollinating plants and controlling pest populations.

7.3.1 Pollinators

Although Temephos is primarily used in aquatic environments, there is a possibility that pollinators could be affected through drift or contact with contaminated water sources^[51]. While studies on the specific impact of Temephos on pollinators like honeybees are limited, there is concern that repeated exposure to sublethal doses could affect their foraging behaviours, reproduction, and colony health. Protecting pollinators is vital for maintaining biodiversity and agricultural productivity, and minimizing Temephos application near flowering plants or pollinator habitats is important for reducing risks to these species. It is evident that the Temephos, an organophosphate, registration was cancelled in 2011 by United State, Environmental Protection Agency with all remaining stocks to be discontinued by December 2016^[52].

7.3.2 Predatory Insects

Temephos has been shown to affect predatory insects that naturally control mosquito populations, such as dragonflies, damselflies,^[36] and aquatic beetles^[53]. The reduction of these predators can lead to unintended increases in mosquito populations, as natural predation is an essential component of mosquito control in many ecosystems. The loss of predator populations due to larvicide use may result in an over-reliance on chemical control measures, leading to a vicious cycle of pesticide application and ecosystem disruption.

8. Environmental Persistence and Bioaccumulation

Temephos exhibits relatively low environmental persistence^[54] with a half-life in water ranging from several days to weeks, depends on environmental factors such as temperature, pH, and the presence of organic material. Nevertheless, Temephos can persist for extended durations in sediments and soils, potentially causing long-term contamination of aquatic ecosystems. This persistence is especially concerning in regions with repeated Temephos applications or slow water body turnover. According to Takayuki Hanazato *et al.* (1989), application of the chemical at a target concentration of 500 µg litre⁻¹ eliminated almost all zooplankton. No recovery of Cladocera was evident at the termination of the experiment after 47 days^[56].

Bioaccumulation of Temephos in aquatic organisms, particularly fish and invertebrates, poses a risk to higher trophic levels including birds, mammals, and humans that consume contaminated food. Monitoring programs are necessary to ensure that Temephos concentrations remain within safe limits in environments where it is used regularly.

9. Human Health Concerns

Temephos is considered to have low toxicity to humans when used at recommended levels,^[57] but there are concerns about potential long-term effects, especially in communities with repeated or chronic exposure to the chemical. Consequently, an acceptable daily intake or reference dose has not been established, primarily because numerous studies were of insufficient quality due to non-compliance with good laboratory practices (GLP)^[58, 59].

Ingestion of contaminated water, dermal exposure during application, and inhalation of aerosols are potential routes of exposure for humans. Acute exposure to high levels of Temephos can lead to symptoms of organophosphate poisoning, including nausea, headaches, dizziness, and, in severe cases, respiratory failure and death. The World Health Organization (WHO) estimates approximately 3,000,000 acute pesticide poisoning cases annually, resulting in 220,000 fatalities. A significant proportion of these incidents occur in developing nations^[60, 61]. Therefore, it is critical that public health authorities monitor the use of Temephos and ensure that safety measures are in place to protect communities living near treated areas.

10. Current Status and Future Directions

Temephos remains a crucial tool in managing mosquito populations in India and other countries grappling with mosquito-borne diseases^[11, 57]. To ensure its continued effectiveness, its application must be carefully monitored to prevent resistance and reduce potential risks to the environment and public health^[26, 66]. Ongoing research into the mechanisms of resistance, as well as the development of new control agents and technologies, will be crucial for ensuring the continued effectiveness of mosquito control efforts^[27].

Scientists are continuously studying how mosquitoes develop resistance and are working to create new control methods and technologies. Alternative strategies like using genetically modified mosquitoes, the sterile insect technique (SIT), and biological controls have also become more appealing in recent years. These approaches offer the potential to reduce mosquito populations without the heavy reliance on chemical insecticides like Temephos. However, these methods are still in the experimental stage and require further validation before they can be widely implemented.

Looking ahead, the integration of Temephos with these novel strategies could provide a more sustainable and effective approach to mosquito control. By combining chemical, biological, and genetic methods, it may be possible to achieve long-term reductions in mosquito populations and the diseases they transmit, while minimizing the risks associated with insecticide use.

The current dose and frequency of Temephos for mosquito control are based on specific recommendations set by public health authorities and depend on the mosquito species, environmental conditions, and depend on the water bodies being treated. Temephos is typically applied in water bodies where mosquito larvae develop, and its dosage is difficult to controlled as the job mostly handled by low educated people or lay man after minimal training. The agency and staff engaged in anti-mosquito programme need to trained regular interval for safe treatment practice while minimizing harm to non-target species.

General Guidelines for The Application of Temephos.

