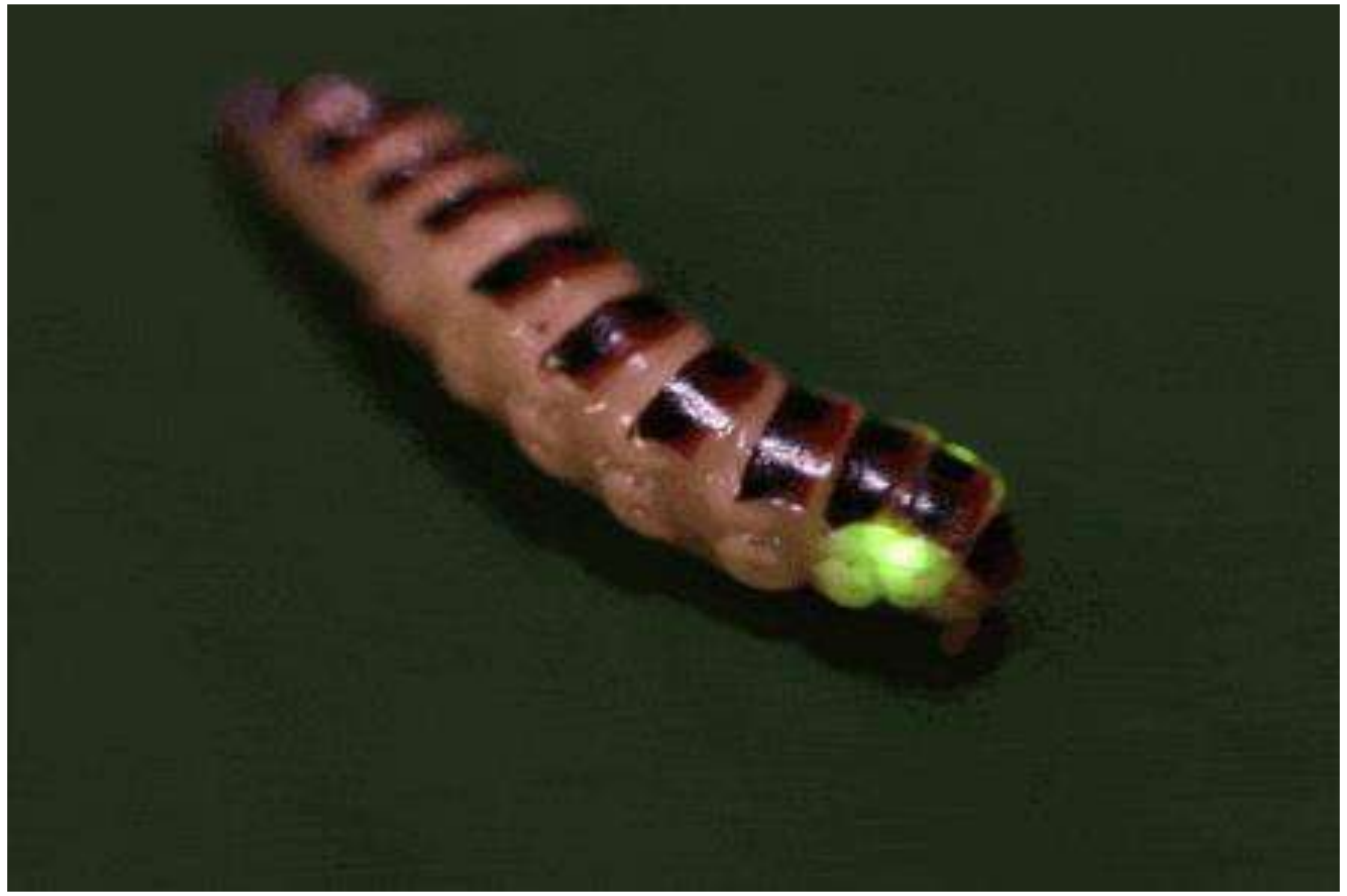
朱寰　孙梦实　李小龙
2022 2 24

A brief Introduction of Locomotion

What is **Locomotion**?

- Any of a variety of methods that animals use to move from one place to another.
- Including **self-propelled locomotion**, e.g., running, swimming, jumping, and **passive locomotion**, e.g., sailing (some jelly fish), rolling (some beetles and spiders)
- There are some reasons for animal to move, such as to find food, a mate, a suitable environment, or to evade predators.



A beetle larva performing a rectilinear locomotion.

Topic

1. General Overview & The locomotion circuits
2. The locomotion inducers
3. The locomotion neurotransmitters

General Overview &
The Locomotion Circuits

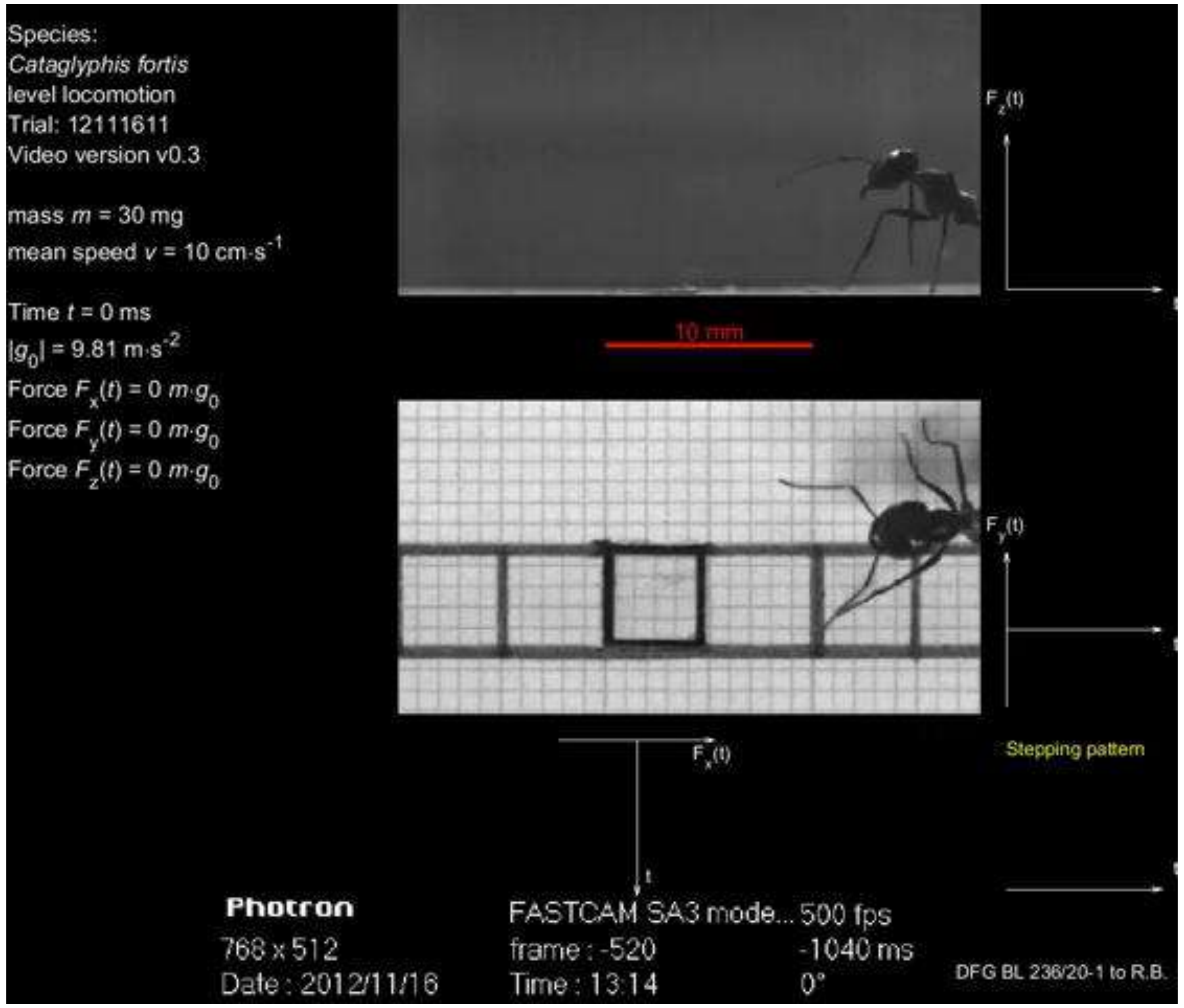
Parameters

A **Female** *Drosophila*'s:

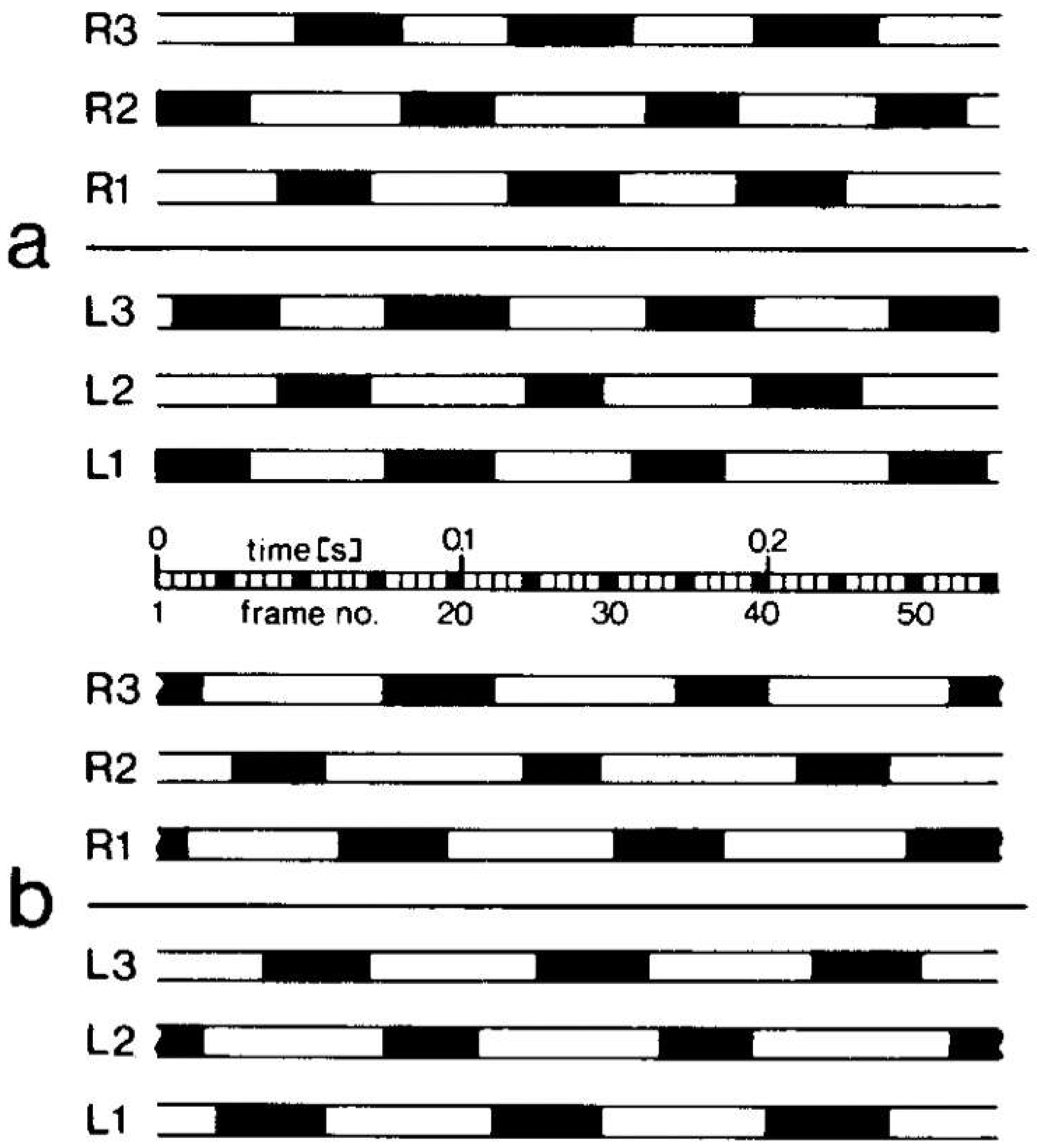
- Maximum walking speed is 4.2cm/s
- Continuous straight walking speed is about 1.5cm/s
- Duration of single step ranges from 60ms to 150ms in continuous straight walks
- Step rate is from 6.7 to 16.5 step/s in continuous straight walks

(Strauss R, Heisenberg M, 1990)

Tripod Gait

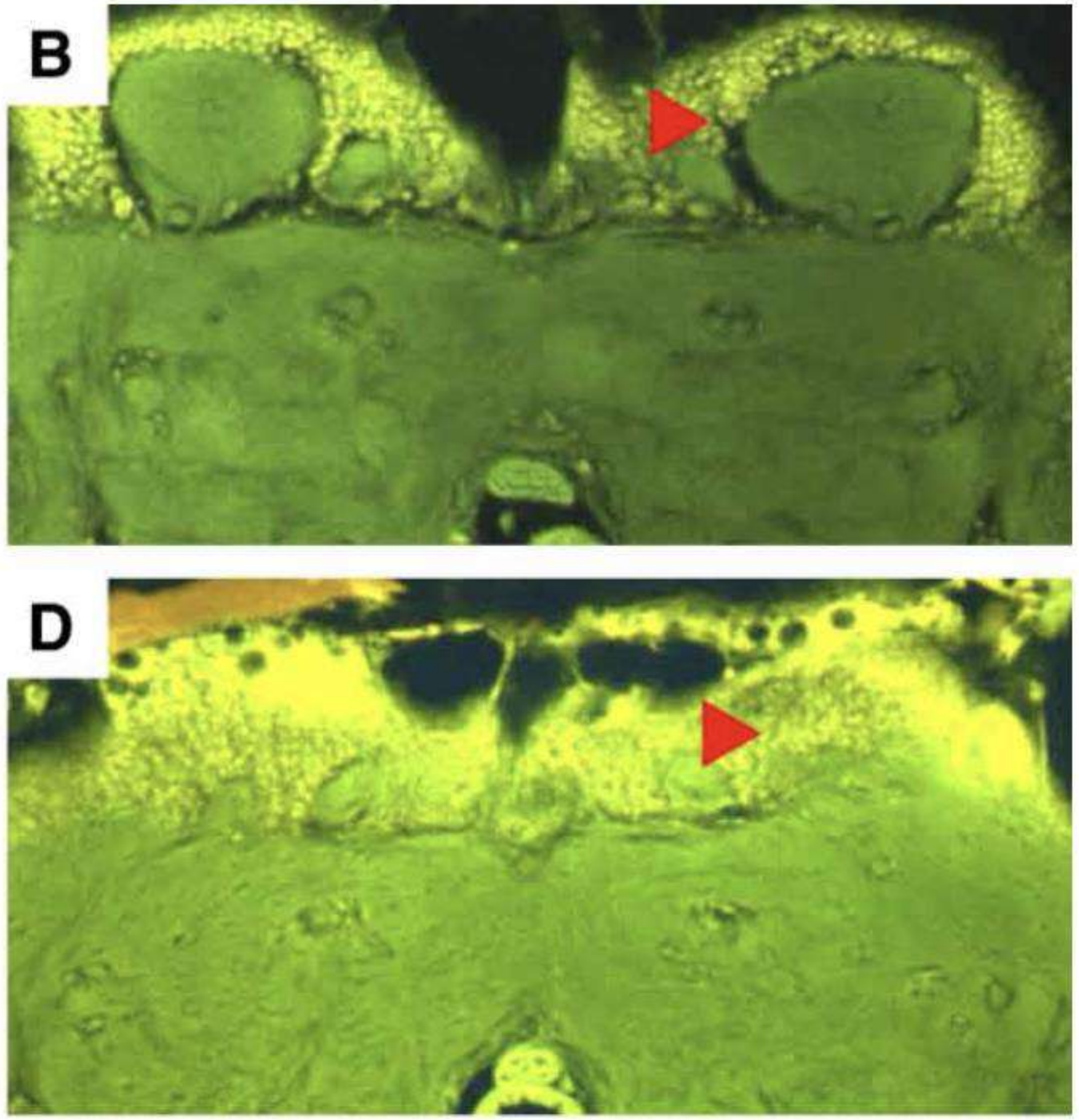


Alternating tripod gait of walking desert ants.



Two examples of leg coordination during straight walk obtained from the same individual.
(Strauss R, Heisenberg M, 1990)

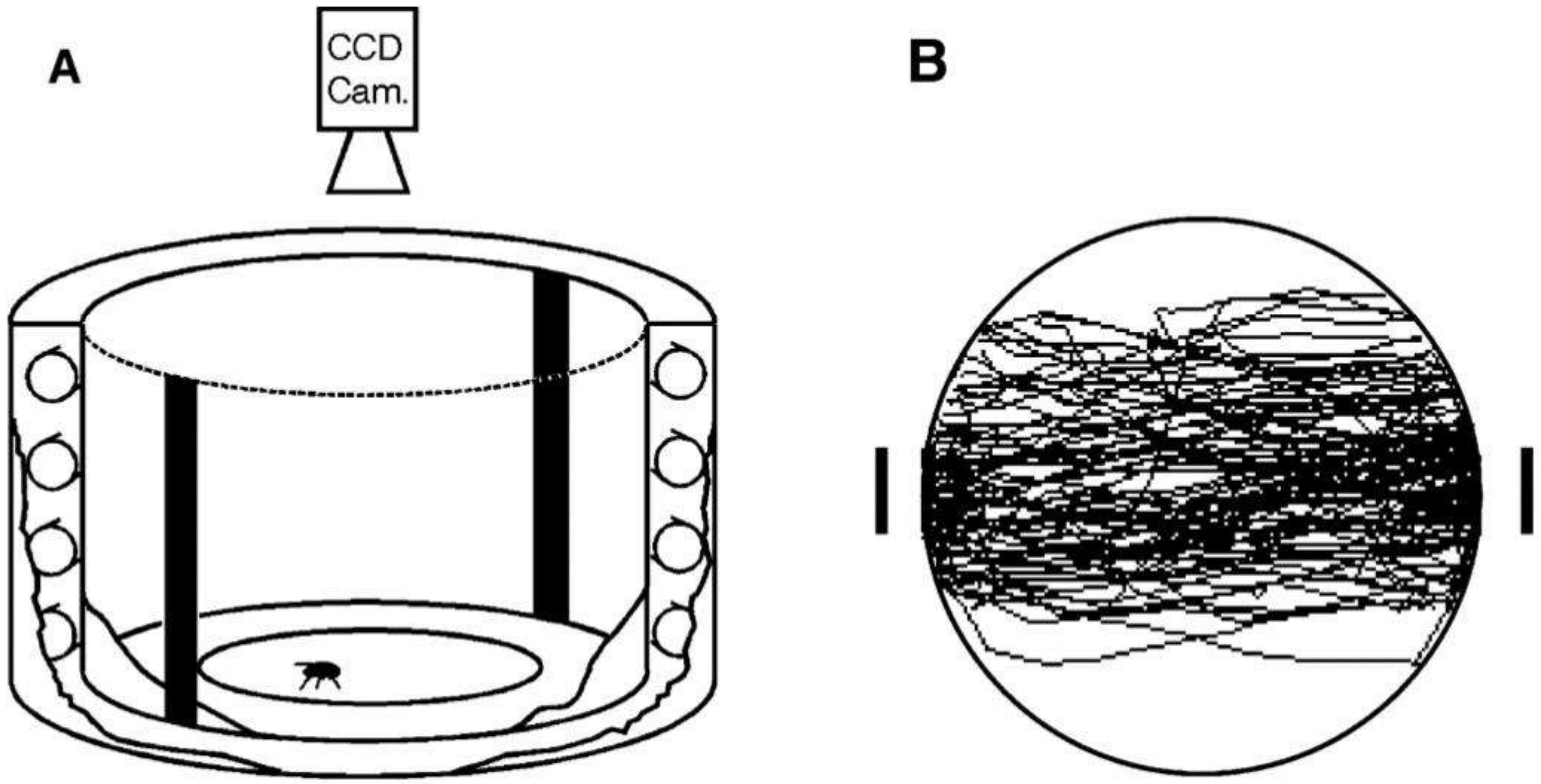
Mushroom body for locomotion



Head of (B) a *CS* male and (D) a *CS* male with MB ablated by HU (hydroxyurea, 硫酸羟脲)

(Serway CN, Kaufman RR, 2009)

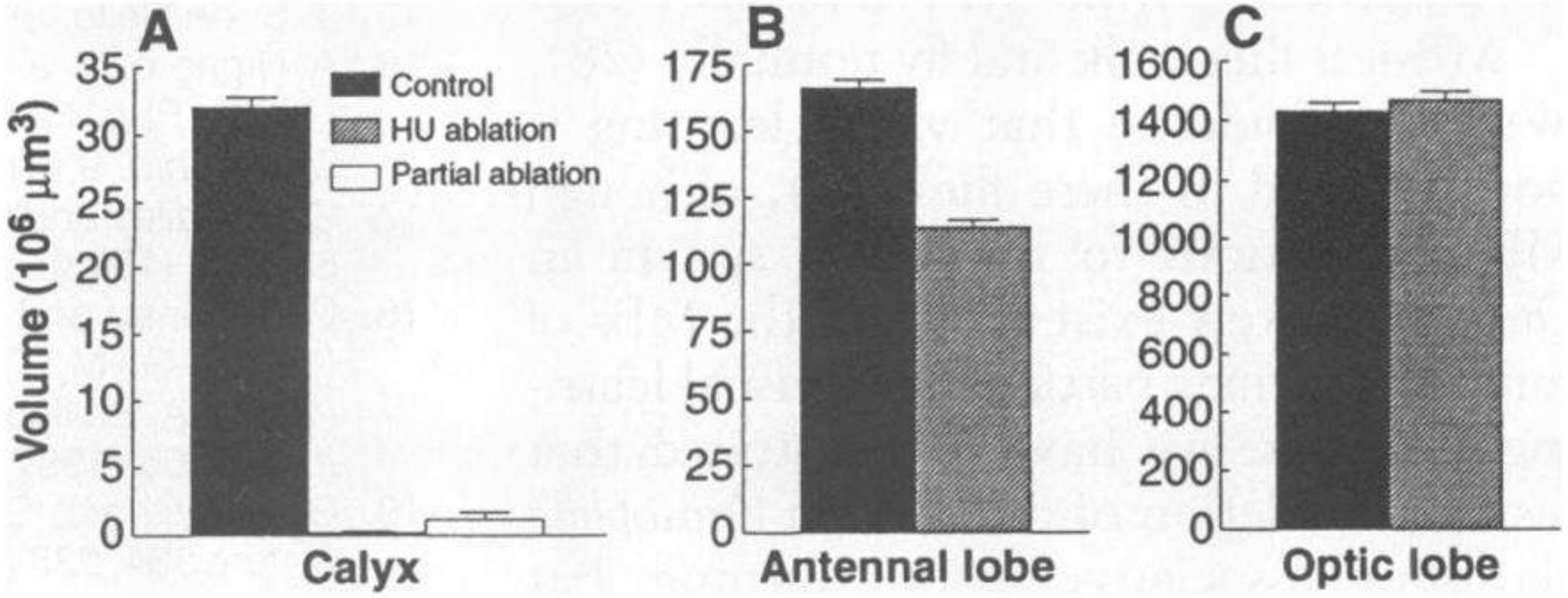
Buridan’s Paradigm



Single flies with **clipped wings** were confined to an elevated **circular disk (8.5 cm in diameter)** surrounded by a water-filled moat between **two opposing and inaccessible landmarks**

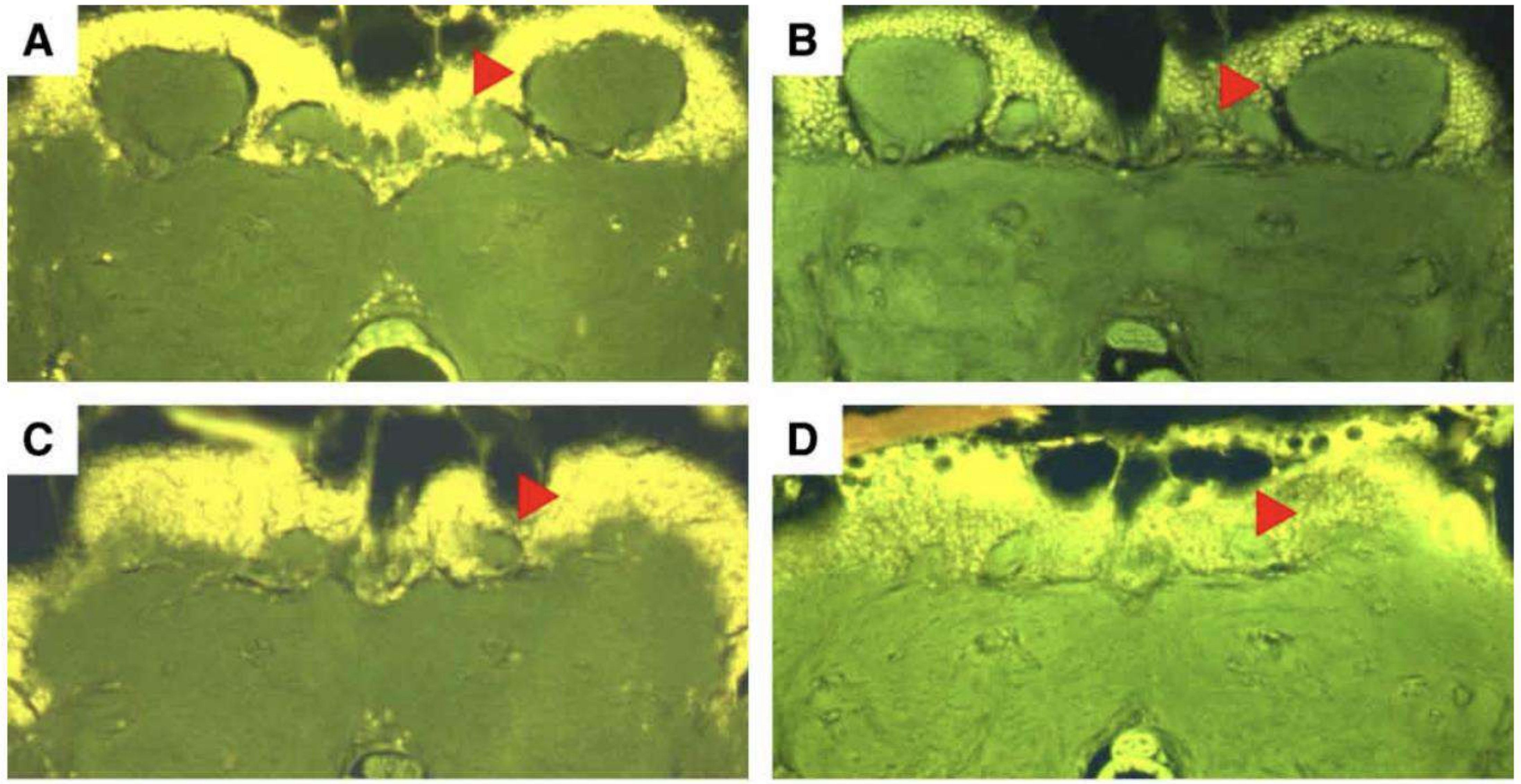
(Serway CN, Kaufman RR, 2009)

MB Ablation by HU



Brain structure volume from brain of HU ablated fly and control.

