Social behavior and its impact in *Drosophila*

赵环 陈洁 孙梦实

2019-04-30


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outline

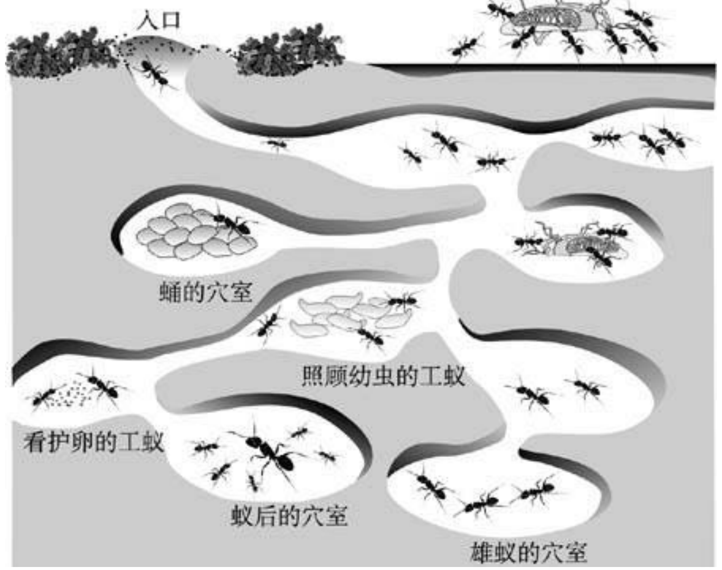
- The definition and classification of social behavior in *Drosophila,* the latest analysis methods.

- The Social experiences affect survival-related behaviors in *Drosophila melanogaster*

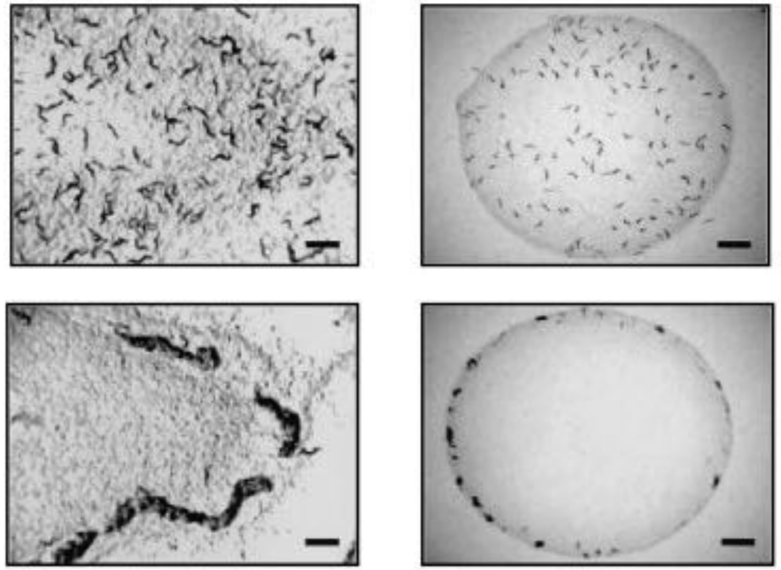
- Effects of social experience on productive behavior in *Drosophila*

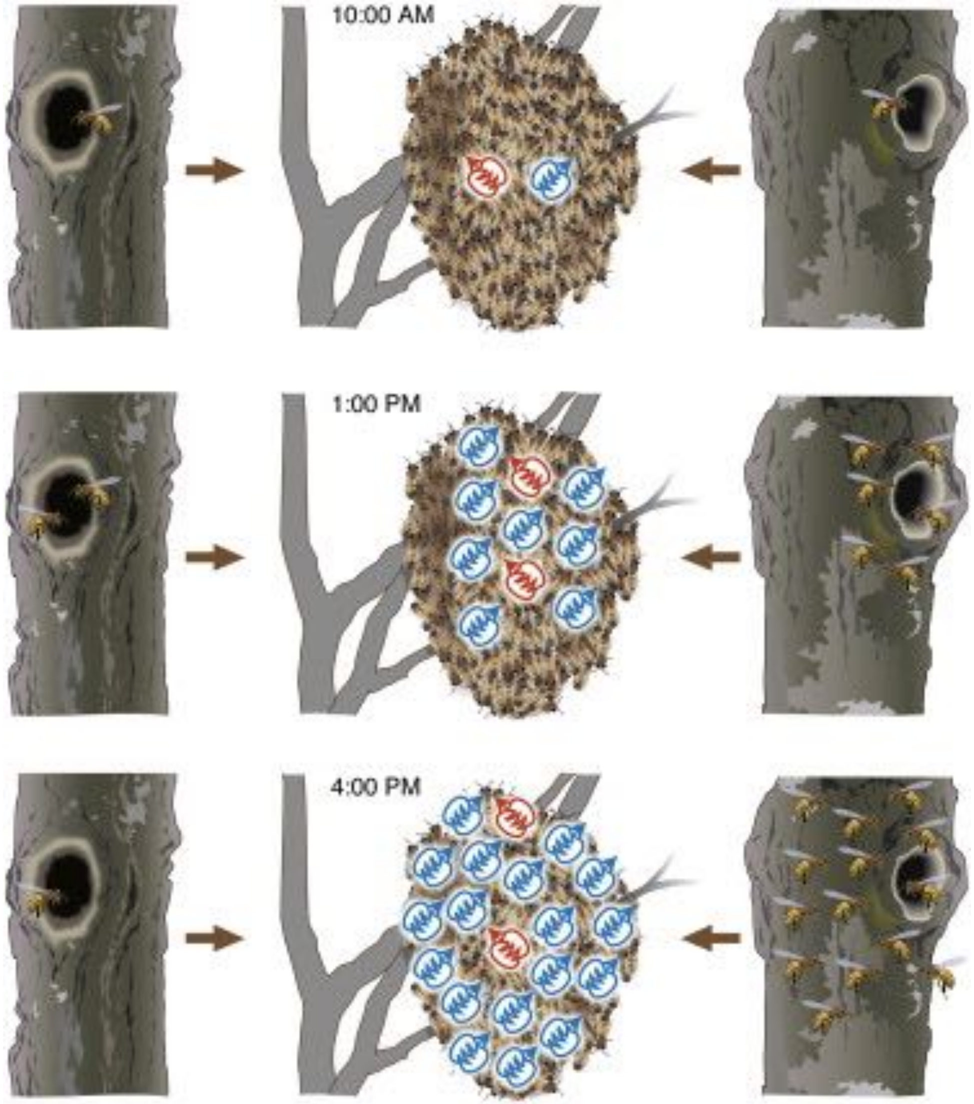
The definition and classification of social behavior in *Drosophila*

Social behavior in animal kingdom



Social behavior in insects world





Advantages Of Using *Drosophila* As A Model

- *Drosophila* has a broader set of social behaviors
- Complex nervous system and its complex physical and social environments
- *Drosophila*'s long history as a genetic model, along with its cadre of genome resources, makes it an ideal organism to identify genes and molecules involved in normal social behavior.

Classification and definition of social behavior in *Drosophila*

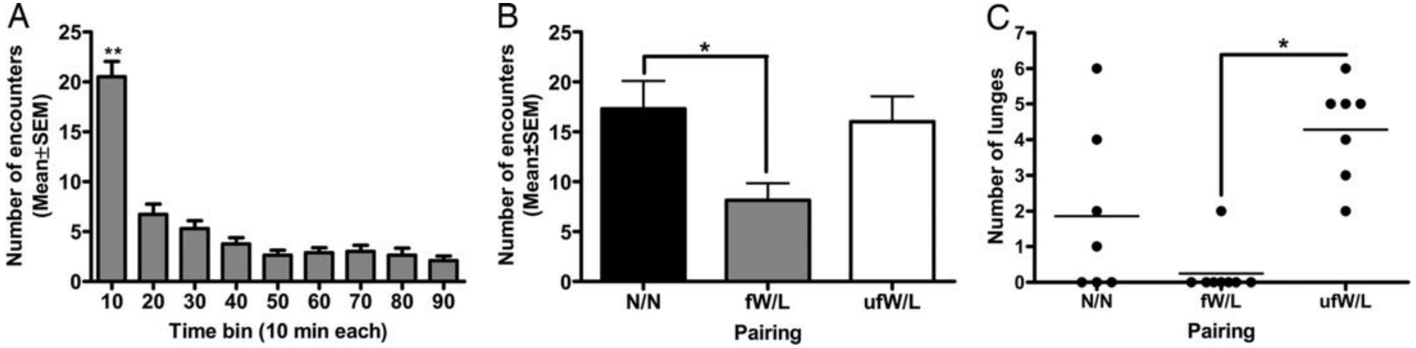
Information transmission :

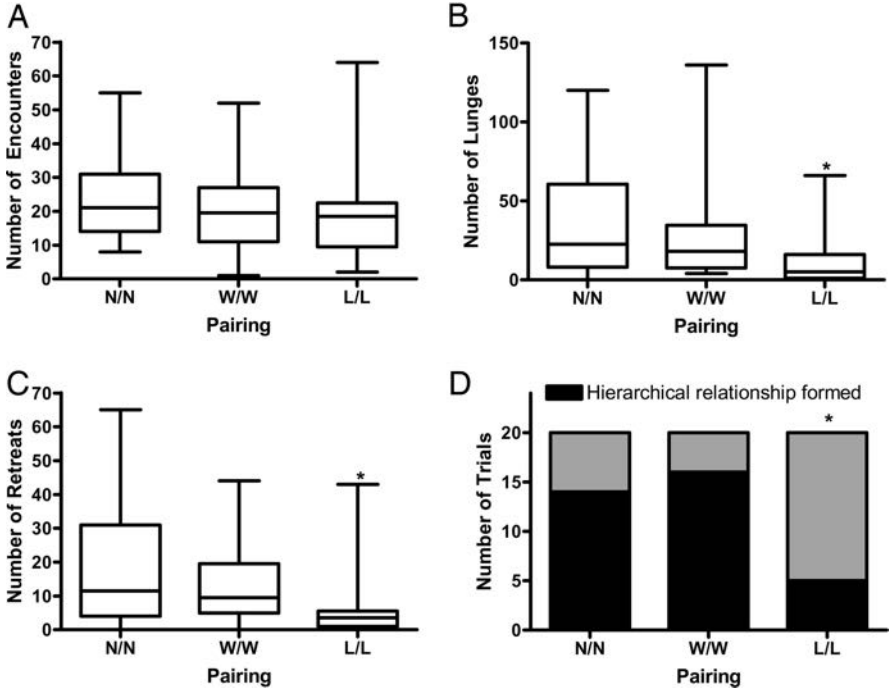
- competitive : aggression
  social learning-- individual recognition and dominance hierarchies or networks
- cooperative : Information sharing– learning and memory , searching , court and mate,
  mate copying ,egg laying ,
  avoidance of enemy

The Way of Social Behavior Contact

- Visual communication
- Auditory sense
- Olfactory sense
- Chemical communication : Pheromones
- Touch

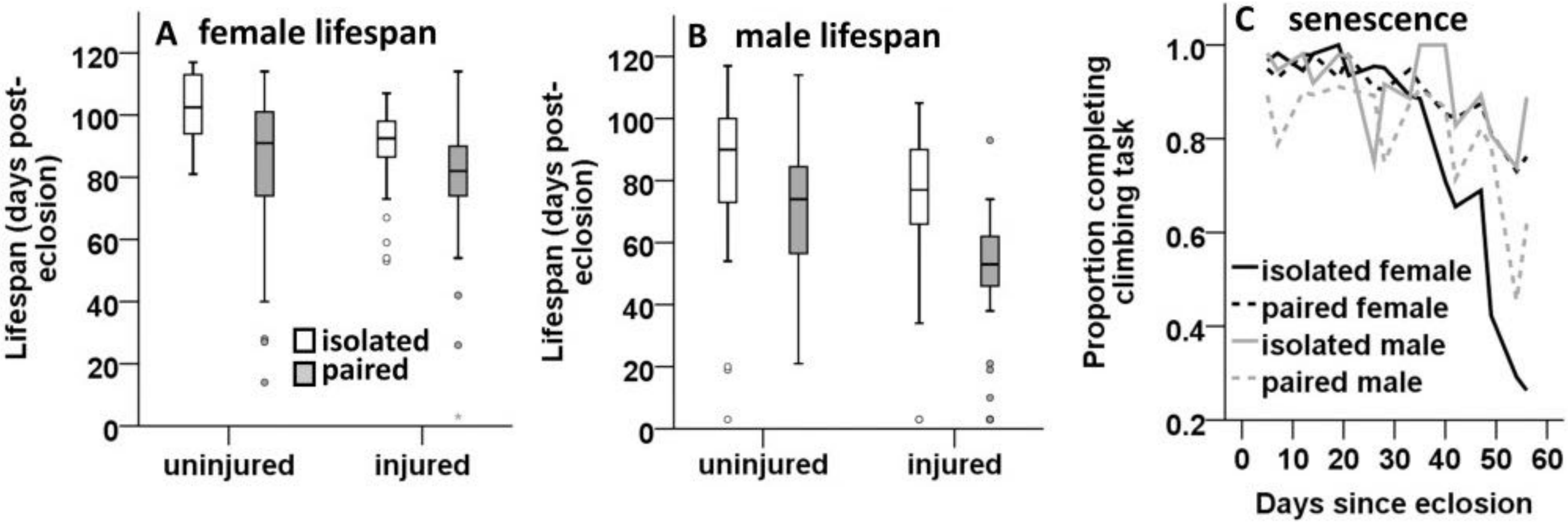
Individual recognition and hierarchies establishment





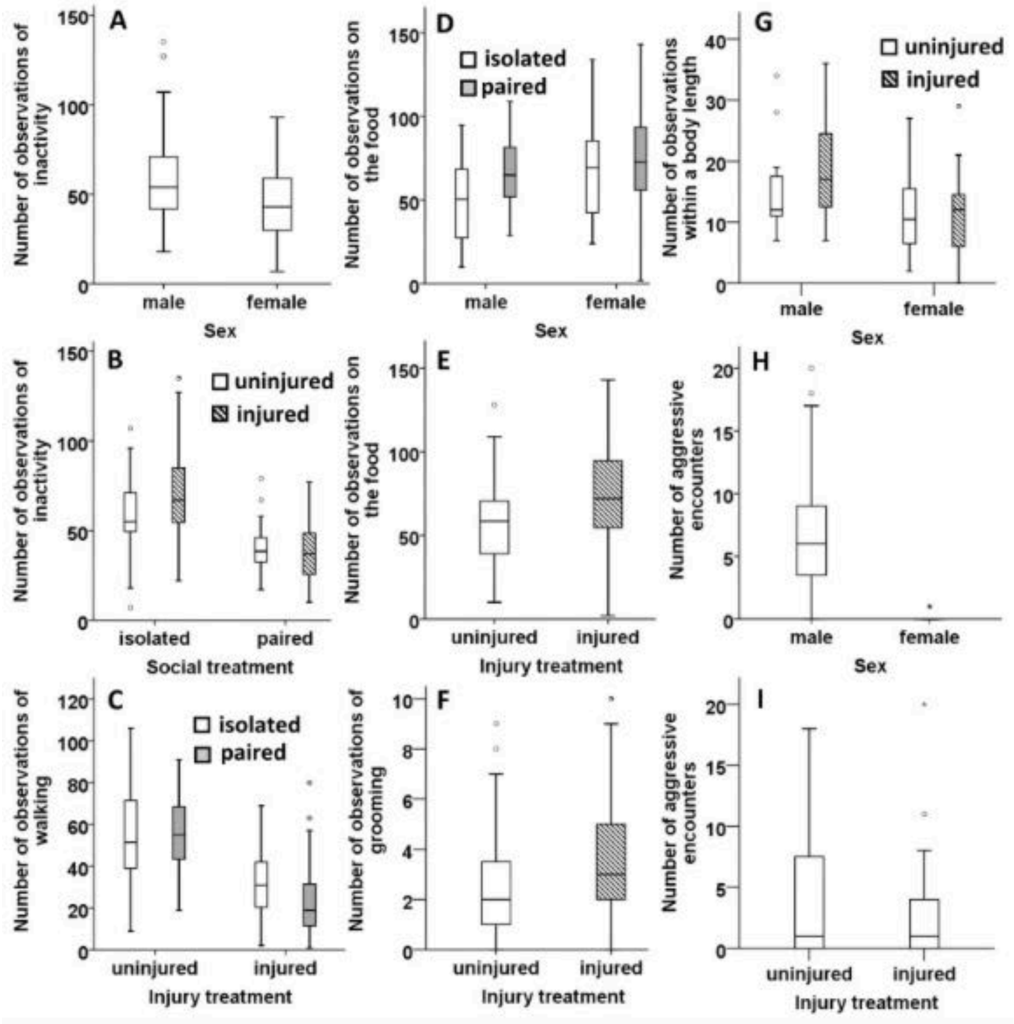
Alexandra Yurkovic et al. 2006

Social contact reduces lifespan for both sexes, but is more severe for males.



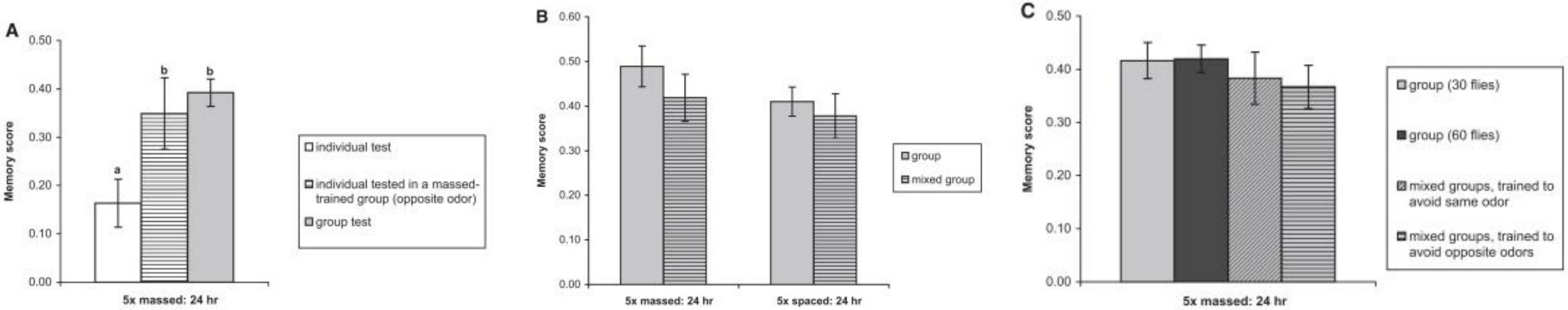
Thomas Leech et al. 2009

Different performance after social conditioning



Thomas Leech et al. 2009

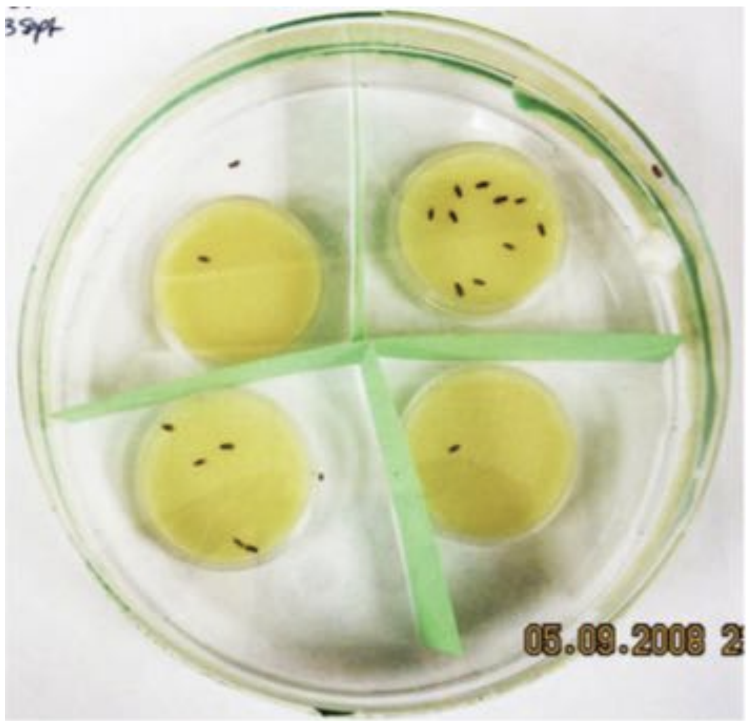
Effects on learning and memory: LTM improvement in individual flies , social interactions between flies enhance their performance in ARM

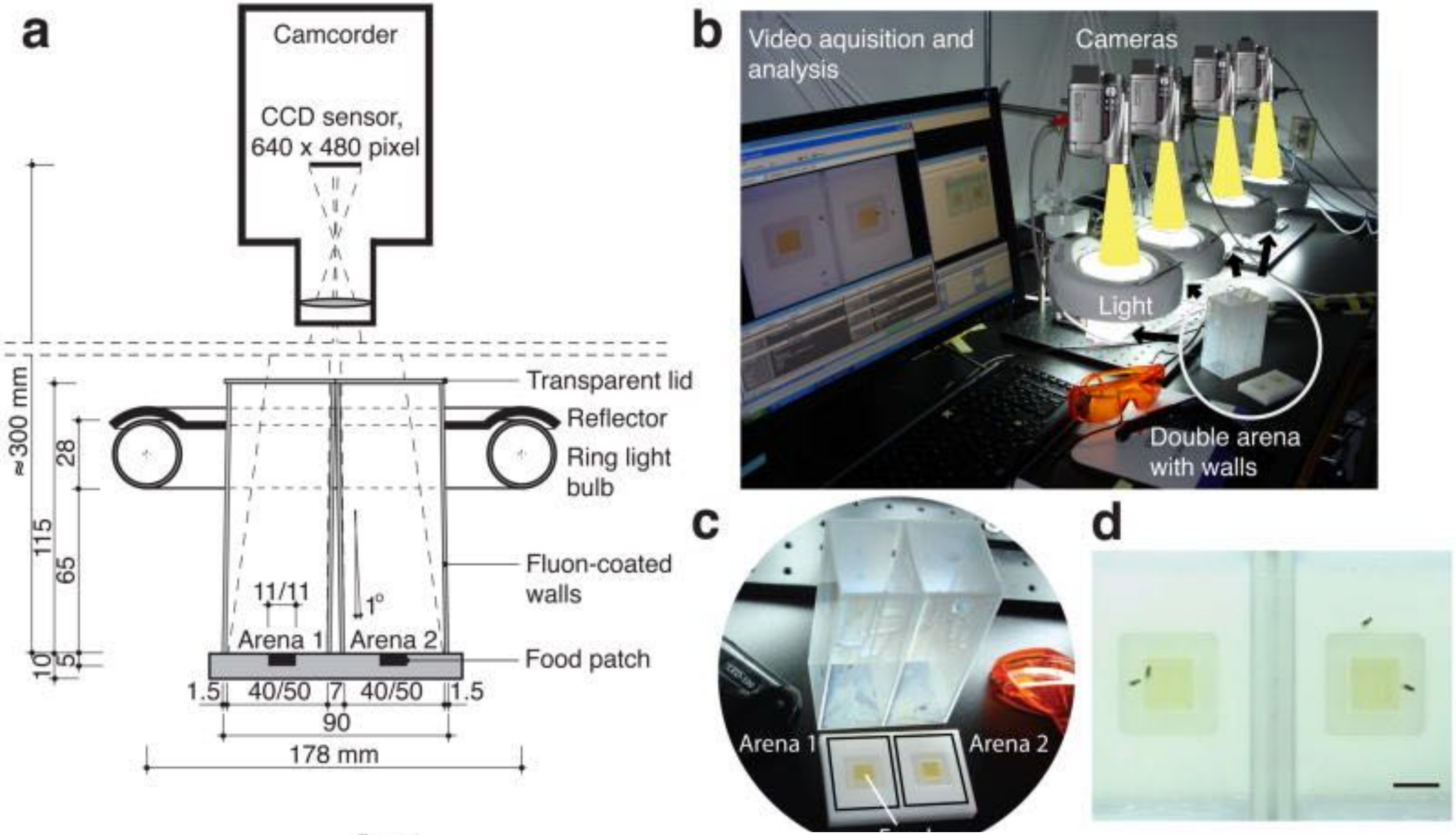


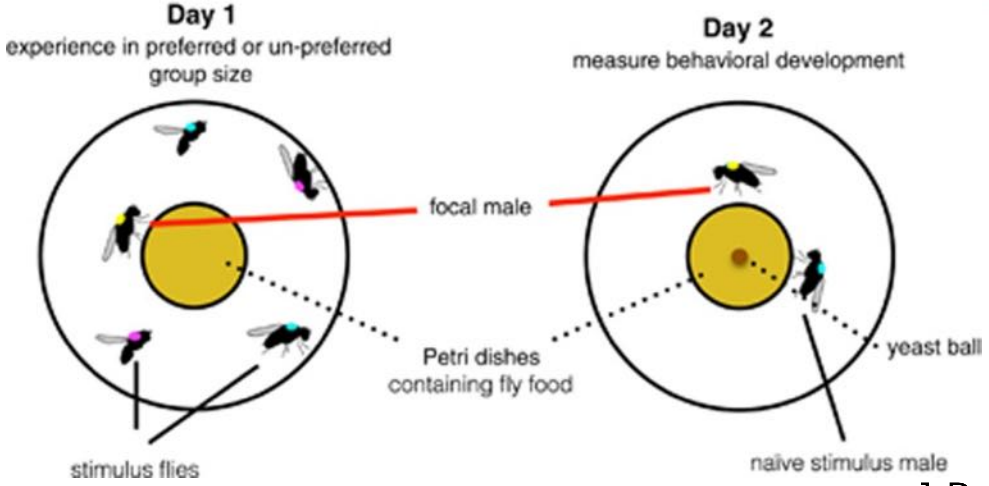
Chabaud MA et al. 2009

Methods to analyze the social interaction among Drosophila

- Genetic way
- Behavior way

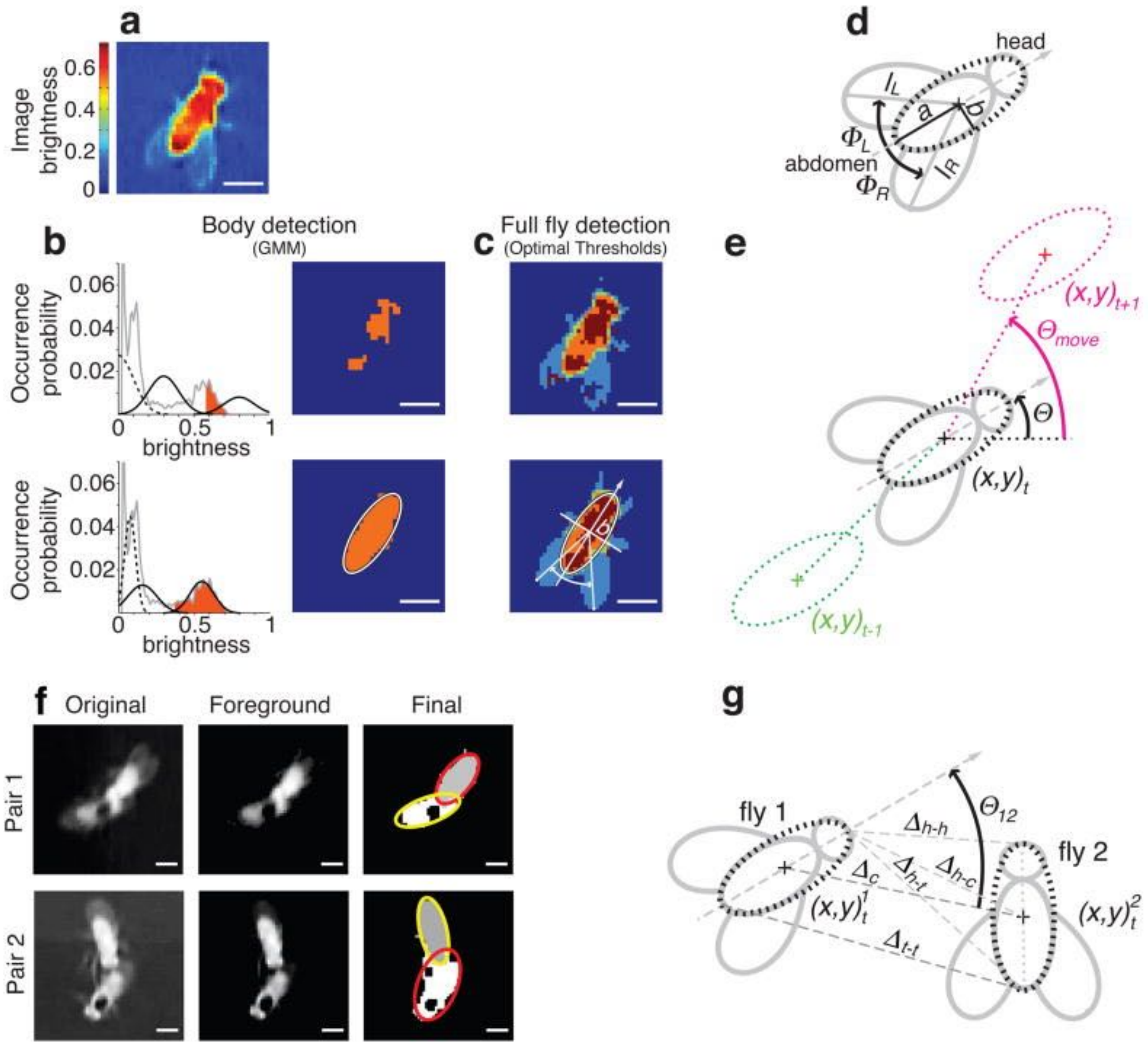






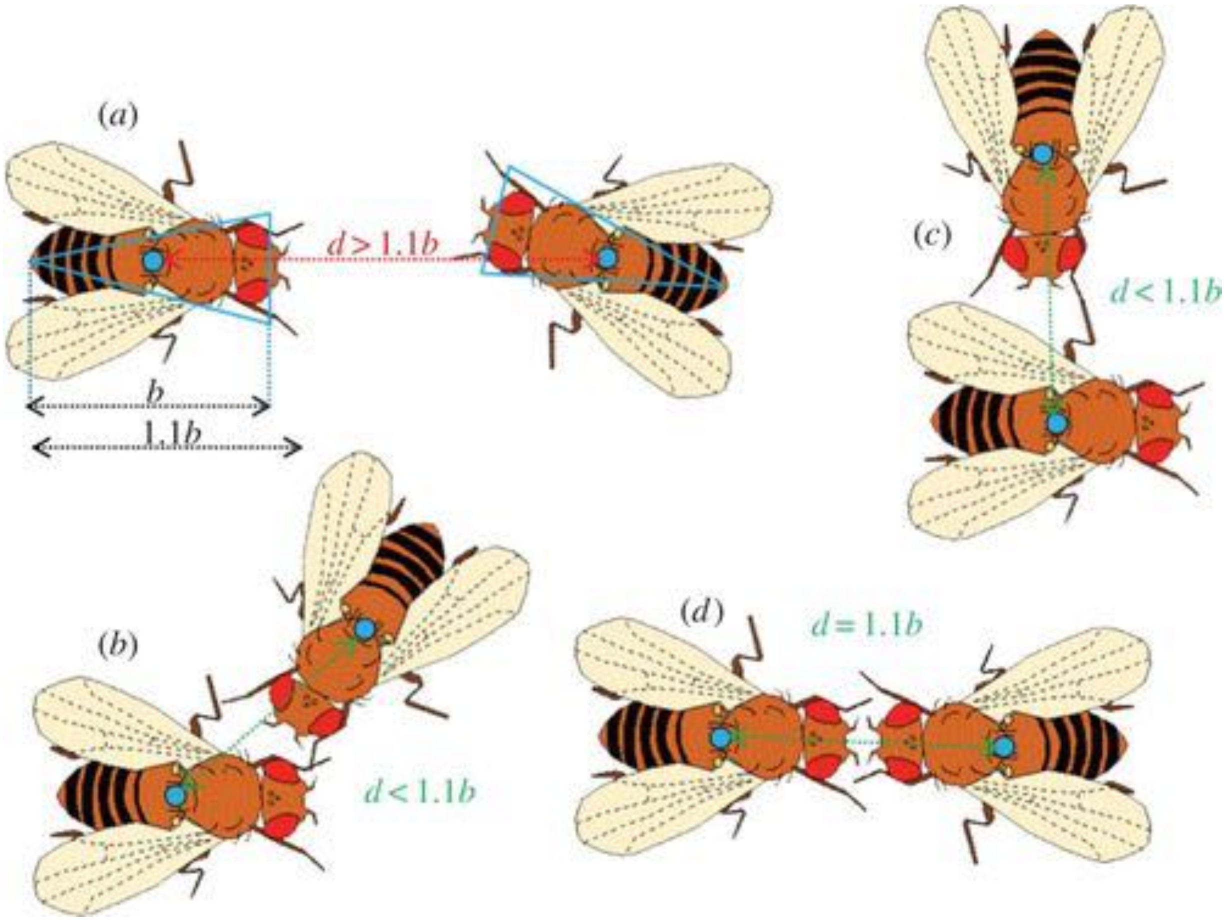
J B Saltz 2011

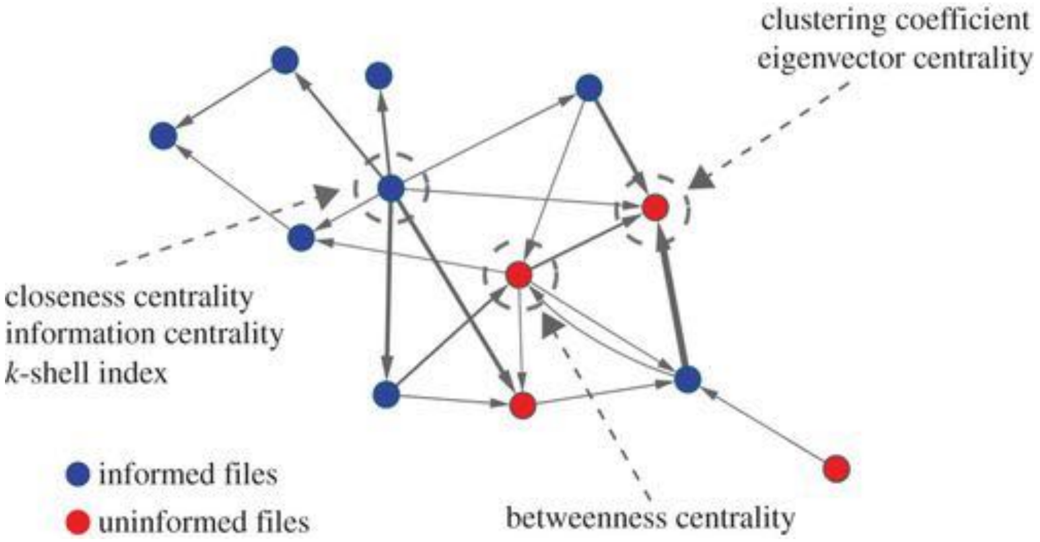
J B Saltz 2017



Heiko Dankert et al.2009

Social network analysis





Cristian Pasquaretta et al. 2016

Social experiences affect survival-related behaviors in *Drosophila melanogaster*

