



# Complex ungulate and predator effects on foraging behaviour and acorn dispersal by Algerian mice: an experimental approach



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**Dehesas** are human-managed oak woodlands (*Quercus*) of SW Spain

**Scattered distribution of trees** on a grassland matrix

**Natural regeneration failure**

Regeneration of Mediterranean woodlands **depends on seed dispersal by scatter-hoarding animals**

Seed dispersal is a **conditional mutualism**



Campos P, Huntsinger L, Oviedo JL, Díaz M, Starrs P, Standiford RB & Montero G. 2013. Mediterranean Oak Woodland Working Landscapes: Dehesas of Spain and Ranchlands of California. New York (NY): Springer.

Díaz M, Campos P & Pulido FJ. 1997. The Spanish dehesas: a diversity in land-use and wildlife. In: Pain D & Pienkowski M, editors. Farming and birds in Europe: The Common Agricultural Policy and its implications for bird conservation. London (UK): Academic Press. p. 178-209.

Pulido FJ & Díaz M. 2005. Regeneration of a Mediterranean oak: a whole-cycle approach. *Ecoscience*. 12:92-102.

Vander Wall SB. 1990. Food hoarding in animals. University of Chicago Press.

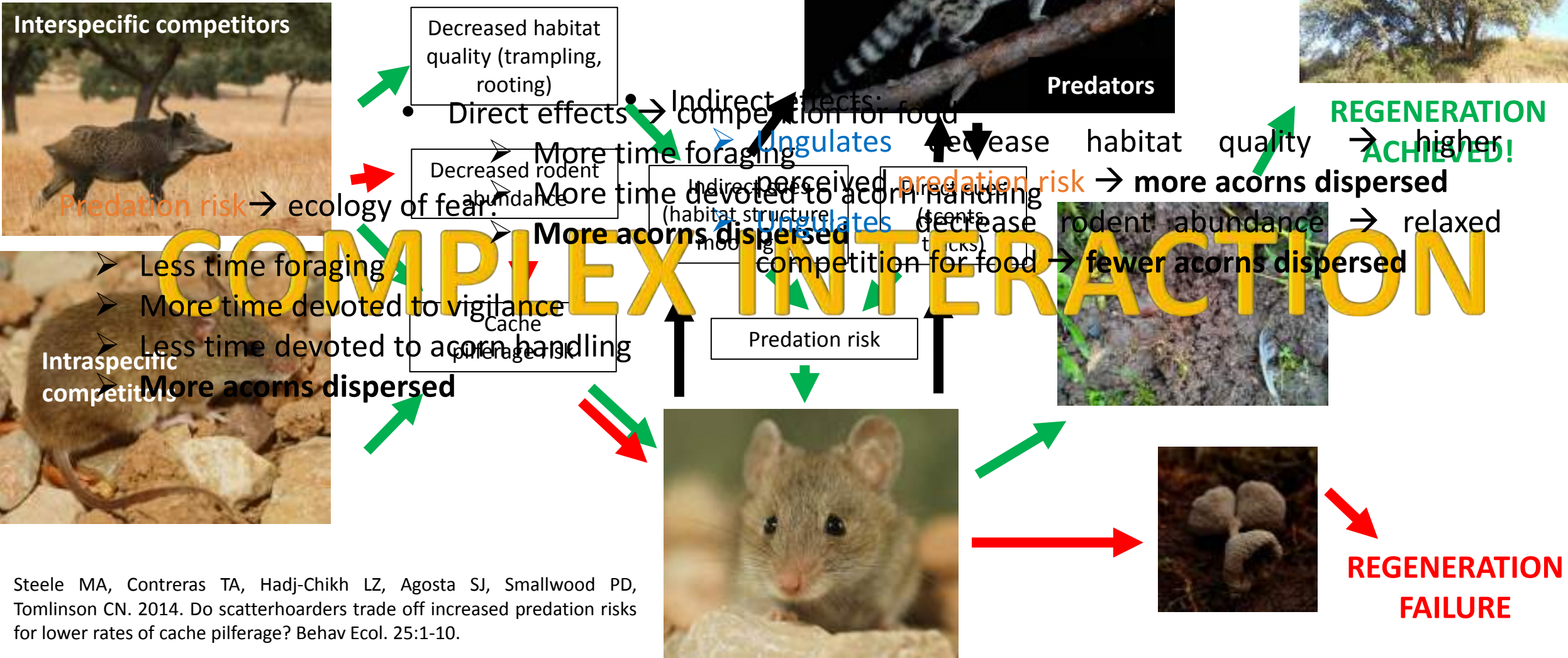
# Introduction

Keasing F. 1998. Impacts of ungulates on the demography and diversity of acorn trees. *Oecologia* 116:381-389.

Puerta-Piñero C, María Gómez J & Schupp EW. 2010. Spatial patterns of acorn dispersal by rodents: do acorn crop size and ungulate presence matter? *Oikos* 119:179-187.



Steele MA, Contreras TA, Hadj-Chikh LZ, Agosta SJ, Smallwood PD, Tomlinson CN. 2014. Do scatterhoarders trade off increased predation risks for lower rates of cache pilferage? *Behav Ecol*. 25:1-10.