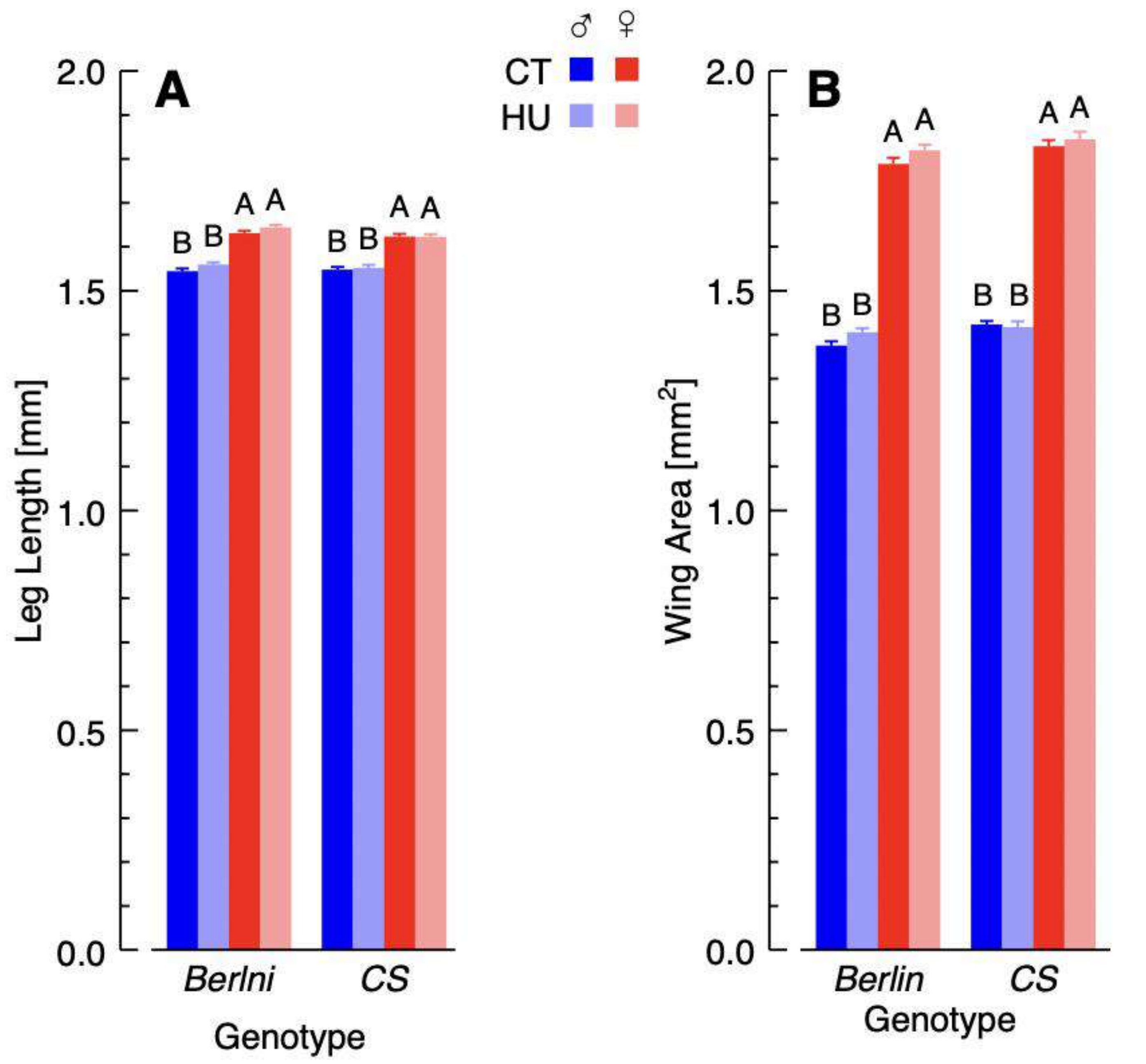
(de Belle JS, Heisenberg M. 1994)



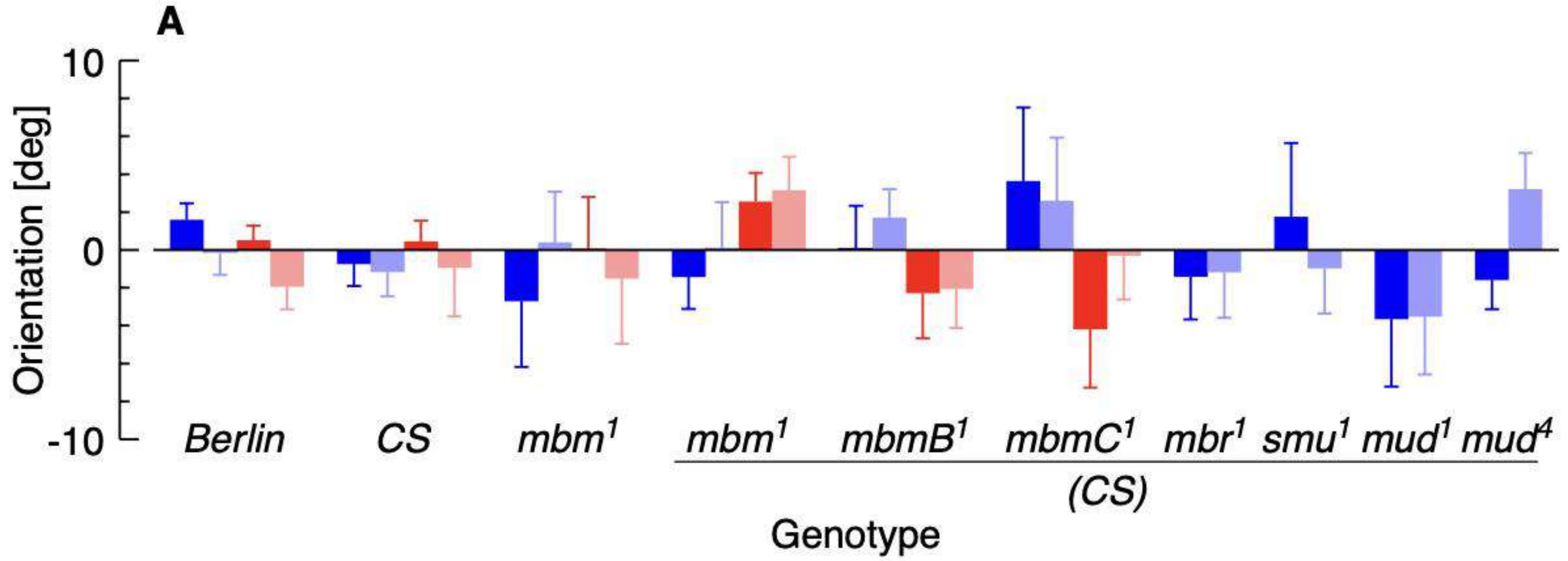
Head of (A) a *Berlin* male and (C) a *Berlin* male with MB ablated by HU (hydroxyurea, 硫酸羟脲), (B)(D) is same as (A)(C) but is from *CS.*

(Serway CN, Kaufman RR, 2009)

Anatomy and **Orientation** are **Not Influenced** by HU ablation



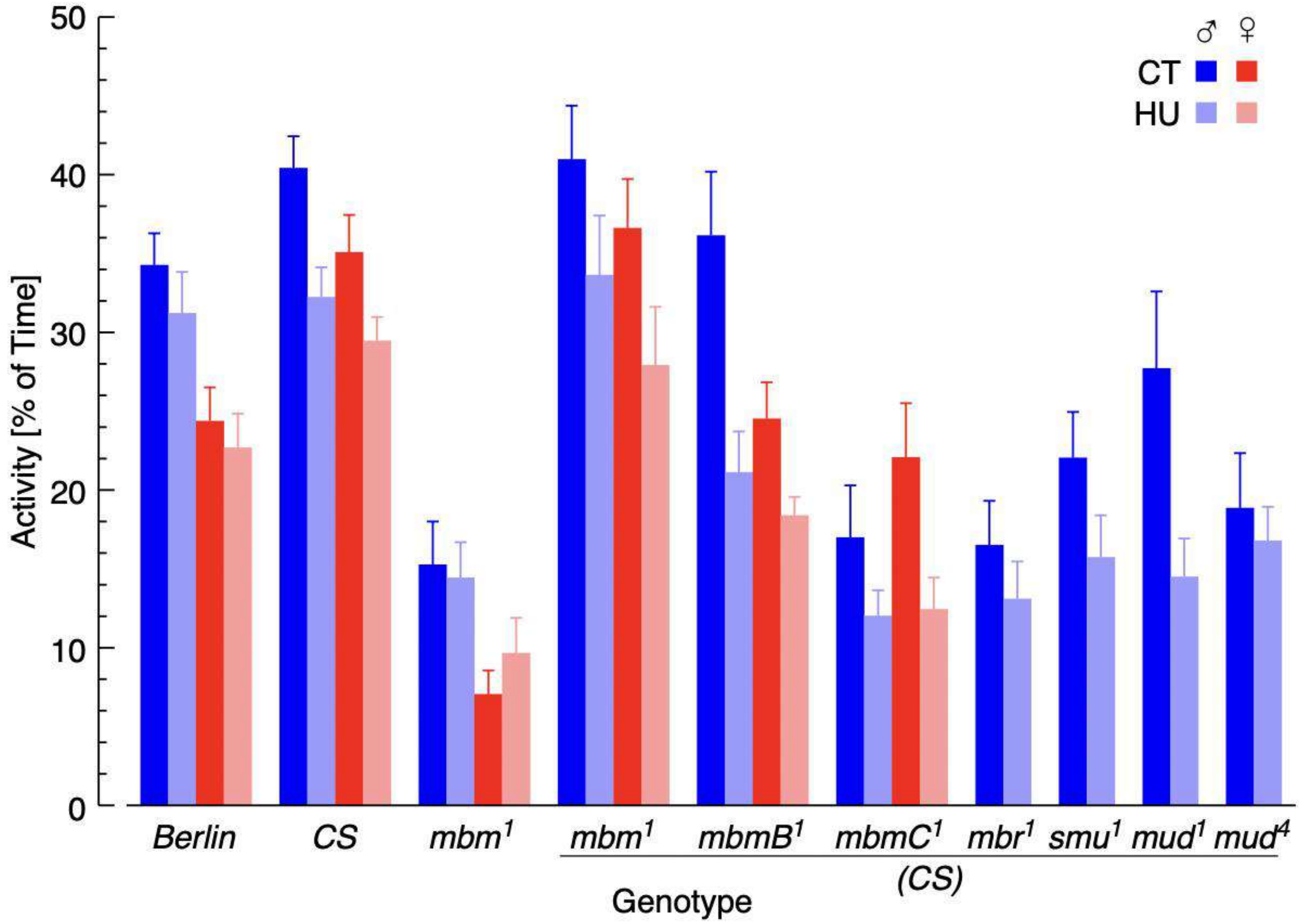
External anatomy was not influenced by genotype or HU treatment.



All groups of flies demonstrated comparable patterns of landmark orientation

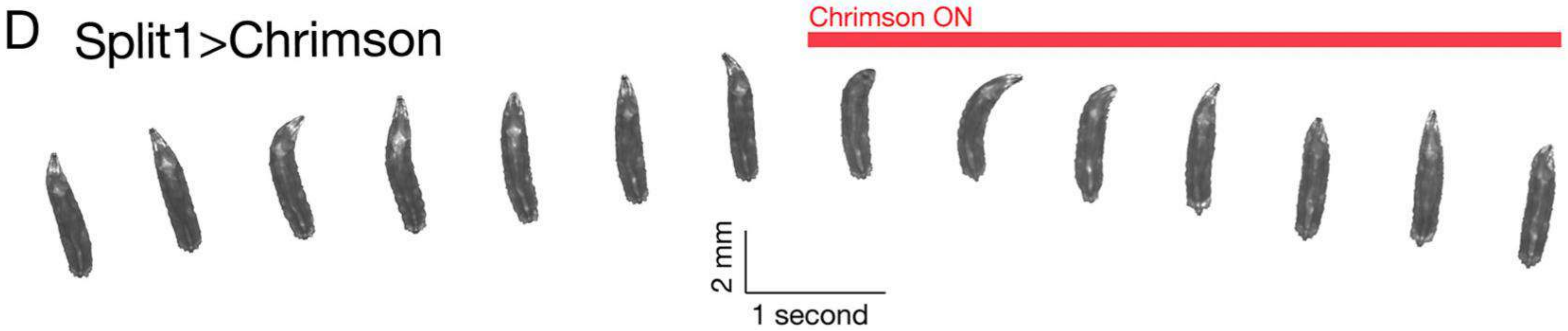
(Serway CN, Kaufman RR, 2009)

…But **Activity** is **Damaged**



Mean percent of time flies were actively walking during 15 minutes in Buridan's paradigm.

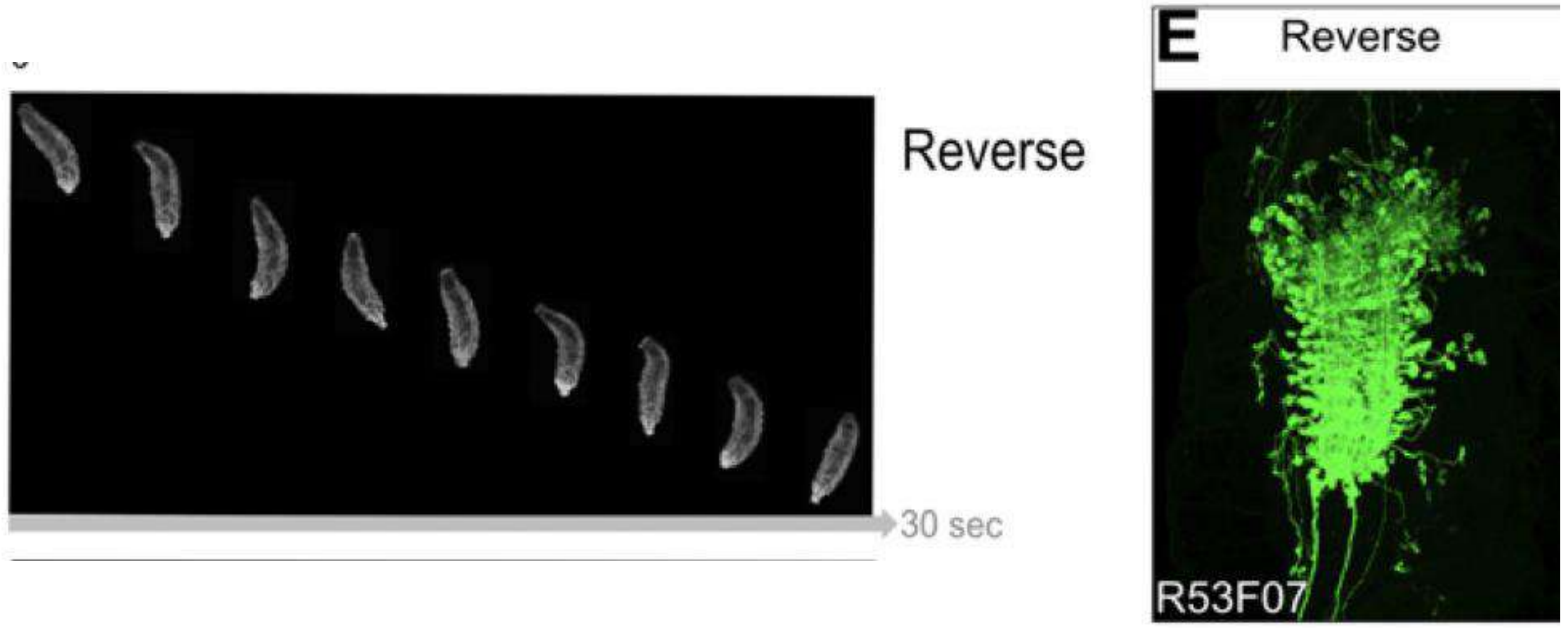
(Serway CN, Kaufman RR, 2009)



Larva Circuit in locomotion

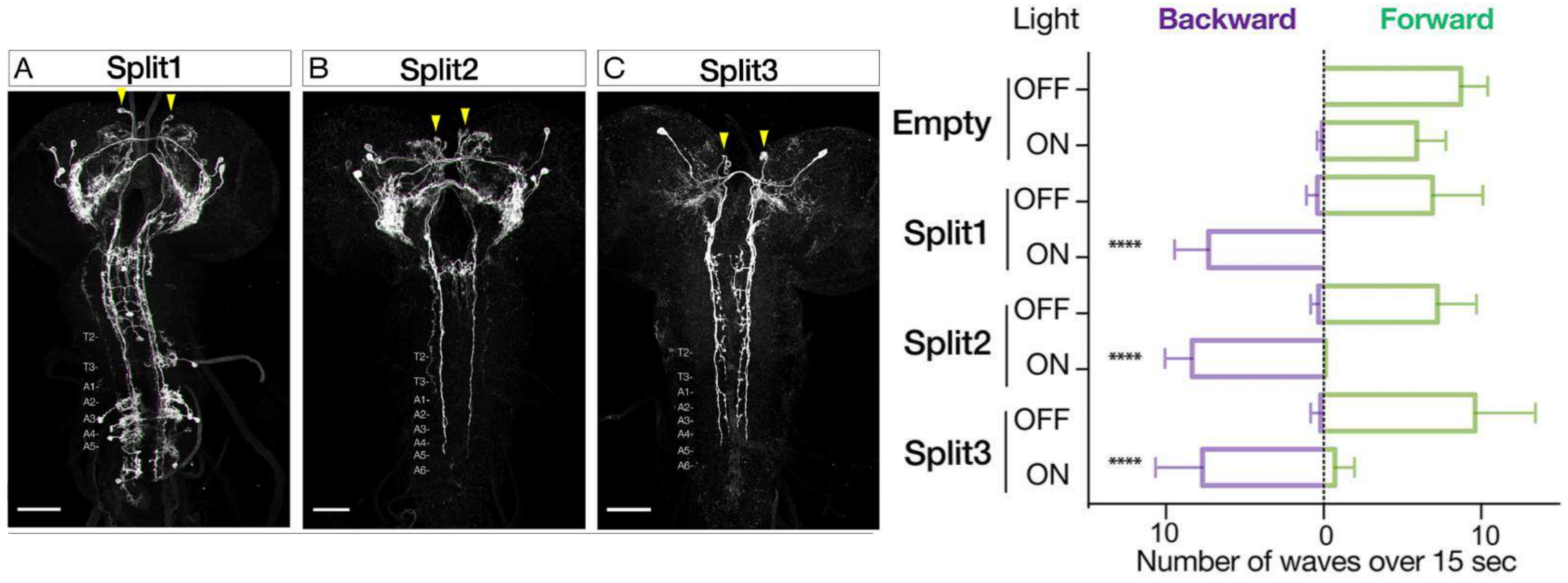
(Carreira-Rosario A, Zarin AA, Clark MQ, et al., 2018)

Refinery of backward crawling neuron



After a screening of 75 sparse expressing *Gal4* lines,
TrpA1 activationof R53F07 induces backward crawling.

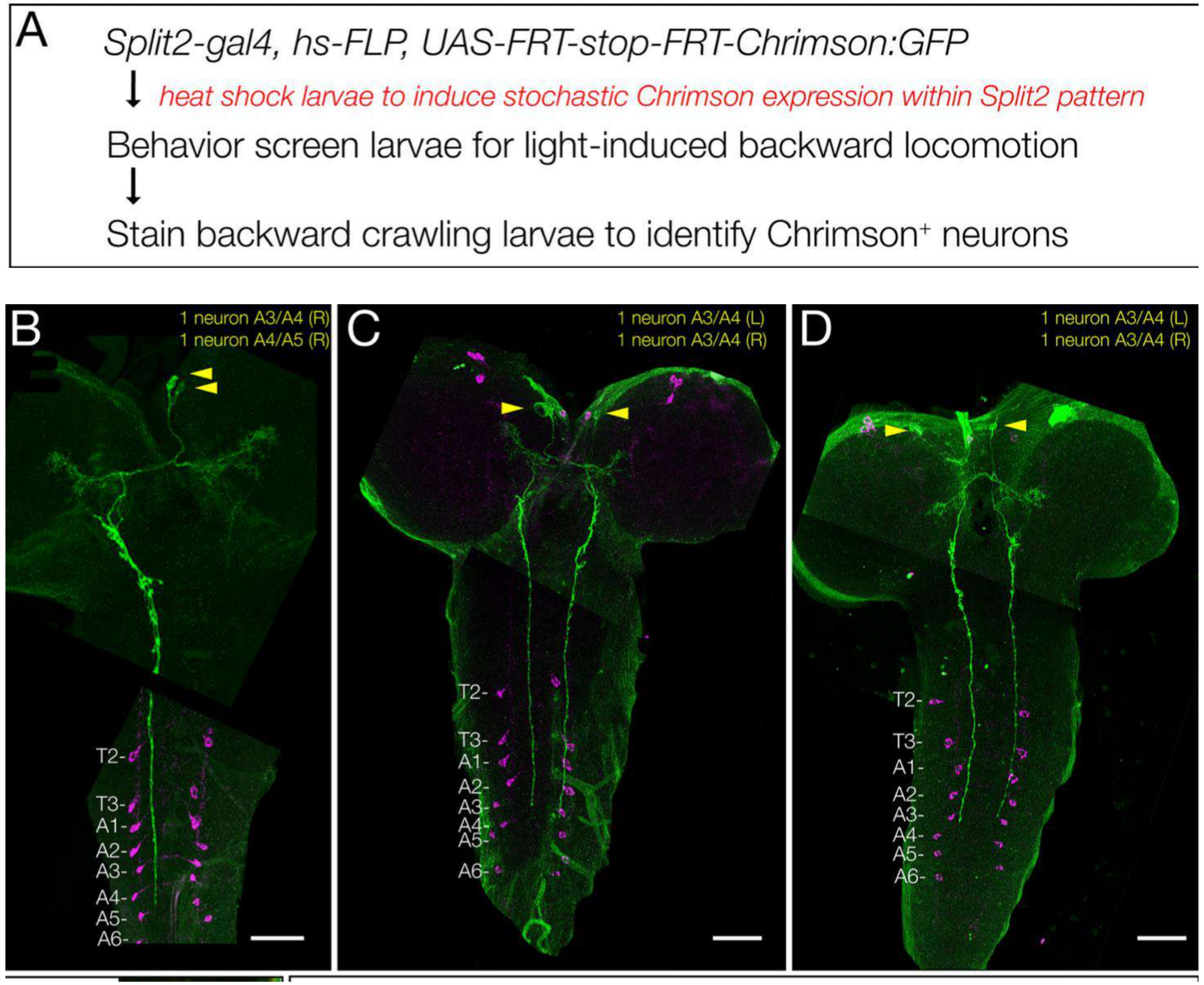
(Clark MQ, McCumsey SJ, Lopez-Darwin S,
Heckscher ES, Doe CQ, 2016)

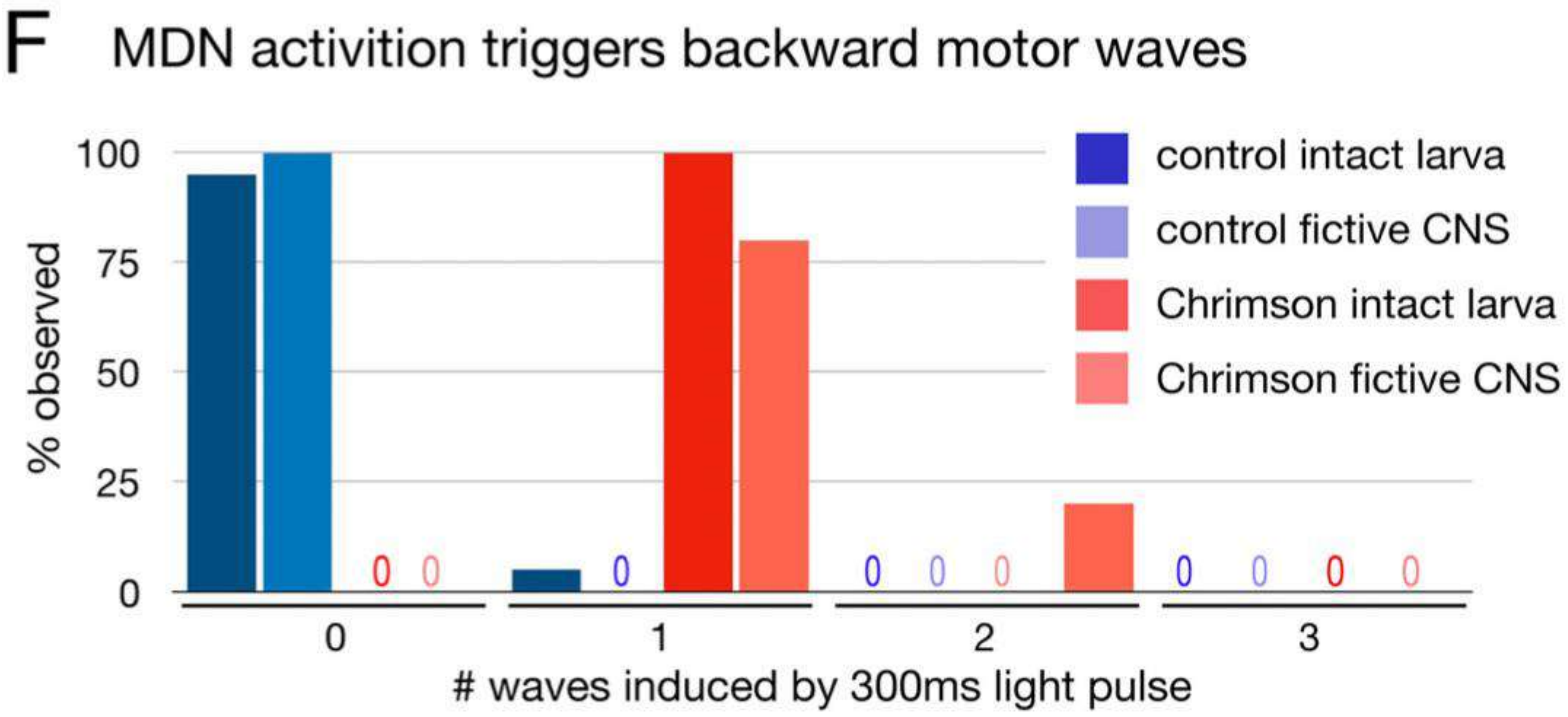


3 lines that induce backward crawling once activated
are identified by cross section.

