Selective grazing behaviour of chironomids between three microalgal species under pesticide pressure

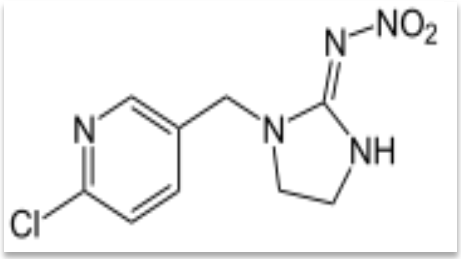
Julie Neury-Ormanni, Caroline Doose, Betty Chaumet, Nicolas Mazzella, Nabil Majdi, Jacky Vedrenne, Soizic Morin, Walter Traunspurger

May 2018

Chironomids larvae
tanytarsinae tribe

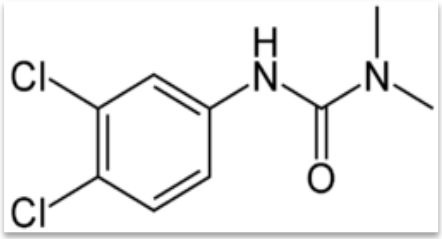
www.irstea.fr

Introduction:



Imidacloprid

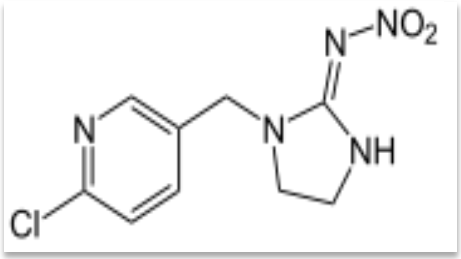
Insecticide
Insect nicotinic receptor



Diuron

Herbicide
Photosystem II

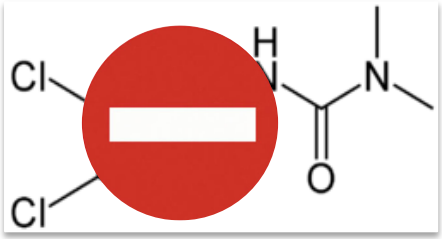
Introduction:



Imidacloprid

Insecticide

Insect nicotinic receptor



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Herbicide

Photosystem II

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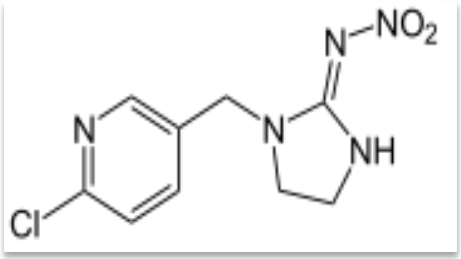
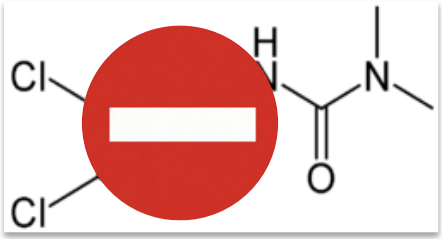


Imidacloprid

Insecticide

Insect nicotinic receptor



Diuron

Herbicide

Photosystem II

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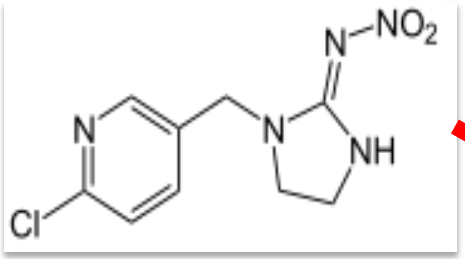

Imidacloprid

Insecticide

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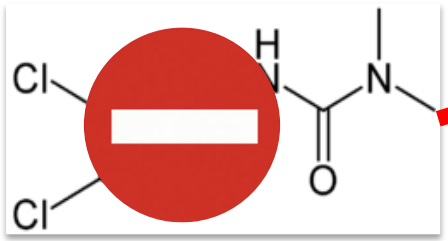

Diuron

Herbicide

Photosystem II

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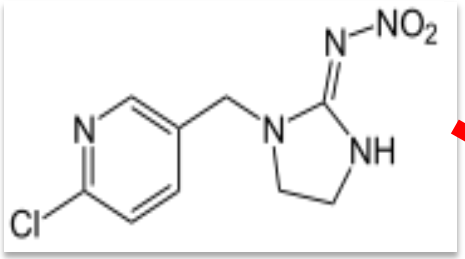

Imidacloprid

Insecticide

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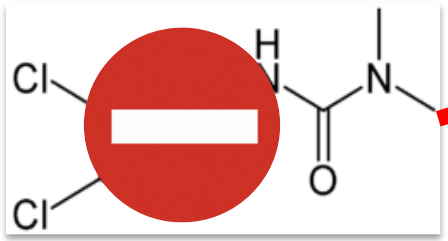

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Herbicide

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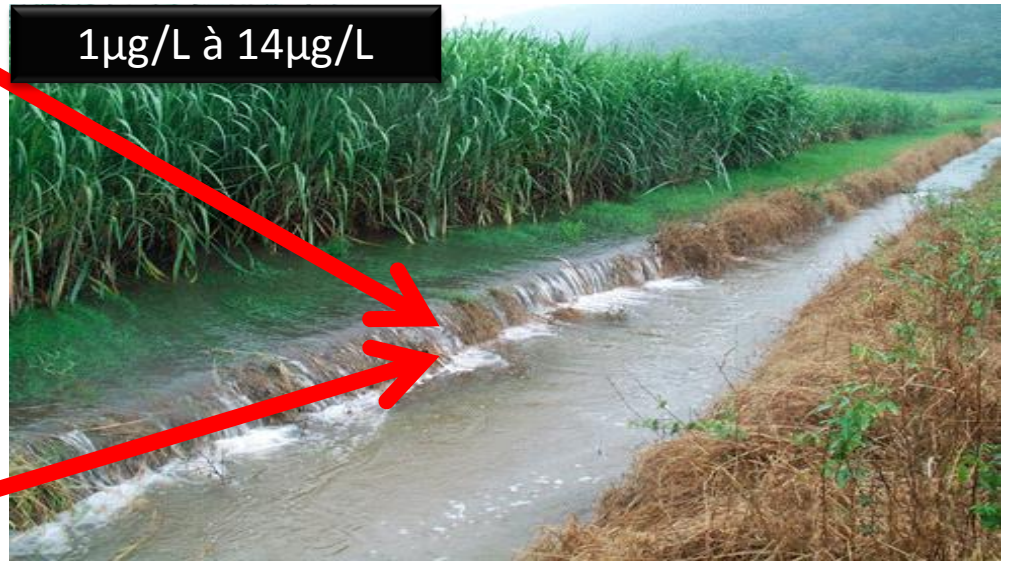

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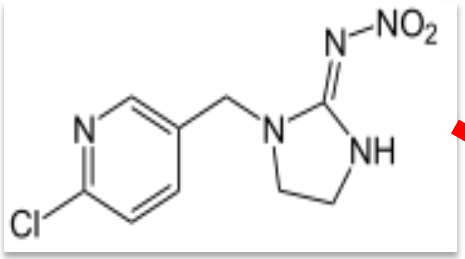

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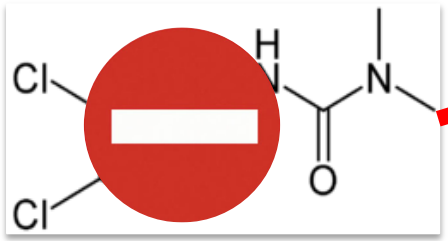
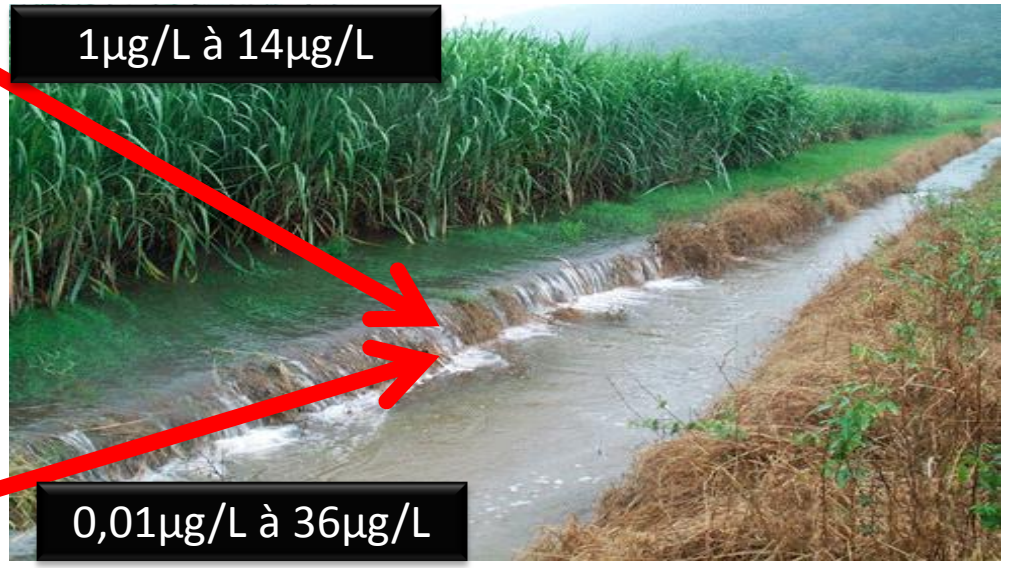


Diuron

Herbicide

Photosystem II



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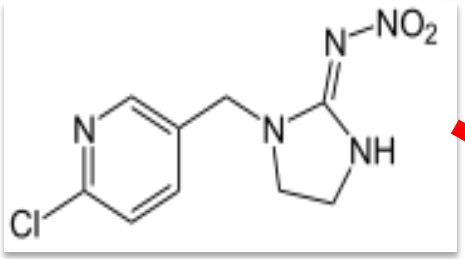

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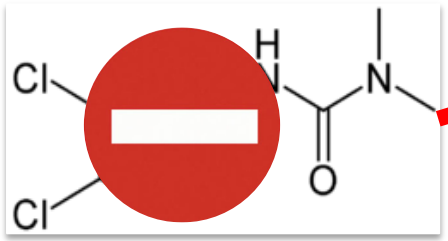

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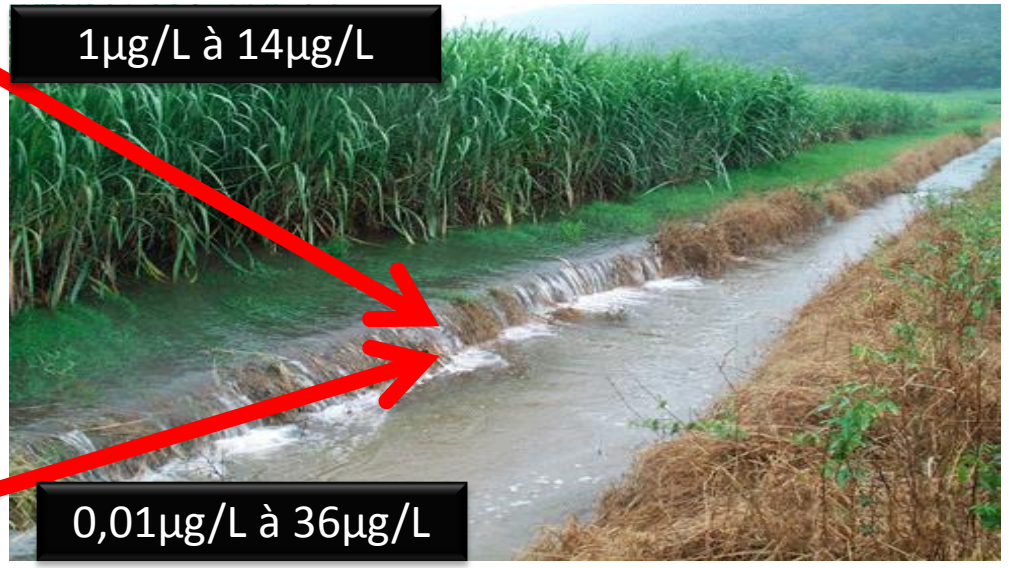
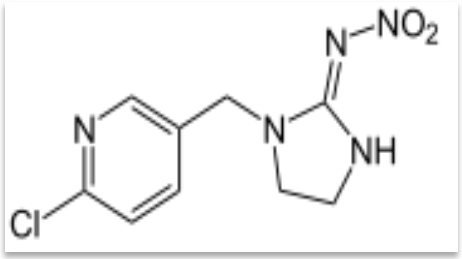
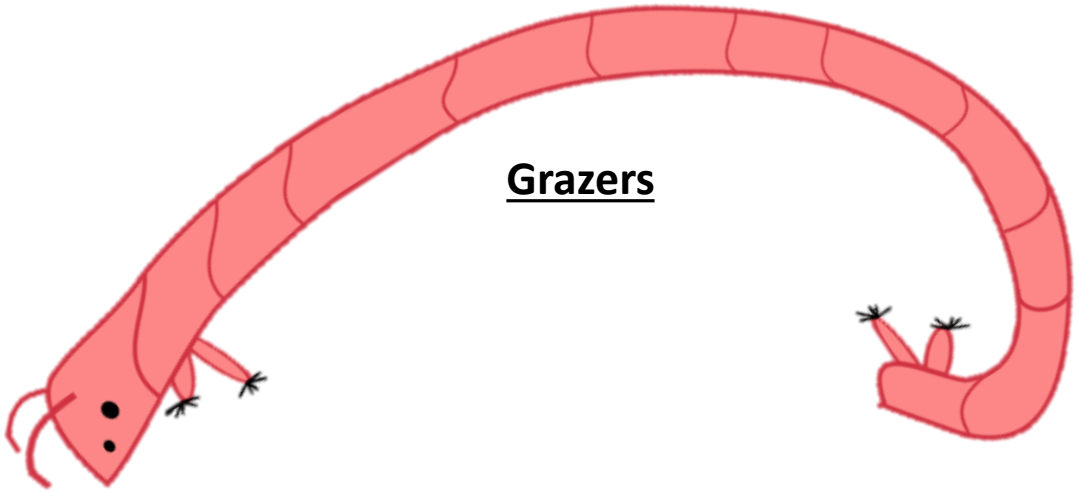


Most frequently detected pesticide in European rivers

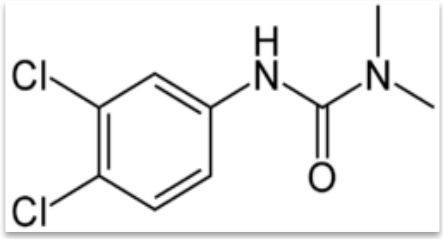
Aims:



Imidacloprid



Grazers



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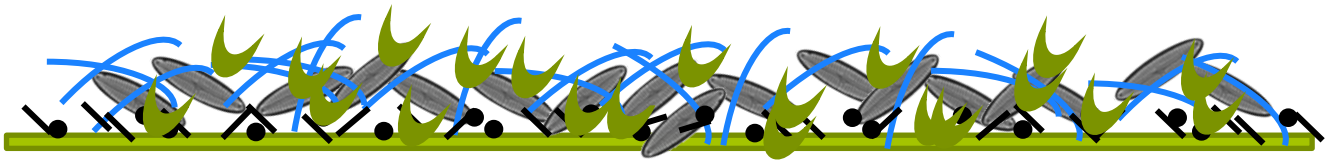
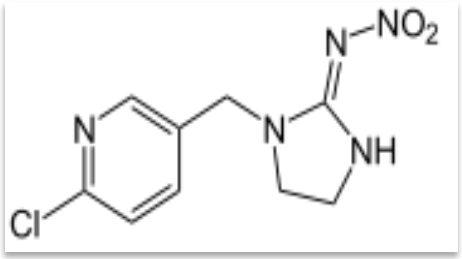


Primary producers

Aims:



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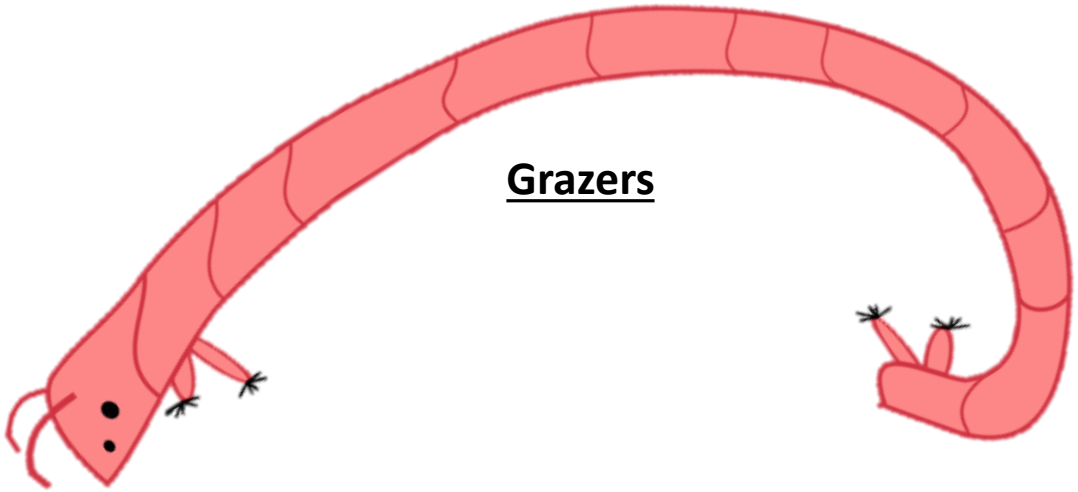

