

Laboratory evaluation of the toxicity of selenium and gold nanoparticles against the housefly (*Musca domestica*)

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Article Info	Abstract
Article history: Received: 15 January 2025 Accepted: 10 December 2025 Available online: 15 April 2026	Selenium (Se) and gold (Au) nanoparticles (NPs) possess unique properties such as high absorption ability, low toxicity and minimal environmental persistence. These properties, combined with demonstrated anti-parasitic effects against certain parasites, suggest their potential as candidate for house fly control. This study aimed to evaluate the effectiveness of Se and AuNPs in controlling house flies. We investigated the insecticidal effect of Se and AuNPs on <i>Musca domestica</i> using a dipping method. Several concentrations (20.00, 60.00, 100, 400, and 1,000 ppm) were prepared using deionized water. Fifteen larvae <i>per</i> concentration were tested, with each test repeated three times. The larvae were dipped in the NP solutions for 30, 60 and 90 sec in 10.00 mL of the tested concentrations. Distilled water was used for the control group. Larval mortality was recorded 24 hr post-treatment. No mortality was observed in house fly larvae 24 hr after exposure to different concentrations of Se and AuNPs, regardless of the incubation time. Thus, Se and AuNPs showed no insecticidal effect on house fly larvae. In conclusion, Se and AuNPs cannot be used to control house flies. Due to the issues associated with chemical control, it is crucial to search for alternative pesticides.
Keywords: Gold nanoparticles House fly <i>Musca domestica</i> Selenium nanoparticles	

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Introduction

Musca domestica (Diptera: Muscidae), commonly known as the house fly, is the most common fly species. It is a synanthropic insect that belongs to filth flies group and has a close association with humans and their environment. House flies can be found wherever people live and are also associated with animal. House flies are the carriers of more than 65 human and animal intestinal diseases agents.^{1,2} Although, these flies cause minimal direct disturbance to animals, they significantly contribute to the transmission of diseases such as cholera, typhoid, tuberculosis, bacillary dysentery and infantile diarrhea in both humans and animals.³⁻⁵ House fly control primarily relies on chemical insecticides that target the insect nervous system, including pyrethroids, organophosphates, and carbamates. However, extensive use of these insecticides has led to problems such as insecticide resistance and environmental degradation.^{6,7}

Chemical insecticides can negatively impact soil fertility, persist in the environment, biomagnify through the food chain, and increase non-target organism

mortality. Considering the biohabitat of housefly insecticides favorable or at least compatible to human surroundings are needed, which is not possible with chemical insecticides. Hence, there is a growing demand for alternative control materials that are effective and safe for humans and the environment.^{8,9} Nanoparticles (NPs), defined as particles between 1.00 - 100 nm, have emerged as promising tools with applications in drug delivery, diagnostics, cosmetics, and pest control. Their minute size facilitates rapid reactions and has been applied in various fields, including environmentally friendly pesticide development.^{10,11} Recent studies have shown potential insecticidal effects of NPs on various pests.¹²⁻¹⁴ Selenium (Se) is an essential micronutrient in human and animal bodies, but its dietary levels must be balanced as both excess and deficiency can be harmful.¹⁵ Elemental Se has numerous industrial applications, including high photoconductivity and catalytic properties.¹⁶

Gold (Au) NPs have a broad range of applications in medicine, food industry, water treatment, and biological fields due to their unique properties. Their synthesis is of significant interest in parasitology and entomology.¹⁷

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In 2013, Beheshti *et al.*, investigated the effectiveness of SeNPs on *Leishmania major*. The results of this study showed the high toxicity of SeNPs on both the promastigote and amastigote forms of *L. major*.¹⁸ Also, in 2014, Mahmoudvand *et al.*, studied the scolexicidal effect of biosynthesized SeNPs produced by a strain of marine bacteria. The results indicated that SeNPs in all concentrations have strong scolexicidal effects.¹⁹