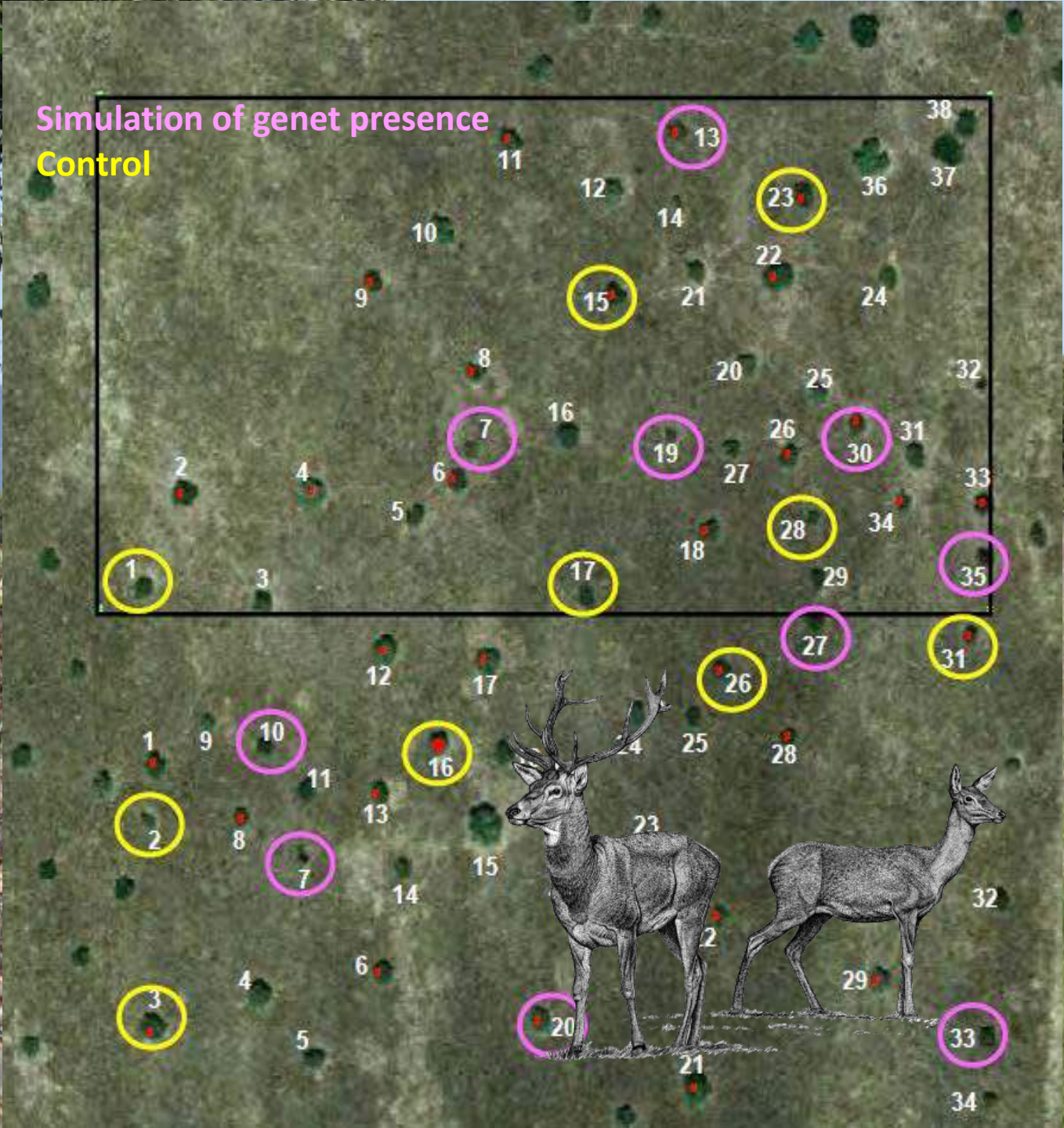
## Predictions

**PREDATION RISK** AND **UNGULATE PRESENCE** WILL MODIFY  
THE AIM OF THE STUDY IS TO ASSESS THE EFFECTS OF  
MICE FORAGING AND ACORN DISPERSAL BEHAVIOUR  
**UNGULATE PRESENCE** AND **PREDATION RISK** ON THE  
FORAGING BEHAVIOUR AND ACORN DISPERSAL OF  
ALGERIAN MICE  
**UNGULATE PRESENCE** WILL MODULATE THE  
EFFECTS OF **PREDATION RISK**





Simulation of genet presence  
Control





- Identification of individuals:
  - ✓ Dominant (larger)
  - ✓ Relatives (smaller, tolerated)
  - ✓ Sneakers (non-tolerated)
- Analyses of behavioural responses to experimental treatments focused on dominant individuals
- Time that conspecifics (relatives or sneakers) spent in the cage was added as a continuous covariate

# Mixed linear models

(We worked with the means obtained for each tree)

## RESPONSE VARIABLES

Duration of foraging events

Proportion of time devoted to:

✓ Vigilance (*“freezing”*)

✓ Acorn handling (*“handling”*)

