Science | AAAS

EVOLUTIONARY BIOLOGY

Cross-species implementation of an innate courtship behavior by manipulation of the sex-determinant gene

Xinyu Zhang

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Cross-species implementation of an innate courtship behavior by manipulation of the sex-determinant gene

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Research Interests:
courtship behavior
Neuron circuit
...

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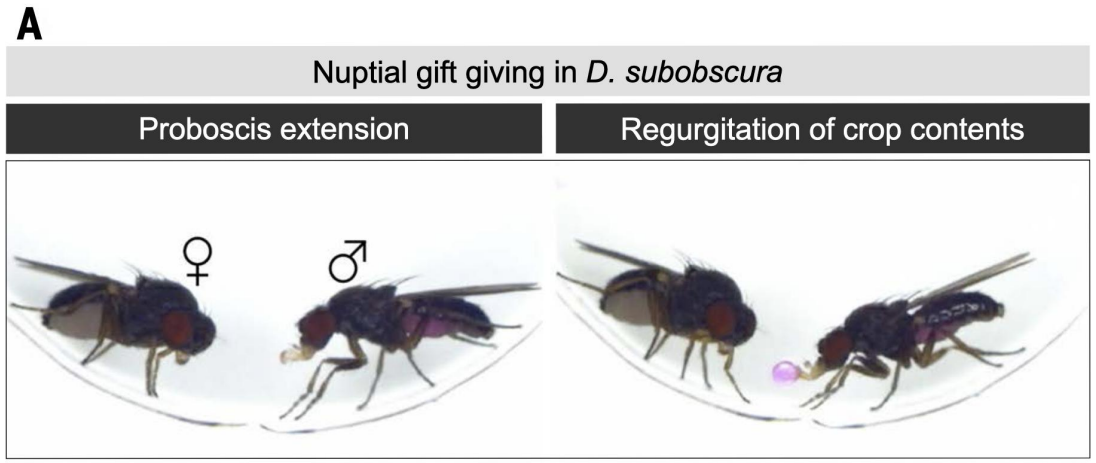
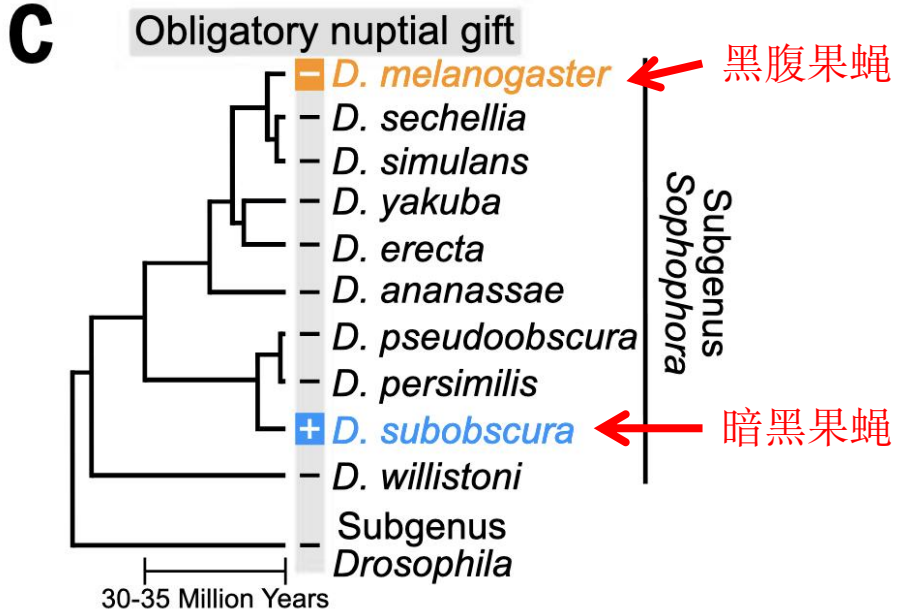
What is Nuptial gift giving (NGG) ?





Courtship behavior in *D. subobscura*

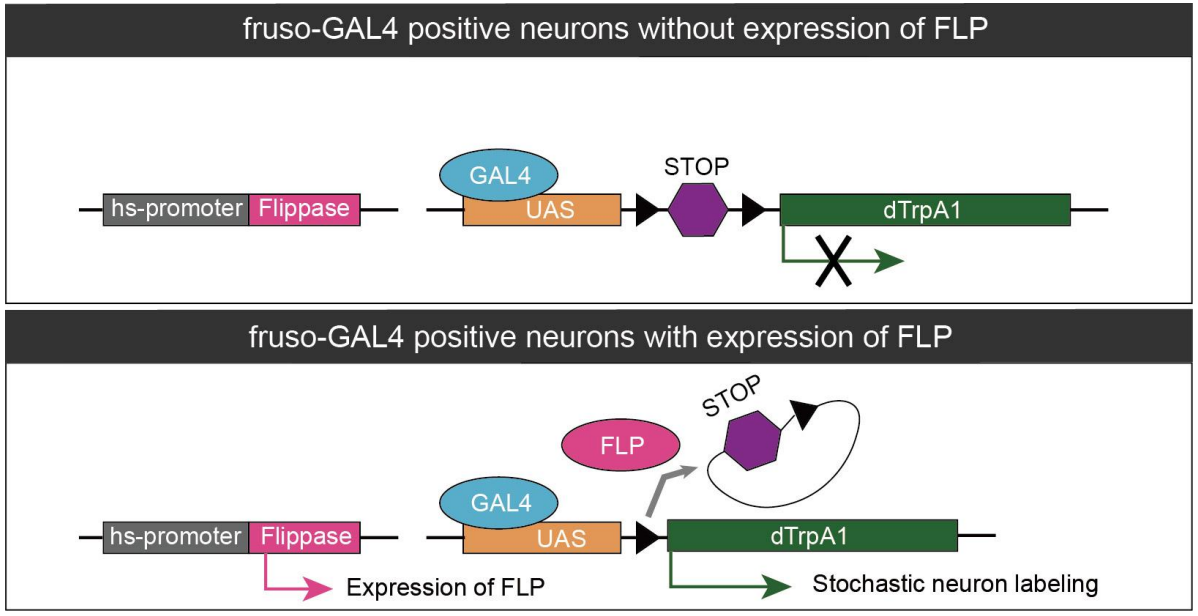
No Drosophila species other than D. subobscura exhibits any similar behavior