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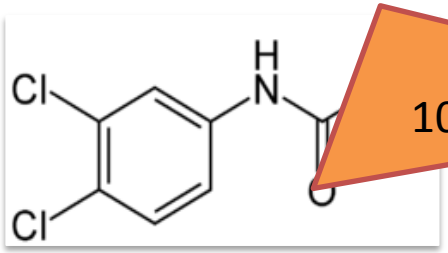
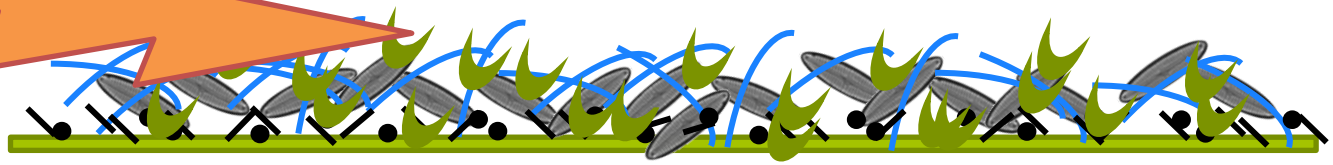


Diuron

10 µg/L



Primary producers

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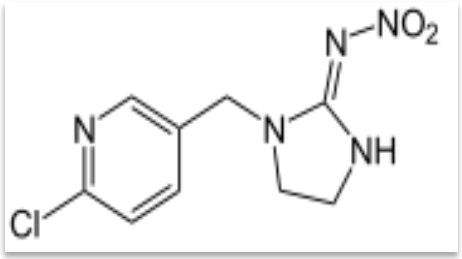

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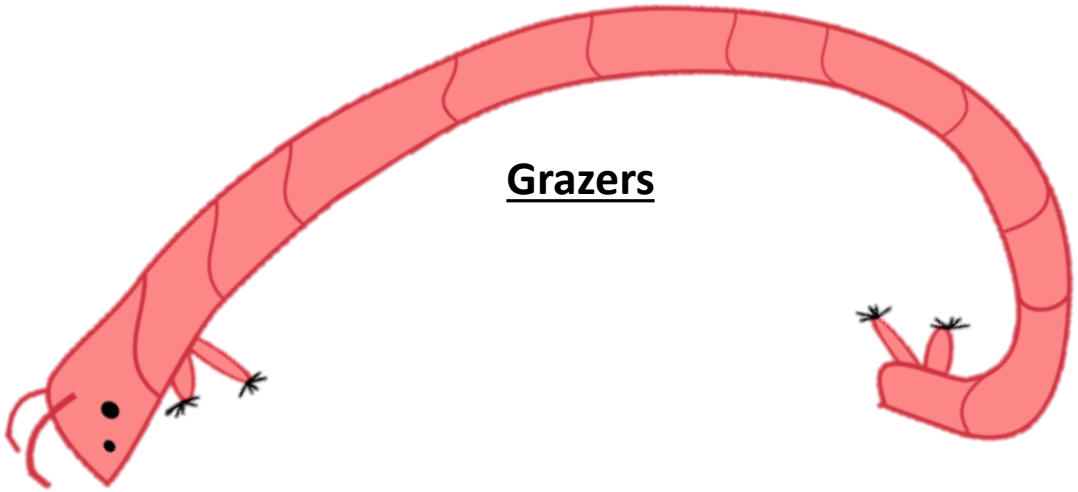

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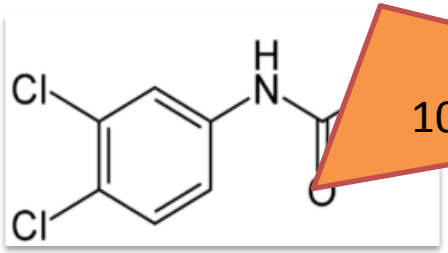
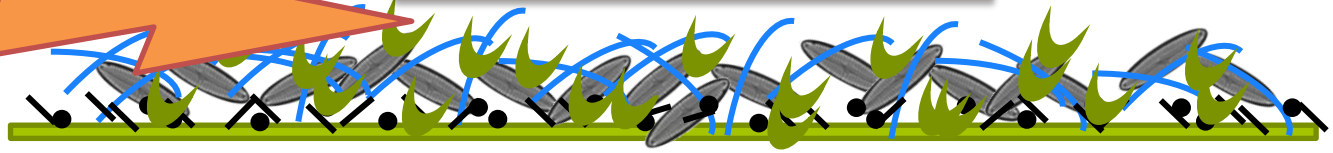


Diuron

10 µg/L

Effect on algal community



Primary producers

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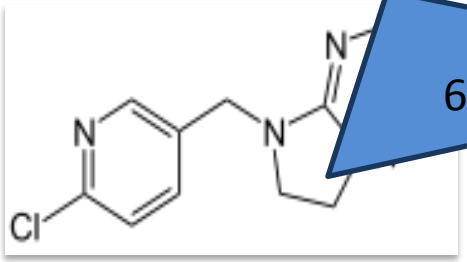
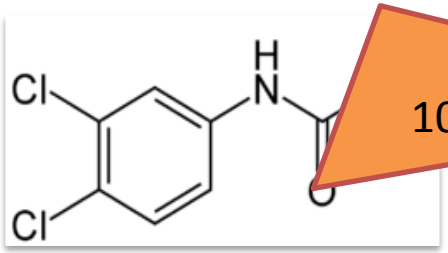


Imidacloprid

6 µg/L

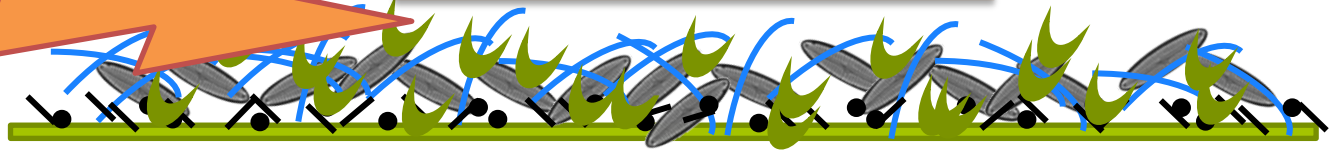
Grazers



Diuron

10 µg/L

Effect on algal community



Primary producers

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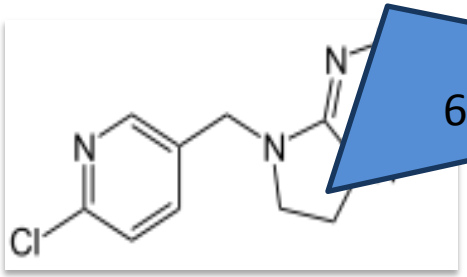
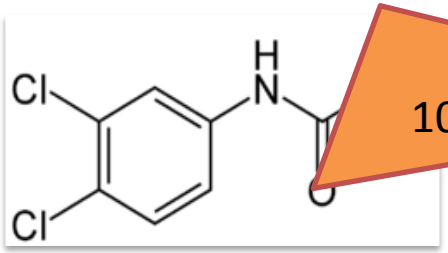


Imidacloprid

6 µg/L

Grazers

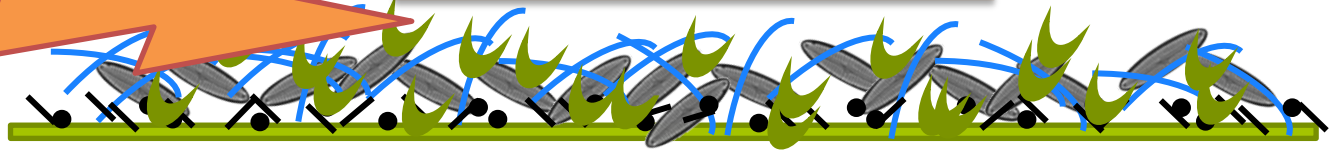
Effect on grazer community



Diuron

10 µg/L

Effect on algal community



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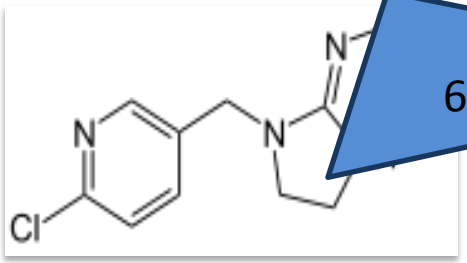


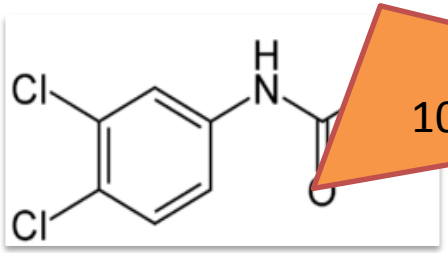
Imidacloprid

6 µg/L

Grazers

Effect on grazer community

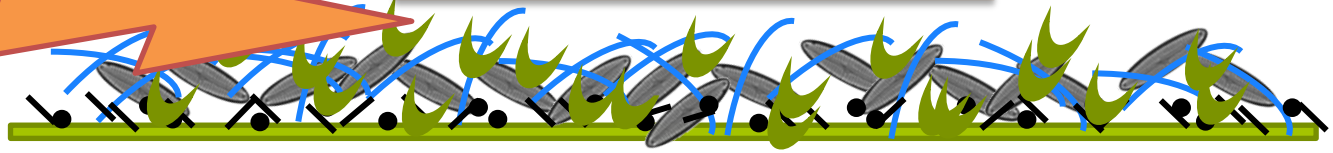
Effect on grazing behaviour?



Diuron

10 µg/L

Effect on algal community



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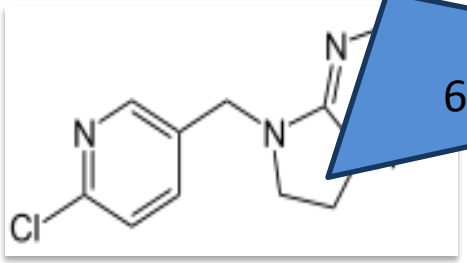


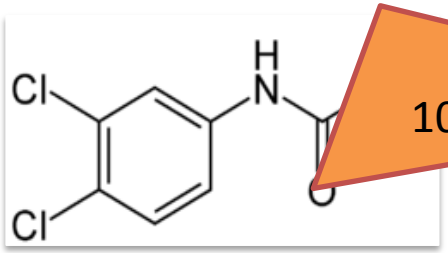
Imidacloprid

6 µg/L

Grazers

Effect on grazer community

Effect on grazing behaviour?

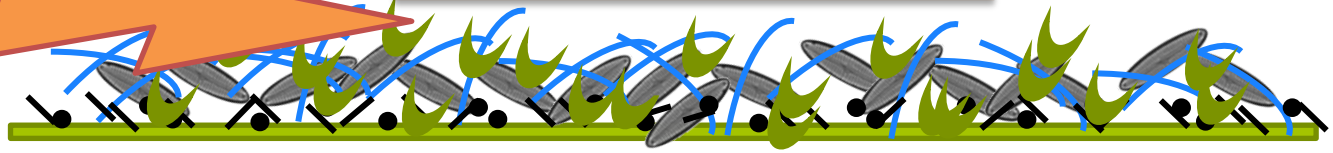


Diuron

10 µg/L

Effect on algal palatability?

Effect on algal community



Primary producers

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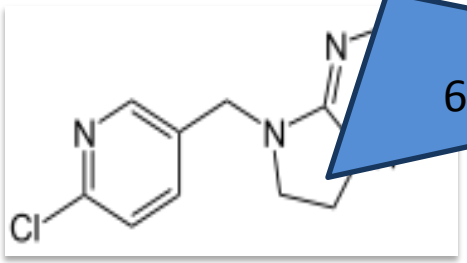


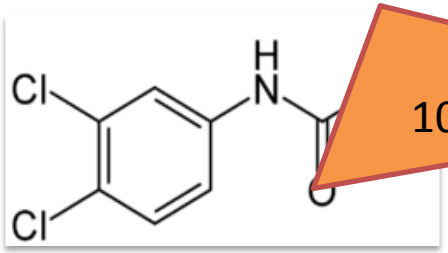
Imidacloprid

6 µg/L

Grazers

Effect on grazer community

Effect on grazing behaviour?

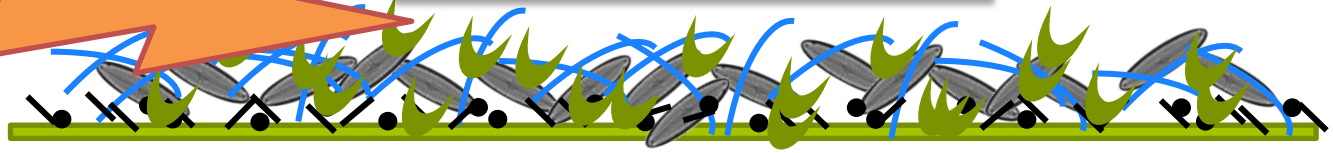


Diuron

10 µg/L

Effect on algal palatability?

Effect on algal community



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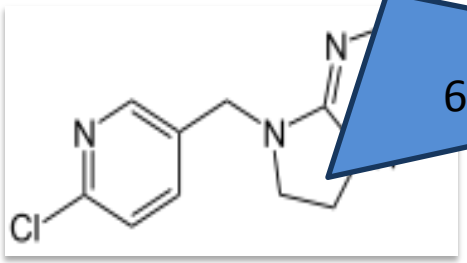

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6 µg/L

Grazers

Effect on grazer community

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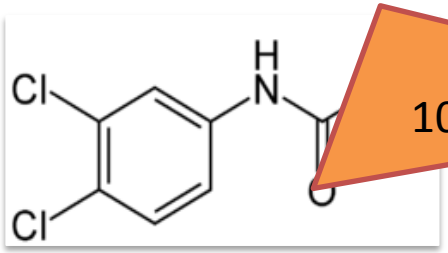

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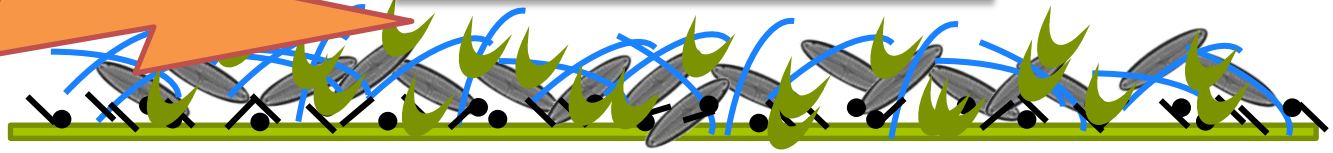
10 µg/L

Effect on algal palatability?

Effect on algal community



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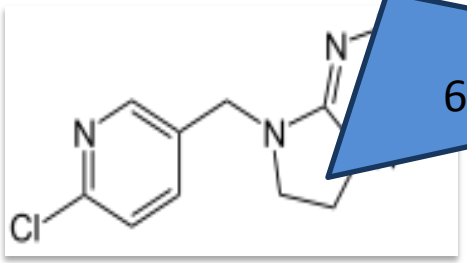


Imidacloprid

6 µg/L

Grazers

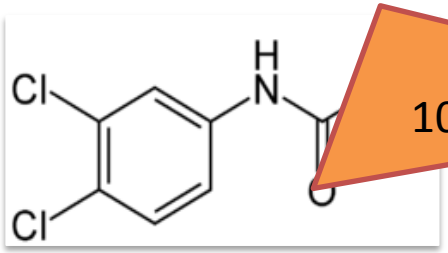
Effect on grazer community

Effect on grazing behaviour?

Contamination influence on herbivory relationship?
Ingestion rate?
Food selectivity?

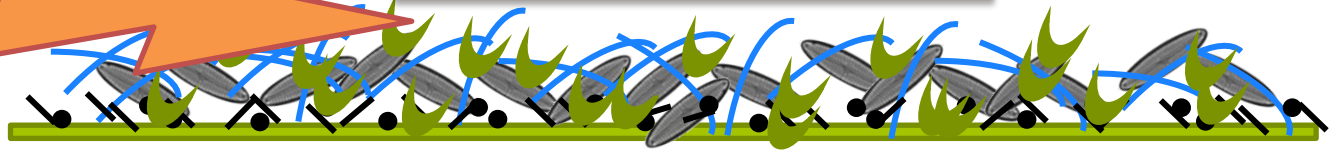
Effect on algal palatability?

Effect on algal community



Diuron

10 µg/L



Primary producers

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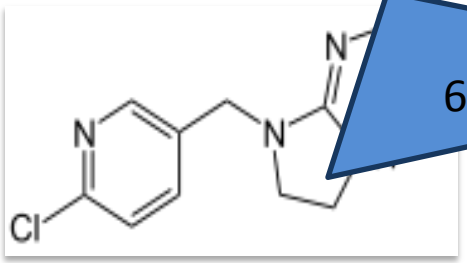

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6 µg/L

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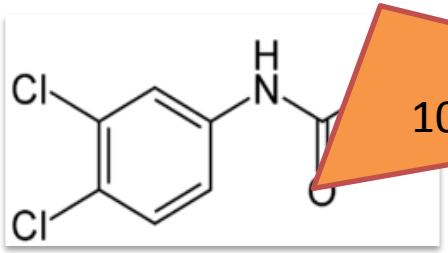
Food selectivity?

Effect on algal palatability?

