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Response to mechanical stress in yellow mealworms (*Tenebrio molitor*) with regards to welfare considerations

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Ÿnsect France

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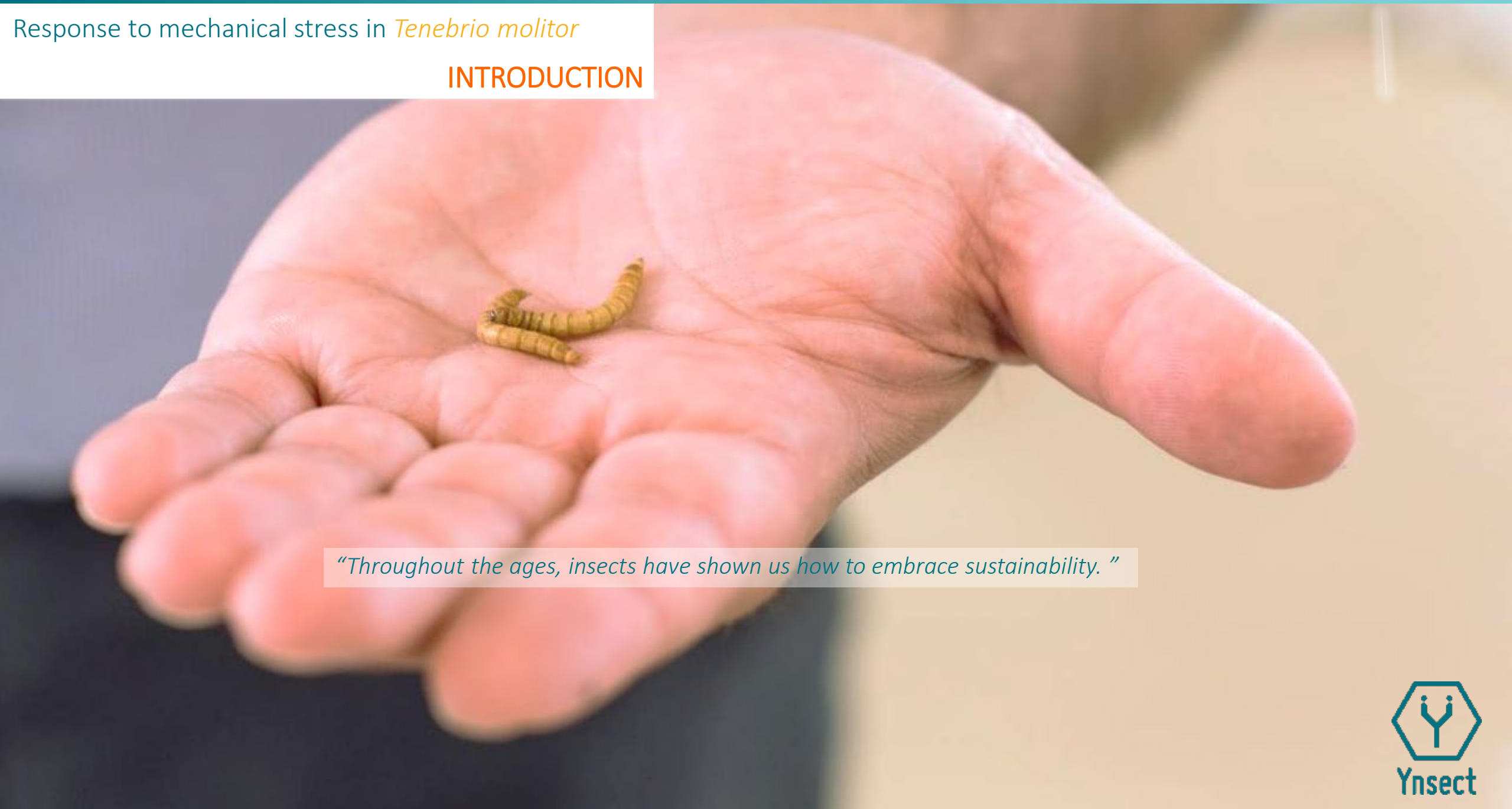
INTRODUCTION



“Throughout the ages, insects have shown us how to embrace sustainability. ”

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THE EMERGENCE OF WELFARE CONSIDERATIONS IN INSECT FARMING

What place for insects in agriculture ?

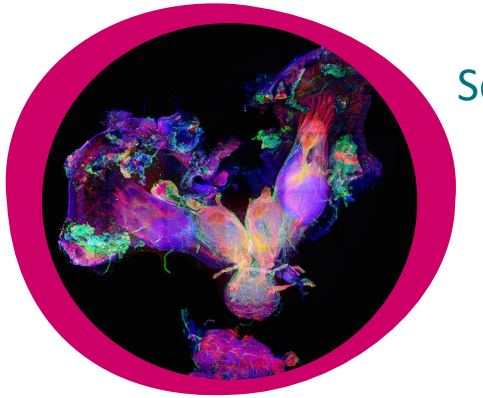
Insects are mainly considered as pests in crops in husbandry or in houses, largely and unscrupulously exterminated using insecticides (including neurotoxics) and other control measures.

Silkworms or honeybees are notorious exceptions

Domesticated and reared for centuries, these species prove that beneficial association could exist with insects.

A crucial need for more empathy for insects!

While insects are facing a dramatic threat of extinction, empathy or compassion towards these species (even endangered ones) remains low, at a score similar to plants



Science is progressing on insect cognition

Recent findings is encouraging us to change our preconceptions about the cognitive and perhaps emotional capacities of insects.
This is an exciting area of research that deserves to be explored in greater depth, particularly in relation to farmed insects, where knowledge is lacking.

Let's take a positive look on insects!

Similarly, farming insects for food and feed, which holds out the promise of improving the food system and its impact on the environment and biodiversity, brings this kind of positive outlook on insects.

Welfare of farmed insect should therefore be regarded paramount for ethical, ecological and economic reasons. Insects must be at the heart of the farmer's concerns, who is committed to respecting the basic needs of his livestock.