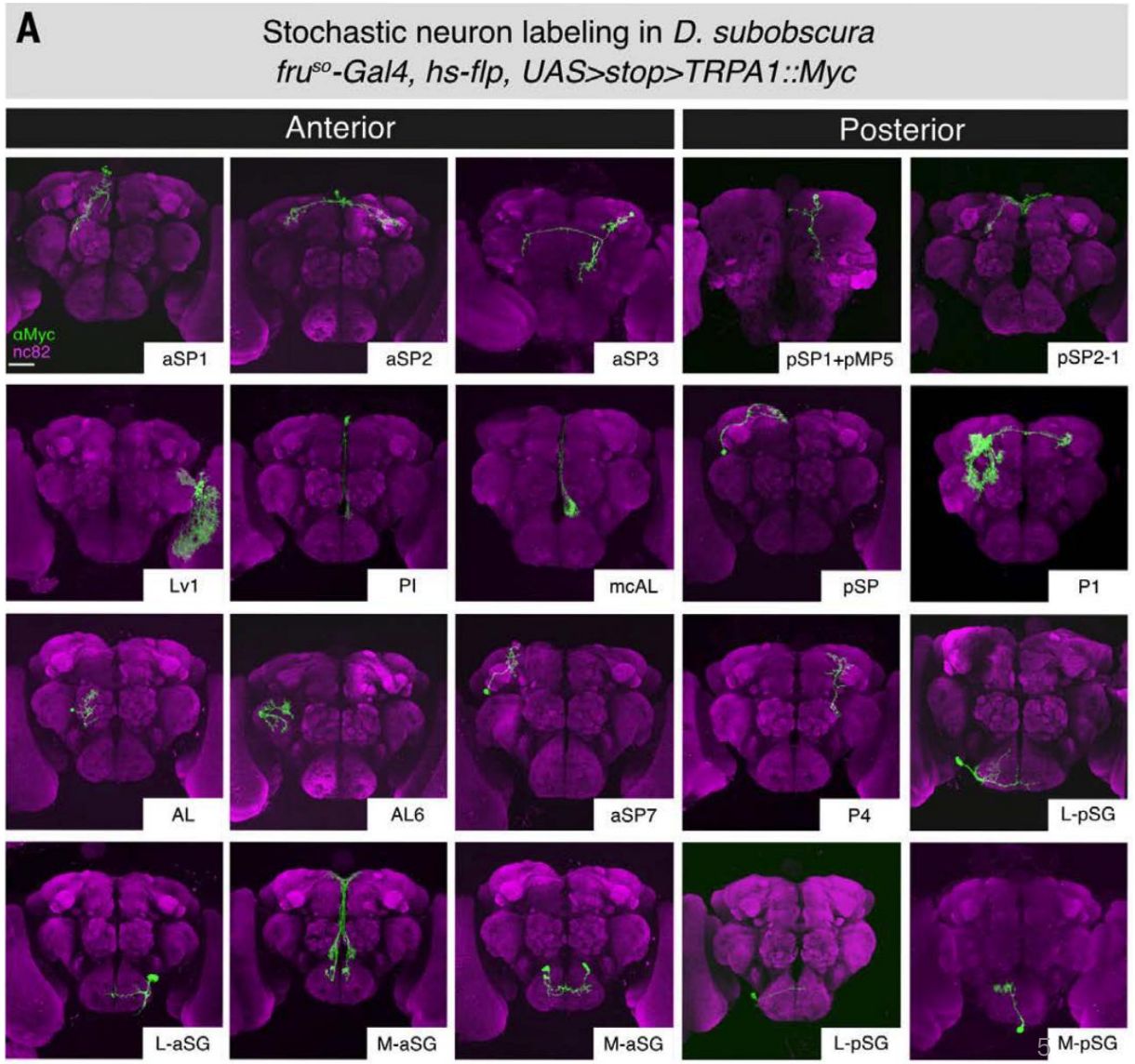
Key questions

- Why only D. subobscura?
- Does NGG improve male fitness?
- What neural mechanisms are responsible for this unique behavior?

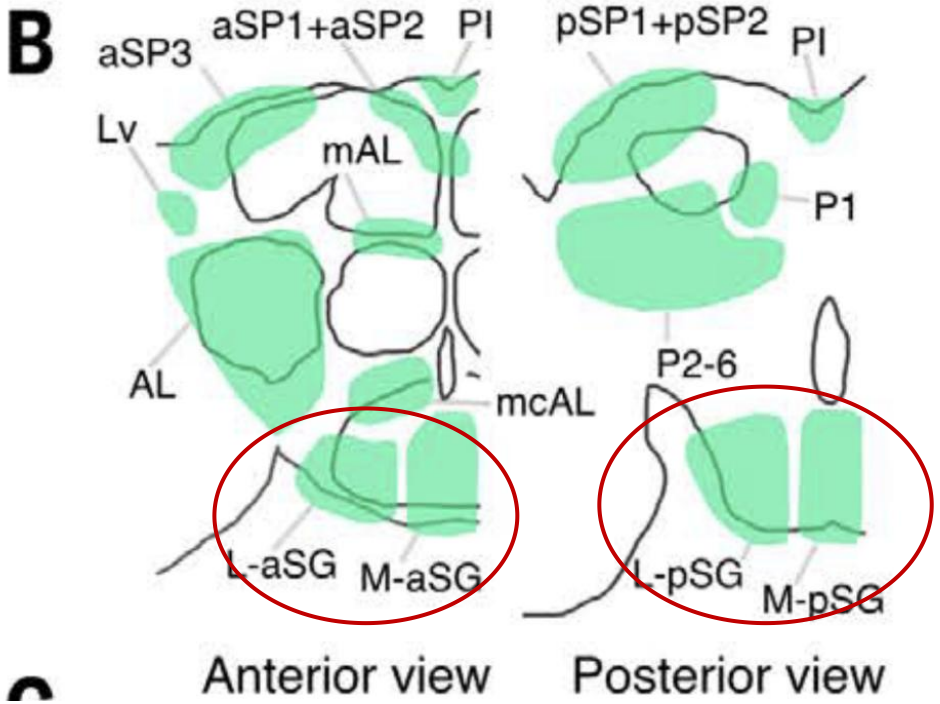
Mosaic analysis

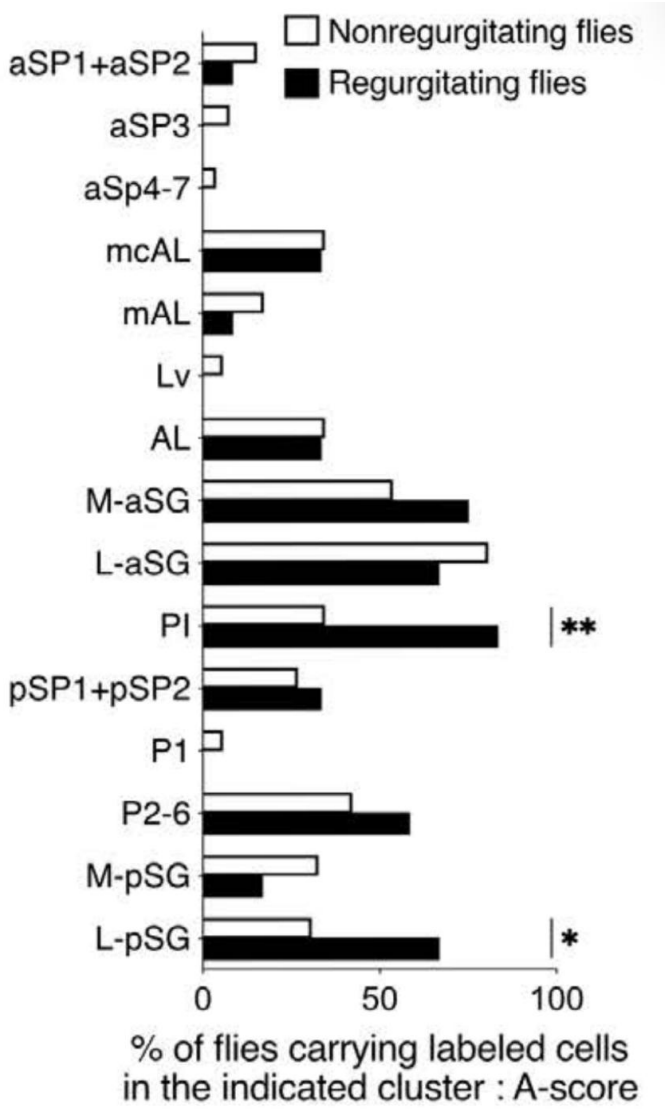
- Focused on fruitless (fru) gene
- Mosaic system: fru^{so}–GAL4, UAS>STOP> dTrpA1::Myc, and hs–flp
- Random activation of small sets of fru neurons
- Observe behavior → regurgitation–positive and negative