1. How Much to Use

Granular Form: For temephos granules (1% concentration), a common suggestion is to use about 1 part of the active ingredient for every million parts of water (1 ppm)^[62]. In real-world tests using this 1 ppm application in containers with *Aedes aegypti* mosquitoes, it effectively kept them under control for weeks or even months in certain situations^[63].

Liquid Form (Emulsifiable Concentrate): If when using a

liquid concentrate, typically apply somewhere between 0.5 to 1 litre per hectare. The exact amount depends on how concentrated the active ingredient is in the product.

For Drinking Water/Containers: The World Health Organization (WHO) advises that the concentration of the active ingredient should not go over 1 milligram per liter (1 ppm) when you're using the granular form in drinking water or water storage containers ^[64].

2. How Often to Apply: Stagnant or Slow-Moving Water: For areas like ponds, ditches, containers, or other still or slow-moving water sources, it's often necessary to re-apply temephos every 7 to 14 days to ensure control of larvae emerging after the previous dose has declined in effect.

High-Risk/Peak Season Areas

When there are a lot of mosquitoes breeding, some control programs might switch to applying temephos every week (7 days). This helps to quickly suppress the developing larvae.

Long-Term Problem Areas

In water bodies that are relatively stable, temephos can last longer. In good conditions, it might continue to be effective for 3 to 4 weeks. Some lab studies have even shown it can kill larvae for up to 15 weeks under controlled conditions ^[4]. However, in actual field settings, it usually doesn't last that long (often 2-4 weeks) because of things like dilution, water turnover, and the presence of organic matter ^[65].

Table 1: Temephos larval susceptibility / resistance Test

No.	(Author, Year)	Location	Species (stage)	Method / assay	Key finding
1.	Carvalho, <i>et al.</i> , 2004. ^[66]	Brazil	<i>Aedes aegypti</i> (larvae)	WHO diagnostic dose standard larval bioassay.	A 2004 study indicated that initial monitoring of temephos sensitivity in Brazilian <i>Aedes aegypti</i> larvae populations utilized the World Health Organization (WHO) standard method to determine their susceptibility
2.	Chediak <i>et al.</i> , 2016. ^[67]	Brazil	<i>Aedes aegypti</i> (larvae)	Large spatial survey using WHO larval bioassays and dose-response tests.	A 2016 study found variable yet widespread decreased sensitivity or increased resistance to temephos in numerous Brazilian states, with resistance documented in some regions since the mid-1990s.
3.	Sivabalakrishnan <i>et al.</i> , 2023. ^[68]	Jaffna, Sri Lanka	<i>Aedes aegypti</i> (larvae)	Larval bioassays; investigated association of salinity tolerance and temephos susceptibility.	In Jaffna, Sri Lanka, a 2023 study revealed that <i>Aedes aegypti</i> larvae that tolerate higher salinity levels showed a decreased sensitivity to temephos, accompanied by changes in their cuticle and egg characteristics.
4.	Singh <i>et al.</i> , 2025 ^[69]	Dehradun (Uttarakhand), India	<i>Aedes aegypti</i> & <i>Anopheles stephensi</i> (larvae)	WHO larval susceptibility methods (diagnostic/dose-response).	According to a 2025 study in Dehradun (Uttarakhand), India, there is a reported potential for <i>Aedes aegypti</i> to develop resistance and <i>Anopheles stephensi</i> was also assessed. Recent local data from India indicates reduced susceptibility in some urban areas, suggesting a need for monitoring resistance.
5.	Palomino <i>et al.</i> , 2022 ^[70]	Peru	<i>Aedes aegypti</i> (larvae)	Dose-response following WHO recommendations, LC ₅₀ /LC ₉₅ estimated.	A 2022 study presented the first country-wide assessment in Peru, revealing varying degrees of resistance to temephos.
6.	Grisales <i>et al.</i> , 2013 ^[71]	Colombia	<i>Aedes aegypti</i> (larvae)	WHO larval bioassay, dose-response	A 2013 study in Colombia showed that high levels of resistance to temephos were interfering with effective mosquito control.
7.	Dos Santos Dias <i>et al.</i> , 2017 ^[72]	Brazil	<i>Aedes aegypti</i> (larvae)	Dose-response bioassays (LC ₅₀ /LC ₉₅) per WHO methods.	In some Brazilian <i>Aedes aegypti</i> populations, high-intensity resistance to temephos was observed. Additionally, tests were conducted to assess cross-toxicity with spinosad, revealing that the LC ₉₅ value (the concentration required to kill 95% of the population) was significantly higher in resistant populations.
8.	Davila-Barboza <i>et al.</i> , 2024. ^[73]	Mexico	<i>Aedes aegypti</i> (larvae)	Bioassays were performed on late 3rd instar/early 4th instar larvae. WHO diagnostic-concentration assays across 23 populations.	In Mexico, a 2024 study revealed that resistance to temephos is widespread among the <i>Aedes aegypti</i> populations sampled. Specifically, 96% of the populations tested were classified as resistant, indicating widespread resistance in the areas studied and serving as a strong warning against continued reliance on temephos.
9.	Adhikari <i>et al.</i> , 2021. ^[74]	India	<i>Aedes aegypti</i> (lab generations)	Laboratory selection over 28 generations. Bioassays were performed	<i>Aedes aegypti</i> mosquitoes subjected to prolonged exposure to temephos over 28 generations showed a rapid development of resistance. The toxicity of temephos was reduced by approximately 7.8-fold in these mosquitoes, indicating a decreased susceptibility to the insecticide
10.	Morgan <i>et al.</i> , 2021. ^[75]	UK	<i>Aedes aegypti</i> (larvae)	Gene-expression profiling + bioassays	A 2021 study of <i>Aedes aegypti</i> larvae in the UK reported LC ₅₀ values for sampled populations and also characterized transcriptional differences related to how they susceptible to temephos.
11.	Bisset <i>et al.</i> , 2013. ^[76]	Costa Rica	<i>Aedes aegypti</i> (larvae)	WHO larval assays + synergist tests	LC ₅₀ and LC ₉₅ reported Biochemical/synergist data link temephos resistance to metabolic enzymes.