Acorn dispersal rate → Number of acorns dispersed from the cage/number of events

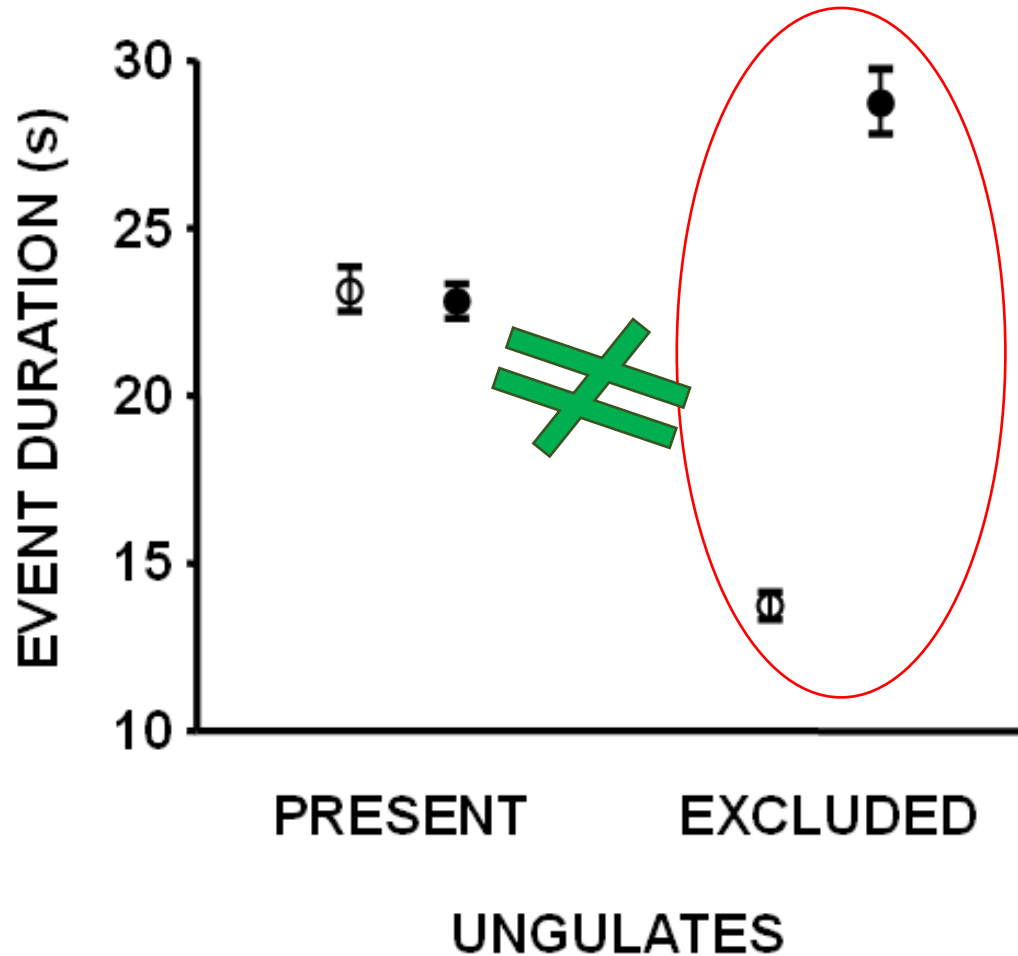
**FIXED EFFECTS** → Exclosure + Scent Treatment + Interaction (exclosure x scent treatment)

**RANDOM FACTORS** → Site



# EVENT DURATION

- Control
- Scent treatment (genet)

