Ingestion and reproductive effects of gold nanoparticles in *Blattella germanica*.

T. Small[a], **M.A. Ochoa-Zapater[a]***, F.M. Romero[b], A. Ribera[b], G. Gallello[c], A. Torreblanca[a], M.D. Garcerá[a].

[a] Departamento de Biología Funcional y Antropología Física, Universitat de València, Dr. Moliner 50, 46100 Burjassot, Valencia, Spain.
[b] Instituto de Ciencia Molecular, Universitat de València, Catedrático José Beltrán, 2. 46980, Paterna, Valencia, Spain.
[c] Departamento de Química Analítica, Universitat de València, Dr. Moliner 50, 46100 Burjassot, Valencia, Spain.
* ozama@alumni.uv.es

Abstract

Introduction:

Many biomedical, commercial and industrial advances have on their agenda the use of nanoparticles of different chemical elements, shapes and grade of aggregation due to their multiple applications and novel properties. All this progress must go hand in hand with studies verifying that the use of these nanoparticles is not harmful to biological compounds and the environment, while helping to establish threshold values for their application. The objective of this study is to investigate the possible toxic effects of nanoparticles that could be used as insecticide carriers in order to determine its hazard over an organism as *Blatella germanica*.

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Methodology:

The effects of daily administration through the diet of gold nanoparticles (AuNPs) on the reproduction of *Blattella germanica* were studied. Nanoparticles were synthesized following the method described by Bastús *et al.* [1] and characterized by UV-VIS and Transition Electron Microscopy (TEM) (figure 1).

Fifteen newly molted females from a laboratory reared population were feed with a solution of AuNPs (diameter range between 22 and 25 nm) in sodium citrate mixed with crushed rodent chow. Harborage and water were provided ad libitum. Food was weighted daily to estimate consumption.

Females were inspected daily for ootheca formation and for monitoring development, releasing and hatching times of oothecas. During the experiment females were in contact with males only until the formation of the first ootheca since it has been shown that a single mating is sufficient to fulfill the reproductive life of a female [2]. All studied parameters were monitored until the hatching of the third ootheca of each female cockroach and mortality rates were recorded.

At the end of the study, which was performed two times, all insects were frozen and gold content was determined using inductively coupled plasma optical emission spectroscopy (ICP-OES).

Furthermore, injection of nanoparticles solution, spray exposure by a Potter spray tower and the tarsal contact test bioassays were carried out for the study of the AuNPs toxicity [3]. Each bioassay was replicated three times using 5 to 10 adults of the same laboratory-reared population, aged 1 day; mortality rates were scored 24 h, 48 h and 72 h post-treatment.

Results:

As described in bibliography [2, 4], food consumption increased previously, and decreased following, the ootheca formation. But in our case, females treated with AuNPs showed a significantly higher food consumption rate than control ones (3,69 mg and 1,28 mg per insect and day, respectively). No Au content was detected in control individuals while treated insects had a mean concentration of this element of 12,70 µg per mg of insect. These results point to the existence of some degree of accumulation of AuNPs in the body of the insects; however, the difference between the amount of gold measured and the one estimated from the amount of food ingested suggests that Au NPs were mostly excreted.

Regarding the ootheca formation parameter, treated females showed a significant delayed onset of the first ootheca (figure 2). Moreover, only one control female released her first ootheca empty while in the case of treated cockroaches, two females released the first ootheca empty, three the second one and five the third one. Generally, *Blattella germanica* ootheca occasionally breaks off prematurely in the case of virgin females with sterile eggs [5]. Similarly, ootheca can be ruled out by females when they have been exposed to insecticides [6]. As suggested by Pompa *et al.* [7], AuNPs may act as catalysts accelerating the oxidative processes and the production of reactive oxygen species, affecting fertility and reproduction. Despite these alterations, both development and release times of all ootheca were not significantly different between the control group and the group of treated insects (figure 3).

Neither of the bioassays performed for the assessment of AuNPS toxicity showed significant mortality rates.