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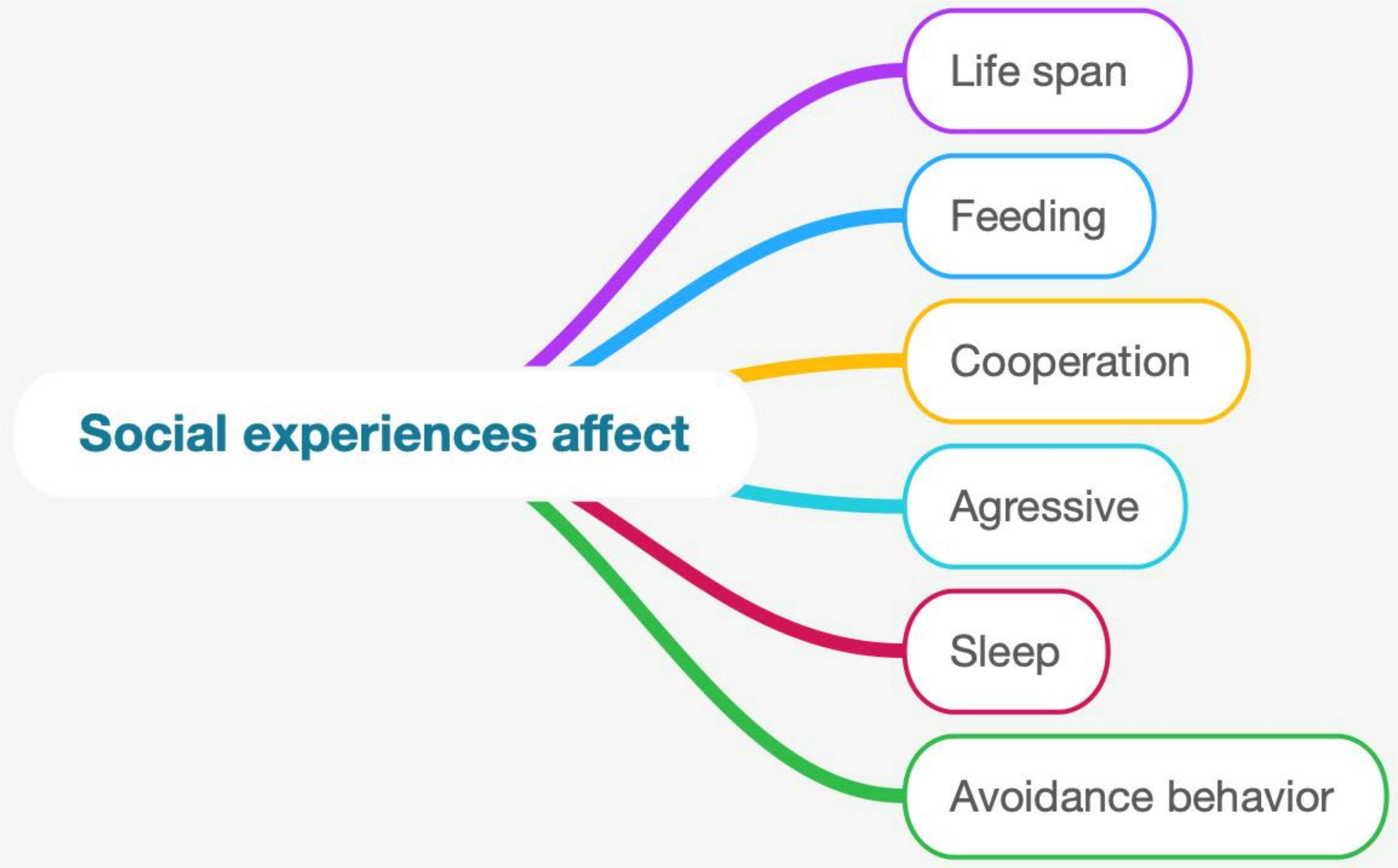
Overview


Social experiences affect
Life span
Feeding
Cooperation
Agressive
Sleep
Avoidance behavior

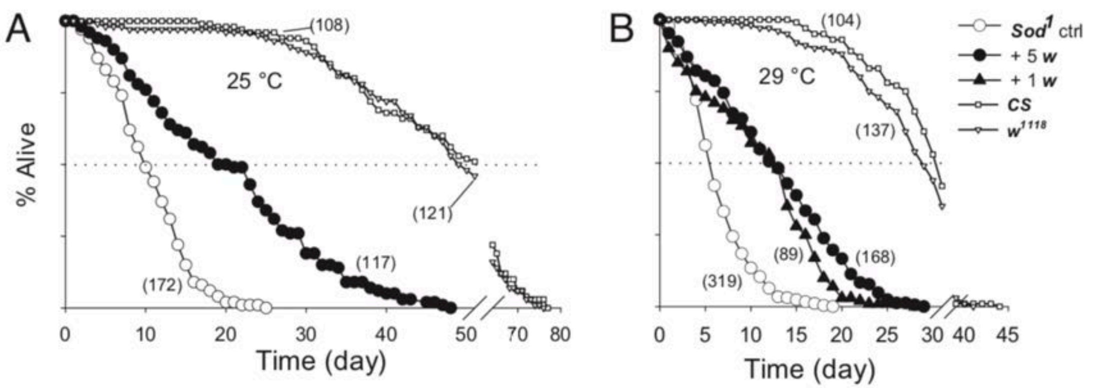
Social behavior and life span

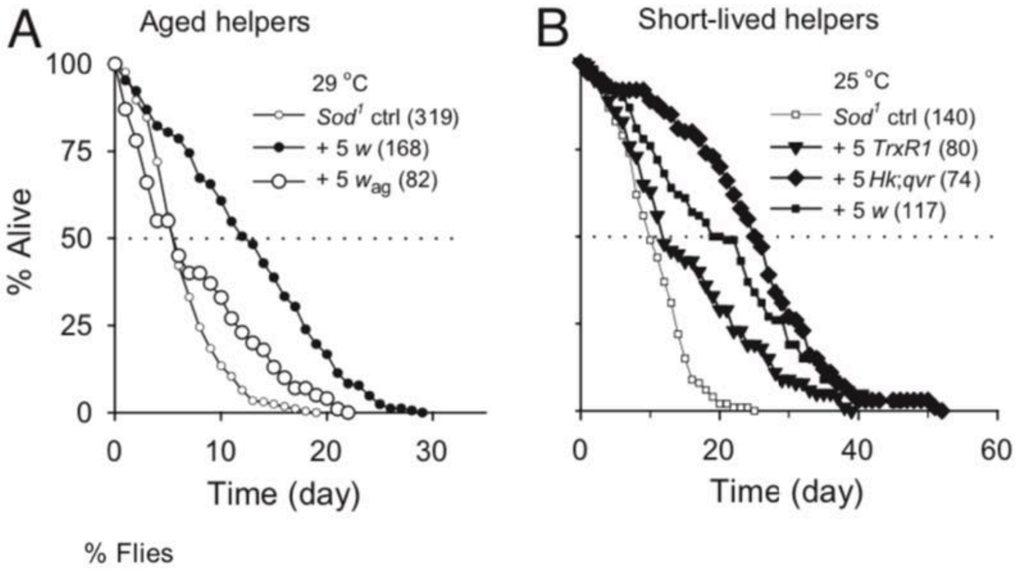
Social interaction-mediated lifespan extension of *Drosophila* Cu/Zn superoxide dismutase mutants

Hongyu Ruan and Chun-Fang Wu*

Department of Biology, University of Iowa, Iowa City, IA 52242

Edited by Barry Ganetzky, University of Wisconsin, Madison, WI, and approved March 24, 2008 (received for review November 27, 2007)





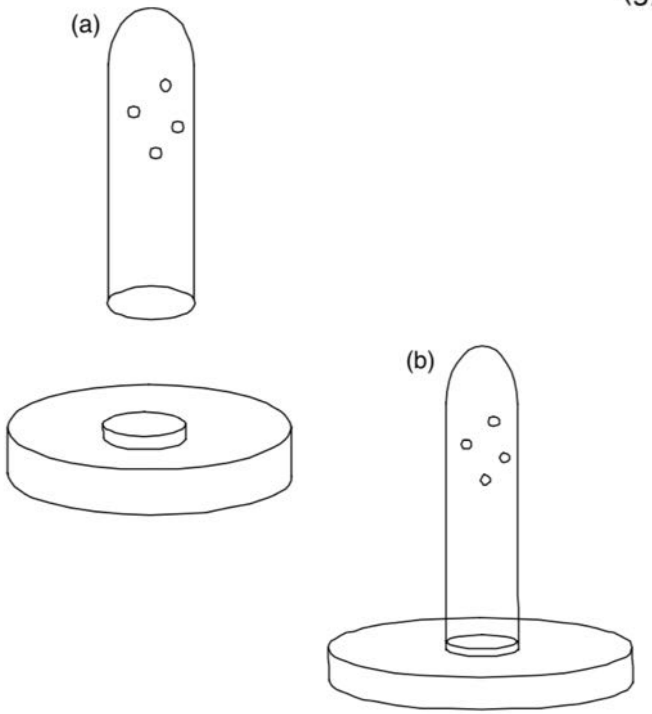
Short-lived *Drosophila* mutants of the antioxidant enzyme Cu/Zn superoxide dismutase displayed a robust lifespan extension, upon cohousing with active flies of longer lifespan or younger age.

Social behavior and feeding behavior

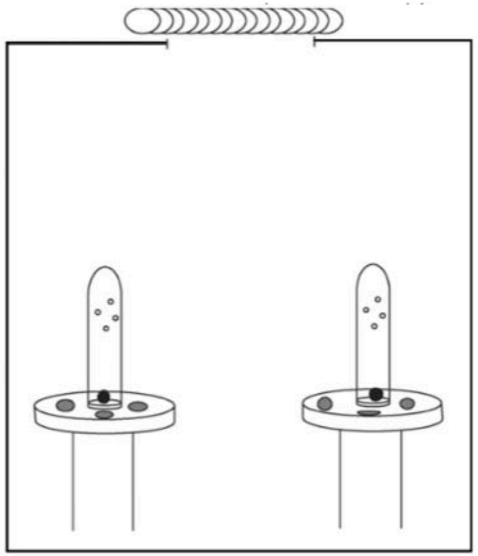
Genes, Brain and Behavior (2004) **3:** 39–50

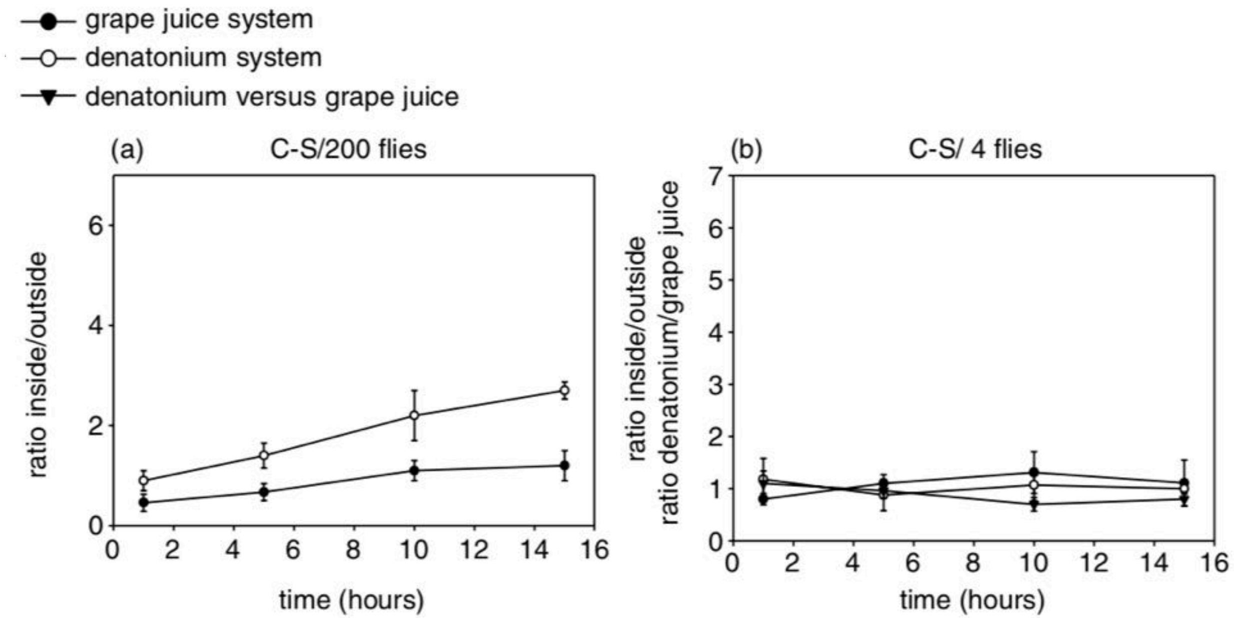
Cooperation between *Drosophila* flies in searching behavior

S. Tinette, L. Zhang and A. Robichon*



(g)

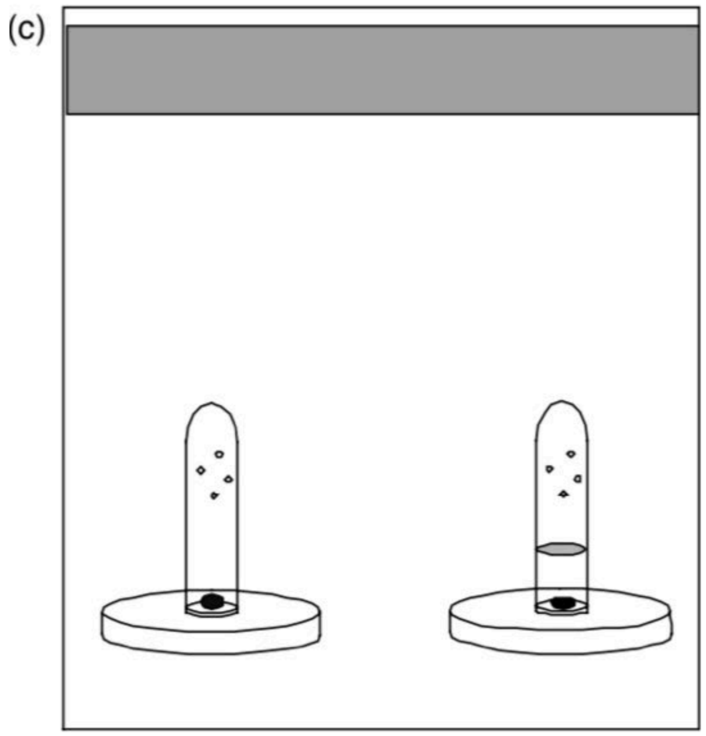




Searching index depends on the size of the fly population

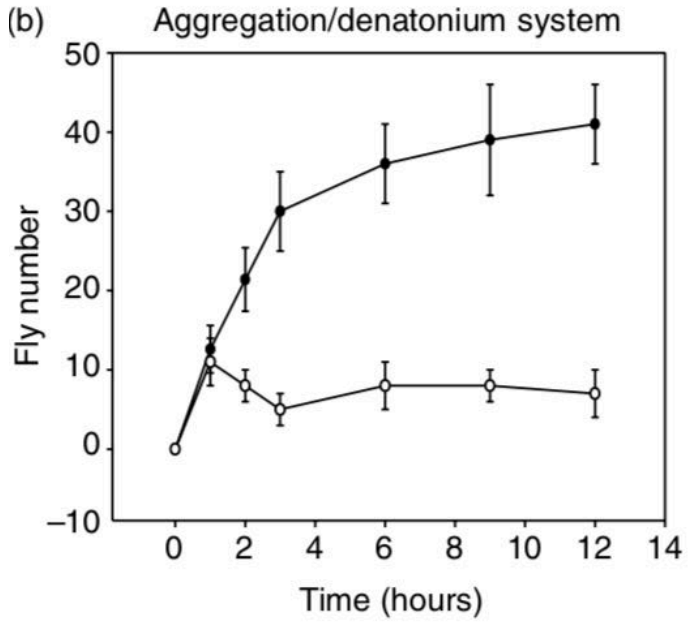
Social behavior and feeding behavior

The searching / aggregation behavior suggests that Drosophila adults are gregarious and cooperative

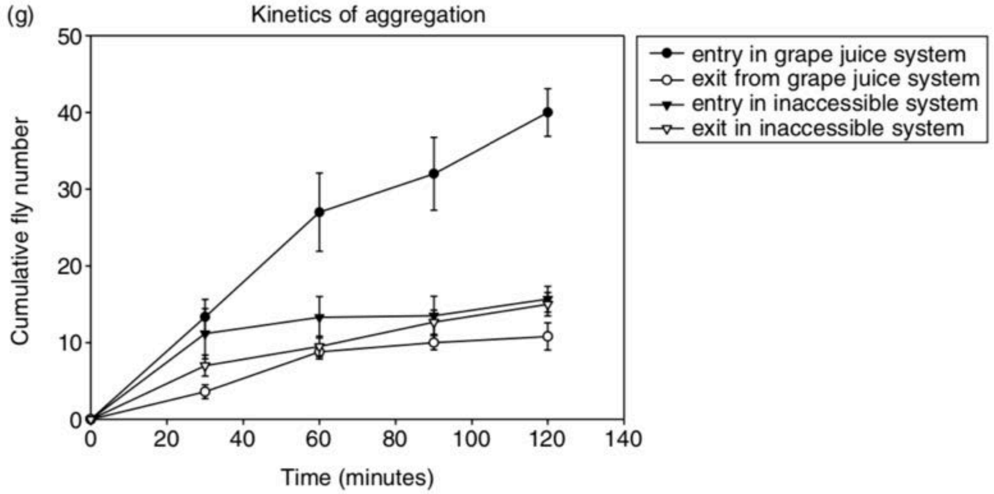


grape juice system

Inaccessible system
(gradient of odors
is stonger)



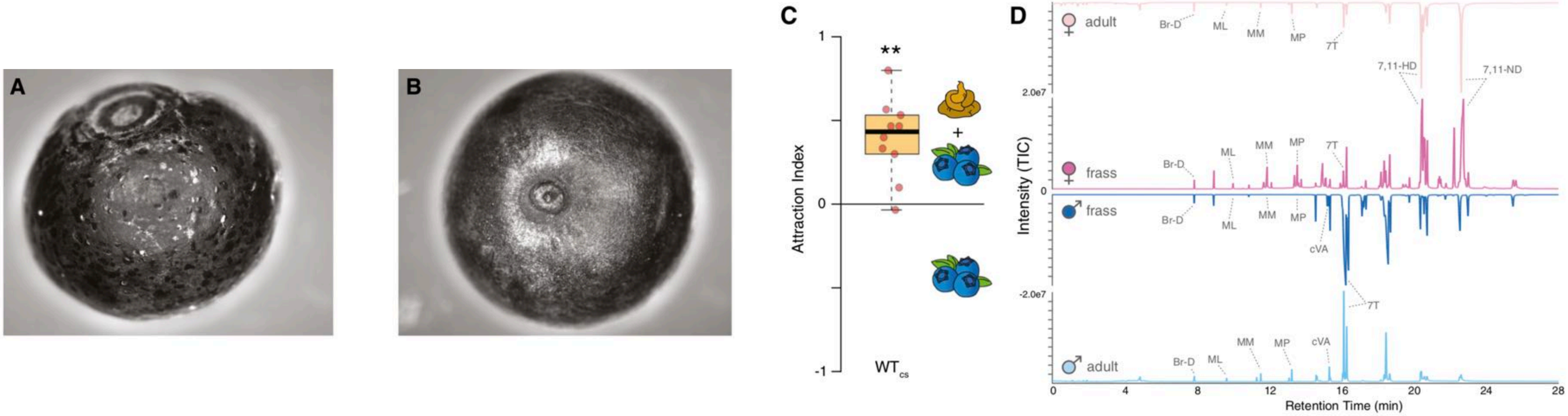
the denatonium/grape juice column (open circle)
the grape juice column (filled circle)



Social behavior and feeding behavior

Adult Frass Provides a Pheromone Signature for *Drosophila* Feeding and Aggregation

Ian W. Keesey[1] · Sarah Koerte[1] · Tom Retzke[1] · Alexander Haverkamp[1] · Bill S. Hansson[1] · Markus Knaden[1]



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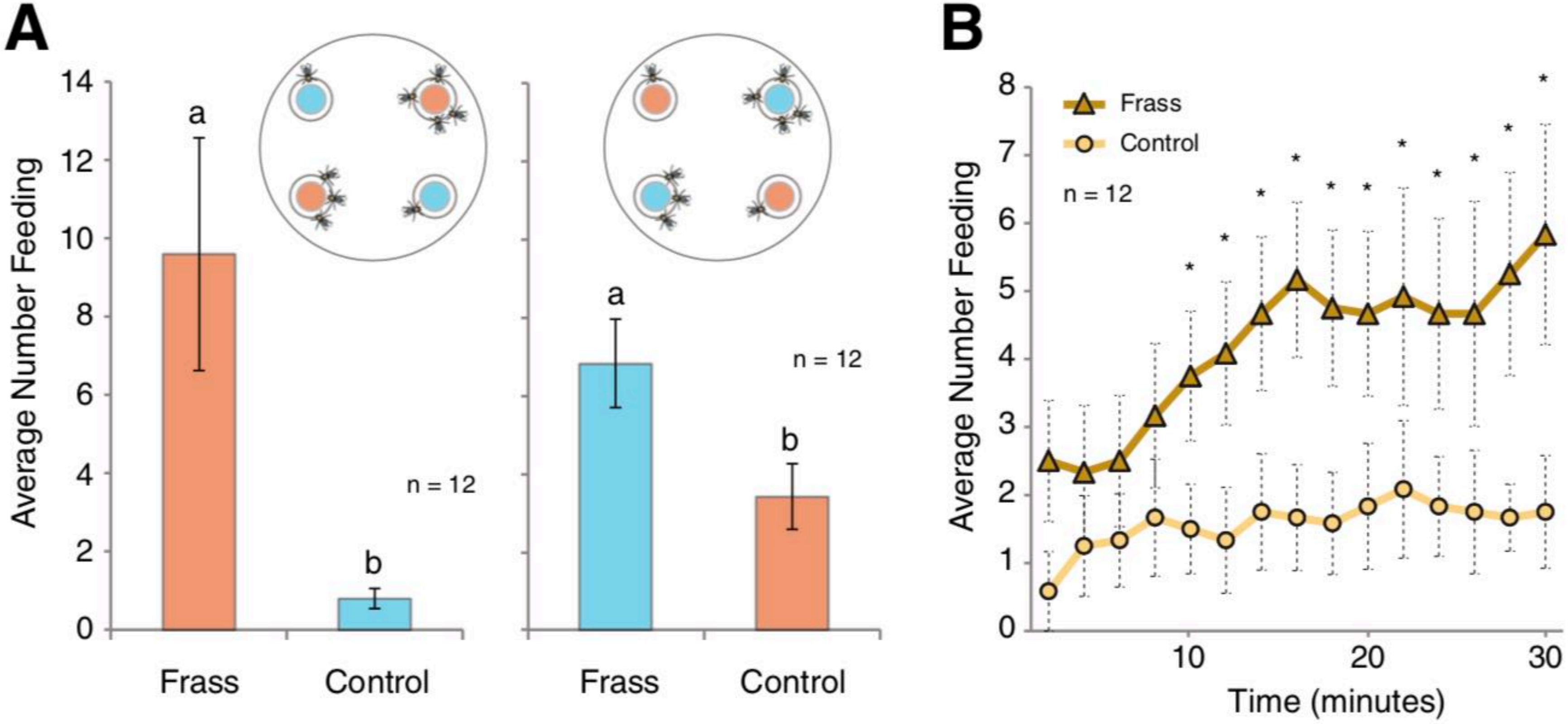
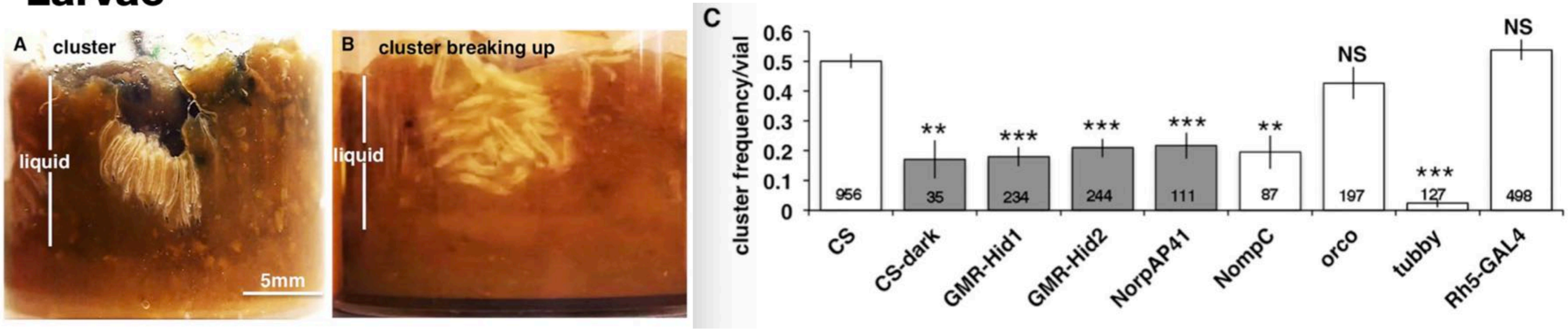
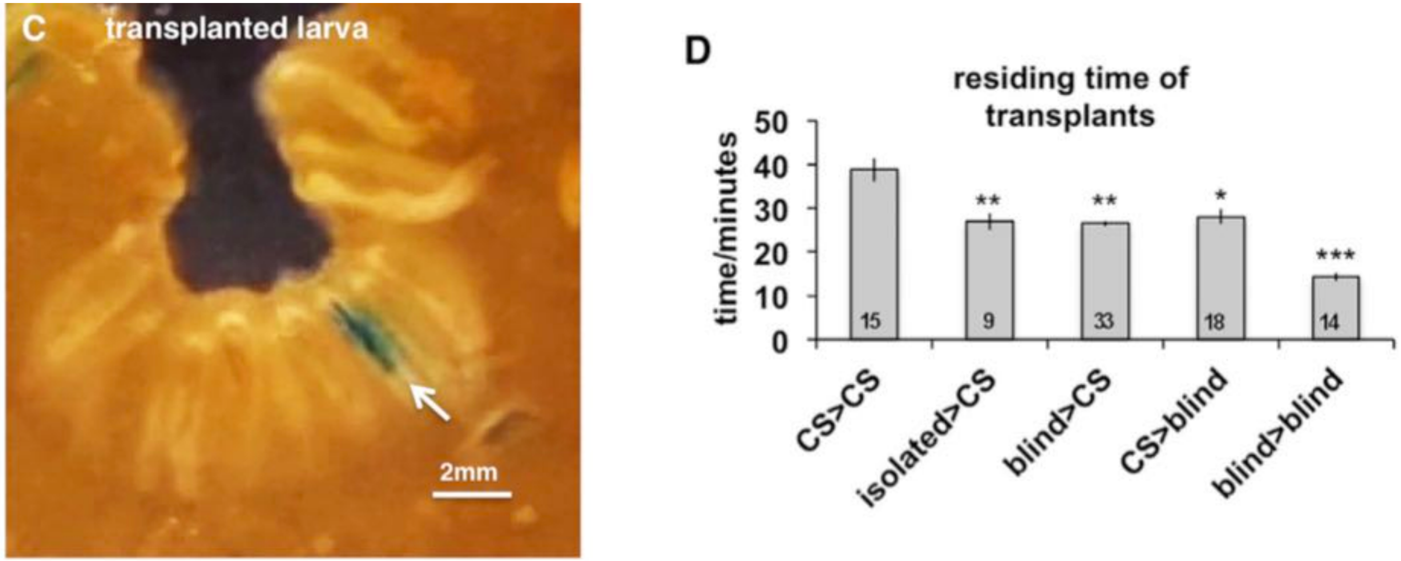