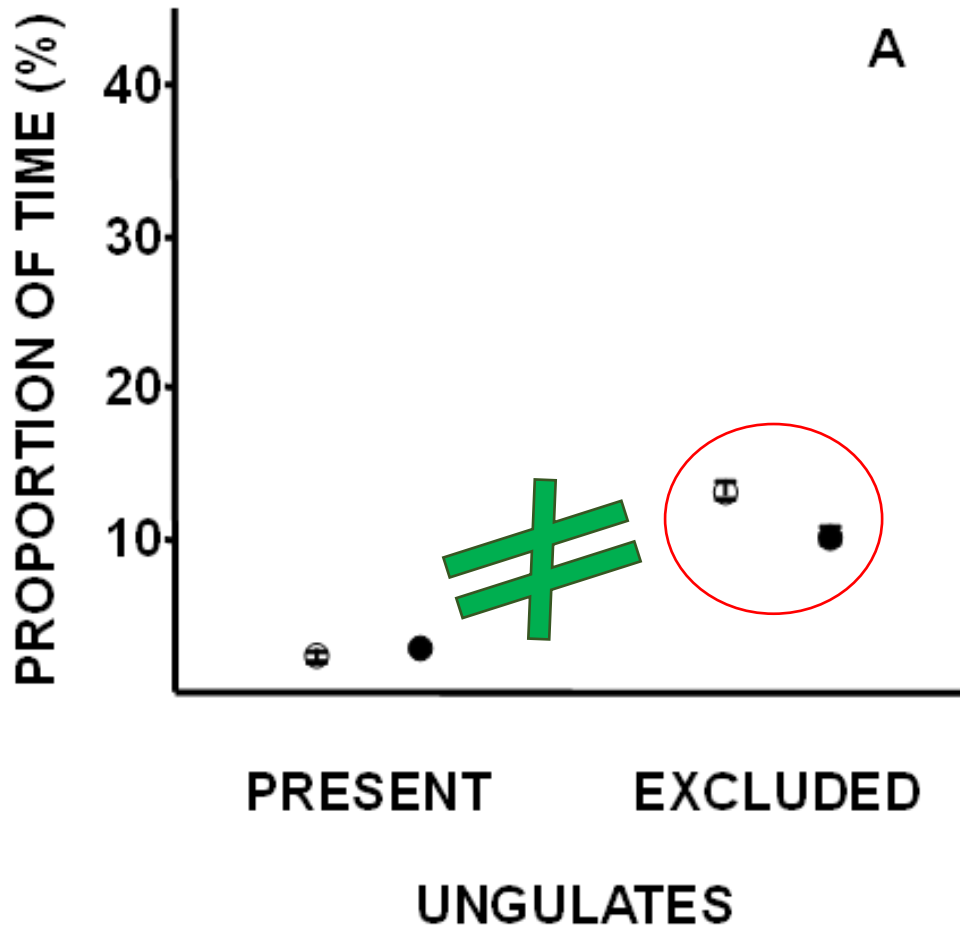


Effect	d.f.	F	p
Site	1	0.54	0.463
Exclosure	1	25.70	<b>0.000</b>
Scent	1	173.62	<b>0.000</b>
Excl. x Scent	1	189.21	<b>0.000</b>
Error	956		

- Longer events with ungulates ✓
- Longer events as a response to scent treatment ✗
- Interaction:
  - ✓ With ungulates: no significant effects of scent treatment
