ASSESSING THE TOXIC EFFECTS OF DELTAMETHRIN AND ACETAMIPRID ON THE LAND SNAIL *CORNU ASPERSUM* (O. F. MÜLLER, 1774): (GASTEROPODA, HELICIDAE) AS BIOACCUMULATOR AND BIOINDICATOR OF SOIL POLLUTION

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Abstract. Assessing the levels of pesticide-contaminated terrestrial ecosystems hinges on selecting effective and ecologically relevant bioindicator organisms. In this study, we highlight the bio indication potential of the terrestrial gastropod *Cornu aspersum*, a species widely distributed in north-east Algeria, to evaluate soil contamination by two commonly used insecticides: deltamethrin (a pyrethroid) and Acetamiprid (a neonicotinoid). Adult snails were exposed to increasing concentrations of both insecticides under controlled laboratory conditions of one month. Survival analysis revealed no significant mortality across treatment groups, indicating a lack of acute toxicity under the tested concentrations. Biometric measurements, including body weight, shell length, and shell diameter, show there was an effect of deltamethrin and acetamiprid concentrations on growth parameters. However, detailed histopathological examination revealed pronounced sublethal effects. Both insecticides, particularly at higher concentrations, induced marked structural damage in internal tissues. The most notable alterations included widespread necrosis and degeneration in the secretory cells of the hepatopancreas, as well as muscle fiber fragmentation and cellular disorganization in the foot sole region. Additionally, signs of epithelial hyperplasia were observed in the foot sole, indicating an inflammatory or adaptive response to chemical stress. These findings underscore the capacity of *C. aspersum* to serve as a sensitive histological bioindicator for detecting sublethal pesticide exposure in terrestrial ecosystems. The study also emphasizes the importance of integrating histological biomarkers alongside traditional endpoints such as survival and growth in ecotoxicological assessments.
Keywords: *Cornu aspersum, xenobiotics, physiological change, cellular alteration, bioindication*

Introduction

The phytosanitary products effectively protect crops against harmful vectors and pests and enhance crop production potential (Oerke and Dehne, 1997). However, contaminations of the global terrestrial environment limits their use (Zhang et al., 2019; Mentor et al., 2023). Insecticides can induce serious and harmful effects on soil-dwelling organisms, including earthworms and terrestrial gastropods, when present at concentrations above threshold levels (Peters et al., 2013). Accordingly, earthworms and gastropods have been found to be highly sensitive to various pollutants, but can also tolerate certain contaminants through bioaccumulation activity. Moreover, they have reported to be as effective bioindicator organisms, providing clear insights into pollution levels in the soils they inhabit (Moncef, 2014; Baroudi et al., 2020; Lauzon et al., 2021). Hence, the health status of chemical-contaminated environments is evidenced by the pollutant concentrations detected by physiological and behavioural disturbances, and

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tissue alterations of bioindicator animals or plants (Casas, 2005). *C. aspersum* is an important component of the food chain and plays a significant role in the transfer of soil contaminants, owing to its sedentary behavioral pattern in conjunction with an herbivorous nutritional intake. In addition, soil and air are the main exposure sources to toxic pesticides and trace metals, which consequently can be accumulated in their soft tissues (Scheifler et al., 2002; Viard et al., 2004; Moncef, 2014). In this regard, this study evaluates the effects of two commonly used insecticides in Algeria, deltamethrin and acetamiprid, on the mortality and growth of *C. aspersum*. A morphobiometric approach, coupled with histological analysis of the hepatopancreas and foot sole, the primary pollutant bioaccumulation organs, was employed to assess the biological impact of these xenobiotics.

Materials and methods

Biological material

C. aspersum was used as a biological material due to its wide distribution, ease of identification and breeding, and ecological relevance, as previously reported (Scheifler et al., 2002; Viard et al., 2004).

Breeding and sampling sites

C. aspersum snails were collected randomly from Ghellale Snails Farm in Beni-Ahmed, Kaous (Jijel, northeastern Algeria; 36°48′N, 5°46′E), a coastal region spanning 2,398 km² with 120 km of Mediterranean shoreline, bordered by Skikda (east), Bejaia (west), and Sétif (south) (*Figure 1*).