ADDRESSING INSECT WELFARE @ ŸNSECT

While insect welfare standards are still in debate, Ÿnsect is engaged in a "care ethics" proactive approach towards its insects in farms and research centers, aimed at better understanding, monitoring and respecting their essential needs.

Internal training and awareness raising

- Creation of a "Welfare committee"
- One day training session this committee
- Awareness session for new-comers
- Internal communications

Development of knowledge and monitoring tools

- Definition of *T.molitor*'s welfare requirements in regard to the 5 freedoms of animal welfare principles,
- Prevention of health hazard through biosecurity measures and veterinary research.
- Tools for monitoring changes in science, opinions and regulations

Concrete implementation in farms and labs

- 3R principles adapted to R&D activities
- Including welfare specifications in equipment and process design
- Creation of specific indicators for monitoring welfare in rearing operations

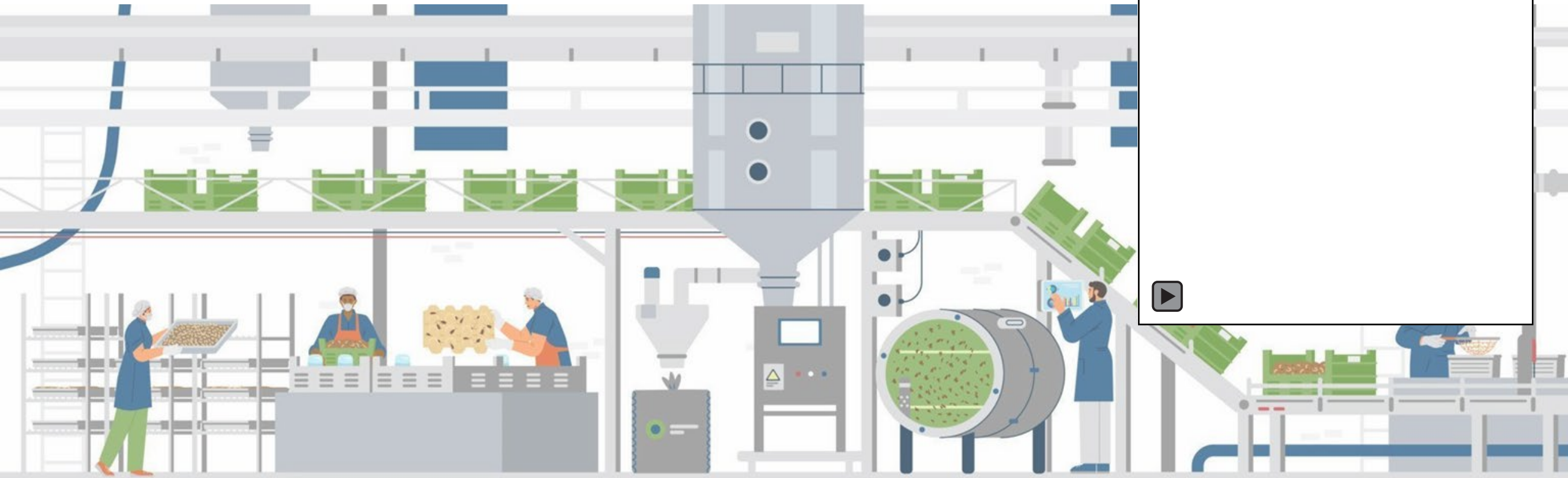
KIWI
Key Insect Welfare Indicators

WHAT ABOUT THE IMPACT OF MECHANICAL STRESS ?

Insect fundamental requirements in nutrition and rearing conditions (temperature, humidity, density…) have beer
However, little is know about the "welfare requirements" during on-farm rearing operations.

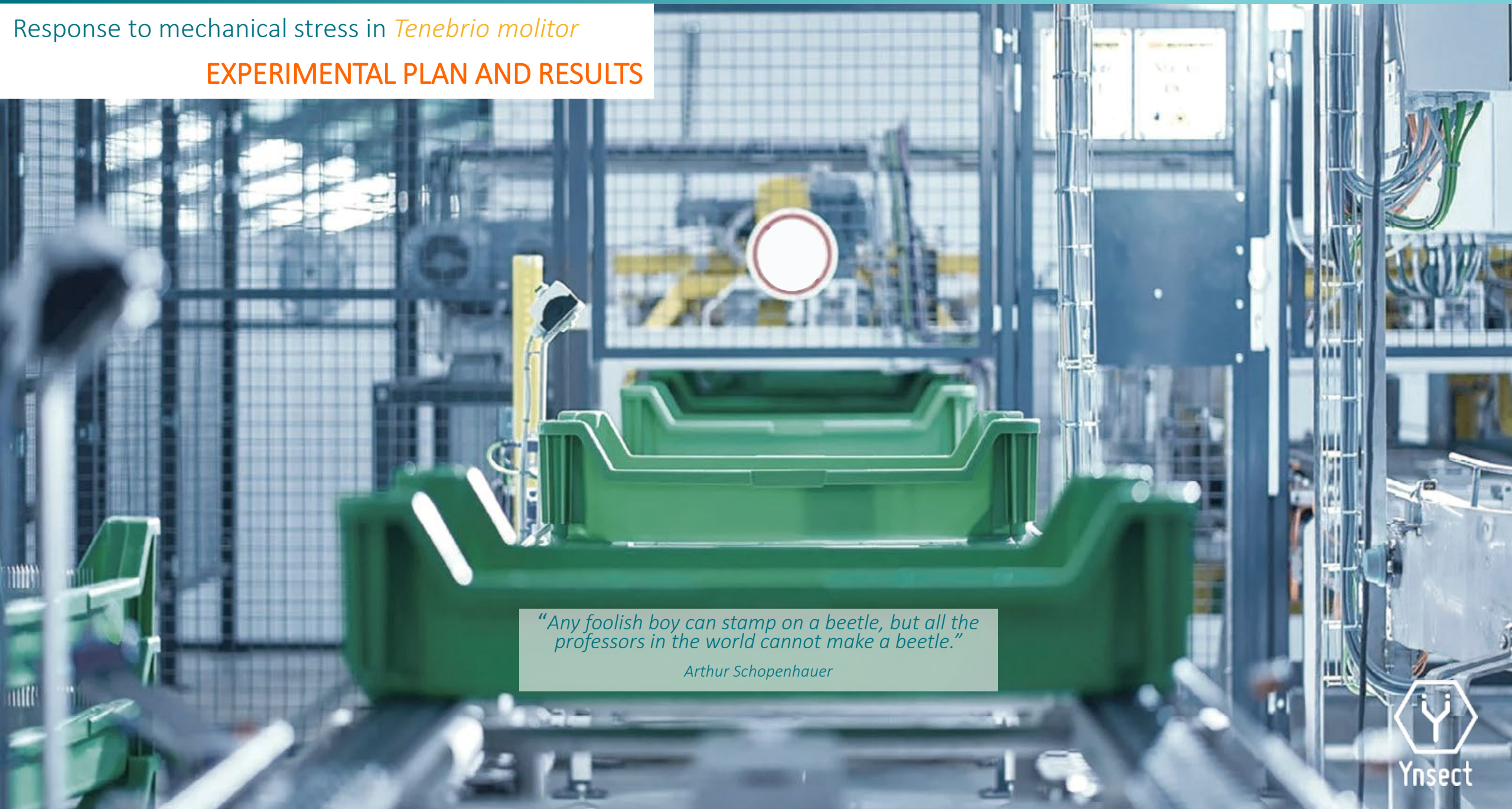
Farmed insects are indeed submitted to various mechanical stress like :
vibration, acceleration, pressure/compression, impact after falling, …