  - ✓ Without ungulates: longer events as a response to scent treatment ✗

# VIGILANCE TIME (%)

- Control
- Scent treatment (genet)



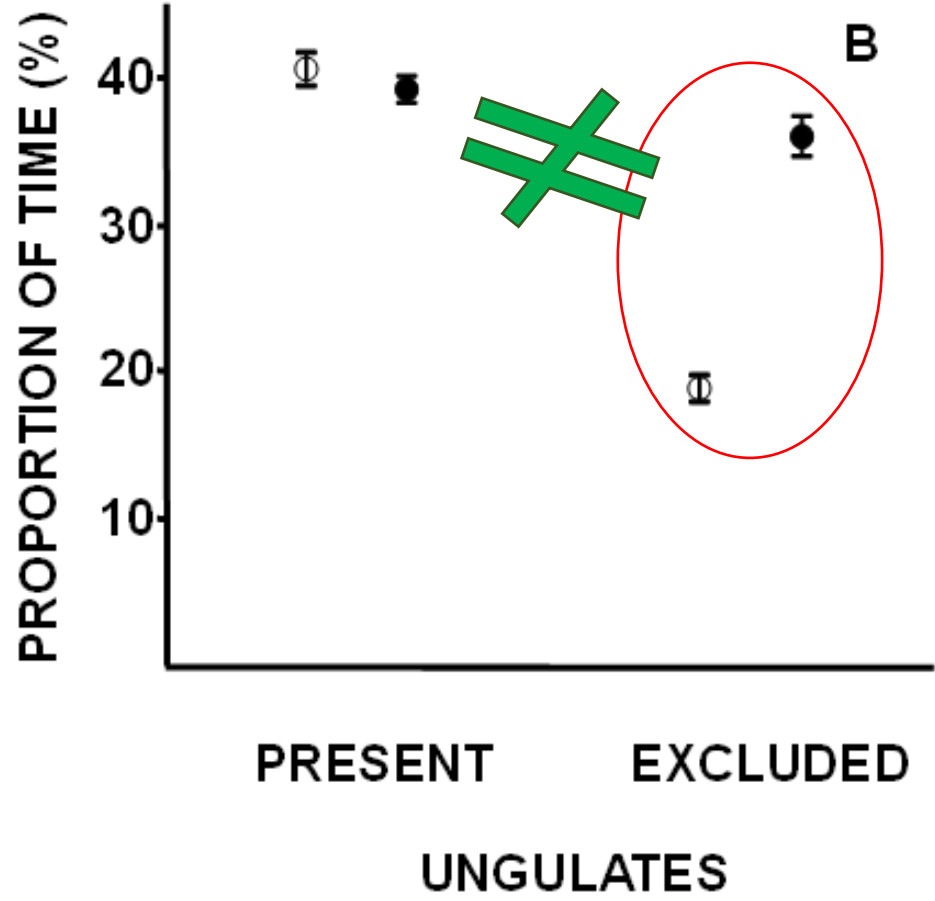
Effect	d.f.	F	p
Site	1	97.09	<b>0.000</b>
Exclosure	1	394.66	<b>0.000</b>
Scent	1	2.58	0.109
Excl. x Scent	1	12.07	<b>0.001</b>
Error	956		