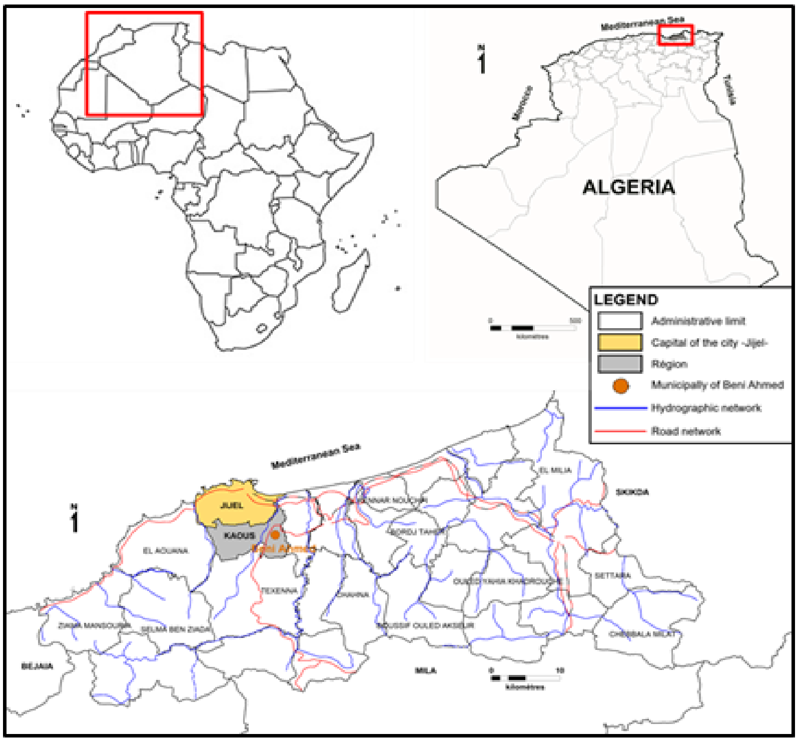

Figure 1. *Geographical location of Beni-Ahmed, Kaous (Jijel, Northeast, Algeria). (Breeding and sampling site)*

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Climatology

Beni Ahmed has a Mediterranean climate with mild, humid winters (5–15 °C) and hot, dry summers (20–25 °C), receiving 800–1200 mm of annual rainfall—making it one of Algeria's rainiest regions.

Soil analysis

To support the ecotoxicity assessments, physicochemical properties of the soil from the snail breeding plots were analyzed by the accredited Soil, Water, and Plant Analysis Laboratory (Authorization No. 41/19; Bulletin No. 03/005). The detailed results are presented in *Table 1*.

Table 1. *Physicochemical properties of breeding plot soil (Lab Auth. No. 41/19; Bulletin 03/005)*

Parameters	Values
pH	8.56
EC	205 µs/cm
Total $CaCO_3$	41.8%
Active $CaCO_3$	10.5%
Assimilable phosphorus	0.1 (poor)
Potassium	113.5 (poor)
Structural class	Clayey

As a result, the farm soil is clayey, with an alkaline pH (8.56), non-saline (205 µs/cm), highly calcareous (41.8%), and poor in phosphorus and potassium.

Chemicals

Two widely used insecticides were selected for this study based on their prevalence in agricultural practices and their representative field application concentrations.

Deltamethrin, a pyrethroid insecticide in wettable powder form (2.5% active ingredient; AFPPUA No. 5634411, MH002), acts through contact and ingestion, targeting pests such as aphids, whiteflies, moths, and fruit flies, and is applied to crops like vines, potatoes, vegetables, and citrus fruits at rates ranging from 70–500 mL/ha.

Acetamiprid $C_{10}H_{11}ClN_4$ CAS No. 160430-64-8), a neonicotinoid compound with 20% active ingredient, is an odorless, systemic insecticide that also acts via contact and ingestion to control pests such as aphids, miners, and whiteflies on vegetable crops and fruit trees. It has a molecular weight of 222.68 g/mol and a density of 1.17 g/cm³. Field application rates range from 10–30 g/hL. Both insecticides were obtained from SARL DEKACHIM (Algeria).

Experimental design

Sub-adult *C. aspersum* snails collected from the Ghellale snail farm, sampling was carried out in the morning on a rain-free day, without taking size into consideration, which the size selection is done later, were housed in the animal laboratory of our institution under controlled conditions (20 ± 2°C, 18 h photoperiod, 80% relative humidity), and fed exclusively with fresh lettuce leaves. Sixty *C. aspersum* snails (8–11 g, shell diameter 18–25 mm) were divided into a control group (15 individuals) fed fresh lettuce and three treated groups (45 individuals) fed lettuce dipped in increasing concentrations of

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deltamethrin (1.25, 2.5, 4 g/L) or acetamiprid (0.3, 0.6, 0.9 g/L), The concentrations chosen are directly related to the concentrations applied by farmers in the fields. Solutions were prepared in distilled water, renewed weekly, and contaminated food was provided 3–4 times per week during box cleaning. Each group was tested in triplicate. Mortality was recorded daily, and weight gain was measured weekly over one month (*Figure 2*).

Figure 2. *Experimental conditions. A: Experimental groups. B: Snails food*

Mortality assessment

Daily monitoring of snail mortality was conducted during routine maintenance of cleaning and food renewal, in addition to the removal of dead specimens from the test chambers. Mortality was assessed based on distinct indicators, including a flaccid, yellowish foot protruding from the shell, loss of adhesion to surfaces, increased body viscosity suggestive of tissue liquefaction, a pronounced putrid odor, and lack of reaction confirming death of snails (Coeurdassier, 2001).

Assessment of biometry and weight growth

Before initiating the toxicological experiment, biometric parameters, including shell diameter (D), height (L), and fresh weight (P, including soft tissues and shell), were measured using a digital caliper (precision: 0.1 mm) and a KERN.ABJ-NN/ABS-N precision balance. These parameters were reported as key indices for evaluating weight growth in both control and treated *C. aspersum* with the two insecticides (Stiévenart et al., 1990; Huberty, 1994).

Histopathological assessment

Histopathology of hepatopancreas and foot tissues from control snails and those treated with the highest concentrations of both insecticides were performed at the Pathology Laboratory of the Souk-Ahras Regional Hospital (North-eastern Algeria).