12.	Thornton <i>et al.</i> , 2020. ^[77]	Brazil	<i>Aedes aegypti</i> (larvae)	Dose-response bioassays (WHO Lab selection / reversal studies)	LC ₅₀ values measured. Demonstrates possible partial reversion of resistance with selection withdrawal.
13.	Paeporn <i>et al.</i> , 2003. ^[78]	Thailand	<i>Aedes aegypti</i> (larvae)	WHO bioassays	Early lab-selection demonstration of enzyme-mediated resistance.
14.	Thongwat <i>et al.</i> , 2015. ^[79]	Thailand (several sites)	<i>Aedes aegypti</i> (larvae)	WHO larval bioassays	A 2015 study in Thailand reported the LC ₅₀ values for temephos in different locations, indicating that some sites showed susceptibility or low to moderate resistance. The study also found regional differences in how susceptible <i>Aedes aegypti</i> larvae were to temephos
15.	Faraj <i>et al.</i> , 2010. ^[80]	Morocco	<i>Anopheles Sp.</i>	WHO larval assays	Methodological review defining discriminating concentrations and interpretation.
16.	Jangir <i>et al.</i> , 2023. ^[81]	Chittorgarh district, Rajasthan, India	<i>Aedes aegypti</i> (larvae & adults)	WHO standard larval bioassays (field sampling, reference strain comparisons).	A 2023 study in Chittorgarh district, Rajasthan, India indicated that there are local differences in <i>Aedes aegypti</i> and <i>Aedes albopictus</i> populations, with some showing decreased susceptibility to temephos. The study also found varying levels of resistance among local mosquito populations and a decline in temephos susceptibility in some districts.
17.	Piedra <i>et al.</i> , 2023 ^[82]	Cuba (Havana)	<i>Aedes aegypti</i> (larvae)	WHO larval bioassays.	High resistance reported in several municipalities.
18.	Azizi <i>et al.</i> , 2019 ^[83]	Iran (An. stephensi focus)	<i>Anopheles stephensi</i> (larvae)	Lab + semi-field residual and susceptibility tests.	Susceptibility/residual persistence evaluated for temephos and pyriproxyfen. Toxicity and residual activity for <i>An. stephensi</i> larvae.
19.	Viafara-Campo <i>et al.</i> , 2025 ^[84]	Colombia (Caquetá / Florencia)	<i>Aedes aegypti</i> (larvae)	Larval bioassays + microbiome analyses	Links larval resistance phenotype with gut microbiota differences.
20.	Haidy Massa <i>et al.</i> , 2025 ^[85]	(Nouakchott, Mauritania)	<i>Aedes sp.</i>	Larval assays	A recent study in Nouakchott, Mauritania (2025), provided a dataset showing the LD ₅₀ values for temephos-susceptible <i>Aedes</i> larvae, highlighting the variability in susceptibility among local larval groups.

Conclusion

Temephos has been a critical tool in the global fight against mosquito-borne diseases since its discovery in the mid-20th century. Its ability to target mosquito larvae in aquatic environments has made it an invaluable asset in reducing the transmission of diseases like malaria, dengue, and chikungunya, particularly in countries like India, where these diseases are prevalent. However, the challenges posed by insecticide resistance and environmental concerns underscore the need for careful management of Temephos use.

While Temephos remains a valuable tool for mosquito control, its use must be carefully managed to mitigate its impact on non-target fauna and flora. Aquatic invertebrates, fish, amphibians, and beneficial insects are particularly vulnerable to the toxic effects of Temephos, and its persistence in sediments and potential for bioaccumulation raise concerns about long-term environmental contamination. Moreover, the risk of chronic exposure to humans and wildlife necessitates the implementation of safety guidelines and the exploration of alternative control methods to reduce reliance on chemical agents like Temephos.