What is the "safety range" in machine specifications that could be acceptable for insects?



Response to mechanical stress in *Tenebrio molitor*

EXPERIMENTAL PLAN AND RESULTS



"Any foolish boy can stamp on a beetle, but all the professors in the world cannot make a beetle."

Arthur Schopenhauer

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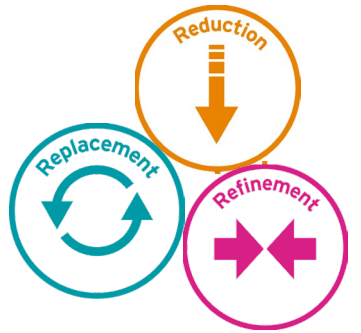
DEFINE THE CRITICAL LEVELS OF PRESSURE ON TENEBRIO MOLITOR

Dose-response approach to assess the NOAEL (No-Observed Adverse Effect Level) using the Benchmark dose (BMD) methodology.

BMD = dose statistically associated with a minimal predefined change in binominal response dataset (Jensen et al. 2020)
BMDL = lower limit of a one-sided confidence interval of the BMD estimate

Observation of immediate impacts (behavioral change, injury, death) and delayed impacts (development, oviposition)

Increasing levels of pressure applied individually to *Tenebrio molitor* at larval, pupal and adult stages

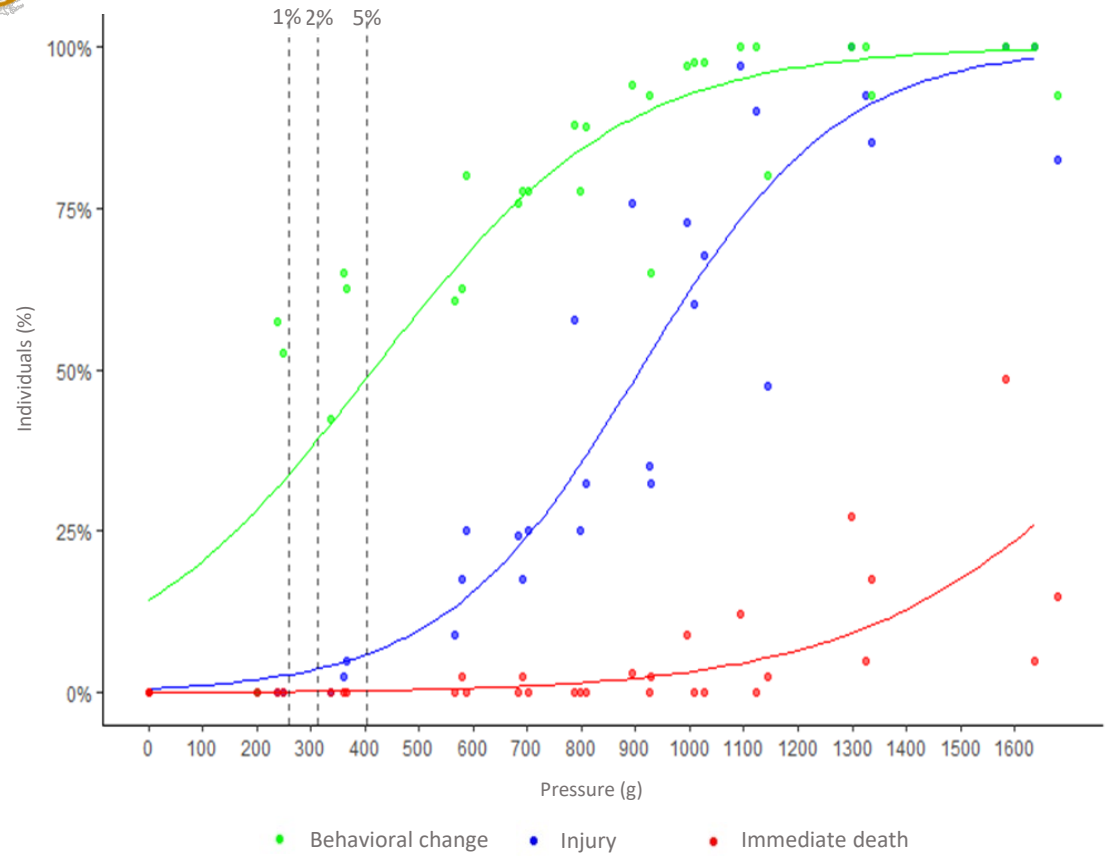


Experimental design defined based on preliminary trials to have the minimal number of insects subjected to as little stress as necessary to statistically reliable (following the 3R principles)