Social behavior and Cooperation

Current Biology

Cooperative Behavior Emerges among *Drosophila* Larvae





*Cooperation requires visually guided
inter-larval coordinated

*Stable membership in cooperative groups requires experience

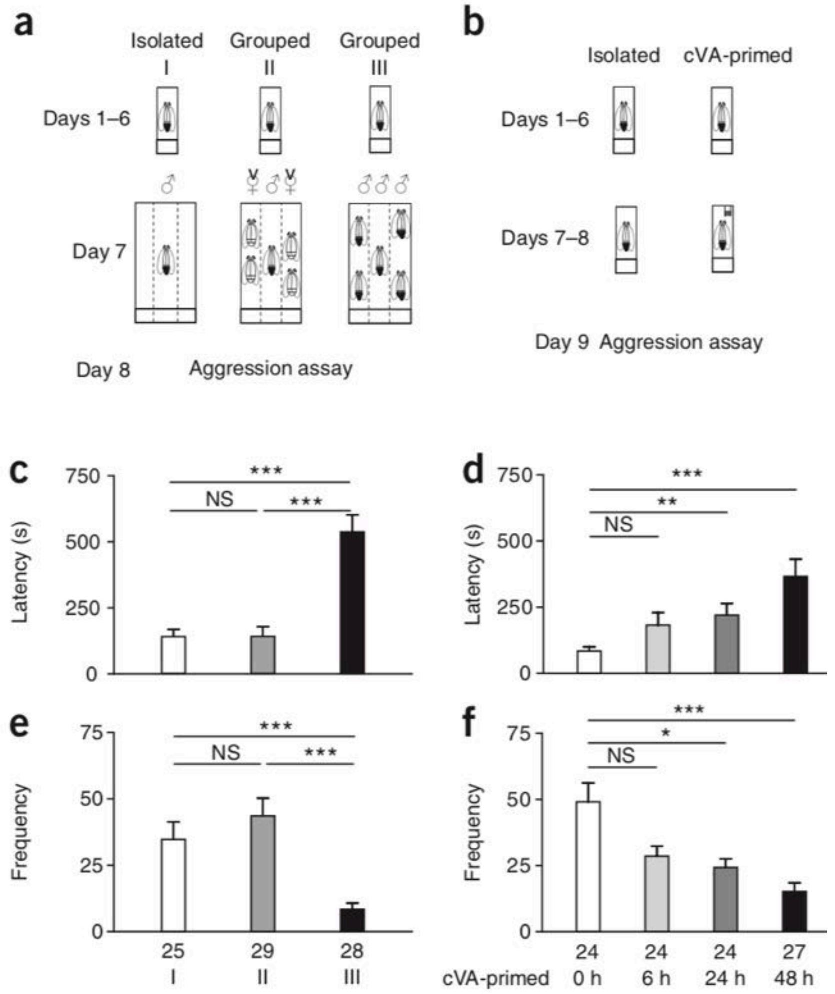
Dombrovski et al., 2017, Current Biology

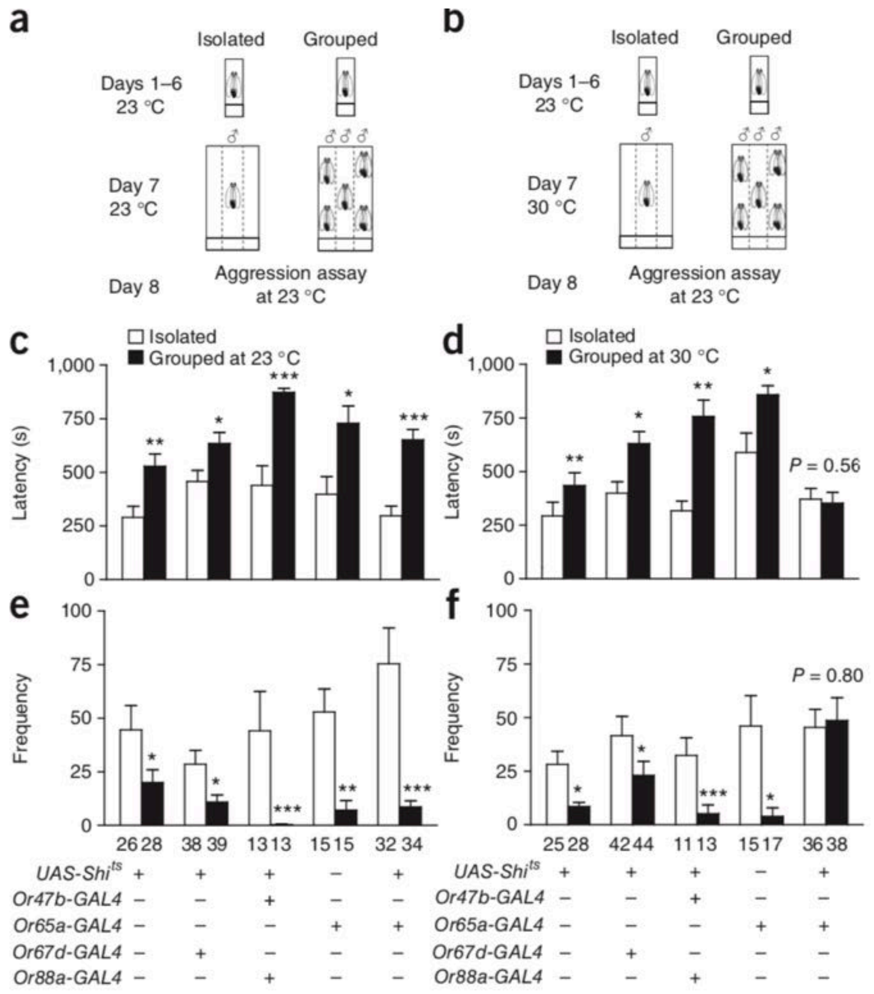
Social behavior and aggressive

Social regulation of aggression by pheromonal activation of Or65a olfactory neurons in *Drosophila*

nature neuroscience

Weiwei Liu[2,3,7], Xinhua Liang[1,3,7], Jianxian Gong[4], Zhen Yang[4], Yao-Hua Zhang[5], Jian-Xu Zhang[5] & Yi Rao[3,6]

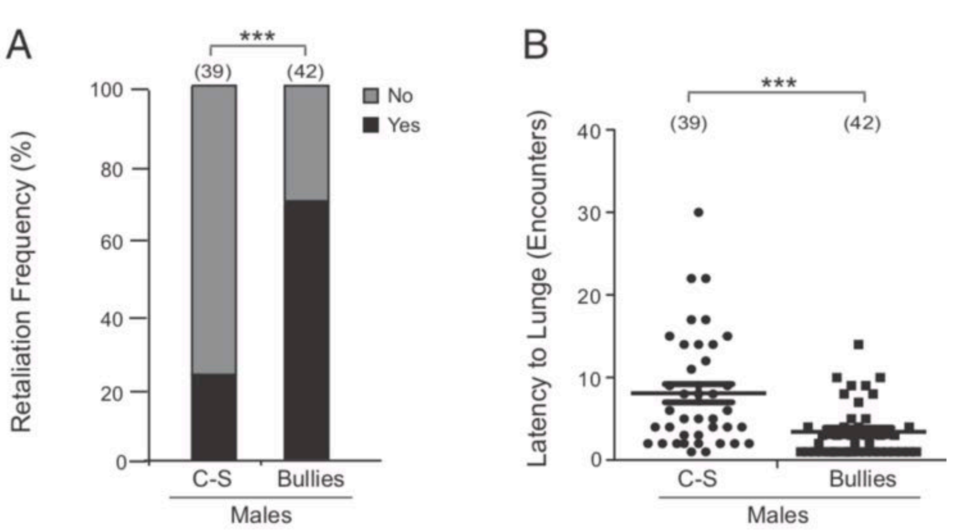


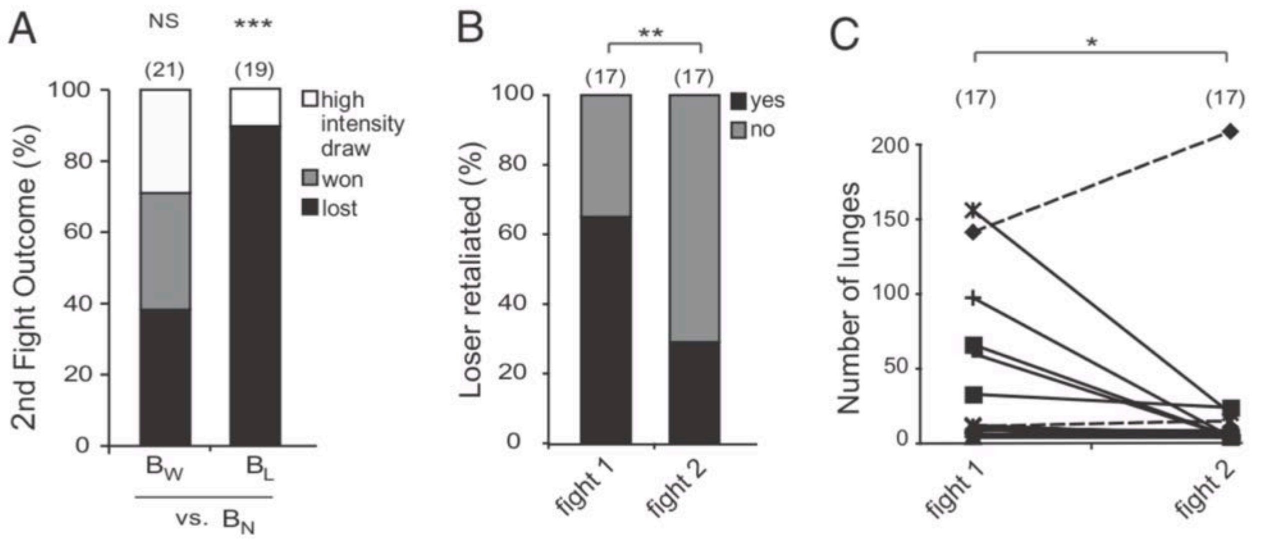


Social behavior and aggressive

A single social defeat reduces aggression in a highly aggressive strain of *Drosophila*

Jill K. M. Penn, Michael F. Zito, and Edward A. Kravitz[1]





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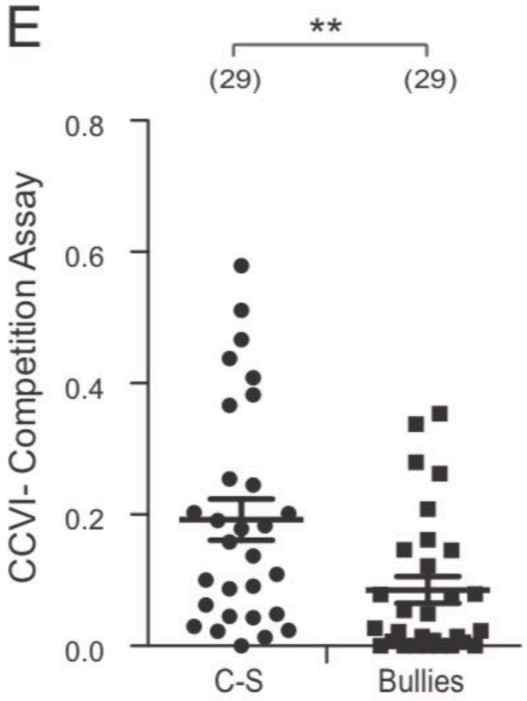
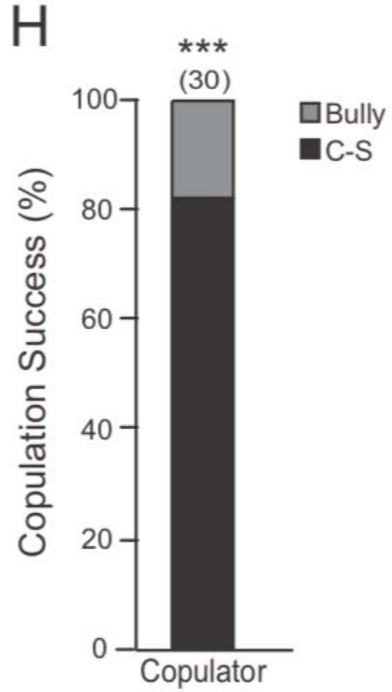


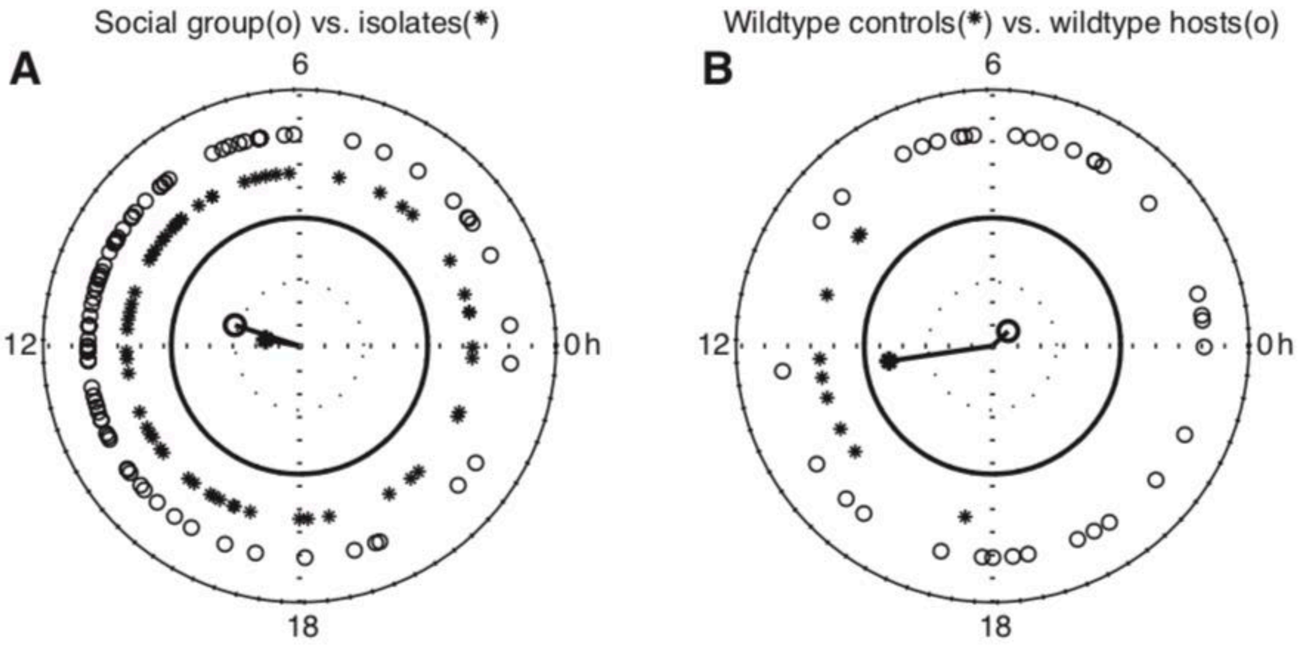
The CCVI was defined as the fraction of time the males spent courting from the first social interaction (courtship or aggression) until copulation



Bullies are poorer courters than Canton-S

Social behavior and sleep

Resetting the Circadian Clock by Social Experience in *Drosophila melanogaster*
Joel D. Levine *et al.*
Science **298**, 2010 (2002);
DOI: 10.1126/science.1076008



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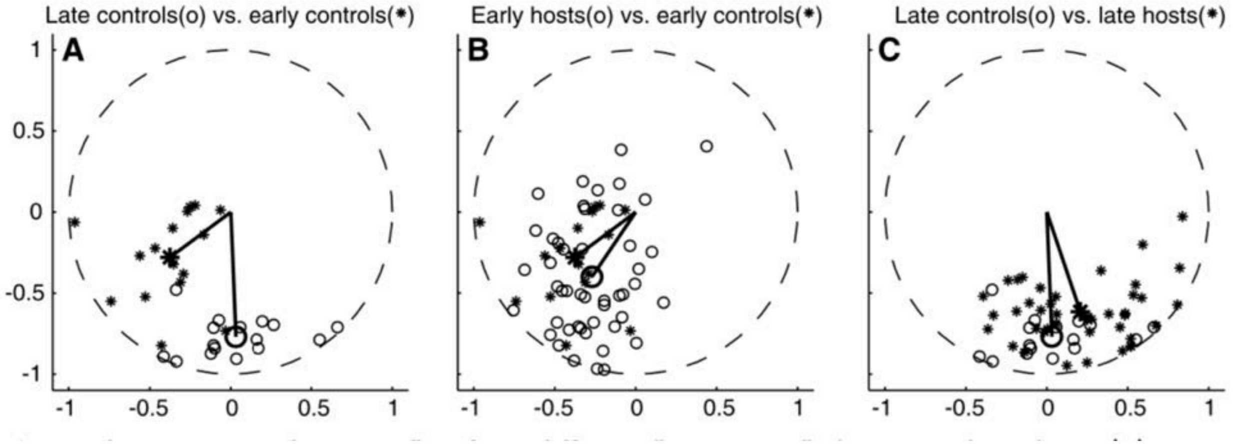
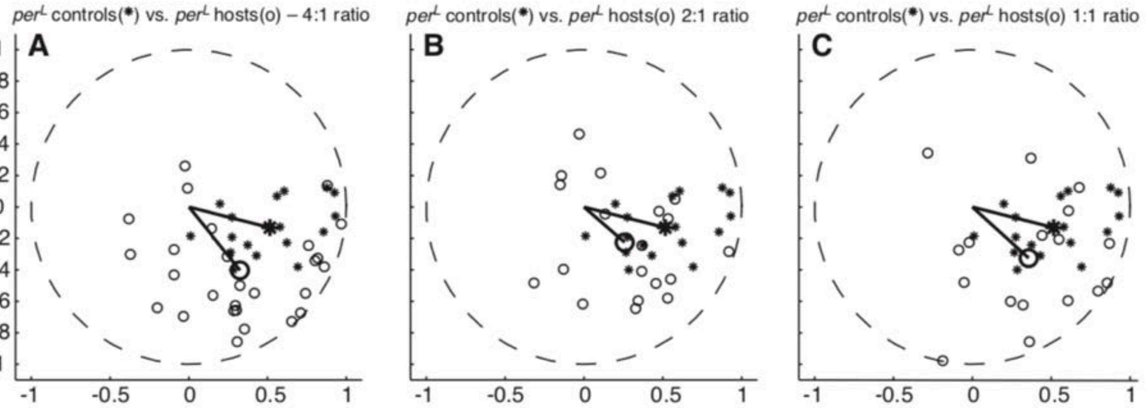




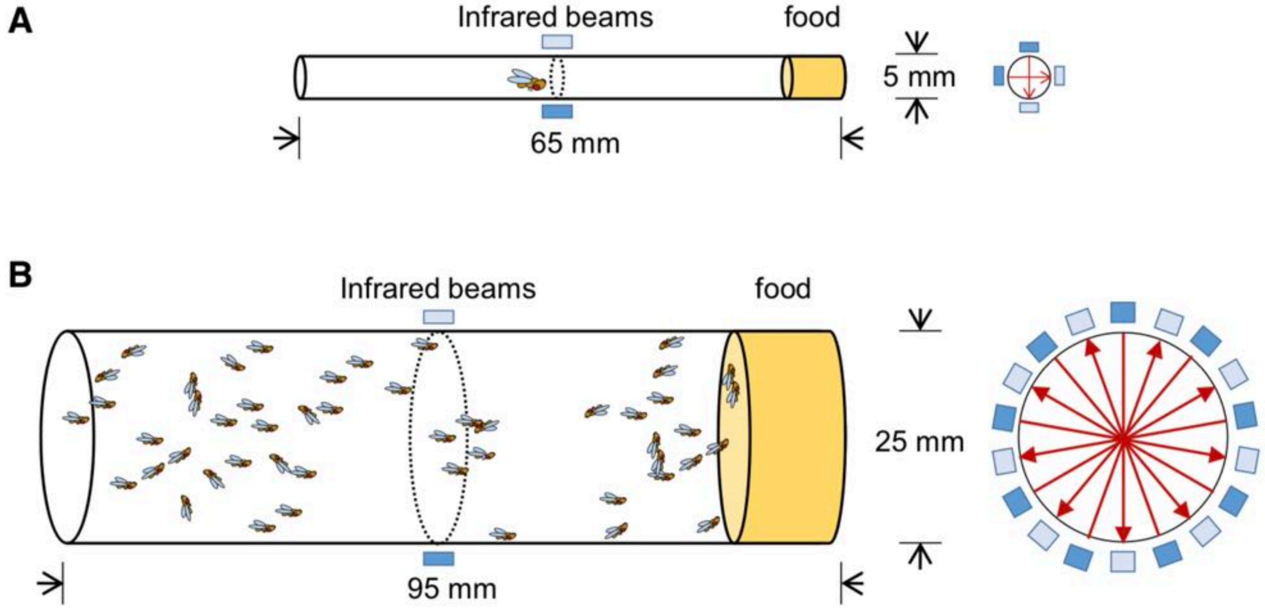
Social behavior and sleep

eNeuro

Novel Tools and Methods

Sleep in Populations of *Drosophila Melanogaster*[1,2,3]

Chang Liu, Paula R. Haynes, Nathan C. Donelson, Shani Aharon, and Leslie C. Griffith



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eNeuro

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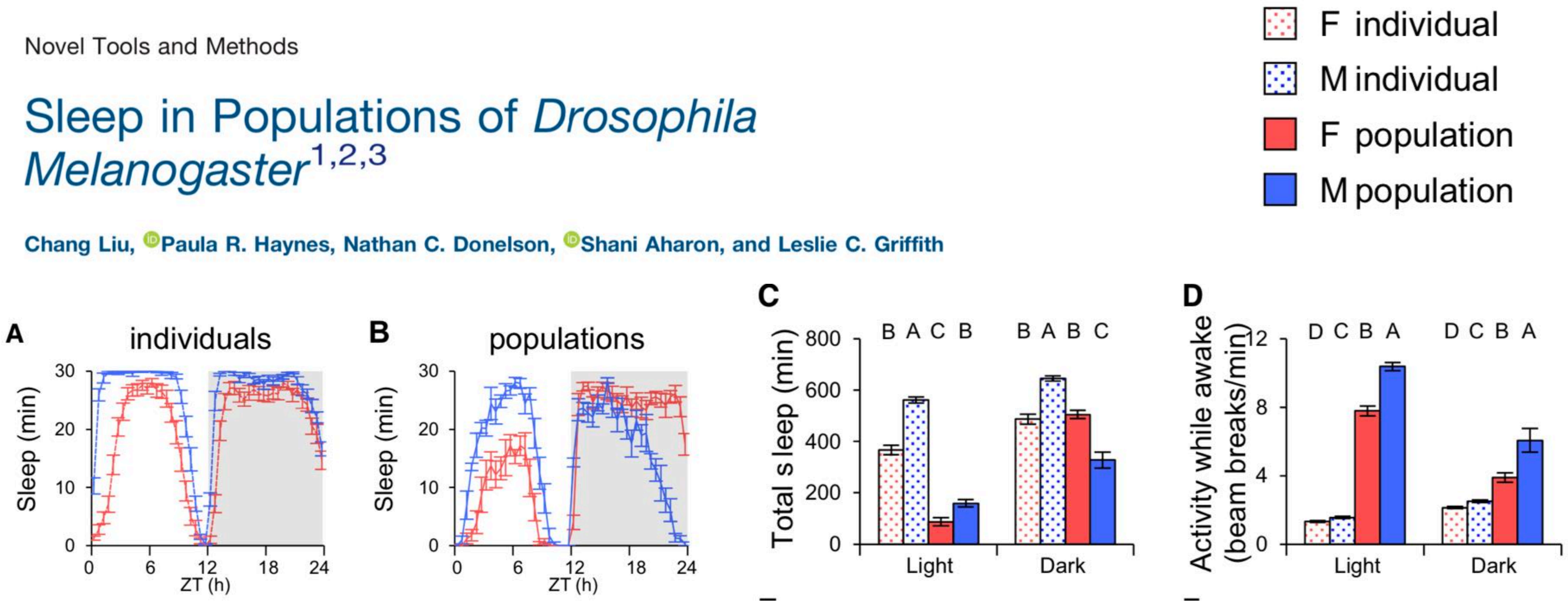

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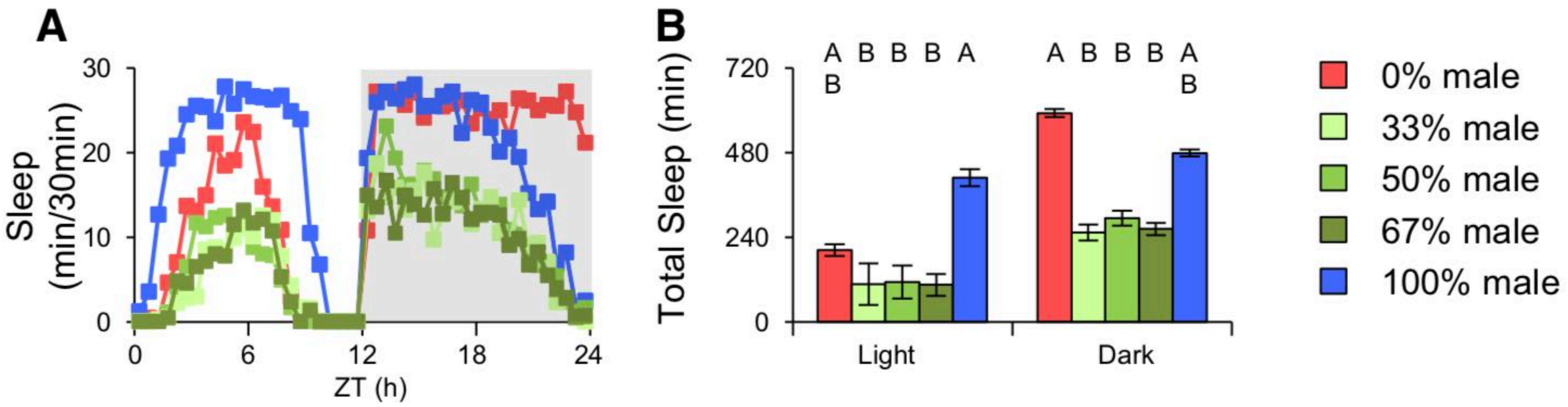
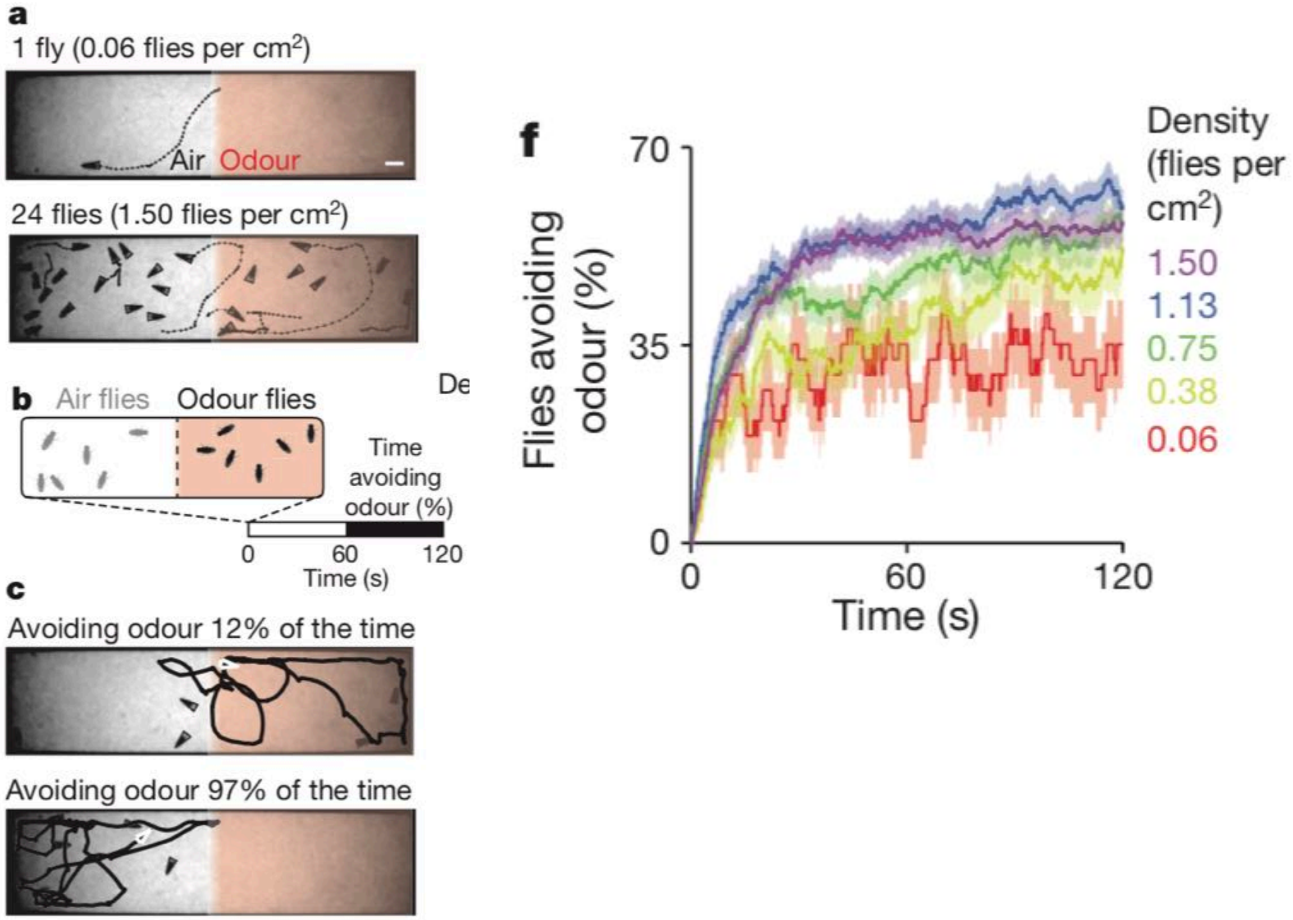