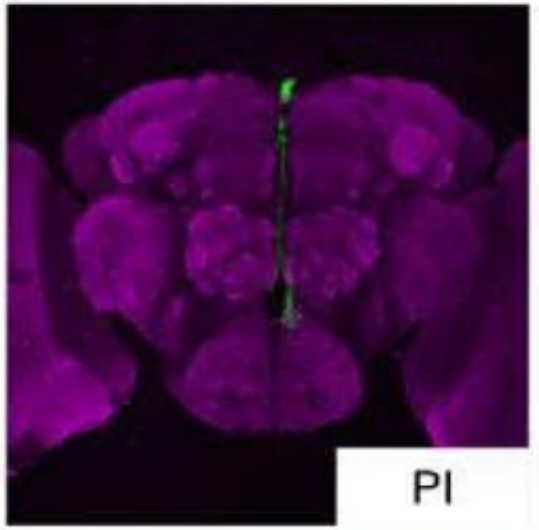


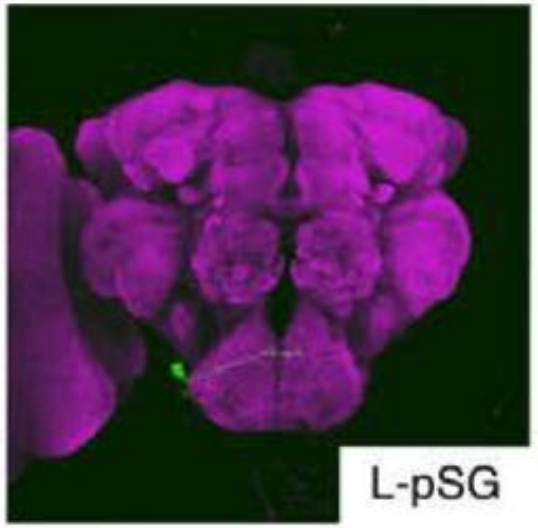


Candidate neurons



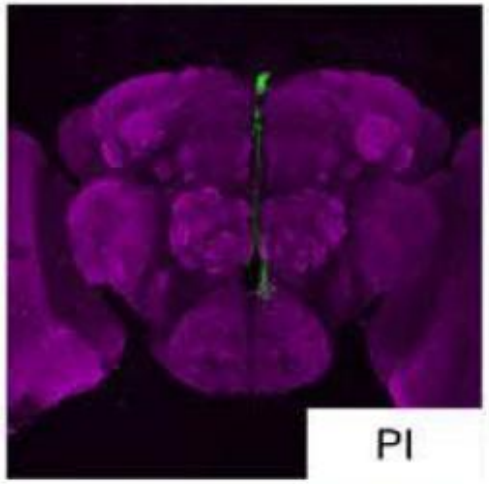


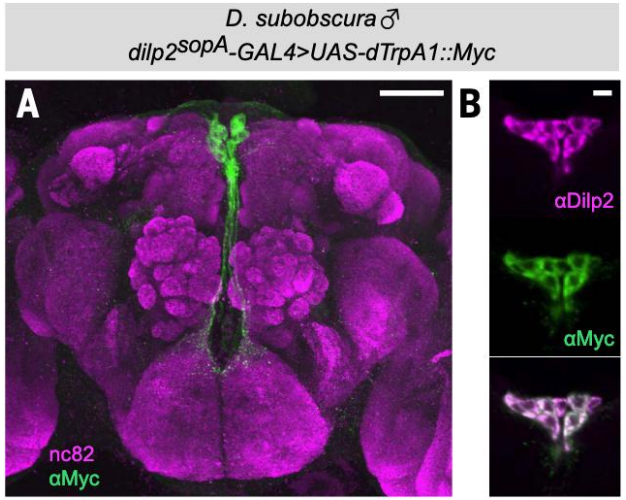




subesophageal ganglion (SG) 食道下神经节

Insulin neurons promote NGG

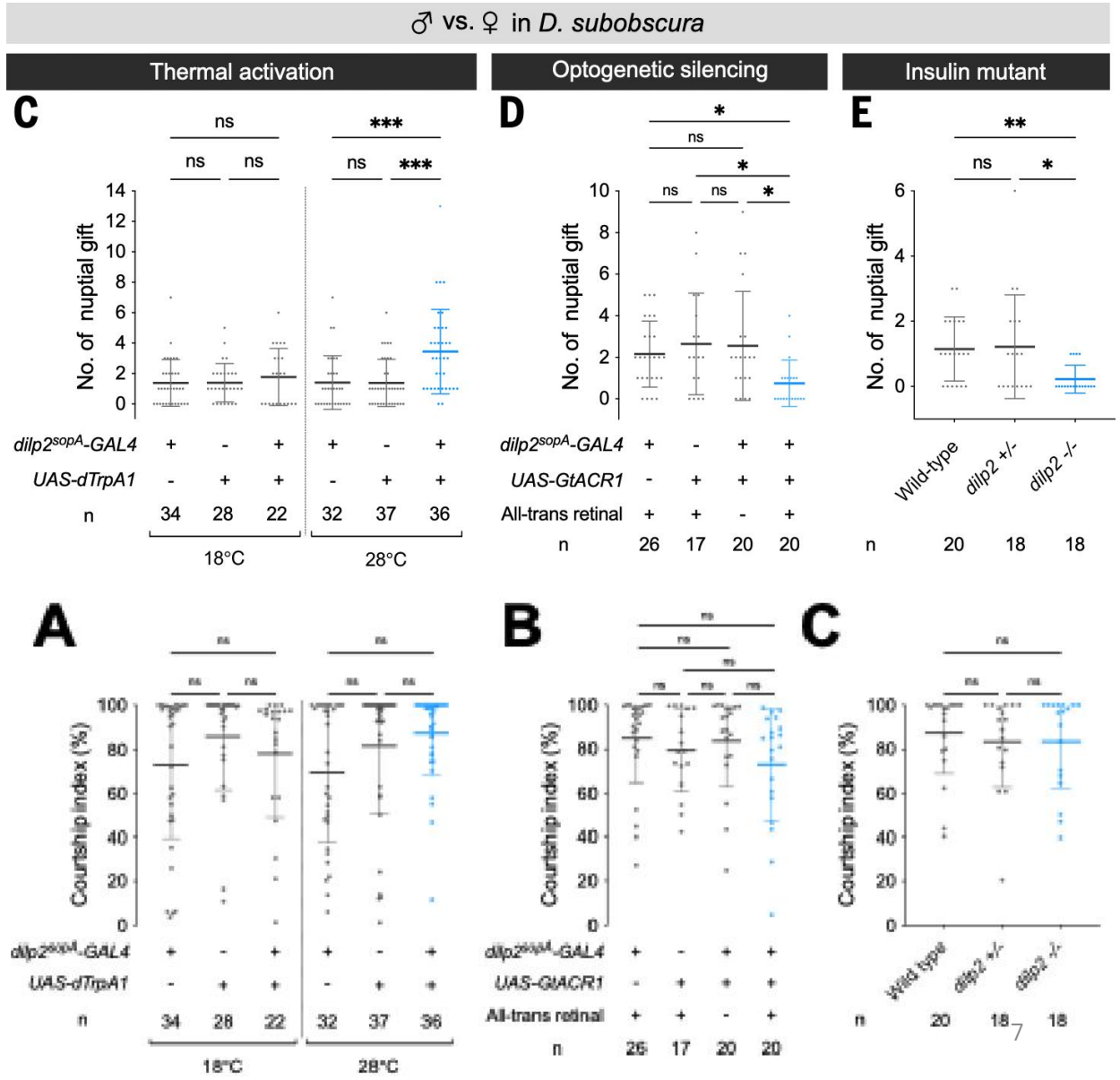




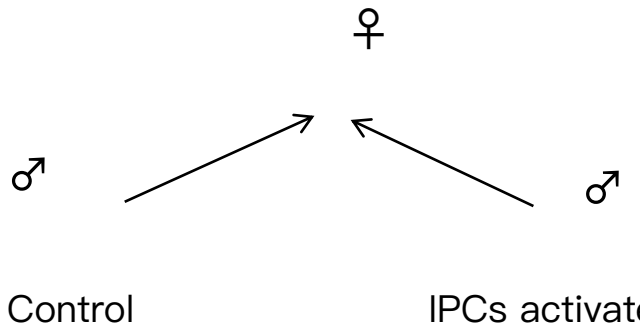
PI neurons resemble *D. melanogaster* insulin–like peptide producing cells（IPCs）

Are IPCs involved in NGG?

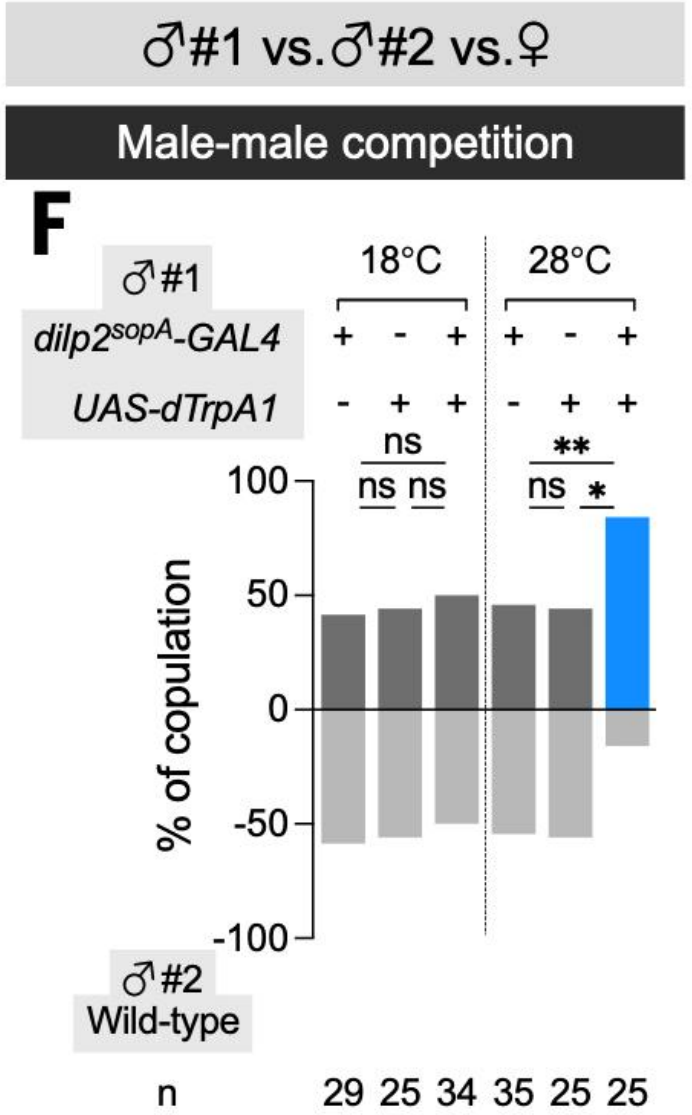
IPCs specifically promote NGG, not general courtship



