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Eco-Friendly Evaluation of Mosquitocidal Effects of Seleniumnano Particles Incorporated in Pontederia Crassipes Extract

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ABSTRACT

Mosquito-borne diseases are a major global health concern, particularly those transmitted by *Aedes aegypti*. Conventional chemical pesticides often lead to resistance and environmental hazards, creating a need for eco-friendly alternatives. This study evaluates selenium nanoparticles (SeNPs) synthesized using *Pontederia crassipes* extract for their mosquitocidal properties. SeNPs demonstrated strong larvicidal, pupicidal, and adulticidal activity at low concentrations, with complete inhibition of egg hatchability at 75 ppm. Compared to crude methanol extracts, SeNPs showed superior efficacy with lower LC_{50} values. These findings highlight the eco-friendly potential of SeNPs as a sustainable agent for mosquito vector control.

Keywords: Ecofriendly vector control, Mosquitocidal activity, Selenium nanoparticles, Pontederia crassipes, Green Synthesis

INTRODUCTION

Mosquitoes, particularly *Aedes aegypti*, are vectors of dengue, chikungunya, and Zika. Chemical insecticides have led to resistance and ecological damage. Plant-based remedies and nanotechnology offer eco-friendly alternatives. *Pontederia crassipes*, an aquatic plant, contains bioactive compounds that can be harnessed for nanoparticle synthesis. Selenium nanoparticles (SeNPs), synthesized via green methods, are biodegradable and effective at low concentrations. This study evaluates SeNPs incorporated in *P. crassipes* extract for their mosquitocidal properties.

MATERIALS AND METHODS

Fresh leaves of *Pontederia crassipes* were collected from Sulur Lake, Coimbatore, Tamil Nadu, and authenticated according to standard botanical references. The leaves were thoroughly washed, shade-dried, powdered, and extracted using methanol following WHO guidelines (WHO, 2005; Sarma et al., 2019). The extract was filtered and concentrated, and this crude extract was later used for nanoparticle synthesis. Selenium nanoparticles were prepared by reducing selenious acid with the plant extract, where phytochemicals acted as reducing and stabilizing agents, and the formation of nanoparticles was confirmed by the characteristic color change from pale yellow to reddish brown (Naseem et al., 2016).

Mosquitoes (*Aedes aegypti*) were reared under controlled laboratory conditions following WHO protocols (WHO, 2012). Eggs were collected and allowed to hatch in dechlorinated water, and larvae, pupae, and adults were maintained for bioassays. Larvicidal, pupicidal, and adulticidal assay*s were conducted using standard procedures (Govindarajan & Sivakumar, 2014; Murugan et al., 2012). Mortality was recorded after 24 hours of exposure to different concentrations of crude extract (150–750 ppm) and SeNPs (15–75 ppm).

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Reproductive suppression was assessed by exposing gravid females to treated surfaces and recording fecundity, oviposition, and egg hatchability (Panneerselvam et al., 2012).

Statistical analysis was performed using regression methods to calculate LC_{50} and LC_{90} values, with confidence intervals determined according to established biostatistical approaches (Tamhane, 2009; Shaban, 2005). Significance was tested at $P < 0.05$, ensuring reliability of the results.

Figure:1. *Pontederia crassipes* plant was collected from Sulur lake Coimbatore, TamilNadu. India.Sulur is located at 11.0295°N, 77.1190°E. It has an average elevation of 340 metres (1115 feet).