To mitigate potential harm to non-target organisms and the environment, integrated vector management (IVM) strategies should be implemented. These strategies combine temephos with biological control agents, environmental management practices, and public health education to promote sustainable and effective mosquito control while protecting biodiversity and maintaining ecosystem health.

Acknowledgement

The authors are grateful to the Principal, Kamla Nehru Institute of Physical and Social Sciences, Sultanpur and Head, Department of Zoology of the institute for providing the

necessary resources and a conducive environment for this study. The author, Dr. Archana Yadav extends heartfelt thanks to the Department of Higher Education, Government of Uttar Pradesh, for sanctioning the research grant (Letter No. 40/2024/335/Sattar-4-2024-002-4(33)/2023, dated 15/03/2024) under the Research and Development Plan for the minor project.

References

- Asad H, Carpenter D O. Effects of climate change on the spread of Zika Virus: A public health threat. *Rev. Environ. Health.* 2018;33:31-42.
- Chang AY, Fuller DO, Carrasquillo O, Beier JC. Social justice, climate change, and dengue. *Health Hum. Rights.* 2014;16: 93-104.
- Leal Filho W, Bönecke J, Spielmann H, Azeiteiro UM, Alves F, Lopes de Carvalho M, *et al.* Climate change and health: An analysis of causal relations on the spread of vector-borne diseases in Brazil. *Clean. Prod.* 2017
- Rathod GK, Jain M, Sharma KK, Das S, Basak A, Jain R. New structural classes of antimalarials. *Euro J Med Chem.* 2022;242:114653.
- Reddya Naik B, Tyagi B K, Xue Rui-de. Mosquito-borne diseases in India over the past 50 years and their global public health implications: a systematic review. *Journal of the American Mosquito Control Association.* 2023;39(4):258-277.
- Sztankay-Gulyás M. Mosquito control with integrated method. *Wiadomosci Parazytologiczne.* 1972;18: 629-33.
- Leyanna George, Audrey Lenhart, Joao Toledo, Adhara Lazaro, Wai Wai Han, Raman Velayudhan, *et al.* Community-Effectiveness of Temephos for Dengue Vector Control: A Systematic Literature Review. *Plos*

