Vector Biology Journal

Research A SCITECHNOL JOURNAL

Predatory efficacy of selected plant extracts and botanical synthesised nanoparticles on Culex (L) fuscanus

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Received date: August 31, 2021; **Accepted date:** November 16, 2021; **Published date:** November 26, 2021

Citation: Dass K, Mariappan P (2021) Model development of Coating Material for Low Carbon Steels using Multi Criteria Decision Making Techniques. Vector Biol J. 6(2).

Abstract

Chemical based insecticides and bio-pesticides are used to control mosquito larvae and in turn these larvicides posse problems to non-target co-inhabitants. In this regard the present study was carried out to find the influence of Aegle marmelos, Coleus aromaticus, Colocasia esculenta and Wrightia tinctoria plant extracts and green synthesized silver nanoparticles on the predation of mosquito predator, Cx (L) fuscanus which is also a mosquito larva. The study indicates that the plant extracts and green synthesized silver nano-particles have no effect (P<0.05) on the predation of Cx (L) fuscanus. Hence use of these plant extract and green synthesized silver nano-particles are recommended to control mosquito larvae along with this predator.

Key words: Predation. Cx (L) fuscanus. Plant extracts. Nanoparticles.

Introduction

Synthetic insecticides such as DDT, Malathion and temephos used for vector control are non-degradable, non-selective and have harmful effect on non-target organisms the alternative for synthetic insecticide, plant derived natural products have many advantages. Being harmless to non-target organisms they do not cause pollution. They are also biodegradable [1]. The use of these natural chemicals in mosquito control program have no adverse effect on biocontrol agents, since biological control is one of the important management strategies of mosquito control where a variety of predators are in use since, different types of predators are used to control of mosquito larvae. Mosquito predator lists start from mosquito larvae of Toxorhynchites to some families of aquatic bugs and beetles, tadpoles, flatworms, nematodes, copepods, fishes, dragonfly nymph etc. Wide spectrums of biological agents are in use as biological agents in mosquito abatement programme[2]. Protozoa, fungi, bacteria and viruses also have been considered as biological control agents [3]. Larvivorous fishes such as Gambusia holbrooki, Pseudomugil signifier [4] Gambusia affinis [5] and Poecilia reticulate [6] are also used in mosquito control programme. Use of these larvivourous fishes show encouraging results [7] and Gambusia affinis is known as 'mosquito fish' due to its feed preference.

Pesticide/ larvicide applied to control mosquito larvae also have negative consequences on non-target organisms [8]. Pesticides both synthetic chemicals and plant derived chemicals are much in use as mosquito larvicides, have direct or indirect effect on the aquatic inhabitant including predator of mosquito [9]. These larvicides may have an indirect effect on larval predation which is reported earlier by Mariappan [10]. A comprehensive review on the effect of different type of chemical agents and its action on non-target organism are reviewed by Talebi[11].

Before advocating a larvicide in mosquito control programme it should be tested for its activity on non-target organism also. In this regard the present study is aimed to find out the effect of plant extracts (A. marmelos, C. aromaticus C. esculenta, and W. tinctoria) and green synthesized silver nano-particles on the predation of mosquito predator, Cx (L) fuscanus which is also a mosquito larvae.

Materials and methods

Larval predation

The prey Cx.quinquefasciatus and the predator Cx (L) fuscanus were cultured in laboratory following the method adapted by WHO. 2005 [12] and the IV instars of predator Cx (L) fuscanus were kept in speared containers without feed for a period of 12 hours before performing the experiment. In a series plastic aquarium of 300ml capacity with 250 ml of test concentrations (Sub lethal concentration of LC50 values, 1/4, 1/5, 1/7 ppm of LC50 values of methanol extract of A. marmelos, C. aromaticus C. esculenta, and W. tinctoria) (1/2, 1/3, 1/6 concentration synthesized silver nanoparticles using A. marmelos, C. aromaticus C. esculenta, and W. tinctoria) were taken. Sub-lethal concentrations were selected on basis of LC50 value obtained based on a series of experiments conducted for plant extracts and green synthesized silver nanoparticles (LC50 values of plant extracts Aegle marmelos 151.43 ppm, Coleus aromatics 188.36 ppm, Colocasia esculenta165.69 ppm and Wrightia tinctoria 210.29 ppm and green synthesized silver nano particles of Aegle marmelos 33.40 ppm, Coleus aromatics 36.07ppm,Colocasia esculenta32.69 ppm and Wrightia tinctoria 42.76 ppm for IV instar larvae).