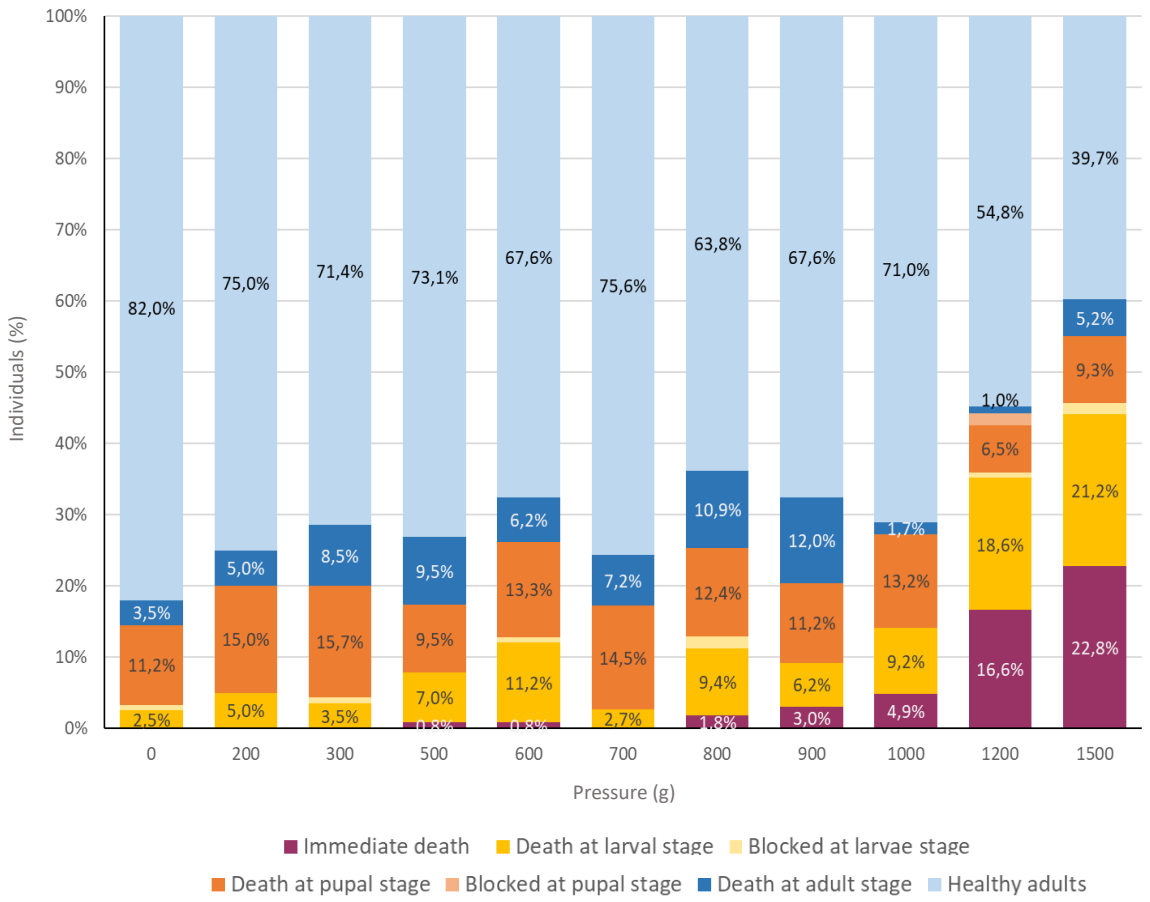
		Replicate 1			Replicate 2			Replicate 3			Replicate 4			TOTAL		
		n	IMM (mg)	SD	n	IMM (mg)	SD	n	IMM (mg)	SD	n	IMM (mg)	SD	n	IMM (mg)	SD
		333	138	17,3	400	174	9,2	400	178	9,7	NA	NA	NA	1133	163	12,1
	M	200	115	6,8	200	130	7,2	200	147	5,8	200	165	21,9	600	142	11,5
	F	200	115	6,8	200	130	7,2	200	148	0,3	200	163	18,2	600	142	08,4
	M	150	103	4,9	150	119	10,1	200	143	NA	200	168	21,0	700	133	12,0
	F	150	103	4,9	150	119	10,1	200	157	NA	200	166	17,7	700	136	10,9