(Carreira-Rosario A, Zarin AA, Clark MQ, et al., 2018)

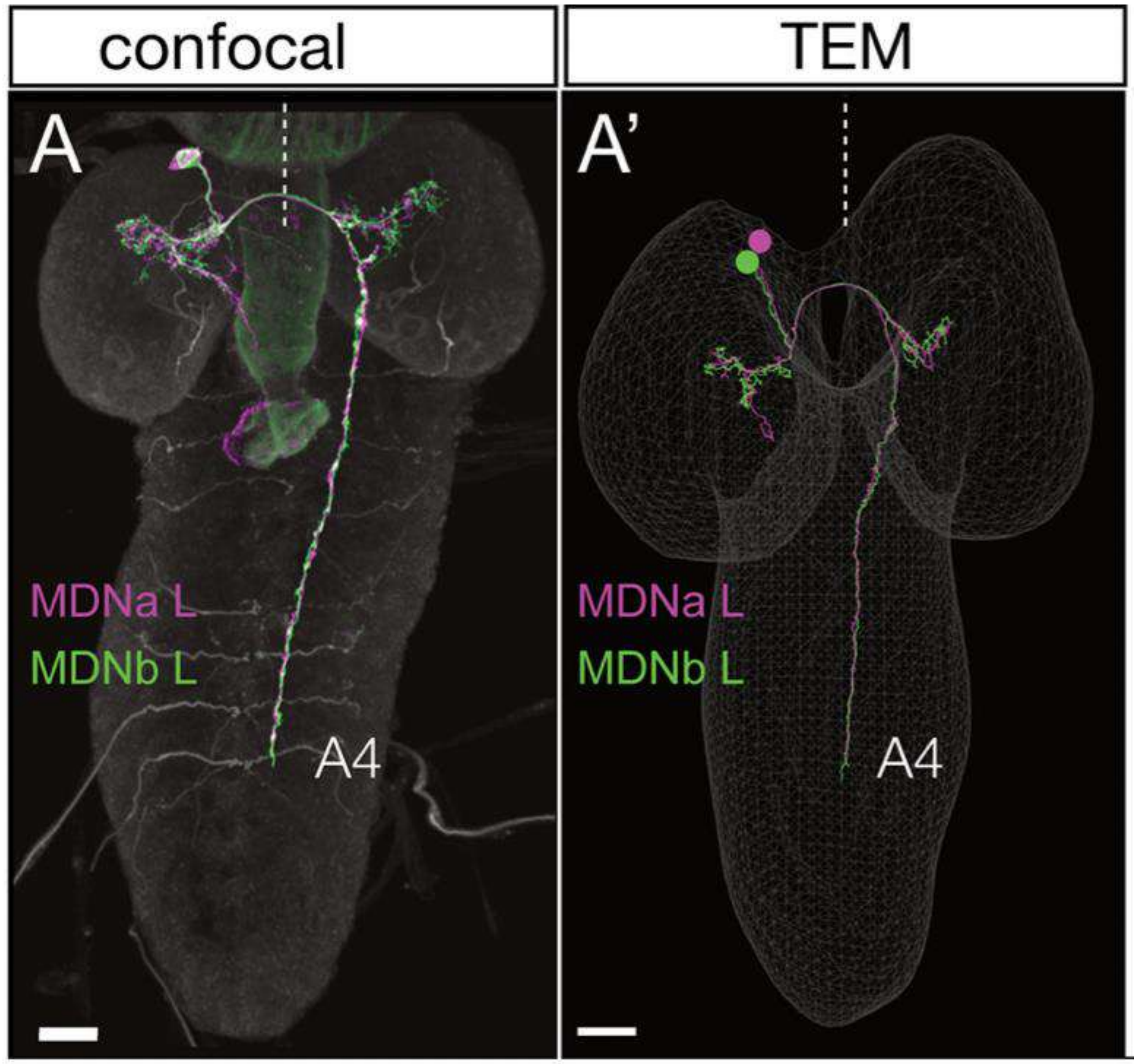
Stochastic Refinery of MDN by ***heatshock***

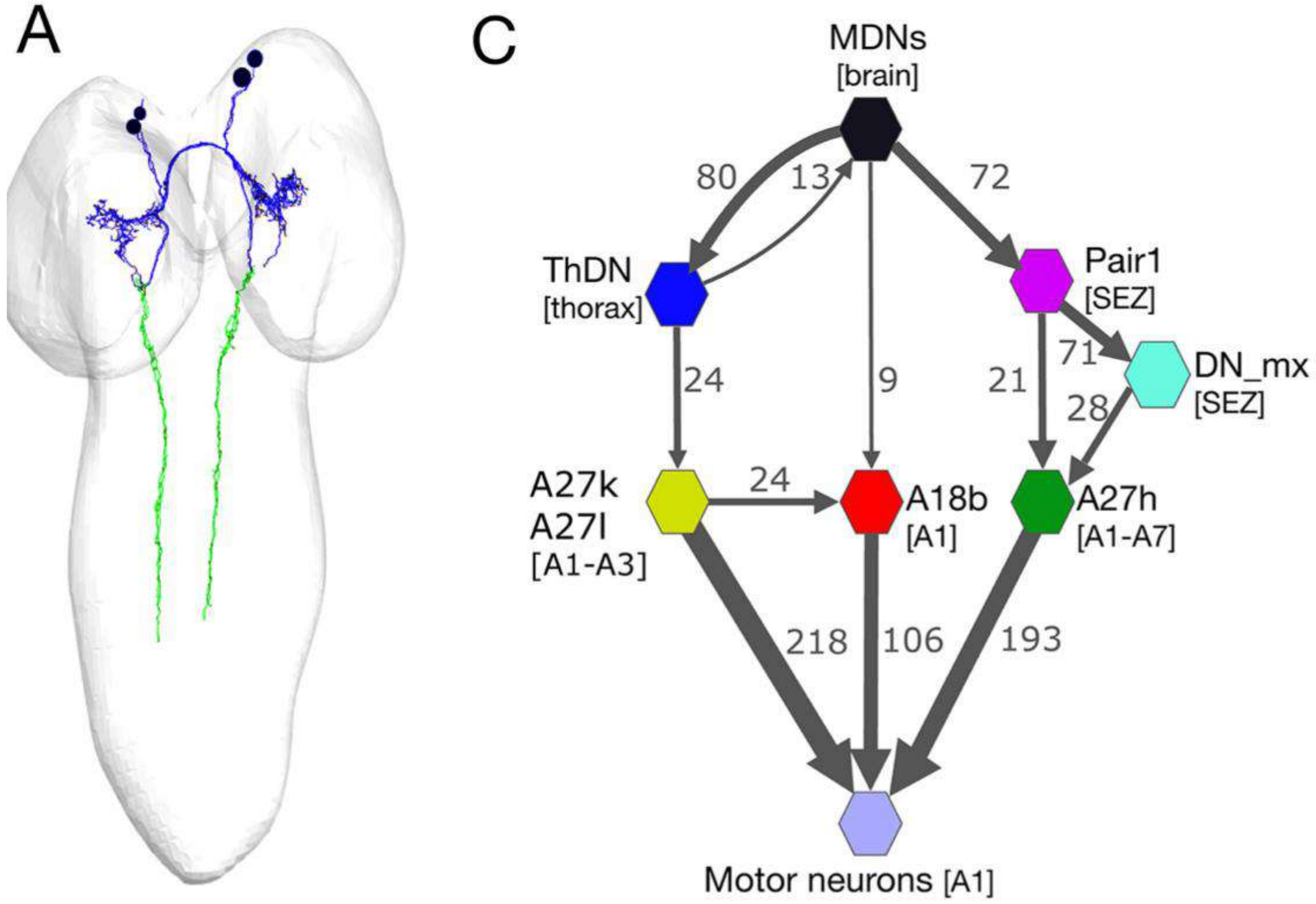




(Carreira-Rosario A, Zarin AA, Clark MQ, et al., 2018)

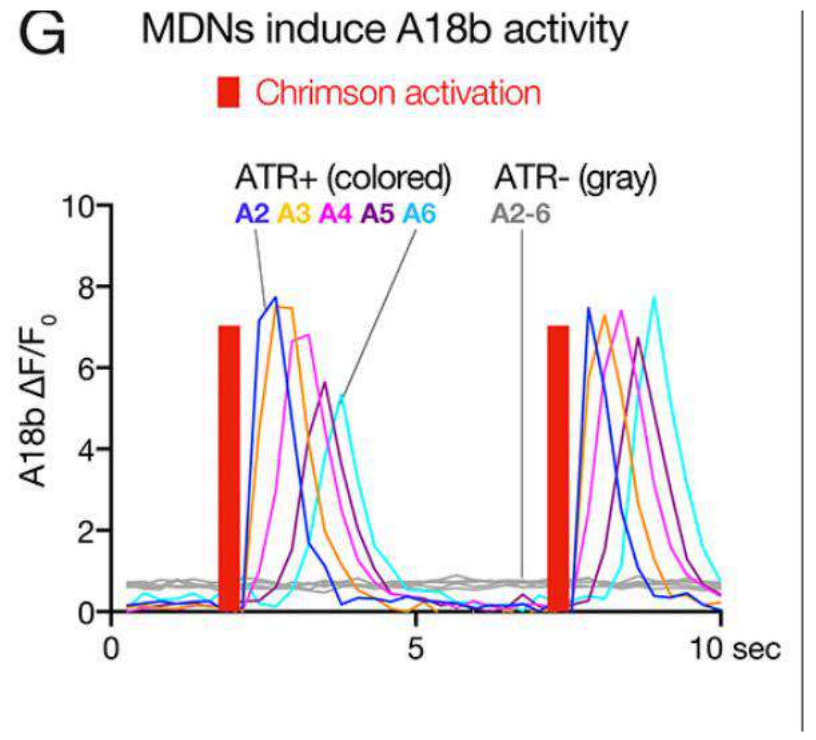
Annotation of MDN by TEM Reconstruction
and find its **Descending Neurons**

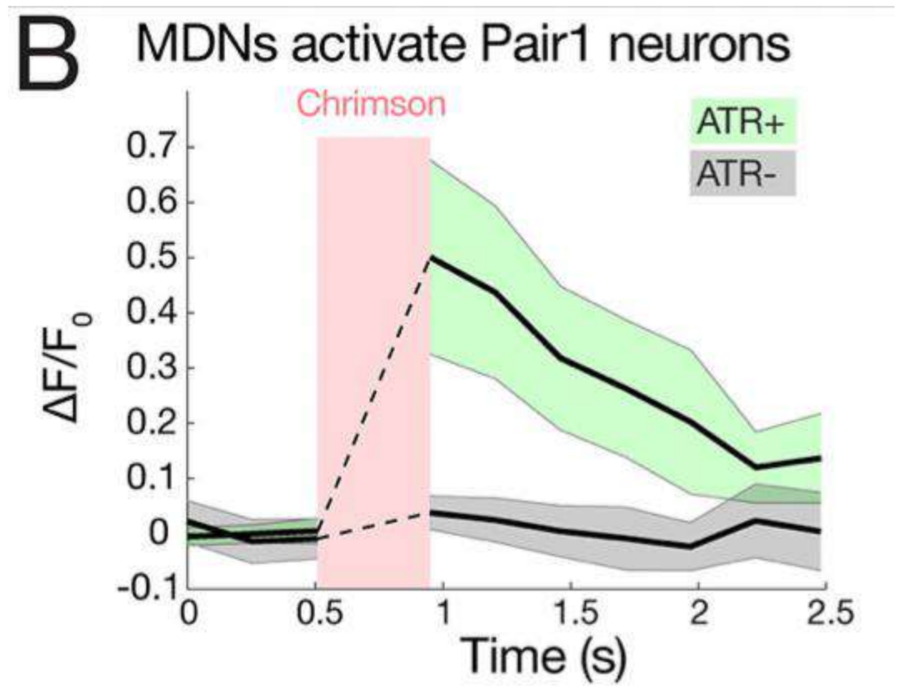


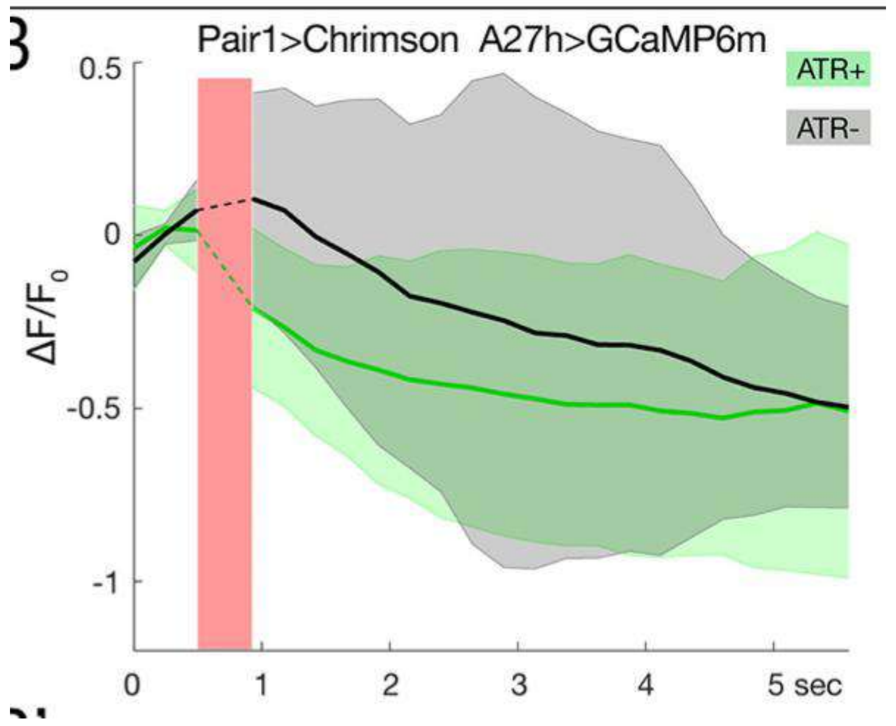


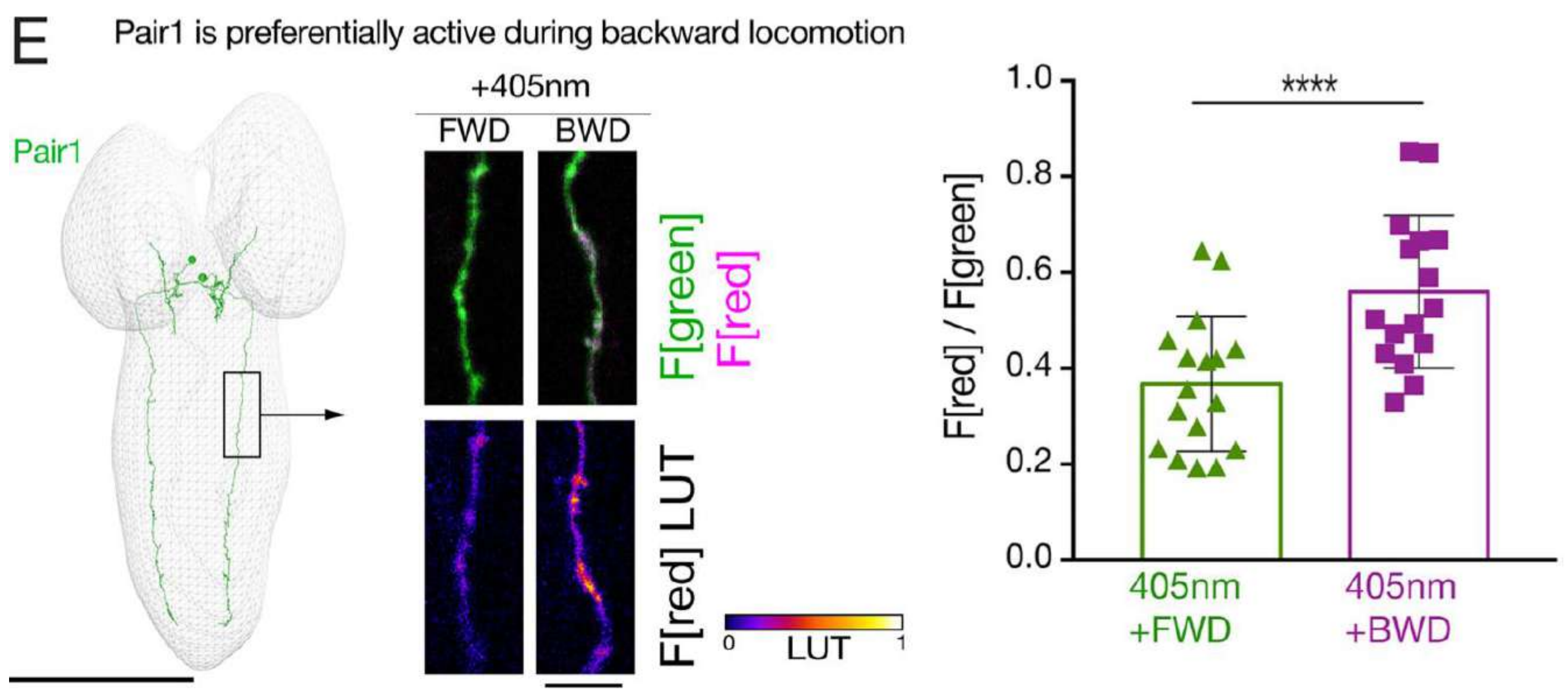
(Carreira-Rosario A, Zarin AA, Clark MQ, et al., 2018)

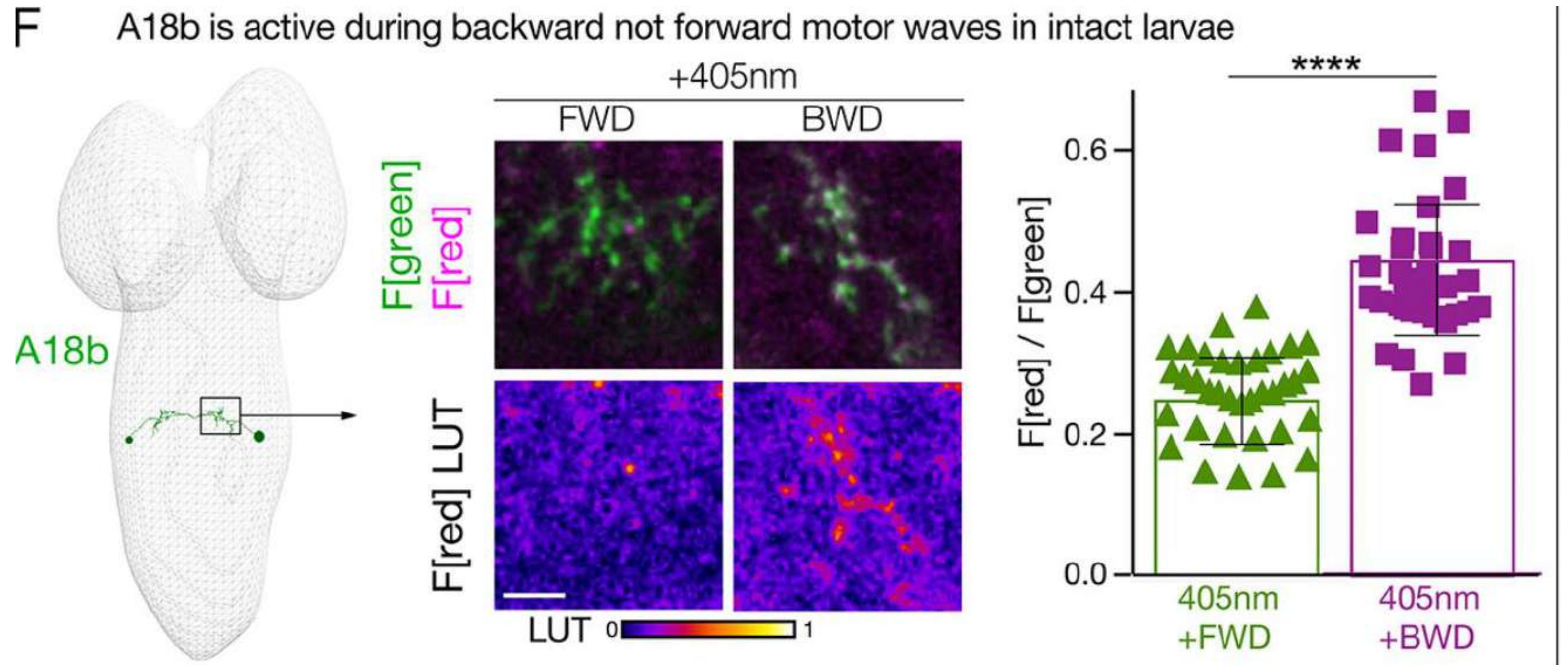
MDN induces backward crawling via
Descending Neurons

