To choose or not to choose a good mate: evolution of sex pheromone receptors in moths

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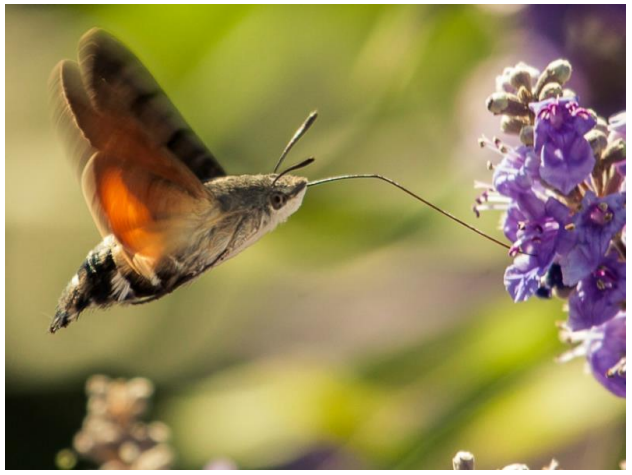
Insect olfaction drives important behaviors

Photos:web





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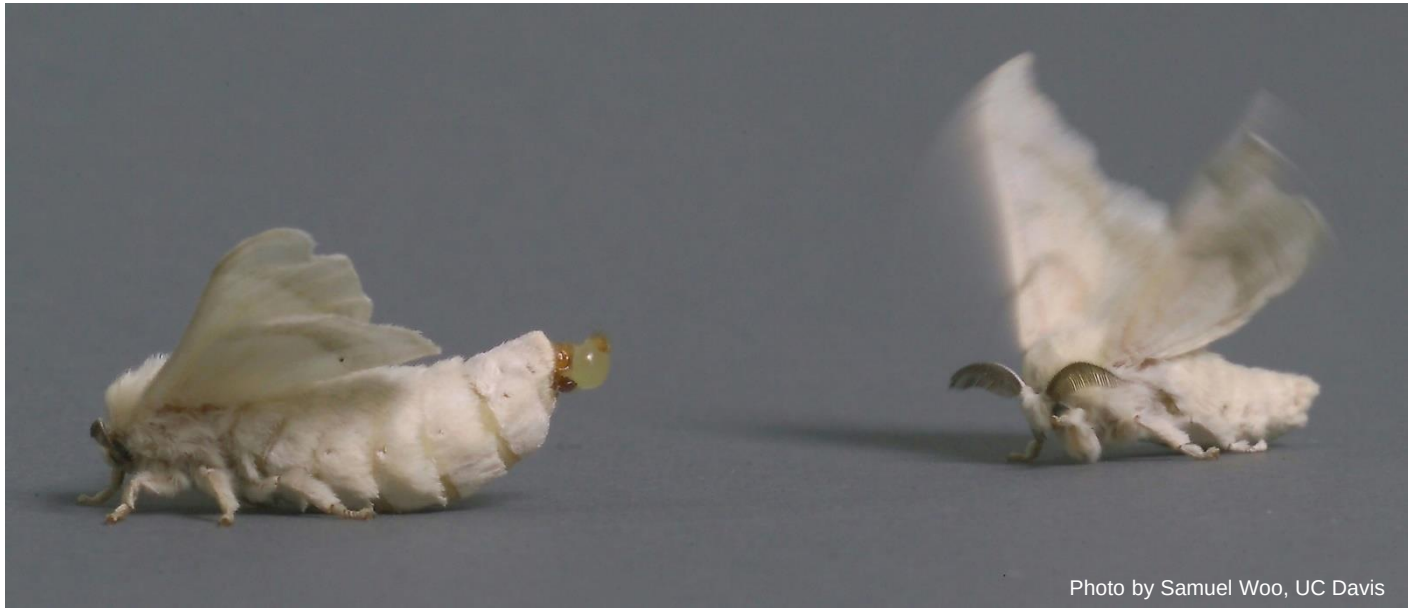
Sex pheromone communication in moths

Female: emission

Male: detection



Even slight alterations in the pheromone communication can prevent mating and can be a starting point for **speciation**

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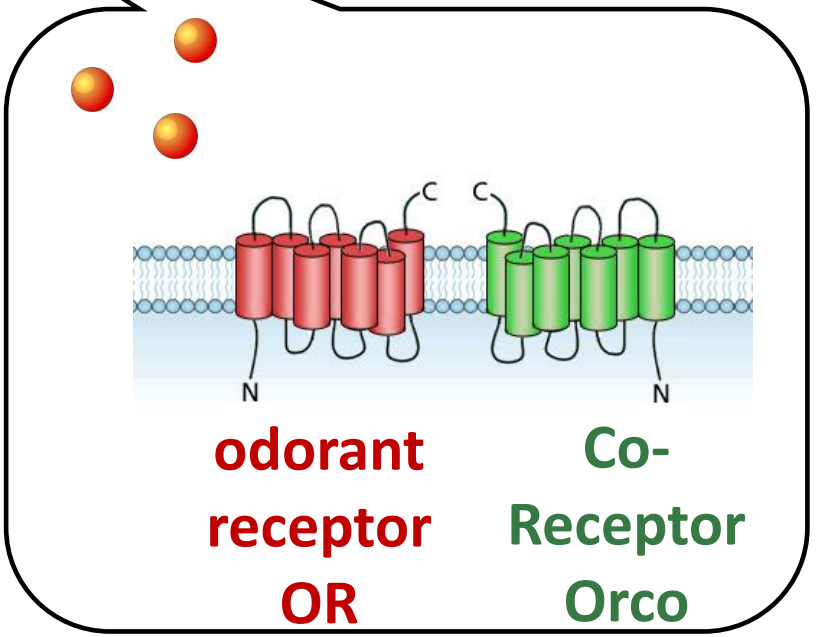
Pheromones are detected by dedicated Odorant Receptors (ORs): the Pheromone Receptors (PRs)