Effect on algal community



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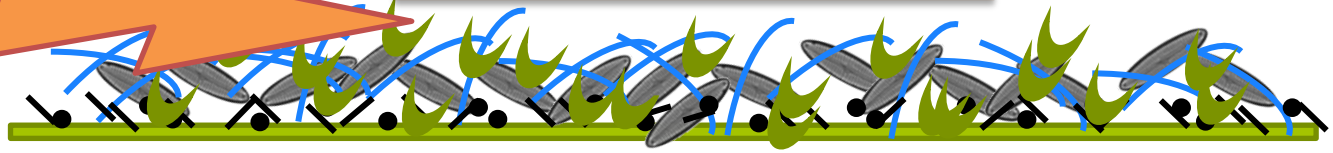
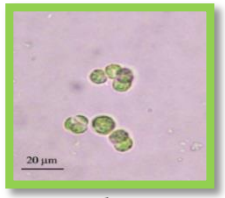


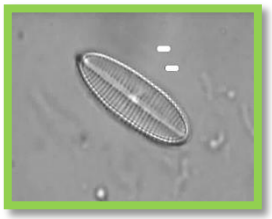
Primary producers

Materials and methods: Ingestion rate



Desmodesmus sp

Planothidium lanceolatum



Gomphonema gracile « normal »

Gomphonema gracile « teratogen »

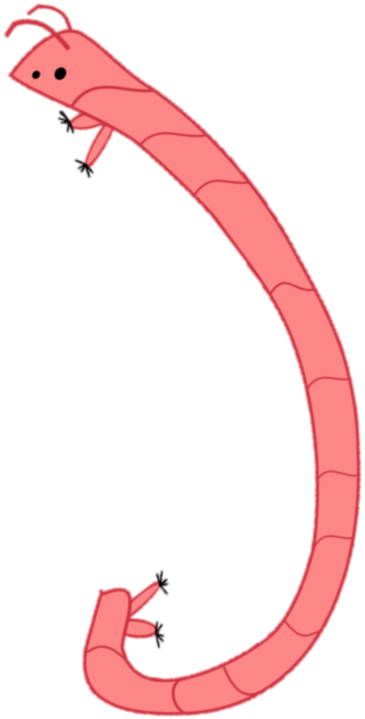
Control

Solvent control
0,5% acetonitrile

Diuron
(5µg/L)

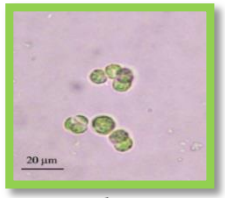
Imidacloprid
(5µg/L)

Diuron + Imidacloprid
(5µg/L + 5µg/L)



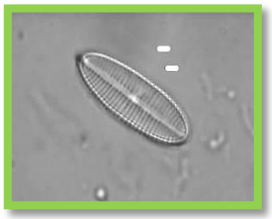
Materials and methods: Ingestion rate

24H + 22°C +



Desmodesmus sp

Planothidium lanceolatum



Gomphonema gracile « normal »

Gomphonema gracile « teratogen »

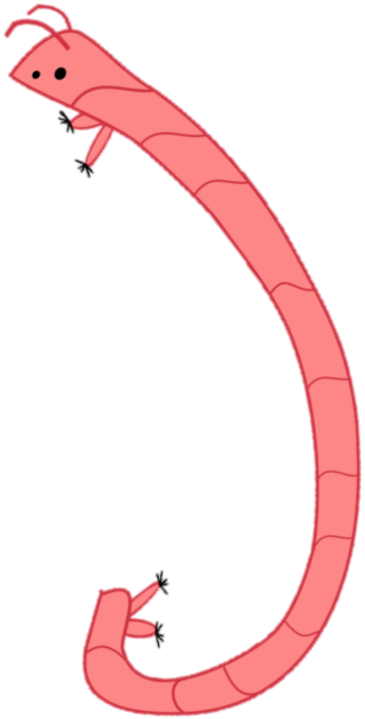
Control

Solvent control
0,5% acetonitrile

Diuron
(5µg/L)

Imidacloprid
(5µg/L)

Diuron + Imidacloprid
(5µg/L + 5µg/L)



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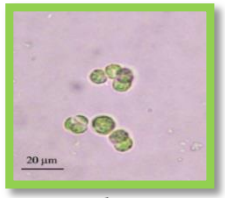
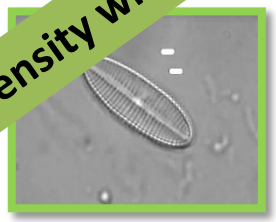
24H + 22°C +



Desmodesmus sp

Planothi… lan… …n



Gomphonema gracile « normal »

Gomphonema gracile « teratogen »

Algal density without grazer in 24h

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Solvent control
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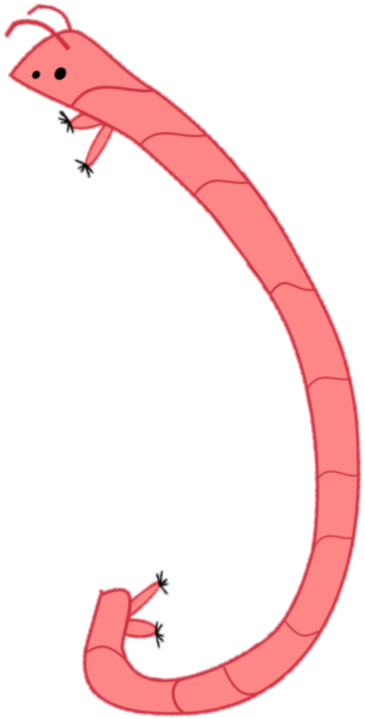
Diuron
(5µg/L)

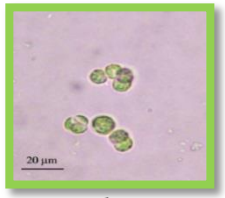
Imidacloprid
(5µg/L)

Diuron + Imidacloprid
(5µg/L + 5µg/L)



Materials and methods: Ingestion rate

24H + 22°C +



Desmodesmus sp

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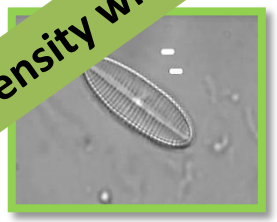

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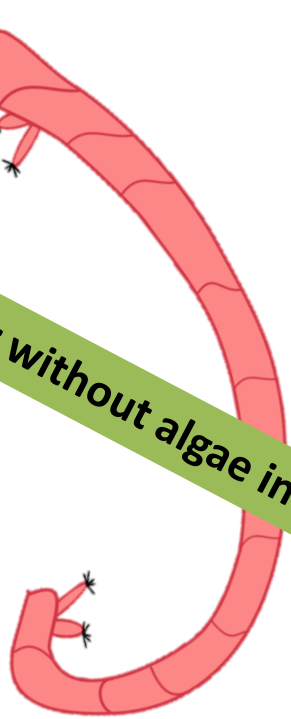
Diuron
(5µg/L)

Imidacloprid
(5µg/L)

Diuron + Imidacloprid
(5µg/L + 5µg/L)

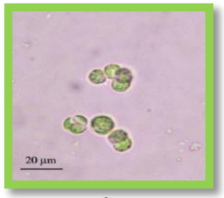
Algal density without grazer in 24h

Toxicity on grazer without algae in 24h



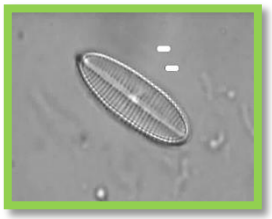
Materials and methods: Ingestion rate

24H + 22°C +



Desmodesmus sp

Planothidium lanceolatum



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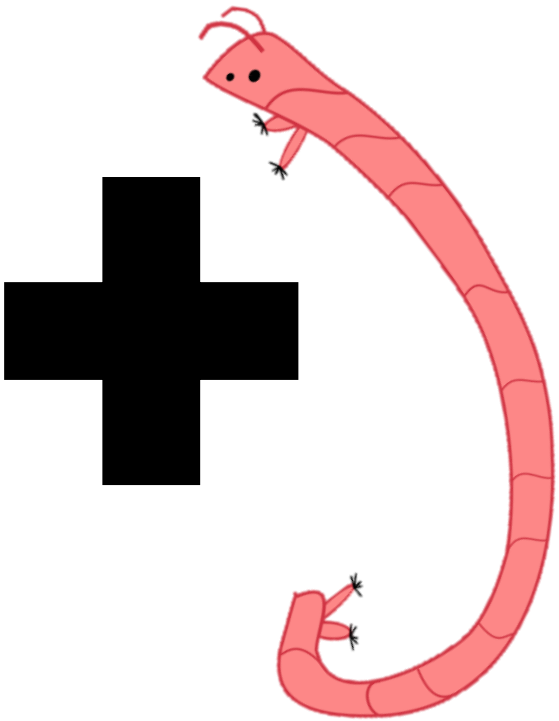
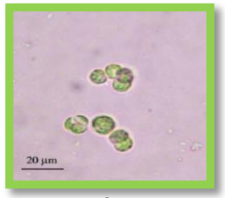


- Control
- Solvent control
  0,5% acetonitrile
- Diuron (5µg/L)
- Imidacloprid (5µg/L)
- Diuron + Imidacloprid (5µg/L + 5µg/L)

Materials and methods: Ingestion rate

24H + 22°C +

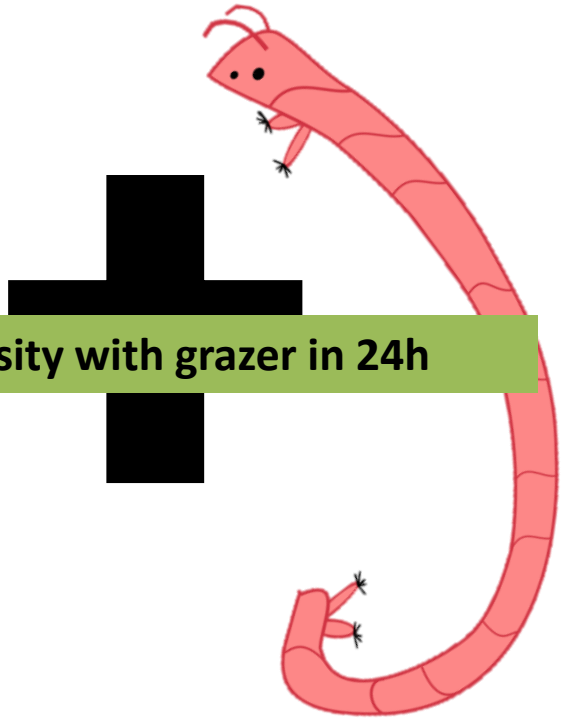


Desmodesmus sp

Planothidium lance

Gomphonema gracile « normal »

Gomphonema gracile « teratogen »

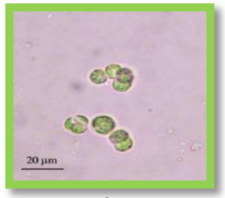


Algal density with grazer in 24h

- Control
- Solvent control
  0,5% acetonitrile
- Diuron (5µg/L)
- Imidacloprid (5µg/L)
- Diuron + Imidacloprid (5µg/L + 5µg/L)

Materials and methods: Ingestion rate

24H + 22°C +



Desmodesmus sp

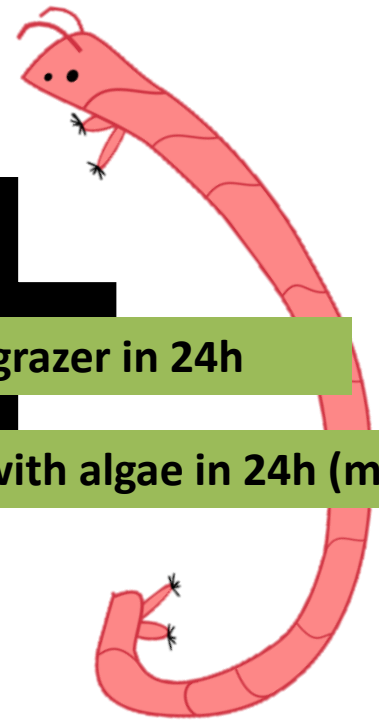
Planothidium lance

Algal density with grazer in 24h

Toxicity on grazer with algae in 24h (mortality)

Gomphonema gracile « normal »

Gomphonema gracile « teratogen »



- Control
- Solvent control
  0,5% acetonitrile
- Diuron (5µg/L)
- Imidacloprid (5µg/L)
- Diuron + Imidacloprid (5µg/L + 5µg/L)

Materials and methods: Ingestion rate

Data treatment and analysis

- For algae:
  - Couting data (Ind/mL) → Biovolume (μm^3/mL)
  - Biovolume (μm^3/mL) → Wet weight µg/mL : 1μm^3 = 1. 10^{-6}µg
  - Dry weight = 8% Wet weight (Sladececk, 1963)

Materials and methods: Ingestion rate

Data treatment and analysis

- For ingestion rate (Ribes et al. 1998) :
  - Algae growth rate without (Kc) and with chironomids (Ka) (h^{-1}):

$$K = \frac{\ln\left(\frac{C1}{C0}\right)}{t1 - t0}$$

  - Grazing coefficient (h^{-1}): $g = Kc - Ka$
  - Elimination rate (Volume swept clear biomass^{-1} h^{-1}): $F = V\frac{g}{b}$

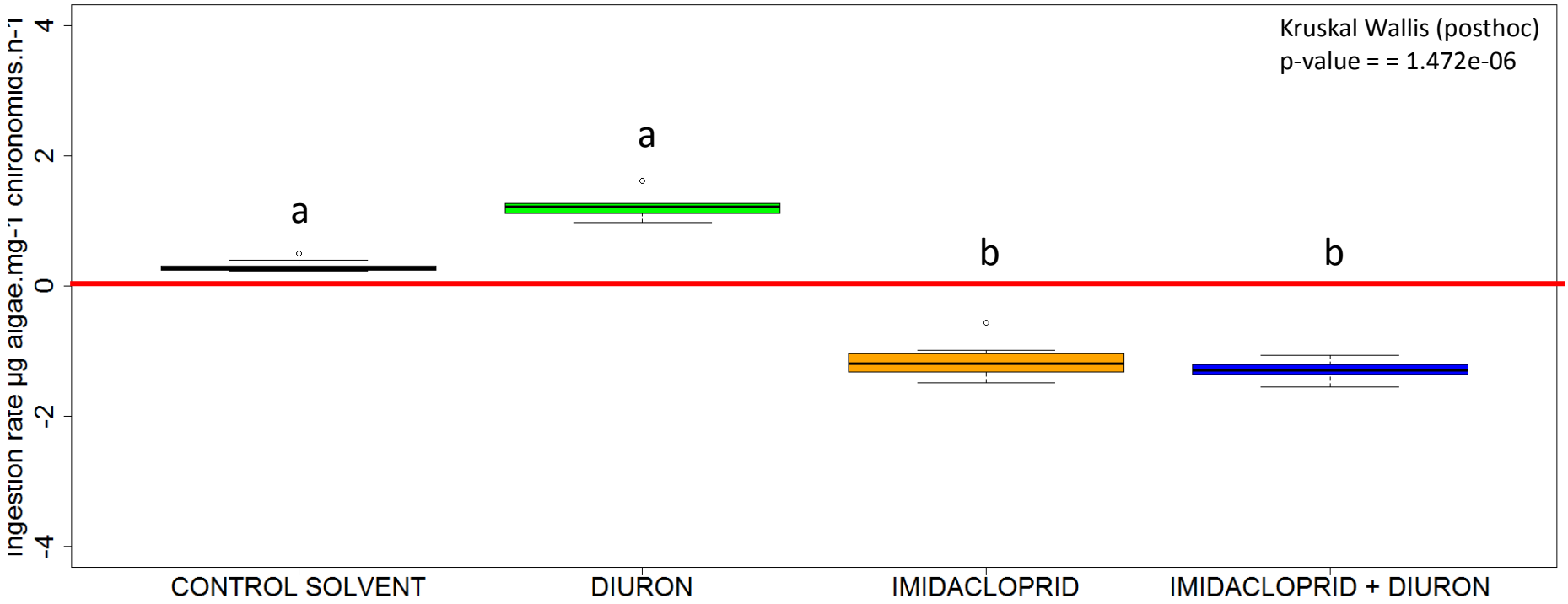
V: Microcosm volume (mL)

b: dry weight of living larvae at the end of the experiment (mg)