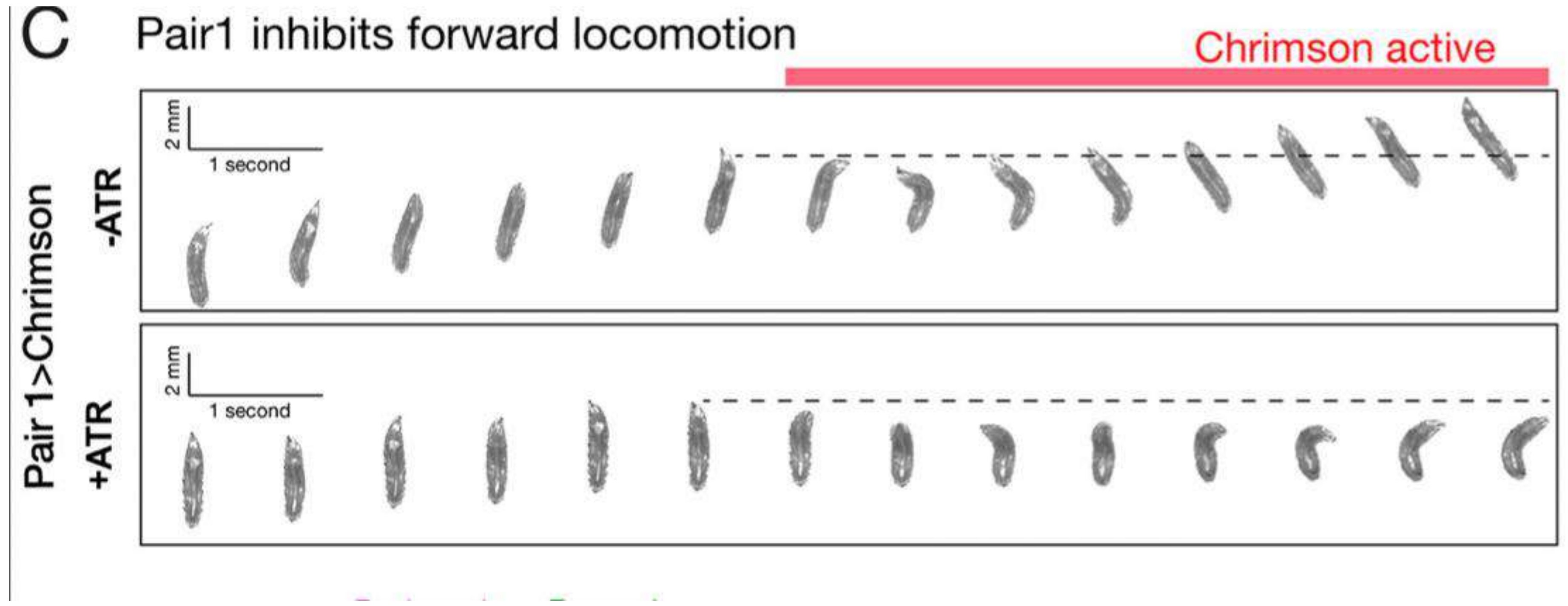


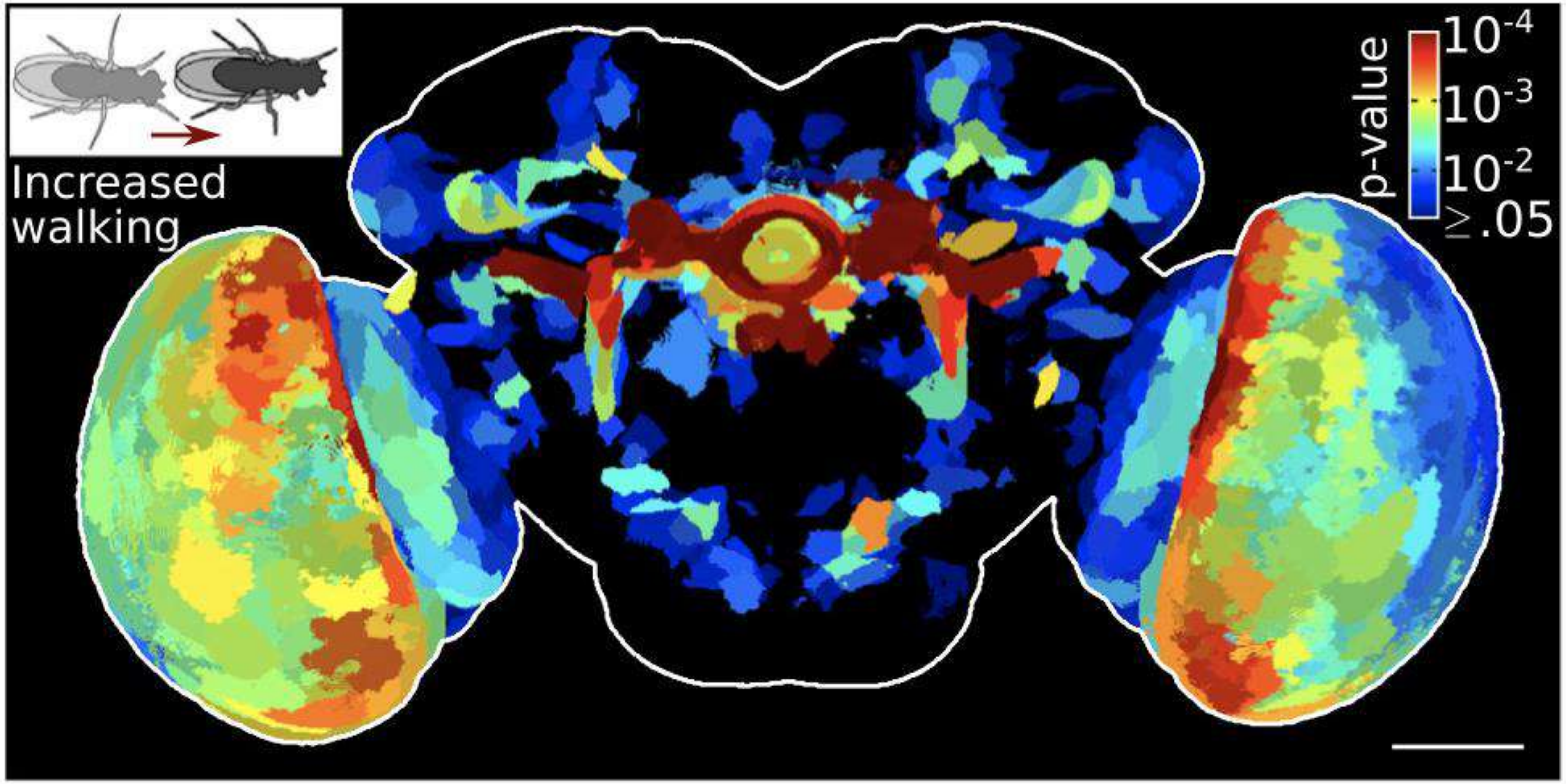








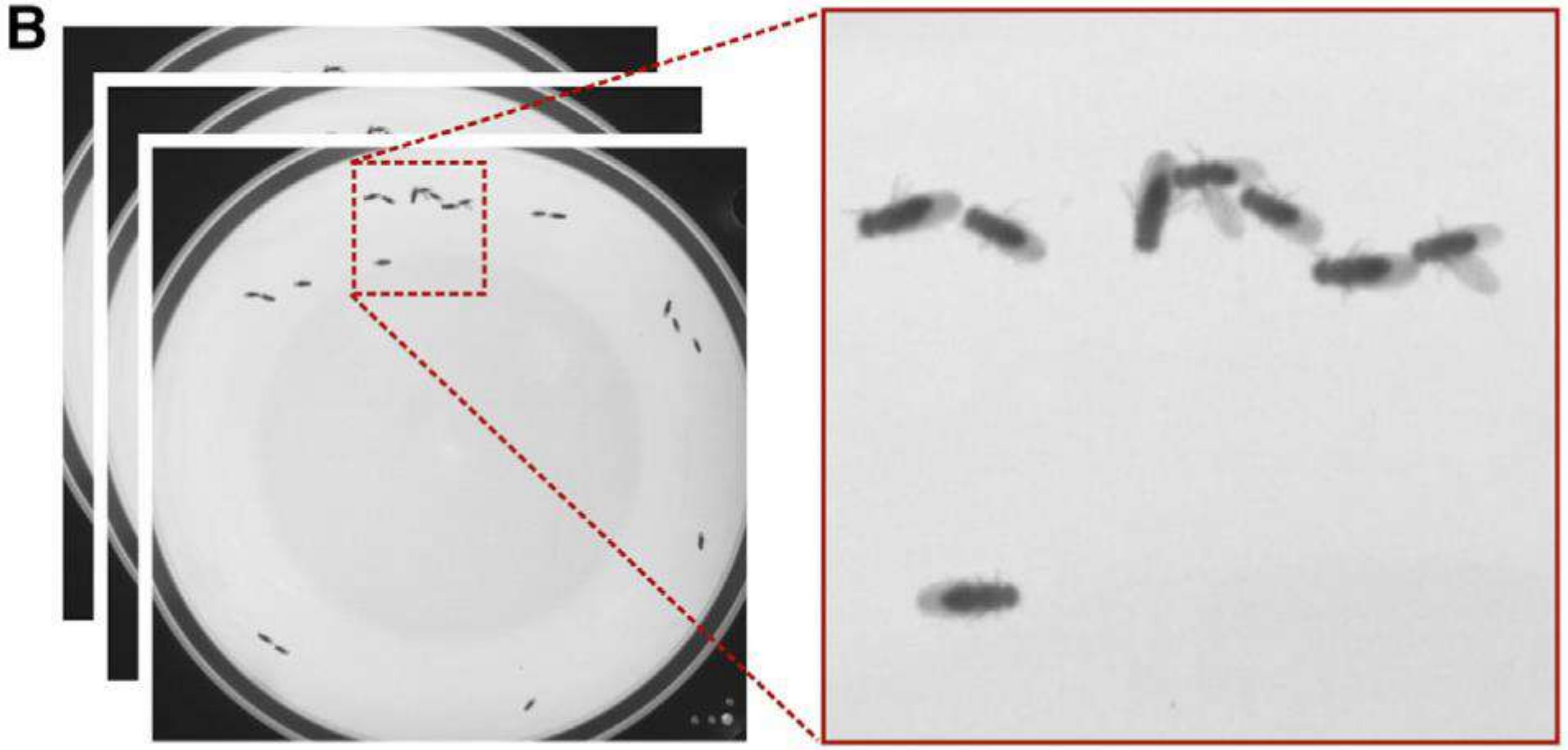




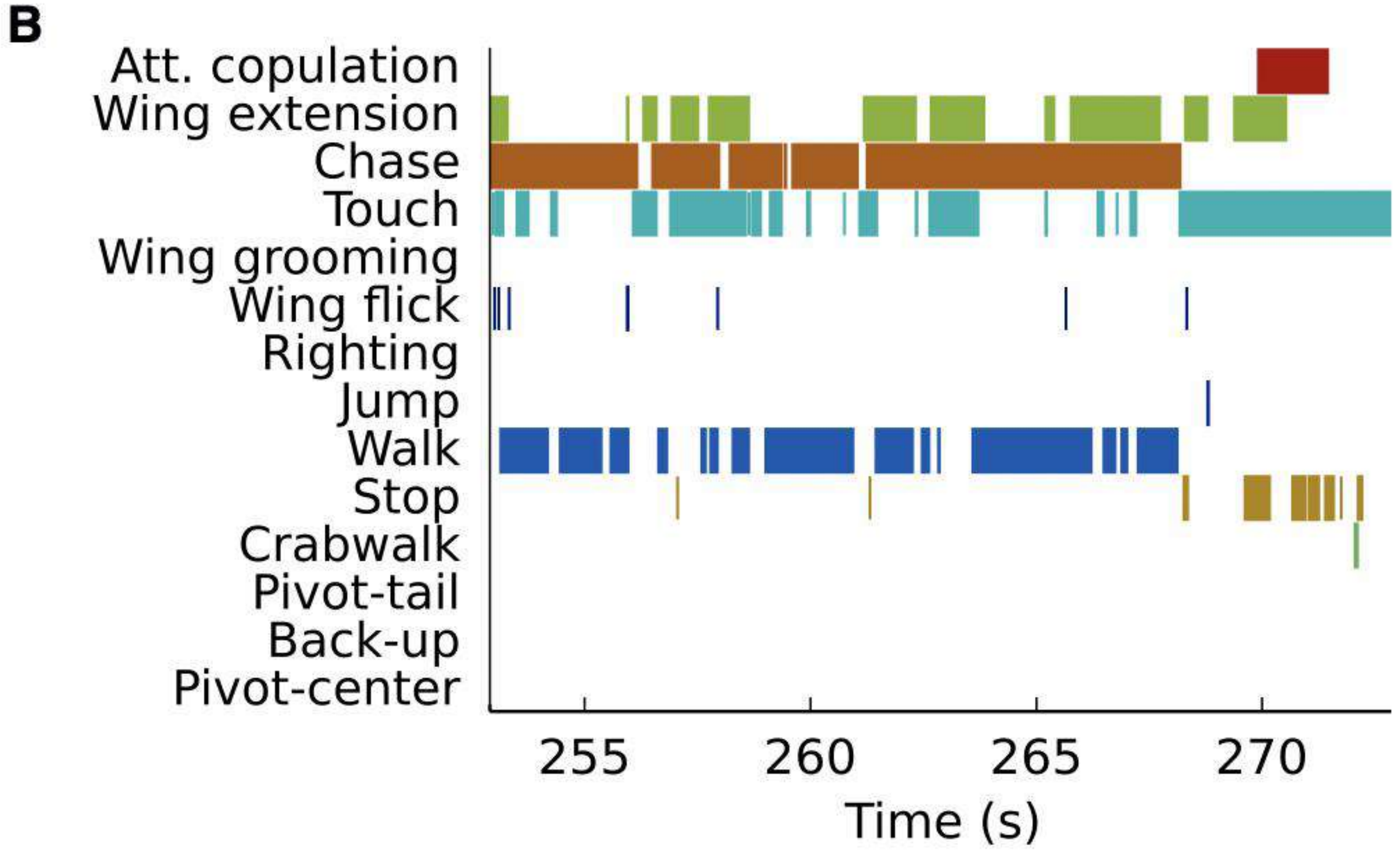
Central Complex in locomotion

(Robie AA, Hirokawa J, Edwards AW, et al., 2017)

Behavior video data **Collection**, **Tracking** and **Quantification of Behavior**



A frame of collected video. Each video consisted of ~30,000 1024x1024 pixel frames of ~10 male and ~10 female flies.



An example of automatic behavior classification results. Color indicates that the classifier predicted that the behavior was occurring.

(Robie AA, Hirokawa J, Edwards AW, et al., 2017)

Behavioral Effects of neural activation and **Anatomical Expression** of Gal4 lines

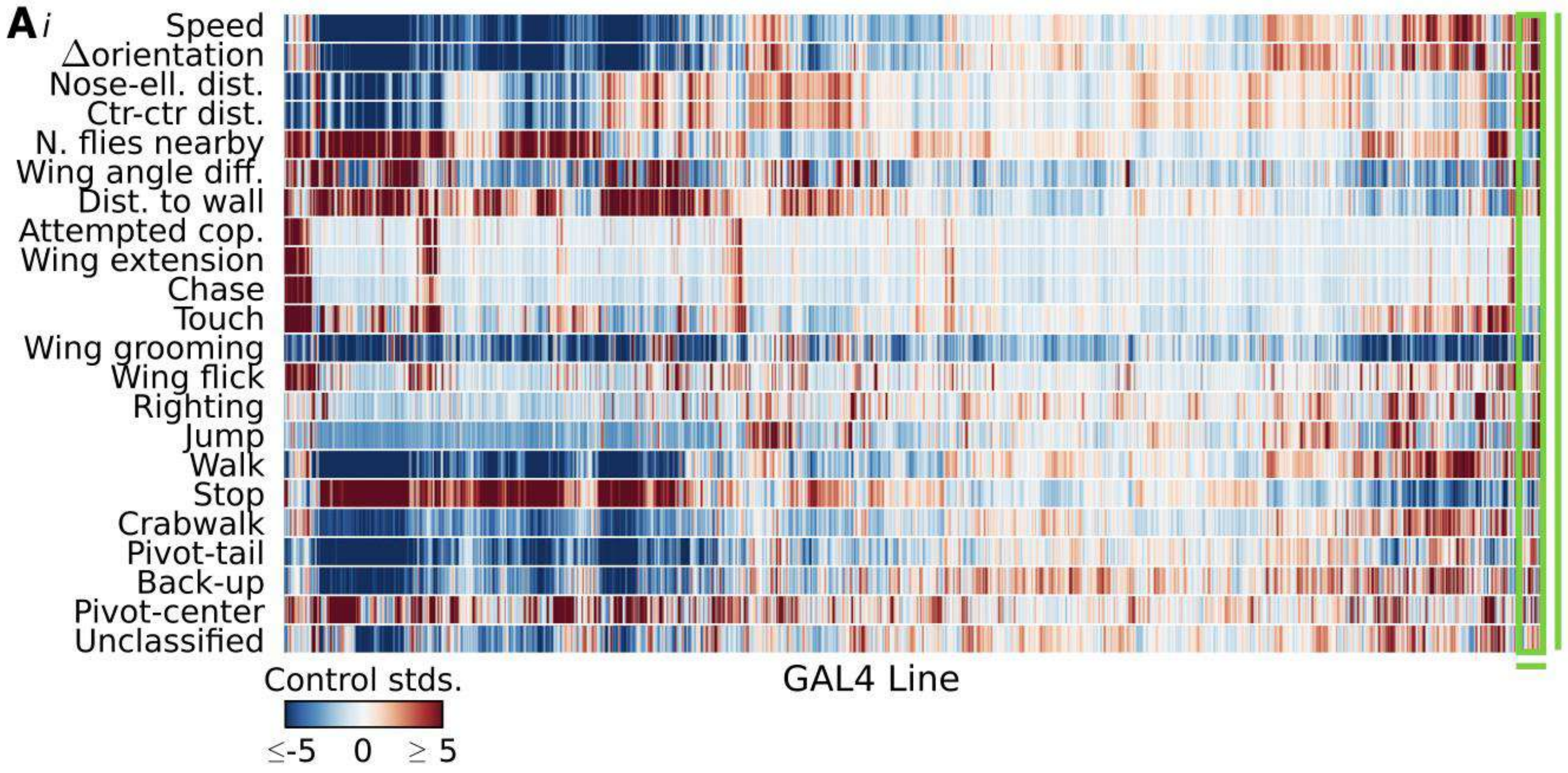


Table of behavioral effects of neural activation for all 2,205 GAL4 lines assayed.

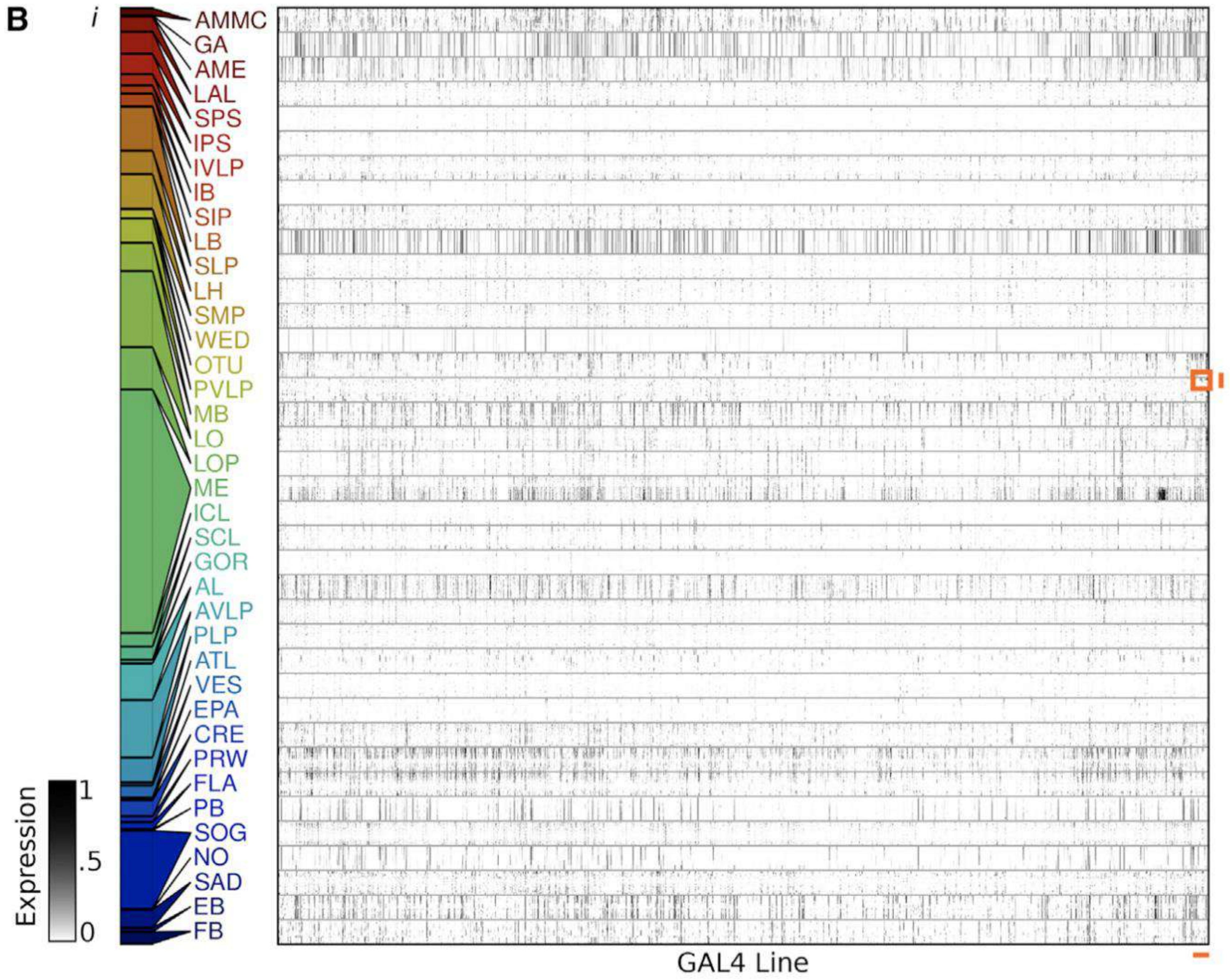
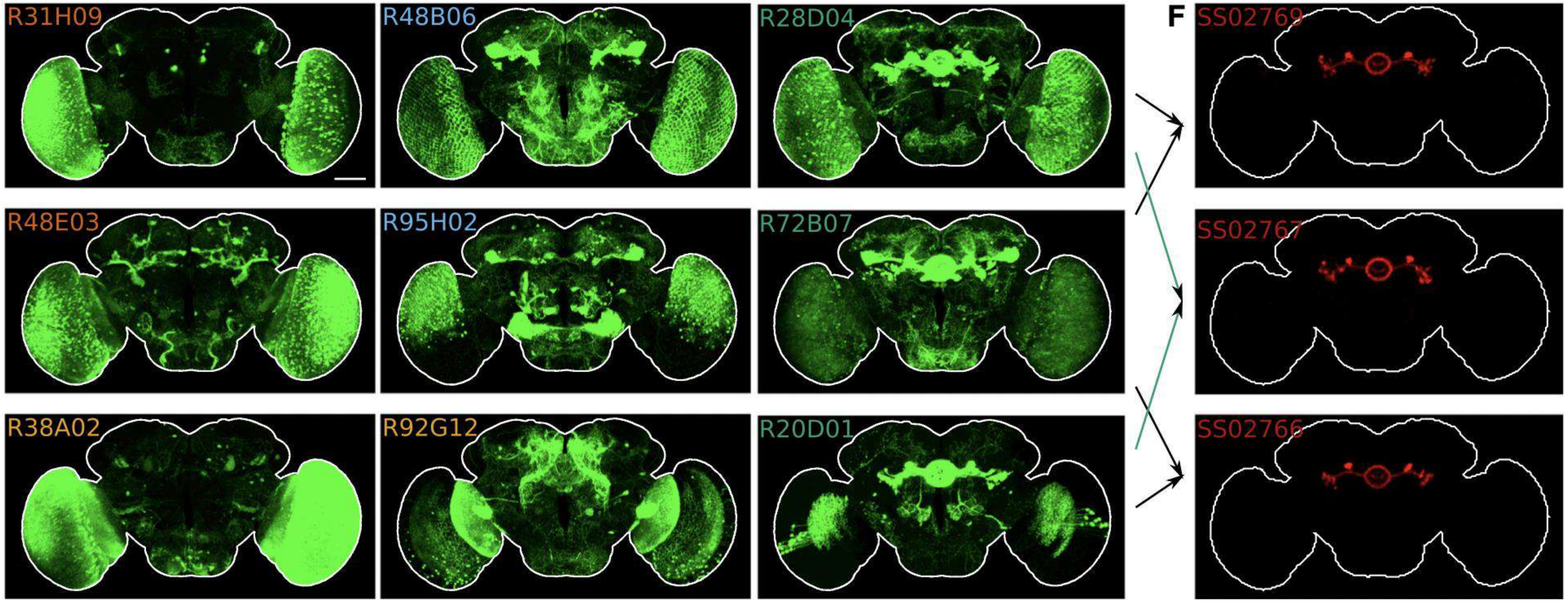


Table of anatomical expression for all GAL4 lines assayed

(Robie AA, Hirokawa J, Edwards AW, et al., 2017)

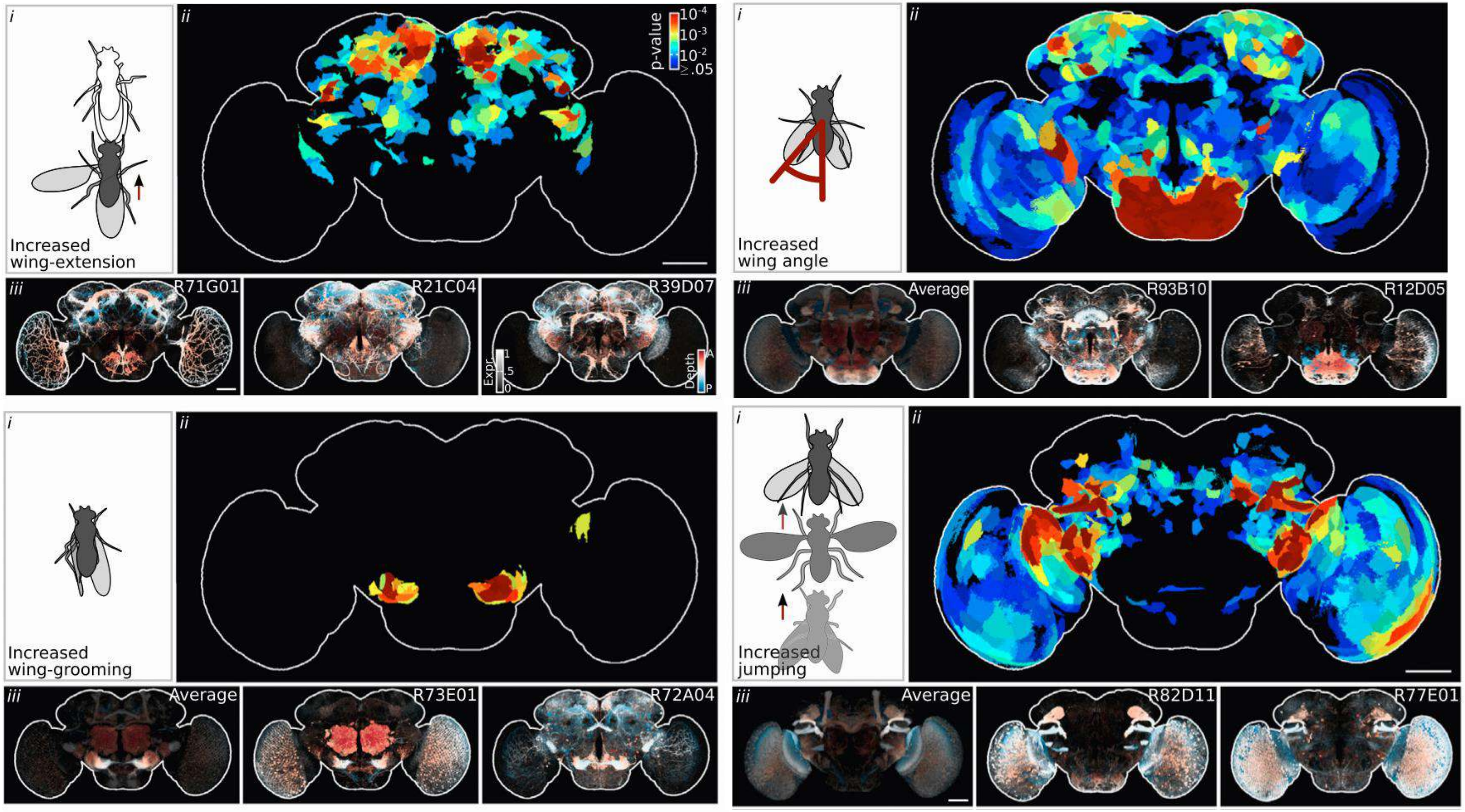
Central Complex activation is walk-increasing



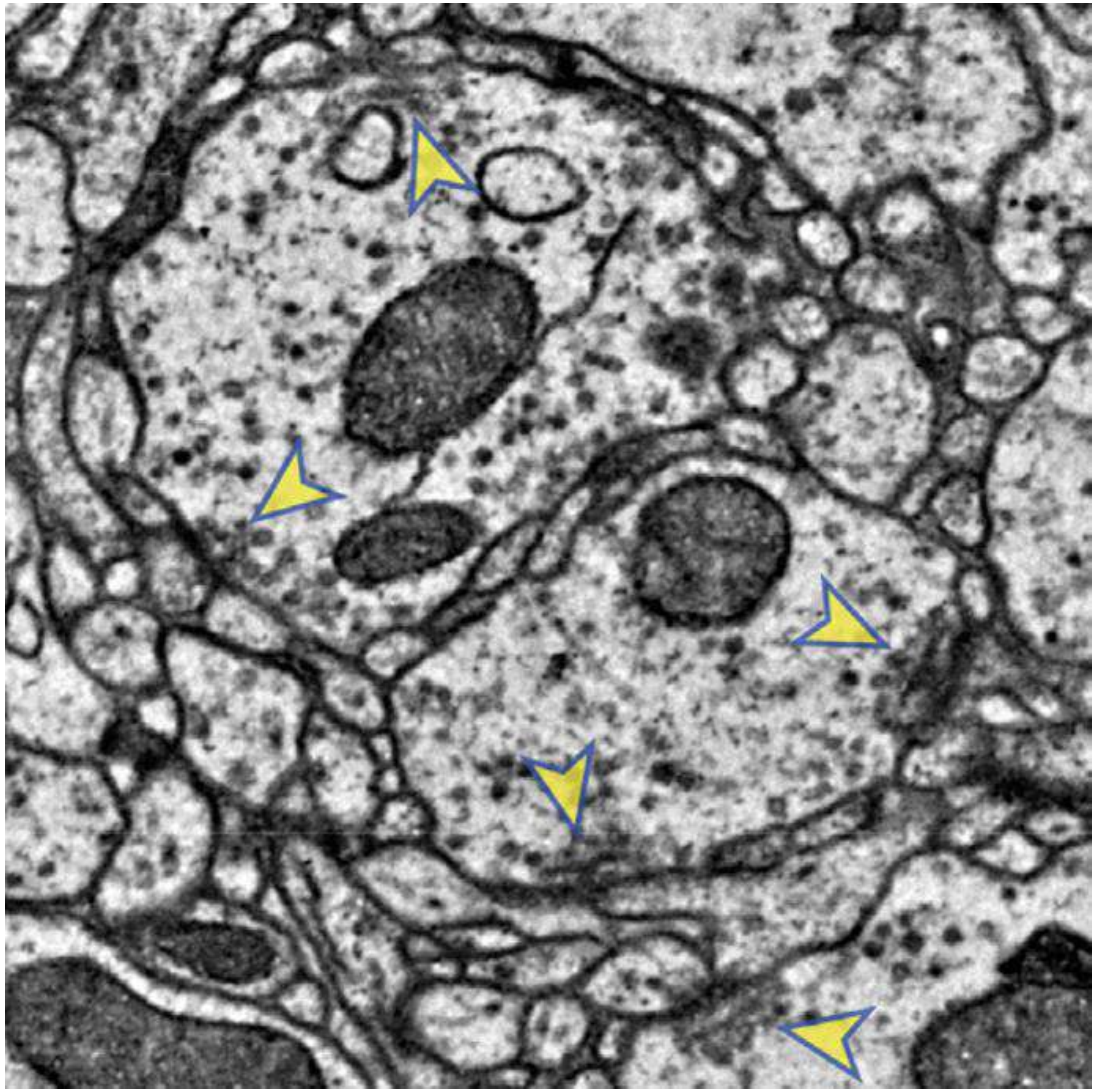
Cross-section of the walk-increasing regions all points to ring neurons.