Photos:iEES



odorant receptor OR

Co-Receptor Orco

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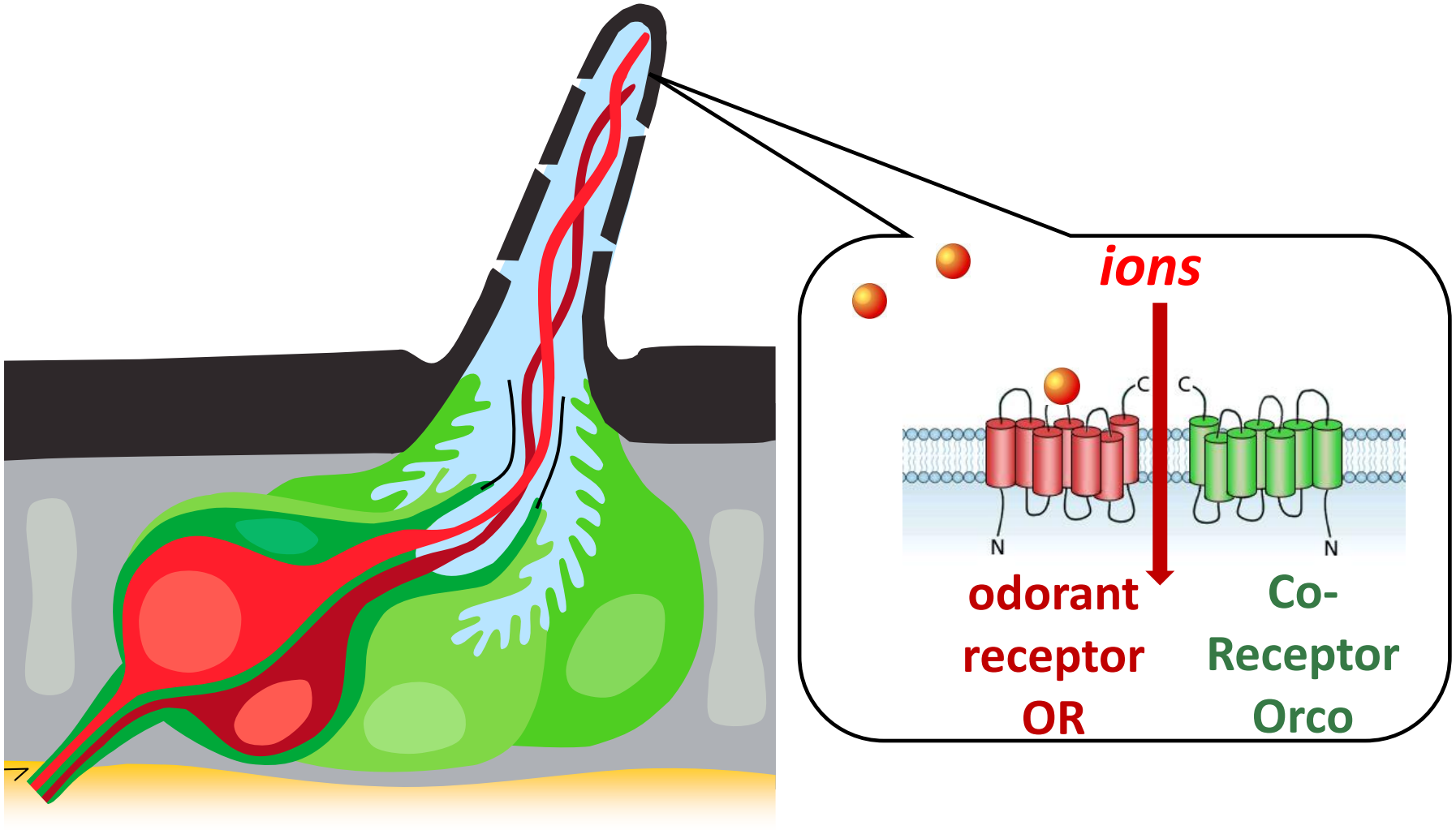
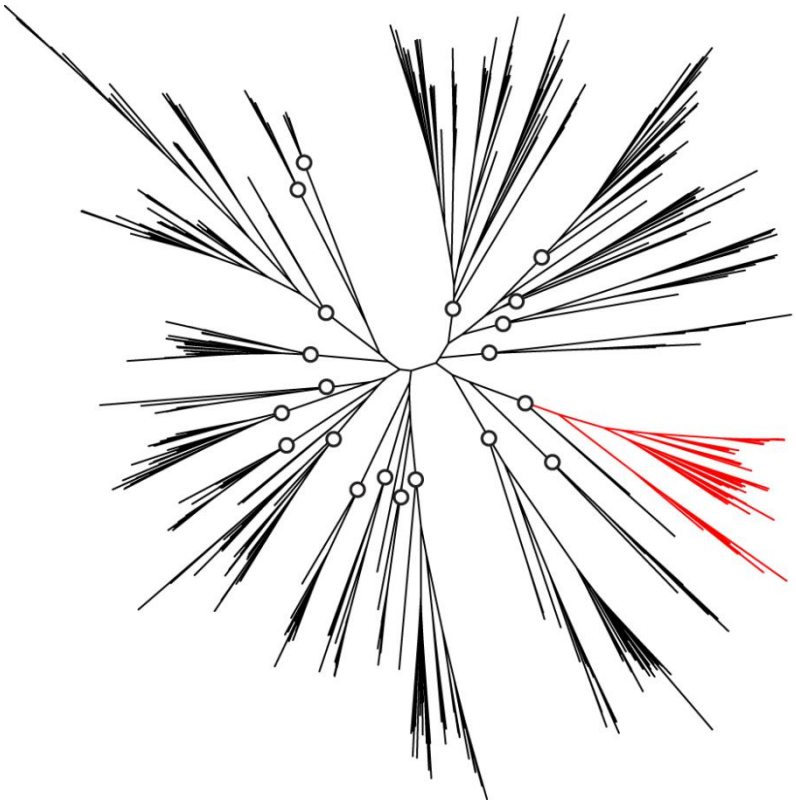
Pheromones are detected by dedicated Odorant Receptors (ORs): the Pheromone Receptors (PRs)



ORs are responsible for the transduction of a chemical signal into an electrical signal

Moth sex pheromone receptors (PRs): a subclass of ORs

Lepidopteran OR phylogeny



pheromone receptor clade

The function of **more than 50 PRs** have been characterized, in ~20 moth species

- ✓ All PRs tuned to type I pheromones **belong to the same clade** of the phylogeny
- ✓ They are **more expressed in male** than in female antennae

➡ **Good criteria to identify candidate PRs**

Montagné *et al* **2021** Insect Pheromone Biochemistry and Molecular Biology

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Our main model: the noctuid moth *Spodoptera littoralis*

- ✓ Crop **pest** in Africa, Middle East and all the mediterranean basin
- ✓ Caterpillars are highly **polyphagous**

>80 host plants

Photos:iEES

S. frugiperda *S. littoralis* *S. litura*

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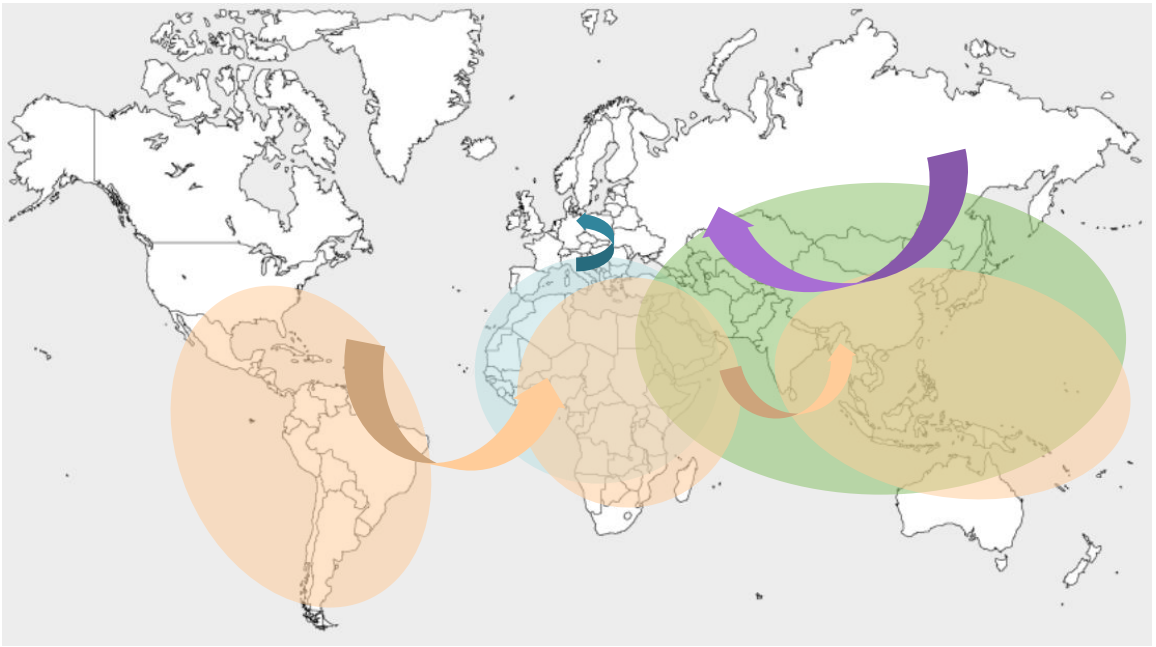
Our main model: the noctuid moth *Spodoptera littoralis*