After 30-day exposure period, snails were fasted for 48 hours to clear their digestive tracts (Druart, 2011), then frozen. Three *C. aspersum* individuals exposed to the highest insecticide concentrations were decapitated, deshelled, and dissected to collect the hepatopancreas and foot. Tissues were fixed in Bouin's solution for 24 hours, rinsed with demineralized water, dehydrated through graded alcohols, and embedded in paraffin (56–58°C). Sections (6 µm) were cut using a Leitz microtome, mounted on slides,

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deparaffinized in toluene, and stained with hematoxylin and eosin. Prepared slides were examined under a Leica microscope.

Statistical analysis

Data are presented as a mean value ± SD (standard deviation) in each treatment group. The normality of data was verified using the Shapiro-Wilk test, and the homogeneity of variances was checked by Levene's test. Snail's average weight, length and diameter of the shell were determined in triplicate, the data were analyzed using a two-way ANOVA, and means were tested for statistical significance by a Post Hoc Tukey's honestly significant difference test. The statistical tests were performed using SPSS software (version 26.0; SPSS, Chicago, IL, USA), where $p < 0.05$ indicates a statistically significant difference.

Results

Snail mortality

During toxicological tests, the viability of *C. aspersum* individuals was monitored every week for one month.

During the experiment with different concentrations of deltamethrin insecticide, snail mortality was low: 8 snails out of 60 individuals over a one-month period, representing 13.36% of the total number, when it was occurred as follows: 3 individuals during the 1st week, 2 individuals during the 2nd week and 3 individuals during the 3rd week (*Table 2*).

For acetamiprid insecticide, the different concentrations showed that mortality was also low affecting 7 individuals out of 60 individuals during one month, which represents 11.61% of the total number, when it was occurred as follows: 3 individuals during the 1st week, 1 individual during the 2nd week and 3 individuals during the 3rd week (*Table 2*).

Table 2. *Cumulative mortality of C. aspersum snails treated with deltamethrin and Acetamiprid insecticides*

Exposure period	0 week	1st week	2nd week	3rd week	4th week	Cumulative Mortality
Control A	0	1	0	0	0	1
Deltamethrin C1	0	1	1	2	0	4
Deltamethrin C2	0	0	0	0	0	0
Deltamethrin C3	0	1	1	1	0	3
Total	0	3	2	3	0	**8**
Control B	0	2	0	0	0	2
Acetamiprid C1	0	0	0	0	0	0
Acetamiprid C2	0	0	0	1	0	1
Acetamiprid C3	0	1	1	2	0	4
Total	0	3	1	3	0	**7**

Morphometric parameters of C. aspersum snail

A two-way ANOVA was conducted for morphometric parameters (Weight, Shell Diameter, Length) of *C.aspersum* snail exposed to deltamethrin and acetamiprid insecticides under different exposure weeks. Where "week 0" served as an adaptation

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period to laboratory condition, without insecticide exposure, establishing baseline growth and health parameters.

Weight changes

There was a significant main effect of deltamethrin concentrations on snails weight decrease, $F_{3,71}$ =22.509; p = 0.0001. The main effect of time was also significant, $F_{5,71}$ = 15.459; p = 0.0001. However, the interaction between concentrations and time exposure had no significant effects on snails' weight decrease, $F_{15,71}$ = 1.185; p = 0.315 (*Table 3*).

Table 3. *Results of two-way ANOVA for morphometric parameters of C. aspersum snail exposed to deltamethrin insecticide*

Parameters	Concentration			Time			Concentration x Time		
	df	F	P	df	F	P	df	F	P
Weight (g)	3	22.509	0.0001a	5	15.459	0.0001a	15	1.185	0.315
Diameter of the Shell (mm)	3	41.667	0.0001a	5	22.742	0.0001a	15	8.086	0.0001a
Length (mm)	3	42.065	0.0001a	5	11.55	0.0001a	15	7.107	0.0001a

[a] Represents a significant effect of deltamethrin concentration, time of exposure, and their interaction on morphometric parameters of snail. df: degree of freedom

In parallel, a significant main effect of acetamiprid concentrations on snails weight decrease was recorded, $F_{3,71}$ =8.368; p = 0.0001. The main effect of time was also significant, $F_{5,71}$ = 4.536; p = 0.002. Also, the interaction between concentrations and time exposure had significant effects on snails' weight decrease, $F_{15,71}$ = 2.401; p = 0.01 (*Table 4*).

Table 4. *Results of two-way ANOVA for morphometric parameters of C. aspersum snail exposed to acetameprid insecticide*

Parameters	Concentration			Time			Concentration x Time		
	df	F	P	df	F	P	df	F	P
Weight (g)	3	8.368	0.0001a	5	4.536	0.002a	15	2.401	0.01a
Diameter of the Shell (mm)	3	19.745	0.0001a	5	3.324	0.01a	15	1.303	0.237
Length (mm)	3	7.232	0.0001a	5	1.877	0.116	15	1.911	0.04a

[a] Represents a significant effect of acetameprid concentration, time of exposure, and their interaction on morphometric parameters of snail. df: degree of freedom

Snails exposed to deltamethrin showed a more pronounced decrease in average weight over the exposure periods compared to those exposed to acetamiprid, despite to its lower active ingredient (2.5%) compared to acetamiprid (20%). This suggests that Deltamethrin

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has a stronger negative impact on the growth or health status of *C. aspersum* snails (*Figure 3*).