IMPACT OF PRESSURE ON LARVAL STAGE

Immediate impact of pressure



Delayed impact of pressure

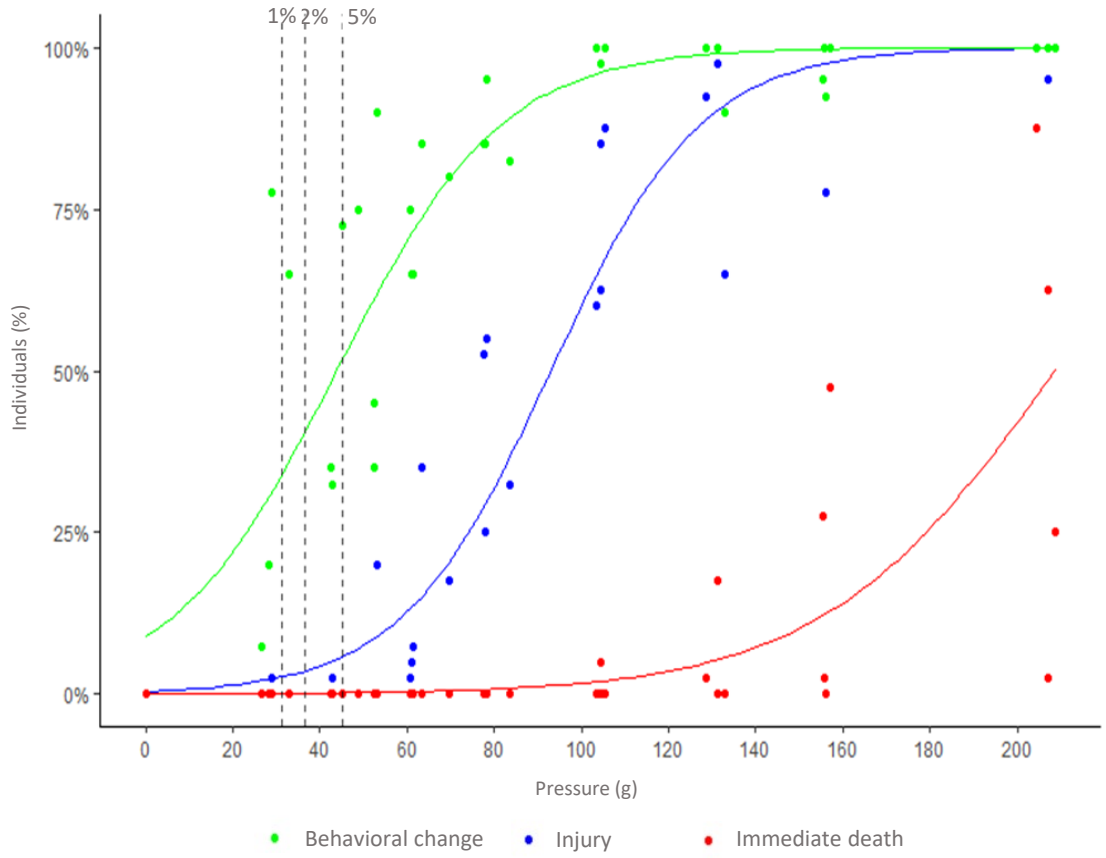


- For a threshold at 1% of observed injury, BMD = 296,7 g and BMDL = 260,7 g

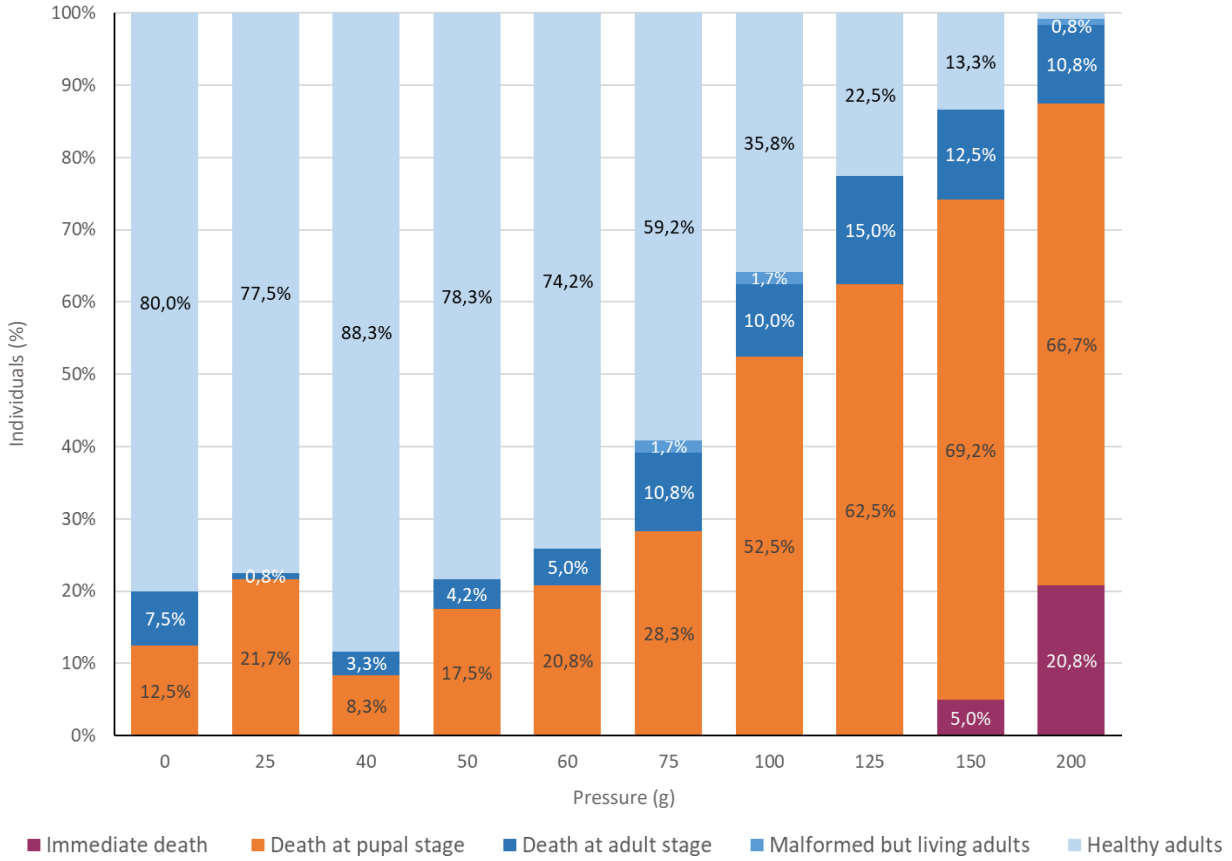
- No statistical effect on pupal and adult stage
- Some delayed mortality on larvae due to injuries (especially above 1200g) $R^2 = 0,70$