  - Ingestion rate (µg Algae ingested. mg^{-1} larvae. h^{-1}): $I = FC$

Results and discussion: *Desmodesmus sp*

Chironomids mortality (%)	0 %	22 %	55 %	33 %



Results and discussion: *Desmodesmus sp*

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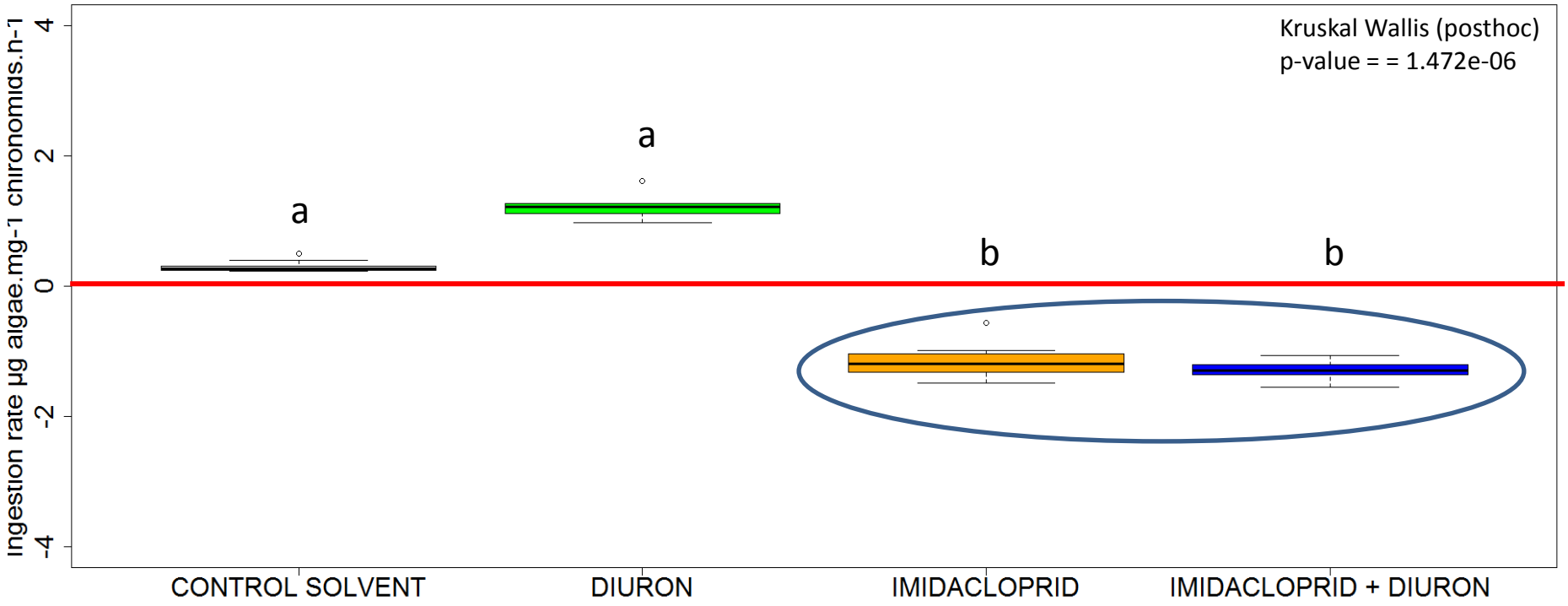
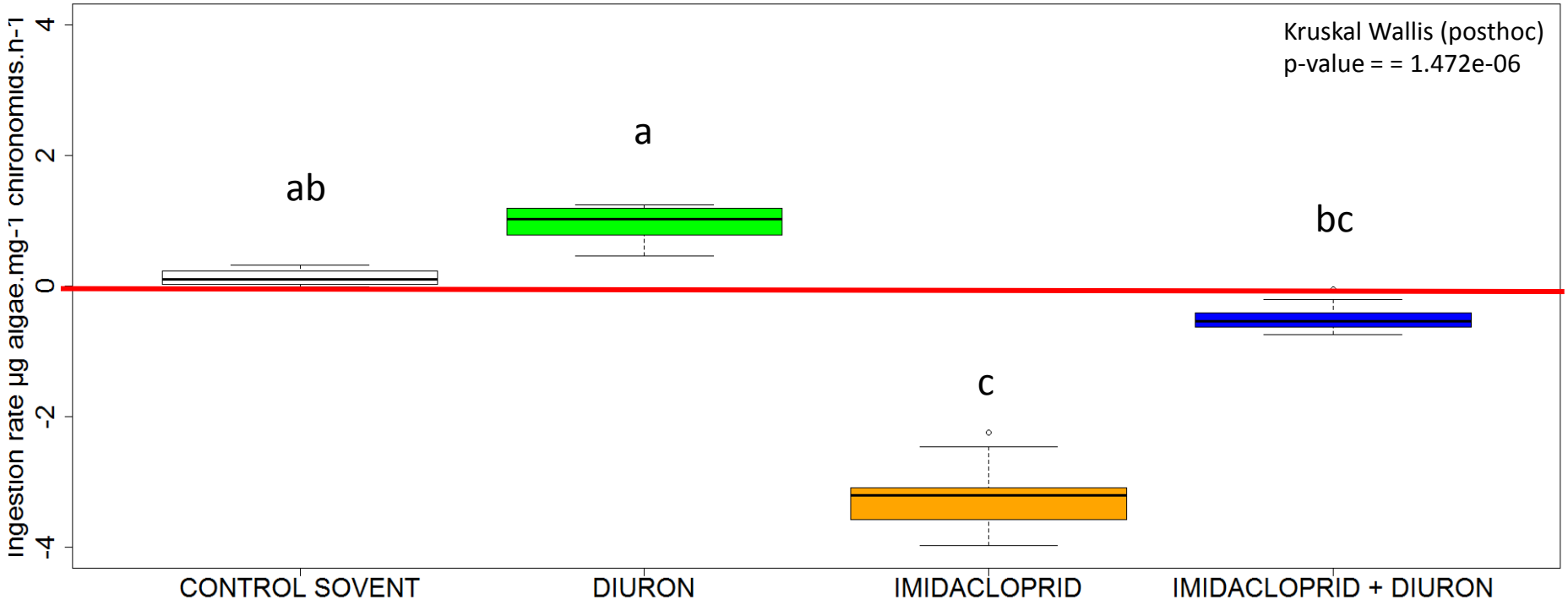


Less grazing pressure (mortality and/or paralysis)

Pesticide mixture follows imidacloprid pattern

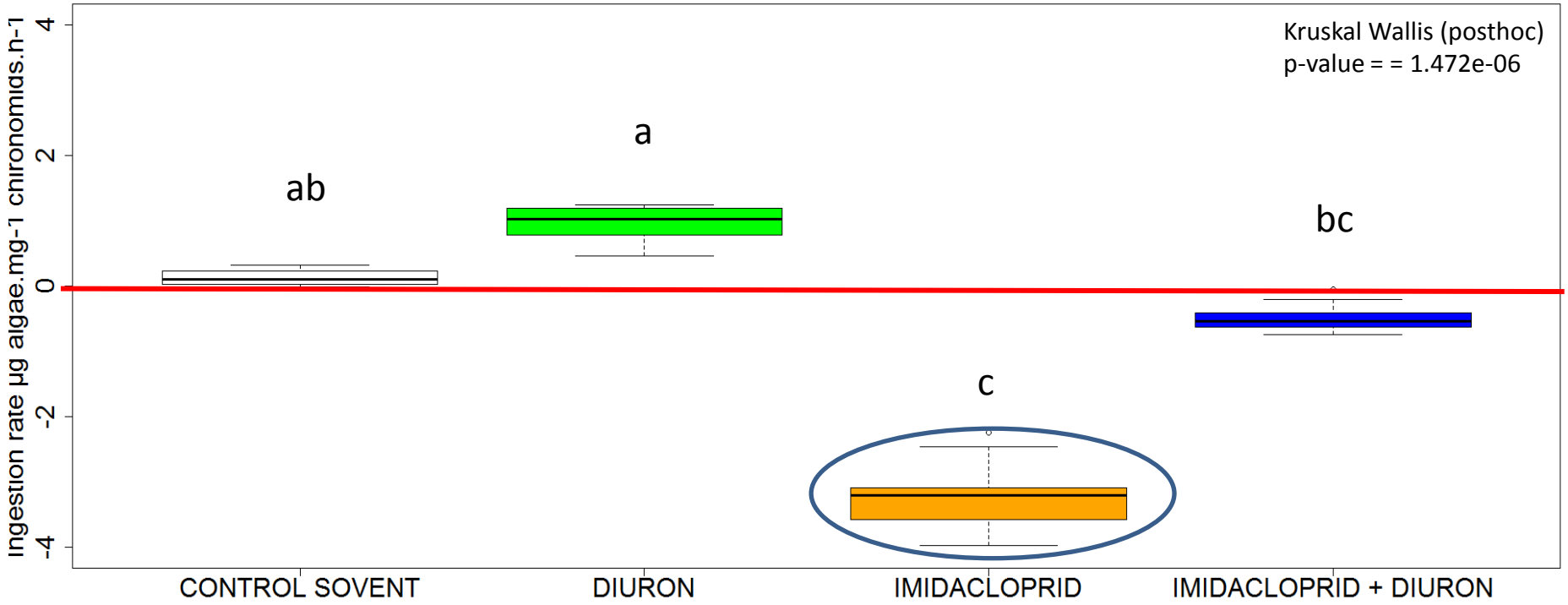
Results and discussion: *Planothidium lanceolatum*

Chironomids mortality (%)	0 %	11 %	65 %	33 %



Results and discussion: *Planothidium lanceolatum*

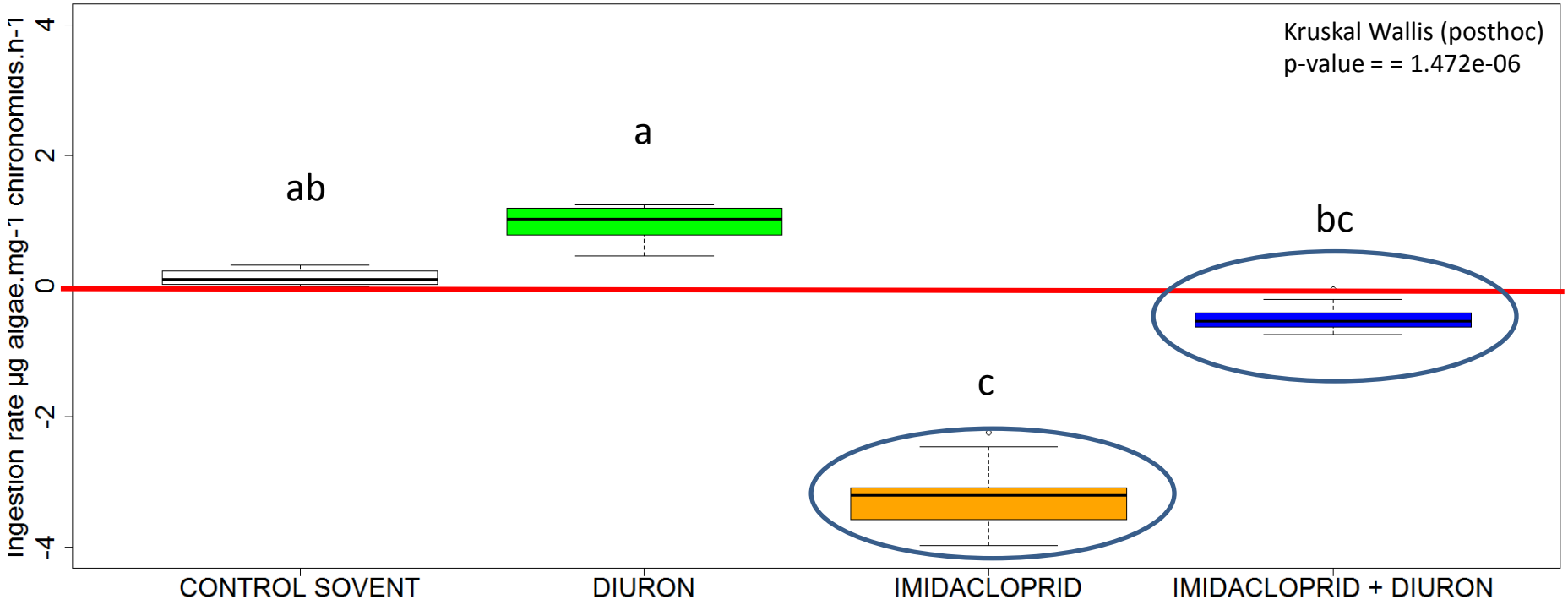
Chironomids mortality (%)	0 %	11 %	65 %	33 %



Less grazing pressure (mortality and/or paralysis)

Results and discussion: *Planothidium lanceolatum*

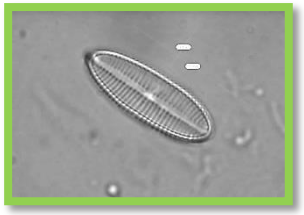
Chironomids mortality (%)	0 %	11 %	65 %	33 %



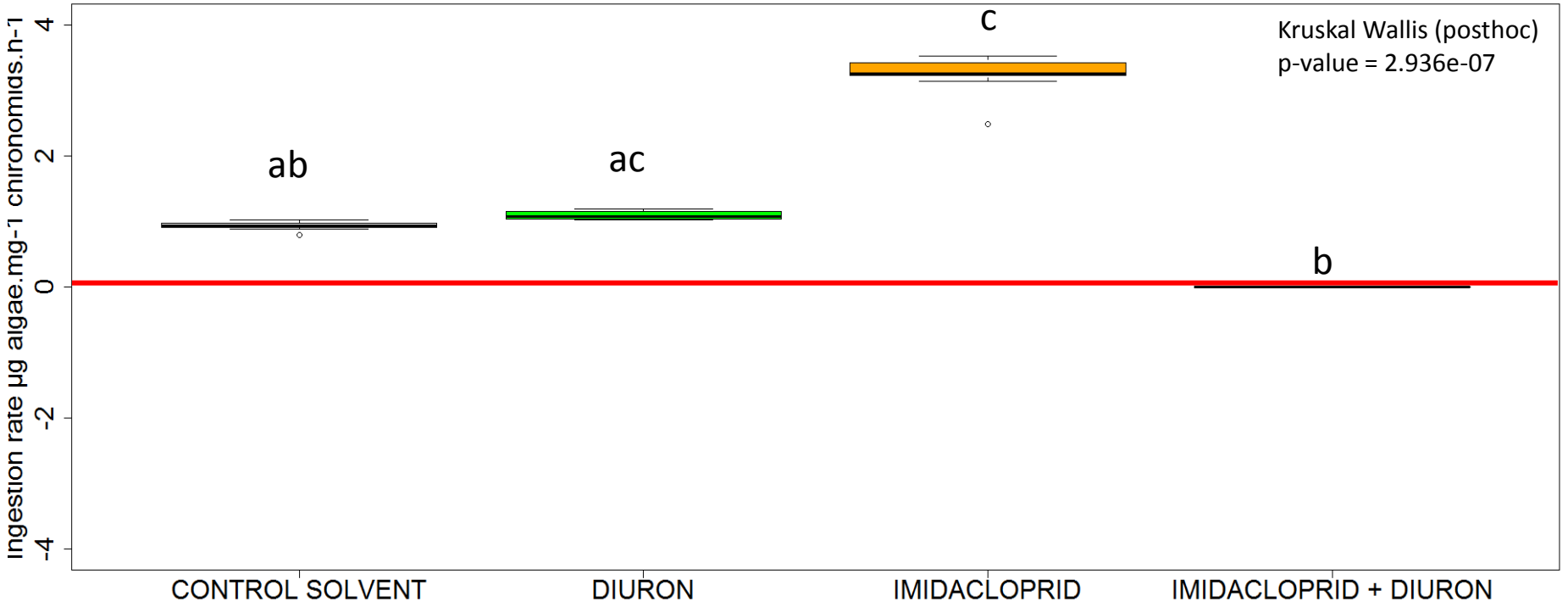
Less grazing pressure (mortality and/or paralysis)

Pesticide mixture shows intermediary effect

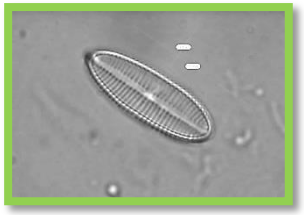
Results and discussion: *Gomphonema gracile* 'Normal'



Chironomids mortality (%)	0 %	11 %	65 %	100 %



Results and discussion: *Gomphonema gracile* 'Normal'



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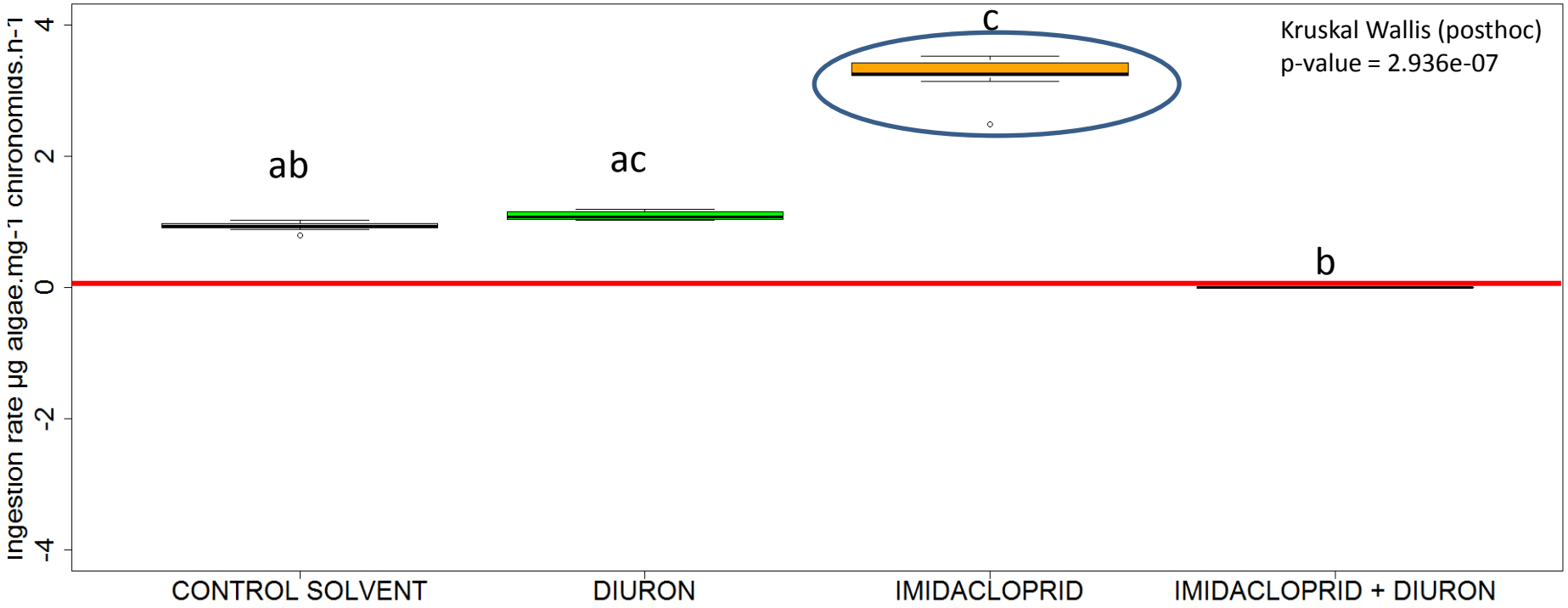
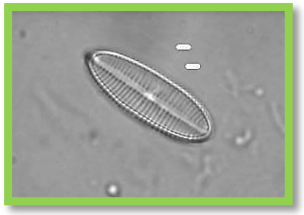