The statistical differences indicated by diverse lowercase letters at the same periods confirm that weight reduction under deltamethrin is significant compared to Acetamiprid and the control (adaptation period at 0 week) (*Figure 3*).

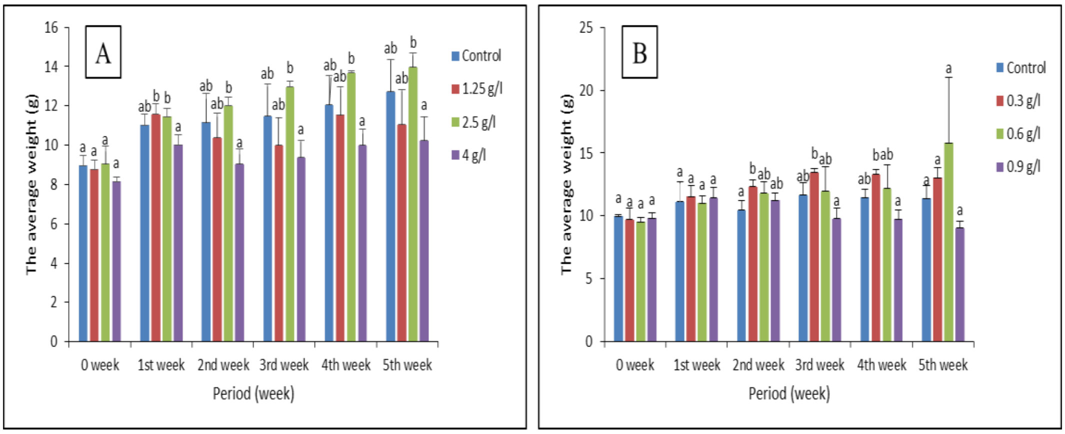

Figure 3. *The average weight of C. aspersum snails exposed to deltamethrine (A) and Acetamiprid (B) insecticides during different exposure periods (mean ± SD, n = 3 repeats, each containing 5 individuals). Diverse lowercase letters designate significant differences at the same period, based on Tukey's HSD test (p < 0.05)*

Shell diameter

There was a significant main effect of deltamethrin concentrations on snails average shell diameter, $F_{3,71}$ =41.667; p = 0.0001. The main effect of time was also significant, $F_{5,71}$ = 22.742; p = 0.0001. In addition, the interaction between concentrations and time exposure had also significant effects on snails' shell growth decrease, $F_{15,71}$ = 8.086; p = 0.0001 (*Table 3*).

Equivalently, a significant main effect of acetamiprid concentrations on snails' shell diameter reduction was recorded, $F_{3,71}$ =19.745; p = 0.0001. The main effect of time was also significant, $F_{5,71}$ = 3.324; p = 0.01. On the other hand, the interaction between concentrations and time exposure had no significant effects on snails' shell growth, $F_{15,71}$ = 1.303; p = 0.237 (*Table 4*).

The average shell diameter of snails treated with deltamethrin decreased or showed less growth compared to those treated with acetamiprid over the exposure periods. Regardless of its lower active ingredient (2.5%) compared to acetamiprid (20%). Significant differences at each time point suggest that deltamethrin inhibits shell growth more effectively than acetamiprid (*Figure 4*).

Since shell diameter is an indicator of snail development and health, this implies that Deltamethrin disrupts normal growth processes more severely.

Length

A significant main effect of deltamethrin concentrations on snails' average length diminution, $F_{3,71}$ =42.065; p = 0.0001. The main effect of time was also significant, $F_{5,71}$ = 11.55; p = 0.0001. Similarly, the interaction between concentrations and time

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exposure had significant effects on snails' length reduction, $F_{15,71} = 7.107$; $p = 0.0001$ (*Table 3*).

In parallel, a significant main effect of acetamiprid concentrations on snails' average length decrease was recorded, $F_{3,71} = 7.232$; $p = 0.0001$. The main effect of time was not significant, $F_{5,71} = 1.877$; $p = 0.116$. Moreover, the interaction between concentrations and time exposure had significant effects on snails' length reduction, $F_{15,71} = 1.911$; $p = 0.04$ (*Table 4*).