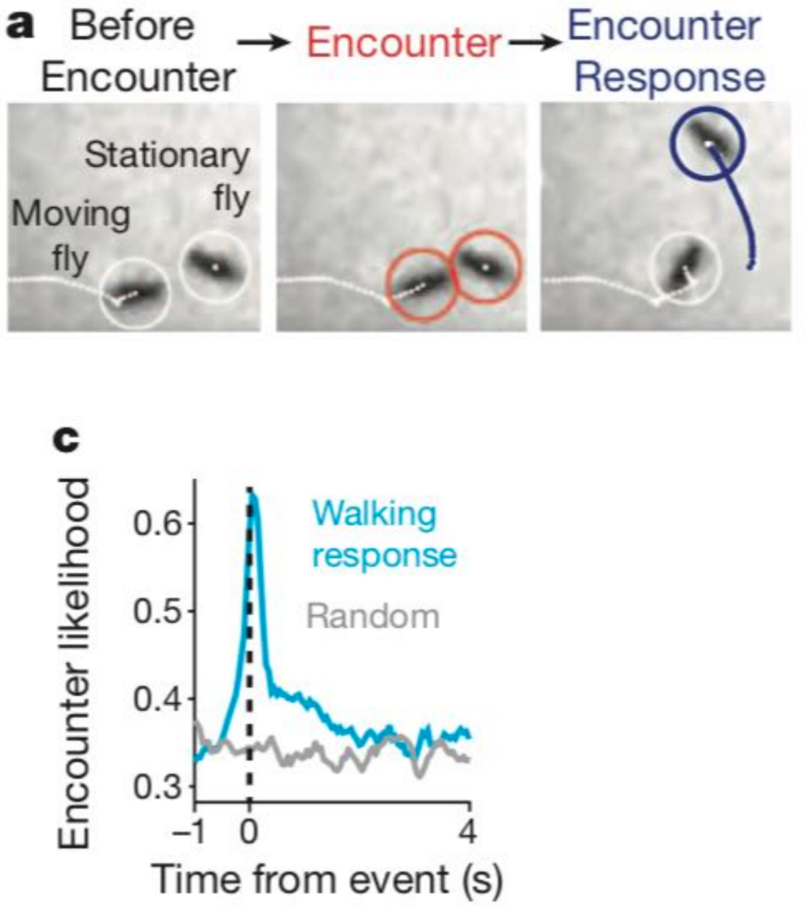
Social behavior and avoidance behavior

doi:10.1038/nature14024

Mechanosensory interactions drive collective behaviour in *Drosophila*

Pavan Ramdya[1,2], Pawel Lichocki[2,3]†, Steeve Cruchet[1], Lukas Frisch[4], Winnie Tse[4], Dario Floreano[2] & Richard Benton[1]





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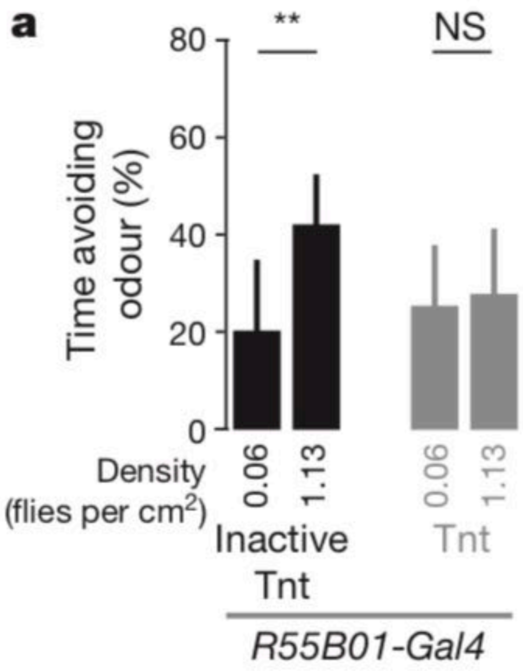
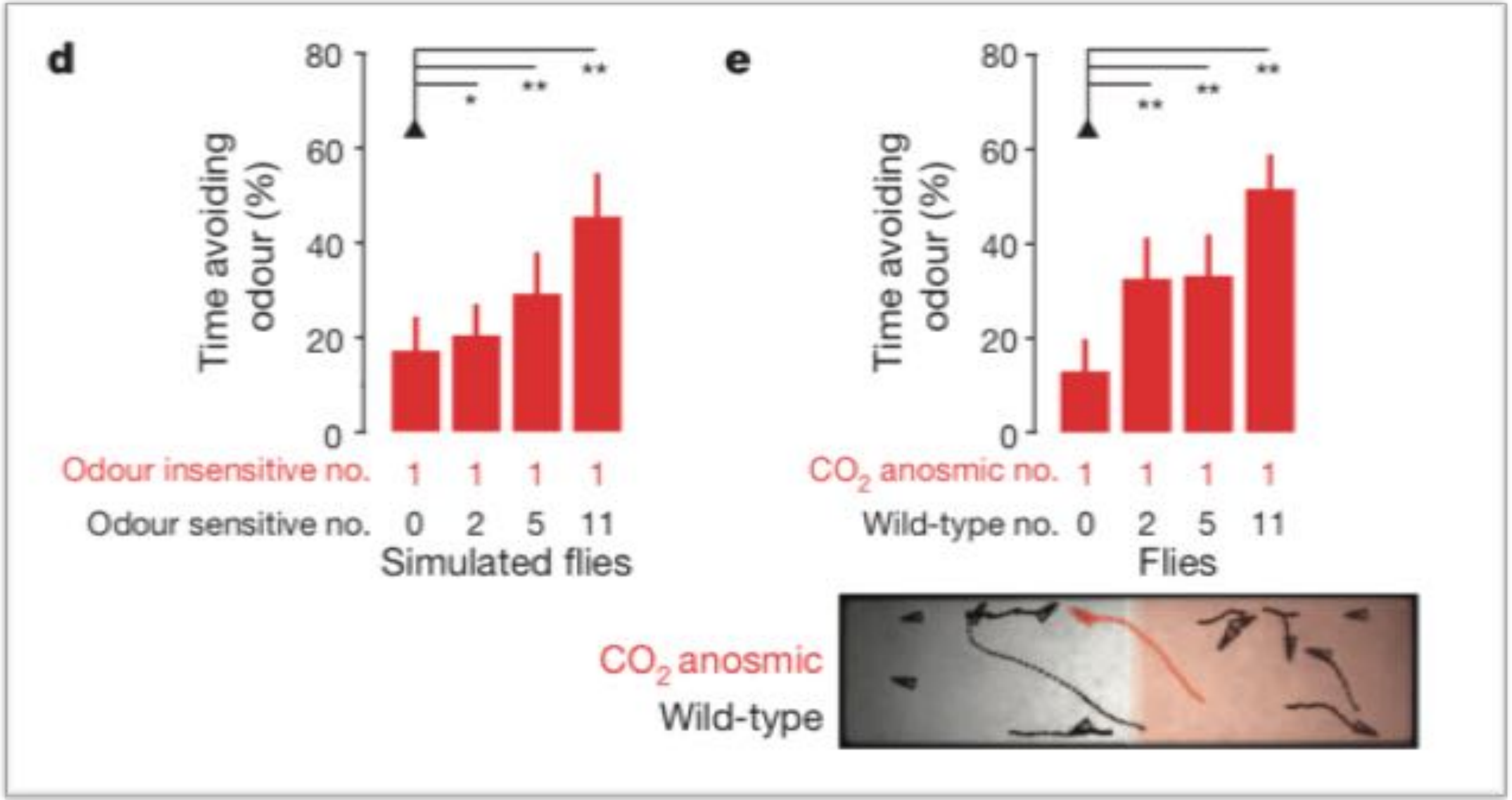




Effects of social experience on productive behavior in *Drosophila*

Sun Mengshi

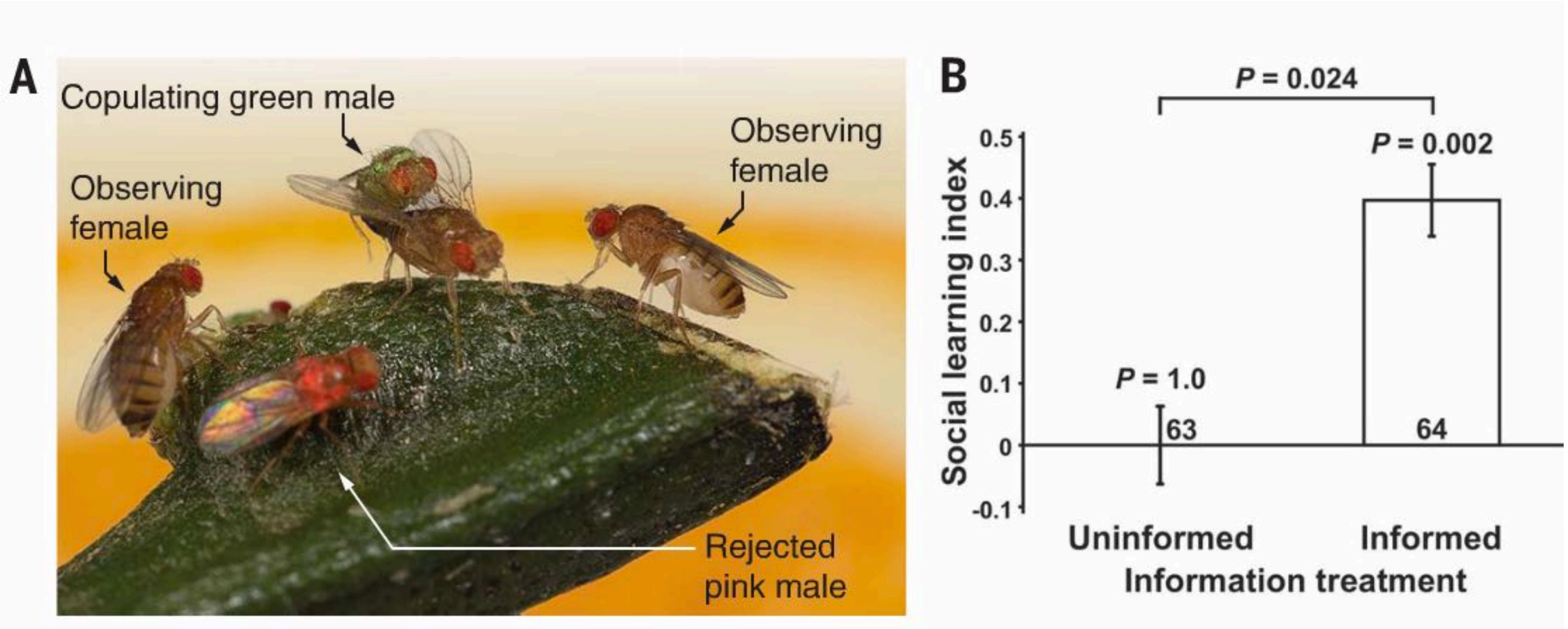
Effects of social experience on productive behavior in *Drosophila*

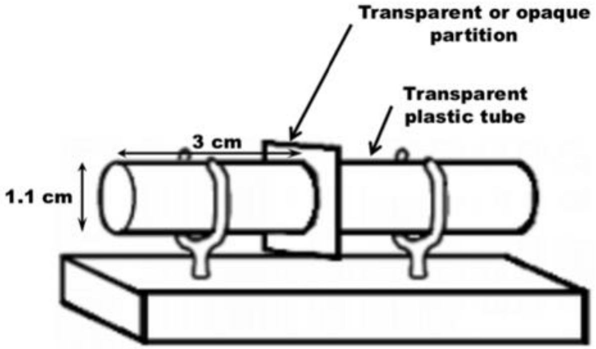
female receptivity
- mating copy
- oviposition

male courtship
- mating duration: rival induce longer-mating-duration
- losers in a fight mate less
- mating copy in males

Mate copying :

One female prefer the male which has successfully copulated with another female .





Danchin, E. et al. 2018.

ANIMAL CULTURE

Cultural flies: Conformist social learning in fruitflies predicts long-lasting mate-choice traditions

Etienne Danchin[1,*,†], Sabine Nöbel[1,2,*], Arnaud Pocheville[3,*], Anne-Cecile Dagaeff[1], Léa Demay[1], Mathilde Alphand[1], Sara...

Animal Culture

Criterion 1:

phenotypic variation that is inherited through a form of social learning

Criterion 2 :

Cultural inheritance will occur if social learning occurs across age classes (minimally, from older to younger individuals)

Criterion 3:

Cultural inheritance is maintained over the long term to be copied

Criterion 4:

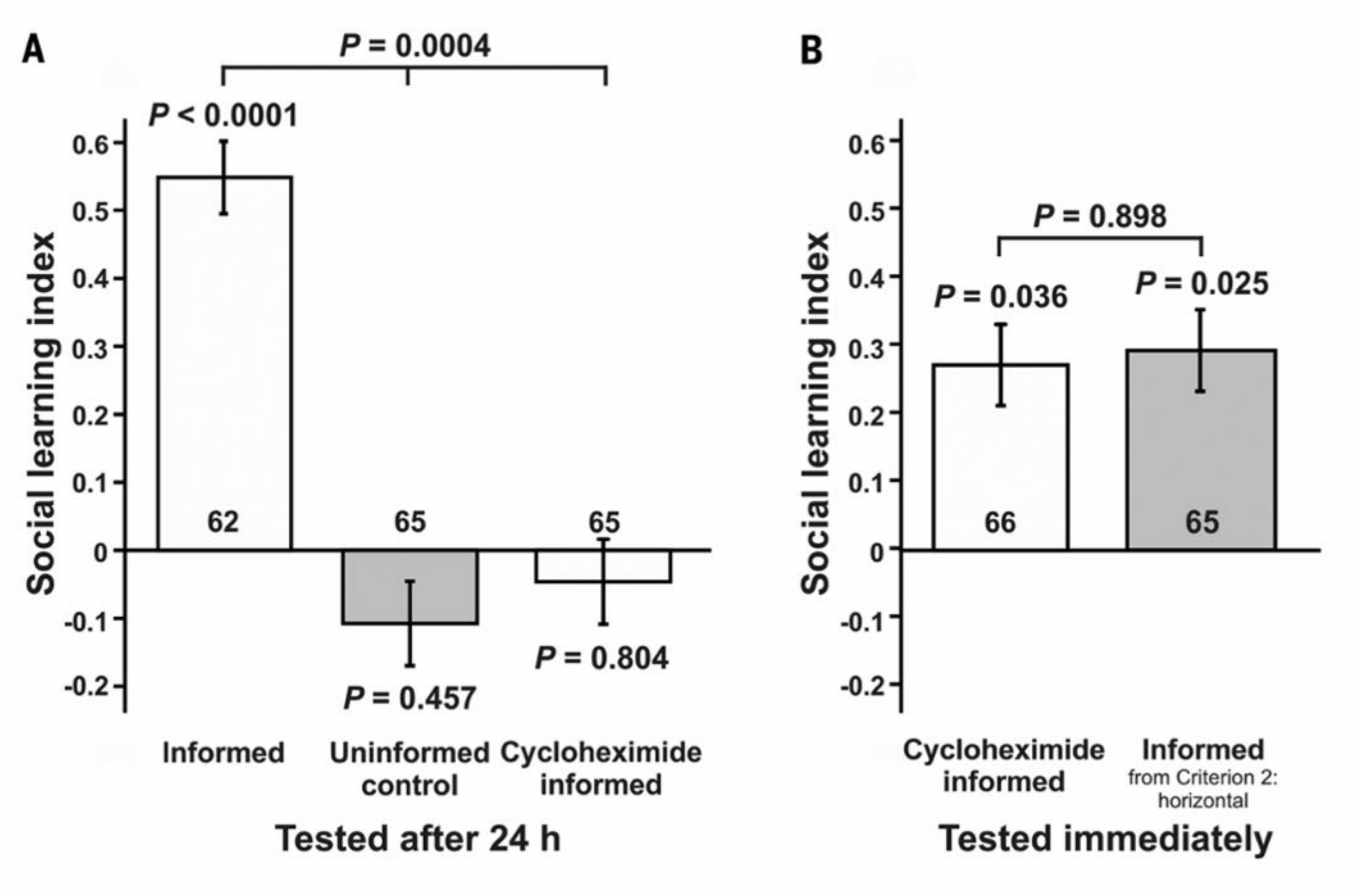
Cultural inheritance produces trait-based copying

Criterion5:

Cultural inheritance incorporates repair or reinforcement mechanisms

Criterion 3:
Cultural inheritance is maintained over the long term to be copied.

Training the observers with five conditioning demonstrations spaced by 15 to 30-min resting periods.



long-term memory depends on de novo protein synthesis

cycloheximide: an inhibitor of protein synthesis

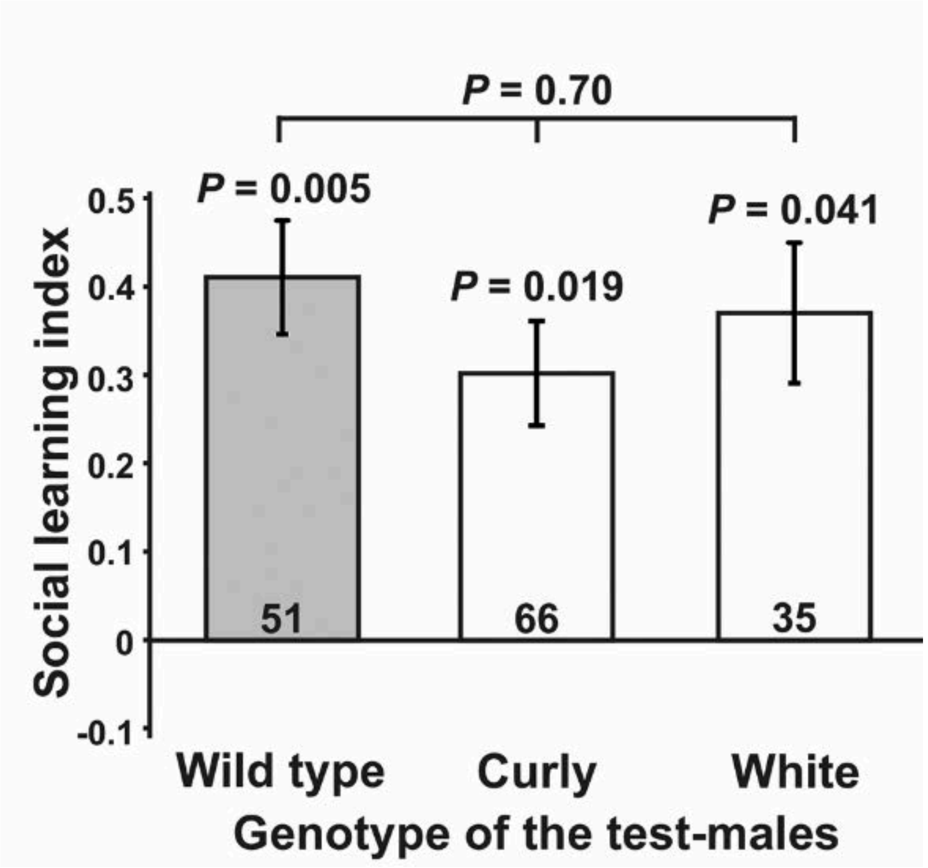
Criterion 4:
Cultural inheritance produces trait-based copying.

Demonstration:

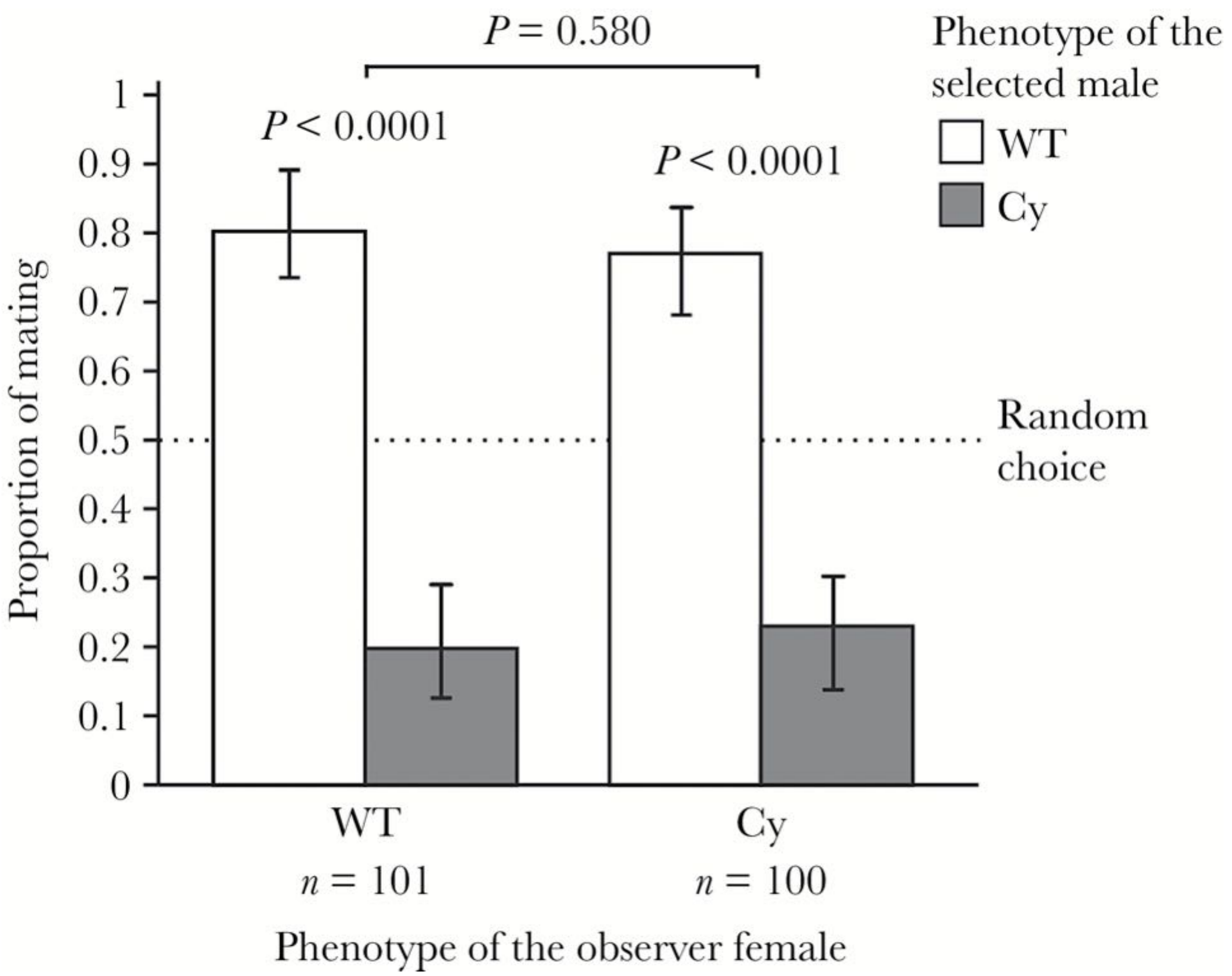
one green and one pink wild-type male + female

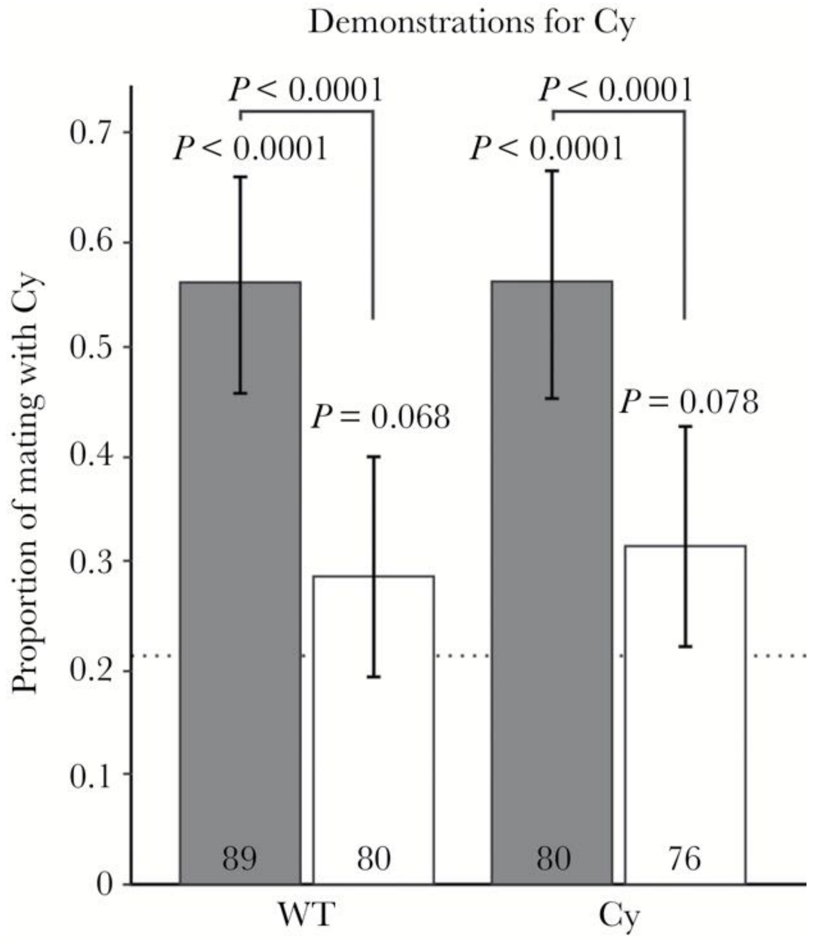
choice test:

- green and pink wild-type males
- green and pink curly-winged males
- green and pink white-eyed males



Criterion 4:
Cultural inheritance produces trait-based copying.

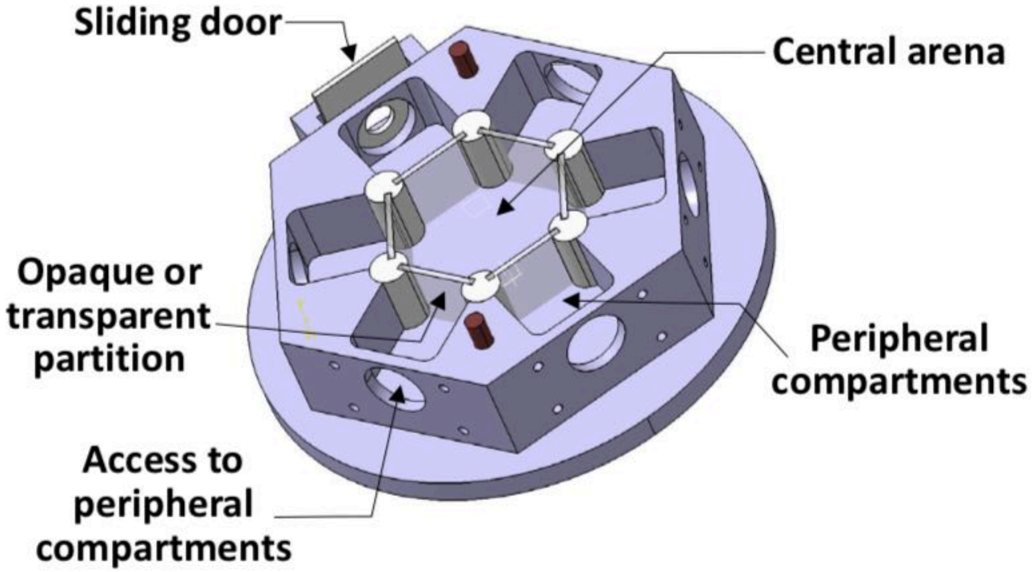


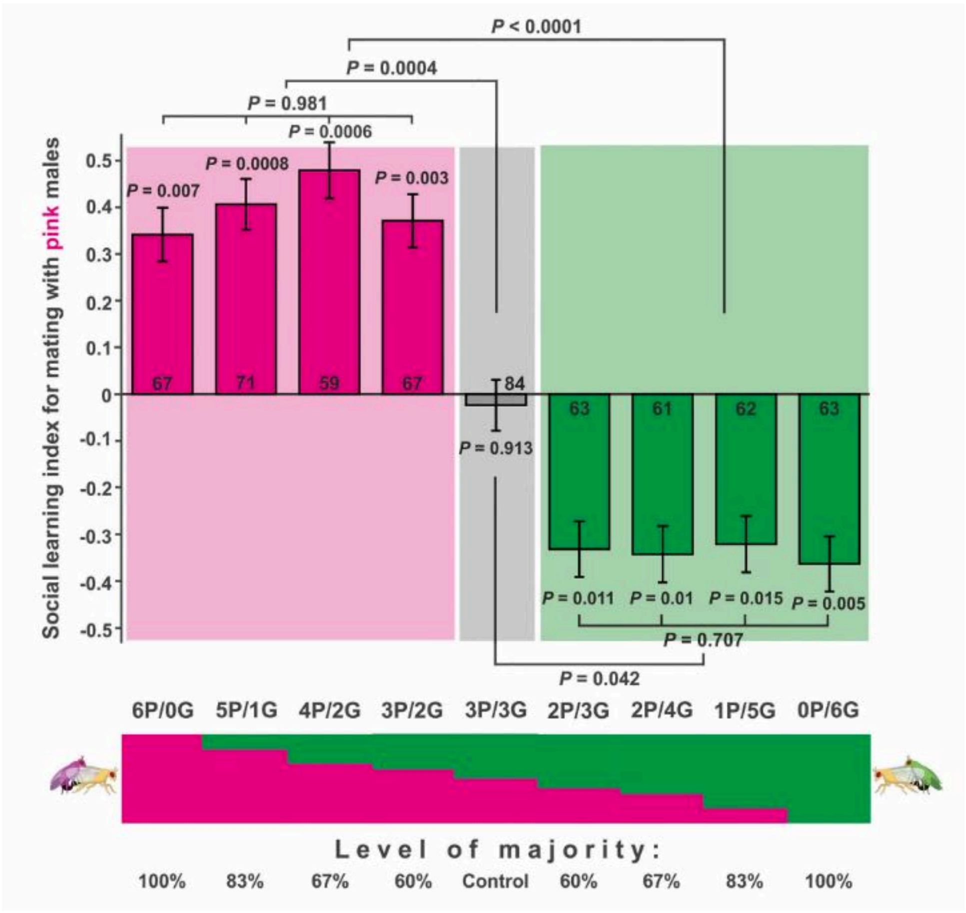


Nöbel,S. et al. ,2018.