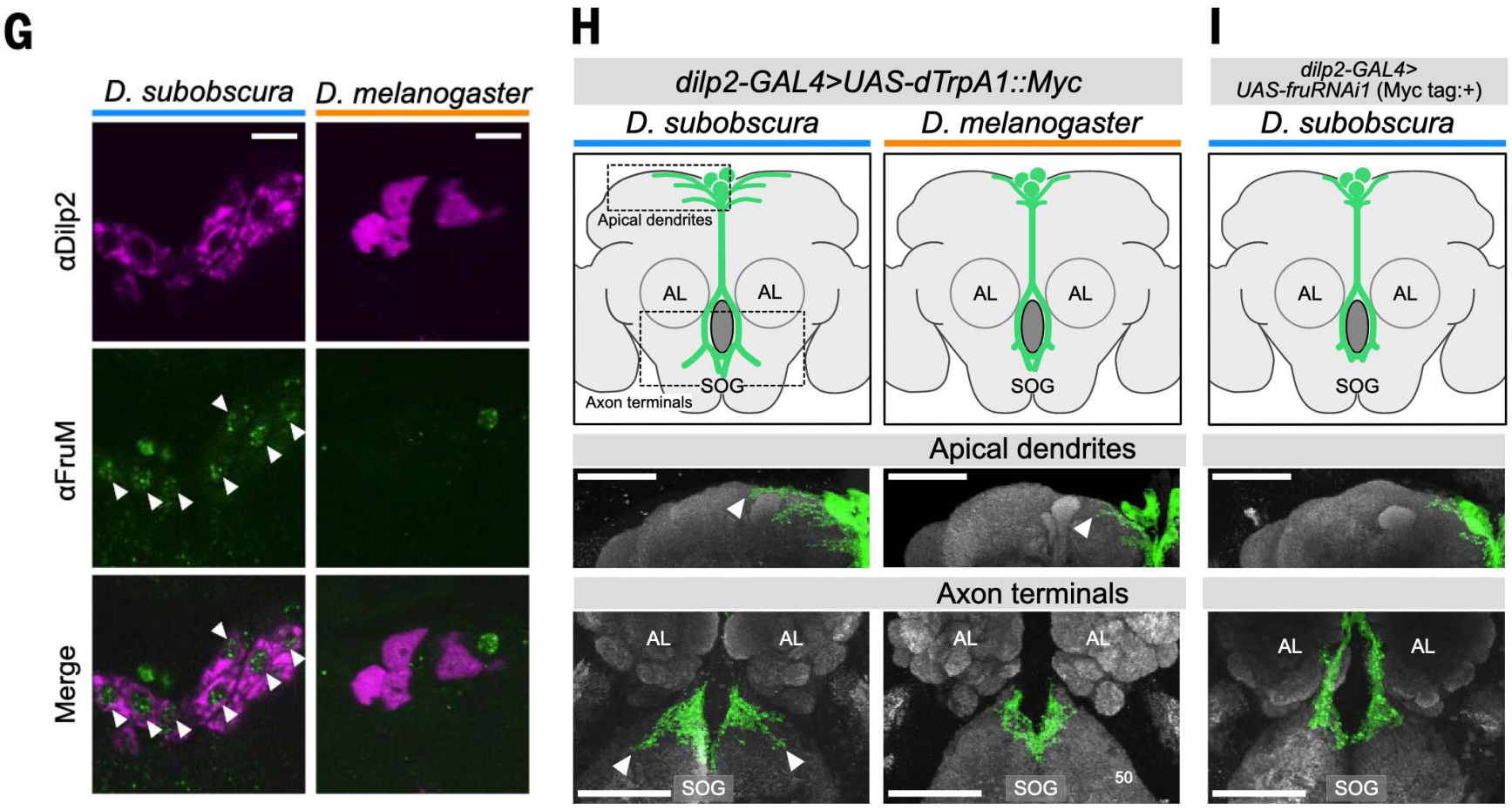
Whether NGG affect male fitness or not?

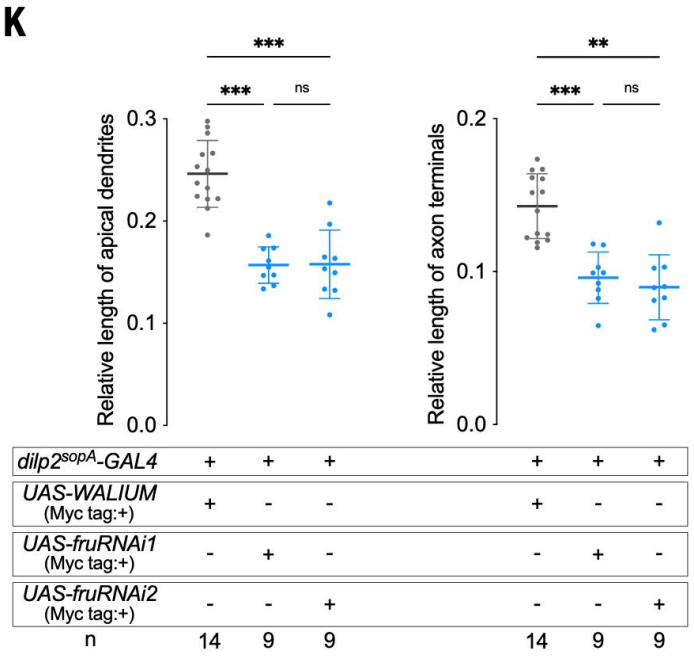


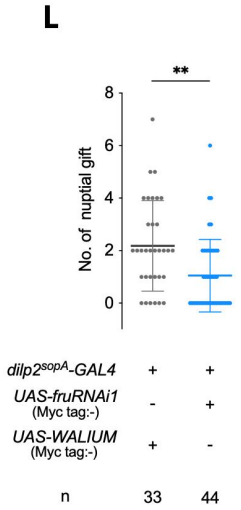
- IPCs are positive modulators of NGG, and IPC activities confer higher fitness on males.