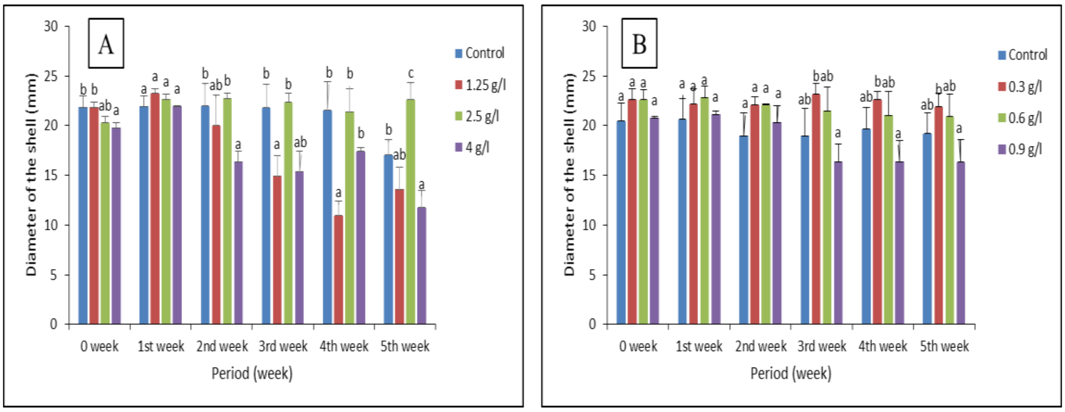

Figure 4. *The average shell diameter of C. aspersum snails exposed to deltamethrine (A) and Acetamiprid (B) insecticides during different exposure periods (mean ± SD, n = 3 repeats, each containing 5 individuals). Diverse lowercase letters designate significant differences at the same period, based on Tukey's HSD test (p < 0.05)*

Similarly, the average length of snails exposed to deltamethrin showed a significant reduction or less increase compared to those exposed to acetamiprid (*Figure 5*). Even though its lower active ingredient (2.5%) compared to acetamiprid (20%). The significant differences across exposure periods reinforce the conclusion that Deltamethrin has a stronger inhibitory effect on snail growth in length.

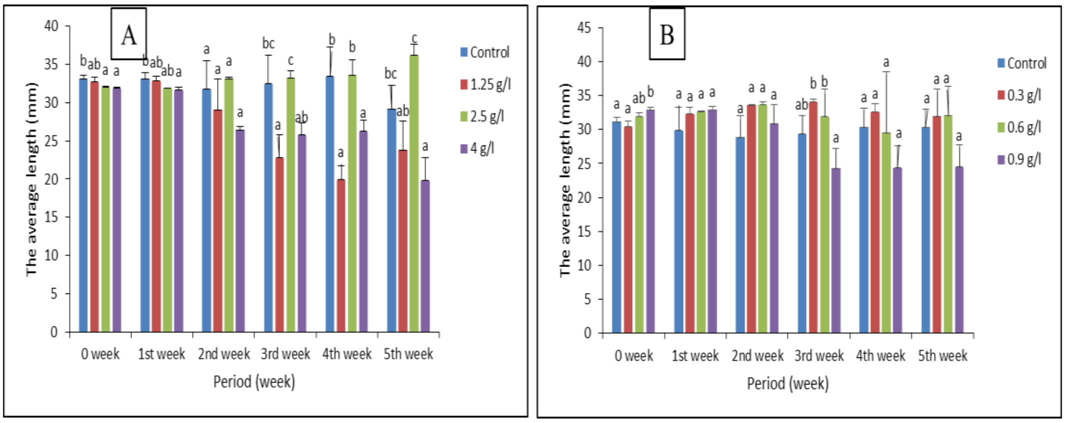

Figure 5. *The average length of C. aspersum snails exposed to deltamethrin (A) and Acetamiprid (B) insecticides during different exposure periods (mean ± SD, n = 3 repeats, each containing 5 individuals). Diverse lowercase letters designate significant differences at the same period, based on Tukey's HSD test (p < 0.05)*

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Histopathological observations

Deltamethrin and acetamiprid induced histological alterations in C. aspersum hepatopancreas

Ultrastructural analysis proved to be a valuable approach for assessing cellular damage induced by xenobiotics, offering insights into their sites and mechanisms of action across different cell types. Various toxicants in the snails' body can be primarily metabolised, accumulated, excreted, and bio-transformed in the hepatopancreas, which consequently becomes the main target organ for the environmental toxicological studies. As shown in *Figure 6A*, hepatopancreatic tissue from control snails exhibited a normal histological structure and preserved tissue integrity, consisting of well-organized acini supported by connective tissue, and the digestive gland displayed numerous intact digestive tubules well separated by intertubular spaces (Sandrine and Henri, 2011).