- More time spent vigilant without ungulates
- No significant effects of scent treatment overall
- Interaction:
  - With ungulates: no significant effects of scent treatment
  - Without ungulates: reduction in vigilance time as a response to scent treatment



# ACORN HANDLING TIME (%)

○ Control  
● Scent treatment (genet)

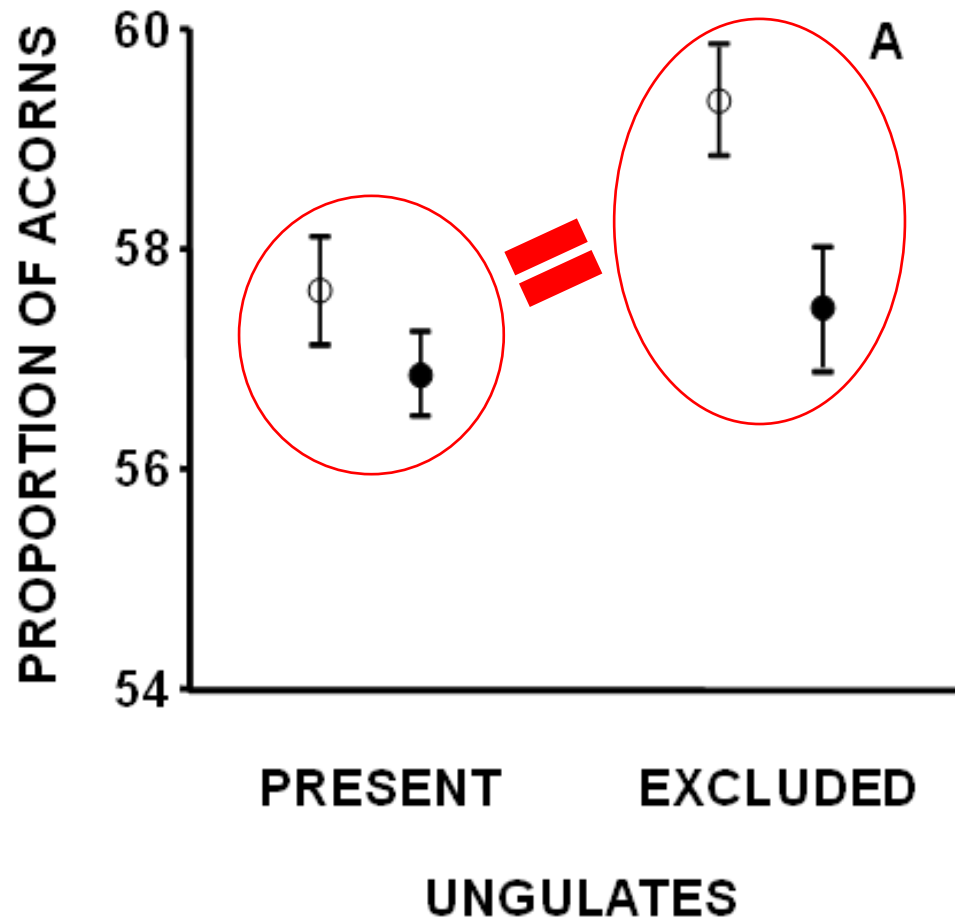


Effect	d.f.	F	p
Site	1	8.23	<b>0.004</b>
Exclosure	1	121.73	<b>0.000</b>
Scent	1	57.34	<b>0.000</b>
Excl. x Scent	1	77.96	<b>0.000</b>
Error	956		