- Negl Trop Dis 2015;9(9):1-22.
8. Brar R, Suri V, Suri V, Singh MP, Biswal M, Sikka P. Fever during pregnancy: etiology and fetal/maternal outcomes. J Obstet Gynaecol India. 2022;72:102-108.
 9. Valecha N. Keeping the momentum: suggestions for treatment policy updates in the final push to eliminate malaria in India. Malar J 2023;22:128.
 10. Benitez-Trinidad AB, Herrera-Moreno JF, Vázquez-Estrada G, Verdín-Betancourt FA, Sordo M, Ostrosky-Wegman P, et al. Cytostatic and genotoxic effect of temephos in human lymphocytes and HepG2 cells. Toxicology in Vitro. 2015;29: 779-786.
 11. Bang YH, Tonn RJ. Evaluation of 1% Abate (OMS-786) sand granules for the control of *Aedes aegypti* larvae in potable water. WHO/VBC/69. 1969a;121: 1-10.
 12. Bang YH, Tonn RJ. Residual life of Abate (OMS- 786) sand granules in water containers under water usage practice. WHO/VBC/69. 1969b;125: 1-10.
 13. Hebert Adrianto, Sri Subekti, Heny Arwati, Etha Rambung, Hanna Tabita Hasianna, Silitonga, Etik Ainun Rohmah. Another Mode of Action of Temephos Against *Aedes aegypti* Larvae. A Stomach Poison Investigation. Pharmacognosy Journal. 2023;15:2 Mar-Apr,
 14. Verdín-Betancourt FA, Figueroa M, Soto-Ramos AG, de Lourdes López-González M, Castañeda-Hernández G, Bernal-Hernández YY, et al. Toxicokinetics of temephos after oral administration to adult male rats. Arch Toxicol. 2021;95(3): 935-947.
 15. Gholivand K, Ebrahimi Valmoozi AA, Bonsaii M. Synthesis and crystal structure of new temephos analogues as cholinesterase inhibitor: Molecular docking, qsar study, and hydrogen bonding analysis of solid state. J Agric Food Chem. 2014;62(25): 5761-5771.
 16. Adhikari K, Khanikar B. Gradual reduction of susceptibility and enhanced detoxifying enzyme activities of laboratory-reared *Aedes aegypti* under exposure of temephos for 28 generations. Toxicol Reports, 2021;8:1883-1891.
 17. Gholivand K, Ebrahimi Valmoozi AA, Bonsaii M. Synthesis and crystal structure of new temephos analogues as cholinesterase inhibitor: Molecular docking, qsar study, and hydrogen bonding analysis of solid state. Journal of Agricultural and Food Chemistry, 2014;62(25): 5761-5771.
 18. Verdín-Betancourt FA, Figueroa M, Soto-Ramos AG, de Lourdes López-González M, Castañeda-Hernández G, et al. Toxicokinetics of temephos after oral administration to adult male rats. Archives of Toxicology. 2021;95(3): 935-47.
 19. Adrianto H, Subekti S, Arwati H, Rambung E, Silitonga HTH, Rohmah EA. Another Mode of Action of Temephos Against *Aedes aegypti* Larvae: A Stomach Poison Investigation. Pharmacognosy Journal. 2023;15(2): 298-303.
 20. Das M, & Subramanian S. Efficacy of Temephos in controlling *Aedes aegypti* in urban environments. Journal of Vector Borne Diseases. 2015;52(1): 33-38.
 21. Kumar P, & Kalyanasundaram M. Larvicidal activity of Temephos against dengue vector mosquitoes. Indian Journal of Medical Research, 2017;145(2): 170-175.
 22. Singh R, & Sharma A. Evaluation of Temephos toxicity against *Anopheles stephensi* in Mumbai. Malaria Journal. 2016;15(1):105.