IMPACT OF PRESSURE ON PUPAL STAGE

Immediate impact of pressure



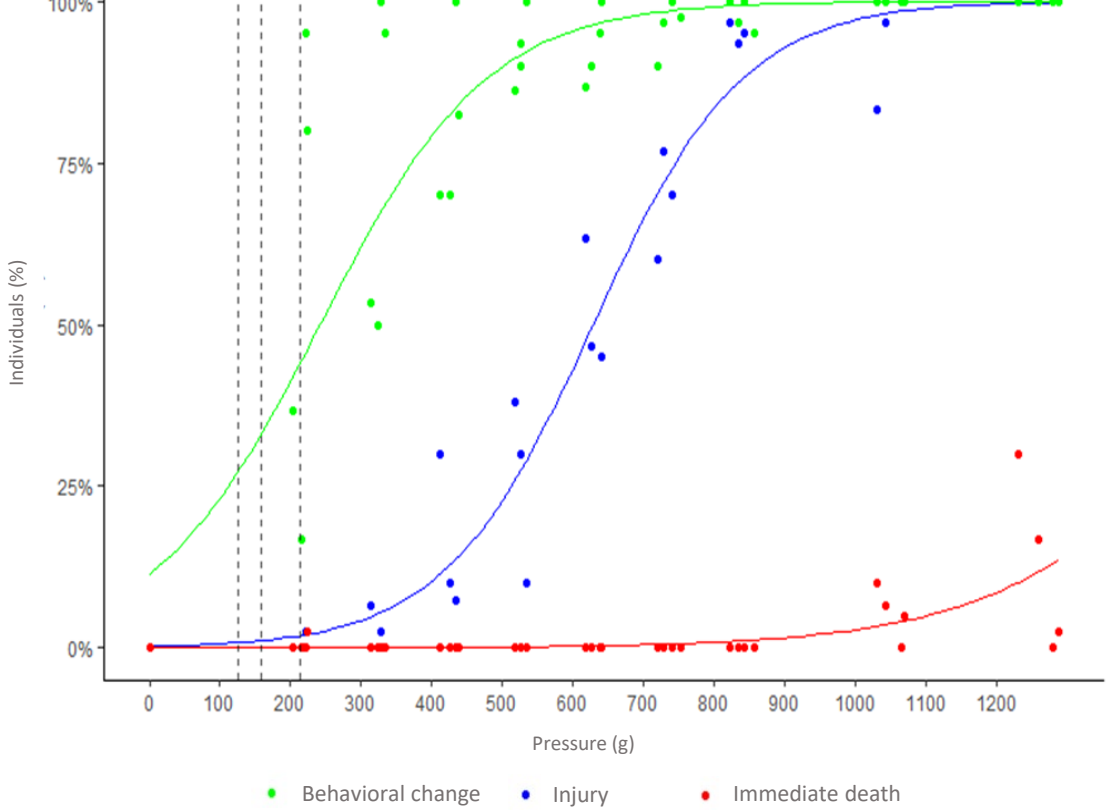
Delayed impact of pressure

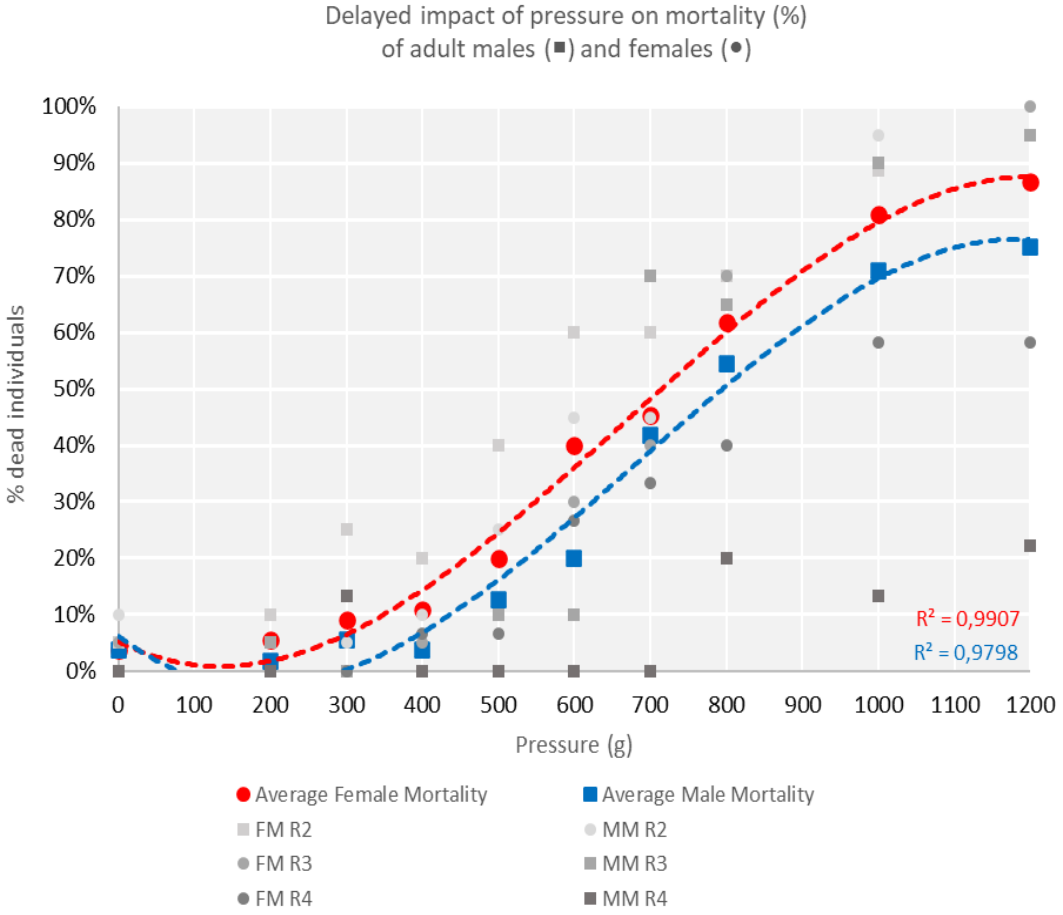


- For a threshold at 1% of observed injury, BMD = 40 g and BMDL = 36,6 g

- Slight statistical effect on adult stage development (increasing number of malformation from 75g of pressure)
- Delayed mortality on pupae due to injuries $R^2 = 0,88$