Sowndarya *et al.*, synthesized SeNPs from leaves of *Clausena dentata* plant and investigated their insecticidal effect against mosquito vectors. The results showed that the mortality rate of mosquito larvae was high at low concentrations of the synthesized SeNPs. The biosynthesis of these NPs has the potential to be used as an environmentally friendly approach to controlling mosquitoes in their early stages.²⁰ In 2023, Arafa *et al.* investigated the anti-toxoplasmic effects of SeNPs in mice infected with *Toxoplasma*. The study showed a significant increase in survival time in the group treated with SeNPs, and a lower number of parasites were observed in blood smears prepared from the spleen and liver compared to untreated mice.²¹ Sundararajan *et al.*, studied the effect of AuNPs on a species of *Aedes* mosquito. The results indicated that AuNPs could be a suitable alternative to synthetic insecticides.²²

In 2017, Dkhil *et al.*, evaluated the effect of AuNPs on mice infected with *Schistosoma mansoni*. The results showed that treating mice infected with *S. mansoni* reduced spleen tissue damage.²³ Halder *et al.*, also studied the anti-leishmanial effect of AuNPs against wild and drug-resistant strains. The study demonstrated that AuNPs were effective against both wild-type and drug-resistant strains, suggesting they are a safer alternative for treating *Leishmania*.²⁴ Malekifard tested the scolexicidal effects of AuNPs on hydatid cyst protoscolexes in laboratory conditions. The result showed that AuNPs had a significant scolexicidal effect in all concentrations used compared to the control group.²⁵ Insecticidal and larvicidal effects of Se and AuNPs have been reported in some mosquito species.^{20,22} This study aimed to evaluate the larvicidal effect of Se and AuNPs on house fly larvae.

Materials and Methods

Sample collection. Tested samples were collected from a poultry farm at Urmia University, Urmia, Iran. Adult flies were collected using insect nets and traps baited with a mixture of water and sugar. The larvae were then transferred along with poultry litter and allowed to grow.

Housefly rearing. *Musca domestica* adults were reared in entomological cages measuring 30.00 × 30.00 cm at a temperature of 24.00 - 28.00 °C, with a 12 : 12 light/dark cycle, and 70.00% humidity. The adult flies were fed a solution consisting of 2.50% sugar, skim milk powder, egg yolk powder, and cholesterol in a ratio of 1 : 5 : 9 : 9 : 2.

Larvae (L3) were a nutrient medium composed of 100 g whole milk powder, 25.00 g dried brewer's yeast, 30.00 g agar, and water up to 1,000 mL.²⁶

Nanoparticles: The SeNPs (size = 10.00 - 45.00 nm) and AuNPs (size = 60.00 - 70.00 nm) were obtained from a commercial supplier (Iranian Nano-materials Pioneers Co., Nanosany, Mashhad, Iran). The NPs were originally produced by US Research Nanomaterials, Inc. (Houston, USA). To create a homogeneous suspension, the NPs were first dispersed in ultrapure water and then sonicated at 100 W and 40.00 kHz for 40 min. During dilution, small magnetic bars were placed in the suspensions so that the particles were not aggregated or deposited. The SeNPs and AuNPs stock suspensions were prepared in phosphate buffered saline (pH = 7.40). An ultrasonic probe (Branson Sonifier, Danbury, USA) was used intermittently for 10 min at 30.00 W to sonicate the solution and prevent agglomeration while achieving uniform dissolution. By diluting the stock solution with deionized water, different concentrations of SeNPs and AuNPs were prepared.²⁷

Laboratory bioassay. The larval bioassay was conducted using a modified dipping method.²⁸ Fifteen larvae were dipped into 10.00 mL of each tested concentration for 30 sec and then transferred to filter paper in a plastic plate. A commercial pyrethroid insecticide, cypermethrin (Melli Shimi, Tehran, Iran) was used as the positive control. Larval mortality was recorded 24 hr post-treatment, and each experiment was repeated three times.