 23. Dutta P, & Baruah B. Temephos resistance in *Culex quinquefasciatus*: a study in southern India. Indian Journal of Parasitology. 2014;38(2): 78-85.
 24. Henk van den B, Clifford M, Mutero, Kazuyo I. Guidance on policy- making for Integrated Vector Management. World Health Organization. 2012.
 25. Karina M, Lizzi, Whitney A, Qualls, Scott C, Brown, and John C, Beier. Expanding integrated vector management to promote healthy environments. Trends Parasitol. 2014;30(8): 394-400.
 26. Lacey LA, Goettel MS. Current Developments in microbial control of insect pests and prospects for the early 21st century. Entomophaga. 1995;40:3-27.
 27. Keller S. Les maladies fongiques des ravageurs et leur importance pratique. Revue Suisse de viticulture, arboriculture, horticulture. 1991;23: 299-310.
 28. Bhan S, Shrankhla, Mohan L, Srivastava CN. Larvicidal toxicity of Temephos and entomopathogenic fungus, *Aspergillus flavus* and their synergistic activity against malaria vector, *Anopheles stephensi*. Journal of Entomology and Zoology Studies. 2013;1(6): 55-60.
 29. Rajavel AR, Natarajan R. Monitoring insecticide resistance in mosquito populations in Tamil Nadu. Journal of Insect Science. 2019;12(3):44-50.
 30. Ghosh A, Chatterjee S. Resistance to Temephos in *Culex quinquefasciatus* from West Bengal. Parasites & Vectors. 2018;11(1): 214.
 31. Pungasem Paeporn, Narumon Komalamisra, Vanida Deesin, Yupha Rongsriyam, Yuki Eshita and Supatra Thongrungrat. Temephos resistance in two forms of *Aedes aegypti* and its significance for the resistance mechanism. Southeast Asian J Trop Med Public Health. 2003;34(4): December
 32. Aiub CAF, Coelho ECA, Sodré E, Pinto LFR, Felzenszwalb I. Genotoxic evaluation of the organophosphorous pesticide temephos. Genet Mol Res. 2002;1:159-166.
 33. Benitez-Trinidad AB, Herrera-Moreno JF, Vázquez-Estrada G, Verdín-Betancourt FA, Sordo M, Ostrosky-Wegman P, et al. Cytostatic and genotoxic effect of temephos in human lymphocytes and HepG2 cells. Toxicol in Vitro. 2015;29:779-786.
 34. Carlos F, Marina J, Guillermo Bond, José Muñoz, Javier Valle, Rodolfo Novelo-Gutiérrez, Trevor Williams. Efficacy and non-target impact of spinosad, Bti and temephos larvicides for control of *Anopheles* spp. in an endemic malaria region of southern Mexico. Marina et al. Parasites & Vectors 2014, 1-10.
 35. José Legorreta-Soberanis, Sergio Paredes-Solís, Arcadio Morales-Pérez, Elizabeth Nava-Aguilera, Felipe René Serrano de los Santos Belén Madeline Sánchez-Gervacio, et al. Ledogar, Anne Cockcroft and Neil Andersson. Coverage and beliefs about temephos application for control of dengue vectors and impact of a community-based prevention intervention: secondary analysis from the Camino Verde trial in Mexico. BMC Public Health 2017;426.
 36. Brown M D 1, Thomas D, Watson K, Greenwood J G, Kay B H. Acute toxicity of selected pesticides to the estuarine shrimp *Leander tenuicornis* (Decapoda: Palaemonidae). J Am Mosq Control Assoc 1996;12(4):721-724.
 37. Pinkney A E 1, McGowan P C, Murphy D R, Lowe T P,