In each aquarium one Cx (L) fuscanus (predator) and 10 Cx. quinquefasciatus IV larvae (prey) were introduced simultaneously. Number of larvae consumed / killed by the predator was recorded for a period of one hour. A control aquarium was also maintained separately by one predator and 10 Cx. quinquefasciatus larvae. These experiments were repeated three times for each test concentration.

Results and Discussion

This experiment was conducted to study the compatibility of the plant extracts and green synthesized silver nanoparticles as larvicides to use in integrated bio-control programme along with mosquito predator Cx (L) fuscanus. Cx (L) fuscanus is also mosquito species which is a co-inhabitant of other mosquito larvae.

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Experiments were conducted in three types of chosen sub-lethal concentrations for plant extracts and green synthesized silver nanoparticles. The chosen concentrations for plant extracts A. marmelos are 23.3, 26.6 and 30, C. aromaticus are 23.3, 30, and 30, C. esculenta are 26.6, 30 and 30, and W. tinctoria are 23.6, 26.3 30 respectively (Table.1).

Table 1: Influence of A. marmelos, C. aromaticus, and C. esculenta and W. tinctoria methanolic leaf extracts on the predation of IV instar of Cx. quinquefasciatus by Cx. (L) fuscanus.

Plant species	Control	Concentration (ppm) (% of consumption)		
		1/4	1/5	1/7
A. marmelos	30.0 ± 3.3	23.3 ± 3.3	26.6 ± 3.3	30 ± 0.0
C. aromaticus	30 .0 ± 0.0	23.3 ± 3.3	30 ± 0.0	30 ± 0.0
C. esculenta	30.0 ± 0.0	26.6 ± 3.3	30 ± 0.0	30 ± 0.0
W. tinctoria	30.0 ± 0.0	23.3 ± 0.0	26.6 ± 6.6	30 ± 0.0

Likewise green synthesized silver nanoparticles A. marmelos are 26.6, 26.6 and 30, C. aromaticus are 23.3, 26.6 and 30, C. esculenta are 26.6, 26.6 and 30 and W. tinctoria are 26.6, 30 and 30 respectively (Table.3). There is no mortality (predator and prey) occurred during the period of experiment in the selected sub-lethal concentration of plant extracts and green synthesized silver nano-particles. An average of 30 % larvae was consumed by Cx (L) fuscanus in the category of control and 27.45 % for plant extracts 27.74% for green synthesized silver nanoparticles.

A two way ANOVA was performed to study the effect of plant extracts and green synthesized silver nanoparticles and their concentrations on the predator organism. The analysis indicates that there is no significant difference in the predation of Cx (L) fuscanus by the plant extracts. Likewise green synthesized silver nanoparticles also have such effect on the predation of Cx (L) fuscanus (Table.2 and 4).

Table 2: Influence of A. marmelos, C. aromaticus, C. esculenta and W. tinctoria green synthesized silver nanoparticles on predation of IV instar of Cx. quinquefasciatus by Cx. (L) fuscanus.