Ingestion rate ++

→No effect of imidacloprid on *G. gracile*

→Bigger algae in biomass

Results and discussion: *Gomphonema gracile* 'Normal'



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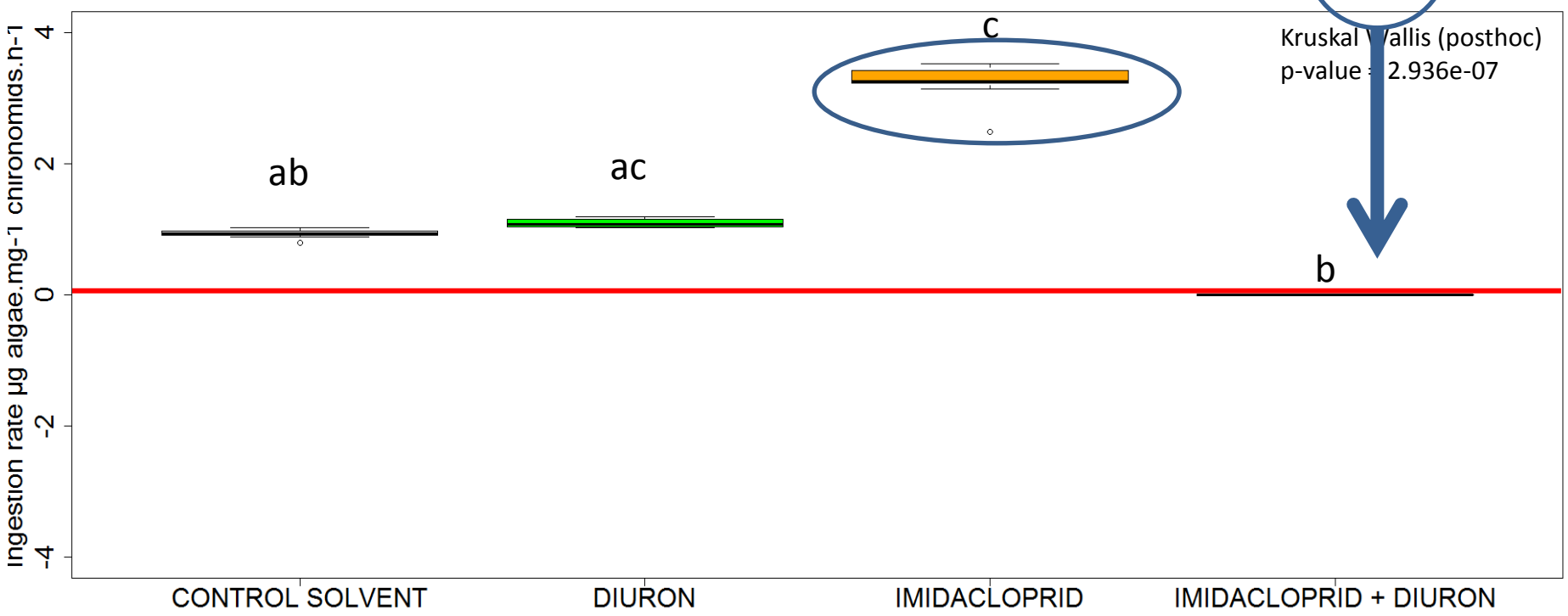

Ingestion rate ++

→No effect of imidacloprid on *G. gracile*

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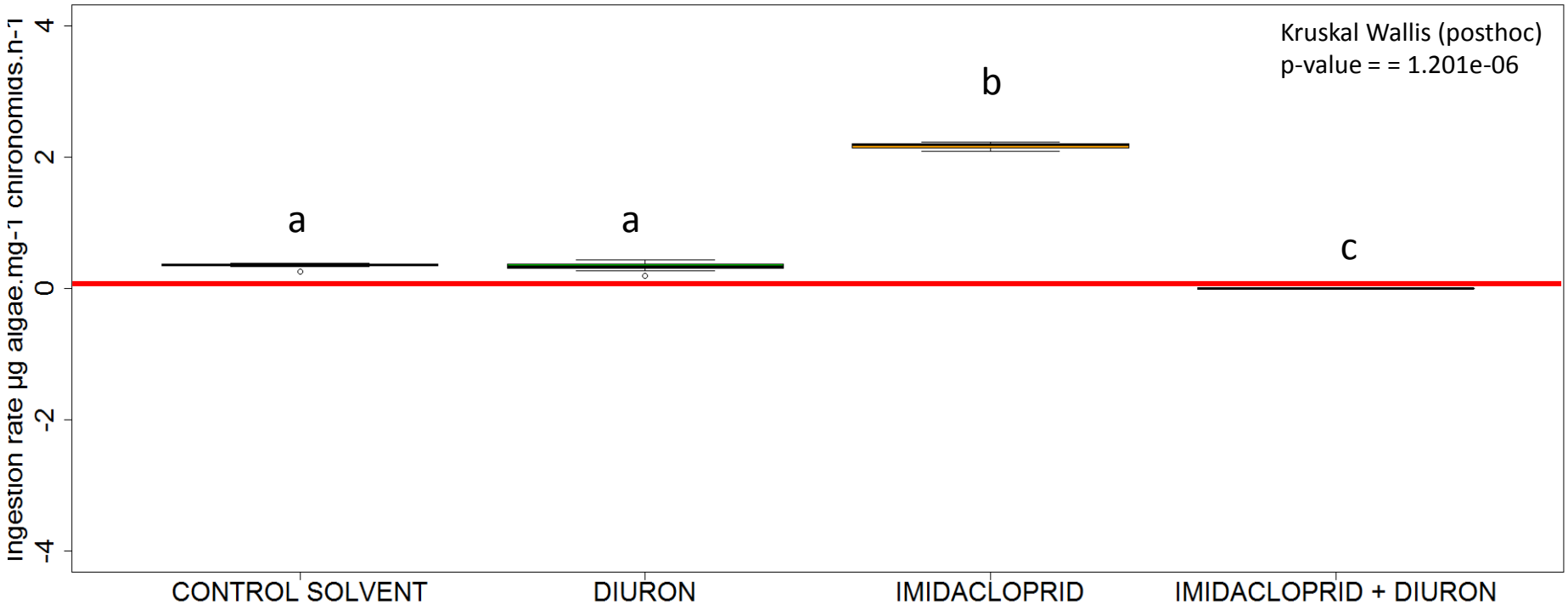
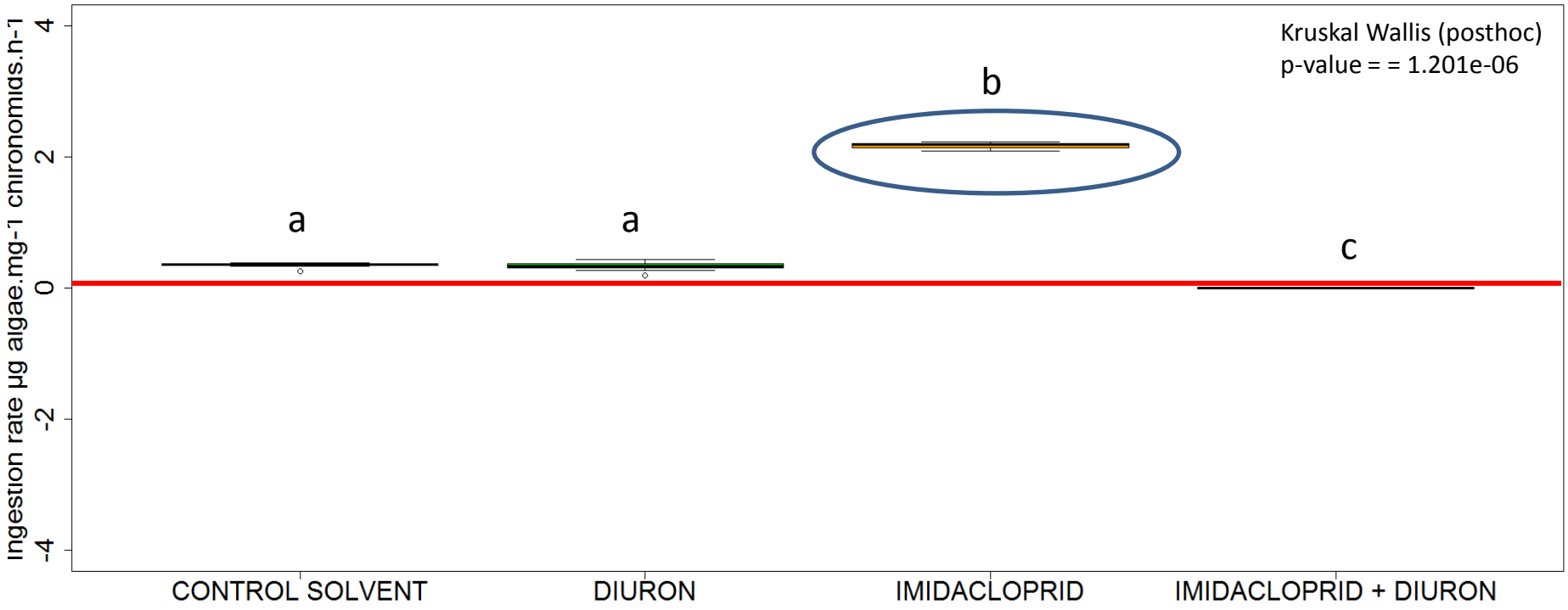
Results and discussion: *Gomphonema gracile* 'teratogen'

Chironomids mortality (%)	0 %	11 %	65 %	100 %



Results and discussion: *Gomphonema gracile* 'teratogen'

Chironomids mortality (%)	0 %	11 %	65 %	100 %



Ingestion rate ++

→No effect of imidacloprid on *G. gracile*

→Bigger algae in biomass

Results and discussion: *Gomphonema gracile* 'teratogen'

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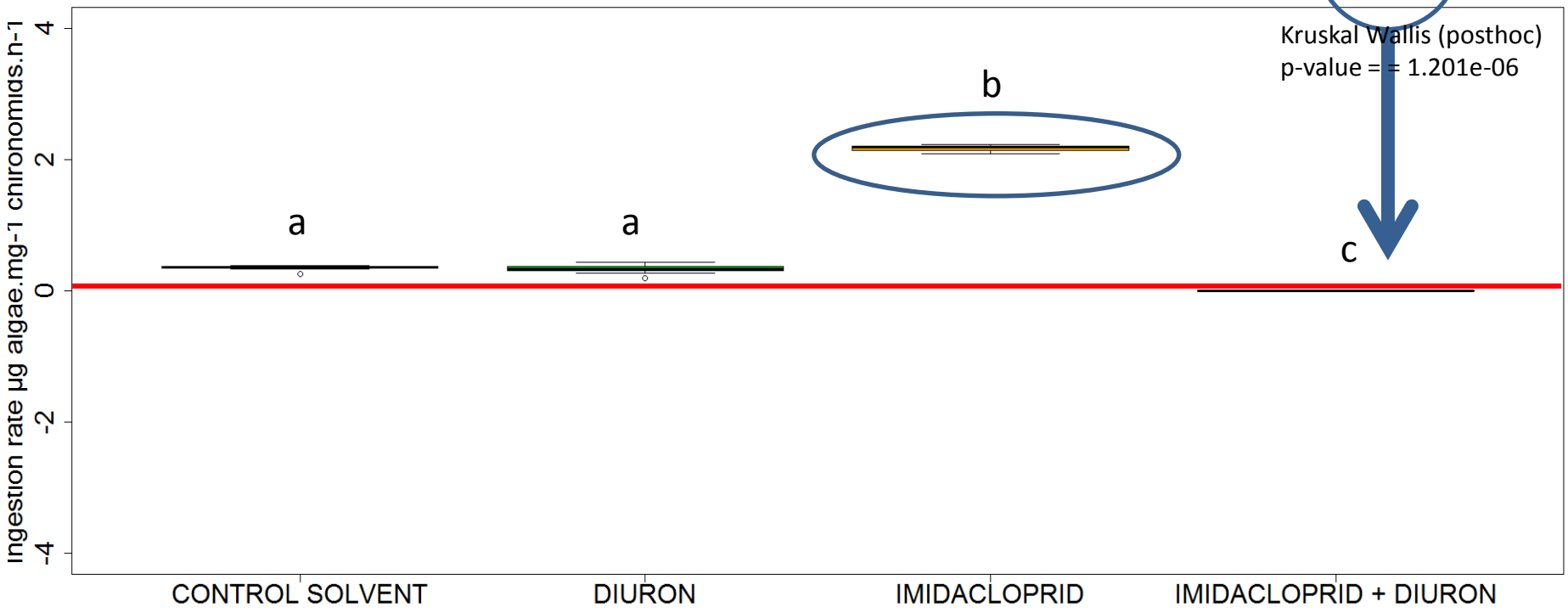

Ingestion rate ++

→No effect of imidacloprid on *G. gracile*

→Bigger algae in biomass

To sum up the first experiment:

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→ Different impact according to algae and pesticide

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DIURON: No effect on ingestion rate

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IMIDACLOPRID: Different effect on ingestion rate according to algae species

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IMIDACLOPRID + DIURON: Follow imidacloprid trend

To sum up the first experiment:

→ Different impact according to algae and pesticide

DIURON: No effect on ingestion rate

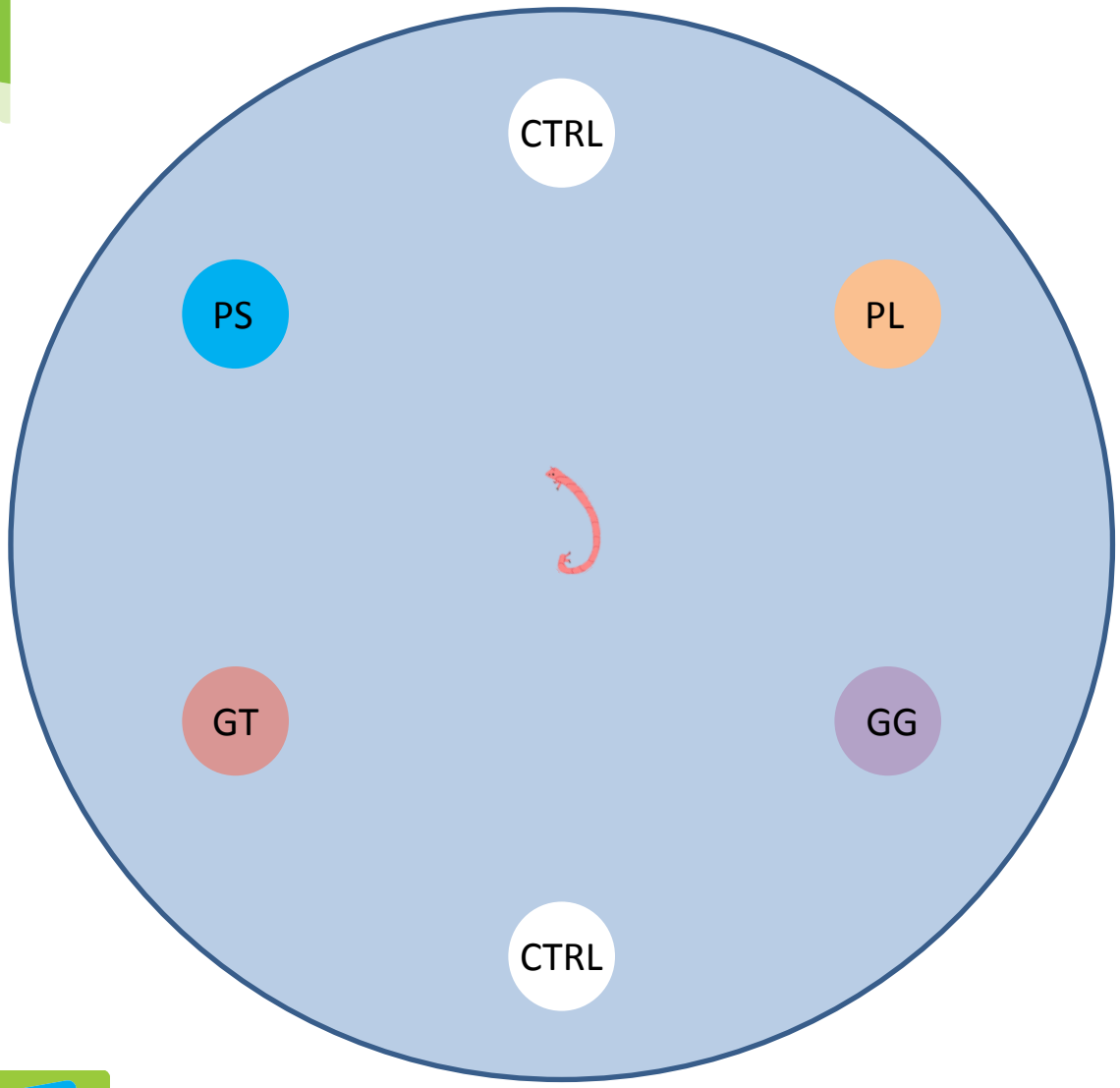
IMIDACLOPRID: Different effect on ingestion rate according to algae species

IMIDACLOPRID + DIURON: Follow imidacloprid trend

→FOOD CHOICE:

Which algae are preferentially selected?
Will this trend change under pesticide pressure?