- ✓ Crop **pest** in mediterranean countries
- ✓ Caterpillars are highly **polyphagous**
- ✓ belongs to the ***Spodoptera* complex**

Photos:iEES



S. frugiperda *S. littoralis* *S. litura*

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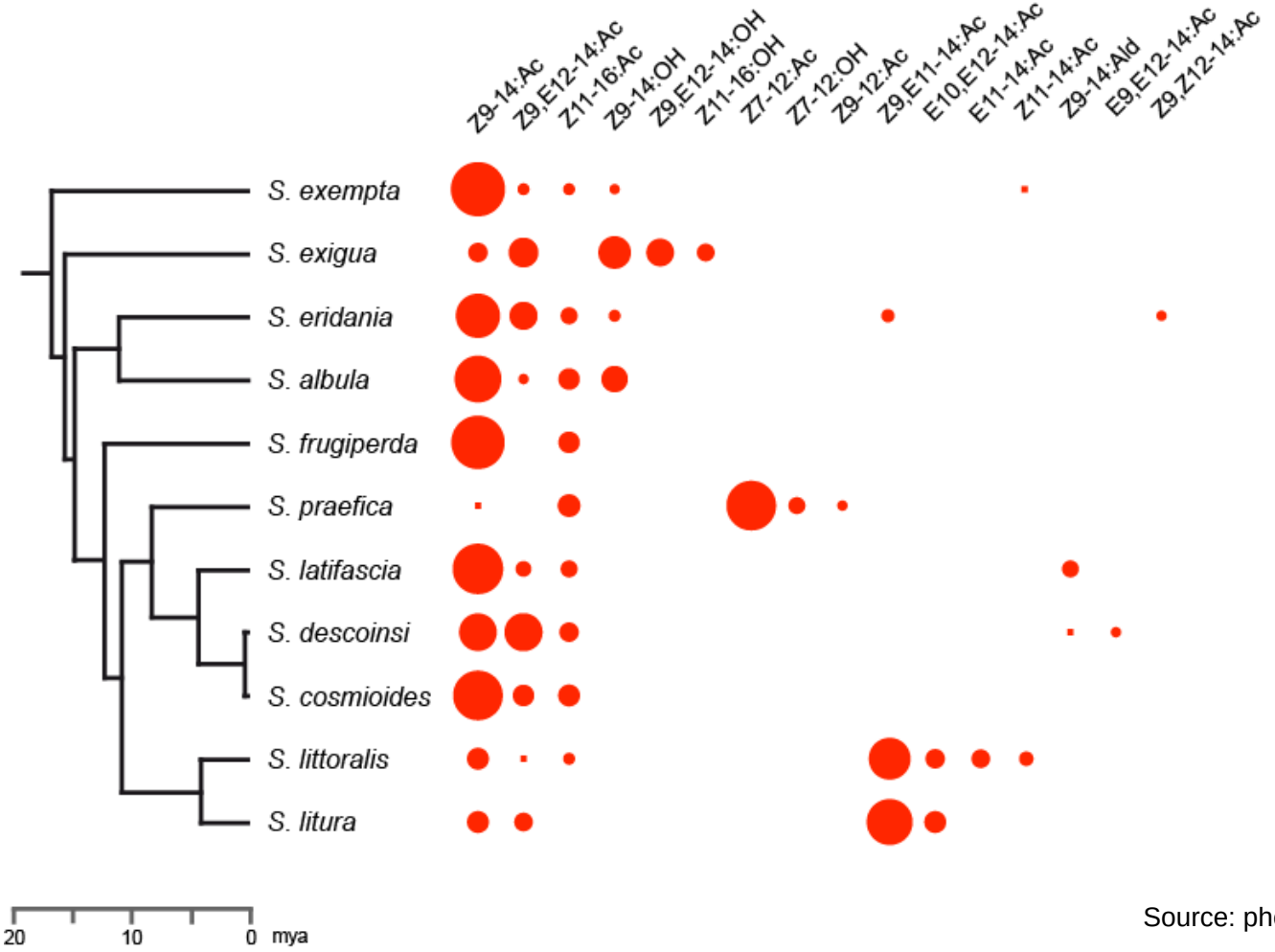
Diversity and conservation of sex pheromone components in the genus *Spodoptera*



Source: pherobase

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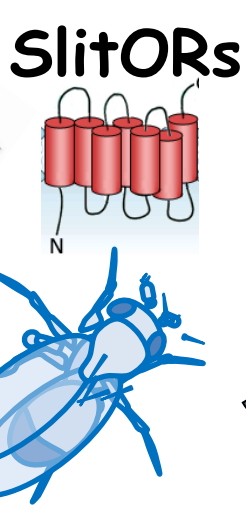
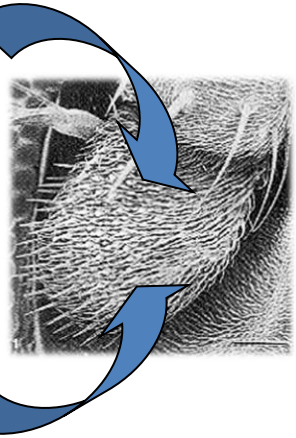
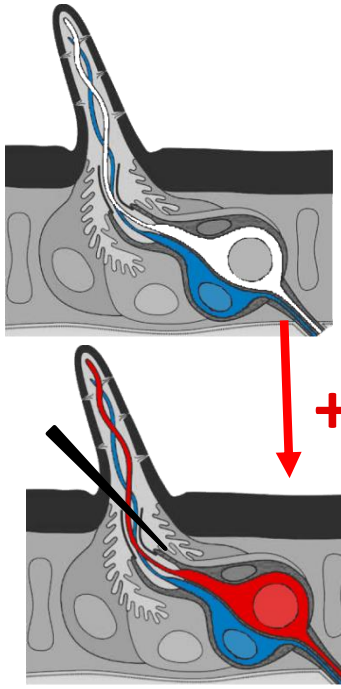
Identifying pheromone receptors in *S. littoralis*

antennal transcriptome and genome sequencing identify PR candidates

→ Functional characterization via expression in *Drosophila* neurons coupled to electrophysiology *(Kurtovik et al 2007 Nature)*







Single Sensillum Recording (SSR)

Nicolas Montagné

Legeai *et al* **2011** *BMC genomics*

Meslin *et al* **2022** *G3.*

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Identifying pheromone receptors in *S. littoralis*

An antennal transcriptome identifies PRs candidates

→ Functional characterization via expression in *Drosophila* neurons coupled to electrophysiology

	S. littoralis pheromone component	Odorant receptor
Major component	**(Z,E)-9,11-14:OAc**	**???**
Minor components	(Z,E)-9,12-14:OAc	**SlitOR6 + SlitOR13**
	(Z)9-14:OAc	**SlitOR13**
	(Z)11-14:OAc	
	(E)11-14:OAc	
	(E,E)-10,12-14:OAc	

