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From bacteria to fish: ecotoxicological insights into the bioinsecticide Spinosad

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INTRODUCTION

SPINOSAD (SPI)

- **Natural bioinsecticide** derived from the actinobacterium *S. spinosa*[1] and widely used in **agriculture;**
- **High selectivity** toward target pests;
- **Low environmental persistence**[1].
- Its **increasing application** raises **concerns** about **potential toxic effects** on **non-target aquatic species**[2].

AIM

To **evaluate the acute toxicity** and **sub-individual effects** of **Spinosad** (SPI) across **multiple aquatic species**, representing **different trophic levels**.

METHODS [3]

BIOASSAYS and BIOMARKERS

Allivibrio fischeri [4]

Inhibition of bioluminescence assay (30 min; 0.59 – 150 mg/L)

Raphidocelis subcapitata [5]

Growth inhibition assay
(3 days; 2.52 – 6.14 mg/L)

Sub-individual evaluation
Total Chlorophyll and Carotenoids contents

Daphnia magna [6]

Acute immobilization assay
(48 h; 0.00066 – 1 mg/L)

Sub-individual evaluation

CAT and GSTs activities	TBARS levels	AChE activity

Danio rerio [7]

Fish embryo acute toxicity test (96 h; 0.625 – 10 mg/L)

Growth | Abnormalities | Hatchability

Sub-individual evaluation

CAT and GSTs activities | TBARS levels | AChE activity

ENVIRONMENTAL HAZARD CLASSIFICATION [8]

Toxicity score - EU-Directive 93/677/ECC

EC_{50} (mg/L)

Non toxic	Harmful	Toxic	Very toxic
> 100	10 – 100	1 – 10	< 1

EC_{50} - Median effective concentration;
NOEC - No Observed Effect Concentration;
LOEC - Lowest Observed Effect Concentration

CONCLUSIONS

- **High toxicity** of SPI to **aquatic invertebrates** namely ***D. magna*;**
- **High potential** to **disrupt key physiological processes** in fish at moderate concentrations;
- **More environmental risk assessments of SPI** are essential, considering **chronic toxicity** and **sublethal responses**, particularly **under realistic exposure scenarios** to **guarantee the health status of aquatic ecosystems**.

RESULTS & DISCUSSION

ACUTE TOXICITY

A. fischeri (bioluminescence)
EC_{50} = 105.66 mg/L (74.83 – 136.49) — NON TOXIC

R. subcapitata (growth)
EC_{50} = 3.93 mg/L (3.53 – 4.34) — TOXIC

D. magna (swimming behavior)
EC_{50} = 0.018 mg/L (0.001 – 0.029) — VERY TOXIC

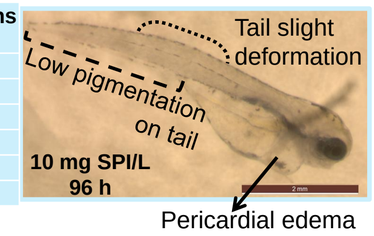
D. rerio (growth)
EC_{50} = 1.37 mg/L (0.06 – 2.67) — TOXIC

Sensitivity Ranking to SPI

Lower EC_{50} = Higher Sensitivity

D. magna < *D. rerio* < *R. subcapitata* < *A. fischeri*

SPI (mg/L)	Malformations (%)
0	0
0.625	5
1.25	7.5
2.5	2.5
5	7.5
10	17.5



SUB-INDIVIDUAL EFFECTS

R. subcapitata

SPI (mg/L)	Total Chlorophyll content	Carotenoids content
LOEC	4.54	4.54
NOEC	4.11	4.11

SPI caused an **impairment of the photosynthetic apparatus**, which may be related to oxidative stress or pigment biosynthesis, **compromising** the **photosynthetic efficiency and physiological status** of *R. subcapitata*.

D. magna

SPI (mg/L)	CAT activity	GSTs activity	TBARS levels	AChE activity
LOEC	0.0256	1.000	0.0160	0.0102
NOEC	0.0102	0.400	0.0007	0.0041

D. rerio

SPI (mg/L)	CAT activity	GSTs activity	TBARS levels	AChE activity
LOEC	10.00	2.50	-	2.50
NOEC	5.00	1.25	10.00	1.25

D. magna exhibited **biochemical responses at low concentrations** of SPI**,** indicating **high sensitivity:**

- activation of antioxidant mechanisms and a later phase of the detoxification, pointing to the onset of **oxidative stress**; **lipid peroxidation**; **early neurotoxic effects**.

SPI's toxicity - effects at environmentally relevant concentrations (recommended usage dose for field applications = 500 µg/L)[2]

D. rerio exhibited **measurable biochemical responses** to SPI, **at moderate concentrations**:

- induction of antioxidant defenses and activation of phase II detoxification pathways, pointing to the onset of **oxidative stress**; no oxidative damage under the tested conditions; **possible neurotoxic effects**.

SPI´s sub-lethal alterations - detoxification and **neural dysfunctions.**

REFERENCES