Insulin neurons are recruited to the courtship circuit



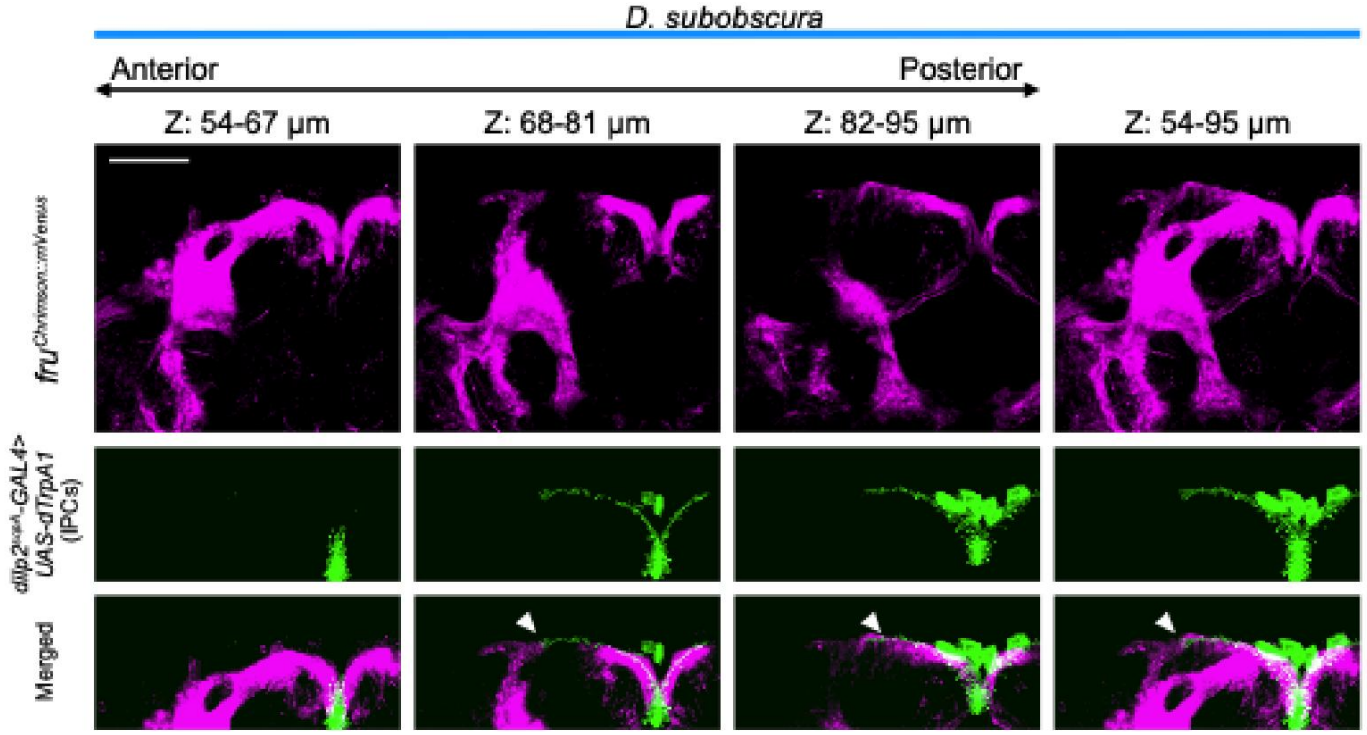


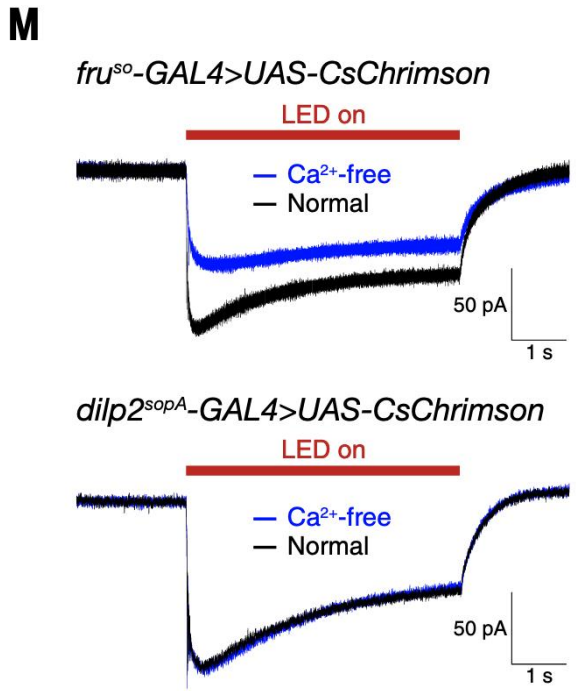


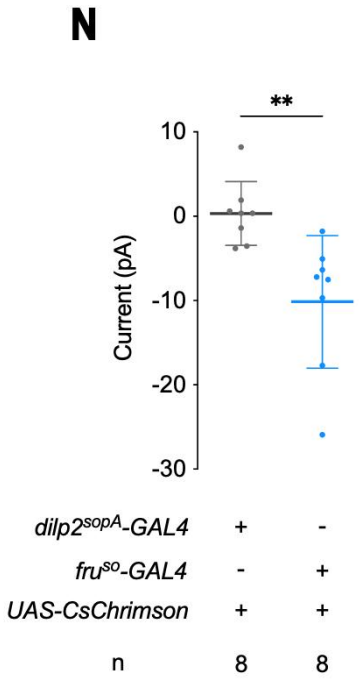
- IPCs express FruM only in *D. subobscura*
- Fru knockdown → loss of dendrite extension + fewer NGG events

Courtship initiator P1 neurons modulate IPC activities

FruM expression → IPC dendrites connect with upstream neurons → a novel neural circuit → NGG behavior ?

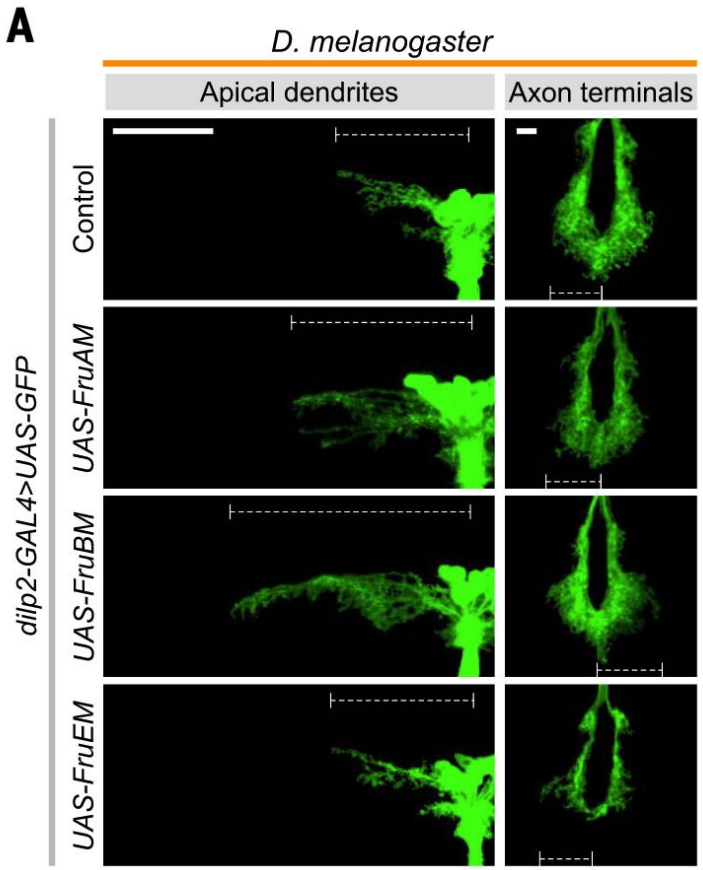


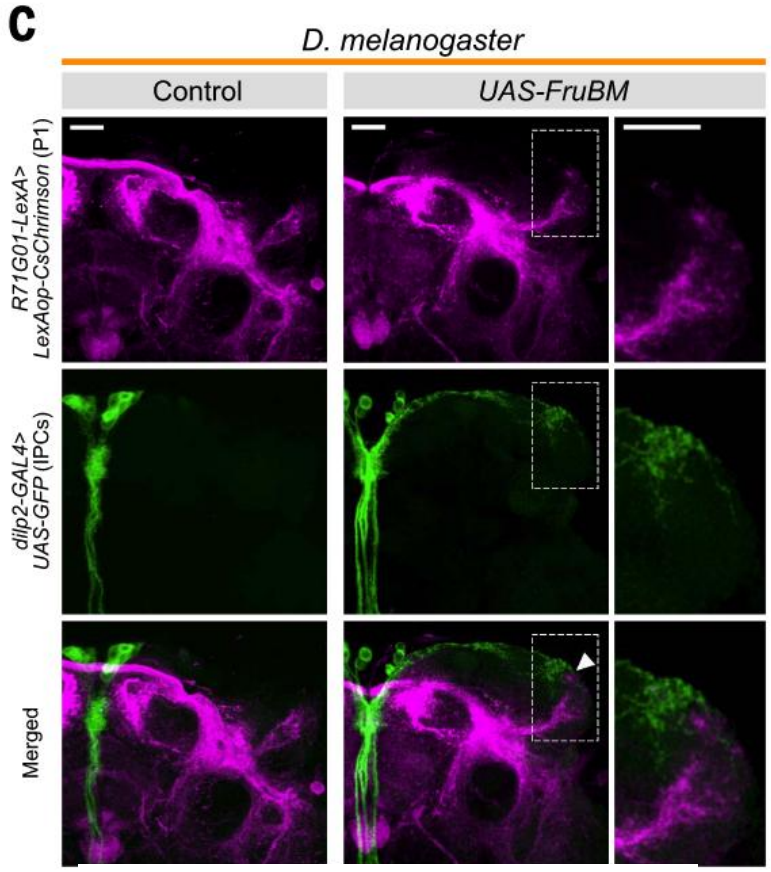


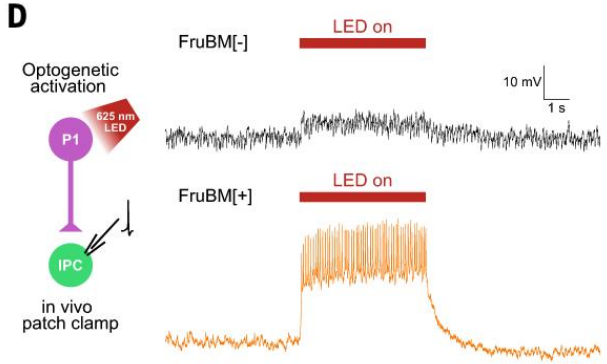


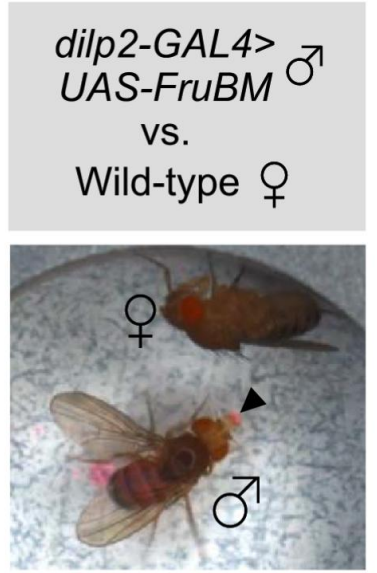
- In *D. melanogaster*, P1 neurons trigger courtship
- In *D. subobscura*, possible P1 → IPC connections
- Functional synaptic connections exist between fru circuit and IPCs