Material and method: Cafeteria design



- Solvent control (0,5% acetonitrile)
- Imidaclopride (5µg/L)
- Diuron(5µg/L)
- Imidaclopride + diuron (5µg/L + 5µg/L)

Material and method: Cafeteria design

- Solvent control (0,5% acetonitrile)
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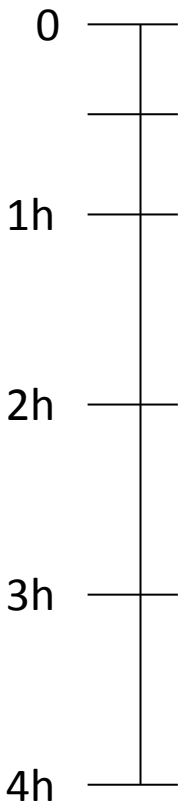

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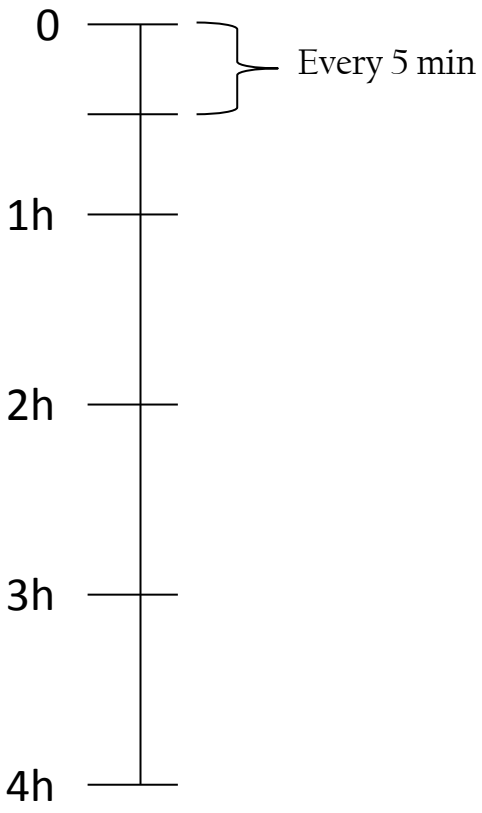

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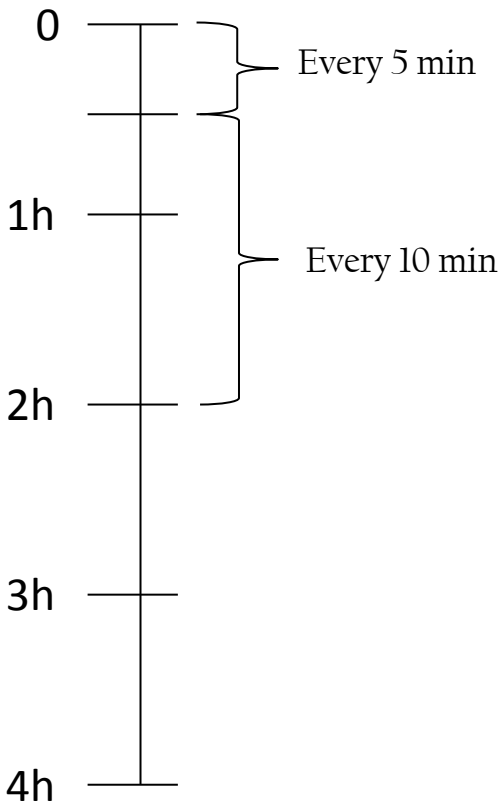

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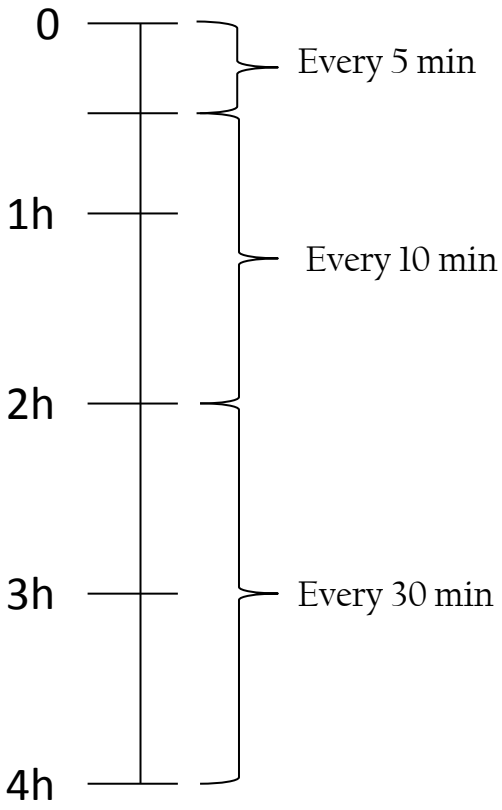
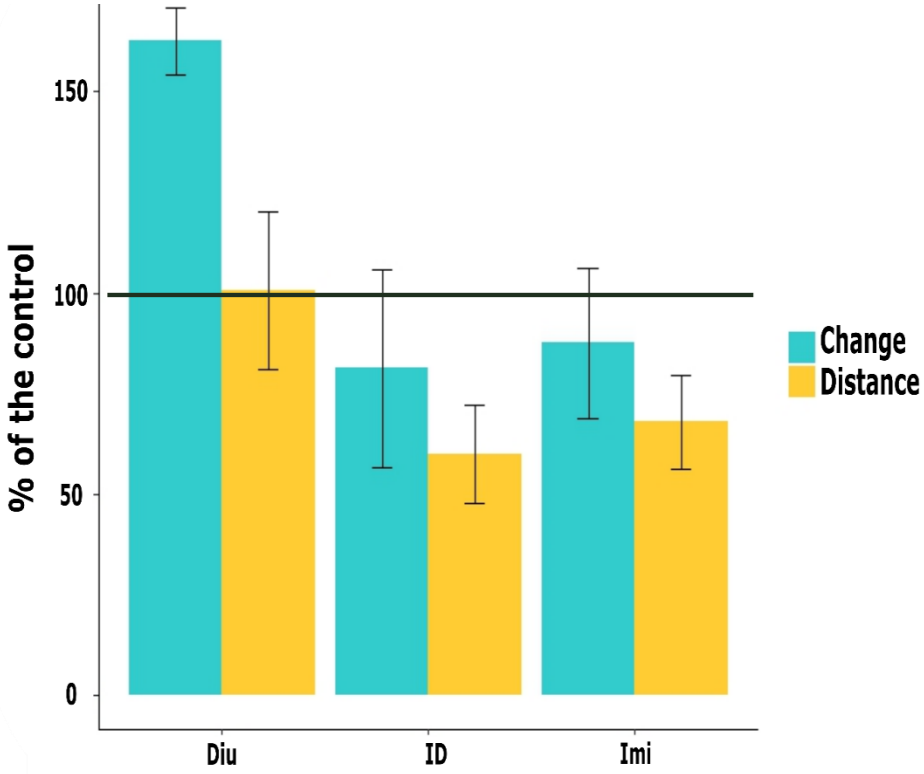
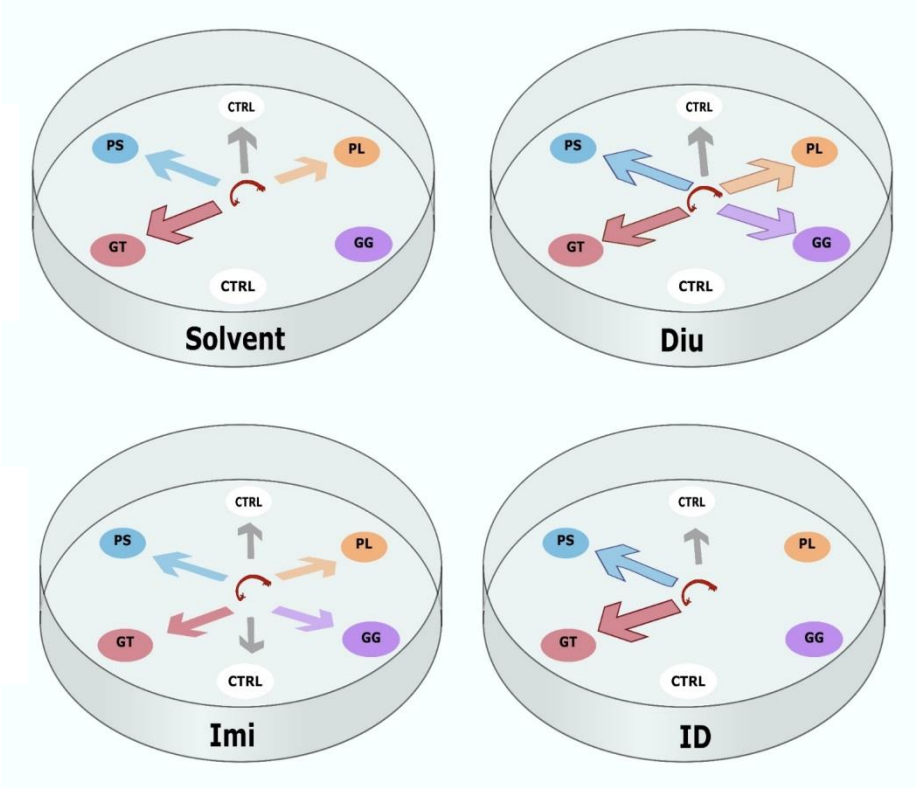


Results and discussion: Food choice

CTRL PS GT GG PL





Results and discussion: Food choice

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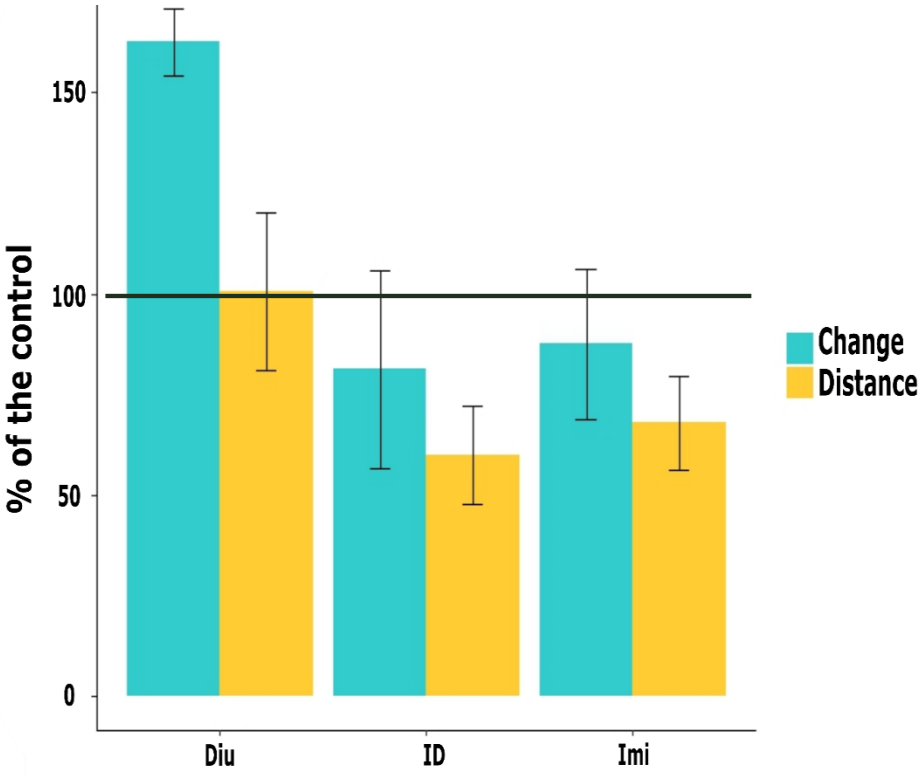
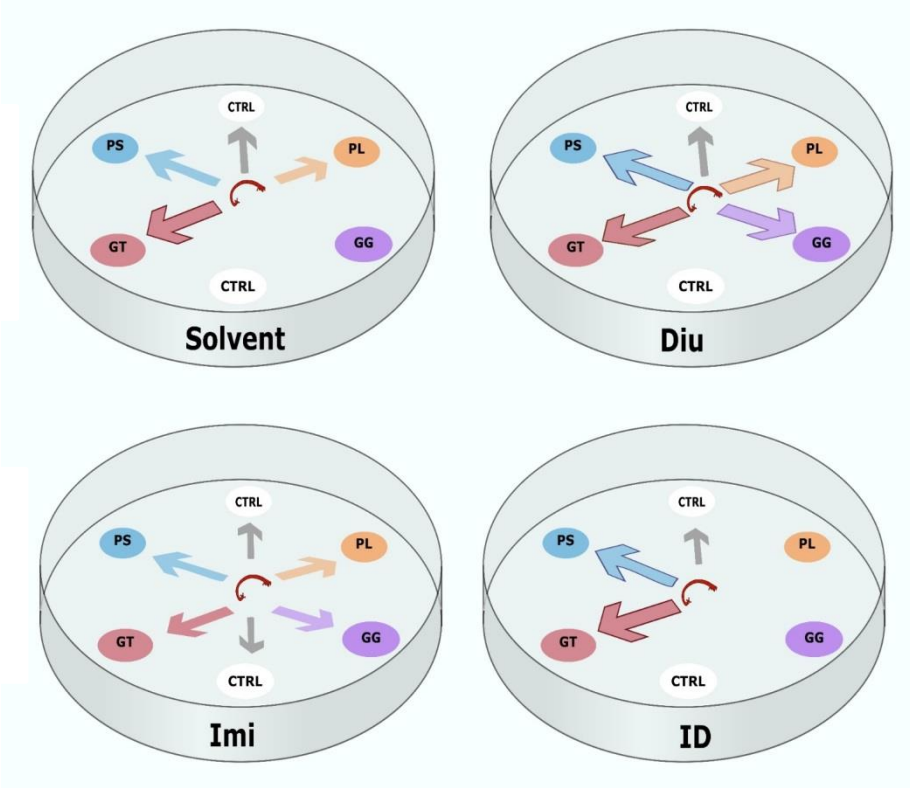
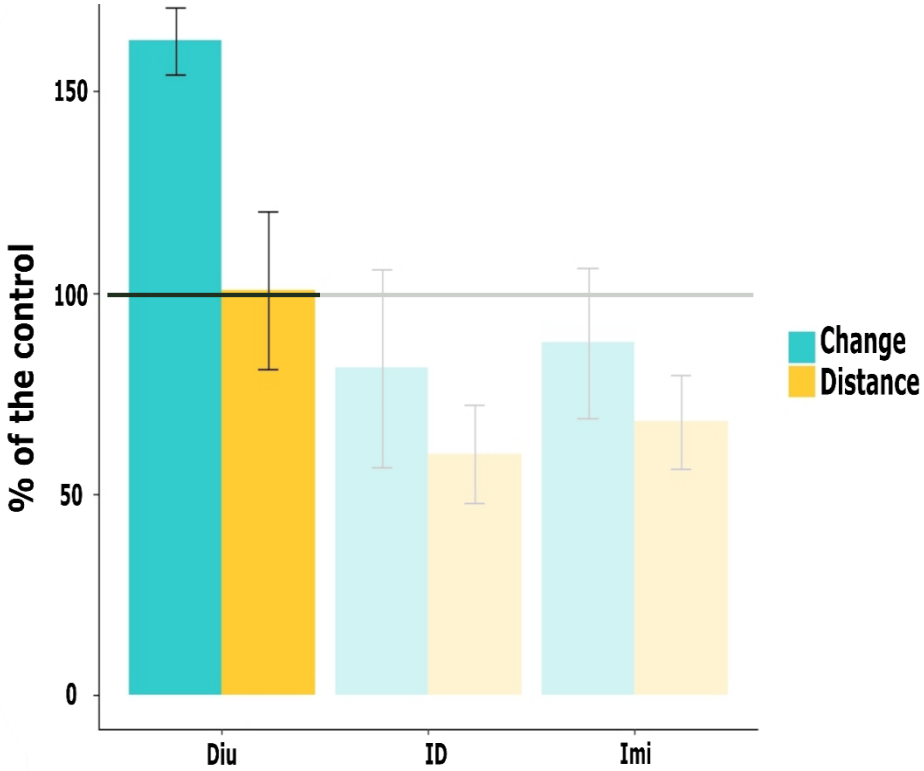