- Sparling D W, Meredith W H, Effects of temephos (Abate 4E) on fiddler crabs (*Uca pugnax* and *Uca minax*) on a Delaware salt marsh. *J Am Mosq Control Assoc.* 1999;15(3):321-329.
38. WHO. Guidelines for Chemical Control of Copepod Populations in Dracunculiasis Eradication Programs. Guidelines for Chemical Control of Copepod Populations in Dracunculiasis Eradication Programs. WHO;1989.
 39. Muller R. Laboratory experiments on the control of cyclops transmitting Guinea worm. *Bull World Health Organ.* 1970;42: 563-567.
 40. Ba-Omar TA, Al-Jardani S, Victor R. Effects of pesticide temephos on the gills of *Aphanius dispar* (Pisces: Cyprinodontidae). *Tissue and Cell.* 2011;43: 29-38.
 41. D.I. Anadu, H.U. Anaso and O.N.D Onyeka, Acute toxicity of the insect larvicide abate® (temephos) on the fish *tilapia melanopleura* and the dragonfly larvae *Neurocordelia virginiensis*. *Journal of Environmental Science and Health*, 2008;1363-1375.
 42. Khaled A, Osman, Amira Ali, Nabila S, Ahmed, Ayman S, El-Seedy. Biochemical and genotoxic effects of some pesticides on the Egyptian Toads, *Sclerophrys regularis* (Reuss, 1833). *Watershed Ecology and the Environment* 2022;4: 125-134.
 43. Hudson R H, Tucker R K, Haeghele MA. Handbook of Toxicity of Pesticides to Wildlife. Resource Publication 153. U.S. Department of Interior, Fish and Wildlife Service, Washington, DC;1984:5-16
 44. Franson J C, Spann J W. Effects of dietary ABATE on reproductive success, duckling survival, behavior, and clinical pathology in game-farm mallards: Temephos. *Arch. Environ. Contam. Toxicol.* 1983;12: 529-534.
 45. Dina Satriawan, Wibi Sindjaja, Timmy Richardo. Toxicity of the Organophosphorus Pesticide Temephos. *Indonesian Journal of Life Sciences.* 2019;01: 62-76.
 46. Christine T Wong, Joshua Wais, Dorota A, Crawford, Prenatal exposure to common environmental factors affects brain lipids and increases risk of developing autism spectrum disorders. *Eur J Neurosci.* 2015;42(10): 2742-2760.
 47. Kumar S, Bhanjana G, Sharma A, Sidhu MC, Dilbaghi N. Synthesis characterization and on field evaluation of pesticide loaded sodium alginate nanoparticles. *Carbohydrate Polymers* 2014;101:1061-1067.
 48. Devi N, Kakati DK. Smart porous microparticles based on gelatin/sodium alginate polyelectrolyte complex. *Journal of Food Engineering* 2013;117(2):193-204.
 49. Johansen, CA. 1977. Pesticides and Pollinators. *Ann. Rev. Entomol.* 22:177-192
 50. USEPA. Controlling Mosquitoes at the Larval Stage. <https://www.epa.gov/mosquitocontrol/controlling-mosquitoes-larval-stage>.
 51. Bruce C. Campbell and Robert F. Denno. The Effect of Temephos and Chlorpyrifos on the Aquatic Insect Community of a New Jersey Salt Marsh. *Environmental Entomology.* 1976;5(5): 477-483
 52. Richard Pierce, Michael Henry, Dan Kelly, Paul Sherblom, Wendy Kozlowsky, George Wiciertmant and Wayne Miller. Temephos distribution and persistence in a southwest florida salt marsh community. *Journal of the American Mosquito Control Association*, 1996;12(4):637-646,
 53. USEPA. Controlling Mosquitoes at the Larval Stage. <https://www.epa.gov/mosquitocontrol/controlling-mosquitoes-larval-stage>.
 54. Takayuki Hanazato, Toshio Iwakuma, Masayuki Yasuno, Mitsuru Sakamoto, Effects of temephos on zooplankton communities in enclosures in a shallow eutrophic lake. *Environmental Pollution.* 1989;59:305-314
 55. Renshaw W, Bobbis A. Temephos. In: Joint by FAO and WHO, with the support of the international programme on chemical safety/joint meeting of the FAO panel of experts on pesticide residues in food and the environment and WHO core assessment group. *Pesticide residues in food.* 2006.
 56. Francisco Alberto Verdín-Betancourt, Mario Figueroa, Ma. de Lourdes López-González, Elizabeth Gómez, Yael Yvette Bernal-Hernández, Aurora Elizabeth Rojas-García, et al. *In vitro* inhibition of human red blood cell acetylcholinesterase (AChE) by temephos-oxidized products. *Scientific Report.* 2019;1-11. www.nature.com/scientificreports/
 57. Guo J X, Wu J J Q, Wright J, Lushington, G H. Mechanistic insight into acetylcholinesterase inhibition and acute toxicity of organophosphorus compounds: A molecular modeling study. *Chem. Res. Toxicol.* 2006;19:209-216
 58. He F. Neurotoxic effects of insecticides current and future research review. *Neurotoxicology.* 2000;21:839-845.
 59. Kushik Jaga and Chandrabhan Dharman. Sources of exposure to and public health implications of organophosphate pesticides. *Rev Panam Salud Publica/Pan Am J Public Health.* 2003;14:171-185.
 60. Jill N Ulrich, Diana P Naranjo, Temitope O Alimi, Günter C Müller, John C Beier. How much vector control is needed to achieve malaria elimination? *Trends Parasitol.* 2013;29:104-109.
 61. Seligman H, Gillen VA, Utner R. *Insect control. Isotopes in everyday life*, Vienna, IAEA 1990;15-18.
 62. Raccolto CIR-181856/2021-Temephos (Granules)(428)-173 Temephos 1% Granules (Insecticide) <http://www.raccolto.in/>
 63. George L, Lenhart A, Toledo J, Lazaro A, Han WW, Velayudhan R, et al. Community-Effectiveness of Temephos for Dengue Vector Control: A Systematic Literature Review. *PLoS Negl Trop Dis.* Sep 2015 15;9(9): e0004006. doi: 10.1371/journal.pntd.0004006. PMID: 26371470; PMCID: PMC4570708.
 64. WHO: WHO specifications and evaluations for public health pesticides Temephos. Geneva, World Health Organization (FAO/WHO Evaluation Report 2005. http://www.who.int/whopes/quality/Temephos_eval_June_2007_corr_aug160807.pdf).
 65. Abai MR, Hanafi-Bojd AA, Vatandoost H. Laboratory Evaluation of Temephos against *Anopheles stephensi* and *Culex pipiens* Larvae in Iran. *J Arthropod Borne Dis.* 2016;Oct 4, 10(4): 510-518. PMID: 28032103; PMCID: PMC5186741.
 66. Carvalho de Maria do Socorro Laurentino, Eloísa Dutra Caldasb, Nicolas Degallierc, Paulo de Tarso Ribeiro Vilarinhosa, Luís César Kenupp Rodrigues de Souza, Maria Amélia Cavalcanti Yoshizawaa, Monique Britto Knox and Cristiane de Oliveiraa. Susceptibility of *Aedes aegypti* larvae to the insecticide temephos in the Federal District, Brazil. *Rev Saúde Pública* 2004;38(5) 1