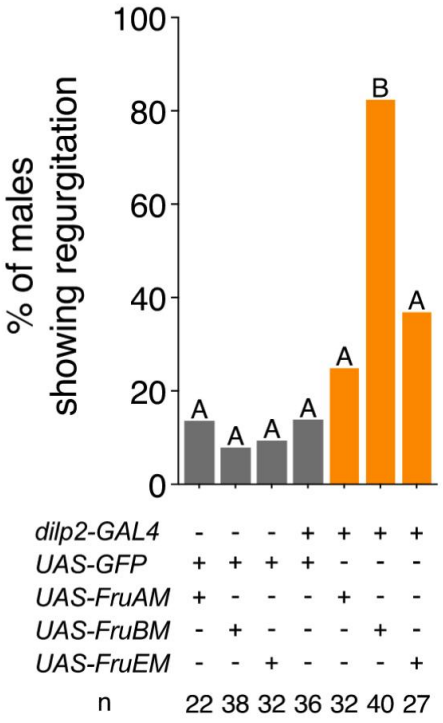
Courtship initiator P1 neurons modulate IPC activities







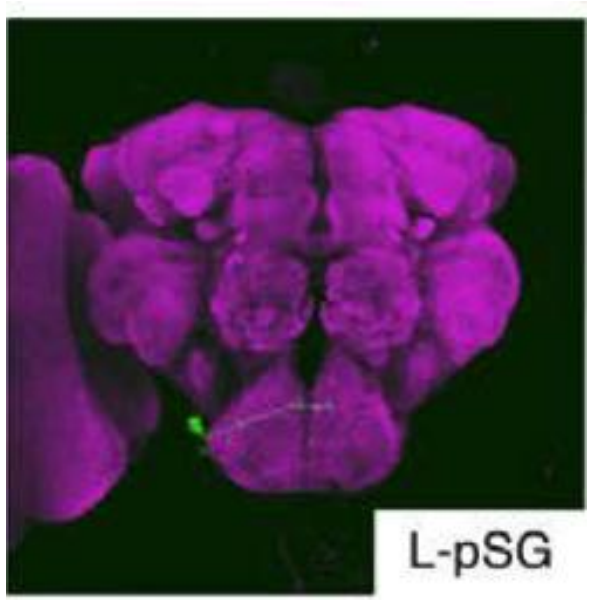


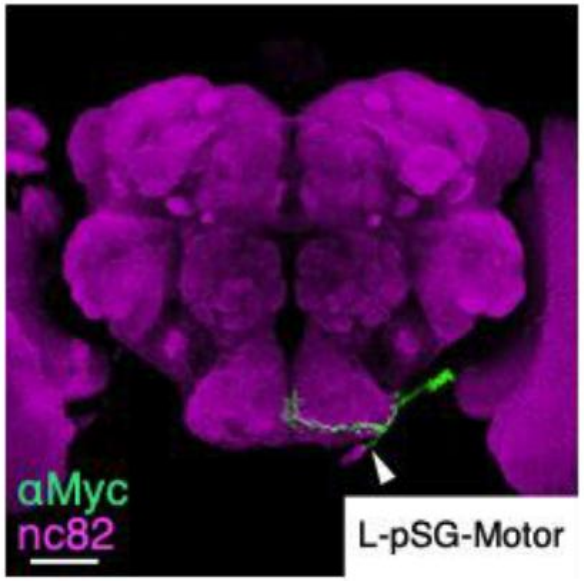


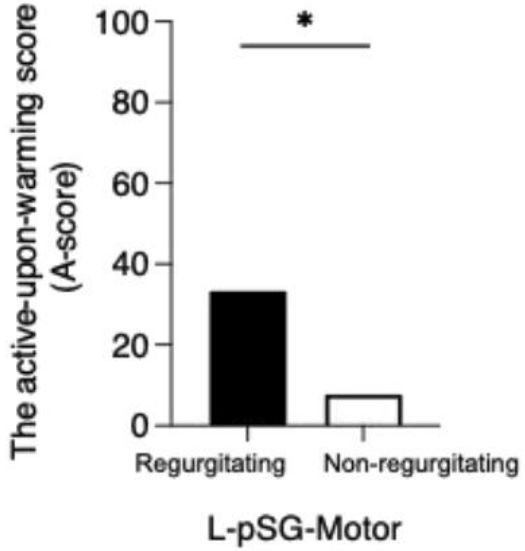
- Overexpression of FruBM in IPCs → dendrite outgrowth

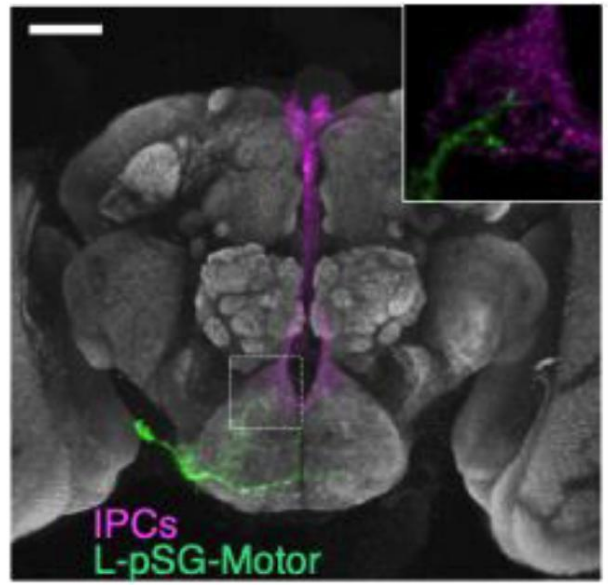
- FruBM IPCs form contacts with P1 neurons
- Stimulation of P1 → excitatory postsynaptic potentials (EPSPs) in IPCs
- FruBM IPC males regurgitate during courtship

Motor pathways for NGG

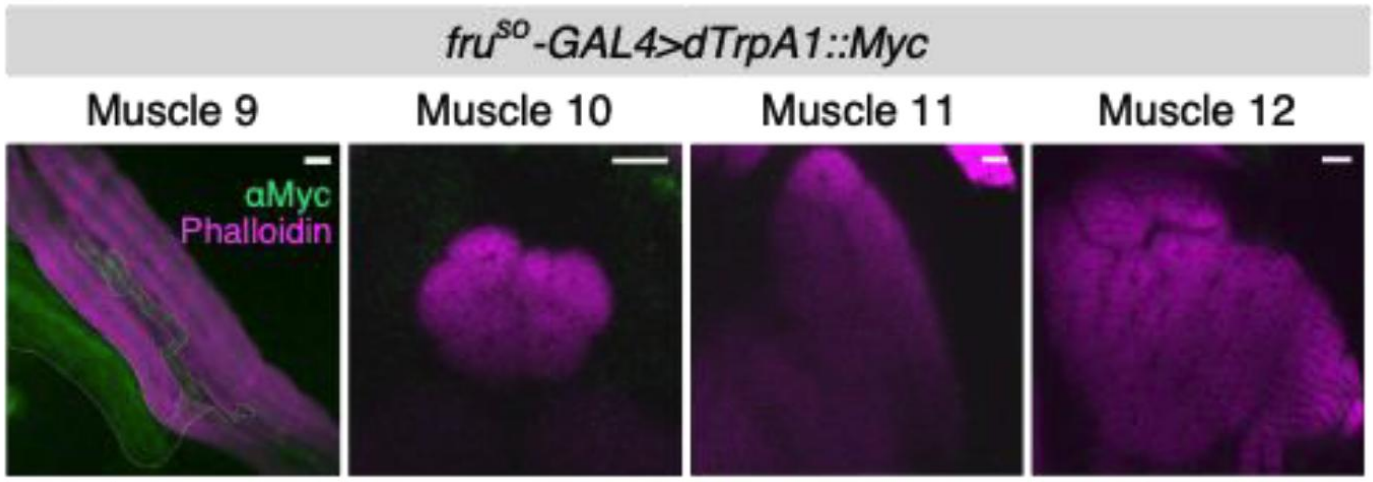


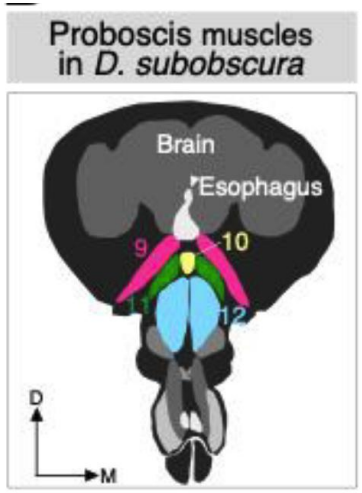






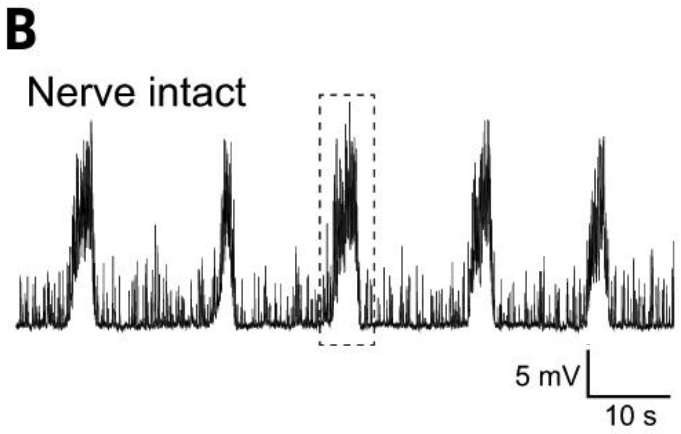
Exited the brain—SG complex through a peripheral nerve