Plant species	Control	Concentration (ppm) (% of consumption)		
		1/2	1/3	1/6
A. marmelos	30.0 ± 0.0	26.6 ± 3.3	26.6 ± 3.3	30 ± 0.0
C. aromaticus	30.0 ± 0.0	23.3 ± 3.3	26.6 ± 3.3	30 ± 0.0
C. esculenta	30.0 ± 0.0	26.6 ± 3.3	26.6 ± 3.3	30 ± 0.0
W. tinctoria	30.0 ± 0.0	26.6 ± 0.0	30 ± 0.0	30 ± 0.0

Insecticides of chemicals origin create several environmental problems in addition to killing non-target organisms such as beneficial natural predators and pollinators. In this regards one should be very careful in integration of biological control and chemical control agents in mosquito control programme. Both agents are must be complement to each other [13]. The effective larvicide and biological control agents are two important components in an integrated pest management system. Since most of the insecticides have a broad spectrum of action, they affect both prey and predator. Selective pesticides are available in few in numbers and these should be identified and integrated in to pest management. A selective pesticide is one that is toxic to pest (target), but has little or no effect on non-target organisms [14]. A list of non-target organism to Bti which is used to control mosquitoes is given by Glare and O'Callaghan [15].

Toxicological studies indicate that allethrin group of compounds are toxic to aquatic organisms like fish and stone fly and are less toxic to other aquatic insect larvae and Daphnia. For other species of arthropods the allethrin toxicity ranges from 20 to 2000 ppm [16]. Toxicity of pyrethrum against various fishes was reported and for Salmo gairdneri the toxicity is 0.056 ppm, for Ictalurus punctatus it is 0.096 ppm, for Lepomis macropchirus it is 0.080 ppm and for stone flies Pteronarcys californica it is 0.010 ppm [17]. Further synergistic effect of pyrethroids had been reported 5 times more toxic to rein trout [18].

Table 3: Analysis of Variance (ANOVA) to test the influence of plant extracts and their concentrations on the predatory efficacy of Cx. (L) fuscanus on Cx. Quinquefasciatus

Source	SS	df	MS	F	P
Main effect Concentration	149.99	3	49.99	2.66	0.0644*
Plant extract	66.66	3	2.22	1.88	0.3309*
Interaction Concentration × Plant extract	83.33	9	9.25	.49	0.8677*
Error	600	32	18.75		
Total	900	47			

*Statistically not significant at 0.05% level

Brown et al. [19] reported the application of organophosporous has hazardous or unknown effect on associated non-target species. Effects of methanolic extract of A. monophylla on non-target organisms have revealed that this extracts is safer to predatory fishes G. affinis and P. reticulata and aquatic bugs D. indicus. Hence it is recommended to use the plants extracts along with these predatory fishes in Integrated Vector Control (IVM) [20].

Three medicinal plants such as Mammea siamensis, Anethum graveolens and Annona muricata were tested for larvicidal and pupal activity against Ae. aegypti and their effect on non-target organisms. The results show that these plants were toxic to Ae. aegypti larvae and pupae but had no adverse effect on guppy fish (Poecilia reticulata) [21].

Table 4: Analysis of variance (ANOVA) to test the influence of green synthesized silver nano-particles and their concentrations on the predatory efficacy of Cx. (L) fuscanus on Cx. quinquefasciatus

Source	SS	df	MS	F	P
Main effect Concentration	106.25	3	35.41	2.42	0.0834*
Silver nano-particles	6.24	3	2.08	0.14	0.9335*
Interaction Concentration × Silver nano-particles	18.75	9	2.08	.14	0.9979*
Error	466.66	32	14.58		
Total	597	47			

*Statistically not significant at 0.05% level

Chloroform-methanol extract of *Solanum villosum* was tested for its larvicidal activity against *An. subpictus* larvae and its effect on larvae of *Chironomus circumdatus. The results indicate that there is no effect of S. villosum* extract on non-target organism [12]. Crude extract of Jasmine, *Cestrum diurnum* was tested for larvicidal activity against C*x. quinquefasciatus*. *C. diurnum* extract have a toxic effect on target organisms and no mortality was noticed for non-target organisms, such as *Oreochromis niloticus* and Chironomid larvae under the laboratory condition [22].