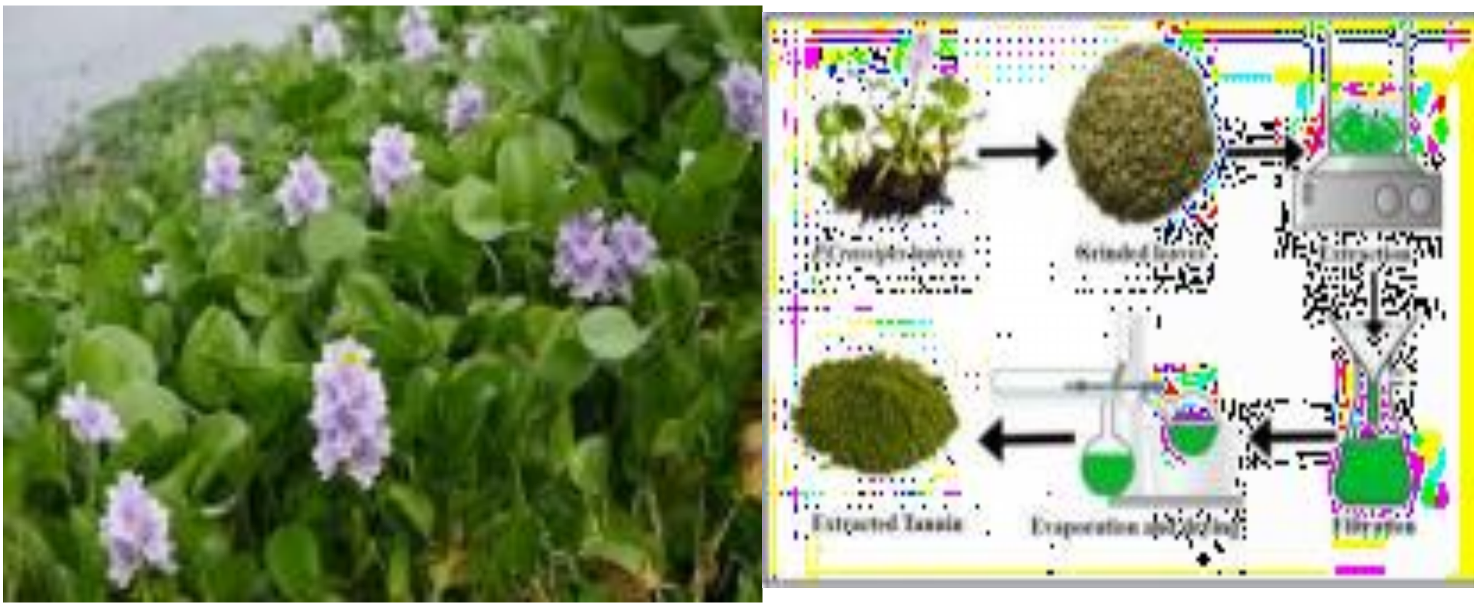

Figure:2. Graphical presentation of green synthesized selenium nanoparticles using *Pontederia crassipes* extract

RESULTS

The evaluation of selenium nanoparticles synthesized using *Pontederia crassipes* extract revealed remarkable mosquitocidal activity against *Aedes aegypti*. The methanol extract alone produced moderate larval and pupal mortality, requiring concentrations above 200 ppm to achieve significant effects. In

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contrast, SeNPs demonstrated potent activity at much lower doses. At 75 ppm, larval mortality reached 99% with LC_{50} values of 11.47 ppm, while pupal mortality was 79.5% with LC_{50} of 11.48 ppm. Adult mortality also followed a dose-dependent pattern, with SeNPs achieving 85.5% mortality at 75 ppm and LC_{50} of 30.27 ppm, compared to crude extracts that required over 300 ppm for similar outcomes. Beyond direct mortality, SeNPs suppressed reproduction by completely inhibiting egg hatchability at 75 ppm, while also reducing fecundity and oviposition. These results confirm that SeNPs are significantly more effective than crude extracts, acting at concentrations nearly twenty times lower, and provide both immediate and long-term control of mosquito populations.