- More time spent handling acorns with ungulates ✓
- Scent treatment increased acorn handling time ✗
- Interaction:
  - With ungulates: no significant effects of scent treatment
  - Without ungulates: scent treatment increased acorn handling time ✗

# ACORN DISPERSAL RATE(%)

- Control  
● Scent treatment (genet)



Effect	d.f.	F	p
Site	1	9.27	<b>0.002</b>
Exclosure	1	5.41	<b>0.020</b>
Scent	1	7.71	<b>0.006</b>
Excl. x Scent	1	1.39	0.238
Error	956		

- Higher acorn mobilization without ungulates ~~X~~
- Lower acorn dispersal in response to scent treatment ~~X~~
- Non-significant effects of the interaction ~~X~~

When we added covariates related to **vegetation structure** to our analysis...

**Resprout cover and resprout height:**

- **Increased** event duration
- **Decreased** vigilance time
- **Increased** acorn handling time
- **Decreased** the number of acorns dispersed

**Reduction in perceived  
predation risk**

However, the effects of fixed factors on mice foraging  
behaviour and acorn dispersal did not change



**The effects of ungulate exclosures on mice foraging  
behaviour and acorn dispersal **WERE NOT MEDIATED** by the  
exclosure effects on vegetation structure**

When we added covariates related to **the activity of sneakers** to our analysis...

**The time that sneakers spent inside the cages:**

- Increased event duration
- Decreased vigilance time
- Increased acorn handling time
- Increased the number of acorns dispersed

**Increase in cache  
pilferage risk**

Once more, the effects of fixed factors on mice  
foraging behaviour did not change

But the effects of fixed factors on  
acorn dispersal changed

The effects of ungulate exclosures on mice foraging  
behaviour **WERE NOT MEDIATED** by the exclosure  
effects on the activity of sneakers

The effects of ungulate exclosures on acorn dispersal  
**WERE MEDIATED** by the exclosure effects on the  
activity of sneakers

**Why did sneakers have an effect on acorn dispersal, but did not  
have the pertinent effect on mice foraging behaviour?**

When we added covariates related to **the activity of relatives** to our analysis...

The time that relatives spent inside the cages:

- Increased event duration
- Decreased vigilance time
- Increased acorn handling time
- Decreased the number of acorns dispersed

**Reduction in perceived predation risk**

- Dilution effect on predation risk
- Reduction of individual vigilance

Elgar MA. 1989. Predator vigilance and group size in mammals and birds: a critical review of the empirical evidence. *Biological Reviews* 64:13-33.

Once more, the effects of fixed factors on mice foraging behaviour **did not change**



The effects of ungulate exclosures on mice foraging behaviour **WERE NOT MEDIATED** by the exclosure effects on the activity of relatives