www.fsp.usp.br/rsp

67. Chediak M G, Pimenta F Jr, Coelho GE, Braga IA, Lima JB, Cavalcante KR, *et al.* Spatial and temporal country-wide survey of temephos resistance in Brazilian populations of *Aedes aegypti*. Mem Inst Oswaldo Cruz. 2016 May;111(5):311-21. doi: 10.1590/0074-02760150409. Epub 2016 Apr 29. PMID: 27143489;PMCID: PMC4878300.
68. Sivabalakrishnan, K, Thanishaichelvan, M, Tharsan A. *et al.* Resistance to the larvicide temephos and altered egg and larval surfaces characterize salinity-tolerant *Aedes aegypti*. Sci Rep. 2023;13: 8160. <https://doi.org/10.1038/s41598-023-35128-1>
69. Singh, RK, Kumar Gaurav, Joshi Subhash, Anvikar Anup. Susceptibility of temephos against *Aedes aegypti* and *Anopheles stephensi* larvae in Dehradun, Uttarakhand, India. Journal of Vector Borne Diseases. Jan-Mar2025;62(1):117-121, | DOI:10.4103/JVBD.JVBD_98_24
70. Palomino M, Pinto J, Yañez P. *et al.* First national-scale evaluation of temephos resistance in *Aedes aegypti* in Peru. Parasites Vectors 2022;15: 254 <https://doi.org/10.1186/s13071-022-05310-x>.
71. Grisales N, Poupardin R, Gomez S, Fonseca-Gonzalez I, Ranson H, Lenhart A. Temephos Resistance in *Aedes aegypti* in Colombia Compromises Dengue Vector Control. PLoS Negl Trop Dis. 2013;7(9):e2438. <https://doi.org/10.1371/journal.pntd.0002438>.
72. Dos Santos Dias L, Macoris MdLd G, Andrighetti MTM, Otrera VCG, Dias AdS, Bauzer LGSdR, *et al.* Toxicity of spinosad to temephos-resistant *Aedes aegypti* populations in Brazil. PLoS ONE. 2017;12(3):e0173689. <https://doi.org/10.1371/journal.pone.0173689>
73. Davila-Barboza JA, Gutierrez-Rodriguez SM, Juache-Villagrana AE, Lopez-Monroy B, Flores AE. Widespread Resistance to Temephos in *Aedes aegypti* (Diptera: Culicidae) from Mexico. Insects. 2024 Feb 7;15(2):120. doi: 10.3390/insects15020120. PMID: 38392539; PMCID: PMC10889149.
74. Adhikari Kamal, Bulbuli Khanikor, Gradual reduction of susceptibility and enhanced detoxifying enzyme activities of laboratory-reared *Aedes aegypti* under exposure of temephos for 28 generations, Toxicology Reports, Volume 8, 2021, Pages 1883-1891, ISSN 2214-7500, <https://doi.org/10.1016/j.toxrep.2021.11.013>.
75. Morgan J, Salcedo-Sora JE, Triana-Chavez O, Strode C. Expansive and Diverse Phenotypic Landscape of Field *Aedes aegypti* (Diptera: Culicidae) Larvae with Differential Susceptibility to Temephos: Beyond Metabolic Detoxification. J Med Entomol. 2022 Jan 12;59(1):192-212. doi: 10.1093/jme/tjab179. PMID: 34718656; PMCID: PMC8755997.
76. Bisset J. A., R. Marín, M. M. Rodríguez, D. W. Severson, Y. Ricardo, L. French, M. Díaz, O. Pérez, Insecticide Resistance in Two *Aedes aegypti* (Diptera: Culicidae) Strains From Costa Rica, Journal of Medical Entomology. March 2013 50(2): 352-361, <https://doi.org/10.1603/ME12064>
77. Thornton J, Gomes B, Ayres C, Reimer L. Insecticide resistance selection and reversal in two strains of *Aedes aegypti*. Wellcome Open Res. Dec 2020;16(5):183. doi: 10.12688/wellcomeopenres.15974.2. PMID: 33521329; PMCID: PMC7814284.
78. Paeporn Pungasem, Narumon Komalamisra1, Vanida Deesin, Yupha Rongsriyam, Yuki Eshita and Supatra Thongrungrat. Temephos Resistance In Two Forms Of *Aedes Aegypti* And Its Significance For The Resistance Mechanism southeast Asian J Trop Med Public Health. December 2003;34(4):786-792.
79. Thongwat Damrongpan, Bunchu Nophawan. Susceptibility to temephos, permethrin and deltamethrin of *Aedes aegypti* (Diptera: Culicidae) from Muang district, Phitsanulok Province, Thailand Asian Pacific Journal of Tropical Medicine Asian Pacific Journal of Tropical Medicine. 2015;14-18.
80. Faraj C1 E, Adlaoui1 M, Elkohli T, Herrak B, Ameur, Chandre F. Review of Temephos Discriminating Concentration for Monitoring the Susceptibility of *Anopheles labranchiae*(Falleroni, 1926), Malaria Vector in Morocco. Malaria Research and Treatment Volume 2010; Article ID 126085, 5 pages doi:10.4061/2010/126085
81. Jangir PK, Prasad A. Insecticide susceptibility status on *Aedes aegypti* (Linn) and *Aedes albopictus* (Skuse) of Chittorgarh district, Rajasthan, India. Exp Parasitol. 2023Nov;254:108619. doi: 10.1016/j.exppara.2023.108619. Epub 2023; Sep 20. PMID: 37739025.
82. Piedra LA, Martínez Y, Camacho E, Garcia I, Rodriguez D, *et al.* Temephos resistance levels in populations of *Aedes aegypti* (Diptera: Culicidae) from Havana, Cuba. Open J Trop Med. 2023;7(1): 017-023. DOI: <https://dx.doi.org/10.17352/ojtm.000025>.
83. Azizi K, Soltani A, Amiri SA, Djaefar Moemenbellah Fard M, Fakoorziba MR. Laboratory and Semi-Field Evaluations on Lethal and Residual Effects of Temephos and Pyriproxyfen Insecticides to Control Malaria Mosquito Larvae, *Anopheles Stephensi* Liston. J Health Sci Surveillance Sys. 2019;7(1):40-47
84. Viafara-Campo JD, Vivero-Gómez RJ, Fernando-Largo D, Manjarrés LM, Moreno-Herrera CX, Cadavid-Restrepo G. Diversity of Gut Bacteria of Field-Collected *Aedes aegypti* Larvae and Females, Resistant to Temephos and Deltamethrin. Insects. 2025Feb8;16(2):181. doi: 10.3390/insects16020181. PMID: 40003811; PMCID: PMC11856030.
85. Haidy Massa M, Ould Lemrabott MA, Gomez N, Ould Mohamed Salem Boukhary A, Briolant S. Insecticide Resistance Status of *Aedes aegypti* Adults and Larvae in Nouakchott, Mauritania. Insects. 2025;16(3):288. <https://doi.org/10.3390/insects16030288>