Criterion5:

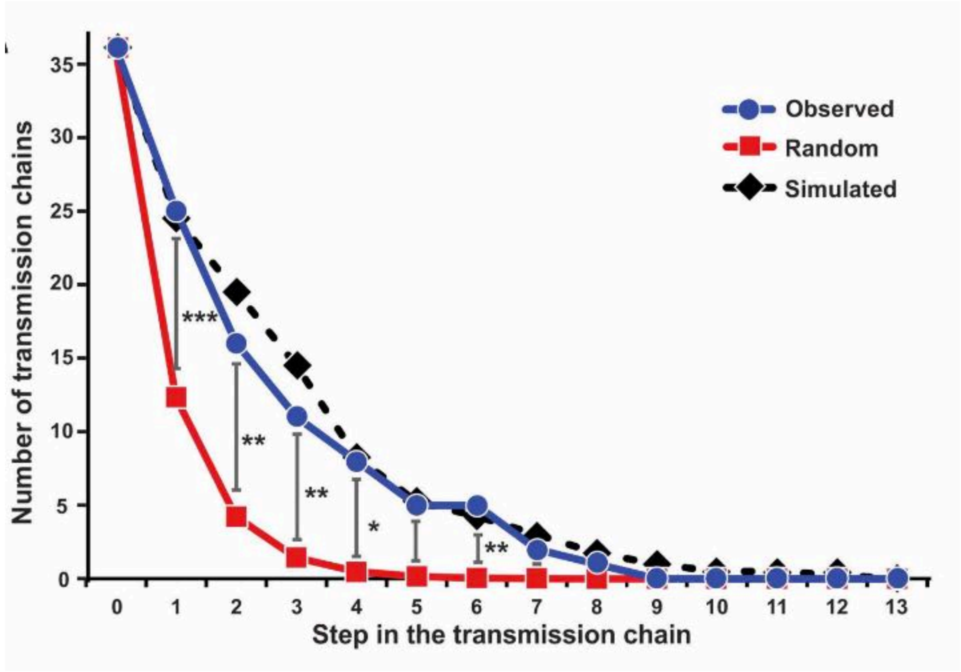
Cultural inheritance incorporates repair or reinforcement mechanisms such as a conformist bias.





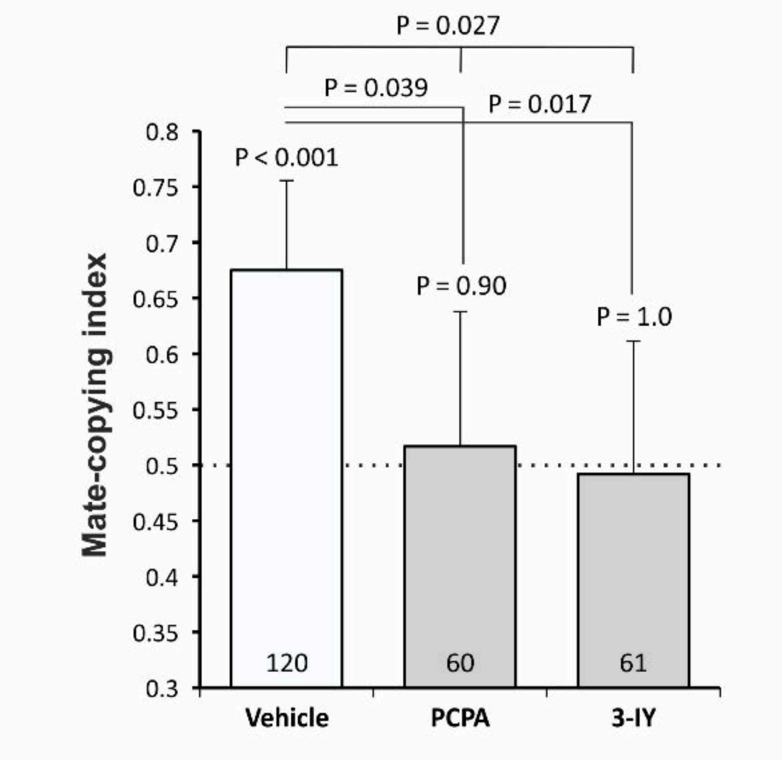
Mate-copying in the fruit fly generates persistent population preference

The transmission chain experiment:
the six observer females of one step were used as the six freely choosing demonstrators of the following step.

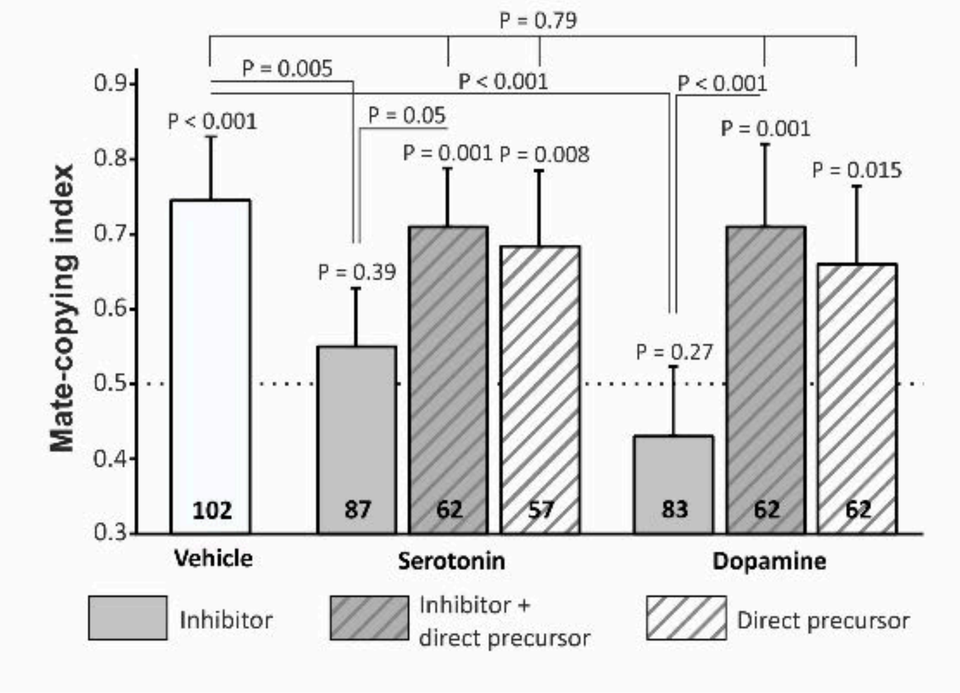


Dopamine and serotonin are both required for mate-copying in *Drosophila melanogaster*

DL-para-chlorophenylalanine (PCPA): reduce serotonin synthesis
3-iodotyrosine (3-IY): reduce dopamine synthesis



measured 3 h after the demonstration.



measured immediately after the demonstration

Monier, M., Nöbel, S., Danchin, E. and Isabel, G. 2019.

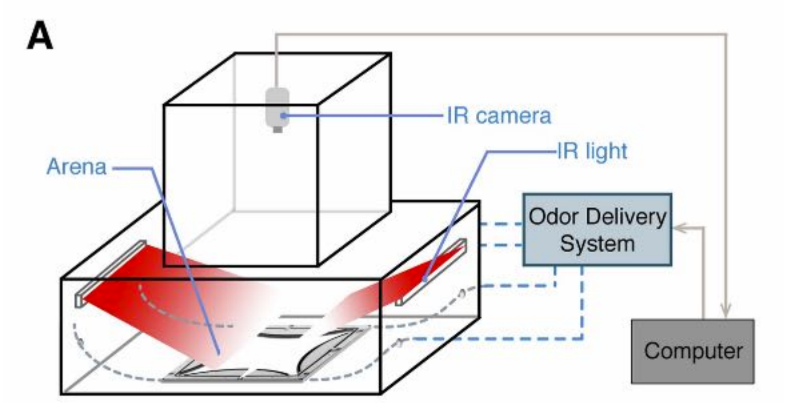
- oviposition
  - egg-laying site choice
    - aggregation pheromone
      - deposited by males
      - deposited by females
    - Social interaction
  - decreasing oviposition

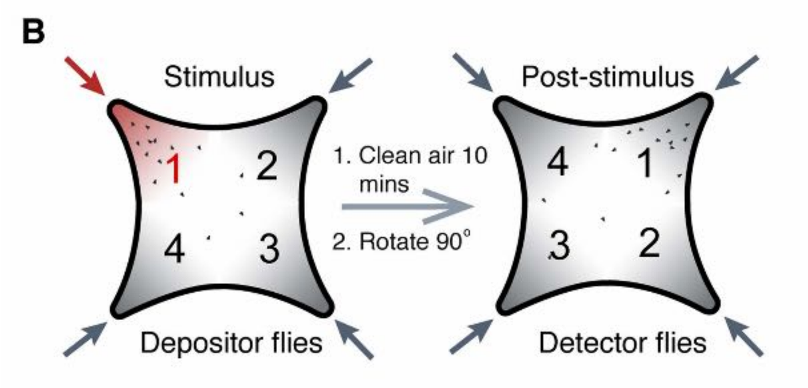
eLIFE
elifesciences.org

Food odors trigger Drosophila males to deposit a pheromone that guides aggregation and female oviposition decisions

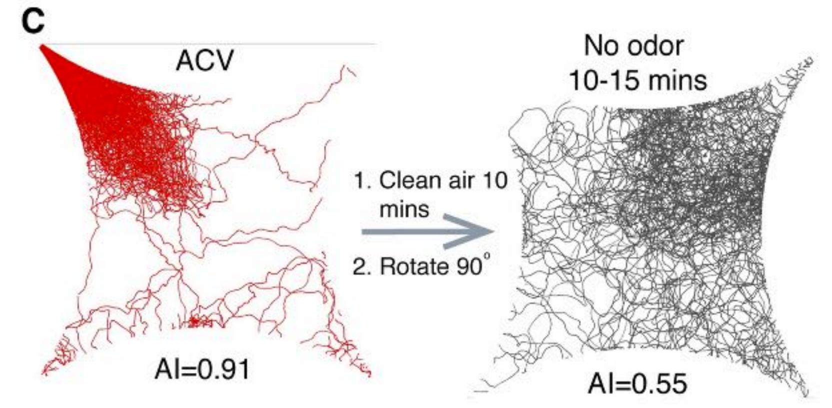
Sep 30, 2015

Chun-Chieh Lin, Katharine Prokop-Prigge, George Preti, Christopher J Potter



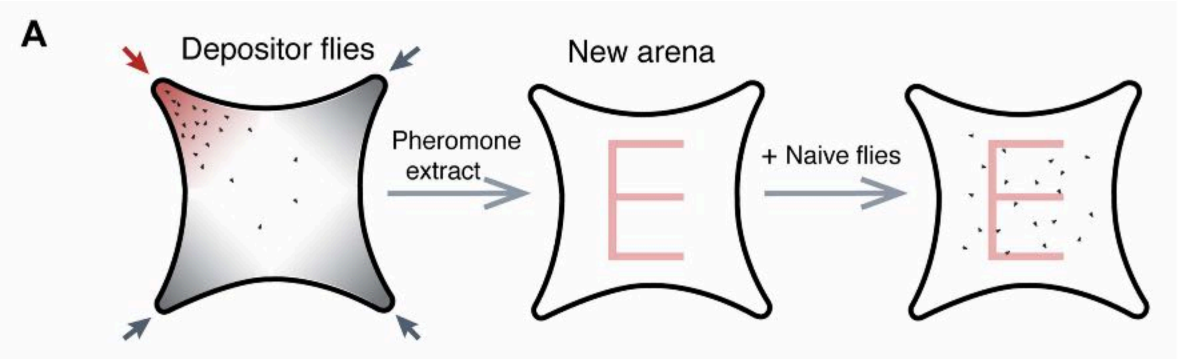


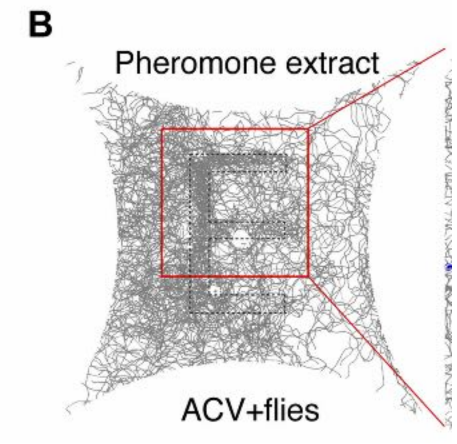
Post-stimulus aggregation behaviors are stimulated by food-odors

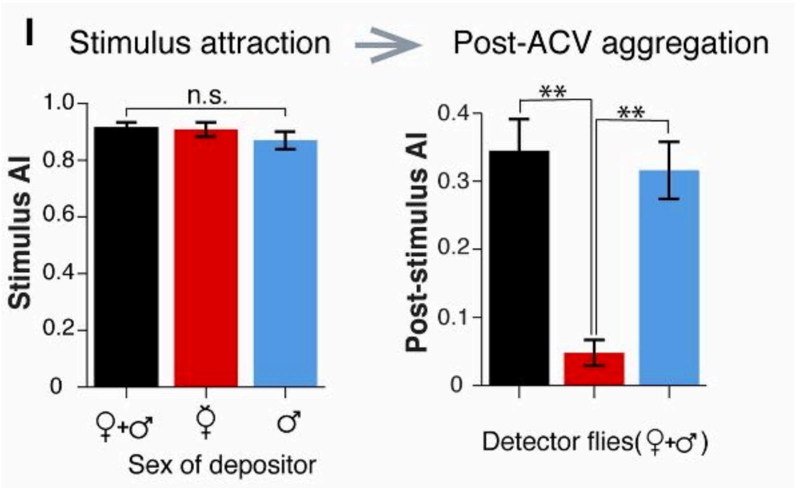


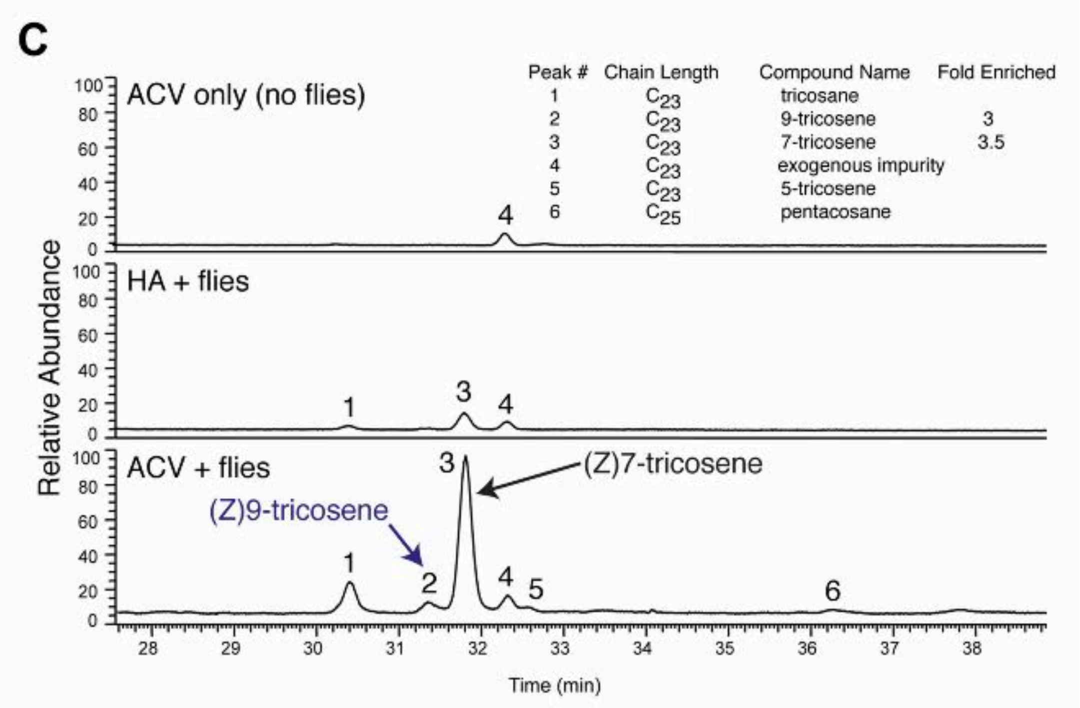
ACV: apple cider vinegar

Males are the source of the aggregation pheromone

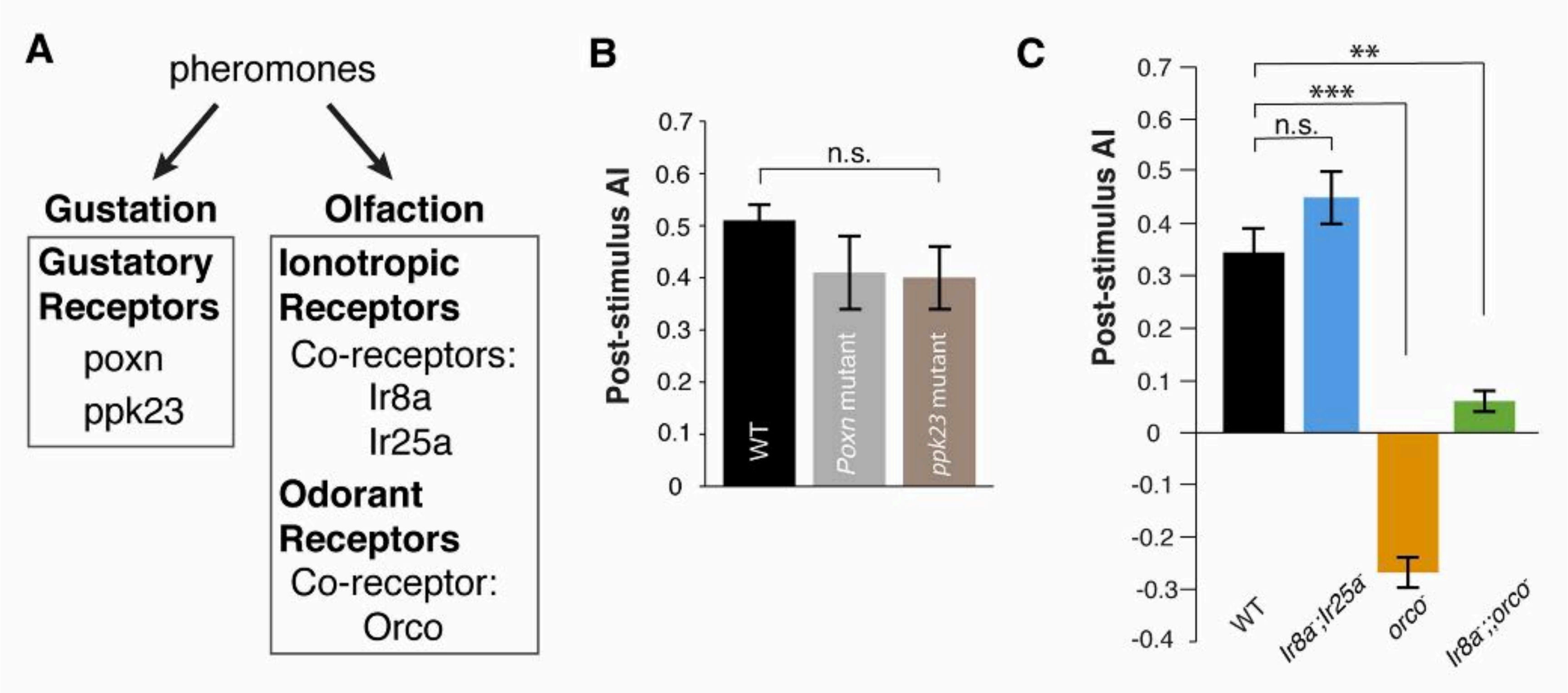






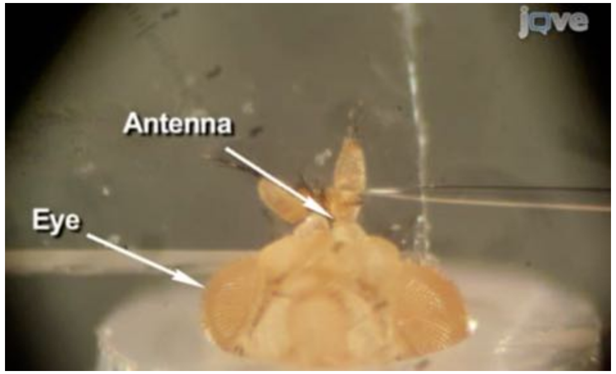


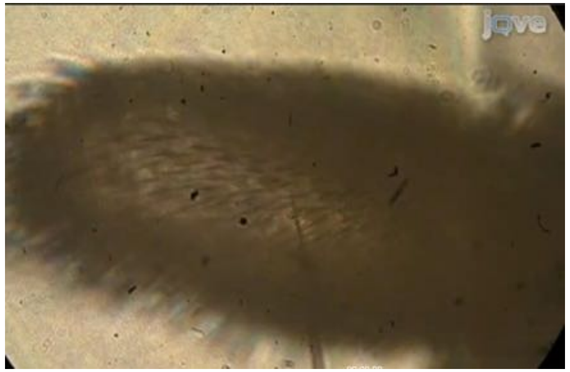
Post-stimulus aggregation requires Orco-dependent olfactory signaling

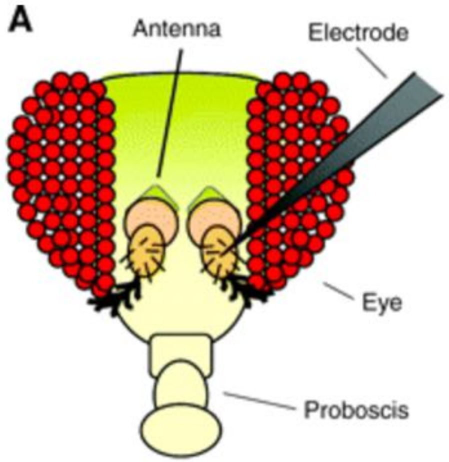


ppk23: sensor 7-tricosene

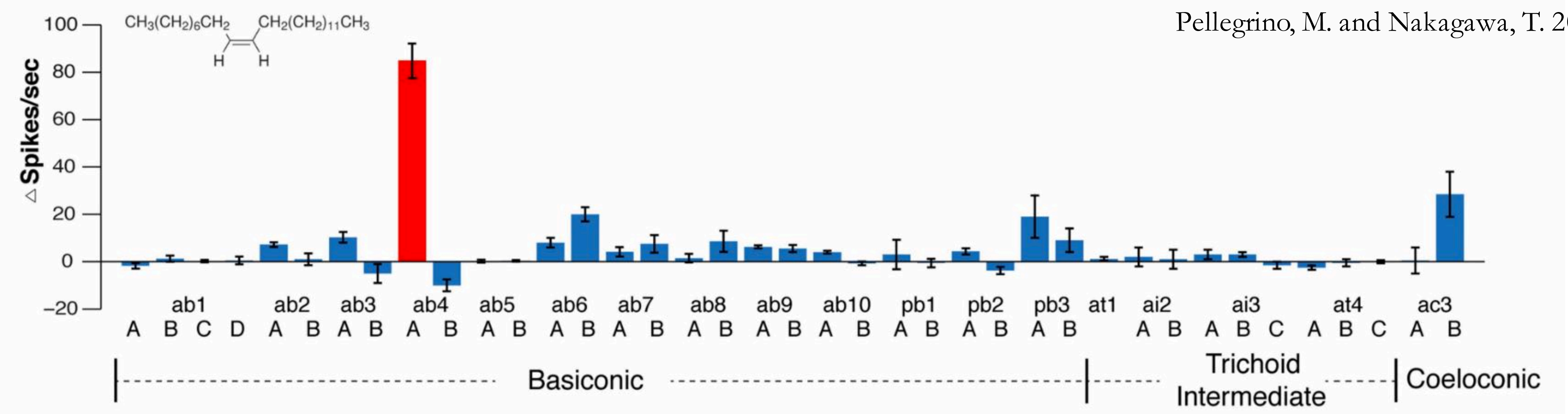
The Or7a receptor is necessary and sufficient for 9-tricosene activation





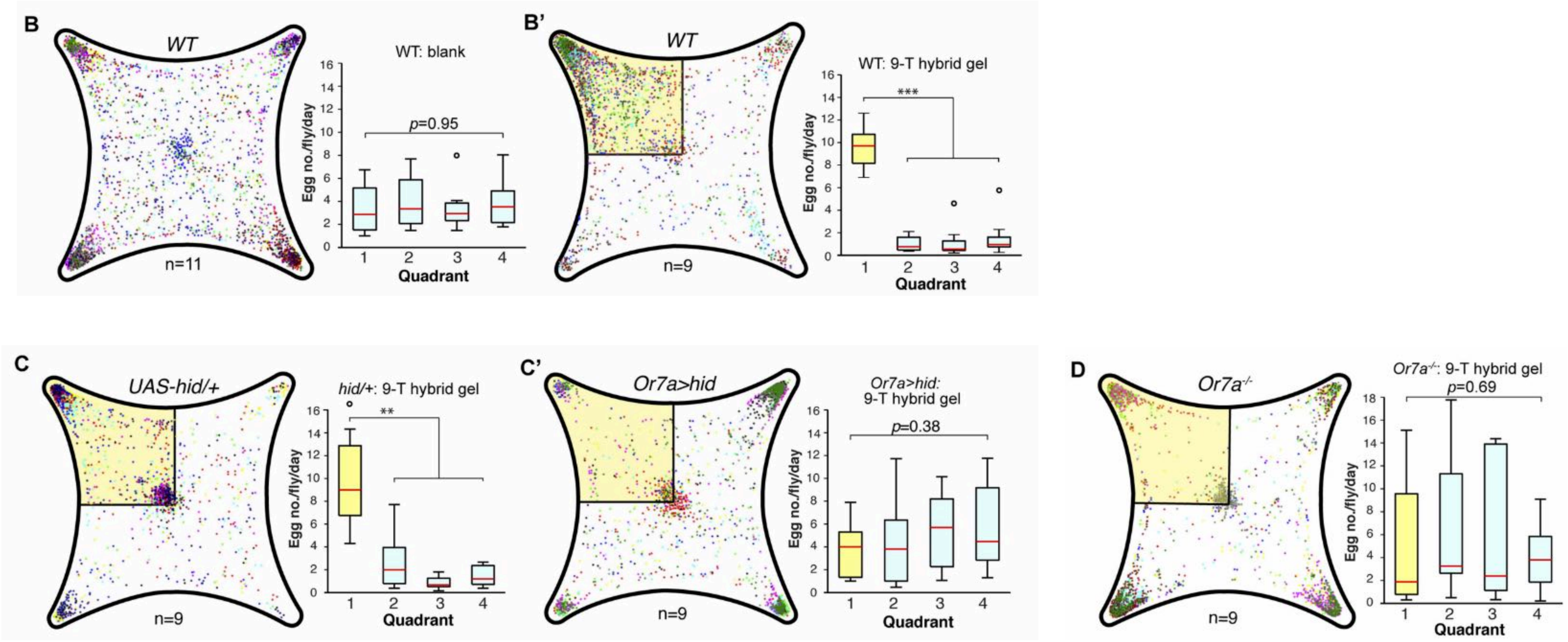


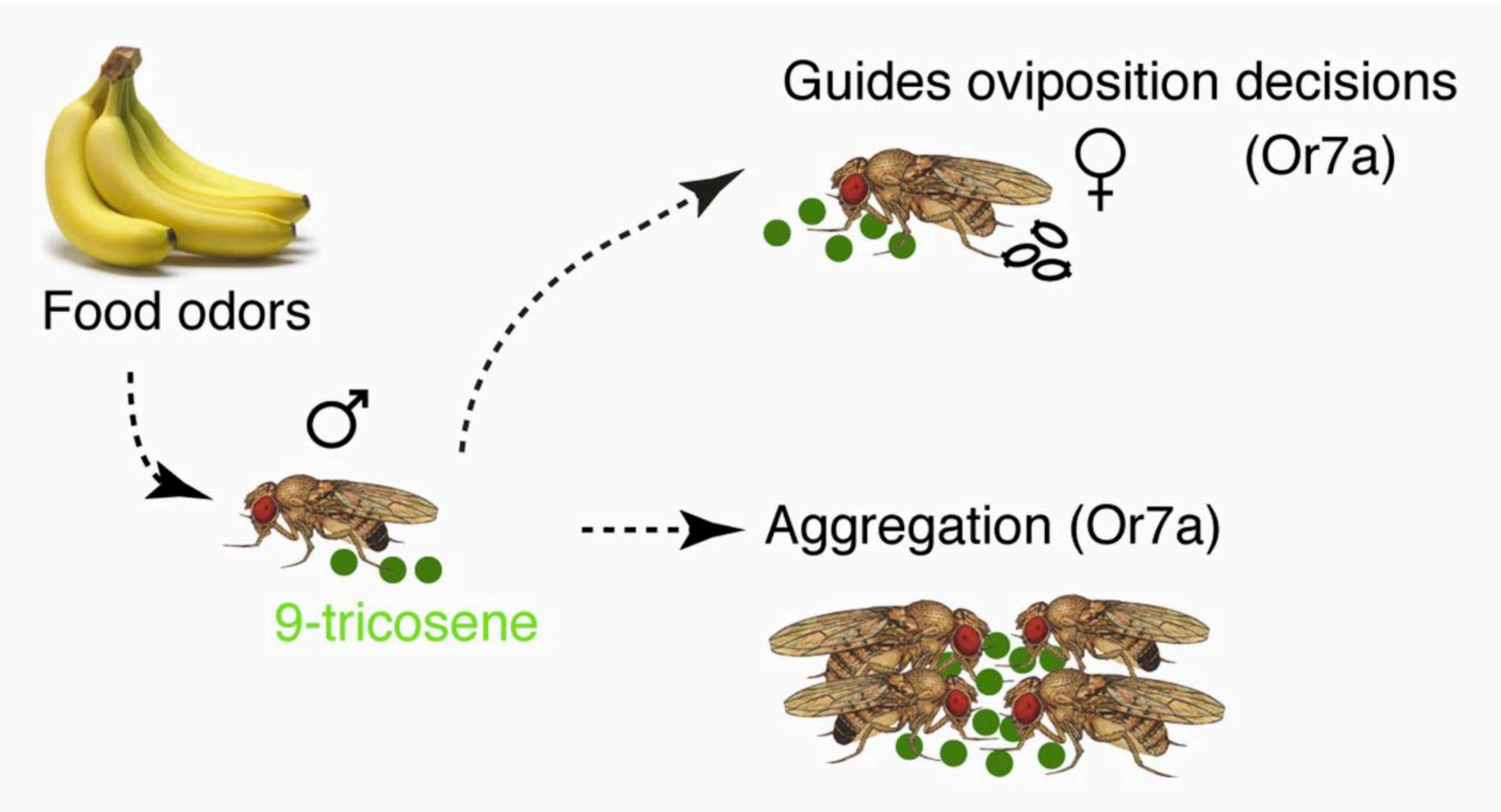
Pellegrino, M. and Nakagawa, T. 2009



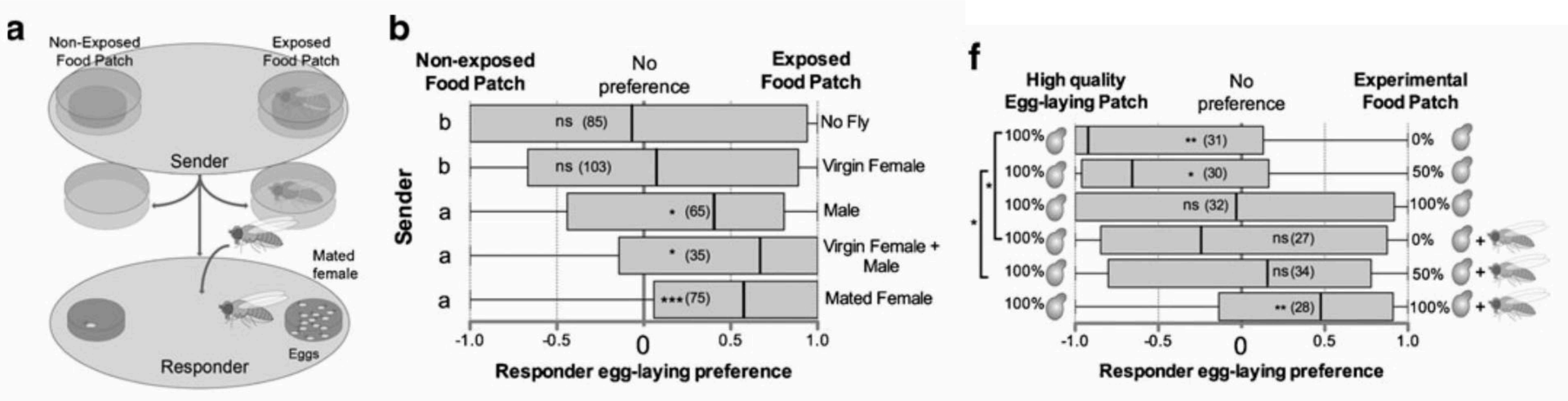
Single sensillum recording (SSR)