Table 1. Effect of methanol leaf extract of *Pontederia crassipes* on larval and pupal mortality of *Aedes aegypti*

Target	150 ppm	300 ppm	450 ppm	600 ppm	750 ppm	LC_{50} (ppm)	LC_{90} (ppm)	95% Confidence Limit (LC_{50})	95% Confidence Limit (LC_{90})	Regression Equation	χ^2
I	40.27 ± 2.02^{a}	54.23 ± 1.78^{b}	70.45 ± 1.06^{c}	88.72 ± 1.65^{d}	97.87 ± 1.02^{e}	231.71	571.14	182.41–270.83	523.57–636.58	Y = −0.004 + 0.879x	4.792*
II	38.67 ± 2.18^{a}	52.18 ± 2.34^{b}	66.43 ± 2.40^{c}	84.24 ± 1.26^{d}	95.48 ± 1.78^{e}	262.90	665.64	209.13–305.68	606.73–749.30	Y = −0.840 + 0.003x	3.006*
III	36.55 ± 2.38^{a}	48.26 ± 1.30^{b}	65.29 ± 1.02^{c}	83.24 ± 1.30^{d}	94.12 ± 2.08^{e}	286.87	692.43	236.24–328.23	631.56–778.90	Y = −0.910 + 0.003x	3.175*
IV	35.58 ± 2.23^{a}	46.25 ± 1.92^{b}	62.62 ± 2.07^{c}	81.48 ± 1.81^{d}	93.71 ± 2.22^{e}	297.64	707.14	247.91–338.69	644.80–795.90	Y = −0.935 + 0.003x	3.073*
V	29.72 ± 1.02^{a}	41.86 ± 2.38^{b}	55.47 ± 2.12^{c}	77.35 ± 1.32^{d}	87.58 ± 1.54^{e}	350.25	792.99	302.47–391.74	719.59–899.81	—	1.587*
Pupae	20.54 ± 2.38^{a}	31.62 ± 2.07^{b}	44.78 ± 1.92^{c}	60.18 ± 2.28^{d}	78.42 ± 2.28^{e}	469.25	957.01	424.66–515.55	859.31–1106.74	—	0.787

Note: Values are presented as Mean ± SE. Means within a row followed by different superscript letters (a–e) differ significantly (P < 0.05). LC_{50} = lethal concentration causing 50% mortality; LC_{90} = lethal concentration causing 90% mortality; LCL = Lower Confidence Limit; UCL = Upper Confidence Limit; χ^2 = Chi-square value.

The larval mortalities are expressed as mean ± SD of five replicates. No mortality was observed in the control. Within each column means followed by the same letter(s) are not significantly different (P<0.05). LFL - Lower Fiducidal Limit; UFL - Upper Fiducidal Limit. x^2, Chi- square value. *Significant at P< 0.05 level.

Table 2. Effect of green synthesized Selenium nanoparticles of *Pontederia crassipes* leaf extract on larval and pupal mortality of *Aedes aegypti*

Target	**Larval and pupal mortality (%)**					**LC50 (LC90)**	**95% confidence Limit**		**Regression equation**	χ^2
	Concentration (ppm)						**LC50 (LC90)**			
	15	**30**	**45**	**60**	**75**		**LCL**	**UCL**		
I	42.53 ± 1.17^{a}	58.12±1.29 B	75.47 ± 2.08^{c}	91.28 ± 1.78^{d}	99 ± 0.00^{e}	11.47 (23.363)	(4.345-18.68)	(16.339 -	Y= -.50310 +0.00438X	*3.22
								47.564)		
II	40.38 ± 1.82^{a}	54.72±1.23 B	70.15 ± 2.18^{c}	87.37 ± 2.50^{d}	97.17 ± 1.78^{e}	12.946 (26.778)	(6.641-19.01)	17.501 (44.782)	Y= -.70946 +0.00413X	*1.56

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III	38.52±1.29^{a}	50.28±2.12 B	66.52±2.45^{c}	85.24±2.32^{d}	94.18±1.92^{e}	13.048 (28.148)	(8.7821 - 21.80)	(18.304 42.246)	Y= -.81741 +0.00393X	*4.04
IV	36.64±2.02^{a}	47.45±1.78 B	63.49±2.64^{c}	83.48±1.82^{d}	92.41±2.64^{e}	14.722 (30.347)	(9.811- 23.89)	21.781 (37.422)	Y= -.76253 +0.00357X	*2.16
V	31.47±2.16^{a}	43.26±1.38 B	58.44±2.21^{c}	78.59±2.38^{d}	88.35±2.64^{e}	16.103 (32.562)	(12.239 - 24.89)	(22.475 (38.577)	Y= -.09999 +0.00394X	*3.06
Pupae	22.61±1.98^{a}	33.72±1.29 B	47.16±1.57^{c}	64.23±1.43^{d}	79.52±1.25^{e}	11.478 (23.363)	(4.345- 18.68)	(16.339 - 47.564)	Y= -.50310 +0.00438X	* 3.22