→ The receptor detecting the major pheromone component of *S. littoralis* remained unknown

Montagné *et al* **2012** *Eur. J. Neurosci.*

de Fouchier *et al* **2015** *Front. Ecol. Evol.*

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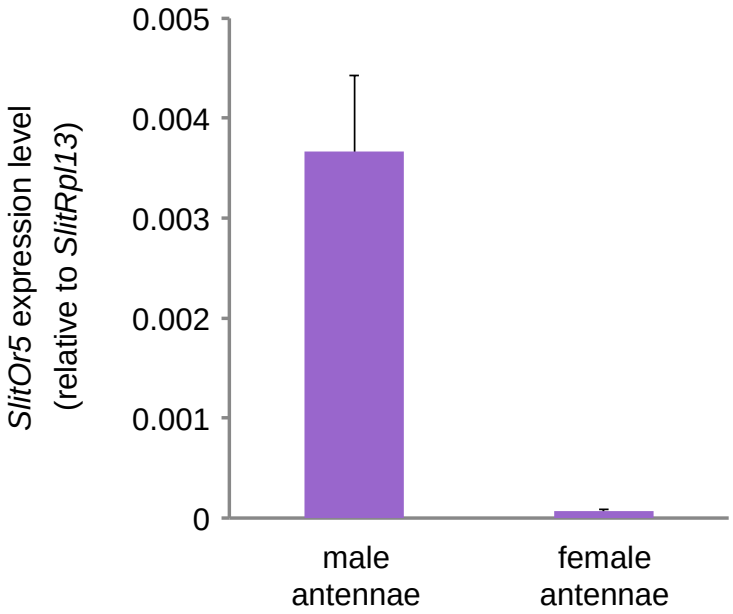
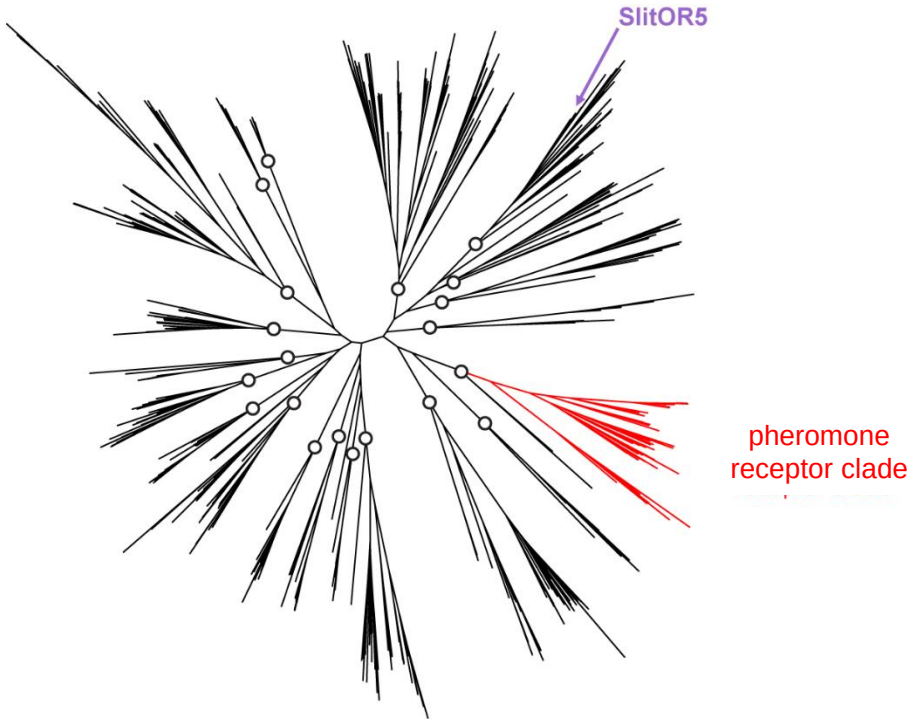
A novel lineage of moth pheromone receptors

qRT-PCR on *S. littoralis* adult antennae



Lepidopteran OR phylogeny



SlitOR5 is strongly male-biased, but does not belong to the classical PR clade

Bastin-Héline *et al* **2019** *eLife*

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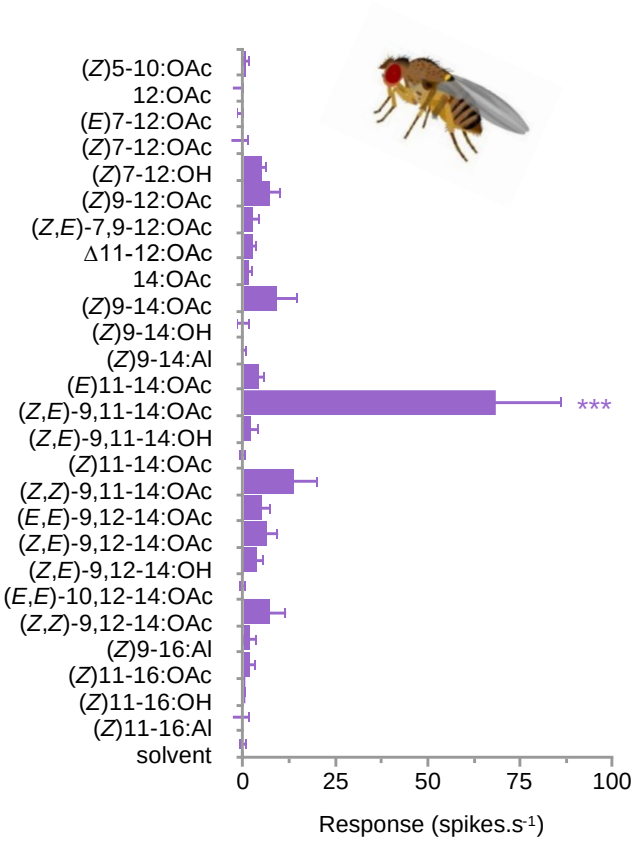
A novel lineage of moth pheromone receptors