Results

Larvicidal effect of SeNPs. The results show that there was no mortality in house fly larvae after being exposed to varying concentrations (20.00, 60.00, 100, 400, and 1,000 ppm) of SeNPs for different incubation times (30, 60, and 90 sec). The experiment was repeated with several concentrations and different incubation times were also considered, with similar results being repeated in all tests. Therefore, it can be concluded that SeNPs did not have an insecticidal effect on house fly larvae.

Larvicidal effect of AuNPs. Five concentrations (20.00, 60.00, 100, 400 and 1,000 ppm) were initially prepared for AuNPs bioassay. After finding that these concentrations were ineffective, the tests were repeated several times with different concentrations, and incubation times. The results from testing different concentrations of AuNPs were consistent showing that AuNPs had no insecticidal effect on house fly larvae.

Discussion

Easy access to insecticides and the convenience of their purchase in ready-to-use formulations, such as sprays, have made chemical control a popular and affordable

method. As a result, people tend to choose these formulations over preventive measures like mechanical or physical control to manage pests.²⁹

Resistance to insecticides affects the environment, because when people face of the resistance to insecticides, they increase the dosage of insecticides beyond the recommended levels. This can result in higher levels of environmental pollution and pose risks to public health.³⁰

The development of resistant strains of parasites to current antiparasitic drugs has become a serious problem in public health. Therefore, there is a strong incentive to develop new antiparasitic agents. Due to limitations in the use of antiparasitic drugs, newer approaches such as nanobiotechnology have shown significant progress in the treatment of parasitic infections.³¹ This is based on the unique properties of NPs, including silver NPs, AuNPs, chitosan, selenium oxide, and other metal oxide NPs, which have shown excellent inhibitory effects against parasitic infections, including insect larvae.³²⁻³⁴

In the last few decades, there has been a low rate of discovery of anti-parasitic drugs.³⁵ The use of NPs is recommended to eliminate parasites due their cytotoxic and inhibitory effects. They are more effective and less harmful than traditional drugs making them even useful for developing vaccines for parasite prevention and control.³⁶

Studies have been conducted worldwide to evaluate the insecticidal and inhibitory effects of various NPs on houseflies. In 2012, Kamaraj *et al.*, evaluated the effect of silver NPs on adult house flies, demonstrating their potential for controlling this pest.⁷ Abd El-Hamid *et al.*, also conducted a study on the effect of silver NPs on houseflies, showing the lethal effect of these NPs on housefly larvae.³⁷ Gul *et al.*, also proved the insecticidal potential of silver NPs against house flies in their study.³⁸

The effects of ZnO NPs were also evaluated by Iqbal *et al.* on the larval stage of houseflies. By exposing housefly larvae to this NP, the growth time was prolonged and the survival rate decreased.³⁹

Previous studies have examined the effects of Se and AuNPs on various parasites.^{18-20,22-25} Bavand *et al.* also suggested that the effect of AuNPs in treating *Giardia lamblia* is similar to that of metronidazole which is a selective drug for *G. lamblia* treatment.⁴⁰

Considering that the insecticidal effect of Se and AuNPs on mosquitoes has been reported, our study aimed to evaluate the insecticidal effect of these NPs on housefly larvae. Surprisingly, no effect on housefly larvae was observed and no mortality occurred when exposed to Se and AuNPs. Initially only five concentrations were tested for the bioassay of NPs. However, when no insecticidal effect was seen in these concentrations we repeated the experiment multiple times with different concentrations ranging from the lowest to the highest dilution. Additionally, we extended the incubation time to 60 and

90 sec, which was only 30 sec according to the test protocol. Despite these adjustments, consistent results were obtained confirming that Se and AuNPs did not have an insecticidal effect on house flies.