(Robie AA, Hirokawa J, Edwards AW, et al., 2017)

…Some other behavior



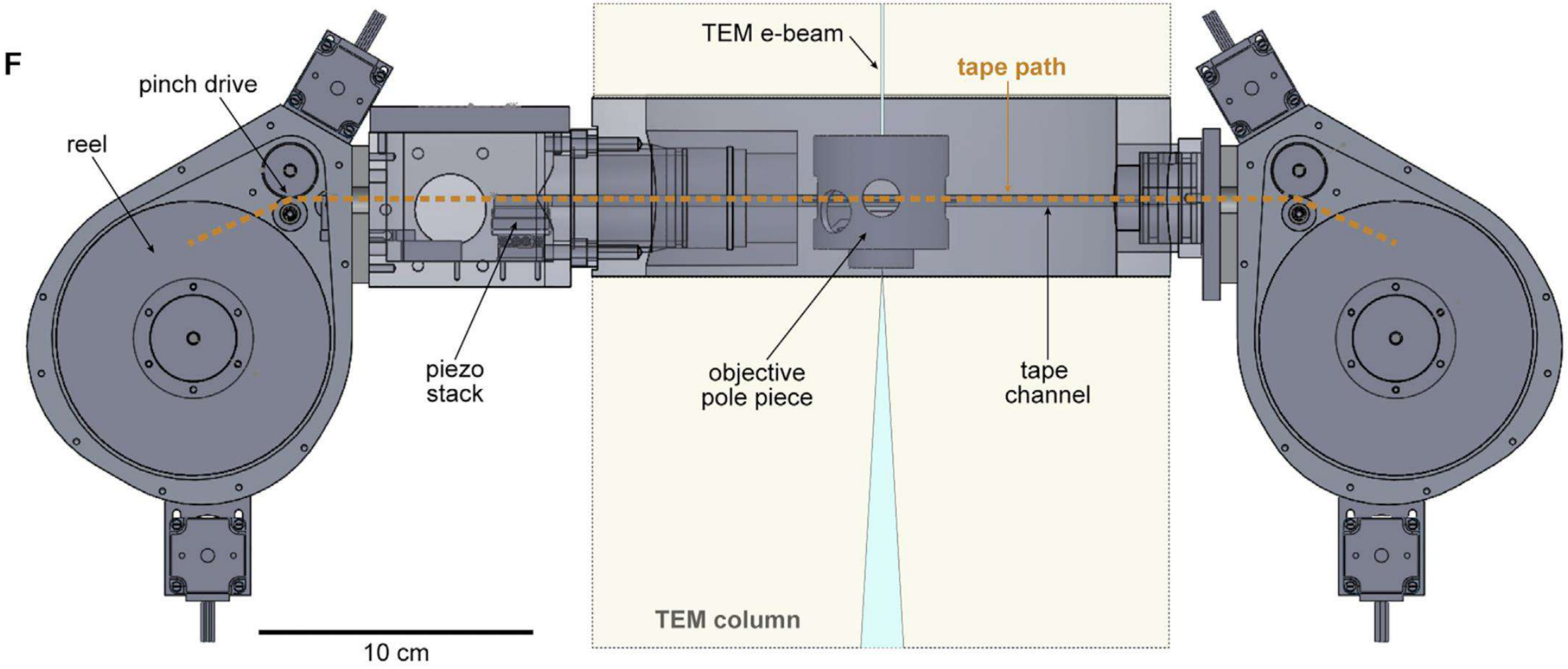
(Robie AA, Hirokawa J, Edwards AW, et al., 2017)



(Phelps JS, Hildebrand DGC, Graham BJ, et al., 2021)

Ventral Nerve Cord in locomotion

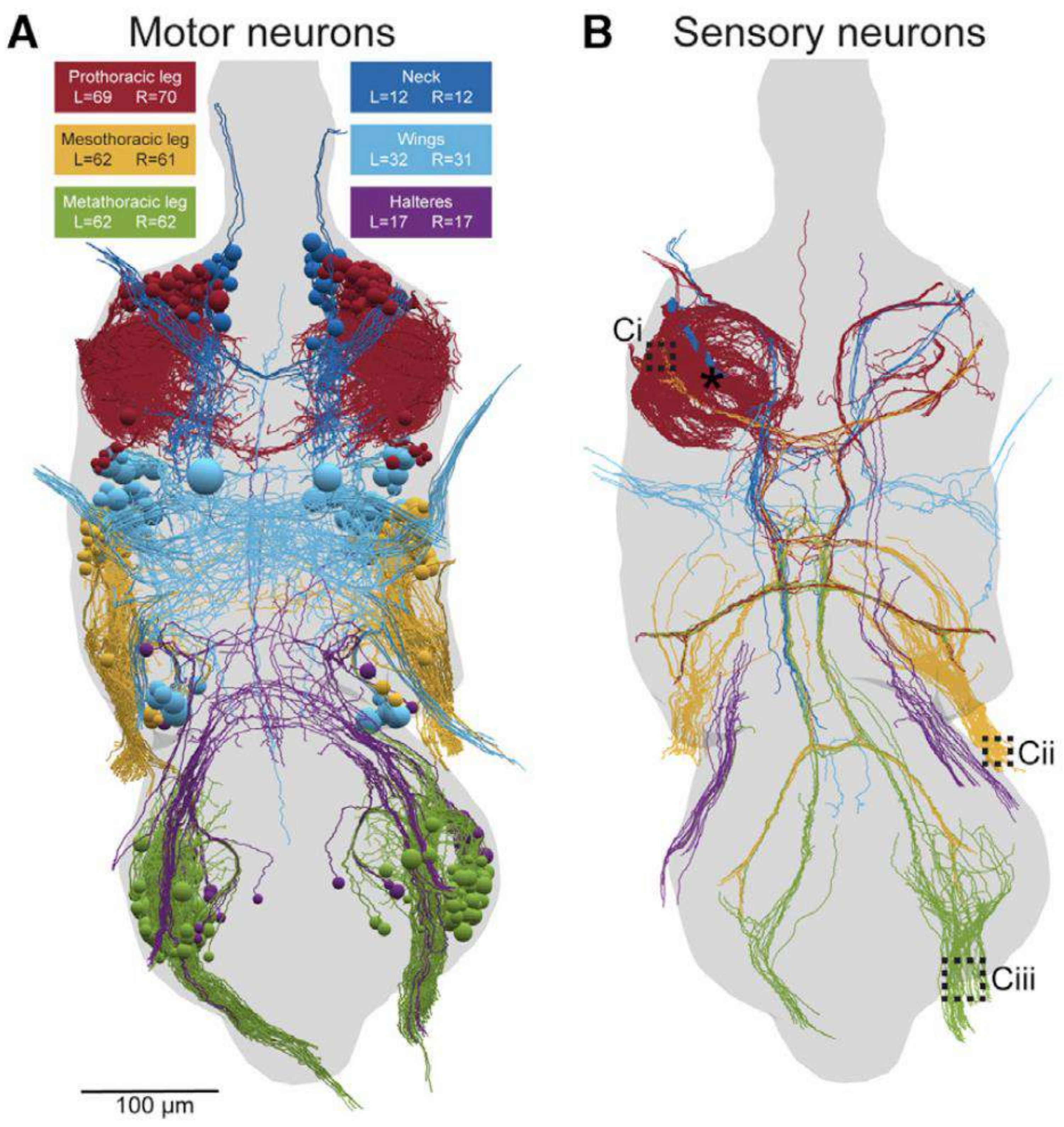
Gridtape



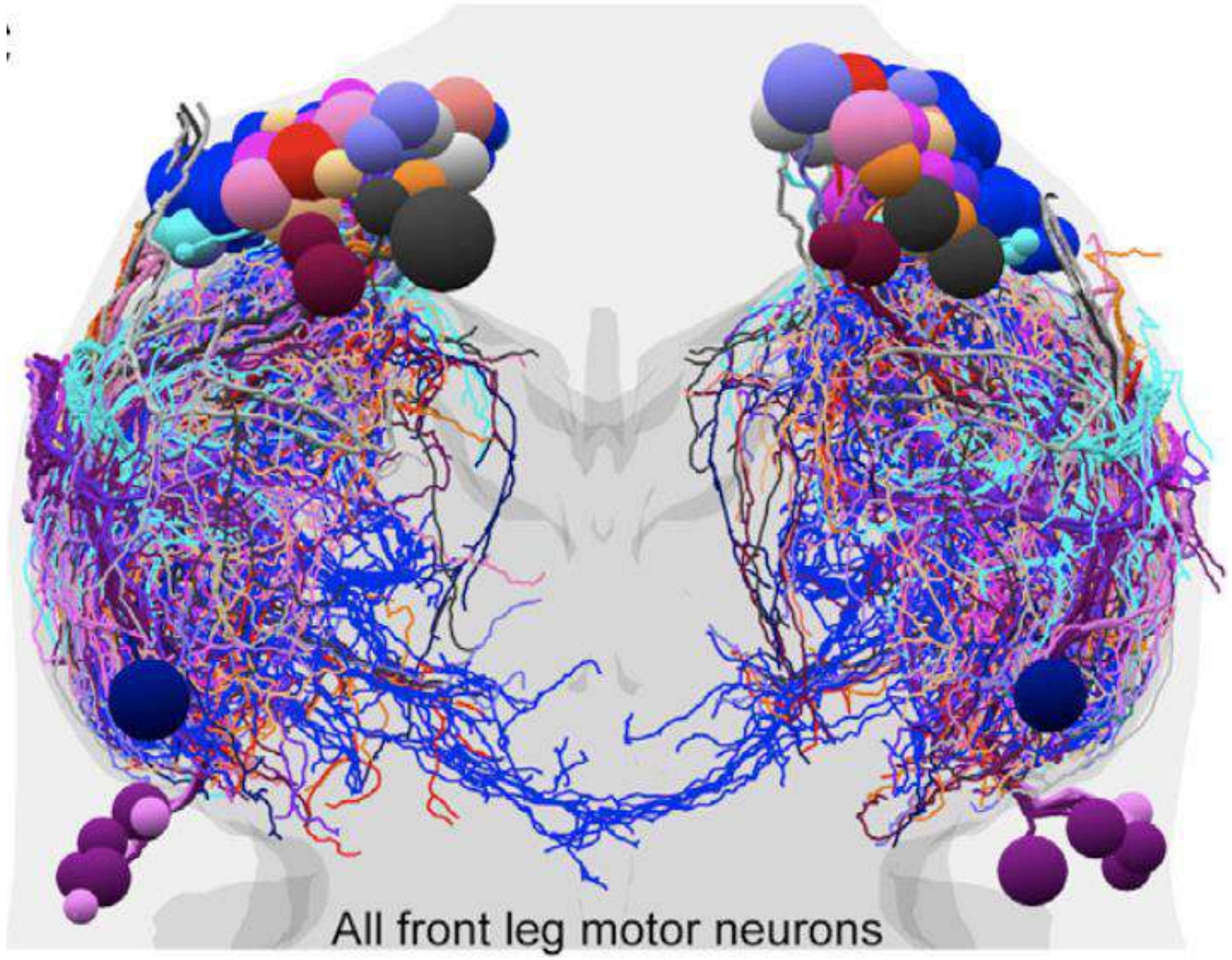
The high-throughput serial-section transmission electron microscopy (TEM) pipeline built around GridTape.

（Phelps JS, Hildebrand DGC, Graham BJ, et al.， 2021）

Reconstruction of VNC and Classification of neurons



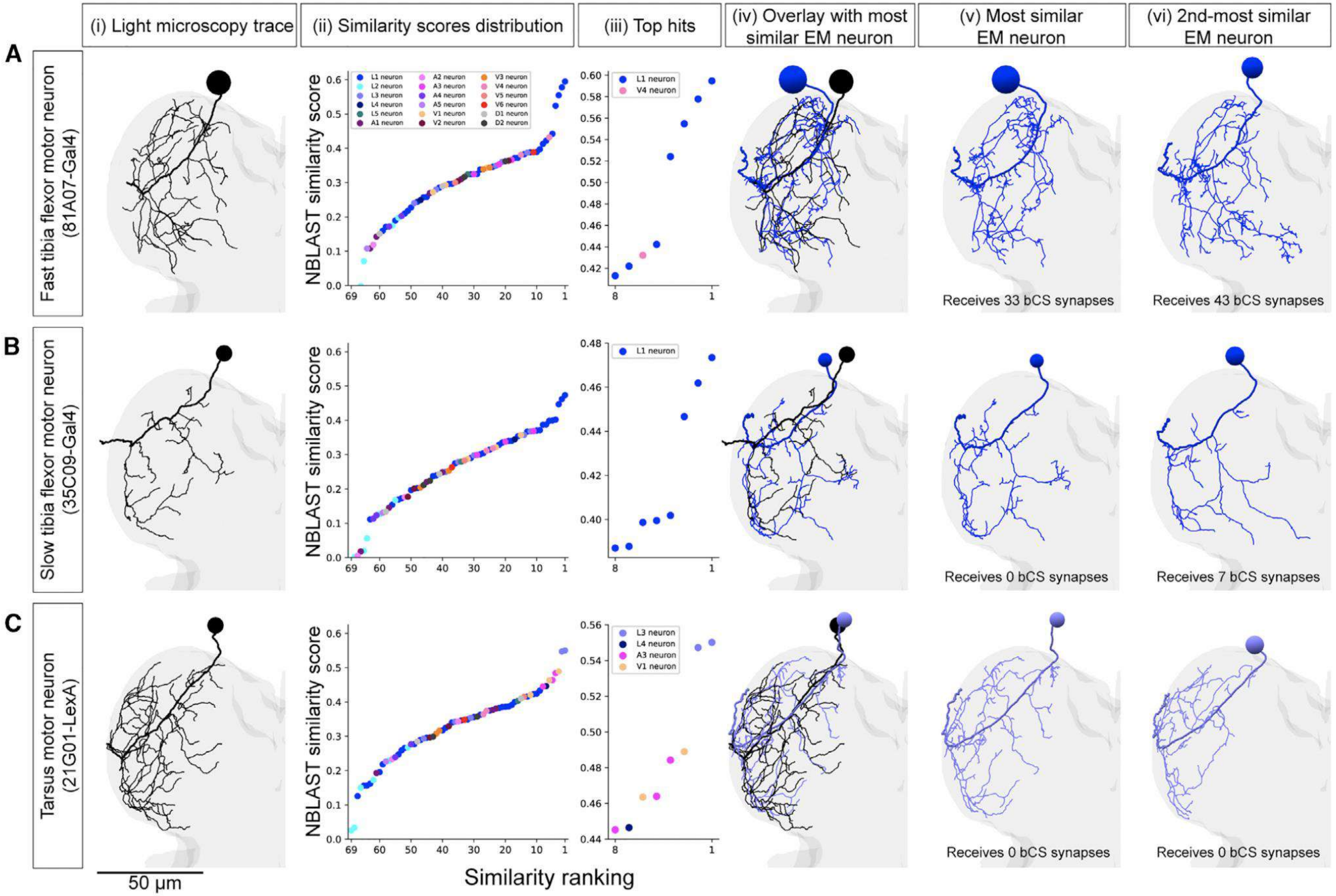
Reconstruction of motor neuron(A) and sensory neurons(B).



Reconstruction of all front leg motor neurons.

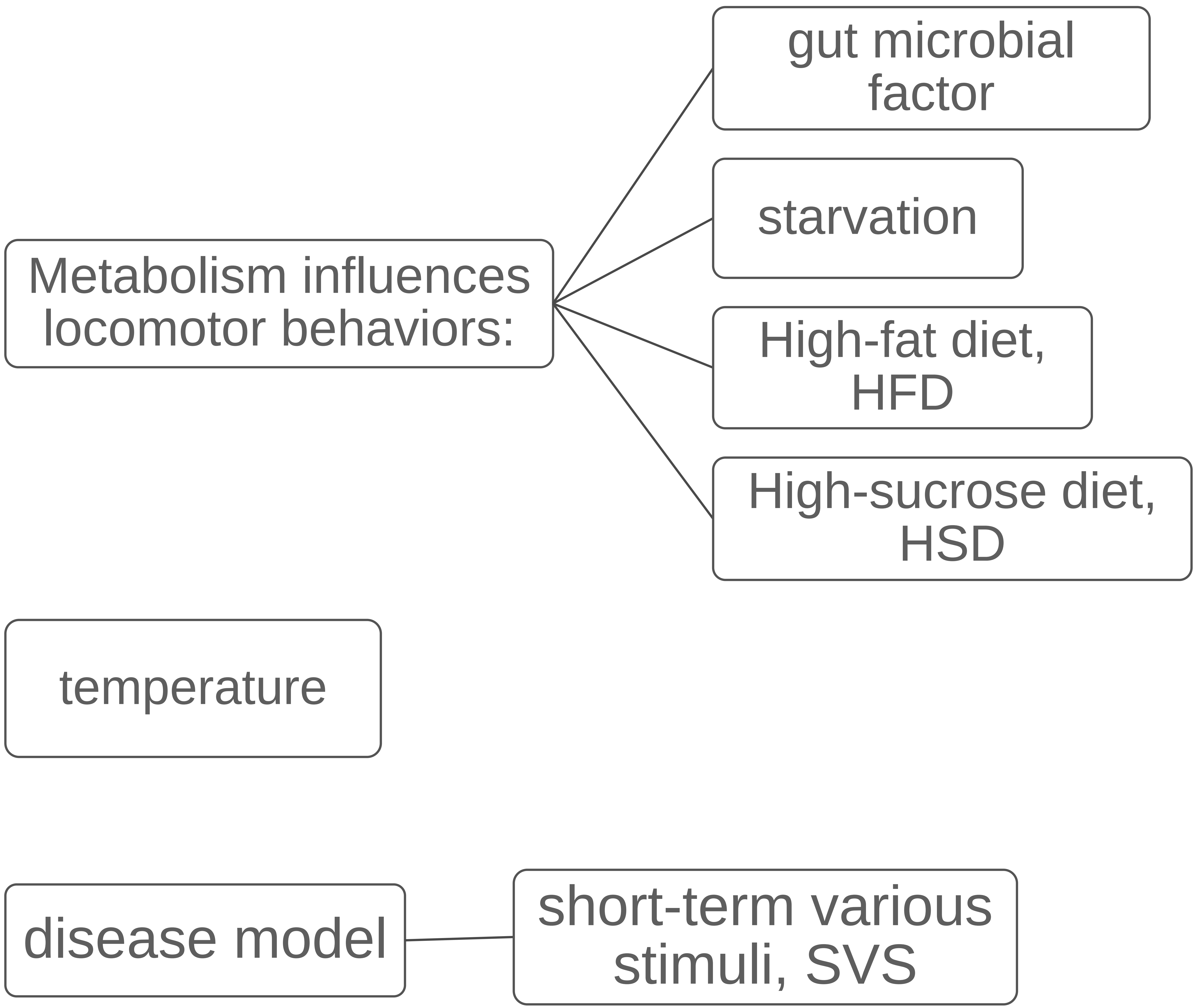
(Phelps JS, Hildebrand DGC, Graham BJ, et al., 2021)

Connection between **bCS** and **MN bundles**, fast tibia flexor MN is a major target



(Phelps JS, Hildebrand DGC, Graham BJ, et al., 2021)

The Locomotion Inducers


Metabolism influences locomotor behaviors:
gut microbial factor
starvation
High-fat diet, HFD
High-sucrose diet, HSD
temperature
disease model
short-term various stimuli, SVS

Gut microbial factor

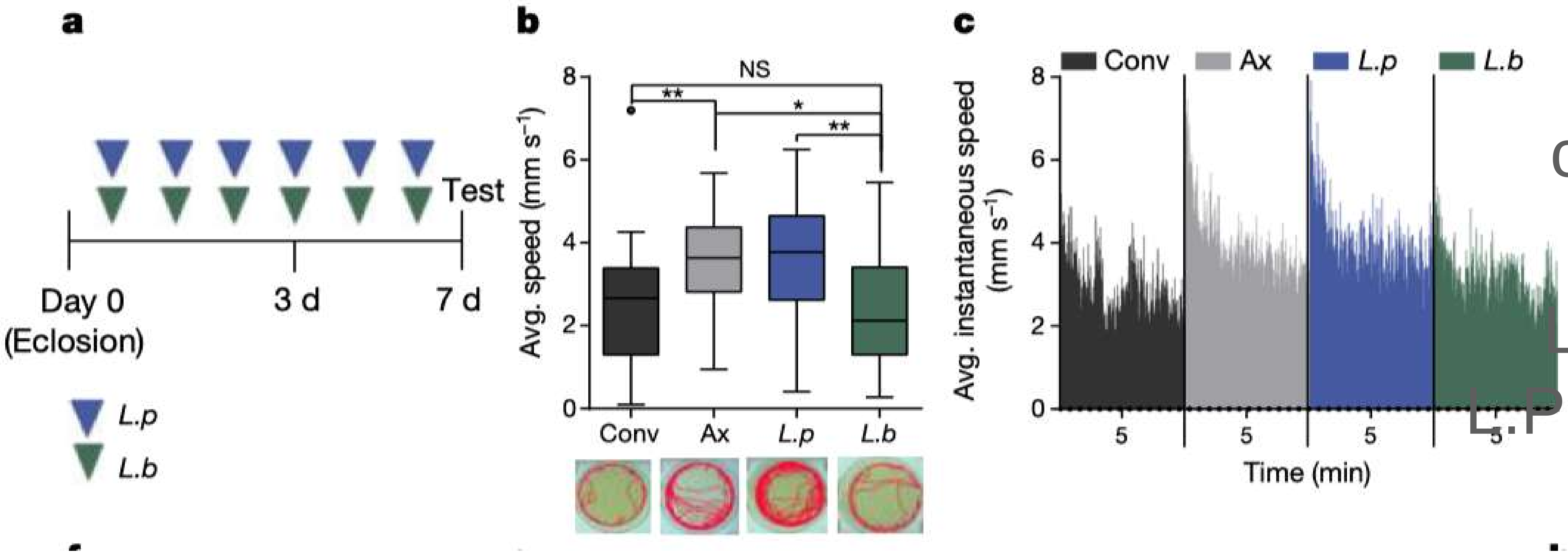
LETTER

https://doi.org/10.1038/s41586-018-0634-9

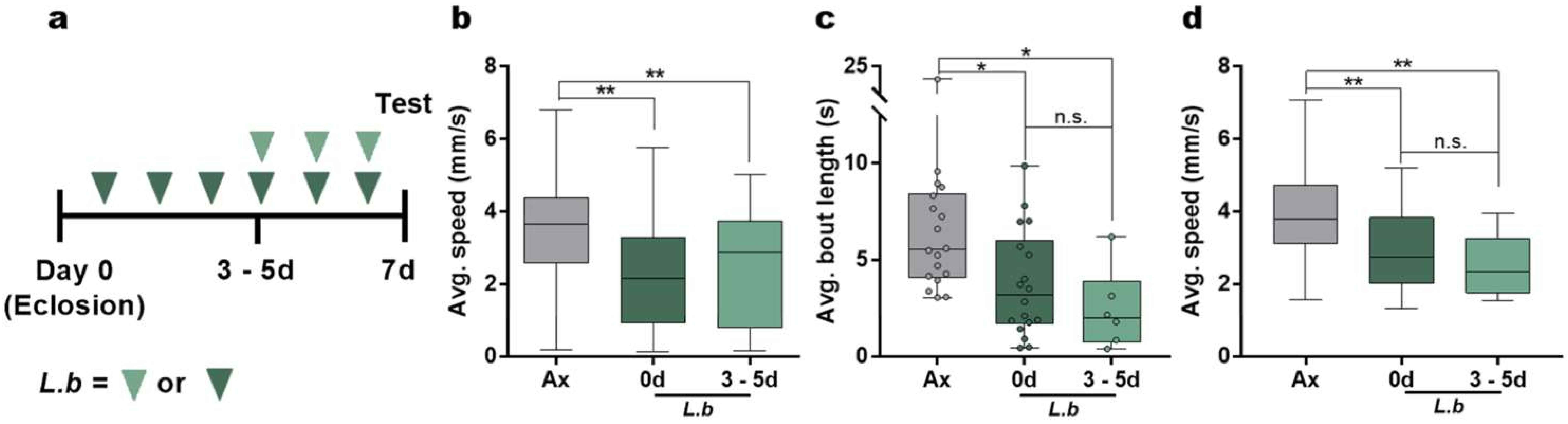
A gut microbial factor modulates locomotor behaviour in *Drosophila*

2018

Catherine E. Schretter[1]*, Jost Vielmetter[2], Imre Bartos[3], Zsuzsa Marka[3], Szabolcs Marka[3], Sulabha Argade[4] & Sarkis K. Mazmanian[1]*

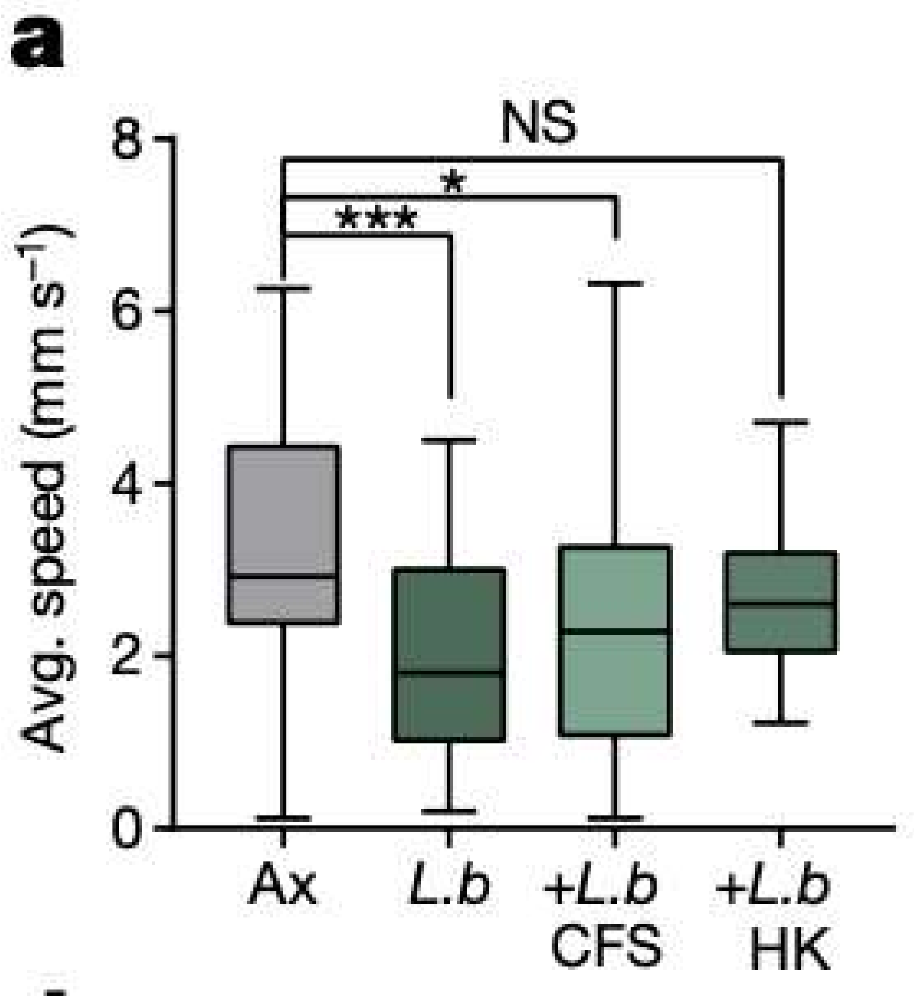


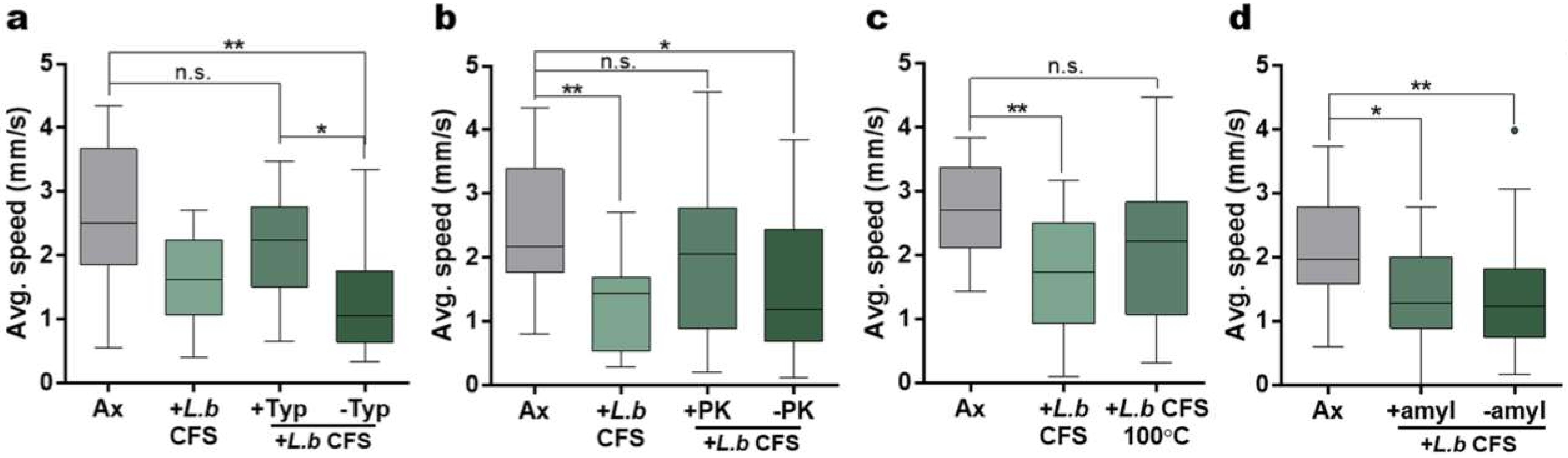
conventional; Conv
axenic; Ax,无菌的
L.b, Lactobacillus brevis： 短乳酸菌
L.P , Lactobacillus plantarum：胚芽乳酸