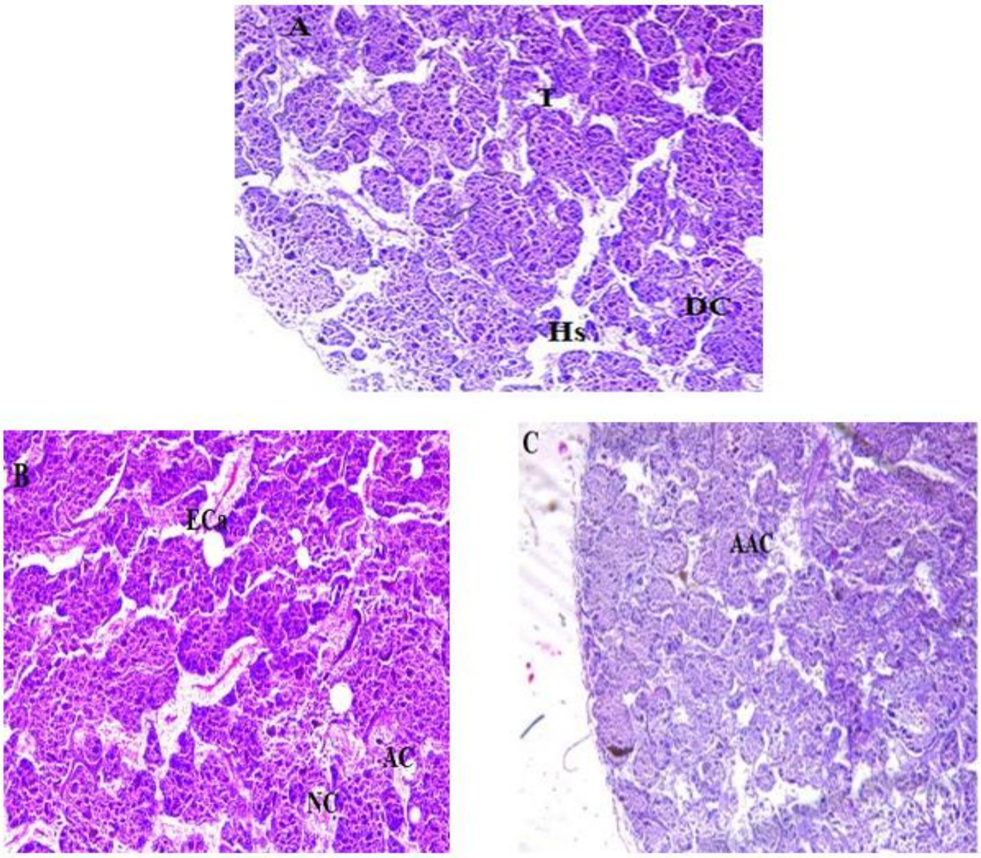

Figure 6. *A- Longitudinal section of hepatopancreas from C. aspersum, after 30-day experimental period (Microscope Leica, ×3.2). A- control, B- treated with 4g of deltamethrin, C- treated with 0.9g of acetamiprid. NC (Necrosis Cell), AC (Atrophied Cells). AA C (Atrophied Absorptive Cells)*

While hepatopancreas from snails treated with 4 g of deltamethrin revealed marked histological alterations evidenced by massively altered parenchyma, disordered cell architecture following cell necrosis, undifferentiated basal lamina, hyperplastic secretory cells, and hyperplastic and abraded canal epithelium, atrophied cells (*Figure 6B*). In

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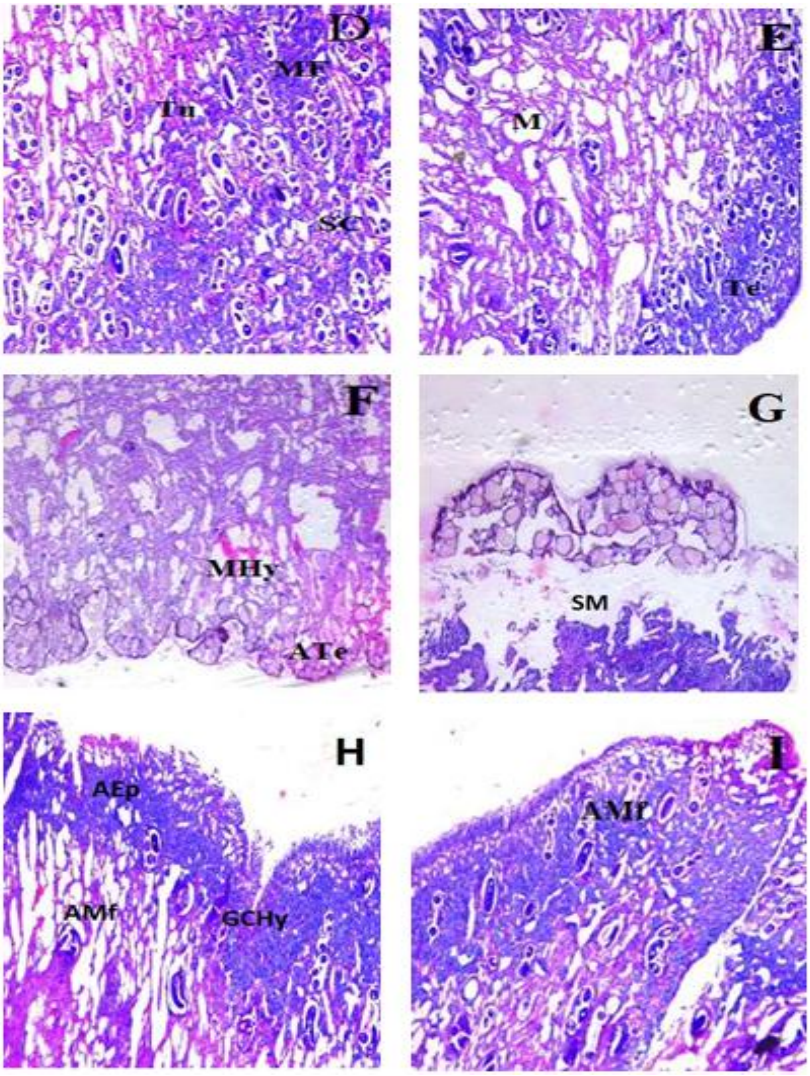
parallel the hepatopancreas from snails received 0.9 g of acetamiprid showed a moderate altered paranchyma but still recognizable and preserved secretory cells, abraded canal epithelium, and atrophied cells (*Figure 6C*).