In summary, NPs offer promising avenues for antiparasitic therapies. However their effectiveness can be hindered by factors such as limited bioavailability, rapid drug elimination, drug resistance, toxicity concerns, and challenges in targeting intracellular parasites.⁴¹⁻⁴³ Addressing these issues requires further research and development to optimize NP design and delivery systems for enhanced efficacy against parasitic infections.

Based on the results, it can be concluded that two commercial NPs made of Se and Au do not have an insecticidal effect on house fly larvae. The housefly has shown resistance to various insecticide groups, such as pyrethroids, organochlorines, and organophosphates. This resistance poses environmental problems like pollution and harm to beneficial organisms, as well as negative economic impacts due to increased insecticide dosage leading to higher costs and more environmental contamination. It is crucial to discover pesticides with minimal environmental impact.

Nanoparticles have demonstrated positive effects against parasitic infections, suggesting their potential as an alternative to current insecticides. Therefore, it is recommended to explore the effects of both commercial and synthesized NPson houseflies and other pests to find a more suitable solution for insect control. Since commercial Se and AuNPs are ineffective against housefly larvae, alternative pesticides should be considered. Research on the effects of different NPs on houseflies is essential in the search for more efficient insecticides.

Acknowledgments

We would like to extend our heartfelt thanks to Dr. Ali Khoshnezhad for his essential role in sample collection and to Dr. Awat Samiei for his dedicated efforts in conducting the research.

Conflict of interest

The authors declare no conflict of interest.

References

1. Shono T, Scott JG. Spinosad resistance in the housefly, *Musca domestica*, is due to a recessive factor on autosome 1. *Pestic Biochem Physiol* 2003; 75(1-2): 1-7.
2. Sasaki T, Kobayashi M, Agui N. Epidemiological potential of excretion and regurgitation by *Musca domestica* (Diptera: Muscidae) in the dissemination of *Escherichia coli* O157: H7 to food. *J Med Entomol* 2000; 37(6): 945-949.