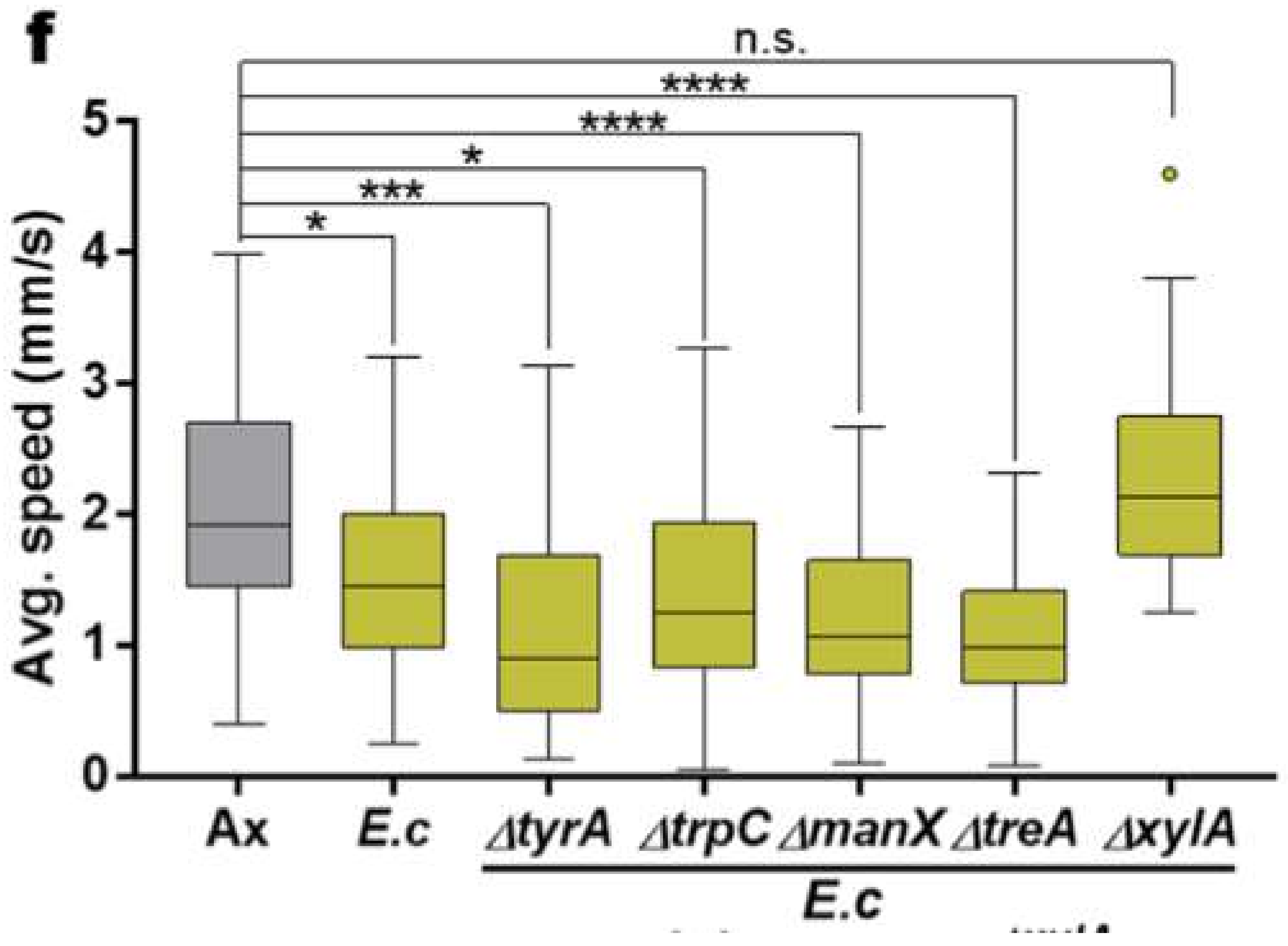


CFS: cell-free supernatant (CFS) collected from bacterial cultures

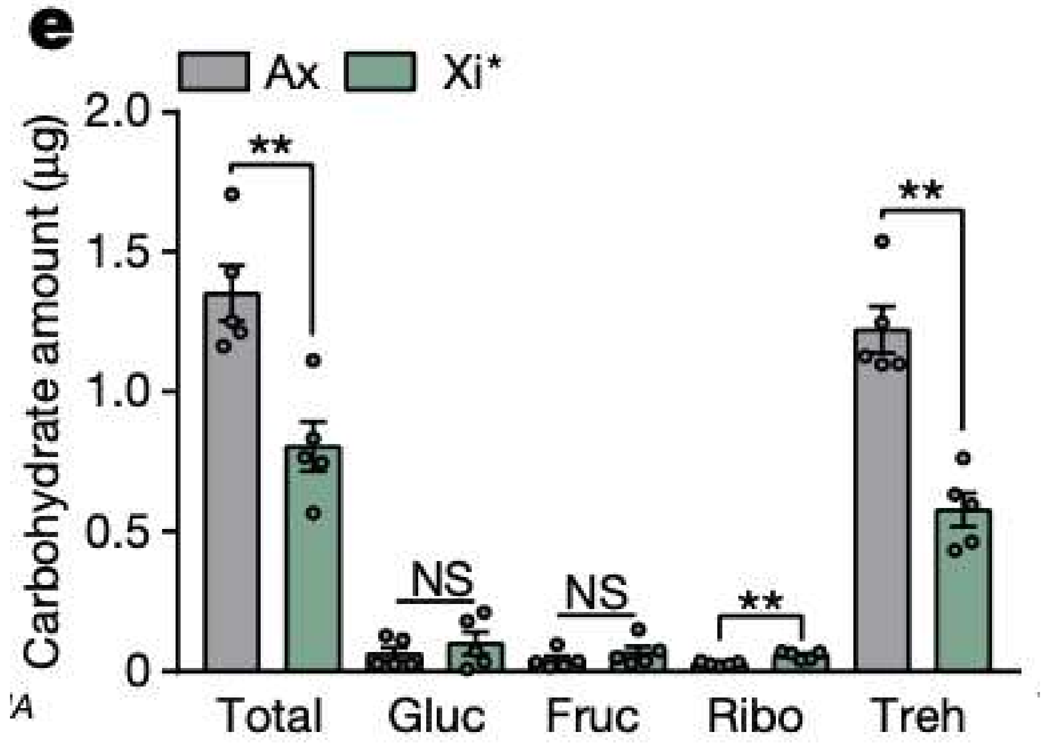
HK: heat-killed bacteria

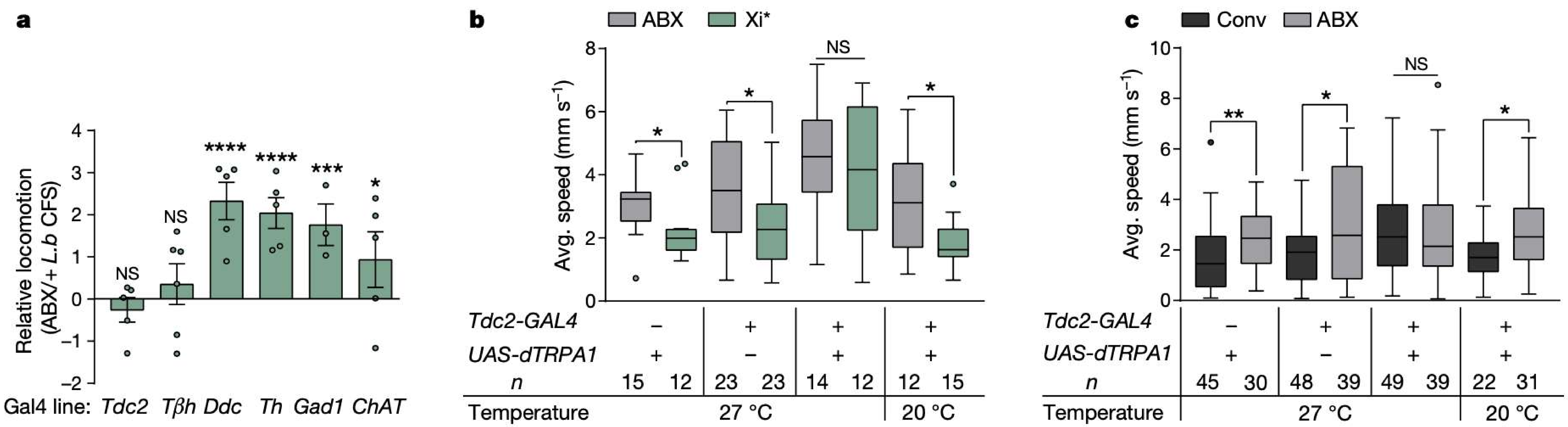


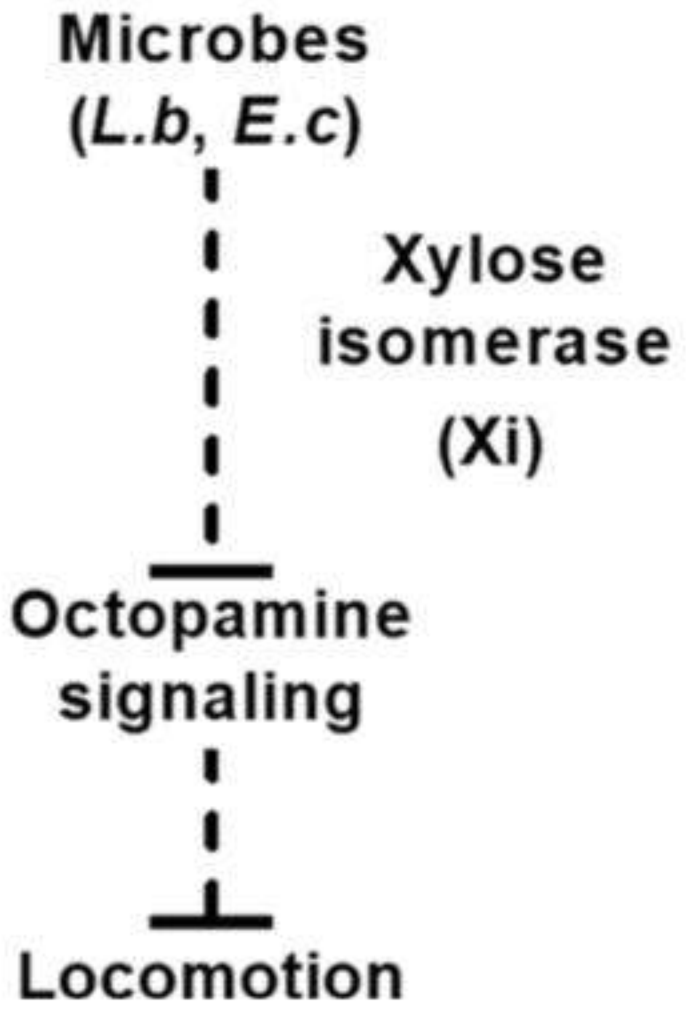




xylose isomerase (Xi)




a
Relative locomotion (ABX/+ L.b CFS)
NS
NS
****
****
***
*
Gal4 line: Tdc2 Tβh Ddc Th Gad1 ChAT
b
ABX
Xi*
Avg. speed (mm s−1)
NS
*
*
*
Tdc2-GAL4
UAS-dTRPA1
n
15 12 23 23 14 12 12 15
Temperature
27 °C
20 °C
c
Conv
ABX
Avg. speed (mm s−1)
**
*
NS
*
Tdc2-GAL4
UAS-dTRPA1
n
45 30 48 39 49 39 22 31
Temperature
27 °C
20 °C


Microbes
(L.b, E.c)
Xylose
isomerase
(Xi)
Octopamine
signaling
Locomotion

starvation

PNAS Proceedings of the National Academy of Sciences of the United States of America

Octopamine mediates starvation-induced hyperactivity in adult *Drosophila*

Zhe Yang (杨哲)[a,1], Yue Yu (于悦)[a,1], Vivian Zhang (张维嘉)[b,1], Yinjun Tian (田引军)[a], Wei Qi (祁伟)[a,c], and Liming Wang (王立铭)[a,2]

[a]Life Sciences Institute, Zhejiang University, Hangzhou, Zhejiang 310058, China; [b]Department of Molecular and Cell Biology, University of California, Berkeley, CA 94720-3200; and [c]College of Life Sciences, Sichuan University, Chengdu, Sichuan 610064, China

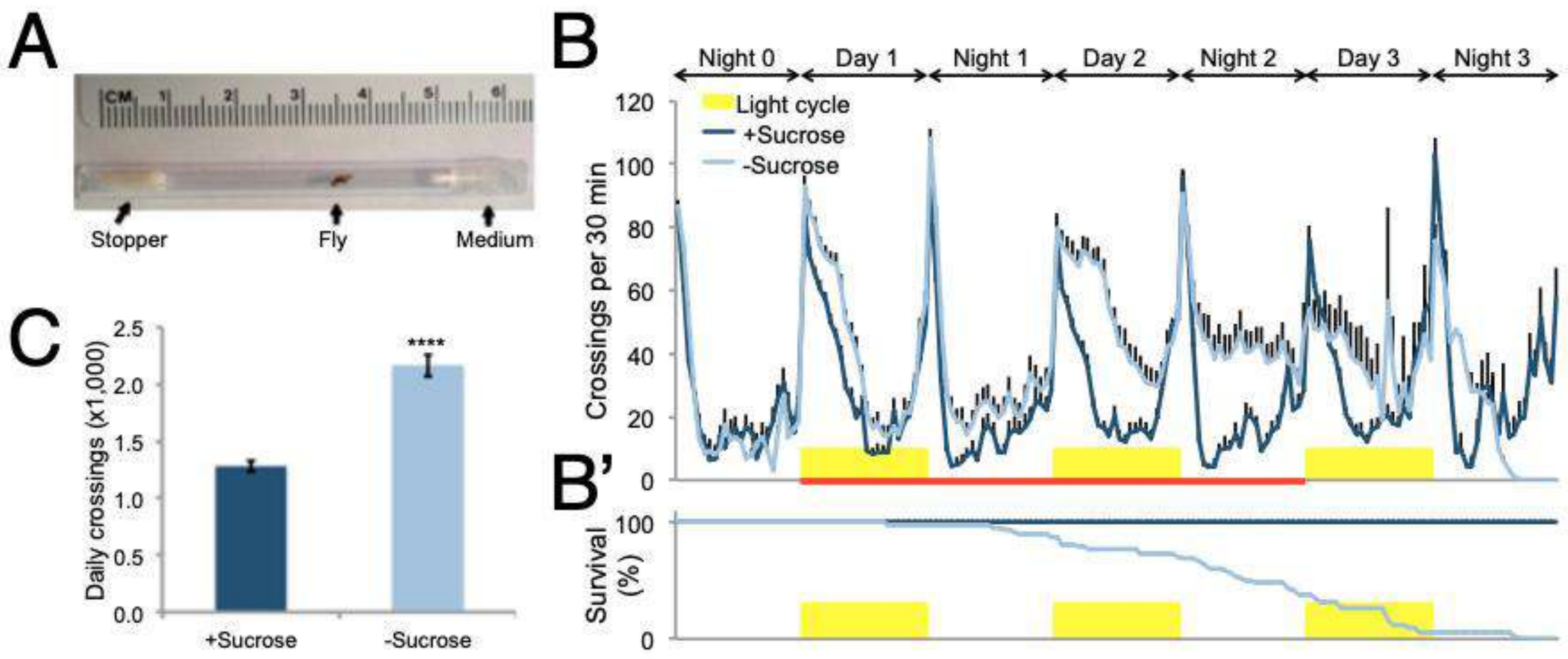
Edited* by David J. Anderson, California Institute of Technology, Pasadena, CA, and approved March 10, 2015 (received for review September 16, 2014)

eLIFE elifesciences.org

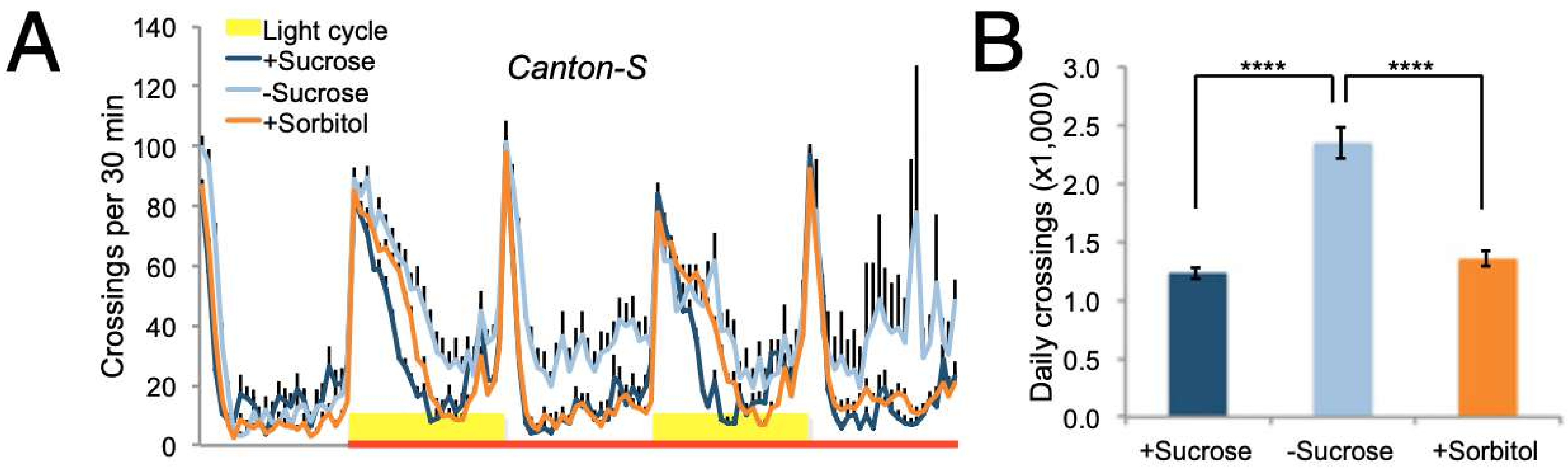
Regulation of starvation-induced hyperactivity by insulin and glucagon signaling in adult *Drosophila*

Yue Yu[1,2†], Rui Huang[1,2*†], Jie Ye[1,2], Vivian Zhang[3], Chao Wu[1,2], Guo Cheng[1,2], Junling Jia[1,2], Liming Wang[1,2*]

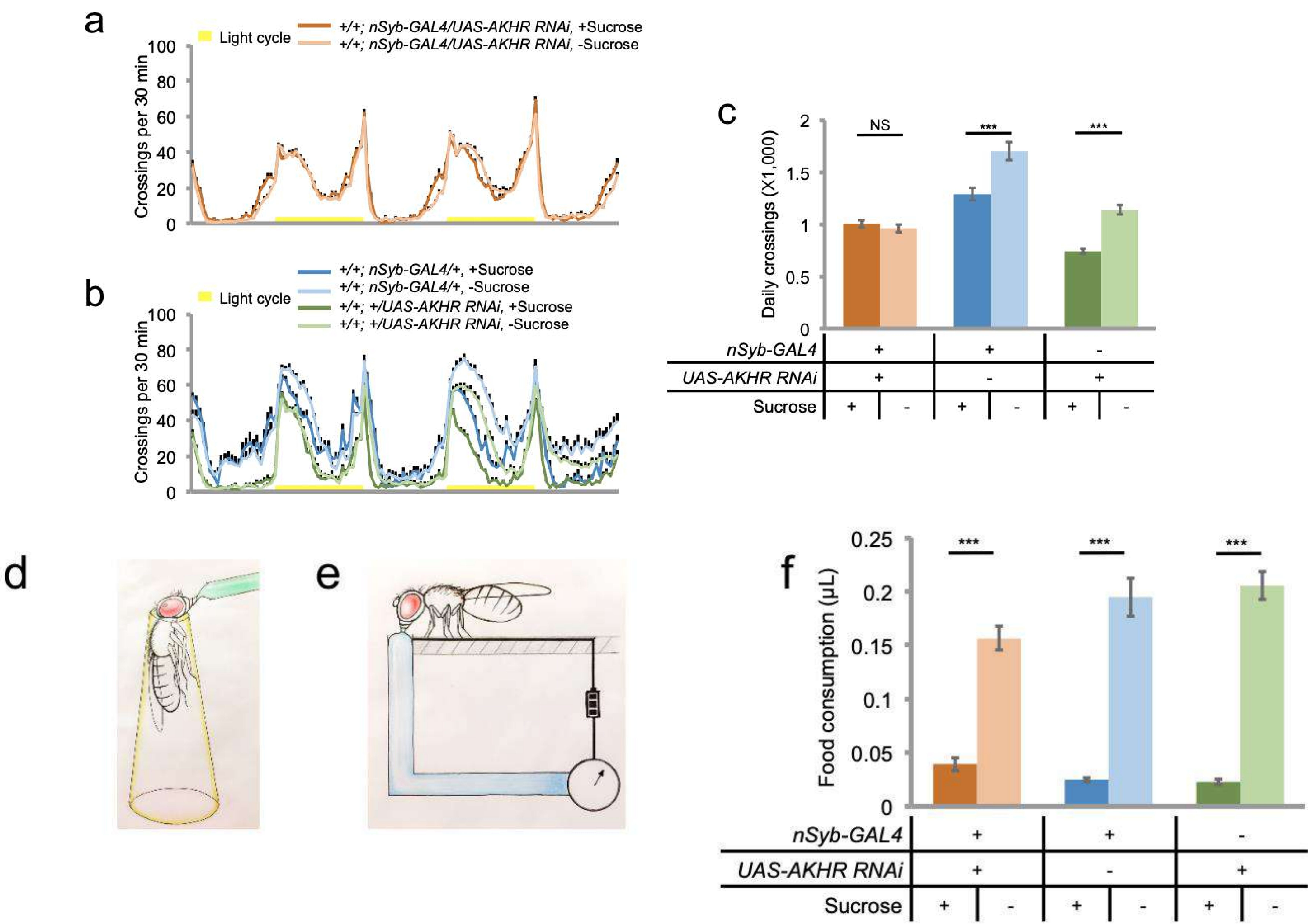
Starvation induces hyperactivity of adult flies



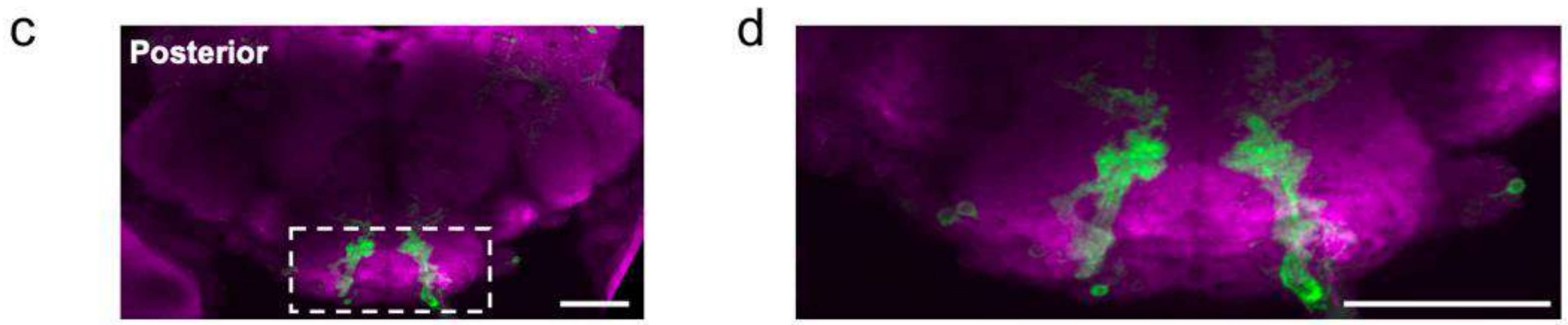
Food Cues Suppress Starvation-Induced Hyperactivity.



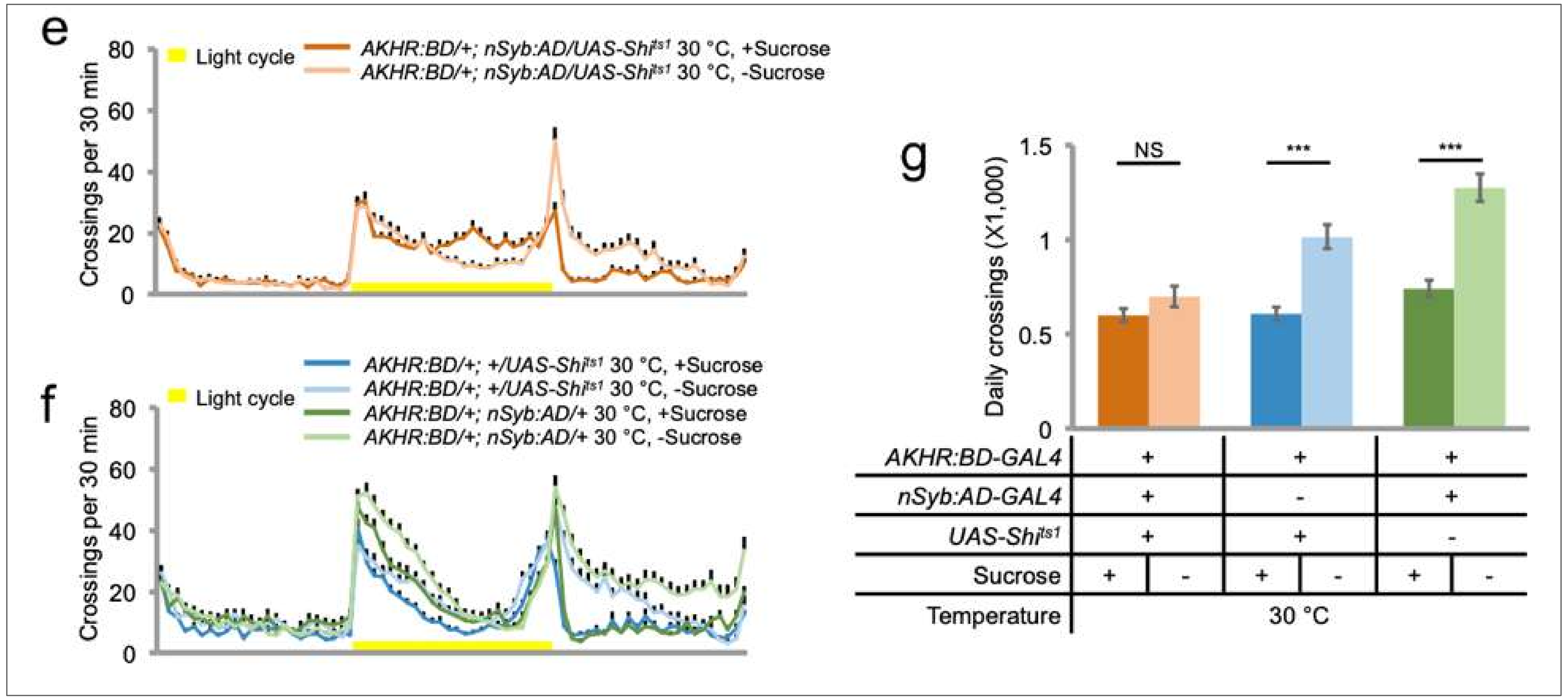
Neuronal AKHR is required for starvation-induced hyperactivity but not food consumption.