Single-sensillum recordings on fly neurons expressing SlitOR5



Lucie
Bastin-Héline

SlitOR5 is tuned to the major pheromone component of *S. littoralis*

Bastin-Héline *et al* **2019** *eLife*

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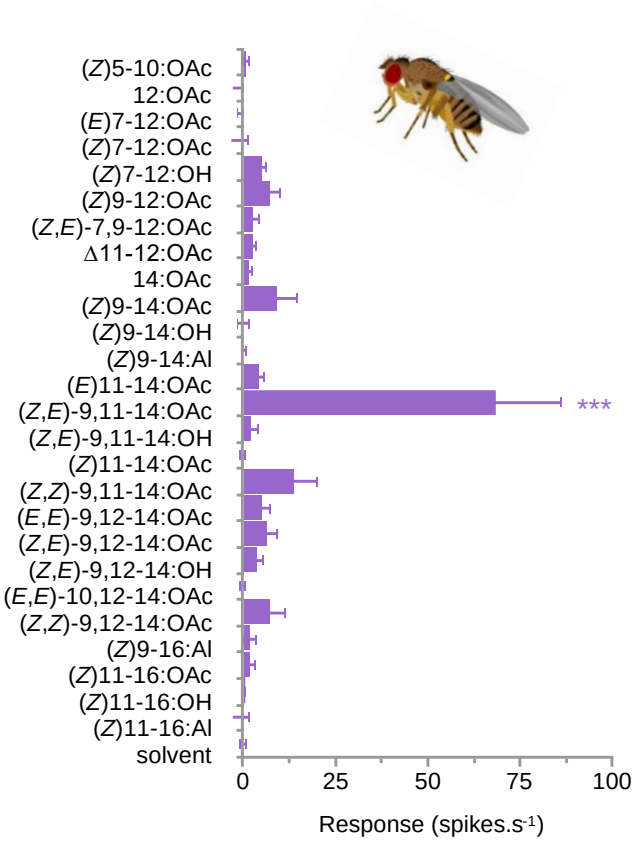
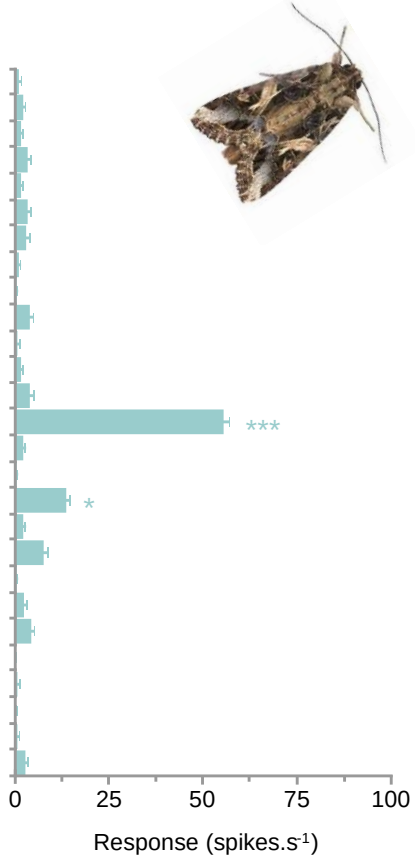


Single-sensillum recordings on *S. littoralis* adult antennae



Lucie Bastin-Héline

Christelle Monsempes

SlitOR5 is tuned to the major pheromone component of *S. littoralis*

Bastin-Héline *et al* **2019** *eLife*

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A novel lineage of moth pheromone receptors

Fotini Koutroumpa

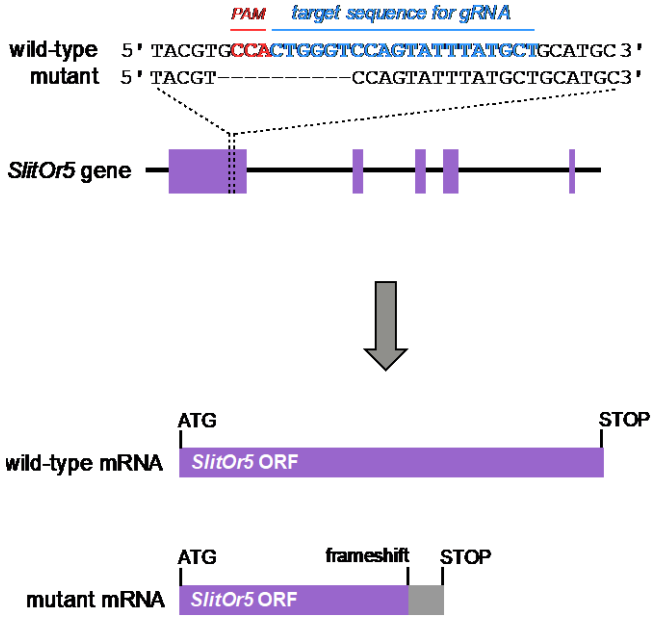
Marie-Christine François

Christelle Monsempes

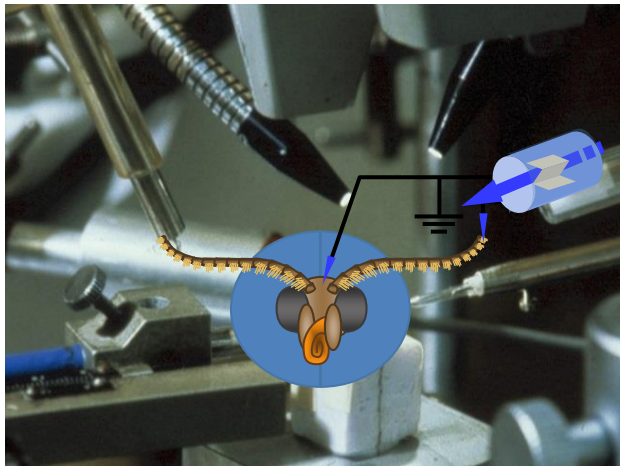
Lucie Bastin-Héline

Deletion in the *SlitOr5* gene via CRISPR-Cas9

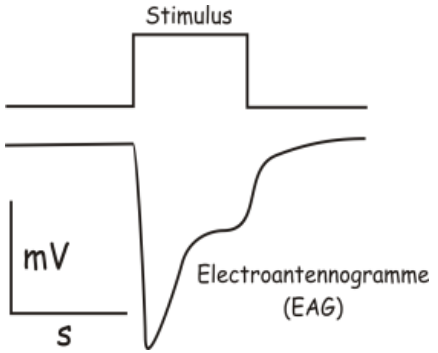
gRNA/Cas9 injection



Phenotyping via electro-antennography in *S. littoralis* males



Photos:iEES



Bastin-Héline *et al* **2019** *eLife*

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A novel lineage of moth pheromone receptors

Electro-antennography in *S. littoralis* males

Odorant tested:

Z9, E12-14:Ac

Z9, E11-14:Ac

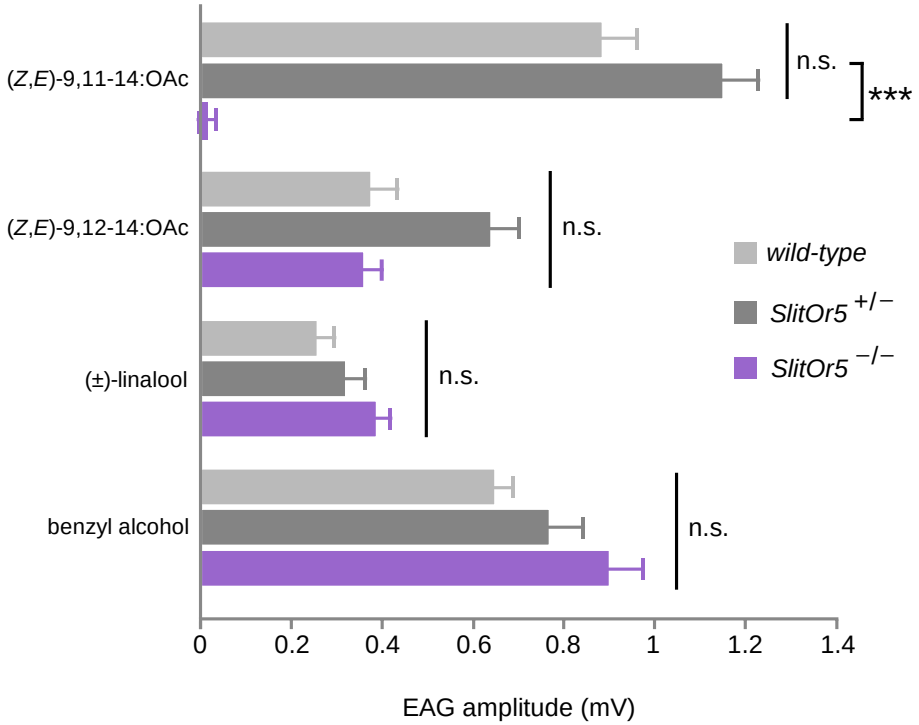
OR6

OR5

Linalool

benzyl OH

ORs



Inactivation of the *SlitOr5* gene by CRISPR-Cas9 impairs detection of (*Z*,*E*)-9,11-14:OAc