3. Pavela R. Insecticidal properties of several essential oils on the housefly (*M. domestica* L.). *Phytother Res* 2008; 22(2): 274-278.
4. Malik A, Singh N, Satya S. Housefly (*Musca domestica*): A review of control strategies for a challenging pest. *J Environ Sci Health B* 2007; 42(4): 453-469.
5. Hinkle NC. Poultry pest management (Arthropods). In: Pimentel D. (ed). *Encyclopedia of pest management*. New York, USA: CRC Press 2002; 657-660.
6. Srinivasan R, Jambulingam P, Gunasekaran K, et al. Tolerance of house fly, *M. domestica* L. (Diptera: Muscidae) to dichlorvos (76.00% EC) an insecticide used for fly controlling the tsunami-hit coastal villages of southern India. *Acta Trop* 2008; 105(2): 187-190.
7. Kamaraj C, Rajakumar G, Rahuman AA, et al. Feeding deterrent activity of synthesized silver nanoparticles using Manilkara zapota leaf extract against the house fly, *Musca domestica* (Diptera: Muscidae). *Parasitol Res* 2012; 111(6): 2439-2448
8. Bag J, Mukherjee S, Ghosh SK, et al. Fe₃O₄ coated guar gum nanoparticles as non-genotoxic materials for biological application. *Int J Biol Macromol* 2020; 165(Pt A): 333-345.
9. Subaharan K, Senthoorraja R, Manjunath S, et al. Toxicity, behavioural and biochemical effect of Piper betle L. essential oil and its constituents against housefly, *Musca domestica* L. *Pestic Biochem Physiol* 2021; 174: 104804. doi: 10.1016/j.pestbp.2021.104804.
10. Chifiriuc MC, Ratiu AC, Popa M, et al. Drosophotoxicology: an emerging research area for assessing nanoparticles interaction with living organisms. *Int J Mol Sci* 2016; 17(2): 36. doi: 10.3390/ijms17020036.
11. El-Ashram S, Kheirallah DAM, El-Samad LM, et al. Relative expression of microRNAs, apoptosis, and ultrastructure anomalies induced by gold nanoparticles in *Trachyderma hispida* (Coleoptera: Tenebrionidae). *PloS One* 2020; 15(11): e0241837. doi: 10.1371/journal.pone.0241837.
12. Xie Y, Wang B, Li F, et al. Molecular mechanisms of reduced nerve toxicity by titanium dioxide nanoparticles in the phoxim-exposed brain of *Bombyx mori*. *PLoS One* 2014; 9(6): e101062. doi: 10.1371/journal.pone.0101062.
13. Roni M, Murugan K, Panneerselvam C, et al. Characterization and biotoxicity of Hypnea musciformis-synthesized silver nanoparticles as potential eco-friendly control tool against *Aedes aegypti* and *Plutella xylostella*. *Ecotoxicol Environ Saf* 2015; 121: 31-38.
14. Khot LR, Sankaran SH, Maja JM, et al. Applications of nanomaterials in agricultural production and crop protection: a review. *Crop Prot* 2012; 35: 64-70.
15. Chen H; Shin DW, Nam JG, et al. Selenium nanowires and nanotubes synthesized via a facile template-free solution method. *Mater Res Bull* 2010; 45: 699-704.
16. Rayman M, Thompson A, Warren-Perry M, et al. Impact of selenium on mood and quality of life: a randomized, controlled trial. *Biol Psychiatry* 2006; 59(2): 147-154.
17. Benelli G. Gold nanoparticles - against parasites and insect vectors. *Acta Trop* 2018; 178: 73-80.
18. Beheshti N, Soflaei S, Shakibaie M, et al. Efficacy of biogenic selenium nanoparticles against *Leishmania major*: *in vitro* and *in vivo* studies. *J Trace Elem Med Biol* 2013; 27(3): 203-207.
19. Mahmoudvand H, Fasihi Harandi M, Shakibaie M, et al. Scolicidal effects of biogenic selenium nanoparticles against protoscolices of hydatid cysts. *Int J Surg* 2014; 12(5): 399-403.
20. Sowndarya P, Ramkumar G, Shivakumar MS. Green synthesis of selenium nanoparticles conjugated *Clausena dentate* plant leaf extract and their insecticidal potential against mosquito vectors. *Artif Cells Nanomed Biotechnol* 2017; 45(8): 1490-1495.
21. Arafa FM, Mogahed NMFH, Eltarahony MM, et al. Biogenic selenium nanoparticles: trace element with promising anti-toxoplasma effect. *Pathog Glob Health* 2023; 117(7): 639-654.
22. Sundararajan B, Sathishkumar G, Seetharaman PK, et al. Biosynthesized gold nanoparticles integrated ointment base for repellent activity against *Aedes aegypti* L. *Neotrop Entomol* 2022; 51(1): 151-159.
23. Dkhil MA, Khalil MF, Diab MSM, et al. Effect of gold nanoparticles on mice splenomegaly induced by *schistosomiasis mansoni*. *Saudi J Biol Sci* 2017; 24(6): 1418-1423.
24. Halder A. Das S, Bera T, et al. Rapid synthesis for monodispersed gold nanoparticles in Kaempferol and anti-lishmanial efficacy against wild and drug resistant strains. *RSC Adv* 2017; 7: 14159-14167.
25. Malekifard F. Solicidal effect of the gold nanoparticle on protoscolices of hydratid cyst *in vitro* [Persian]. *Urmia Med J* 2017; 28(2): 130-137.
26. Singh P, Jerram EM. Rearing housefly larvae in polyethylene bags. *New Zeal J Zool* 1976; 3(1): 57-58.
27. Malekifard F, Tavassoli M, Vaziri K. *In vitro* assessment antiparasitic effect of selenium and copper nanoparticles on *Giardia deodenalis* cyst. *Iran J Parasitol* 2020; 15(3): 411-417.
28. Sinthusiri J, Soonwera M. Effect of herbal essential oils against larvae, pupae and adults of house fly (*Musca domestica*: Diptera). In *Proceedings: 16th Asian agricultural symposium and 1st International symposium on agricultural technology*. Bangkok, Thailand 2010; 639-642.
29. Khan HAA, Akram W, Fatima A. Resistance to pyrethroid insecticides in house flies, *Musca domestica* L., (Diptera: Muscidae) collected from urban areas in Punjab, Pakistan. *Parasitol Res* 2017; 116(12): 3381-3385.