9-Tricosene guides oviposition site selection via Or7a neurons



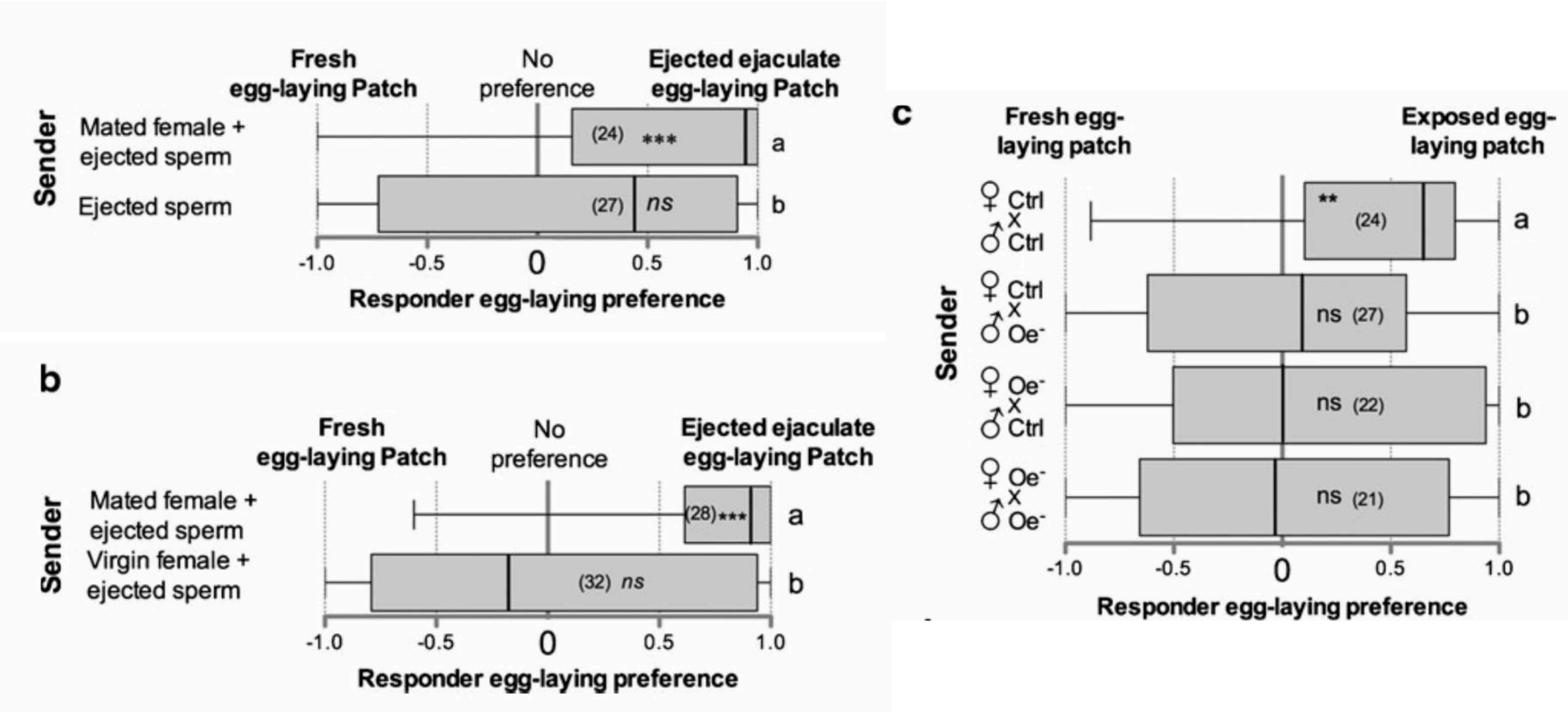

Guides oviposition decisions
♀
(Or7a)
Food odors
♂
Aggregation (Or7a)
9-tricosene

Naïve females learn about egg–laying sites through cues left by mated females.



Duménil, C. et al. 2016.

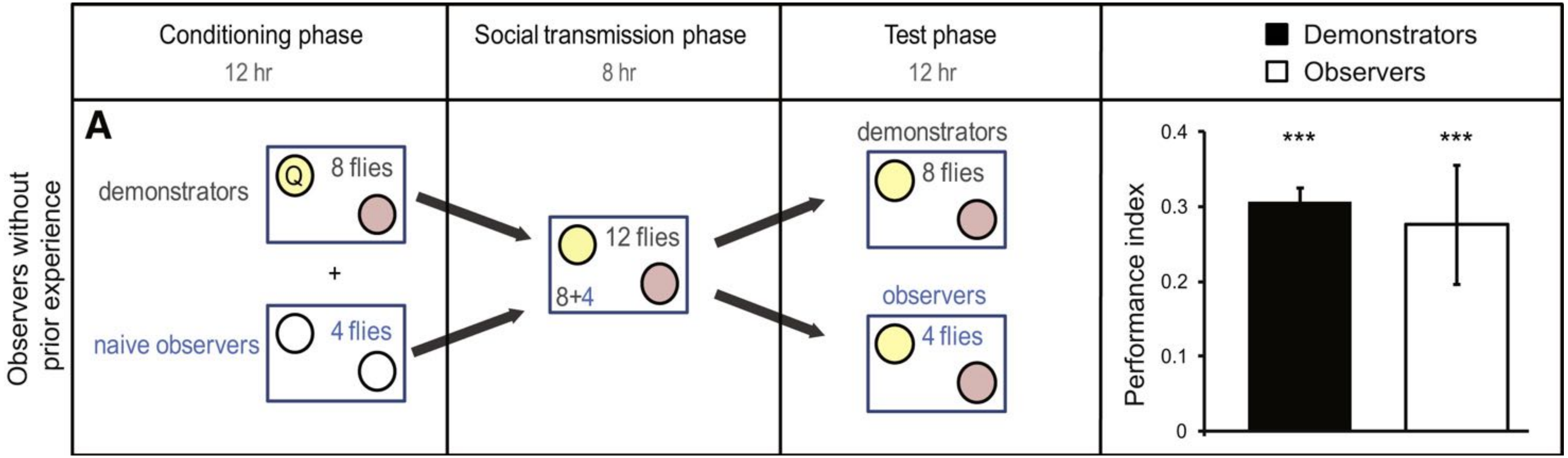
CHC from mated female + ejected sperm + CHC from males guide females to egg-laying sites



Egg-laying site choice

- aggregation pheromone
- Social interaction

Naïve females use social information to make oviposition decisions.



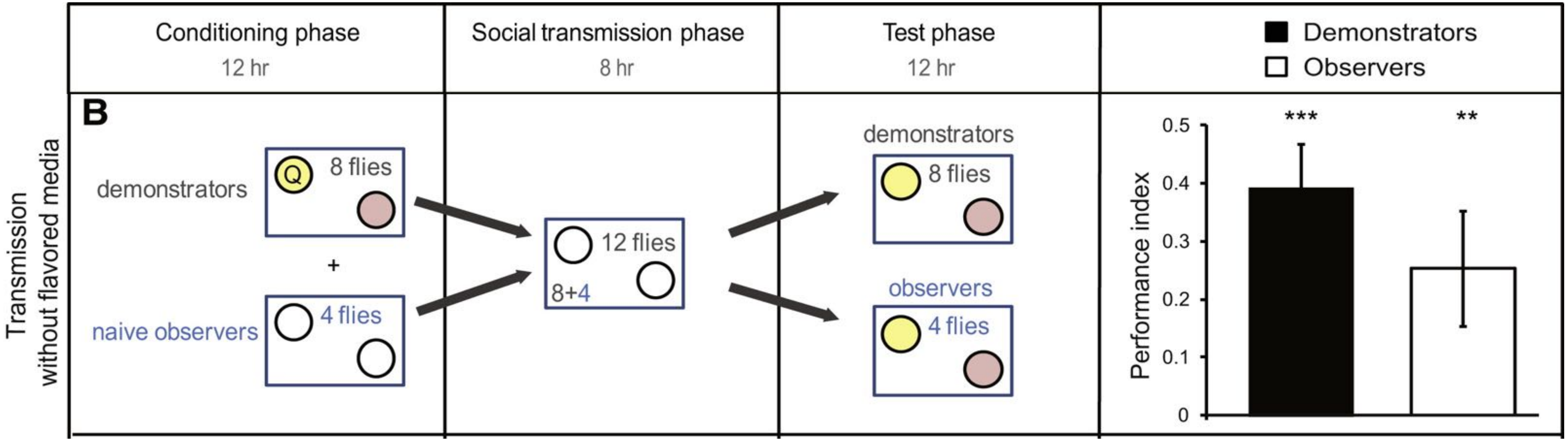
Oviposition site preference is transmitted through direct interactions with demonstrators, not through the mere presence of eggs and aggregation pheromone.

Social transmission phase : no demonstrators
media: containing freshly laid eggs
one with none eggs

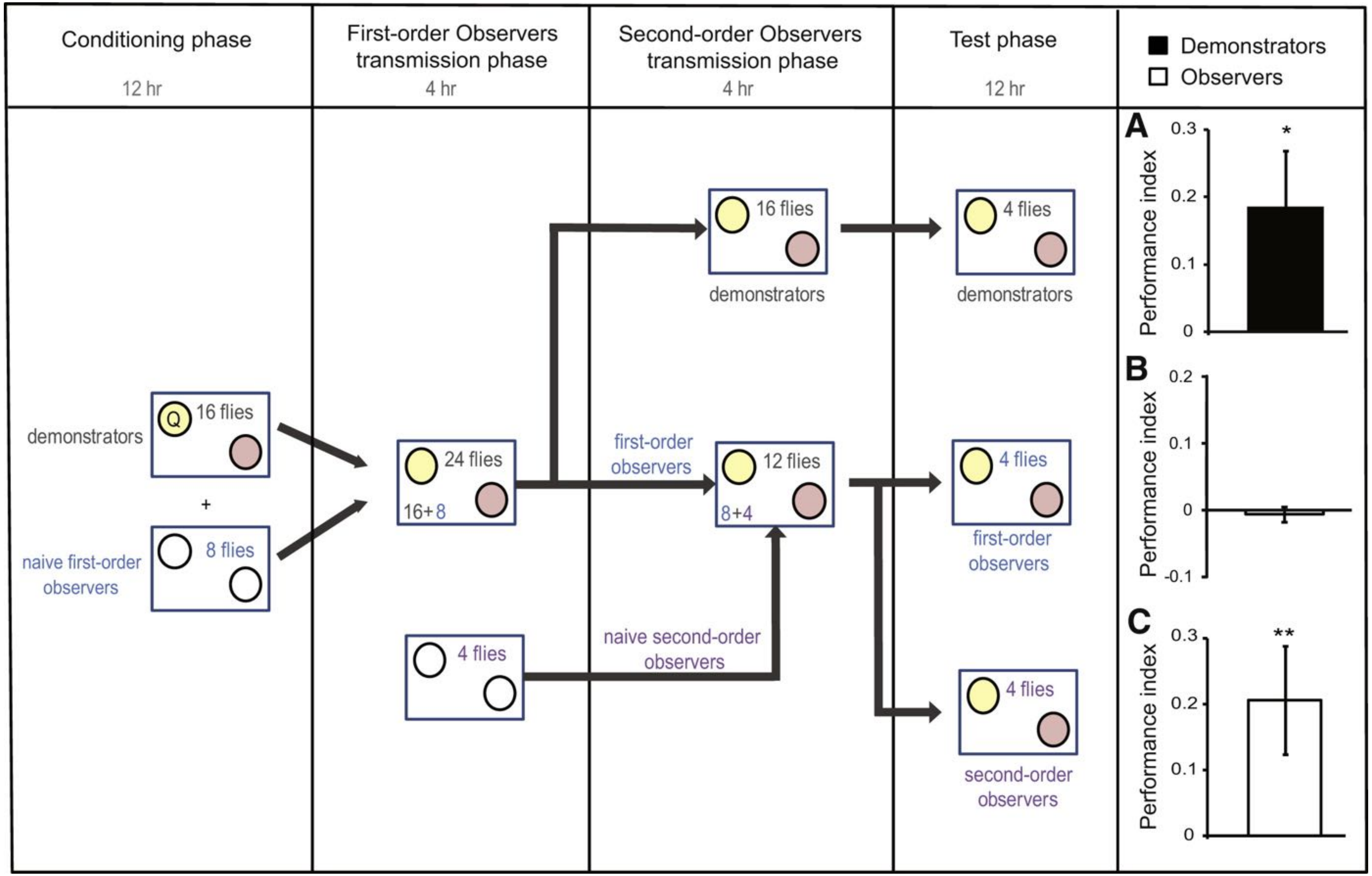
PI: 0.06±0.04 n=80

Battesti, M., Moreno, C., Joly, D. and Mery, F. 2012

Females transmit oviposition site preference even in the absence of the oviposition site choices.



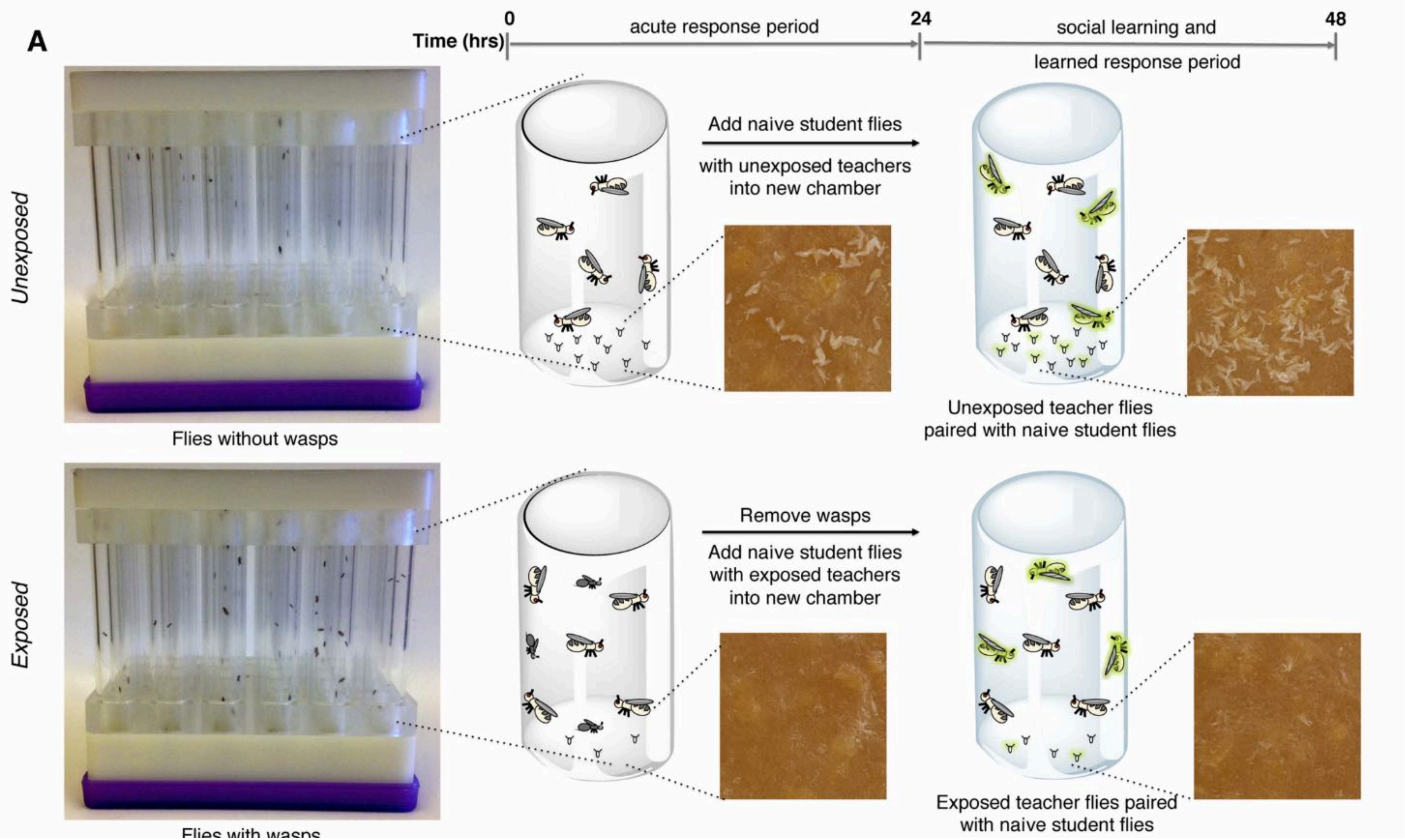
Social information can flow within a group from observer to observer and remain stable over time.



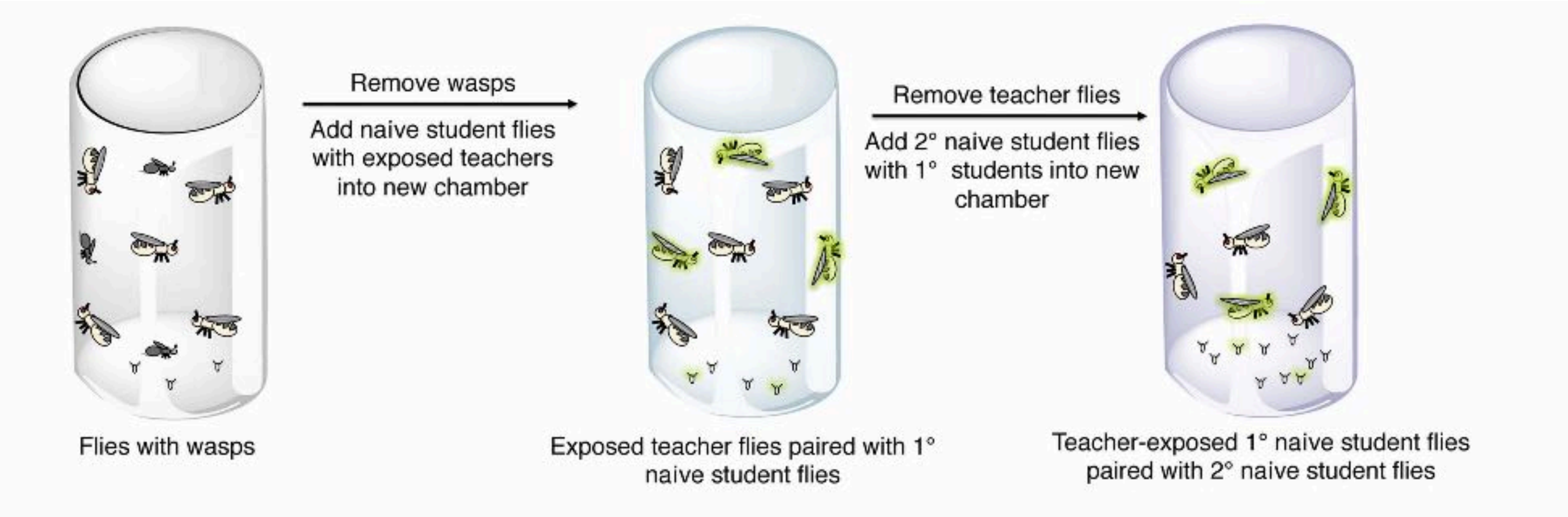
oviposition

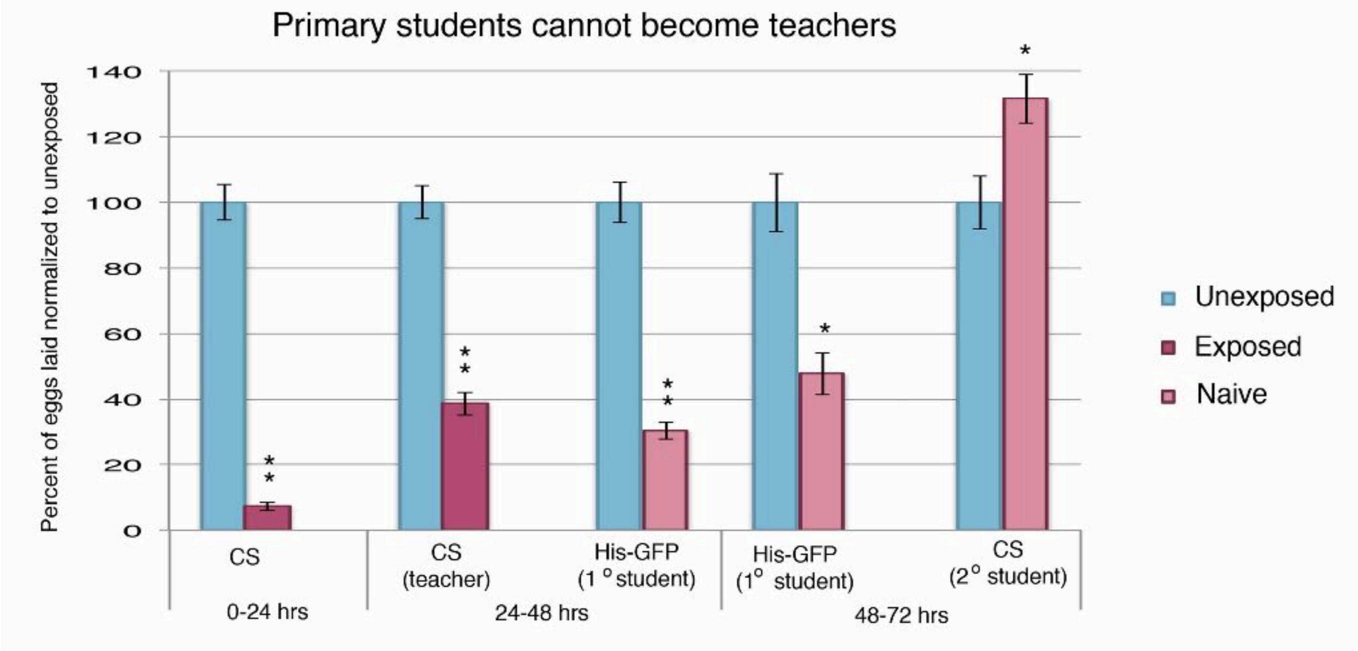
- egg-laying site choice
- decreasing oviposition

Exposure to predator elicits both an acute and learned oviposition depression.



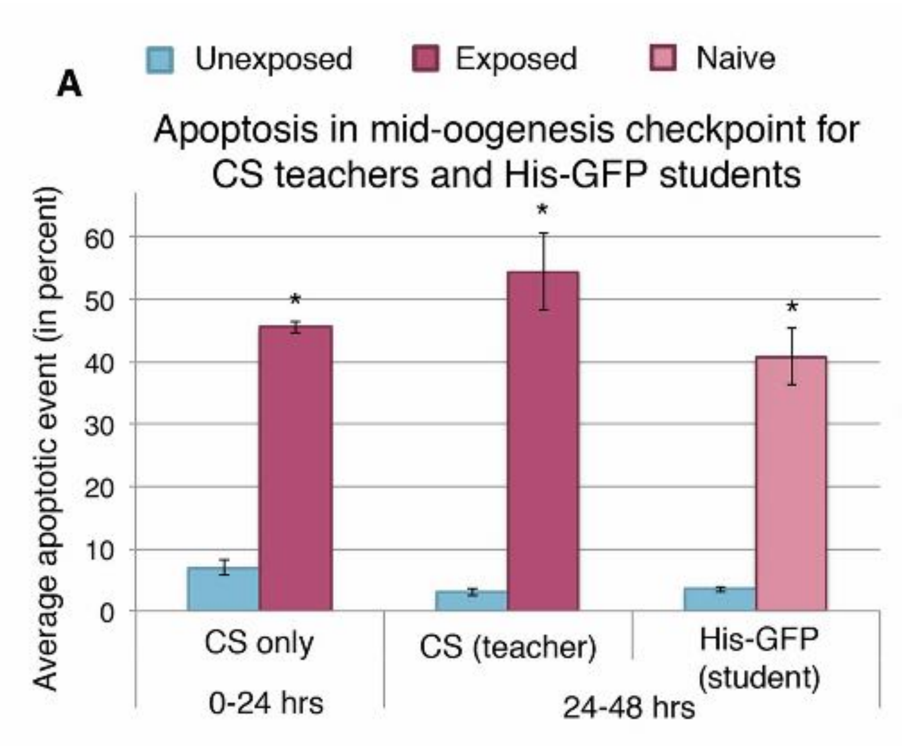
Teacher-instructed student flies are unable to become teachers

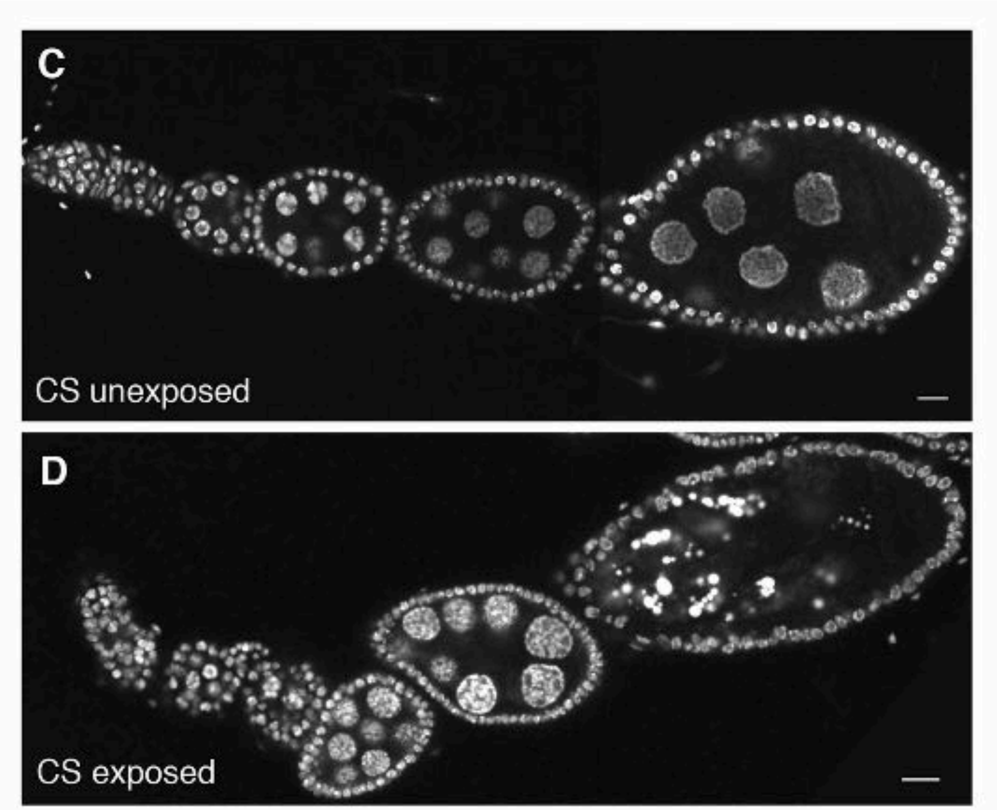




Wasp exposure induces stage-specific apoptosis in wasp-exposed teachers

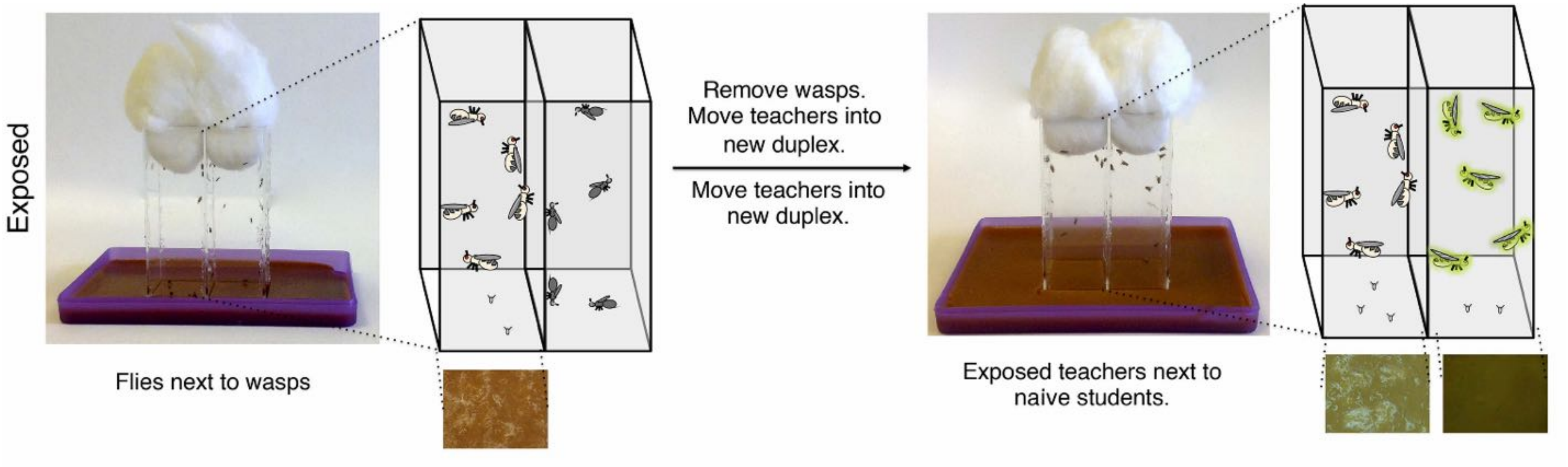
Naive student flies induce apoptosis when paired with wasp-exposed teachers

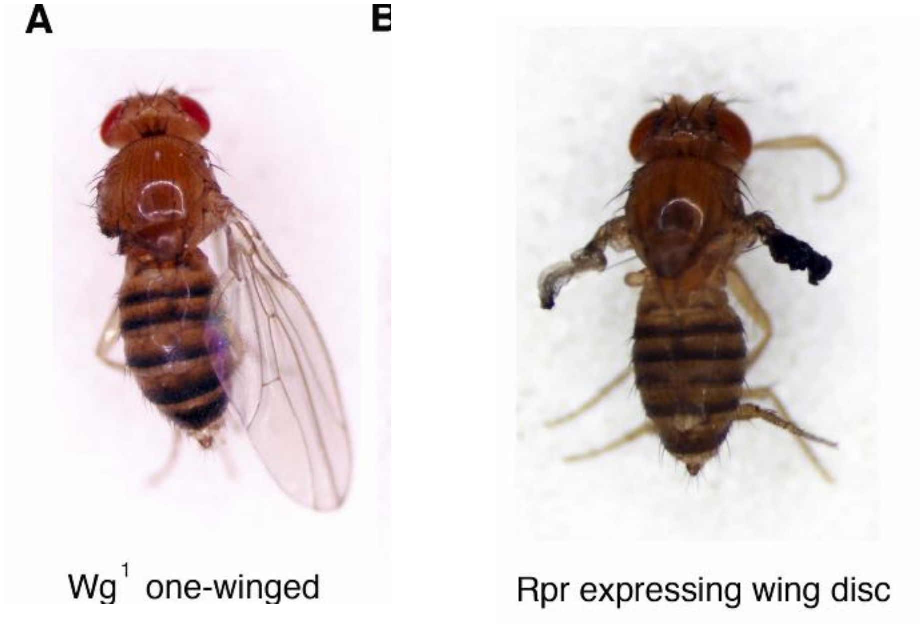


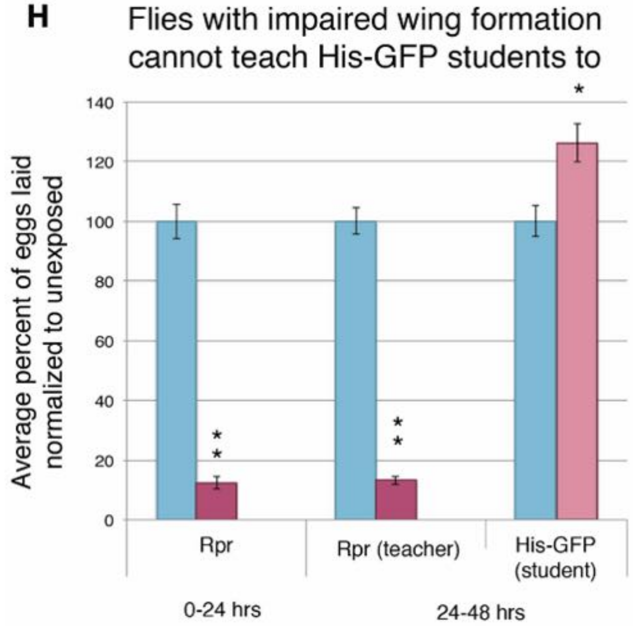


A visual cue alone is sufficient to elicit the behavioral change.