Bastin-Héline *et al* **2019** *eLife*

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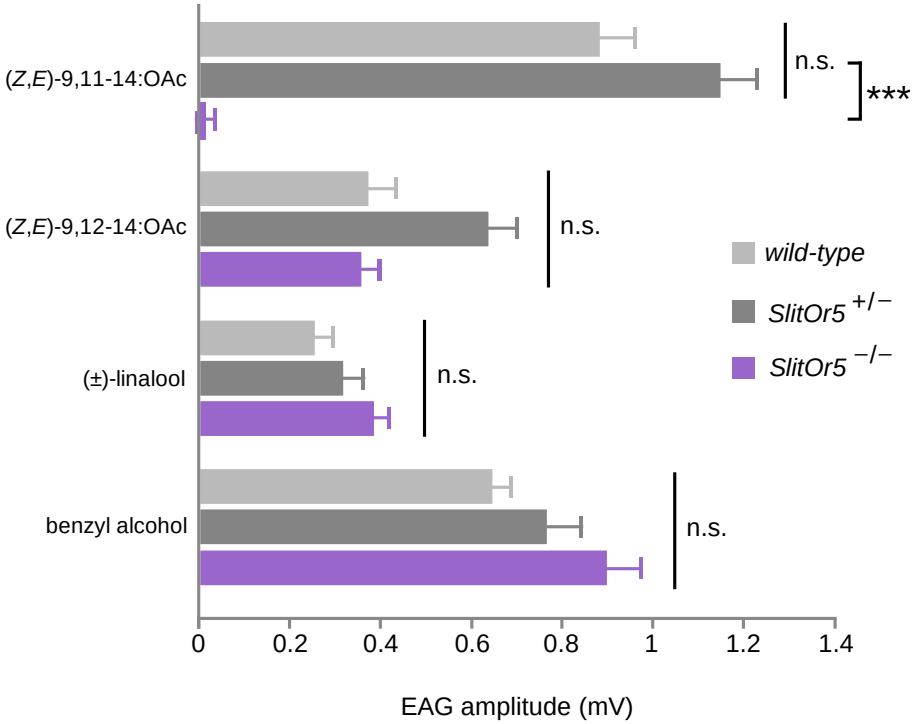
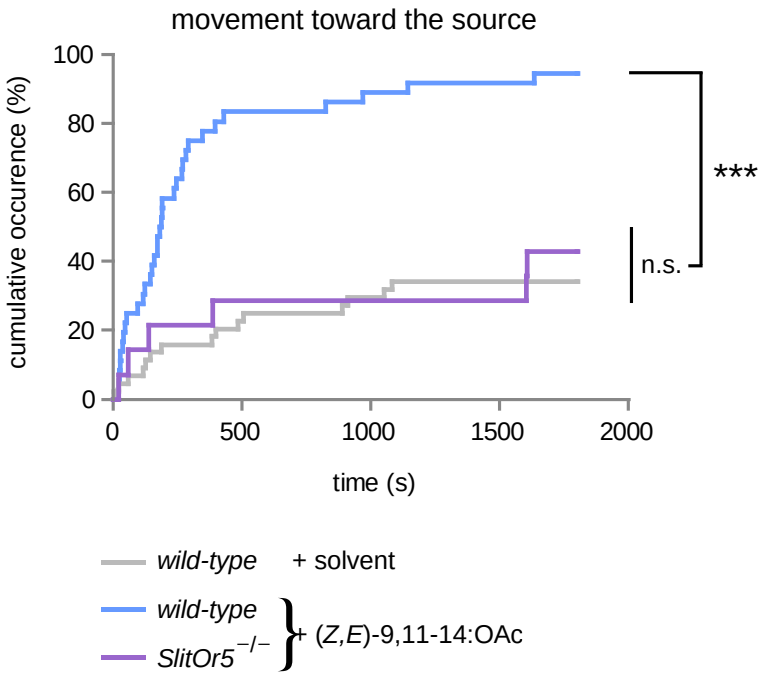
A novel lineage of moth pheromone receptors

Electro-antennography in *S. littoralis* males



Male response (behavior)



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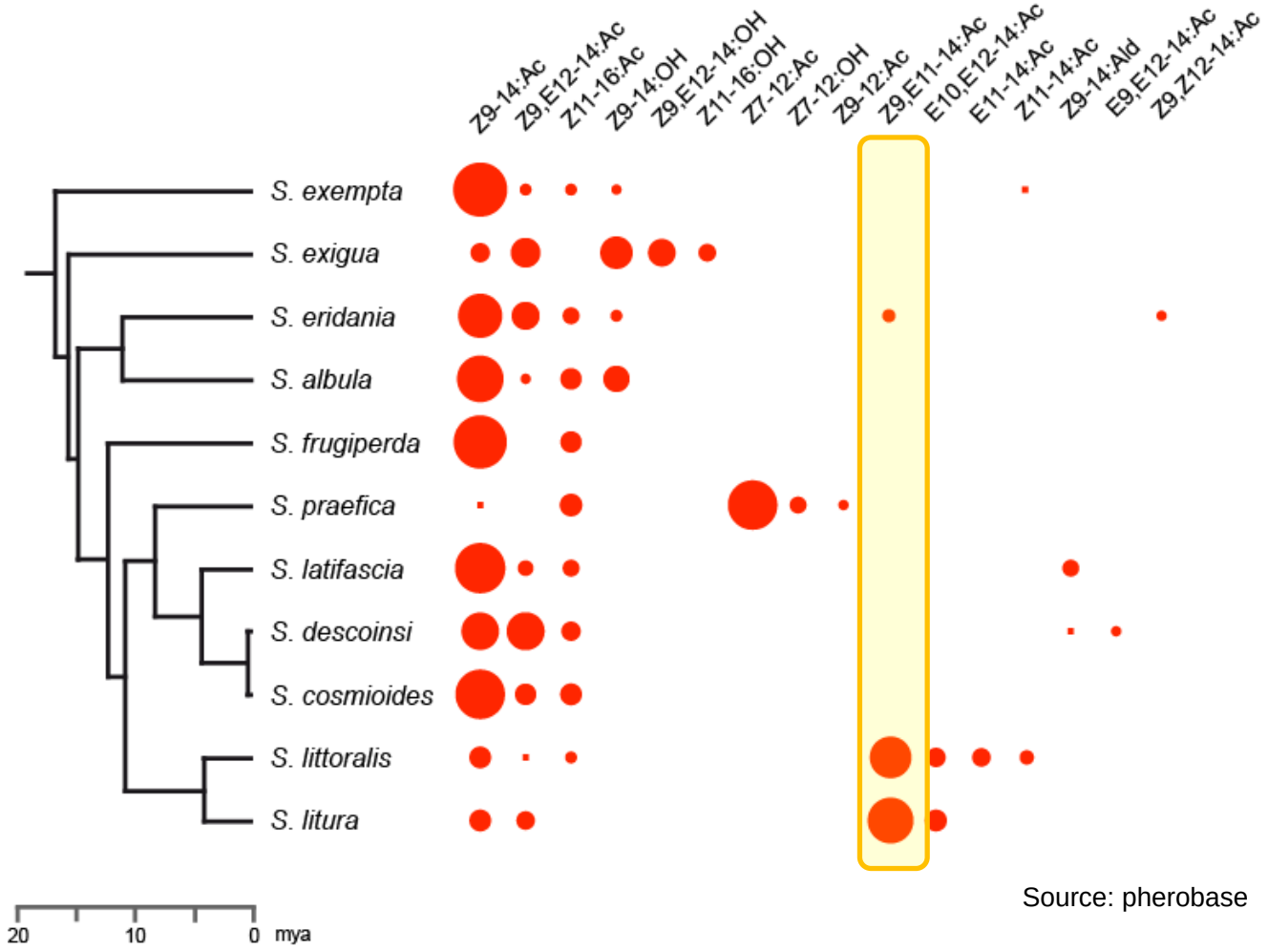
Evolution of sex pheromones in the genus *Spodoptera*