IMPACT OF PRESSURE ON ADULT STAGE



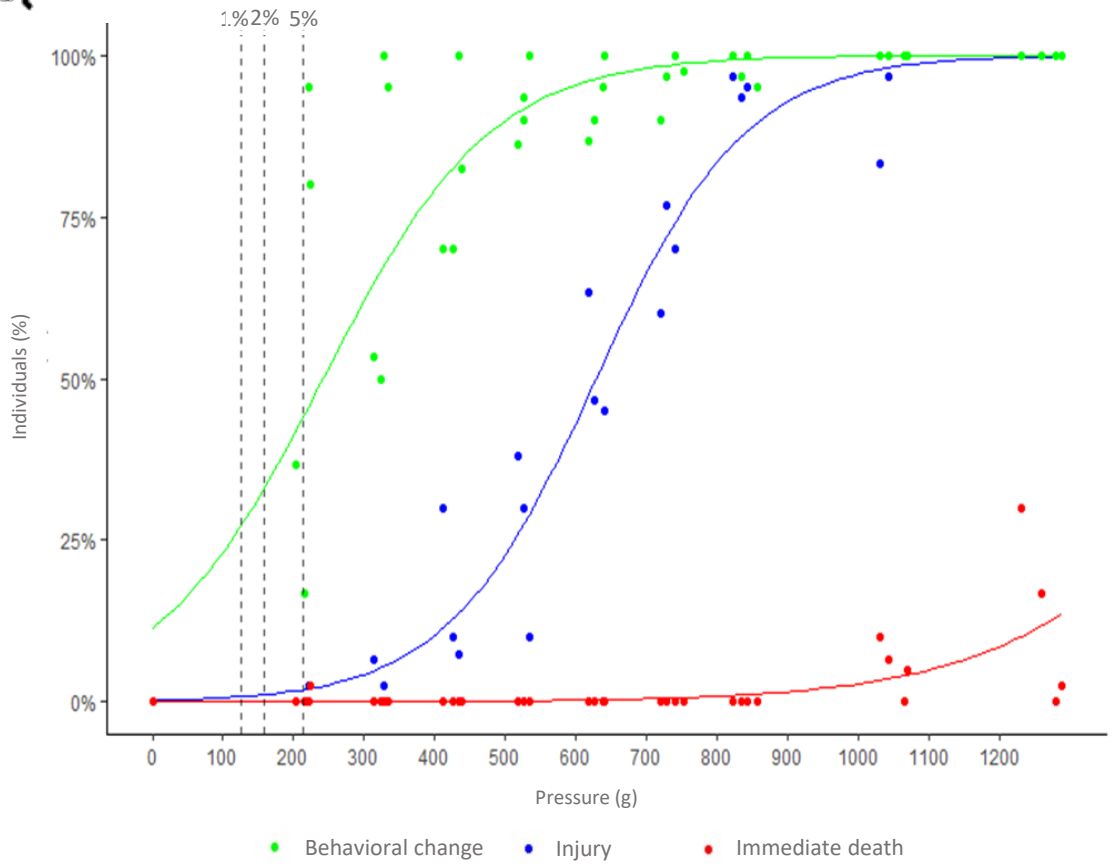


- For a threshold at 1% of observed injury, BMD = 267,6 g and BMDL = 116,3 g

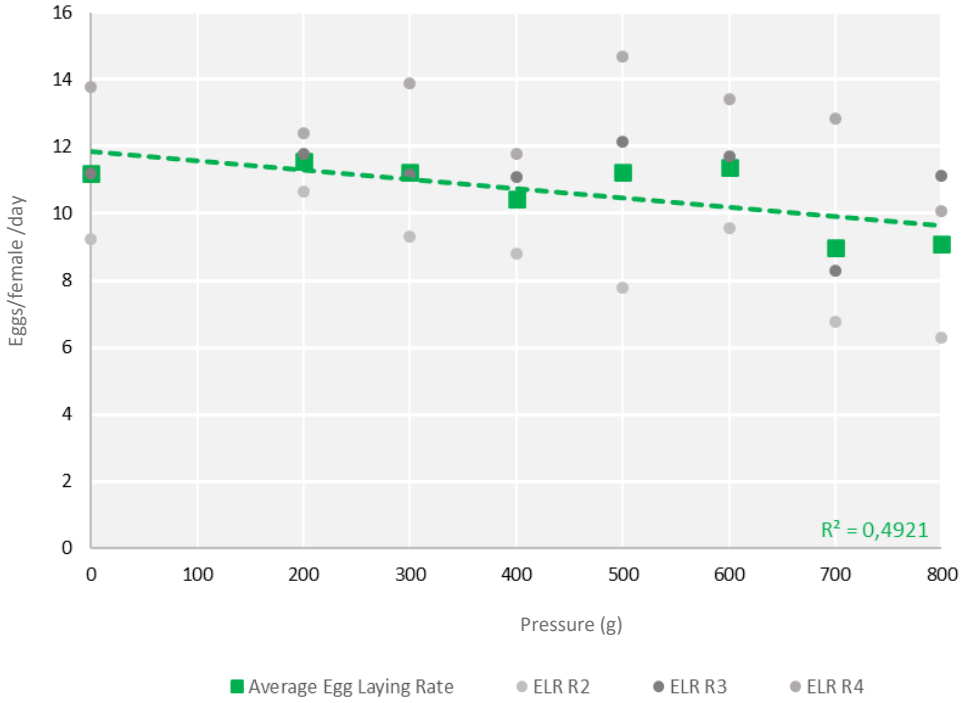
- Delayed mortality on adult due to injuries
- No statistical difference between males and females

IMPACT OF PRESSURE ON ADULT STAGE

Immediate impact of pressure



Delayed impact of pressure on egg laying rate (oviposition) (eggs/female/day)

