HOSTED BY
ELSEVIER

Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Biomedicine

journal homepage: www.elsevier.com/locate/apjtb

Editorial http://dx.doi.org/10.1016/j.apjtb.2015.10.015

Plant-mediated synthesis of nanoparticles: A newer and safer tool against mosquito-borne diseases?

Giovanni Benelli*

Insect Behavior Group, Department of Agriculture, Food and Environment, University of Pisa, via del Borghetto 80, Pisa 56124, Italy

ARTICLE INFO

Article history:
Received 16 Oct 2015
Accepted 28 Oct 2015
Available online 12 Jan 2016

Keywords:
Arbovirus
Dengue
Yellow fever
Malaria
Mosquito vectors
Nanobiotechnology

ABSTRACT

Prevention and control of mosquito-borne diseases is a key challenge of huge public health importance. Plant-mediated synthesis of nanoparticles has recently gained attention as a cheap, rapid and eco-friendly method to control mosquito vector populations, with special reference to young instars. Furthermore, plant-fabricated nanoparticles have been successfully employed as dengue virus growth inhibitors. In this Editorial, parasitologists, entomologists and researchers in drug nanosynthesis are encouraged to deal with a number of crucial challenges of public health importance.

1. Prevention and control of mosquito-borne diseases: A key issue

Mosquitoes cause more human sufferings than any other organisms, and over one million people worldwide die from mosquito-borne diseases every year [1]. Current control strategies mainly rely on synthetic pesticides, insect growth regulators and microbial control agents. However, synthetic chemicals lead to a number of negative implications, including high operational costs, development of resistance and toxic effects on non-target organisms and human health [2]. Limited tools are currently available against the main pathogens and parasites vectored by mosquitoes. Notably, there is no specific treatment for dengue (even if the development of a vaccine is in progress), and its prevention and control solely depends on effective vector control measures. Furthermore, malaria control is being challenging due to the arising number of *Plasmodium* strains resistant to chloroquine and other antimalarial drugs [3].

*Corresponding author: Giovanni Benelli, Insect Behavior Group, Department of Agriculture, Food and Environment, University of Pisa, via del Borghetto 80, Pisa 56124, Italy.
Tel: +39 0502216141
Fax: +39 0502216087
E-mails: g.benelli@sssup.it, benelli.giovanni@gmail.com

Peer review under responsibility of Hainan Medical University. The journal implements double-blind peer review practiced by specially invited international editorial board members.

2. Nanoparticles in the fight against mosquito vectors

To deal with the above mentioned issues, in latest years a growing number of plant-borne compounds have been proposed for efficient and rapid extracellular synthesis of nanoparticles. The green biosynthesis of nanoparticles is advantageous over chemical and physical methods, since it is cheap, single-step, and does not require high pressure, energy, temperature, and the use of highly toxic chemicals [4].

Recently, in more than 60 researches, plant-fabricated nanoparticles have been studied for their highly effective mosquitocidal properties [5]. Most studies focused on larvicidal and pupicidal activity, and extremely low LC_{50} were calculated. The majority of them fall within 1–30 mg/L. Furthermore, nanosynthesis of ovicides, adulticides and oviposition deterrents has also been attempted [5,6]. However, little efforts have been done to shed light on the toxicity mechanism(s) leading to larval and pupal death in mosquito larvae and pupae exposed to green-synthesized nanoparticles. It has been hypothesized that the biotoxicity against mosquito young instars may be related to the ability of nanoparticles to penetrate through the exoskeleton. In the intracellular space, nanoparticles can bind to sulphur from proteins or to phosphorus from DNA, leading to the rapid denaturation of organelles and enzymes. Subsequently, the decrease in membrane permeability and disturbance in proton motive force may cause loss of cellular function and cell death [7].

3. Nanoparticles in the fight against malaria and dengue

It has been recently pointed out that malaria control is being challenging due to a growing number of *Plasmodium* strains resistant to chloroquine and/or other antimalarial drugs. Plants are an outstanding reservoir of antiplamodial molecules. However, also plant-mediated fabrication of nanoparticles may play a role in this field. Indeed, Murugan *et al*. showed that seaweed-synthesized silver nanoparticles were effective against both chloroquine-resistant and chloroquine-sensitive strains of *Plasmodium falciparum*, with IC_{50} values lower than chloroquine (*i.e*. 76.33 μg/mL for chloroquine-sensitive and 79.13 μg/mL for chloroquine-resistant) [3]. Furthermore, the possibility to employ green-synthesized silver nanoparticles in the fight against dengue (serotype DEN-2) has been validated [8]. It has been showed that silver nanoparticles act as inhibitors of the production of dengue viral envelope (E) protein in Vero cells, and down-regulated the expression of dengue viral E gene [9]. However, these studies showed a certain level of cytotoxicity of the tested nanoparticles, *e.g*. about 30% in cell viability reduction when tested at 50 μg/mL [9]. Interestingly, *Centroceras clavulatum*-synthesized silver nanoparticles tested at 50 μg/mL did not show relevant toxicity against Vero cells, but inhibit DEN-2 viral growth of more than 80%. This highlights the concrete potential of *Centroceras clavulatum*-fabricated silver nanoparticles in the fight against arboviral diseases [10].