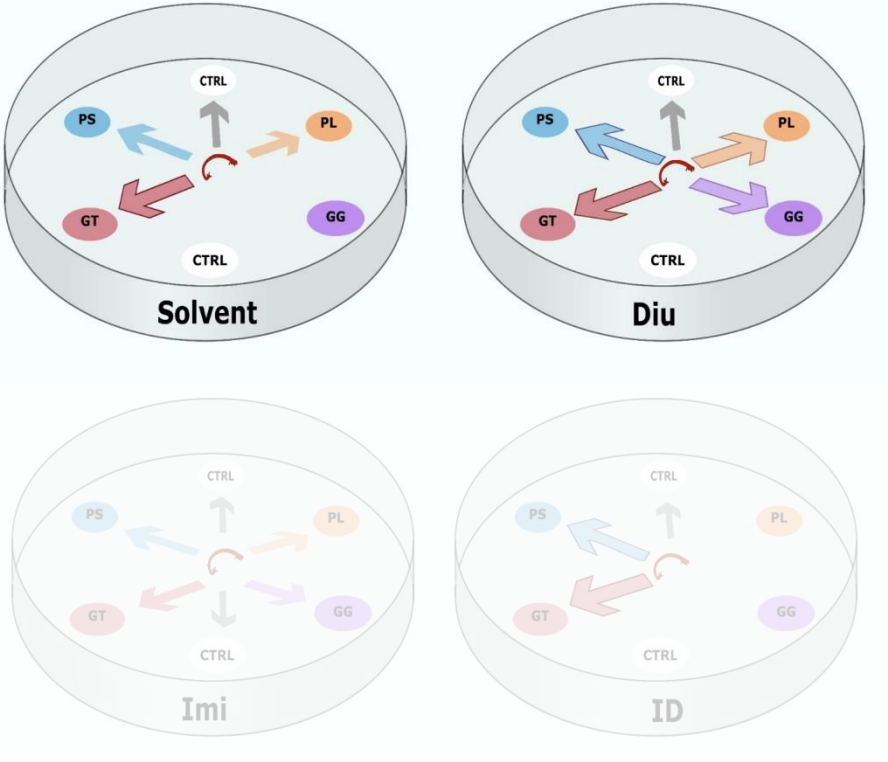


In every modalities, preferential algae is *G. gracile* teratogen

→omega3 (+++) (Demailly, unpublished)

Results and discussion: Food choice





Results and discussion: Food choice

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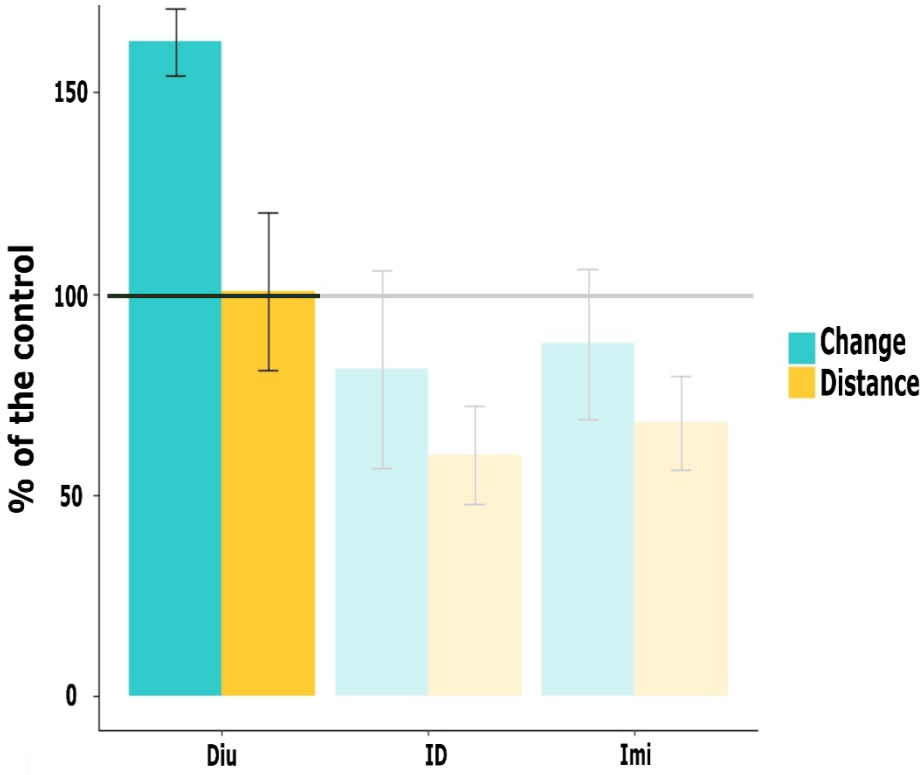
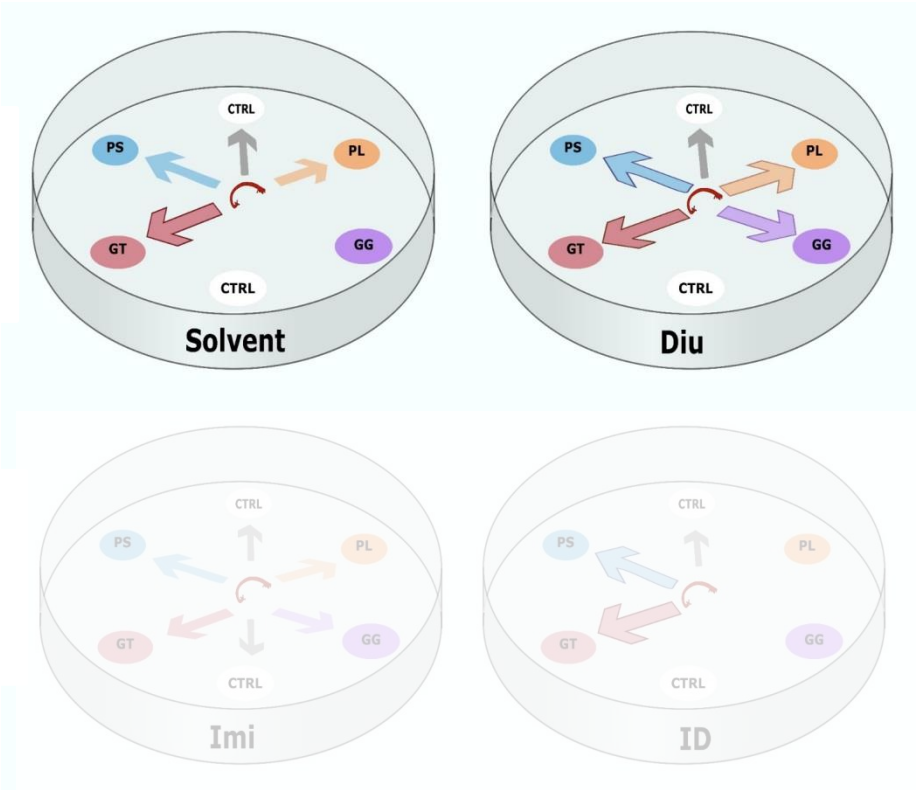


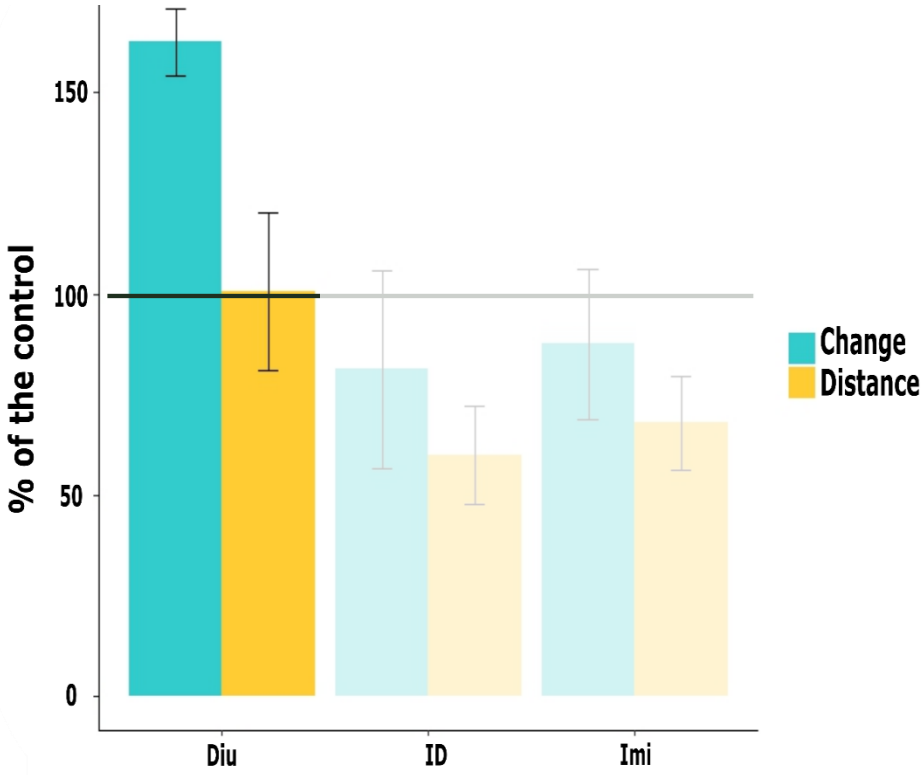


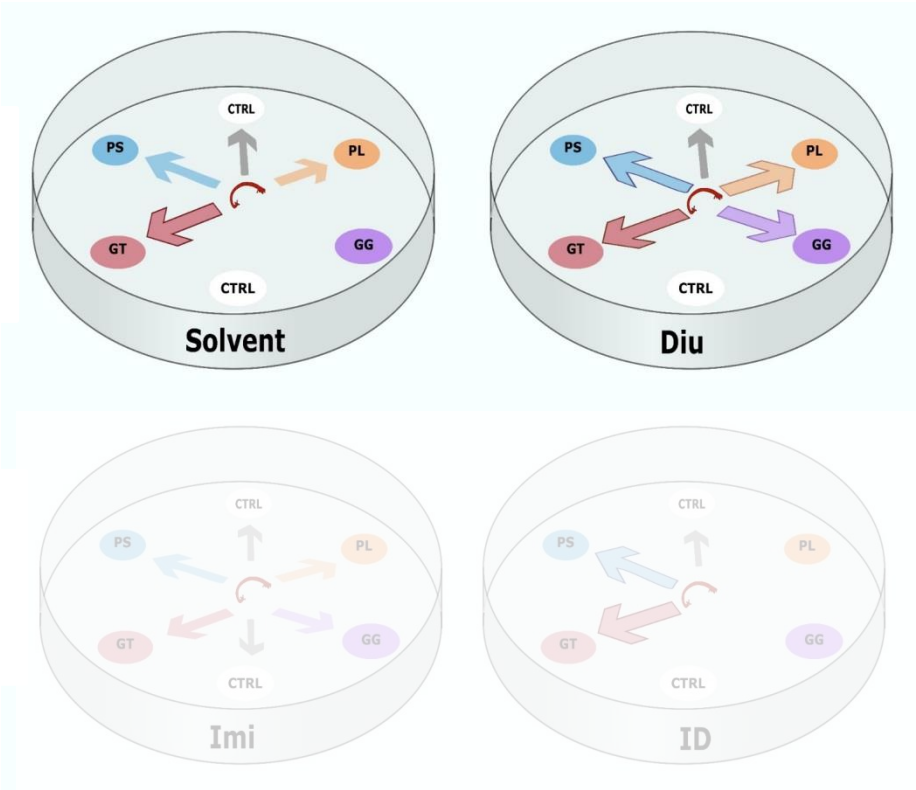
Diuron affects lipid peroxidation and fatty acid nature

(Troton and al. 1986)

Results and discussion: Food choice

CTRL PS GT GG PL





Diuron affects lipid peroxidation and fatty acid nature
(Troton and al. 1986)

Changes = Diversification of nutritional sources

Results and discussion: Food choice

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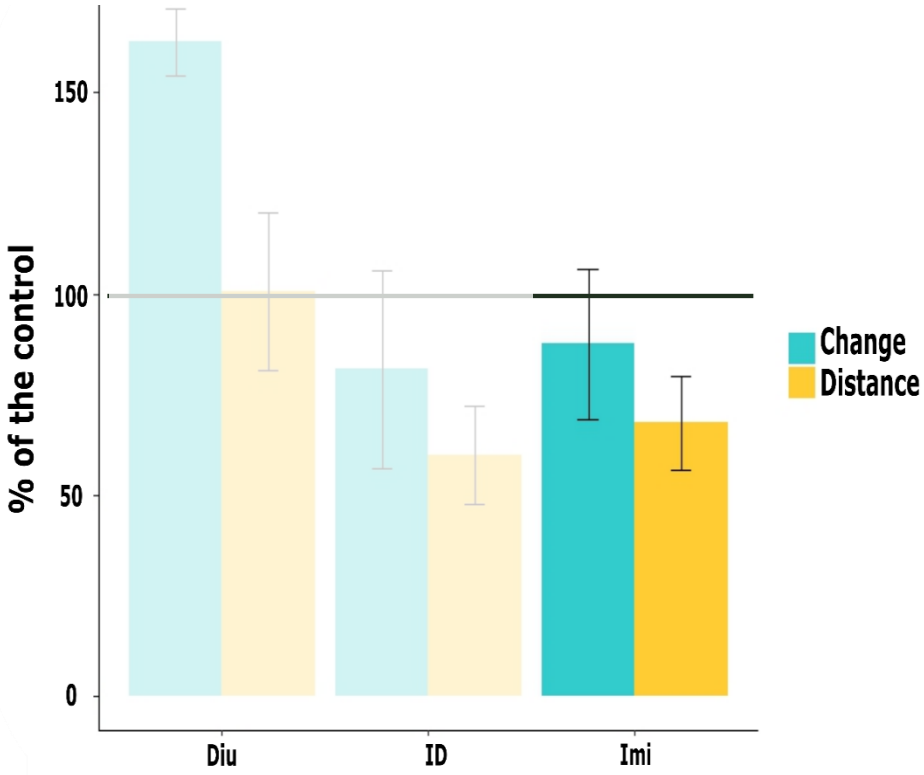

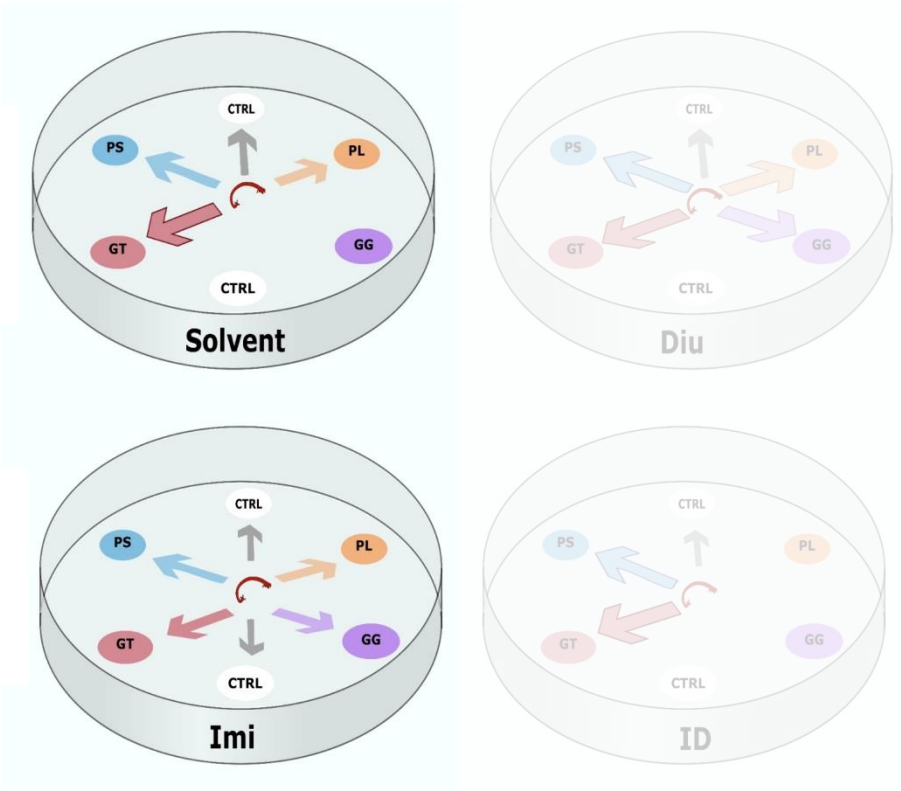

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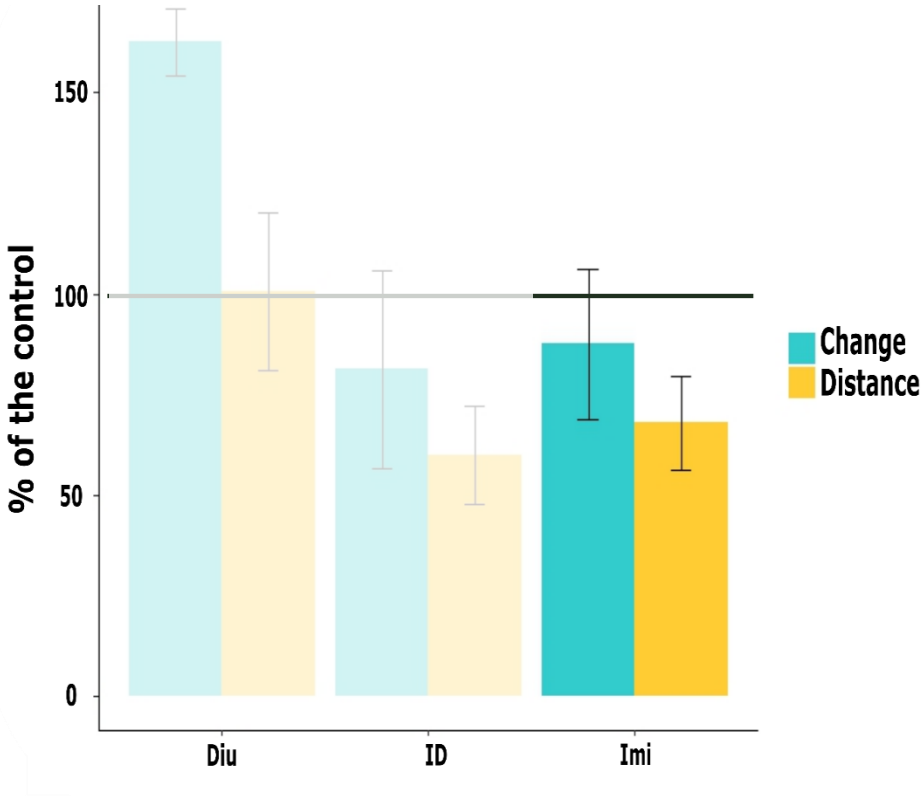