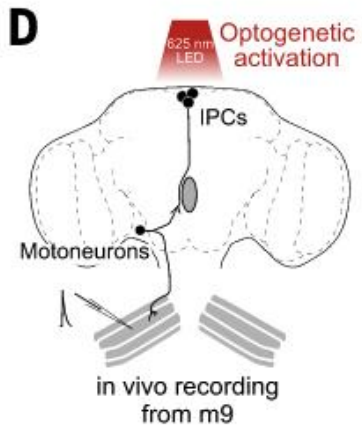


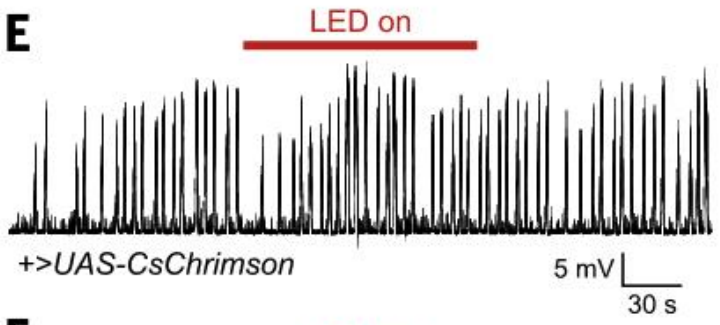


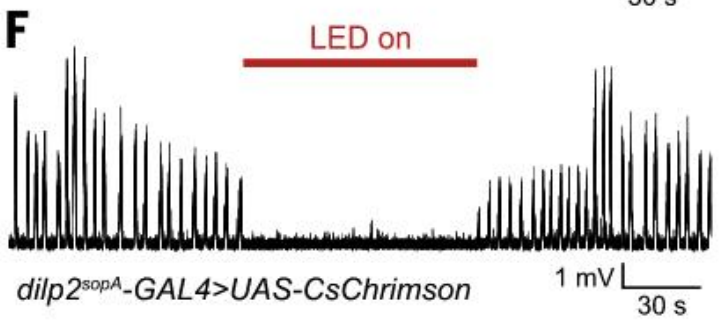
- L–pSG resemble proboscis motoneurons
- Divided into motor vs non–motor
- Motor group enriched in regurgitating flies
- L–pSG arborizations were juxtaposed with lPCs axon terminals

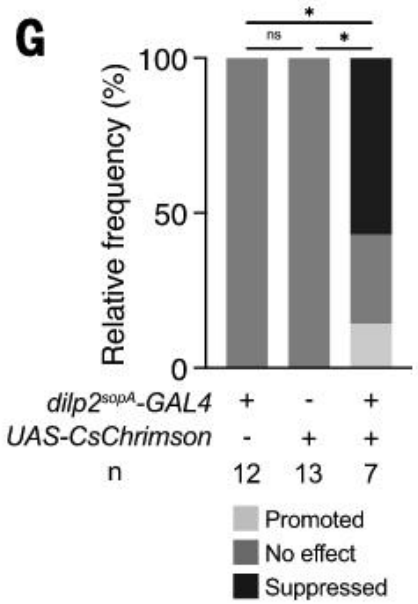
Insulin neurons modulate motor outputs



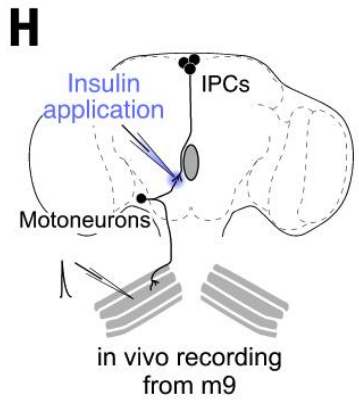


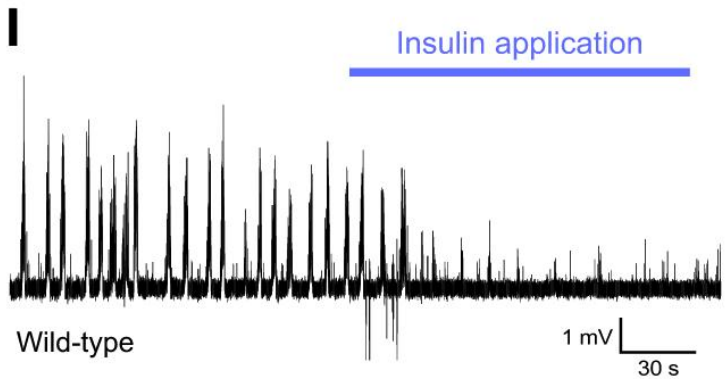


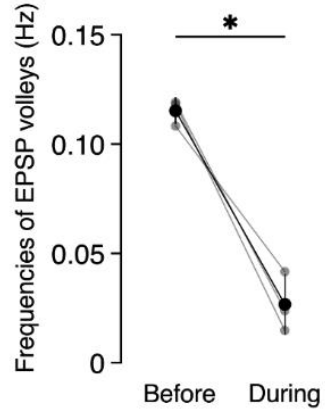




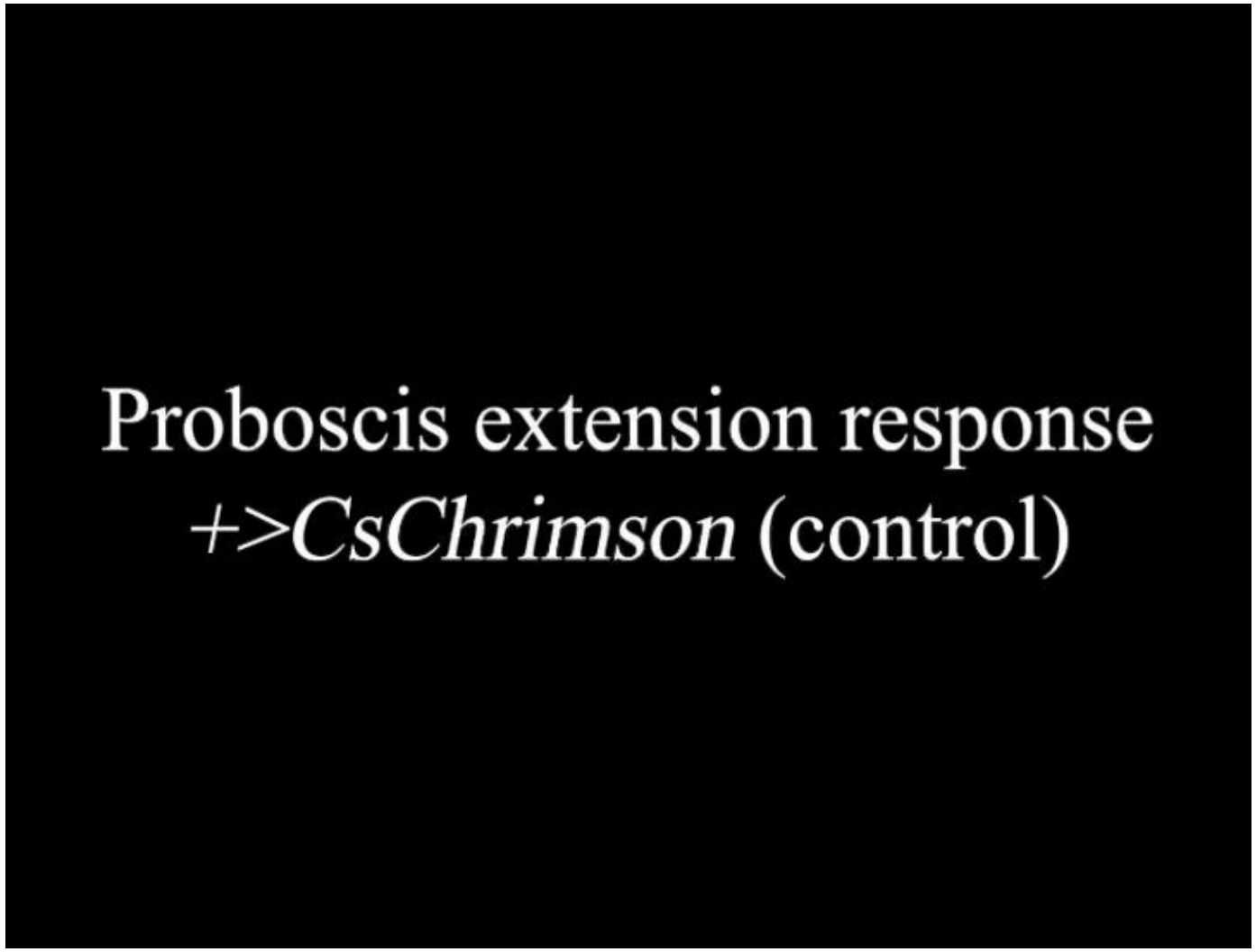
- m9 shows spontaneous volleys of EPSPs (partial extension of the proboscis)
- IPC activation or insulin application suppressed m9 EPSPs