Source: pherobase

How did the capacity to detect (*Z*,*E*)-9,11-14:OAc evolve ?

Li, Capoduro *et al* **in prep.**

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Evolution of sex pheromones in the genus *Spodoptera*

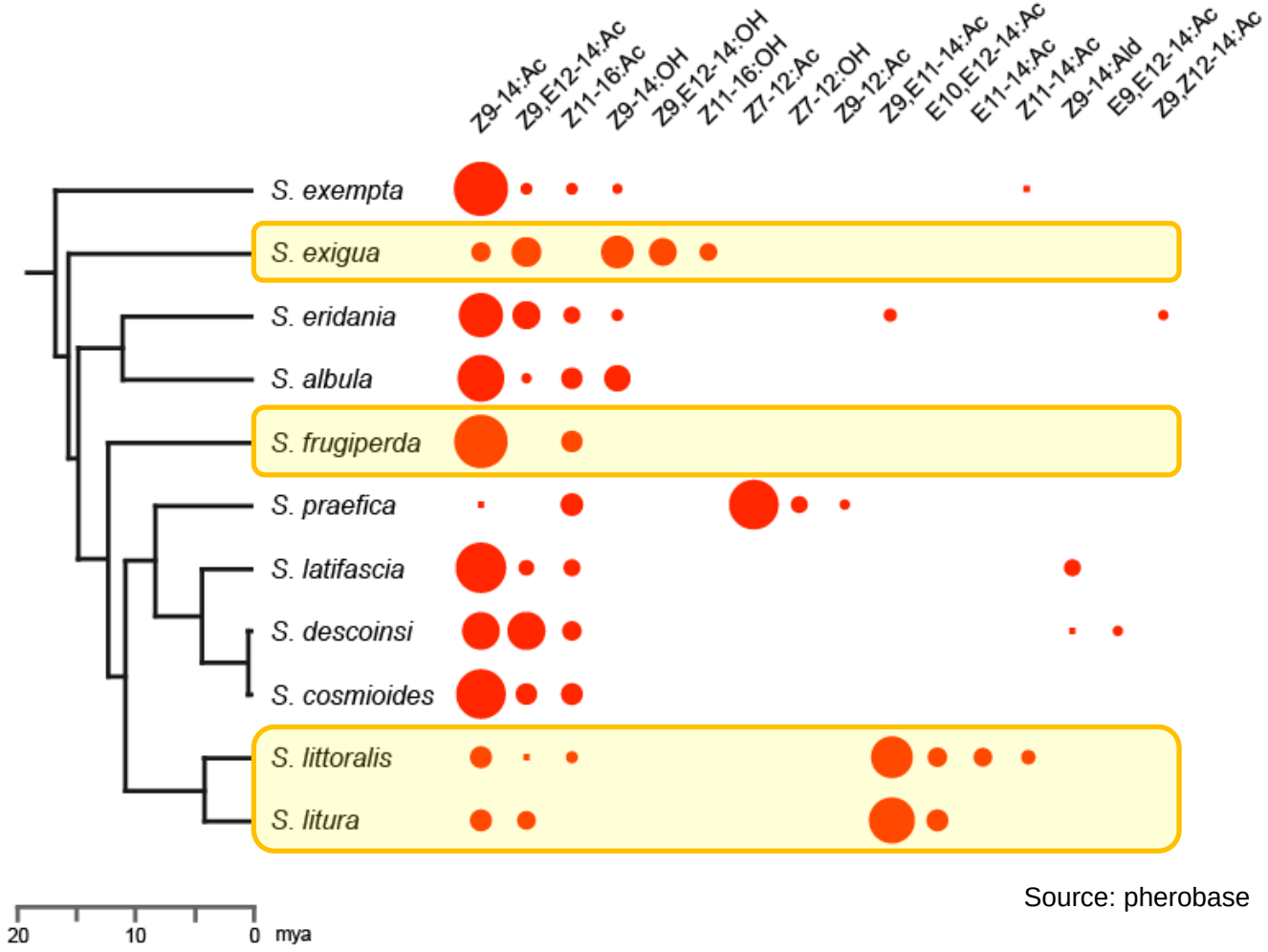
Photos:web

S. exigua

S. frugiperda

S. littoralis

S. litura



Source: pherobase

How did the capacity to detect (*Z,E*)-9,11-14:OAc evolve ?