Deltamethrin and acetamiprid induced histological alterations in C. aspersum foot sole

The foot sole of the snails, a prominent ventral structure involved in locomotion across soil and plant surfaces, was characterized by a mucous-covered surface and a distinct histological organization. Microscopic observation of foot sole of control snails showed the presence of large glandular secretory cells, found in the deeper layers of the tissue, and separated by smooth muscle fibers and connective tissue, and lined by a simple epithelial layer (*Figures 7D,E*), in accordance with the previous reported findings (Sandrine and Henri, 2011).



***Figures 7.** (D, E, F, G,H, I): Longitudinal section of foot sole from C. aspersum after 30-day experimental period (Microscope Leica, ×3.2). D, E- control. F, G- treated with 4 g of Deltamethrin. H, I- treated with 0.9 g of acetamiprid. T (Tégument) Tu (tubule), MF (muscle fibre), Sc (secretory cell). MHy (Mucocyte hyperplasia), SMu (separation of underlying muscles), ATe (Atrophied tegument). AMf (Accentuation of muscle fibers), GCHy (Glandular Cell Hyperplasia)*

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Figures 7F,G corresponding to foot sole tissue tissues from snails treated with 4 g of Deltamethrin, revealed hyperplasia of mucocytes, hyperplasia of underlying muscle fibers, and atrophied covering epithelium, even denuded and abraded , hyperplasia of secretory cells, hyperplasia of glandular cells of the underlying musculature. In *Figures 7H,I.* After treatment with acetamiprid concentration 0, 9 g, structural changes in the *C. aspersum* foot appeared, such as hyperplasia of glandular cells and an accentuation of the musculature.

Discussion

Pulmonate gastropods were reported as efficient accumulating organisms to many environmental toxicants, including heavy metals, nanoparticles, and pesticides, as well as bioindicators of environmental pollution (Arbaa and Soltani, 2014). Thus the performed study aimed to investigate deltamethrin and acetamiprid-induced mortality, changes in physiological aspects (growth and body weight), and histology of hepatopancreas and foot sole in land snails collected from a farm in Jijel city (North-eastern Algeria). Herein, the discussion related to the altered parameters is separately provided in the following sections.

Mortality induction

After one month of exposure, mortality rates of exposed snails were relatively low: 13.36% for deltamethrin and 11.61% for acetamiprid. These results are in line with a previous study (Schuytema et al., 1994) reporting low mortality rate of 13% in *Helix aspersa* exposed to various pesticides (acephate, atrazine) at concentration of 5.000 mg/Kg for 14 days. Viard et al. (2004) found that the mortality rate caused by pesticides varied from 3% to 7%. Druart et al. (2011) found that the mortality caused by 2.8 g concentration of glyphosate did not exceed 5%. Bourbia (2013) mentioned that the concentration 25 mg/L of thiaméthoxam causes mortality of 9.16% of the treated specimens. Douafer (2015) found a 5% mortality rate in both *H. aspersa* and *H. aperta* treated with thiaméthoxam insecticide. Ameur (2021) reported 11% mortality in *H. aspersa* collected from Batna city in Algeria and exposed over a month to metallic dust. The consistently low mortality across these studies may be due to behavioral avoidance in snails, such as their tendency to reject contaminated food, thereby limiting their exposure to harmful substances. On the other hand, Genena and Fatma (2008) reported a marked oxidative injury and a very high mortality rate of 46.6% and 50%, respectively in *Monacha cautiana* and *Eobania vermiculata* snails exposed to constant concentration 2% of deltamethrin. Ali et al. (2020) found that the concentration of 37% of acetamiprid caused a mortality rate of 90% of *Eobania vermiculata* snails. These results of snail mortality may be related to the sensitivity of the selected animal species to the tested substances and the toxic action modes.

Physiological changes

The study of growth enables the assessment of the effects of pollutant-induced stress on organisms exposed to hazardous environmental contaminants. In this study, both insecticides significantly impaired all three measured growth parameters (Total Body Weight, Shell Diameter, and Shell Length). Over subsequent weeks, deltamethrin caused stronger physiological stress, likely due to its neurotoxic effects as a pyrethroid, which