Insulin neurons modulate motor outputs

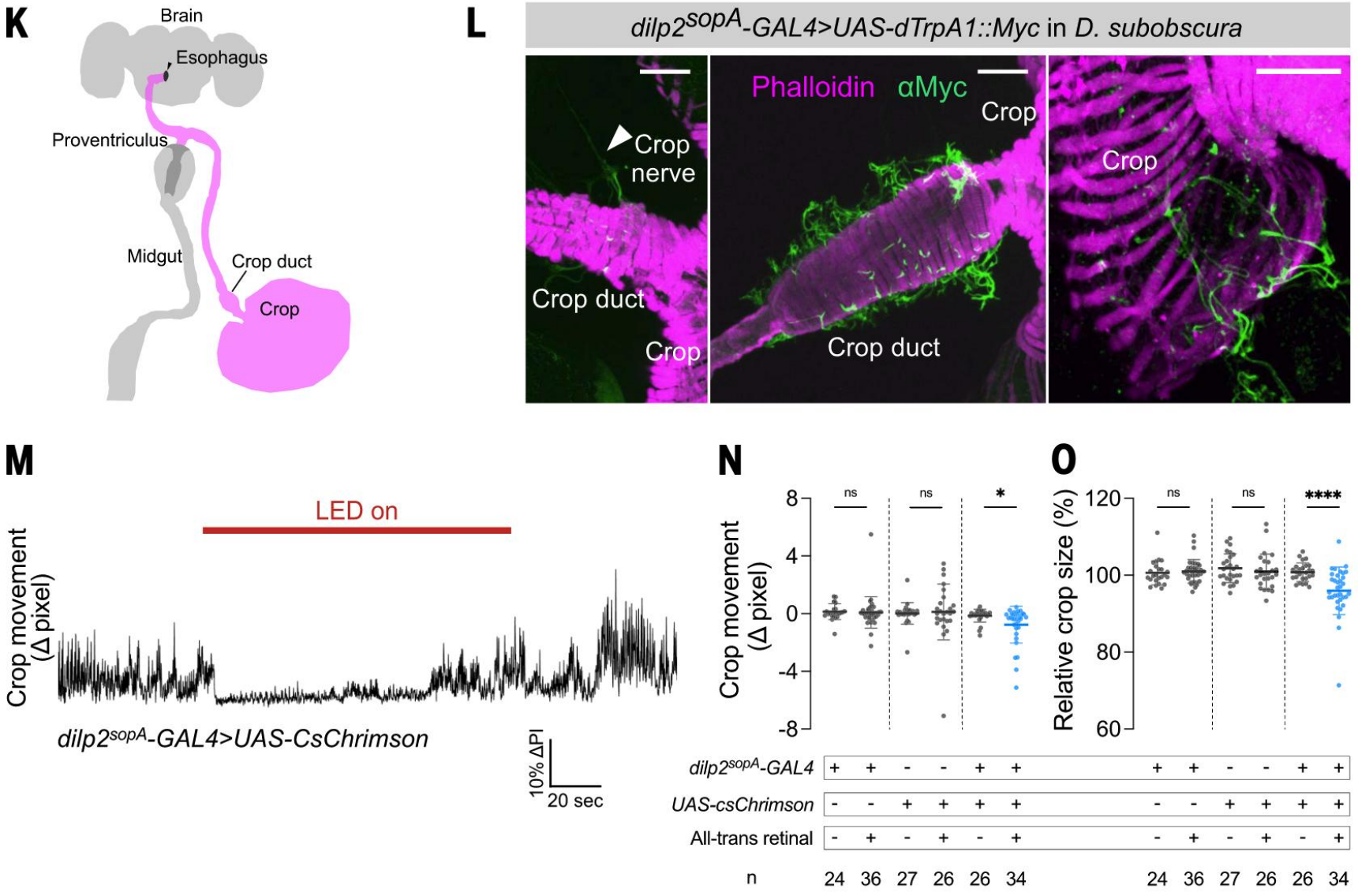


Control:
+>CsChrimson
LED has no influence

Test:
dlip2>CsChrimson
LED on → lPCS activated → spasms

D. subobscura, males extend the proboscis anteriorly for NGG and downward for feeding

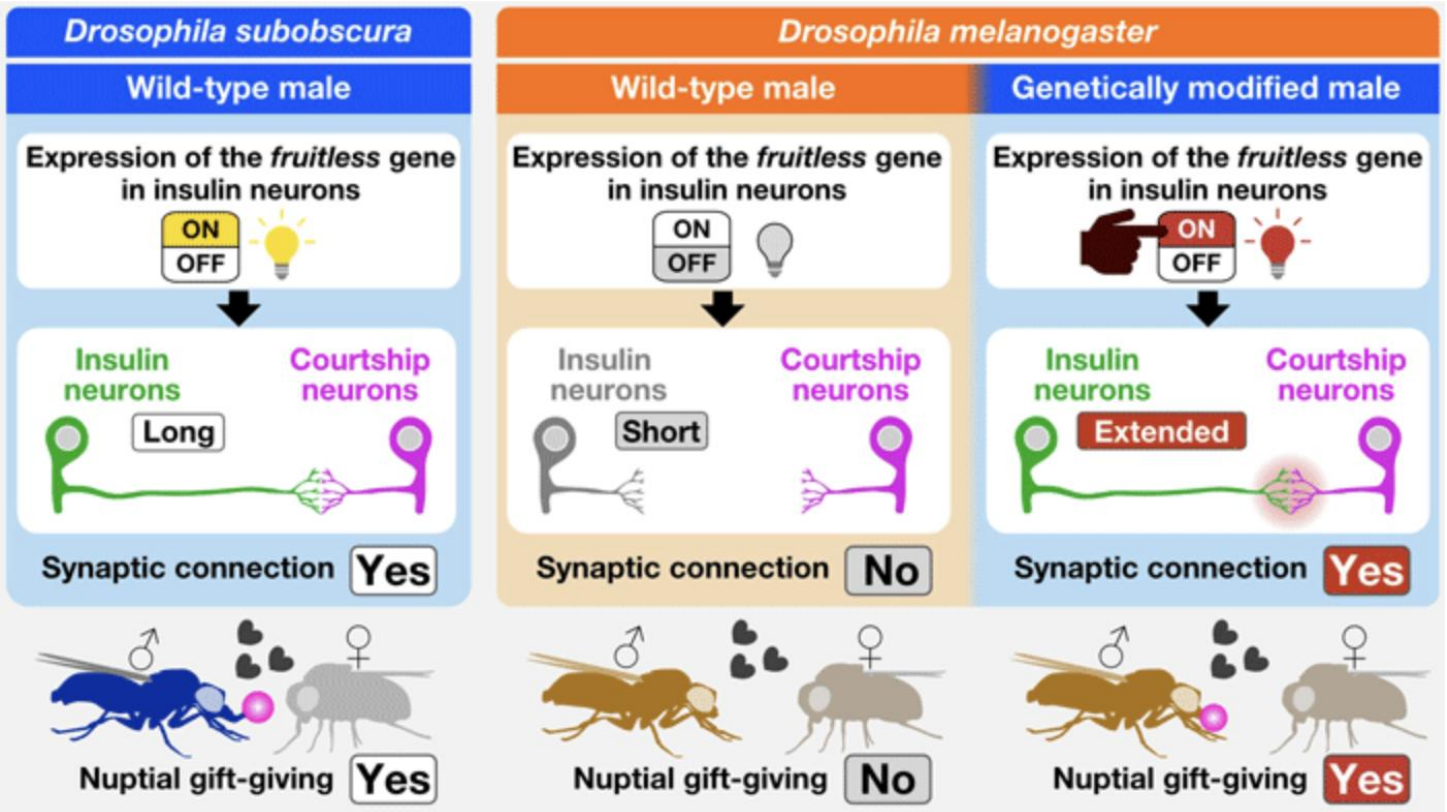
IPC activity induces crop constriction



- IPC terminals also on the crop
- IPC activation reduces crop movement and size
- May promote regurgitation by raising pressure

Take home message

- In nature,NGG is unique to D. subobscura
- FruM expression recruits IPCs into the fru circuit
- P1 neurons trigger NGG initiation, L–pSG motoneurons drive its execution
- NGG enhances male fitness



Thanks
Q&A

- 基因组中含有较少的重复序列。和其他果蝇相比较，识别出了12个倒置，推测形成这些倒置的原因是染色体的断裂修复过程中形成的，而且这些断裂点不在基因序列内。