The larval mortalities are expressed as mean ± SD of five replicates. No mortality was observed in the control. Within each column means followed by the same letter(s) are not significantly different (P<0.05). LFL - Lower Fiducidal Limit; UFL - Upper Fiducidal Limit. x^2, Chi- square value. *Significant at P< 0.05 level.

Table 3. Adulticidal effect of green synthesized Selenium nanoparticles Pontederia crassipes leaf extract against *Aedes aegypti*

Targeted *aegypti*	**Mortality (%) (mean±SD) Concentration(ppm)**					**LC50 (LFL-UFL)**	**LC90 (LFL-UFL)**	**Regression equation**	χ^2
	15	**30**	**45**	**60**	**75**				
Se NPs	32.28±1.73^{a}	51.64±2.02^{b}	63.19±2.08^{c}	75.37±1.54^{d}	85.54±1.92^{e}	30.274 (23.890 - 35.283)	81.832 (73.189 - 95.038)	Y= - 0.753 + -0.025 X	0.526*

Mortality rates are means ± SD of triplicate. No mortality was observed in the control. Within each column means followed by the same letter(s) are not significantly different (P<0.05). LFL - Lower Fiducidal Limit; UFL - Upper Fiducidal Limit. x2, Chi-square value. *Significant at P< 0.05 level.

DISCUSSION

The findings highlight the eco-friendly potential of selenium nanoparticles synthesized using *Pontederia crassipes* extract as a sustainable alternative to chemical insecticides. The superior efficacy of SeNPs compared to crude extracts can be attributed to their nanoscale size, which enhances penetration through larval cuticle and pupal membranes, and to the stabilizing role of plant biomolecules that increase bioavailability. The complete inhibition of egg hatchability at 75 ppm is particularly significant, as it ensures population suppression beyond immediate mortality, addressing the challenge of rapid mosquito resurgence. Compared to conventional chemical pesticides such as temephos, which require higher concentrations and pose risks of resistance and environmental toxicity, SeNPs offer a safer and more sustainable solution. The dual impact on multiple life stages—larvae, pupae, adults, and eggs—makes SeNPs a comprehensive tool for integrated vector management. These results align with global efforts to promote eco-friendly vector control, combining the advantages of botanical insecticides with nanotechnology. By reducing reliance on synthetic chemicals, SeNPs contribute to sustainable public health practices and provide a promising pathway for future mosquito management strategies.

CONCLUSION

The findings highlight the eco-friendly potential of selenium nanoparticles synthesized using *Pontederia* *crassipes* extract as a sustainable alternative to chemical insecticides. The superior efficacy of SeNPs compared to crude extracts can be attributed to their nanoscale size, which enhances penetration through larval cuticle and pupal membranes, and to the stabilizing role of plant biomolecules that increase bioavailability. The complete inhibition of egg hatchability at 75 ppm is particularly significant, as it ensures population suppression beyond immediate mortality, addressing the challenge of rapid mosquito resurgence. Compared to conventional chemical pesticides such as temephos, which require higher concentrations and pose risks of resistance and environmental toxicity, SeNPs offer a safer and more sustainable solution. The dual impact on multiple life stages—larvae, pupae, adults, and eggs—makes SeNPs a comprehensive tool for integrated vector management. These results align with global efforts to promote eco-friendly vector control, combining the advantages of botanical insecticides with nanotechnology. By reducing reliance on synthetic chemicals, SeNPs contribute to sustainable public health practices and provide a promising pathway for future mosquito management strategies.

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