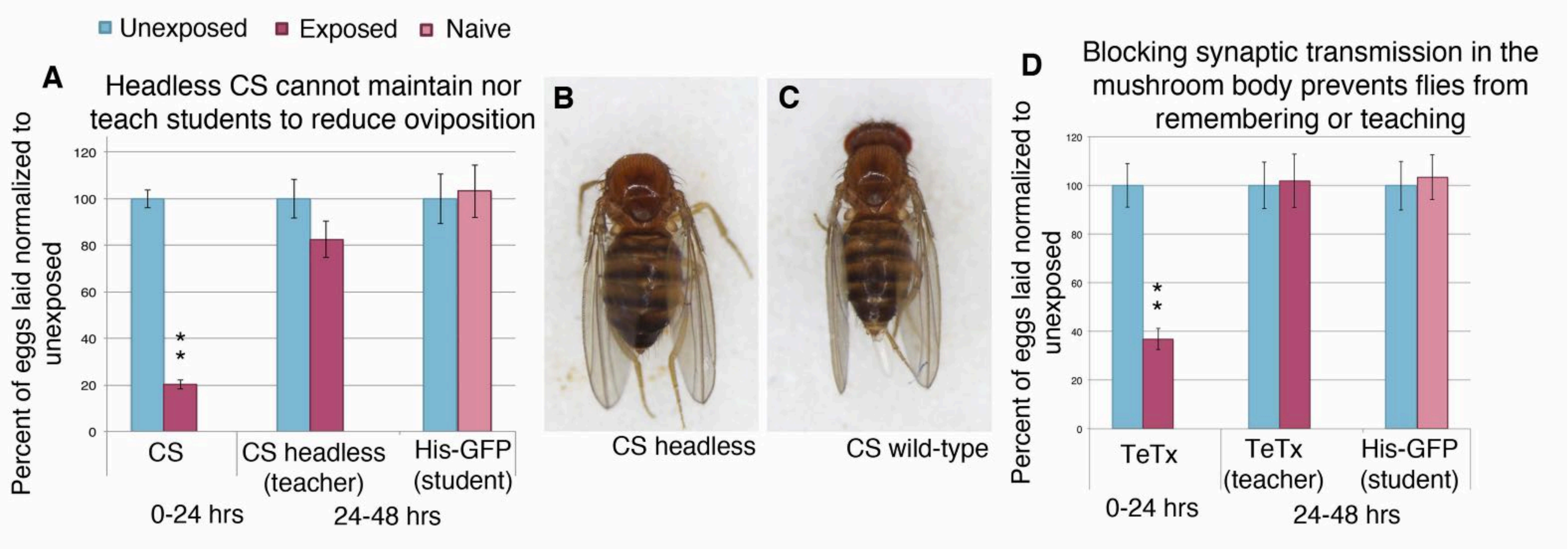
Teacher flies communicate information to naive flies through visual cues by their wings.

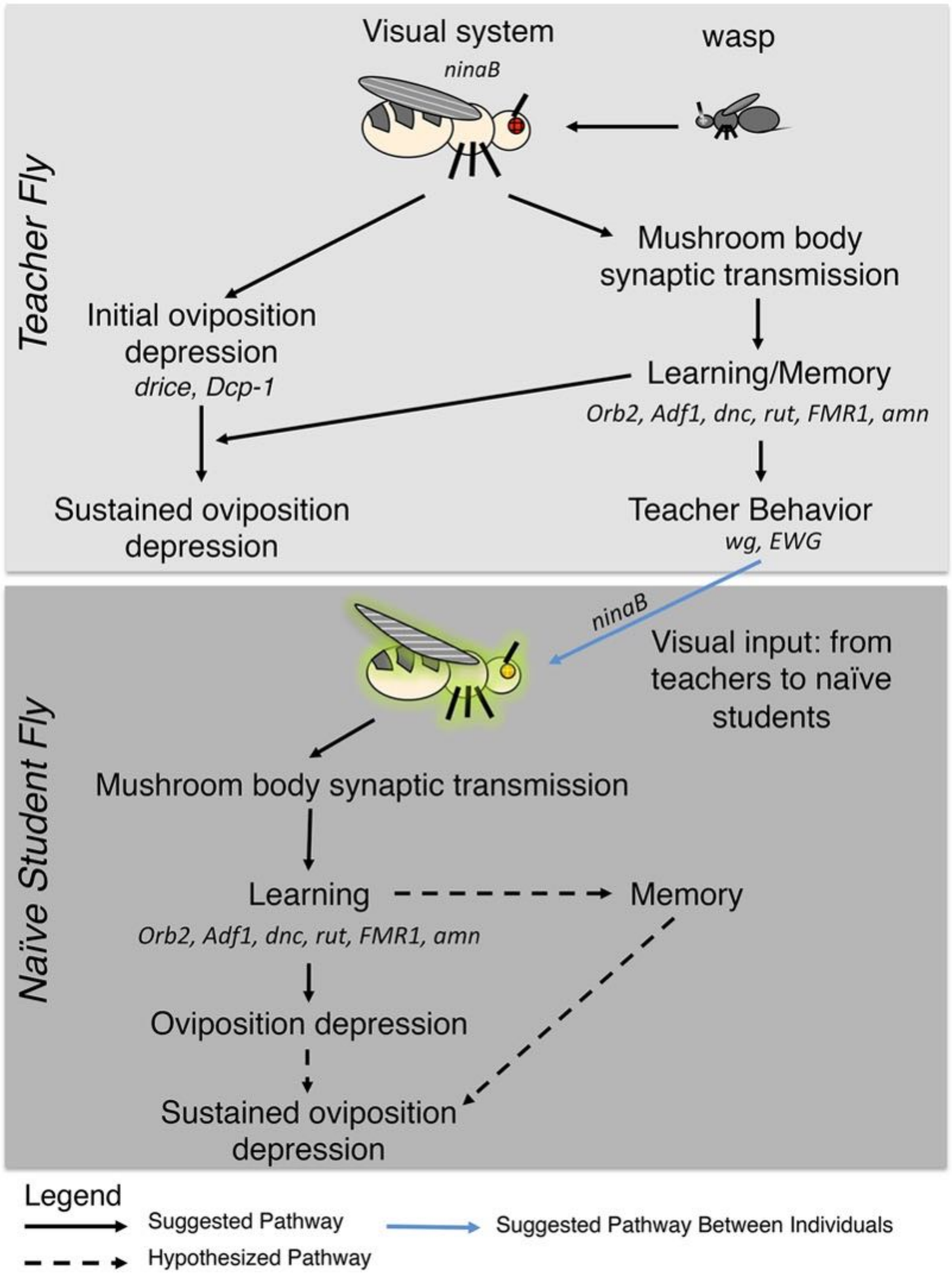






Continued input from the mushroom body is required for the learned response and teaching behavior

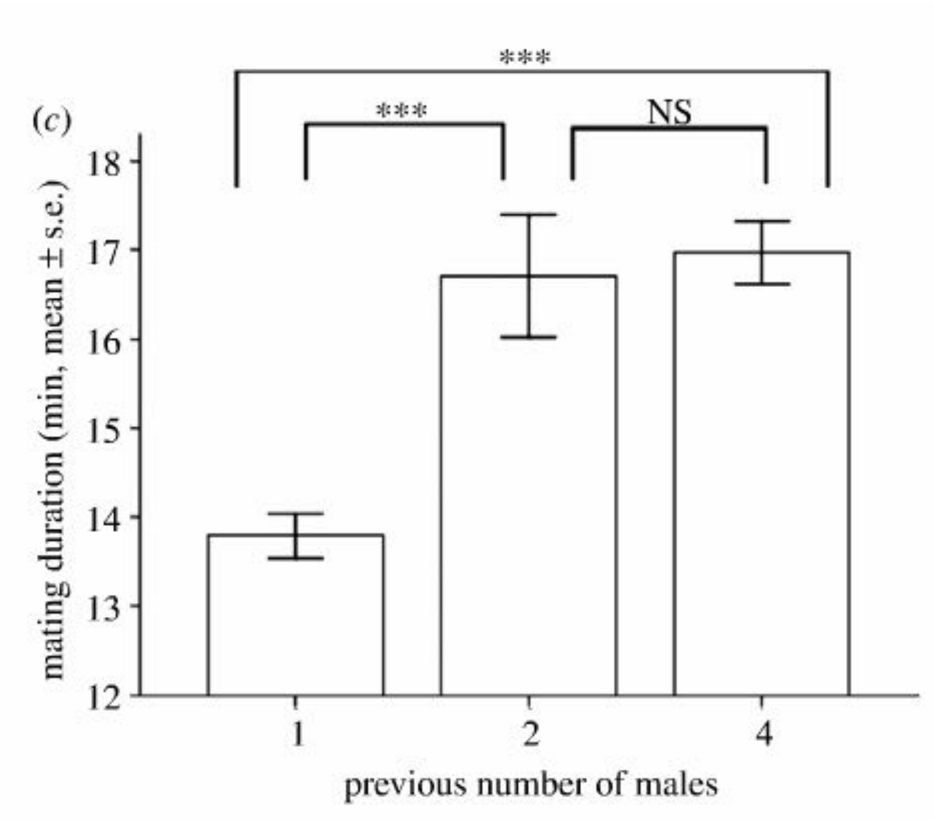


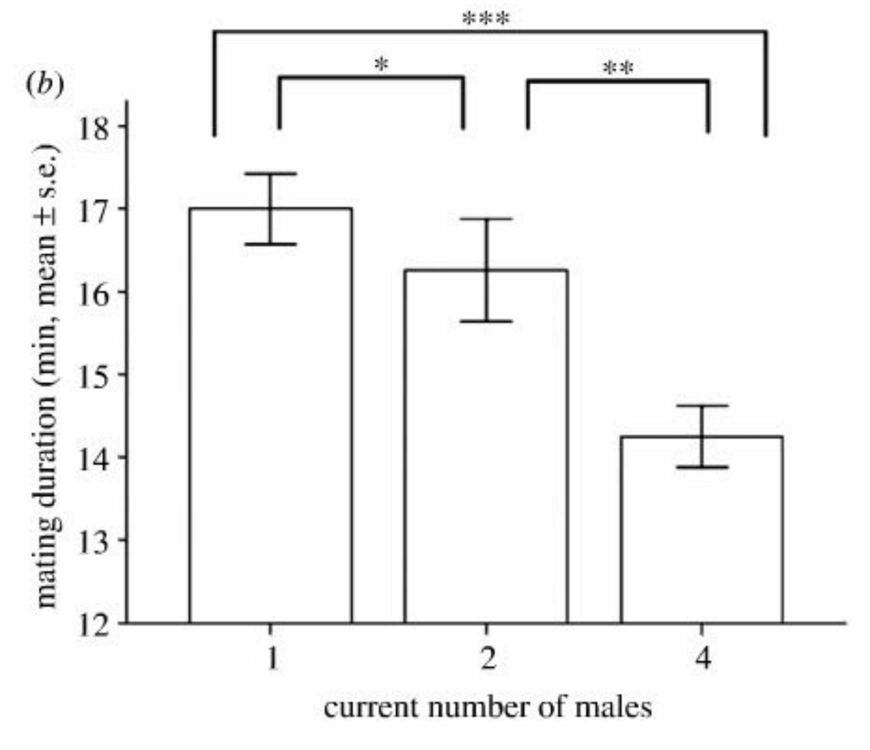

Teacher Fly
Visual system
ninaB
wasp
Initial oviposition depression
drice, Dcp-1
Mushroom body synaptic transmission
Learning/Memory
Orb2, Adf1, dnc, rut, FMR1, amn
Sustained oviposition depression
Teacher Behavior
wg, EWG
Naïve Student Fly
ninaB
Visual input: from teachers to naïve students
Mushroom body synaptic transmission
Learning
Memory
Orb2, Adf1, dnc, rut, FMR1, amn
Oviposition depression
Sustained oviposition depression
Legend
Suggested Pathway
Hypothesized Pathway
Suggested Pathway Between Individuals

male courtship

- mating duration: rival induce longer-mating-duration
- losers in a fight mate less
- mating copy in males

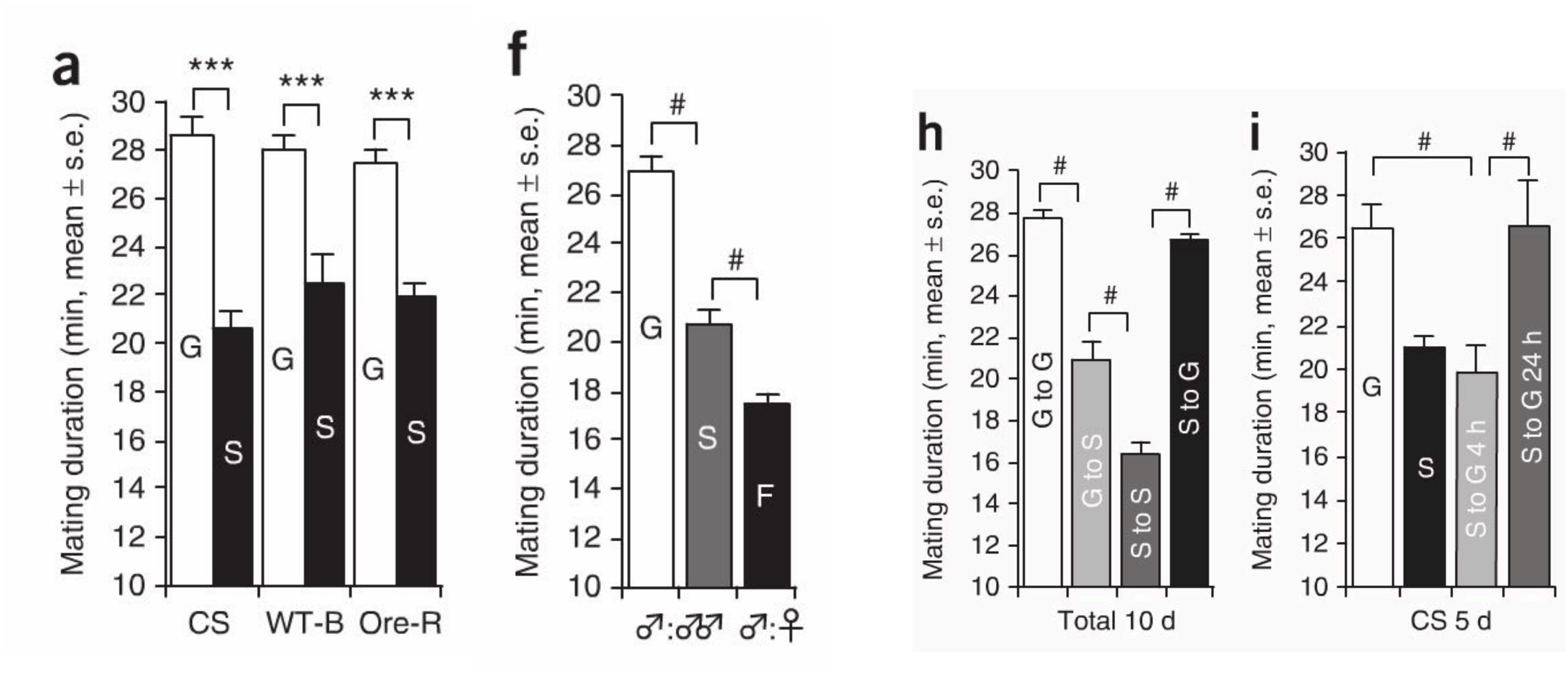
Exposure to rival males prior to mating increased a male's ejaculate investment (measured as mating duration);
by contrast, exposure to rival males during the mating decreased mating duration.





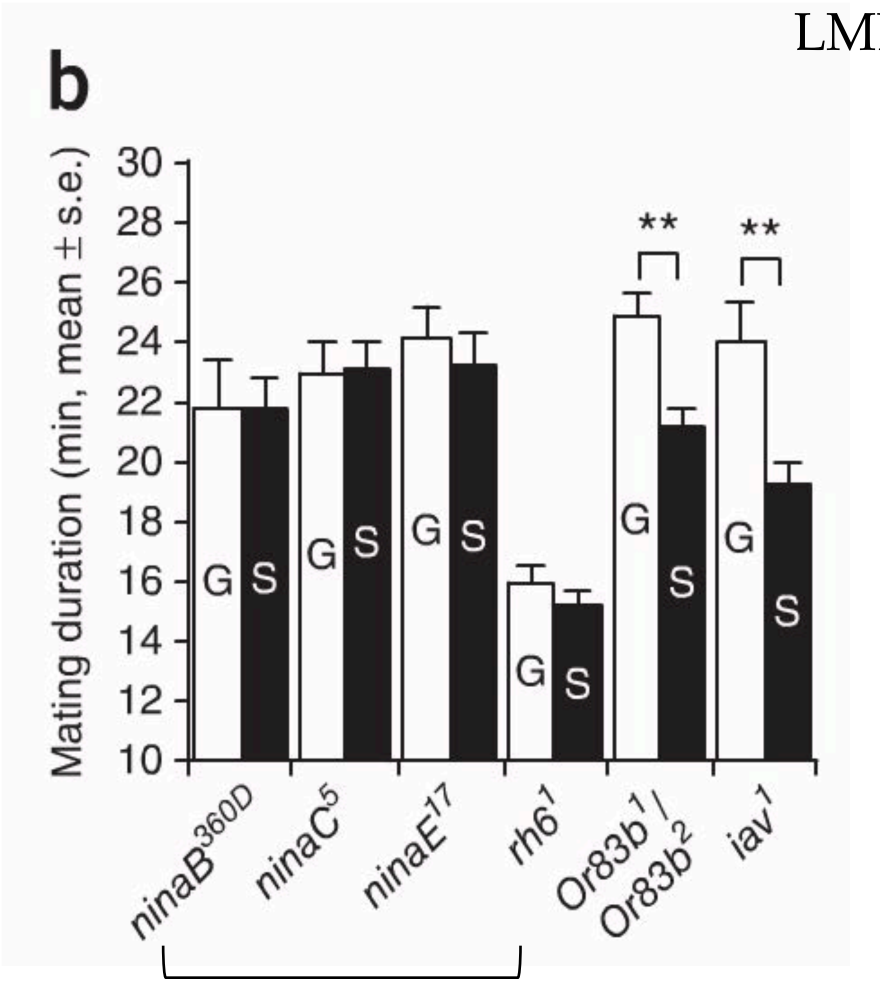
Bretman, A. et al. 2009. *Proceedings. Biological sciences.*

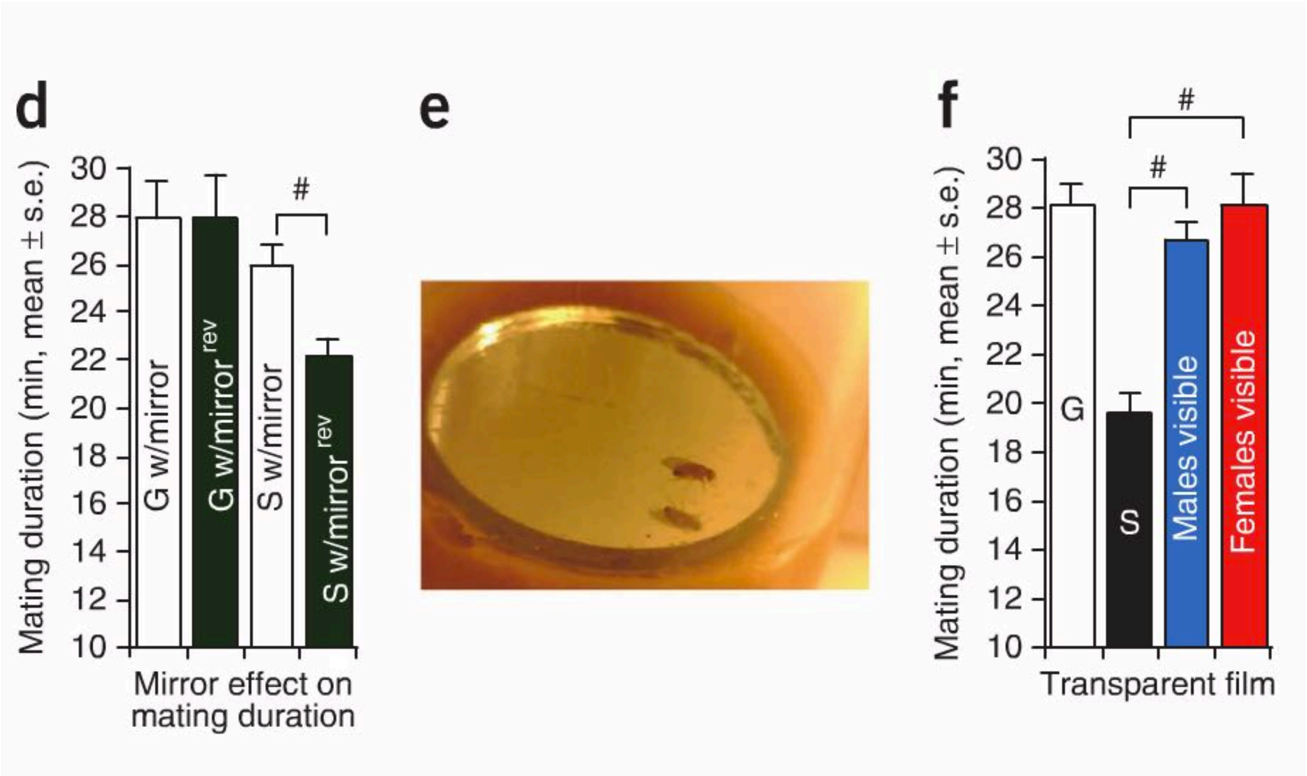
LMD (Longer Mating Duration) is a plastic behavior.



Kim, W. et al. 2012 *Nature Neuroscience*.

LMD is induced by visual stimuli.

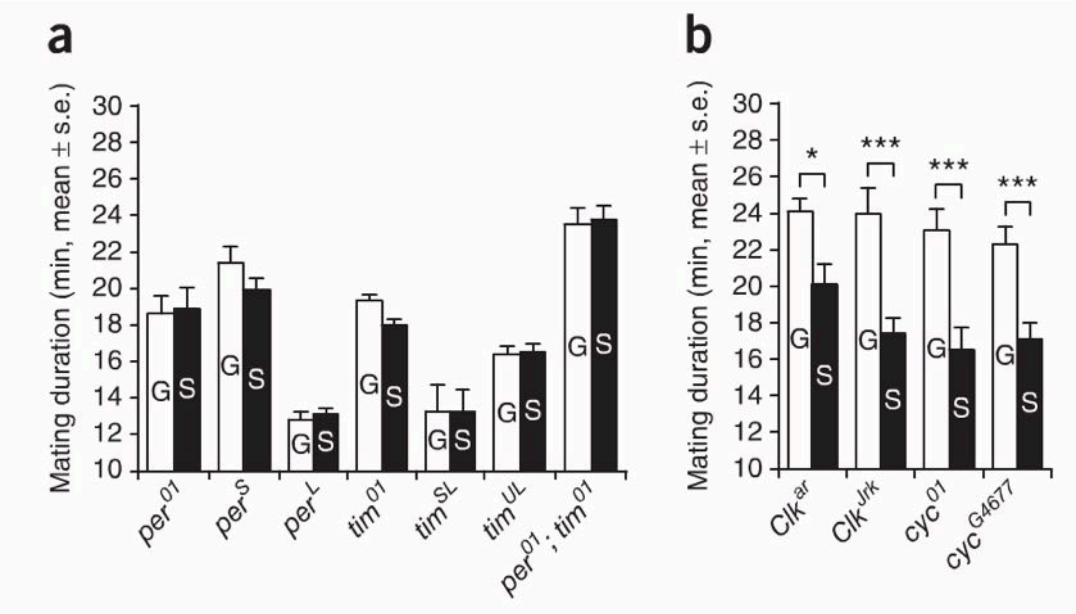


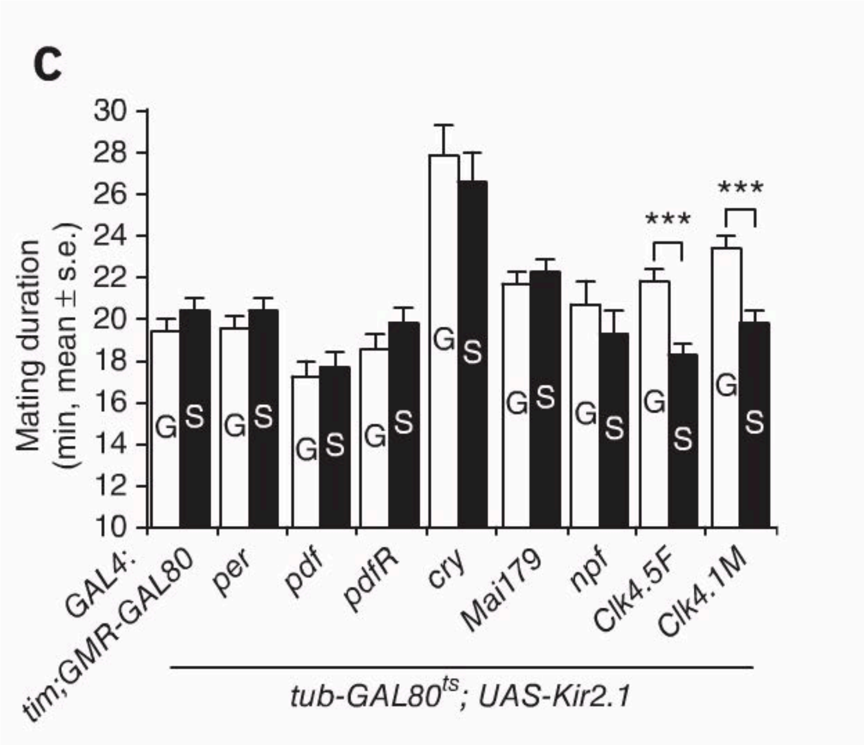


vision olfactory auditory mutants

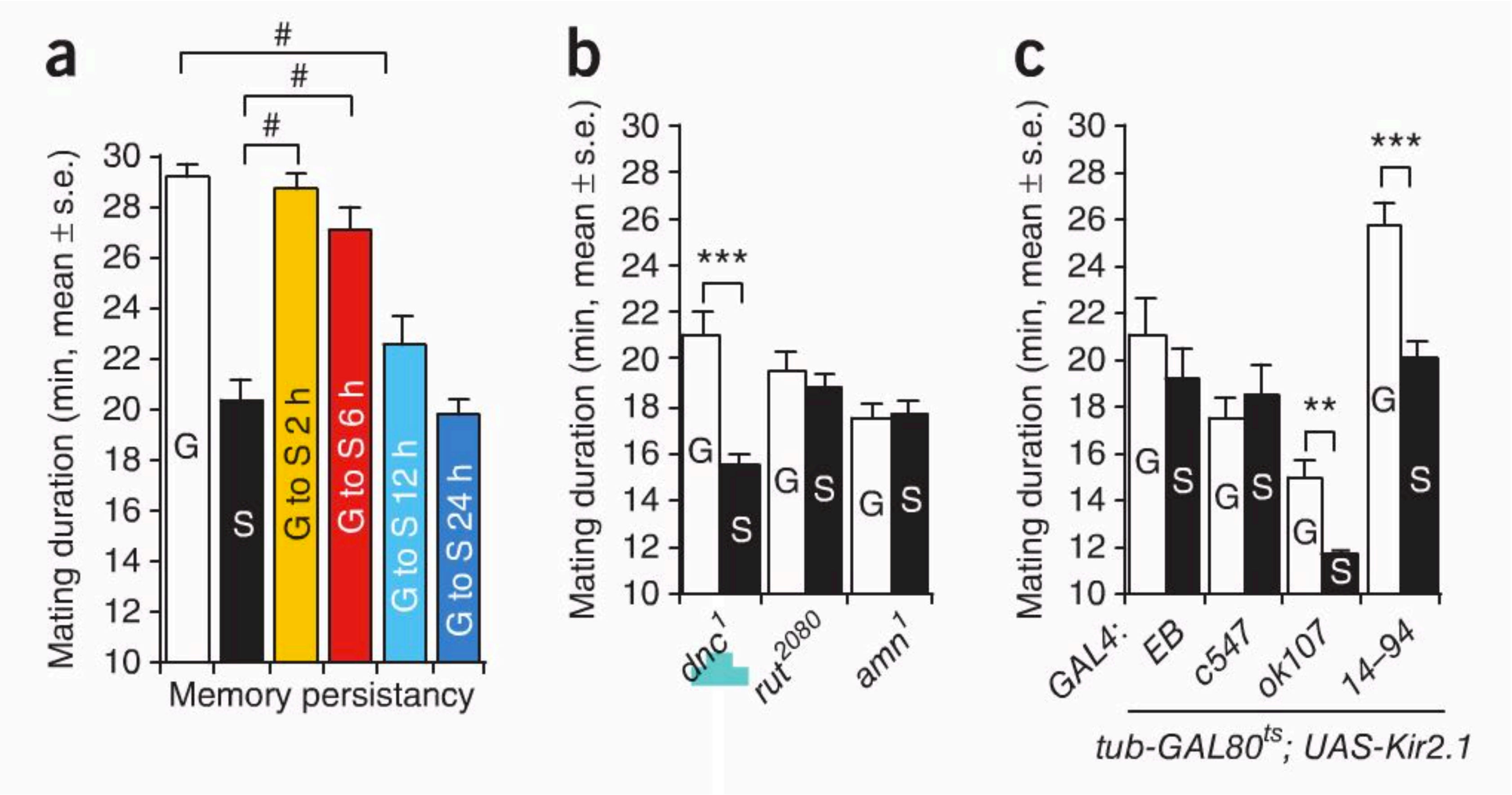
PER and TIM are required for LMD

LMD involves a subset of circadian neural circuits including PDF neurons.