Li, Capoduro *et al* **in prep.**

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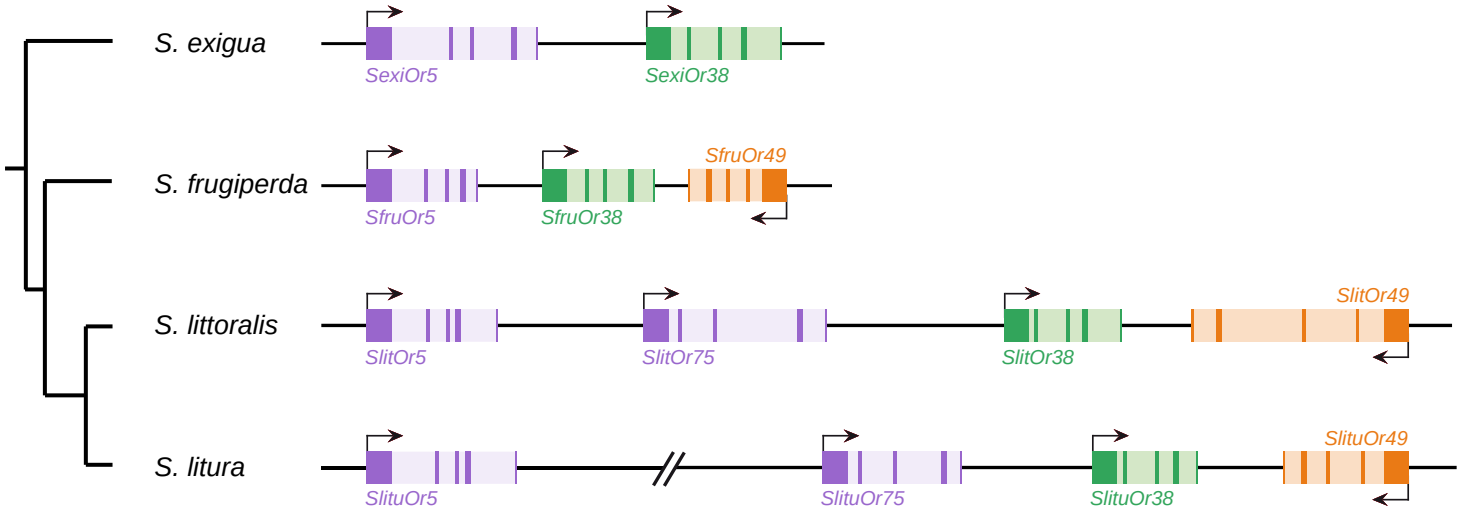
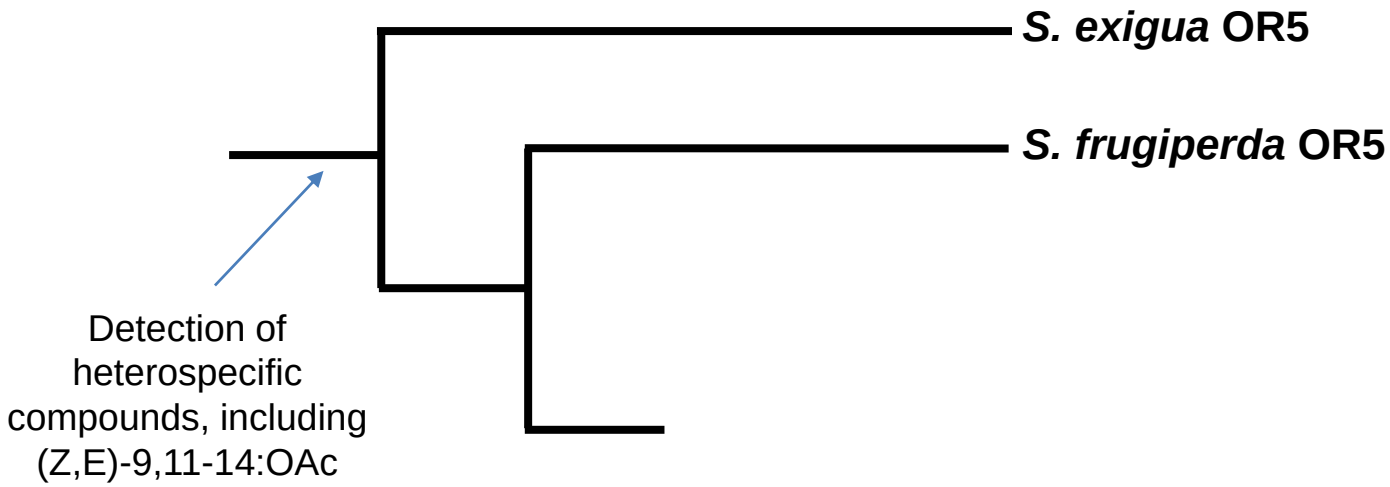
Identification of SlitOR5 orthologues and paralogues functional characterization

Genome analyses



Li, Capoduro *et al* **in prep.**

The functional characterization of SlitOR5 orthologues and paralogues (unpublished) led us to propose an evolutionary scenario for the Or5 gene in *Spodoptera*



unpublished

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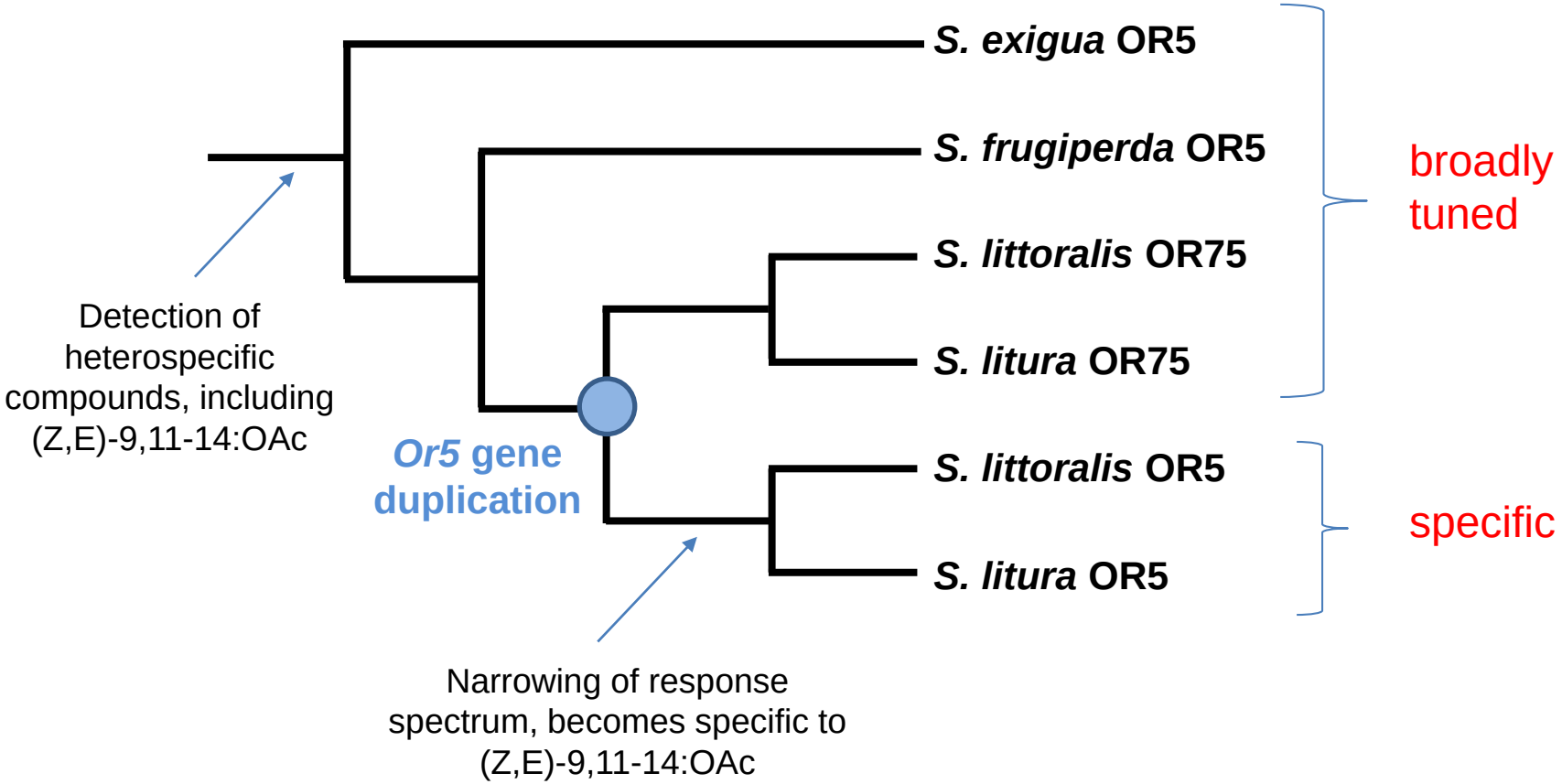
Evolutionary scenario for the Or5 gene in *Spodoptera*



unpublished

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Conclusion and perspectives

- ✓ an atypical pheromone receptor identified, defining a new clade of PRs
  -> *PR evolved at least time in Lepidoptera*

- ✓ Identification of mutations in insect ORs responsible for shifts in function
  -> *links between structure and function*

- ✓ Structure-based virtual screening for the identification of OR agonists
  -> *development of novel products for pest management*

- ✓ Evolution of sex pheromone biosynthesis

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William Walker et al