30. Khan HAA, Akram W. Cyromazine resistance in a field strain of house flies, *Musca domestica* L.: resistance risk assessment and bio-chemical mechanism. *Chemosphere* 2017; 167: 308-313.
31. Navarrete-Vazquez G, Chávez-Silva F, Argotte-Ramos R, et al. Synthesis of benzologues of Nitazoxanide and Tizoxanide: a comparative study of their *in vitro* broad spectrum antiprotozoal activity. *Bioorg Med Chem Lett* 2011; 21(10): 3168-3171.
32. Said DE, Elsamad LM, Gohar YM. Validity of silver, chitosan, and curcumin nanoparticles as anti-Giardia agents. *Parasitol Res* 2012; 111(2): 545-554.
33. Sarasiabi SK, Madani AH, Zare S. Prevalence of intestinal parasites in primary school pupils of Bandar Abbas. *J Hormozgan Univ Med Sci* 2002; 4(5): 25-30.
34. Hazrati TK, Mostaghim M, Hanifian H, et al. A Study on the intestinal parasitic infections among elementary school students at a district (Silvana) in Urmia, West Azerbaijan. *RABMS* 2015, 1(1): 14-19.
35. Heinlaan M, Ivask A, Blinova I, et al. Toxicity of nanosized and bulk ZnO, CuO and TiO₂ to bacteria *Vibrio fischeri* and crustaceans *Daphnia magna* and *Thamnocephalus platyurus*. *Chemosphere* 2008; 71(7): 1308-1316.
36. Elmi T, Gholami S, Fakhar M, et al. A review on the use of nanoparticles in the treatment of parasitic infections [Persian]. *J Mazand Univ Med Sci* 2013; 23(102): 126-133.
37. Abd El-Hamid MM, Helal EM, Mohamadeen FT. Laboratory evaluation of the toxicity of silver nanoparticles against housefly, *Musca domestica* (Diptera: Muscidae). *Alex Sci Exch J* 2018; 39(3): 511-520.
38. Gul S, Ismail M, Iqbal Khan S, et al. Novel synthesis of silver nanoparticles using melon aqueous extract and evaluation of their feeding deterrent activity against housefly *Musca domestica*. *Asian Pac J Trop Dis* 2016; 6(4): 311-316.
39. Iqbal H, Fatima A, Khan HAA. ZnO nanoparticles produced in the culture supernatant *Bacillus thuringiensis* ser. israelensis affect the demographic parameters of *Musca domestica* using the age-stage, two-sex life table. *Pest Manag Sci* 2022; 78(4): 1640-1648.
40. Bavand Z, Gholami S, Rahimi-Esboei B, et al. In vitro evaluation of the effect of gold nanoparticles on *Giardia lamblia* cyst [Persian]. *Arak Med Univ J* 2013; 16(79): 27-37.
41. Sun Y, Chen D, Pan Y, et al. Nanoparticles for antiparasitic drug delivery. *Drug Deliv* 2019; 26(1): 1206-1221.
42. Tiwari R, Gupta RP, Singh VK, et al. Nanotechnology-based strategies in parasitic disease management: from prevention to diagnosis and treatment. *ACS Omega* 2023; 8(45): 42014-42027.
43. Zhang P, Gong J, Jiang Y, et al. Application of silver nanoparticles in parasite treatment. *Pharmaceutics* 2023; 15(7): 1783. doi: 10.3390/pharmaceutics 15071783.