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interfere with nervous system function and feeding behavior, leading to decreased weight and growth Genena and Fatma (2008). Acetamiprid, while still toxic, showed milder effects consistent with its mode of action as a neonicotinoid, which may have slower or less severe impacts on snails compared to pyrethroids (Ali et al., 2020). These findings align with literature showing methomyl and deltamethrin as highly effective molluscicides with rapid and strong mortality effects, whereas other insecticides like acetamiprid tend to have lower initial toxicity and slower cumulative effects (Genena and Fatma, 2008; Ali et al., 2020). Radwan et al. (2008) suggested that the reduction in weight and shell diameter in snails treated with parquat is related to the nature of the pesticide and the concentrations administered. Druart et al. (2011) showed that glycophosate did not have an effect on the weight growth of treated snails. Song et al. (2020) mentioned that microplastics have no effects on the biometrics of African snail *Lissachatina fulica.* Schuytema et al. (1994) revealed that pesticides aminocarb, Azinphos-methyl, and carbaryl cause drops in total weight and reduction in shell diameter of *C. aspersum*. Bourbia (2013) also noted shell disturbances after exposure to Thiamethoxam and tefluthrin. Grara et al. (2016) observed a shell diameter decline due to metal dust coming from Annaba city (Northeast Algeria). While Ameur (2021) reported that metal dust resulting from Batna city (Northeast Algeria) stimulated weight gain in *Helix aspersa* even at low concentrations; however, temporal variations in body weight, shell width, and shell diameter were not statistically significant. In addition, it was previously reported reduced weight of snails exposed to Annaba's metal dust dropping from 9.13 g to 3.55 g after six months was other studies (Atailia, 2017). Benradia et al. (2025) concluded a decrease in total weight and shell diameter in in *H. aspersa* exposed to high concentrations of copper nanoparticles for 28 days, and noteworthy, the shell height increased significantly over the same period and same concentrations. Interestingly, weight loss is widely recognized as an early indicator of toxicity, often linked to reduced food intake due to neurotoxic effects (Genena and Fatma, 2008; Ali et al., 2020). The mechanisms behind growth inhibition may include suppressed hormone synthesis (Gomot and Enée, 1980). Vaufleury (2000) explained the inhibition of growth by the accumulation of contaminant in key organs like hepatopancreas, kidneys, and gonads underscoring the role of *H. aspersa* as a bio indicator species. Aso et al. (2021) suggested that *Eobania vermiculata* representative of gastropods considered as a good bio accumulator of metal pollution in region Sulaimania region (Iraq).

Histological alterations

Histological analysis provides critical insights into tissue architecture and pathological changes resulting from exposure to environmental toxicants. The extent and severity of lesions are influenced by factors such as species, target organ, chemical nature of the contaminant, and exposure concentration. In the present study, Deltamethrin elicited more severe histopathological alterations than acetamiprid, where serious alterations were observed at the level of the integument, muscle fibers and glandular cells corroborating the findings of Russell et al. (1981), who reported extensive tissue damage, particularly in the intestine and digestive gland. Similarly, Frias-Espericueta et al. (2008) observed significant damage in the hepatopancreas, kidneys, and foot tissues due to heavy metal exposure, characterized by epithelial hyperplasia, necrosis, and connective tissue proliferation. Radwan et al. (2008) demonstrated that even low concentrations of toxicants could induce epithelial hyperplasia in the digestive gland, kidney, and ovary of *Helix aspersa*. Sawasdee et al. (2011) reported vacuolization and necrosis in

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hepatopancreatic cells of *Marsia cornuarietus* following exposure to copper and lithium. Bourbia (2013) also observed vacuolization and partial degeneration of hepatopancreatic cells in *H. aspersa* treated with thiamethoxam and/or tefluthrin. Grara et al. (2016) confirmed the deleterious effects of xenobiotic-laden metal dust on hepatopancreas and kidney tissues in *H. aspersa*, while Atailia (2017) highlighted that xenobiotics disrupt cellular dynamics and membrane integrity, enhancing contaminant diffusion and promoting necrosis. This author also noted structural alterations in the gonadal tissues following metal dust exposure. Conversely, Ameur (2021) found no histological changes in the foot sole of juvenile *H. aspersa* at low doses (1.75–2.25 g) of metal dust, although higher concentrations induced marked structural damage. More recently, Benradia et al. (2025) demonstrated that prolonged exposure to high concentrations of copper oxide nanoparticles induced necrosis in hepatopancreatic cells of *H. aspersa*. Bendjebbar et al. (2025) have proven that hepatopancreas and foot in *C.aspersum* are accumulation organs for copper, zinc and sulfate.

Conclusion

This study assessed the toxicological effects of two insecticides, deltamethrin and Acetamiprid, extensively used in Souk Ahras city of Algeria on *C. aspersum*, a terrestrial gastropod and recognized bioindicators of environmental pollution.

Deltamethrin exerts a significantly stronger negative effect on the growth parameters (weight, shell diameter, length) of *C.aspersum* snails compared to acetamiprid, despite to its lower active ingredient (2.5%) compared to acetamiprid. Indicating higher toxicity and growth inhibition over the exposure period following the initial adaptation phase without treatment.

Histopathological evaluation revealed notable tissue alterations, including degeneration of secretory cells in the hepatopancreas and structural disruption of foot muscle fibers. These sublethal cellular changes indicate that, despite the lack of visible physiological effects, both insecticides exert cytotoxic effects that may impair organ function over time. The findings underscore the sensitivity of *C. aspersum* to environmental contaminants at the histological level and confirm its relevance as a sentinel species bioindicator for monitoring terrestrial ecotoxicological risks.

Further studies would be worthwhile as future research in order to investigate other toxic effects, regarding the negative impacts of these insecticides on land snails.

Future research perspectives

Future research should explore the following key points:

- Extend histological examination to other organs, such as the kidney and ovary.
- Evaluate the effects of pesticides on other gastropod species (*Helix maxima*, *Eobania constantina*, *Eobania vermiculata*).
- Conduct biochemical assays for oxidative stress biomarkers (AChE, CAT, MDA, GSH, GST, SOD, POD, LDH, and CYP 450) to identify cellular-level effects, biomolecular level, DNA damage, and innate immunity.
- Utilize additional terrestrial bioindicators and bioaccumulators, such as earthworms and springtails, to broaden ecological relevance.

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