Acknowledgements: This work has been supported by grant AGL2010-21555 from the Ministerio de Economía y Competitividad.

References

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Figures

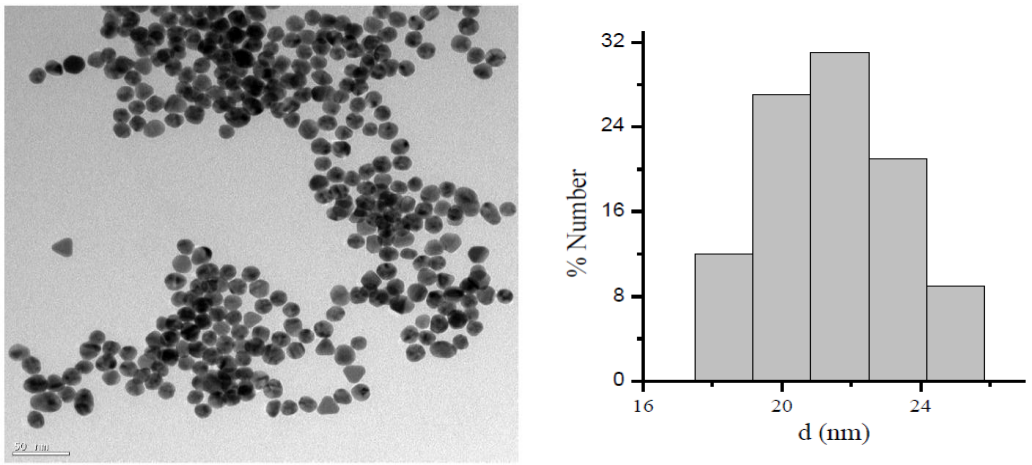

Figure 1.- TEM characterization (left) and frequency of size distribution (right) of gold citrate-capped (scale bar 20 nm) NPs. Average size of 21.8± 3 nm was obtained in these AuNPs.

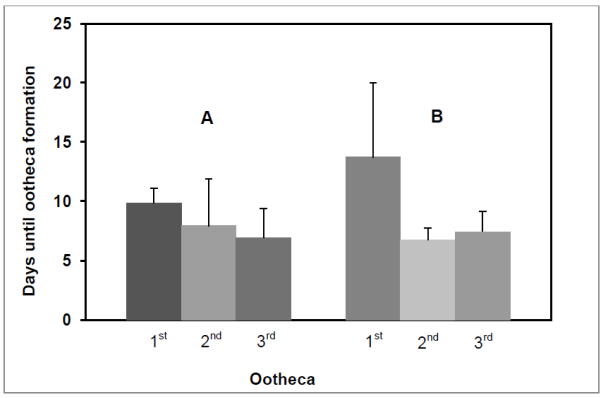

Figure 2.- Average number of days (±SD) until formation of each ootheca. A, control females; B, AuNPs treated females. 1st, first ootheca; 2nd, second ootheca; 3rd, third ootheca.

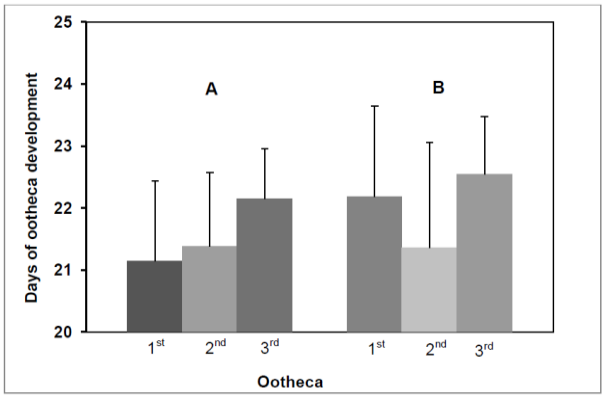

Figure 3.- Recorded mean time (±SD) in days that females carried each ootheca from their formation to their release. A, control females; B, AuNPs treated females. 1st, first ootheca; 2nd, second ootheca; 3rd, third ootheca.