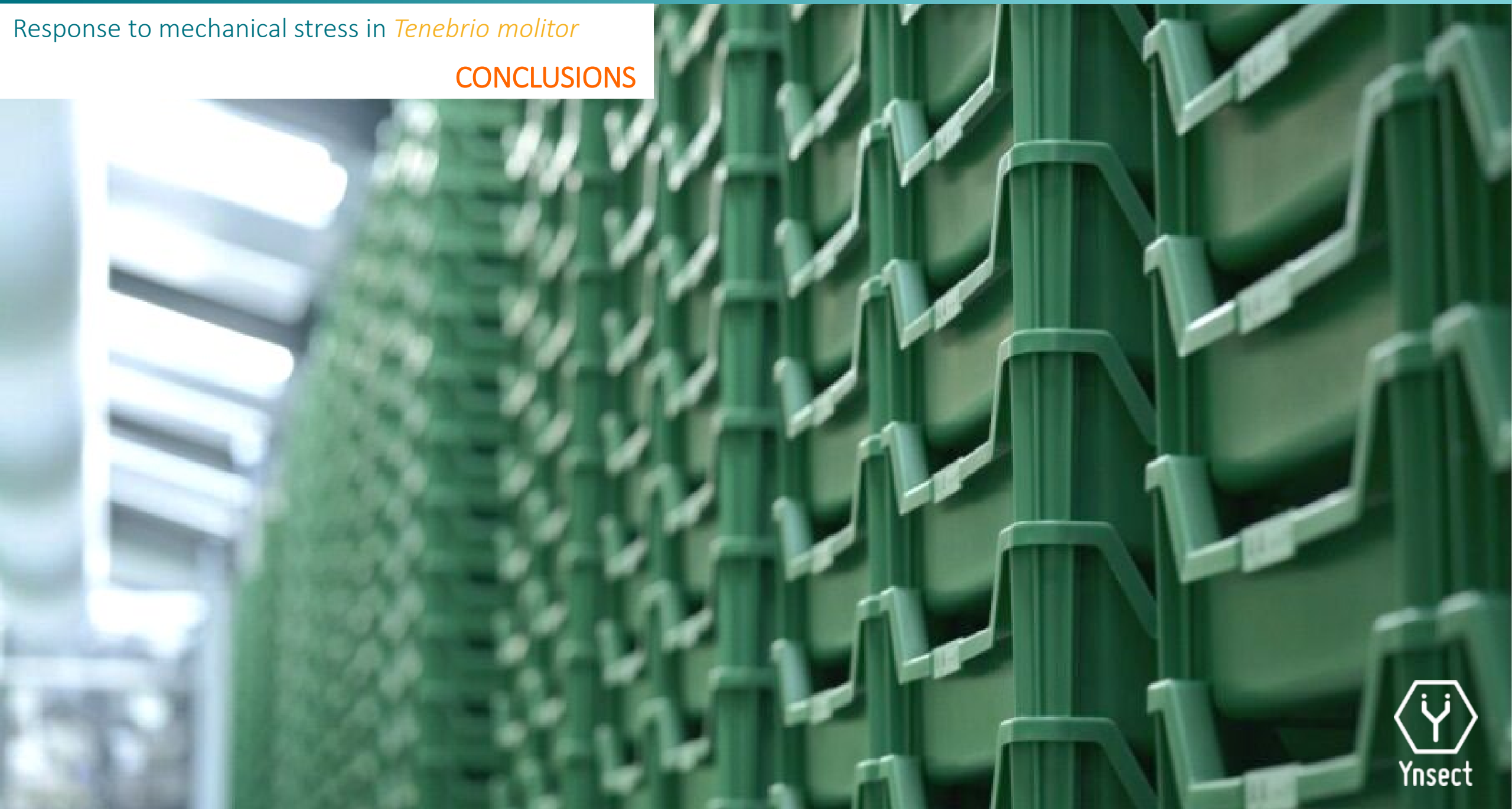


- For a threshold at 1% of observed injury, BMD = 267,6 g and BMDL = 116,3 g

- Delayed mortality on adult due to injuries
- No statistical difference between males and females
- No statistical impact on oviposition (slight decrease in higher pressure due to biased sex-ratio)

Response to mechanical stress in *Tenebrio molitor*

CONCLUSIONS



CONCLUSIONS, RECOMMENDATIONS AND PERSPECTIVES

❖ Resistance to compression and recommended thresholds (maximal pressure) to avoid the risk of harmfulness

BMDL = 260 g > 116 g > 36 g (≈NOAEL for 1% injury)

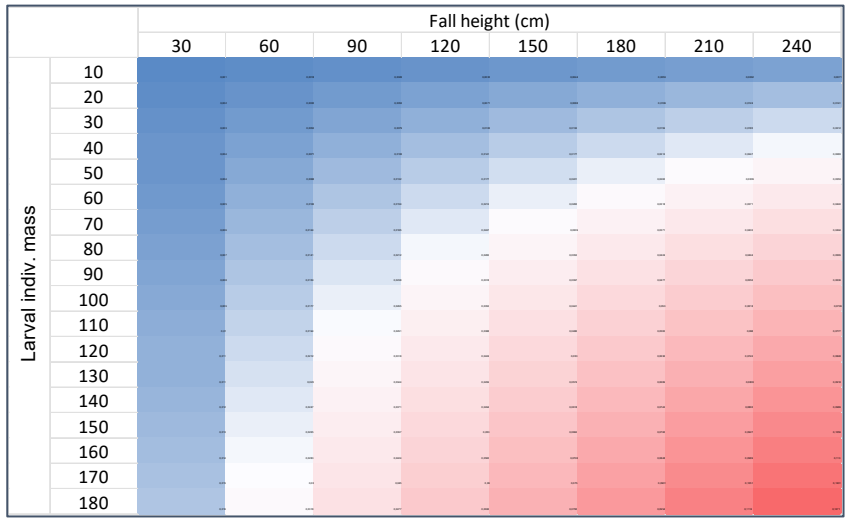
→ Resistance of the exoskeleton (elasticity, structure and shape)

❖ How to make these thresholds more concrete on-farms and for engineers ?

- Modelling in dynamic or populational conditions
- Converting the value for applicable situations (ex: impact at different fall heights) using basics laws of physics and mechanics

❖ Next stressor to be studied ?

- Vibrations!



Thank ÿou

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"And the poor beetle, that we tread upon, / In corporal sufferance finds a pang / As great as when a giant dies." William Shakespeare

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