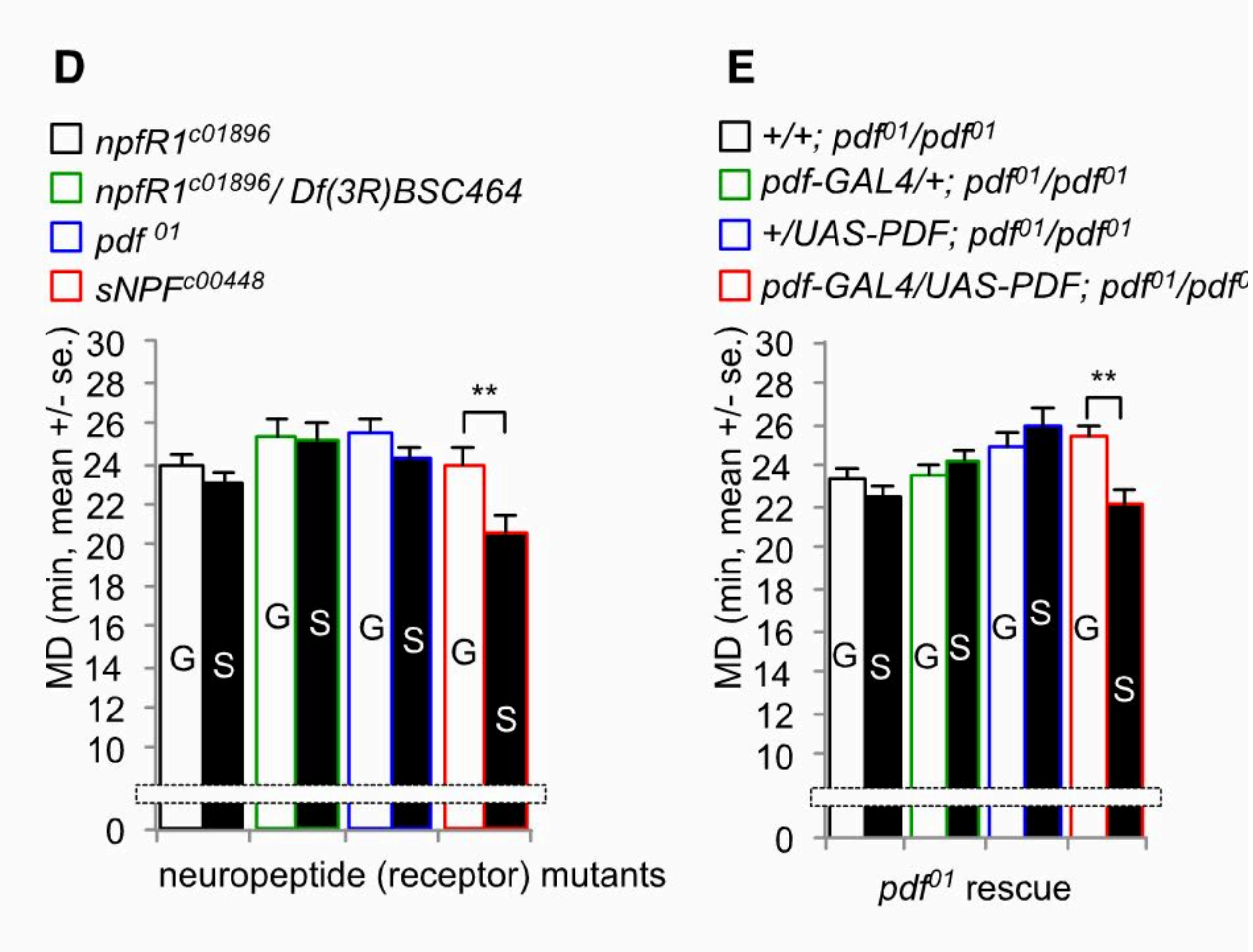


LMD requires visual memory and requires neurons in the ellipsoid body.

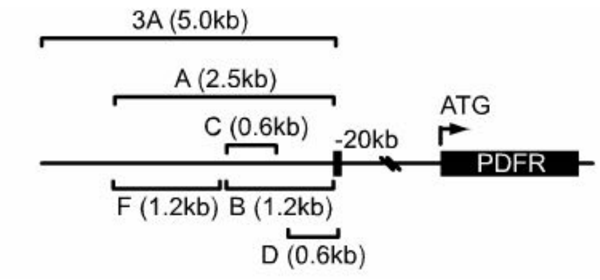


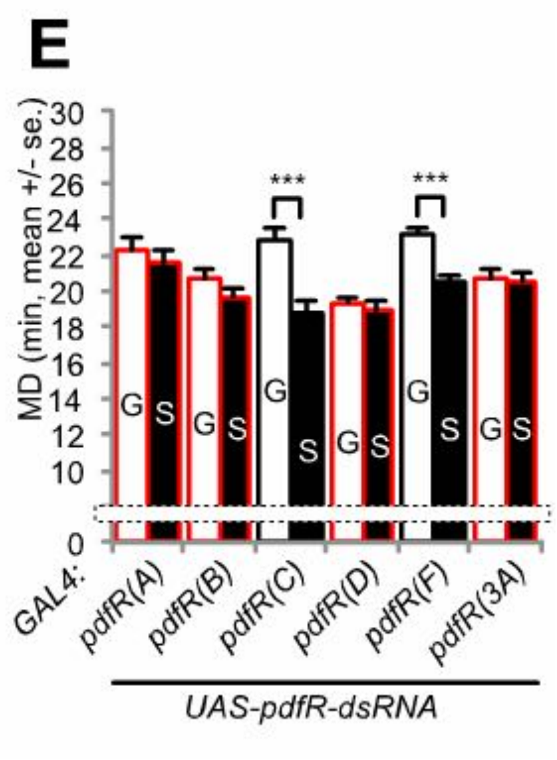
LMD behavior requires the neuropeptides PDF and NPF but not sNPF.

PDF expression in s-LNvs is sufficient to generate LMD



PdfR Expression in LNd Is Required to Generate LMD

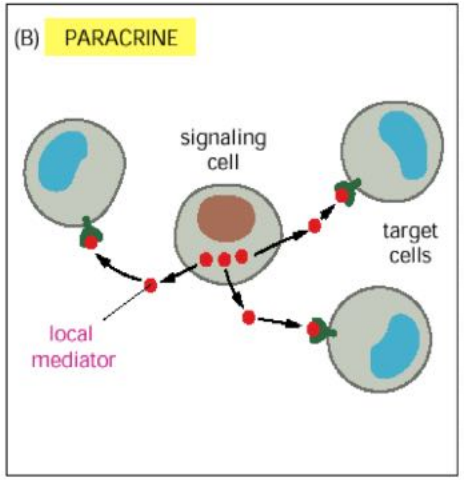


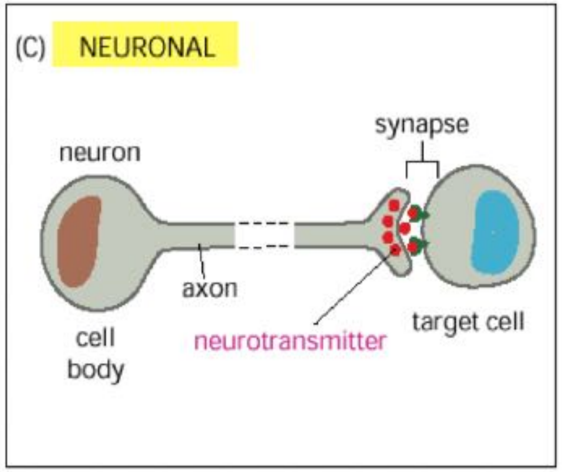


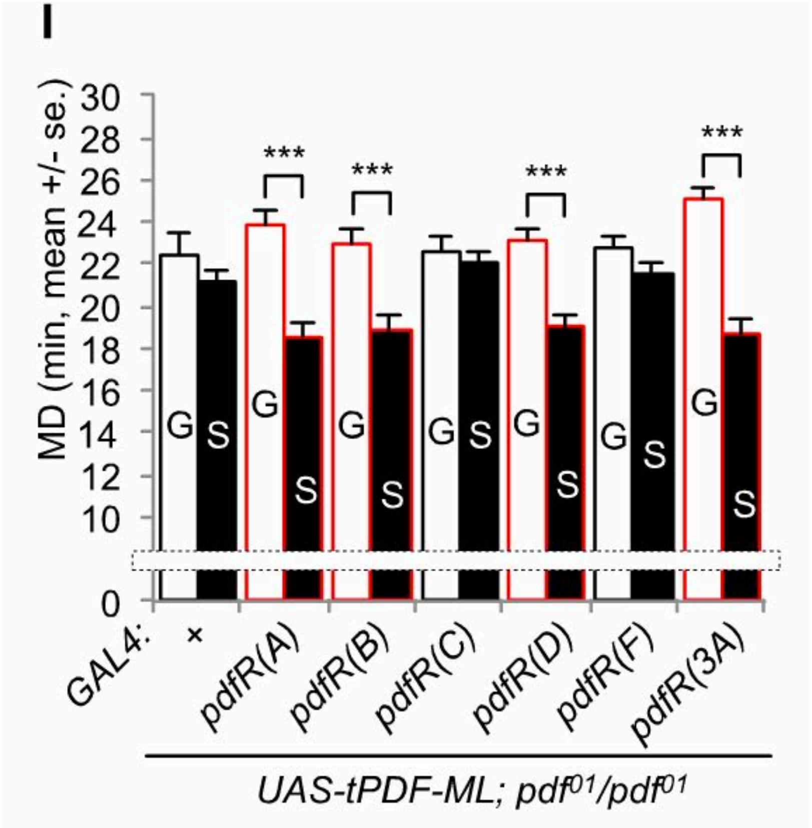
Kim, W. et al. 2013. *Neuron*.

PDFR in a small subset of LNd neurons may be activated by PDF released by nearby s-LNv axons that do not make direct synaptic contacts with them to generate LMD.

UAS-tPDF-ML: a membrane-tethered form of PDF

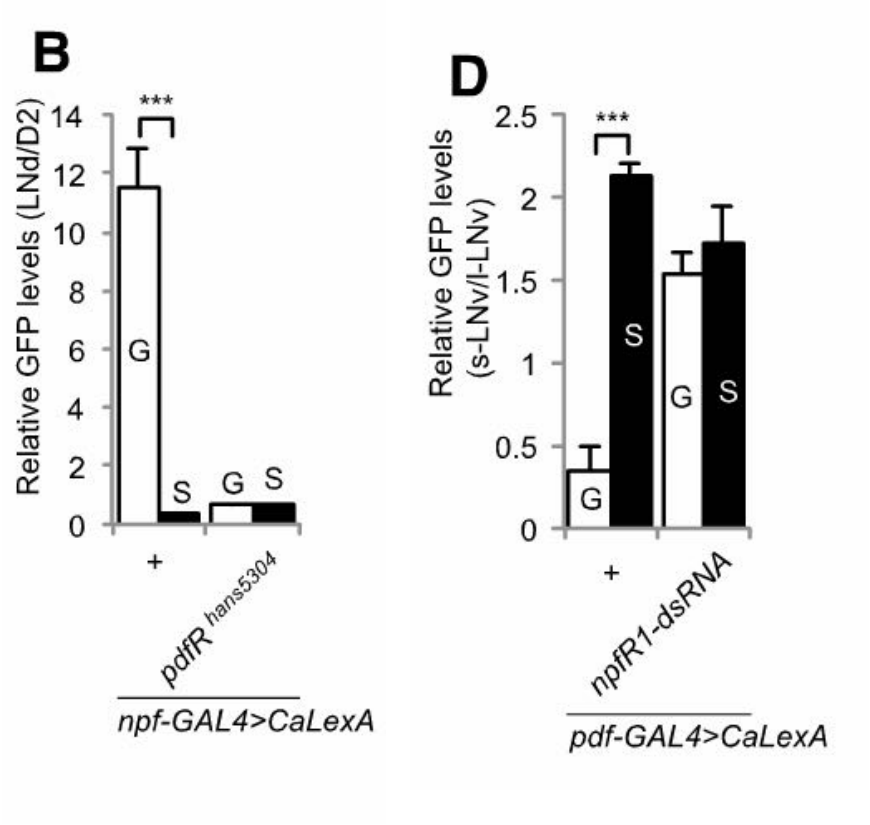


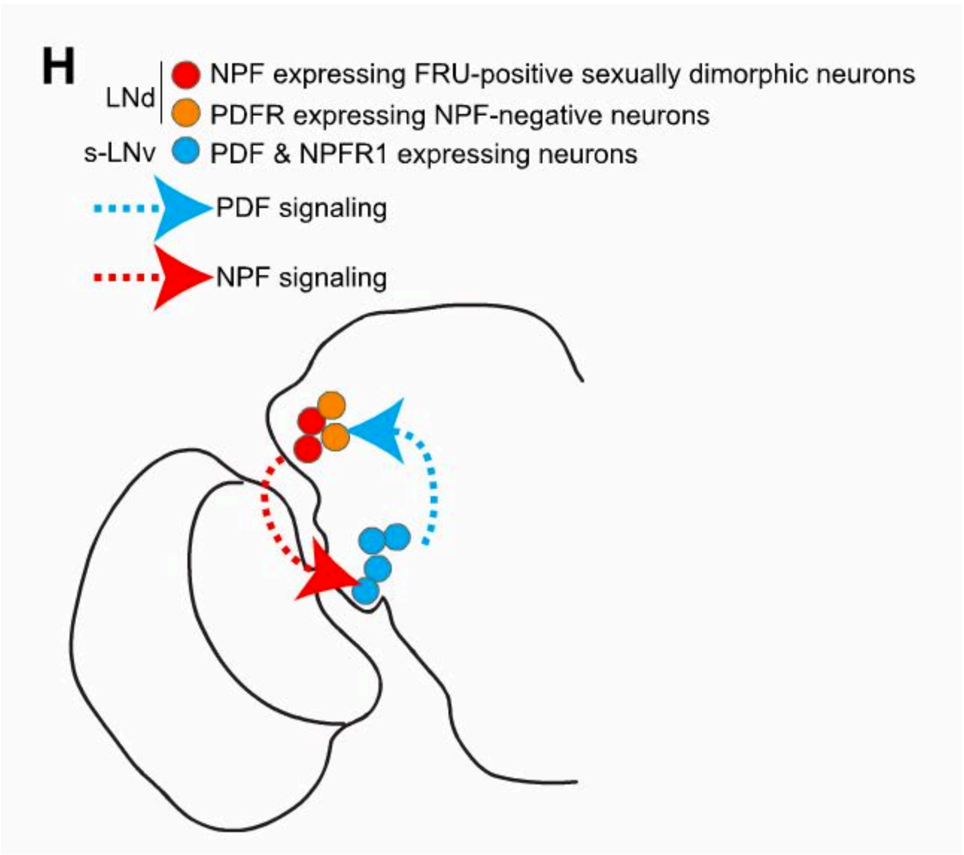




- LMD requires NPFR1 expression in the four PDF-Positive s-LNv neurons.
- LMD requires two NPF-expressing neurons in the LNd region that are sexually dimorphic and positive for CRY but negative for PDFR
- Exposure to rival males caused an increase of activity of the LNd neurons expressing NPF and also decreased the activity of s-LNv neurons expressing PDF and NPFR.

CaLexA

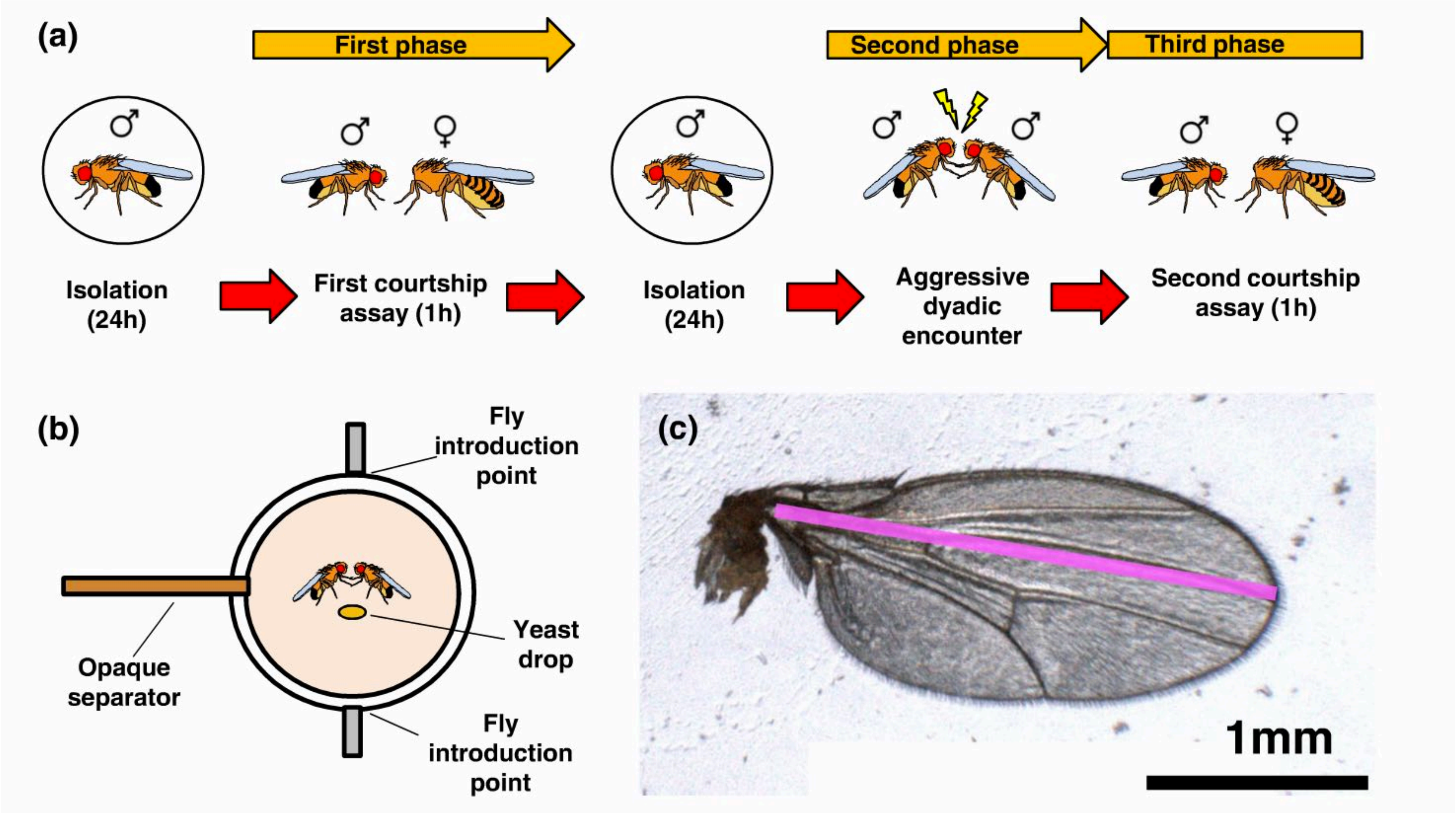




male courtship

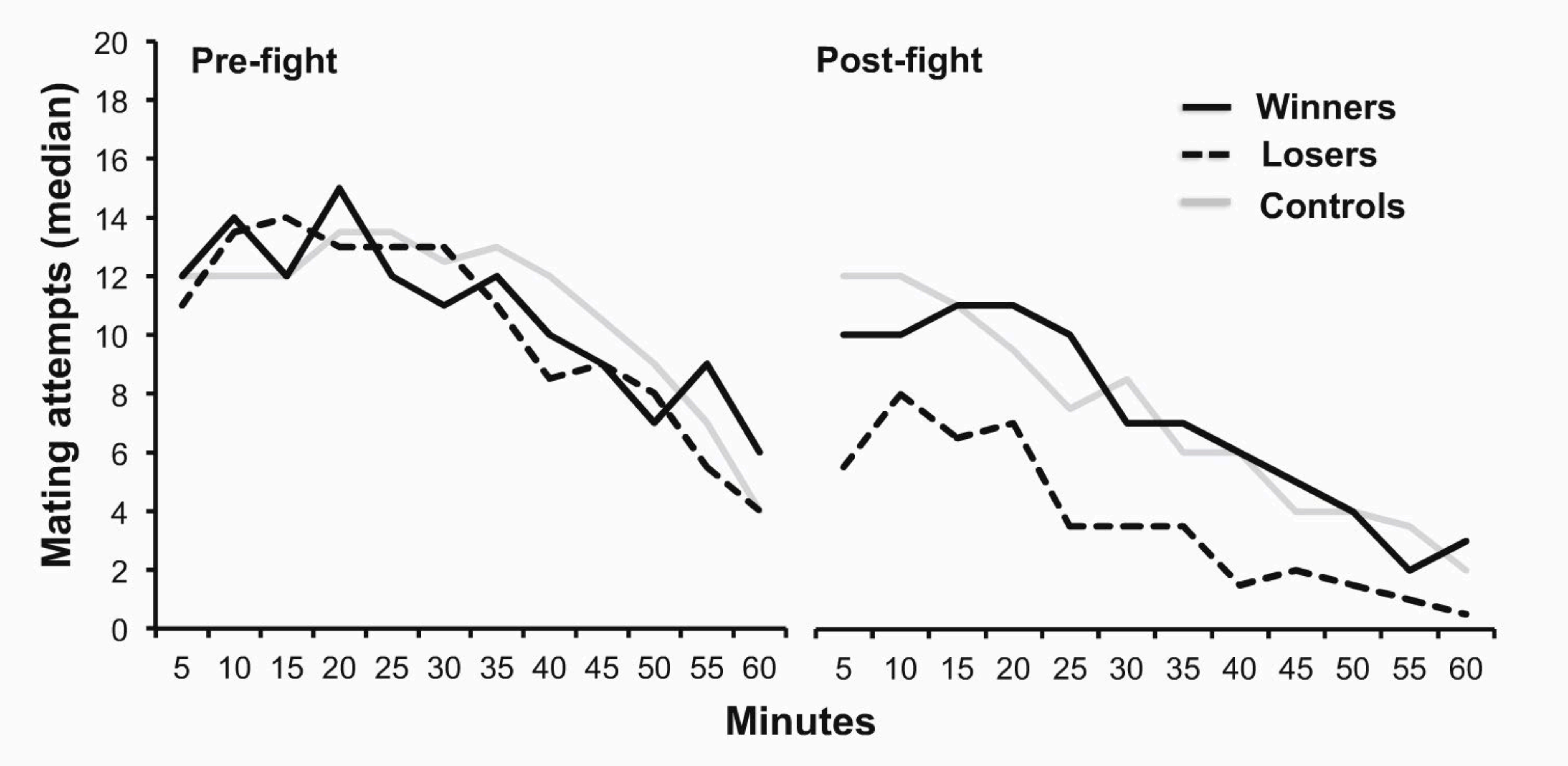
- mating duration: rival induce longer-mating-duration
- losers in a fight mate less
- mating copy in males

Fighting experience affects fruit fly behavior in a mating context.



Teseo, S., Veerus, L. and Mery, F. 2016.

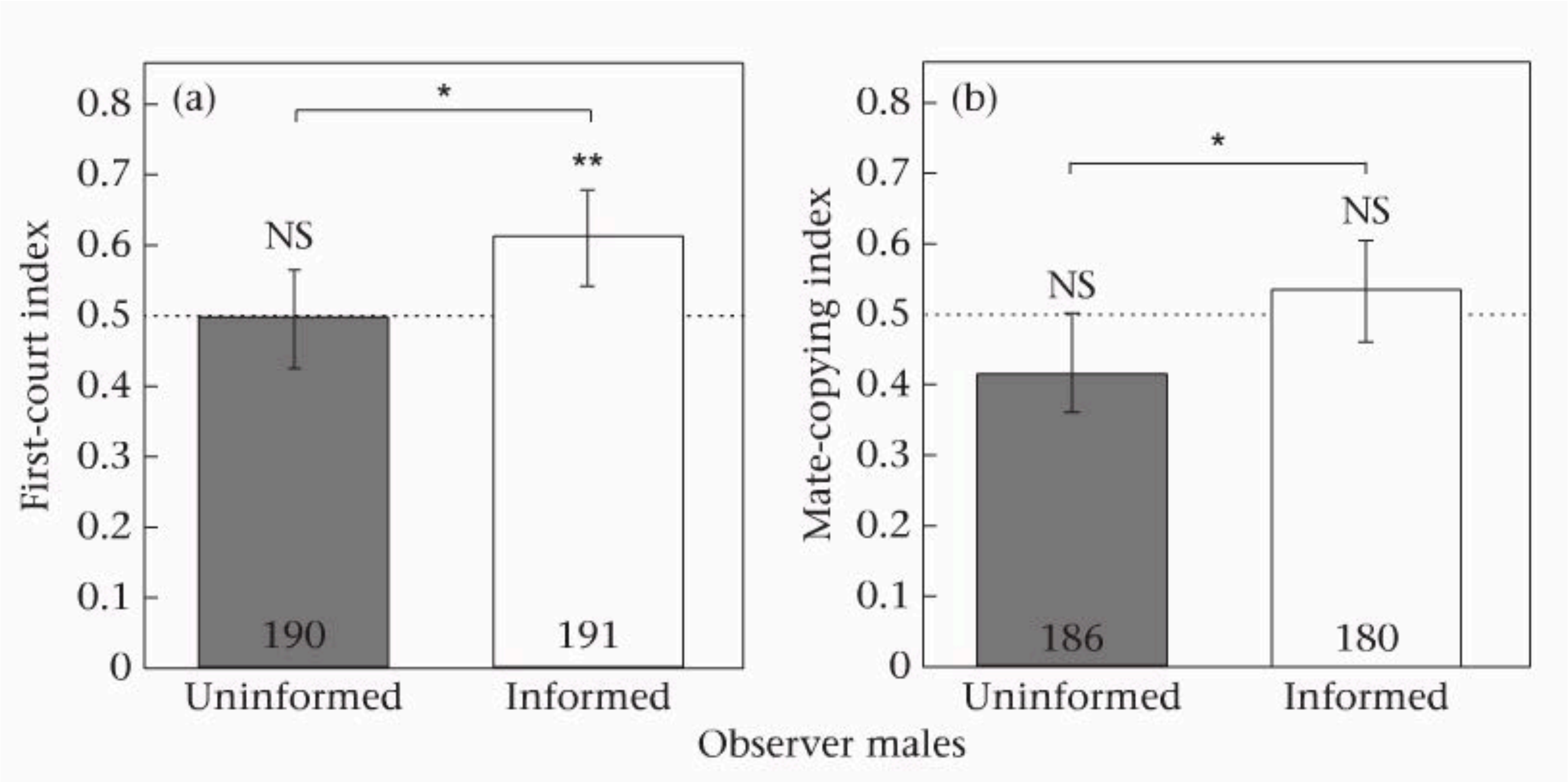
Losers mate less than before and less than winner and control males.



male courtship

- mating duration: rival induce longer-mating-duration
- losers in a fight mate less
- mating copy in males

Mate copying in Drosophila melanogaster males



Nöbel, S., Allain, M., Isabel, G. and Danchin, E. 2018.

Effects of social experience on productive behavior in *Drosophila*

- female receptivity
  - mating copy
  - oviposition
    - egg-laying site choice
    - decreasing oviposition
- male courtship
  - mating duration: rival induce longer-mating-duration
  - losers in a fight mate less
  - mating copy in males

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Thank you!