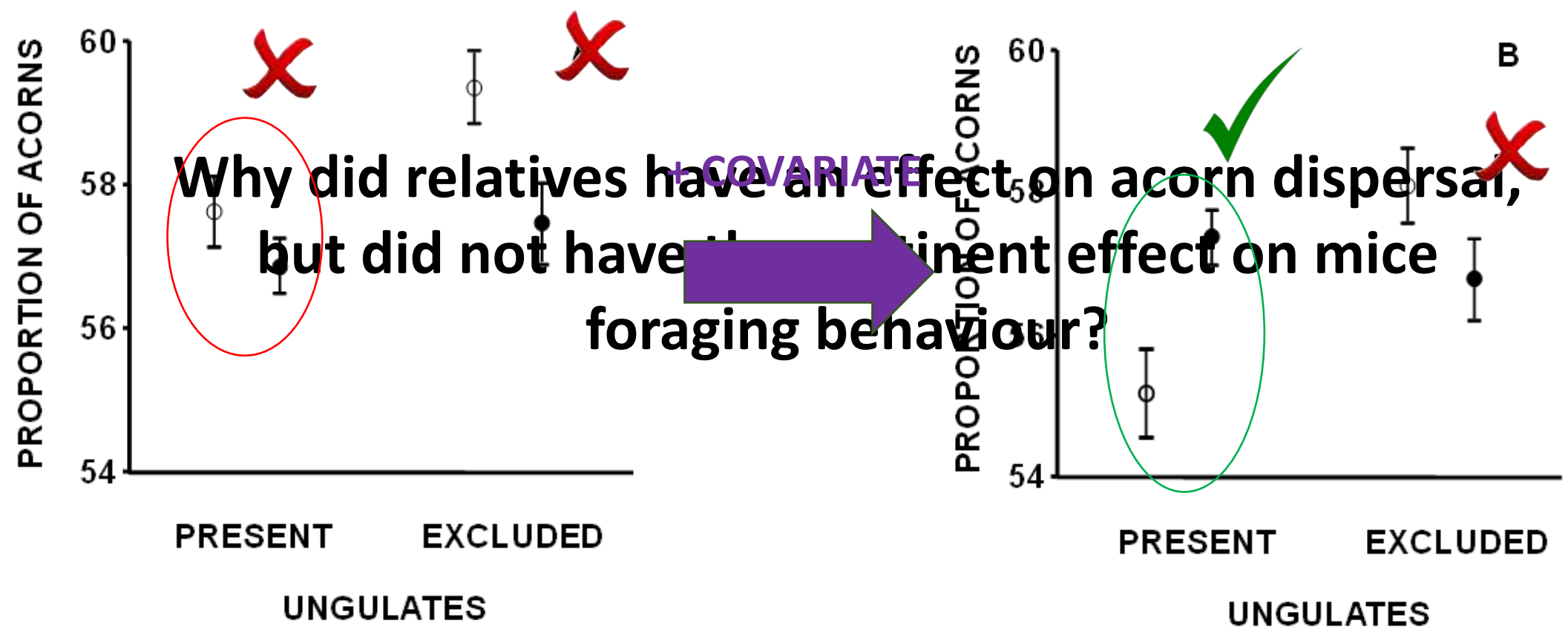
But the effects of fixed factors on acorn dispersal **changed**



The effects of ungulate exclosures on acorn dispersal **WERE MEDIATED** by the exclosure effects on the activity of relatives

- Control
- Scent treatment (genet)

When controlling for the effects of the activity of relatives, outside exclosures scent treatment produced the expected response on acorn dispersal





- Experimental enclosure of ungulates and the addition of predator odor in field conditions proved that **rodents are responsive to the presence and activity of these distantly-related animal groups**
- We obtained **complex (and unexpected) results** regarding the effects of experimental manipulations on mice foraging activity and acorn dispersal:
  - ✓ Scent treatment produced less distressed behaviours inside enclosures, while outside them it produced no significant effects → less acorns were dispersed when predator presence was simulated
- Besides, in the case of **foraging behaviour variables** (event length, vigilance time and acorn handling time) these effects were **not explained by** indirect effects of the ungulate enclosures on **vegetation structure and intraspecific relations** (relatives and sneakers).
- However, **mice acorn dispersal was mediated by enclosure effects on conspecific activity** → foraging decisions are modulated by the presence of conspecifics
- The interaction between the effects of ungulates and predators produced **complex outcomes on factors influencing mice foraging behaviour**. Such outcomes can be mediated by indirect effects of ungulates on vegetation structure and conspecific activity
- These complex, cascading effects **could ultimately determine oak tree regeneration and long-term sustainability of dehesas** if not taken properly into account

A large, spreading tree with a thick trunk and dense foliage stands in a field of golden-brown grass. The sun is setting behind the tree, creating a warm, golden glow. The sky is a clear, light blue. In the background, there are low mountains or hills.

**THANKS FOR YOUR  
ATTENTION!!**

*“La mayor encina fue bellota chiquitina”*

AMAIA  
AITA, AMA  
PAULA  
PABLO  
TOMÁS