Subarani et al [23] studied the larvicidal activity of green synthesized silver nanoparticles of Vinca rosea (L) leaves against the larvae of malaria vector A. stephensi and the filarial vector, Cx. quinquefasciatus. They have compared the toxicity of silver nanoparticles on the target (Cx. quinquefasciatus) as well as non-target organism, (Poecilia reticulate a predatory fish).

Table 5: Impact of pesticides/ larvicides on non-target arthropods organisms.

Pesticides / Larvicides	Bio-control agent	Impact	Reference
Extract of Azadirachta indica seed	Encarsia sp; Aleurodiphilus sp	Reduce the parasitoids population	Price and Schuster 1991[26]
d-allethrin	Culex (Lutzia) fuscanus	Harmless	Mariappan et al., 1997[27]
Acetonic fraction of Trichilia havanensis	Chysoperla carnea	Harmless	Huerta et al., 2003[28]
Natural pyrethrins	Chrysoperla caenea	Harmful	
Azadirachtin	Trichogramma cacoeciae	Reduced life table parameter	Saber et al., 2004[29]
	Amblyseius cucumeris	Harmless	Thoeming and Poehling, 2006[30]
	Hypoaspis aculeifer	Moderately harmful	
Azadirachta indica azal	Opius chromatomyiae	Slightly harmful	Hossain and Poehling, 2006 [31]
Melia volkensii seed extract	Chilocorus bipustulatus and Pharoscymnus anchorago	Slightly harmful	Peveling and Ely, 2006 [32]
Natural oil of jajoba plant	Diaertilla rapae	Harmless	Farag and Gesreha, 2007 [33]
Azadirachta indica	Campoletic chlorideae	Slightly harmful	Rao et al., 2007 [34]
Pyrethrin	Harmonia axyridis	Highly toxic to first instar, harmless to third instar, pupa and adult	Kraiss and Cullen, 2008 [35]
Aegle marmelos leaf extract	Culex (L) fuscanus	Harmless	Present study
Coleus aromaticus leaf extract	Culex (L) fuscanus	Harmless	Present study
Colocasia esculenta leaf extract	Culex (L) fuscanus	Harmless	Present study
Wrightia tinctoria leaf extract	Culex (L) fuscanus	Harmless	Present study
Aegle marmelos silver nano-particles	Culex (L) fuscanus	Harmless	Present study
Coleus aromaticus silver nano-particles	Culex (L) fuscanus	Harmless	Present study
Colocasia esculenta silver nano-particles	Culex (L) fuscanus	Harmless	Present study
Wrightia tinctoria silver nano-particles	Culex (L) fuscanus	Harmless	Present study

Adopted from Talebi et al., 2008

Comparative effect of Alternanthera sessilis, Trema orientalis, Gardenia carinata and Ruellia tuberose leaves was evaluated against target species (Cx. quinquefasciatus) and non-target organisms Diplonychus annulatum and Chironomus circumdatus. There was no significant change in the physiological and behavior of non-target organisms [24]. Singha and Chandra [25] investigated the effect of crude and chloroform: methanol extracts of Cuminum cyminum, Allium sativum, Zingiber offinale, Curcuma longa and germinated tuber of Solanum tuberosum on Toxorhychites splendens, Gambusia affinis, Poecilia reticulate, Diplonychus indicus, Diplonychus annulatum, Anispos bouvieri and Chironomus circumdatus. The studied concentrations had no influence on the survival of non-target organism indicating its safety in field applications on controlling mosquito larvae. Impact of pesticides/ larvicides on non-target arthropods organisms is given in table 5. The present study shows there is no influence of four plants extracts A. marmelos, C. aromaticus C. esculenta and W. tinctoria and green synthesized silver nanoparticles on the predation of Cx (L) fuscanus a non-target organism. The results of this study indicates that both plant extract and synthesized silver nanoparticles have an effect on target organisms and have no adverse effect on non-target organisms. It is assumed that the plant extracts are safe to the environment and may be included in the IPM.

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