4. Conclusions

Overall, despite the extensive research on plant-mediated synthesis of nanoparticles for mosquito-borne diseases prevention and control, there is a gap between theory and practical applications. In particular, much remains to know about the potential of plant-synthesized nanoparticles as antiviral and antiplasmodial drugs, as well as mosquito ovicides and oviderterrents. Further attention should also be given to the non-target effects and environmental fate of plant-synthesized nanoparticles in aquatic environments. In this scenario, Asian Pacific Journal of Tropical Biomedicine is pleased to encourage parasitologists, entomologists and researchers in drug nanosynthesis, to deal with these crucial challenges of public health importance.

Conflict of interest statement

I declare that I have no conflict of interest.

Acknowledgments

The author would like to thank H. Mehlhorn, K. Murugan and M. Nicoletti for helpful discussion on the topic of this editorial.

References

[1] Mehlhorn H, Al-Rasheid KA, Al-Quraishy S, Abdel-Ghaffar F. Research and increase of expertise in arachno-entomology are urgently needed. *Parasitol Res* 2012; **110**: 259-65.
[2] Benelli G. Research in mosquito control: current challenges for a brighter future. *Parasitol Res* 2015; **114**: 2801-5.
[3] Murugan K, Samidoss CM, Panneerselvam C, Higuchi A, Roni M, Suresh U, et al. Seaweed-synthesized silver nanoparticles: an eco-friendly tool in the fight against *Plasmodium falciparum* and its vector *Anopheles stephensi*? *Parasitol Res* 2015; **114**: 4087-97.
[4] Rajan R, Chandran K, Harper SL, Yun SI, Kalaichelvan PT. Plant extract synthesized nanoparticles: an ongoing source of novel biocompatible materials. *Ind Crops Prod* 2015; **70**: 356-73.
[5] Benelli G. Plant-synthesized nanoparticles: an eco-friendly tool against mosquito vectors? In: Mehlhorn, editor. *Nanoparticles in the fight against parasites*. Cham: Springer International Publishing; 2016.
[6] Madhiyazhagan P, Murugan K, Kumar AN, Nataraj T, Dinesh D, Panneerselvam C, et al. *Sargassum muticum*-synthetized silver nanoparticles: an effective control tool against mosquito vectors and bacterial pathogens. *Parasitol Res* 2015; **114**: 4305-17.
[7] Subramaniam J, Murugan K, Panneerselvam C, Kovendan K, Madhiyazhagan P, Kumar PM, et al. Eco-friendly control of malaria and arbovirus vectors using the mosquitofish *Gambusia affinis* and ultra-low dosages of *Mimusops elengi*-synthesized silver nanoparticles: towards an integrative approach? *Environ Sci Pollut Res Int* 2015; http://dx.doi.org/10.1007/s11356-015-5253-5.
[8] Sujitha V, Murugan K, Paulpandi M, Panneerselvam C, Suresh U, Roni M, et al. Green synthesized silver nanoparticles as a novel control tool against dengue virus (DEN-2) and its primary vector *Aedes aegypti*. *Parasitol Res* 2015; **114**: 3315-25.
[9] Murugan K, Dinesh D, Paulpandi M, Althbyani AD, Subramaniam J, Madhiyazhagan P, et al. Nanoparticles in the fight against mosquito-borne diseases: bioactivity of *Bruguiera cylindrica*-synthesized nanoparticles against dengue virus DEN-2 (*in vitro*) and its mosquito vector *Aedes aegypti* (Diptera: Culicidae). *Parasitol Res* 2015; **114**(12): 4349-61.
[10] Murugan K, Aruna P, Panneerselvam C, Madhiyazhagan P, Paulpandi M, Subramaniam J, et al. Fighting arboviral diseases: low toxicity on mammalian cells, dengue growth inhibition (*in vitro*) and mosquitocidal activity of *Centroceras clavulatum*-synthesized silver nanoparticles. *Parasitol Res* 2015; http://dx.doi.org/10.1007/s00436-015-4783-6.