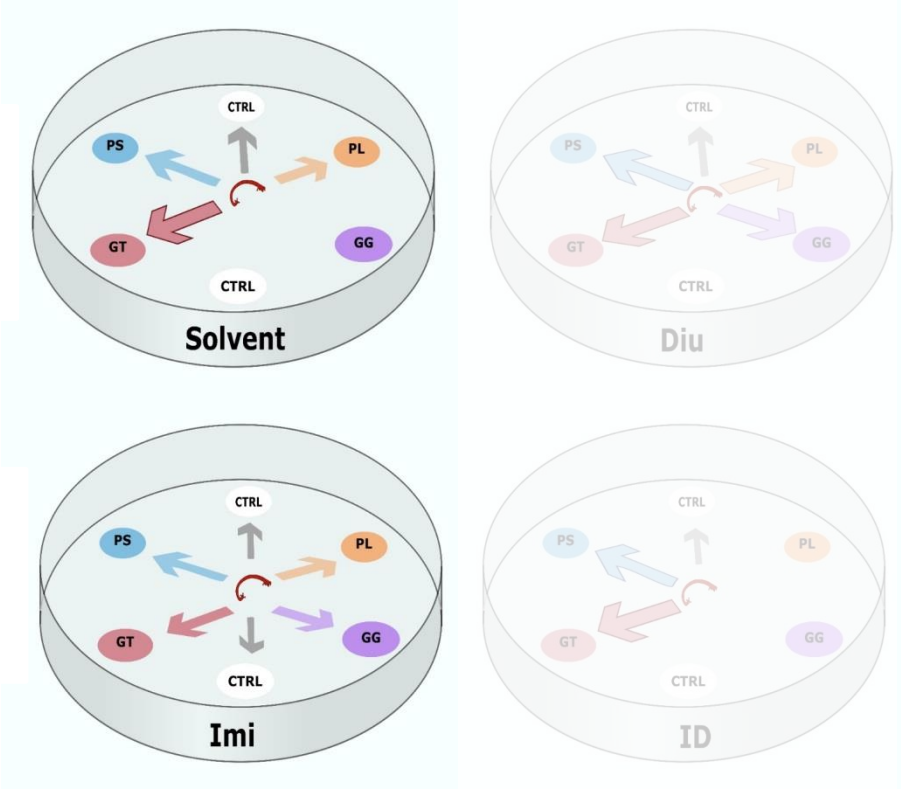

Imidacloprid affects chironomids mobility
→ Chironomids spend more time in the middle than in algae patches

Results and discussion: Food choice

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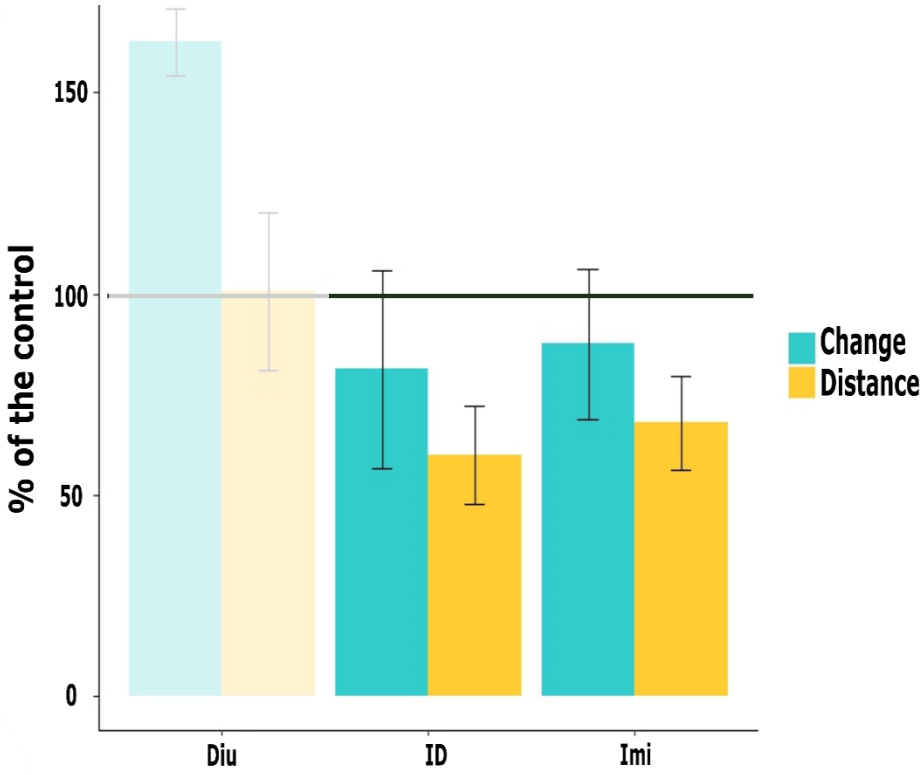

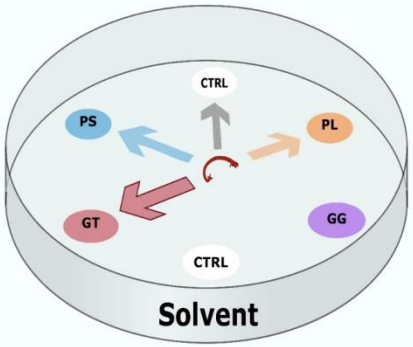

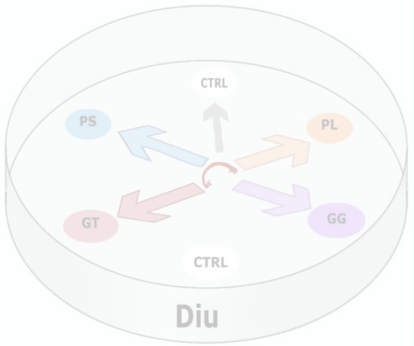

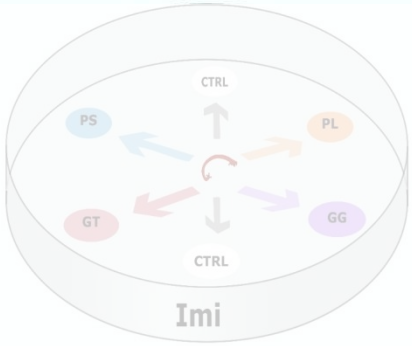

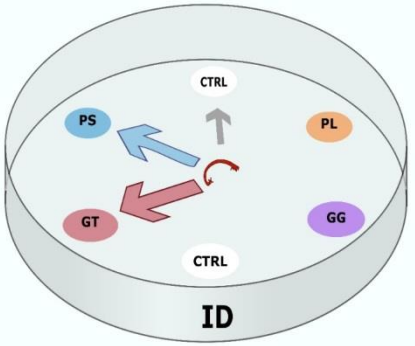

Results and discussion: Food choice

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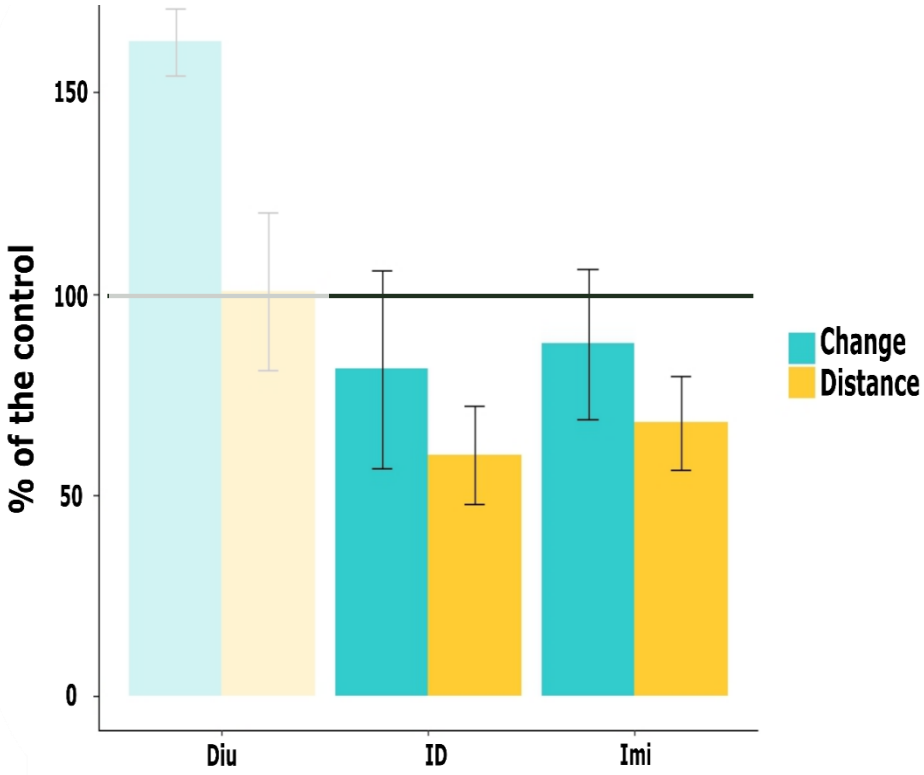
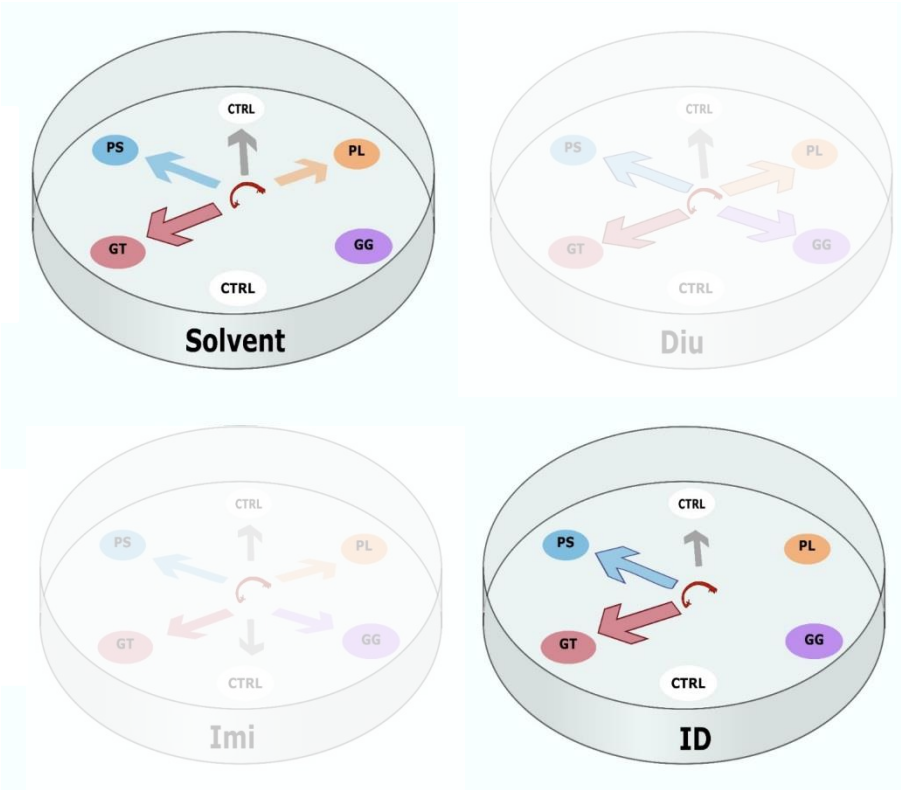




Pesticide mixture follows imidacloprid pattern
→Amorphous chironomids
→Grazing capacity inhibition

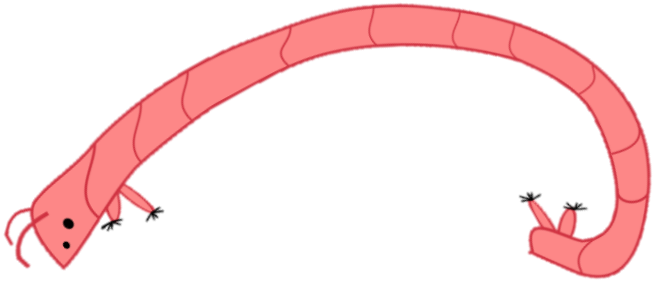
Conclusion:

Conclusion:

Conclusion:

→ ≠ sensitivity to pesticide
→ ≠ sensitivity to grazer

Conclusion:



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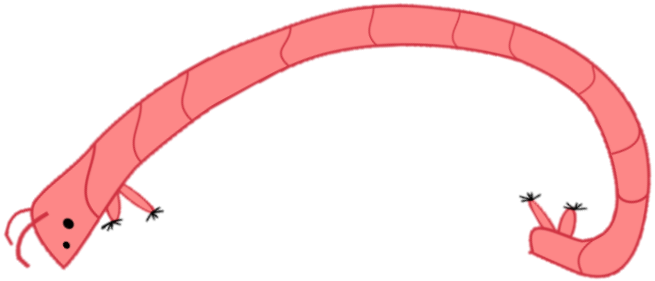

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Ingestion rate variability:
→ ≠ mortality (Bioaccumulation??)
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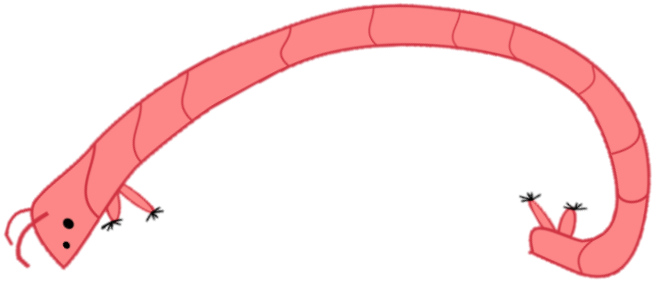

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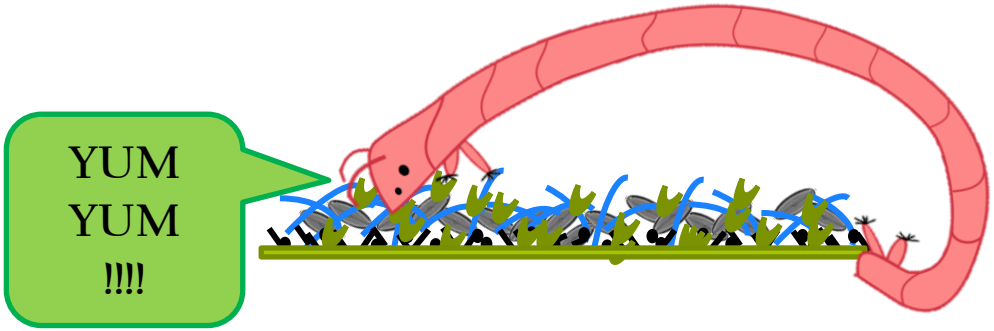
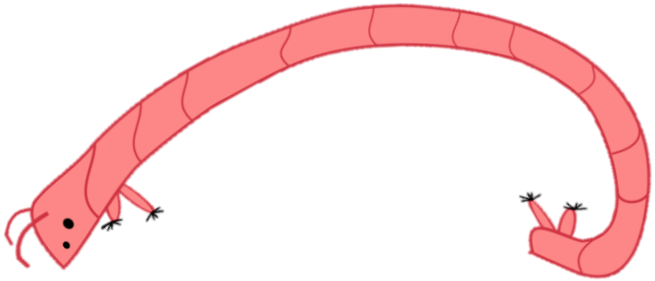


Conclusion:



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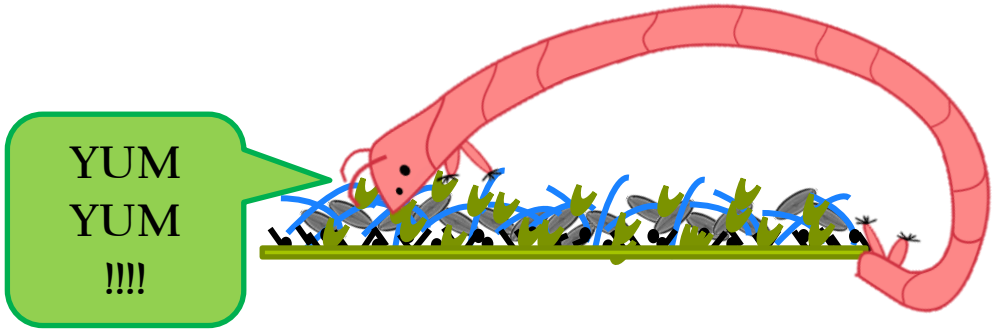

→ Modification algae/grazer relationship under pesticide pressure (Direct/Indirect)
→ Modification benthic community structure
→ Ecotoxicological risk assessment

Acknowledgement:

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