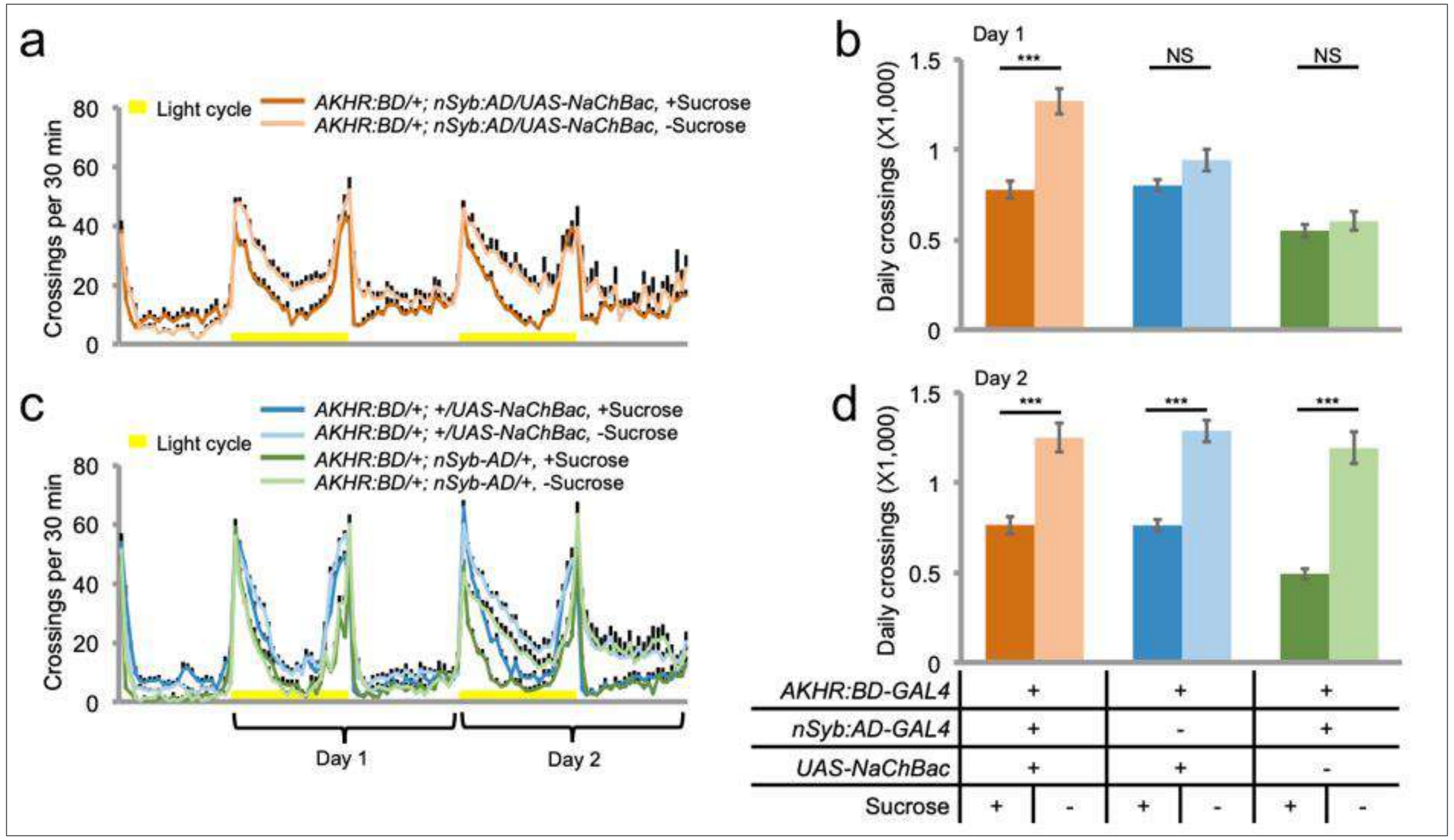
AKHR+ neurons are required for starvation-induced hyperactivity



silencing of AKHR$^+$neurons



facilitating the activation of of AKHR$^+$neurons

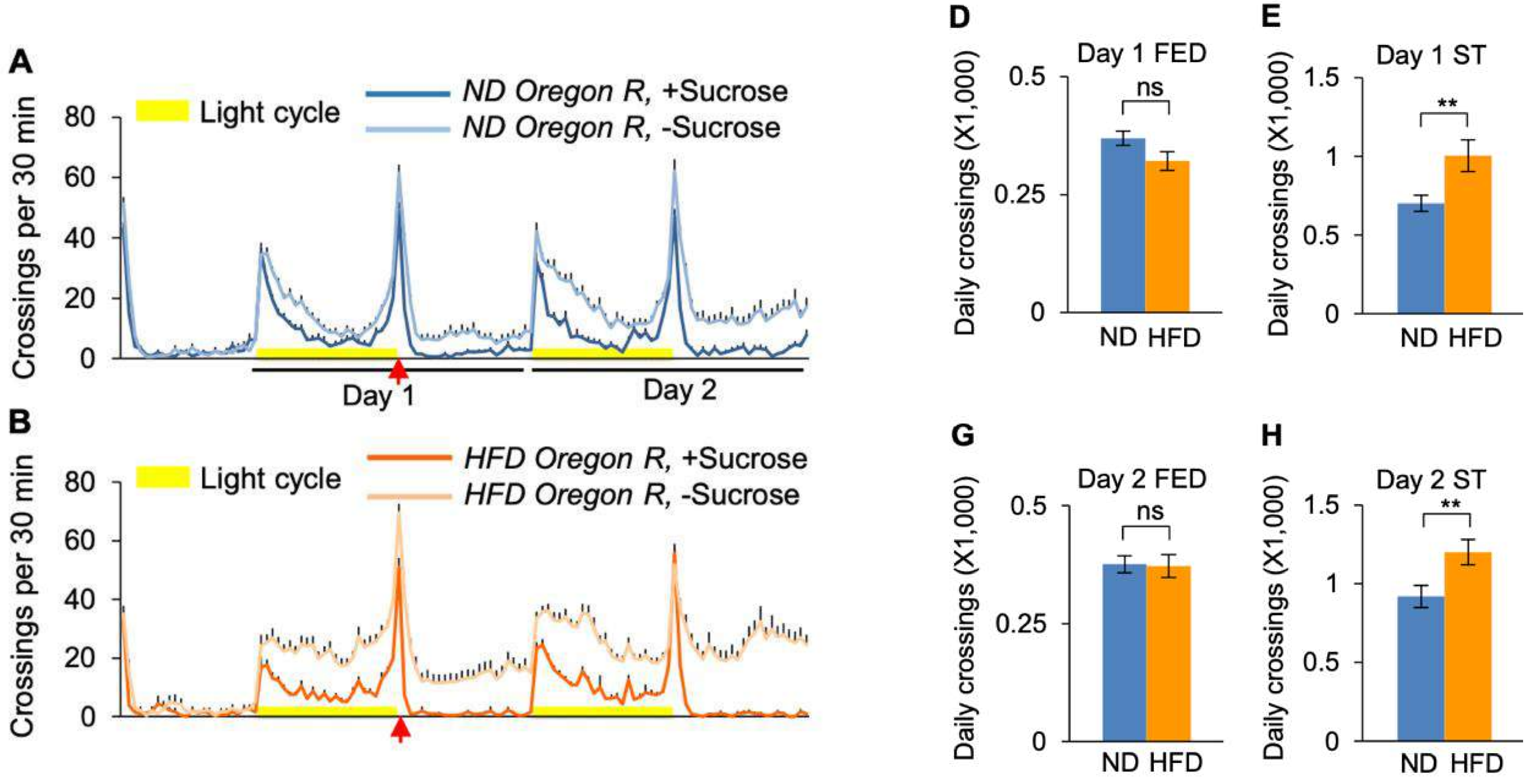


HFD

High-fat diet enhances starvation-induced hyperactivity via sensitizing hunger-sensing neurons in *Drosophila*

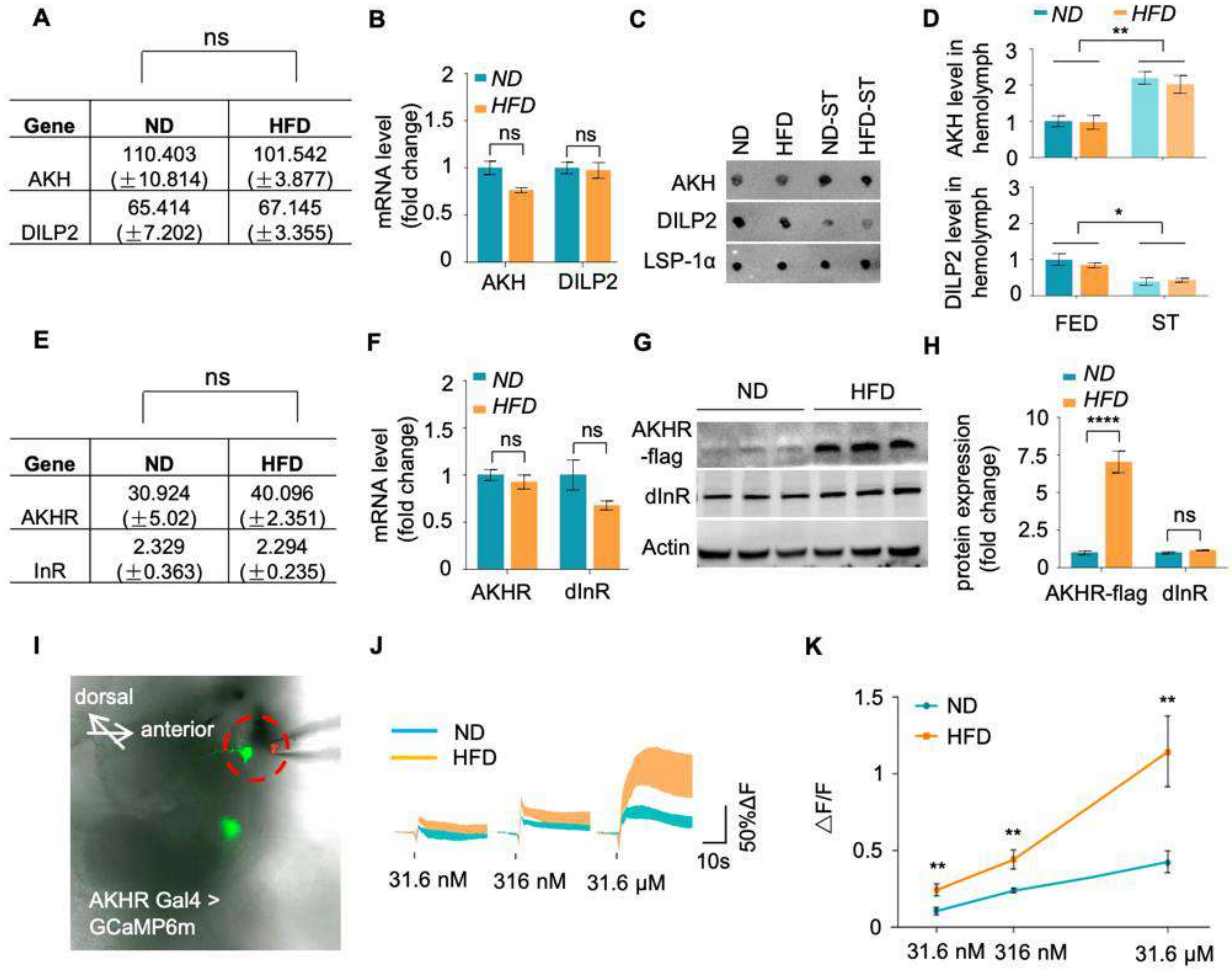
Rui Huang[1,2†*], Tingting Song[2†], Haifeng Su[3†], Zeliang Lai[1,2], Wusa Qin[2], Yinjun Tian[4], Xuan Dong[4], Liming Wang[4*]

HFD promotes starvation-induced hyperactivity in adult Drosophila.



AKHR protein levels were upregulated by HFD feeding.

AKHR^{+}neurons are more sensitive to AKH upon HFD feeding.



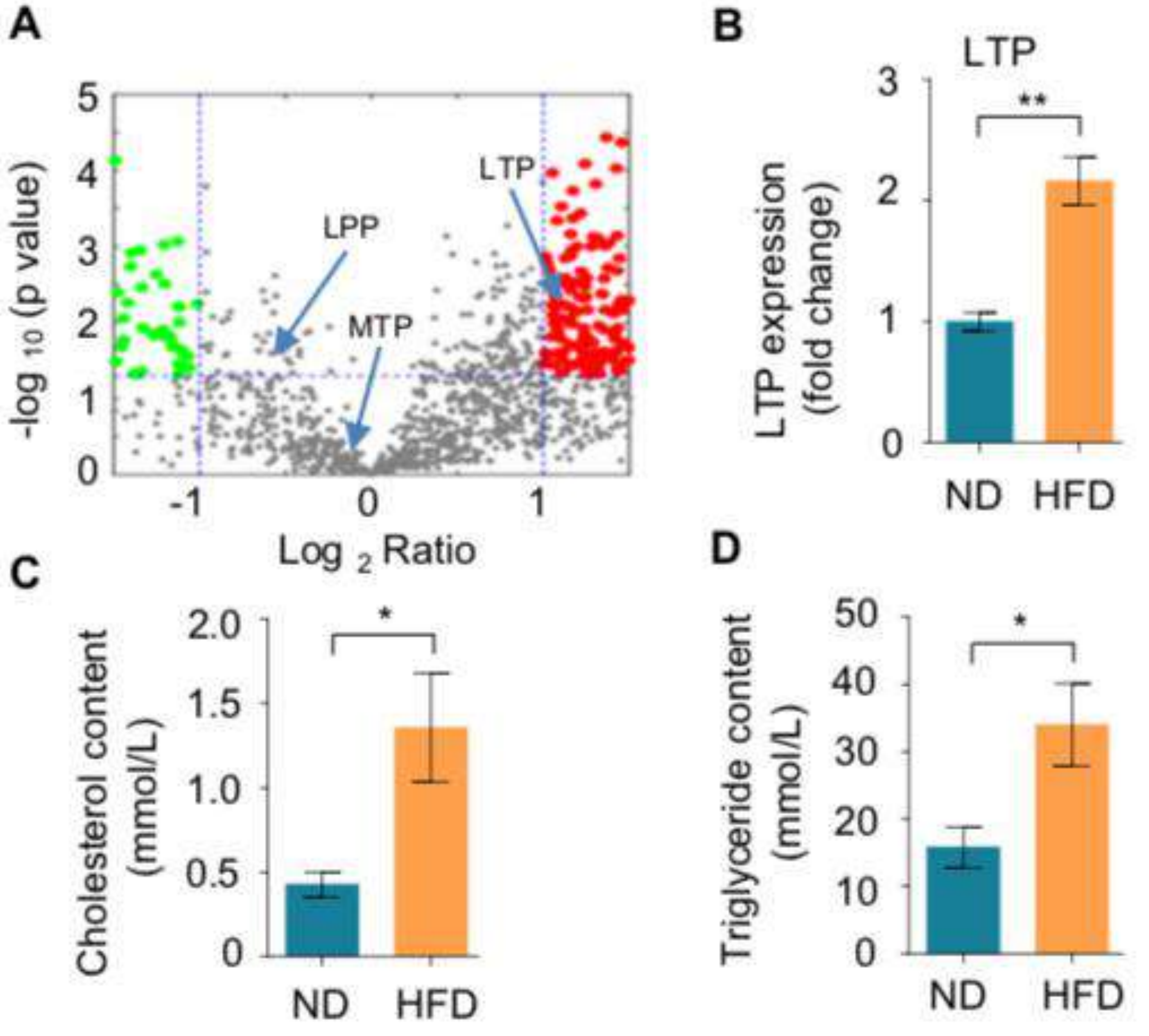
AKHR accumulation is induced by the suppression of autophagy

(lysosome-dependent protein degradation pathw

HFD suppressed autophagy via activating AMPK-TOR signaling

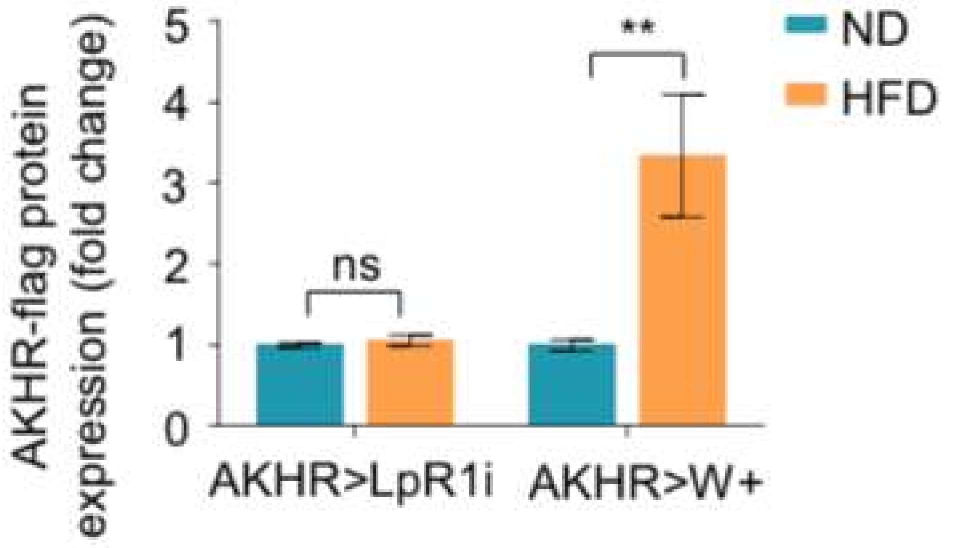
How feeding exert effect on the AKHR+ neurons?

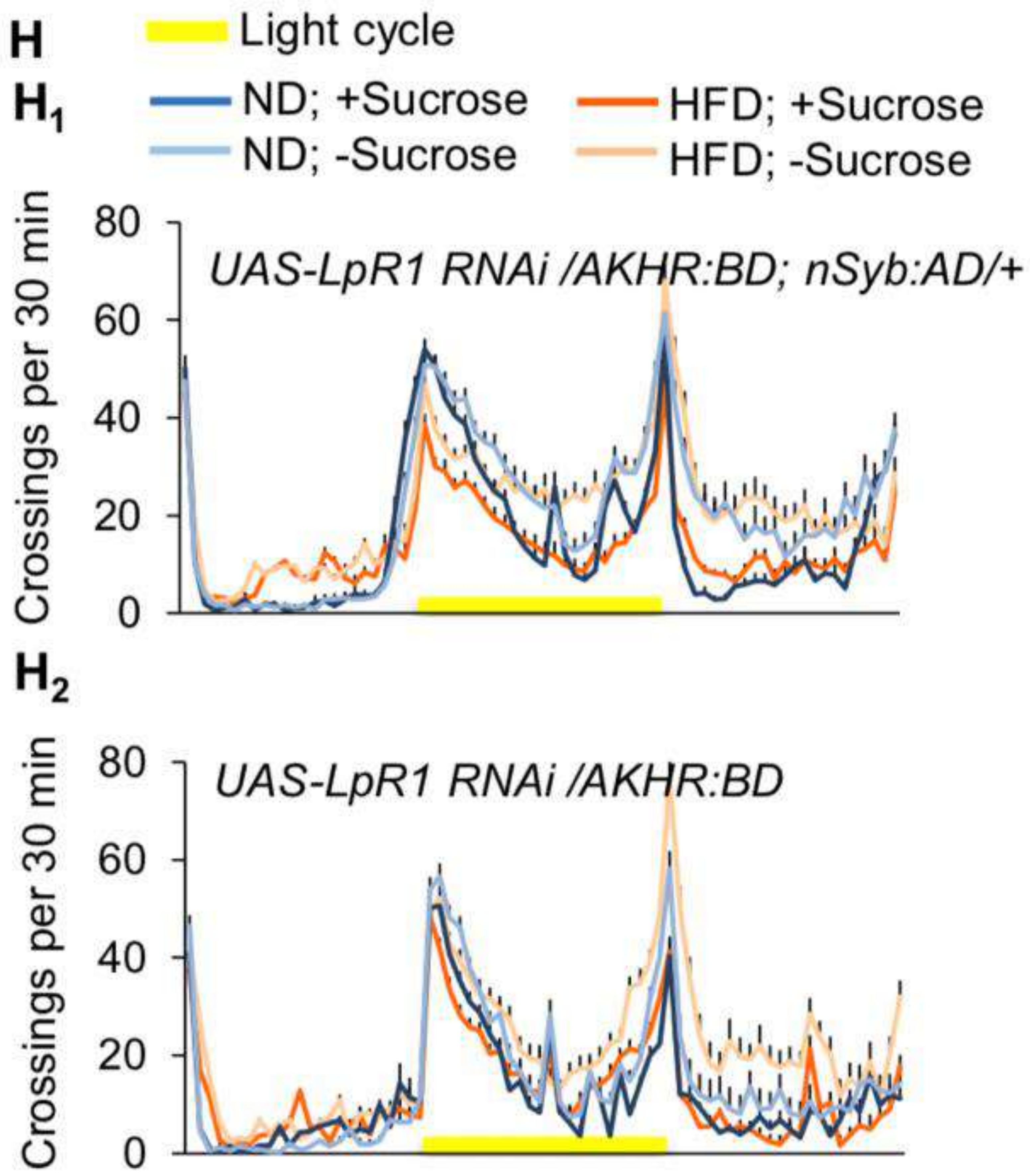
LpR1 is required for HFD-strengthened hyperactivity under starva



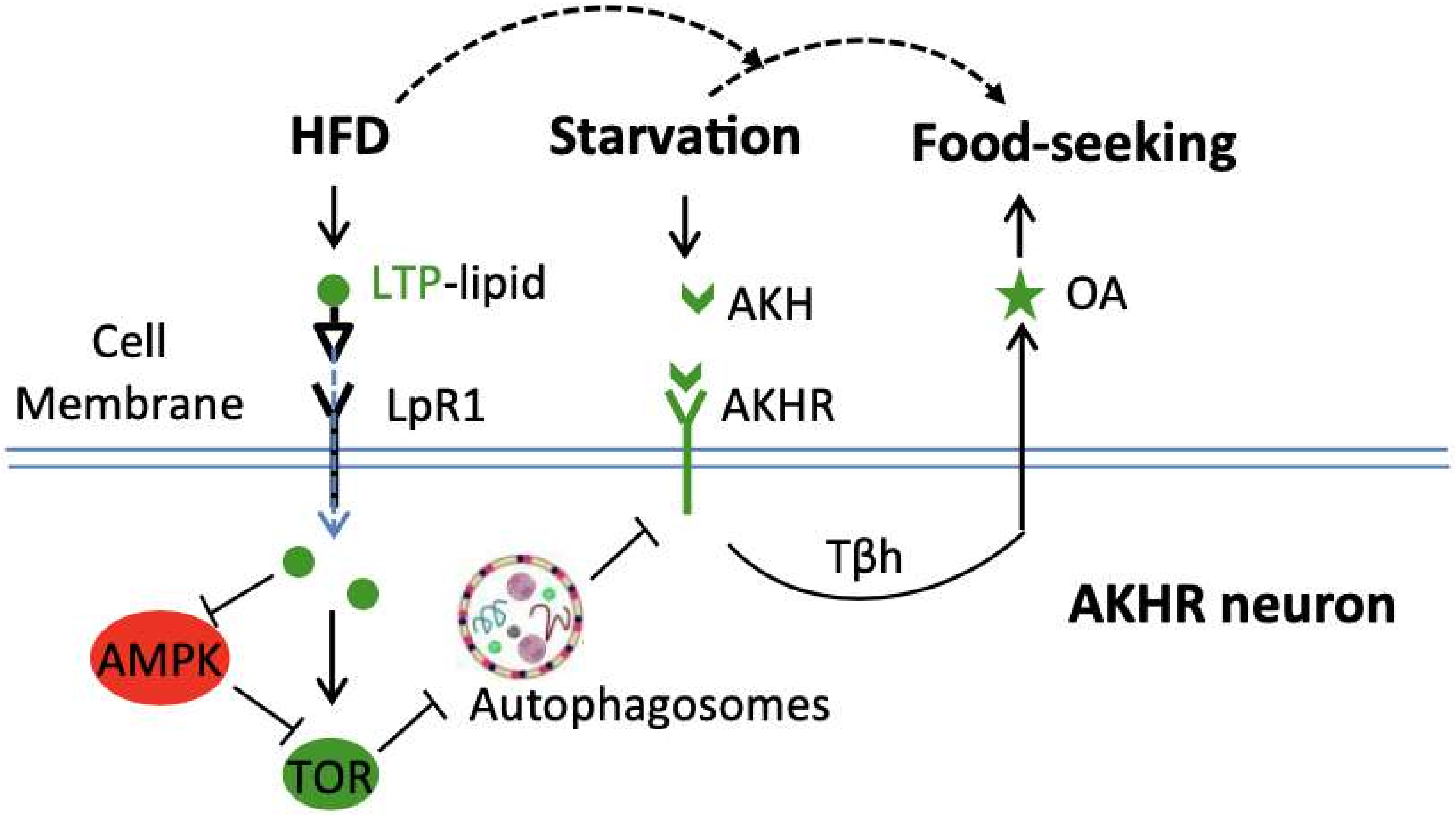
AKHR+ neurons

Gene	FPKM
LpR1	50.338(±14.278)
LpR2	41.753(±27.684)
CG8909	28.405(±22.308)
Megalin	15.185(±8.319)
arr	14.705(±12.975)
LRP1	0.835(±0.793)
AKHR	6.36(±4.16)
yl	0





working model:



HSD

nature > communications biology > articles > article

Article | Open Access | Published: 07 June 2021

Metabolic control of daily locomotor activity mediated by *tachykinin* in *Drosophila*

Sang Hyuk Lee, Eunjoo Cho, Sung-Eun Yoon, Youngjoon Kim & Eun Young Kim

Communications Biology **4**, Article number: 693 (2021) | Cite this article

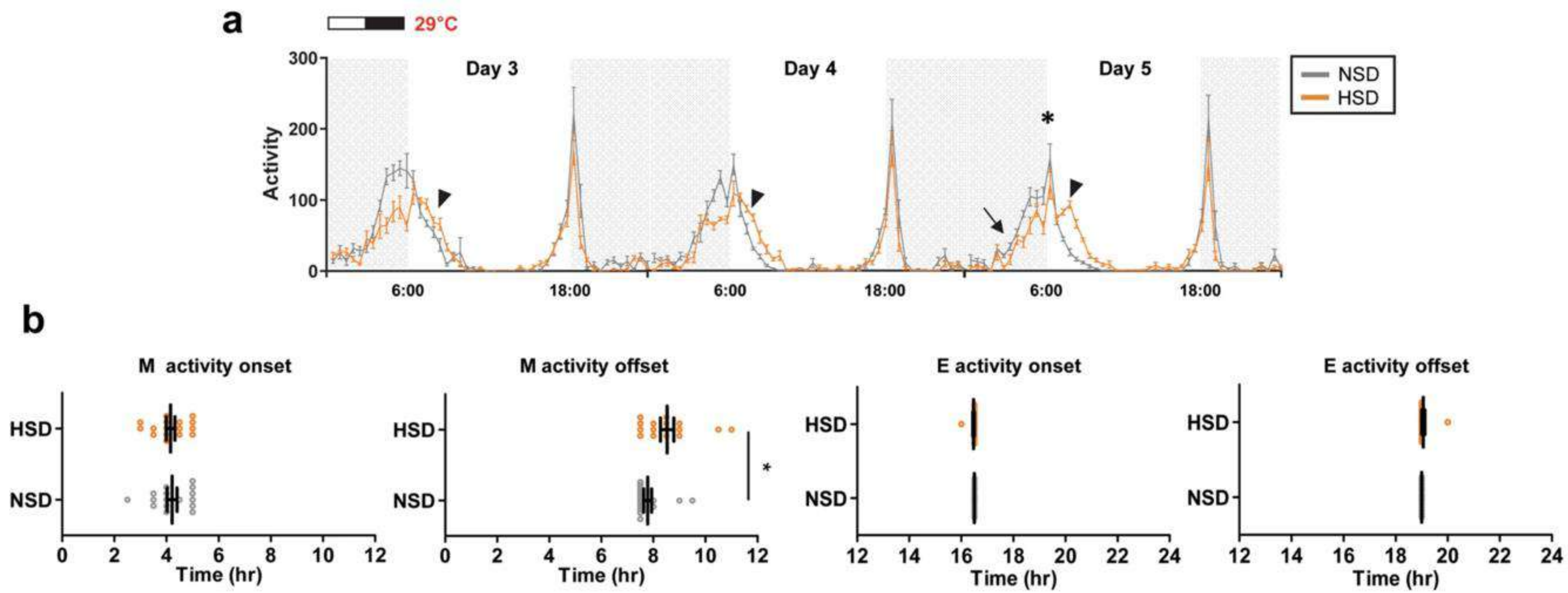
Journal's Impact IF

2021-2022

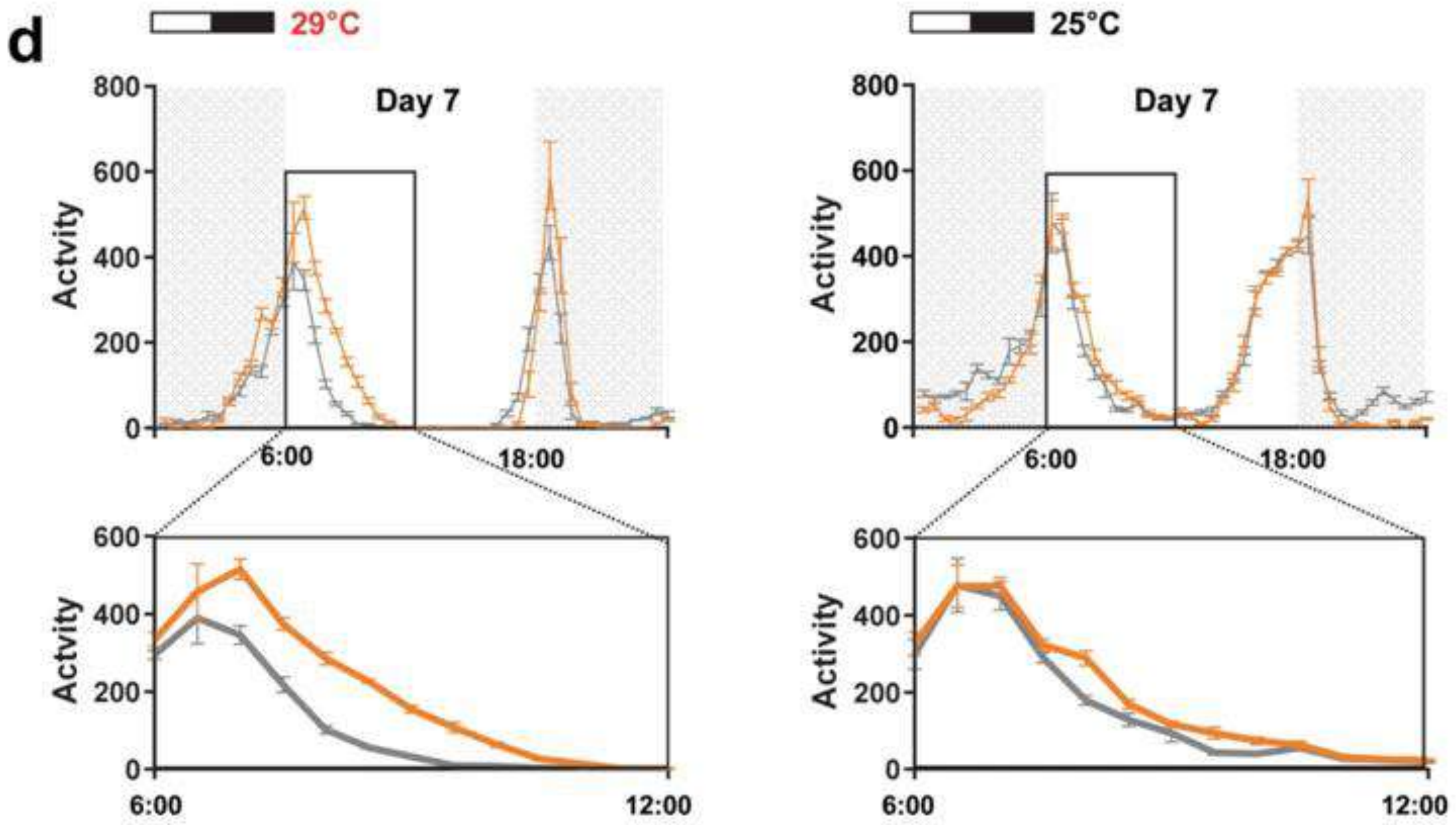
5.489

HSD extended morning activity but not evening activity.

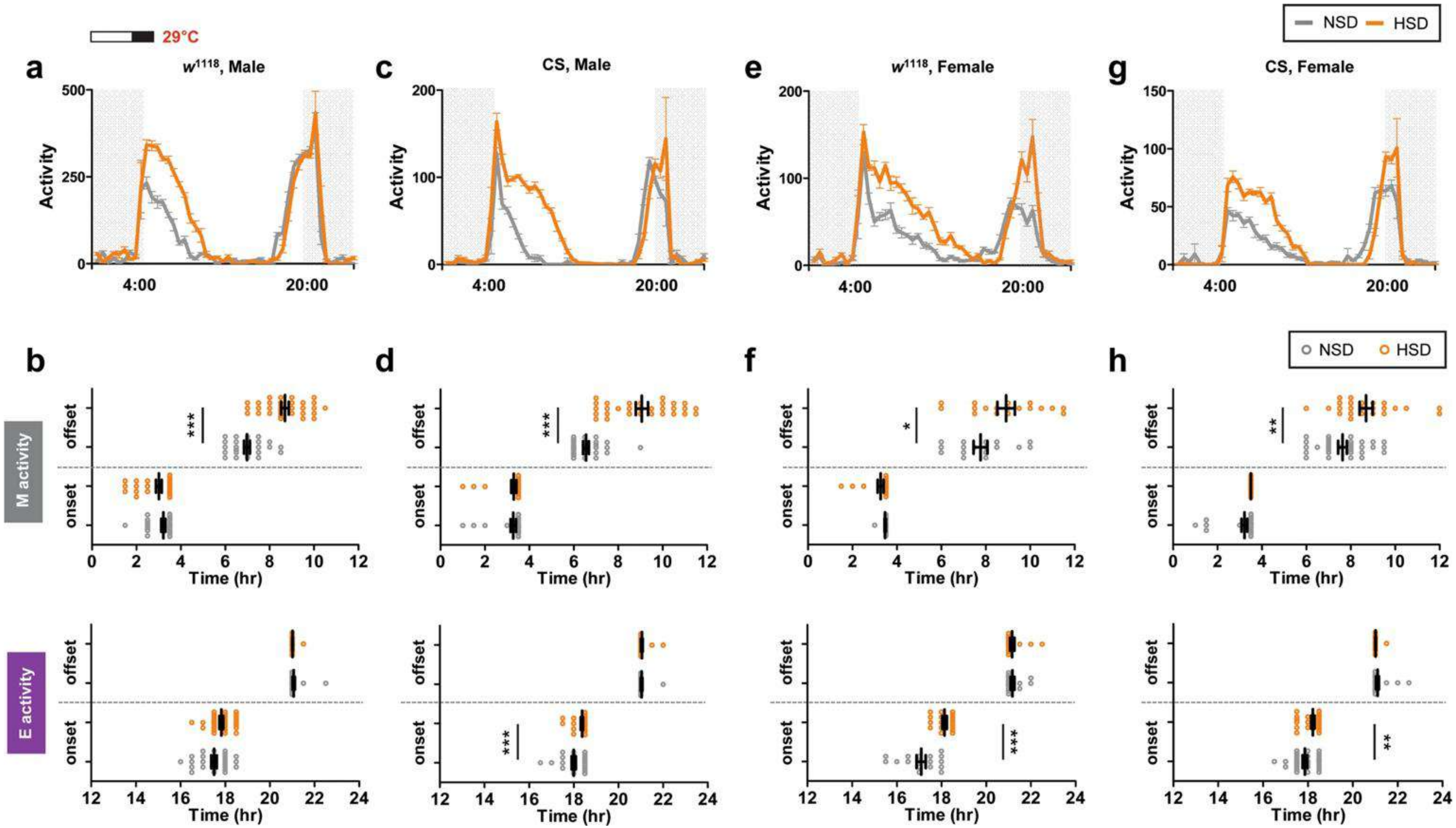
SD, high sucrose di
30% sucrose



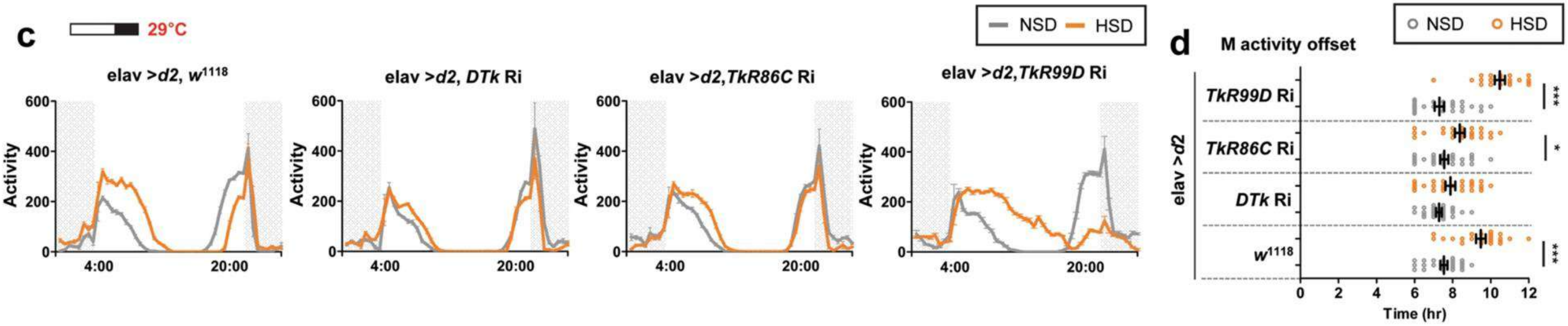
High-temperature augmented this effect.



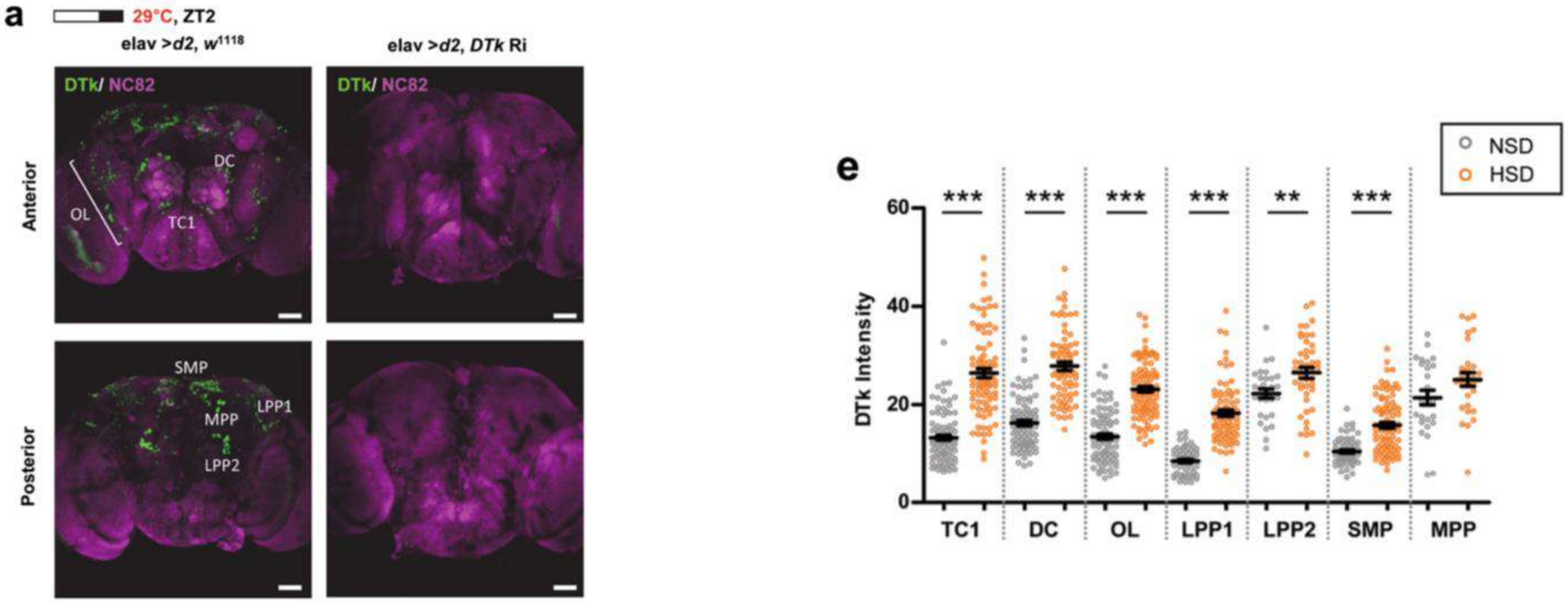
Extended M activity after the startle response was more prominent in the 16L:8D



Neuropeptide DTk and the DTk receptor TkR86C were required for M activity extension in HSD.

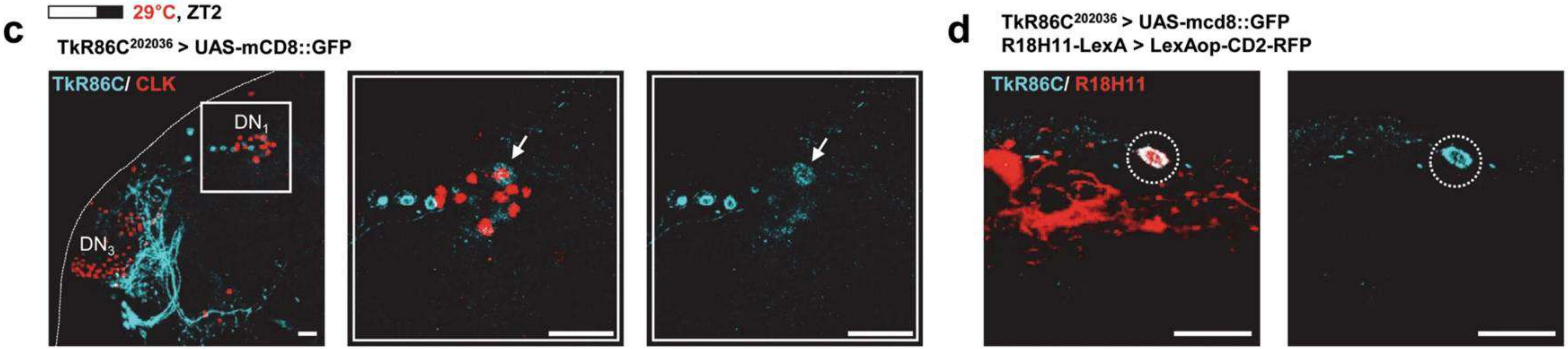


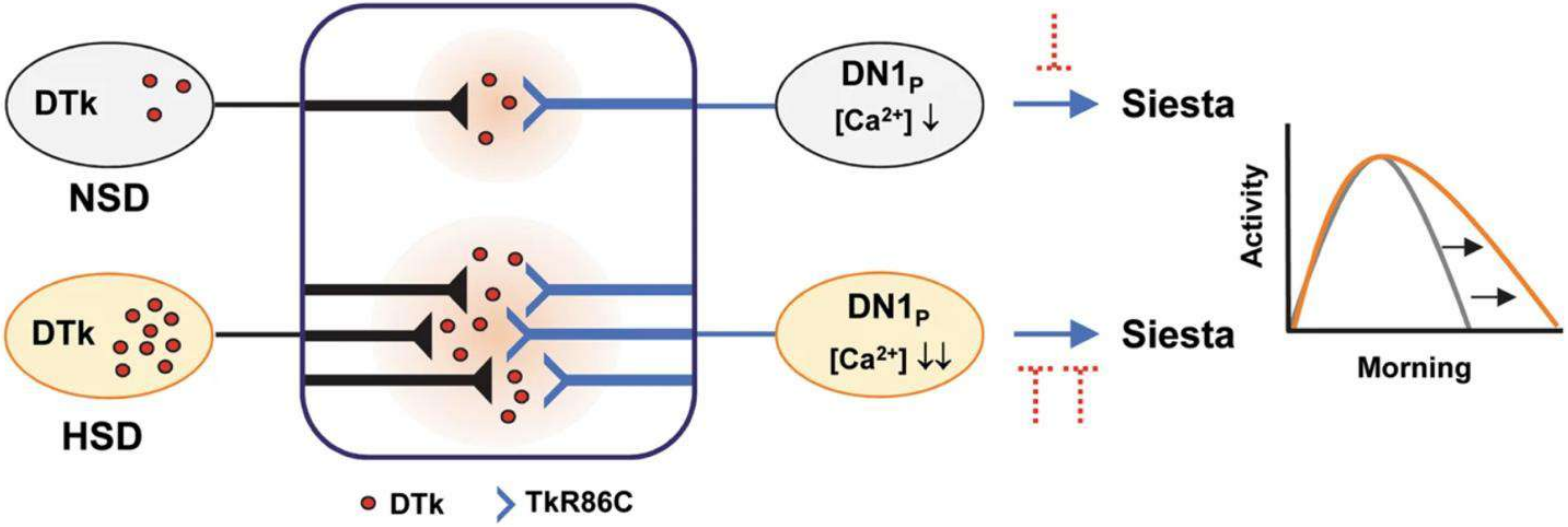
DTk levels were increased in DTk neurons in flies fed a HSD.



DTk neurons and DN1$_P$s were anatomically and functionally connected.

Subsets of $DN1_p$s were TkR86C-positive and were required for M activity extension in HSD.





temperature

PLOS ONE

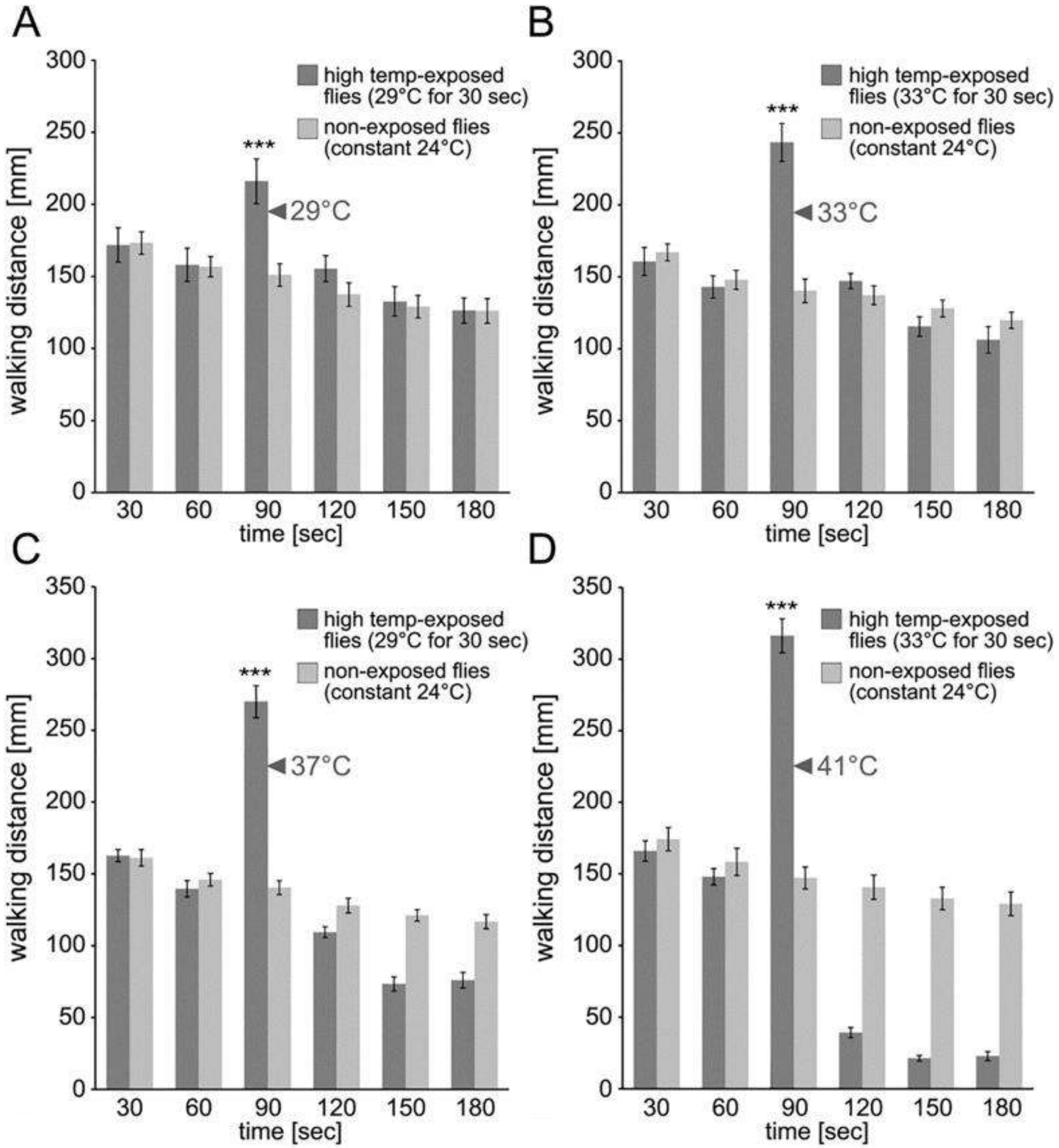
RESEARCH ARTICLE

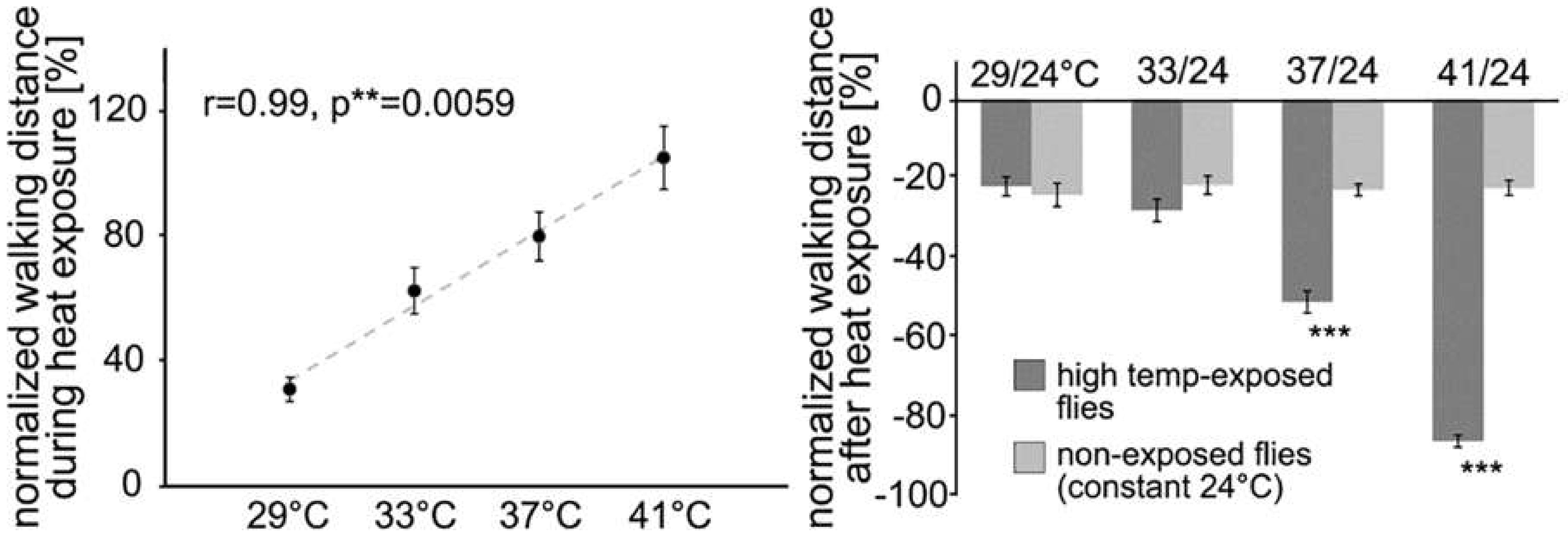
A biphasic locomotor response to acute unsignaled high temperature exposure in *Drosophila*

Daniela Ostrowski[¤a], Autoosa Salari[¤b], Melissa Zars, Troy Zars*

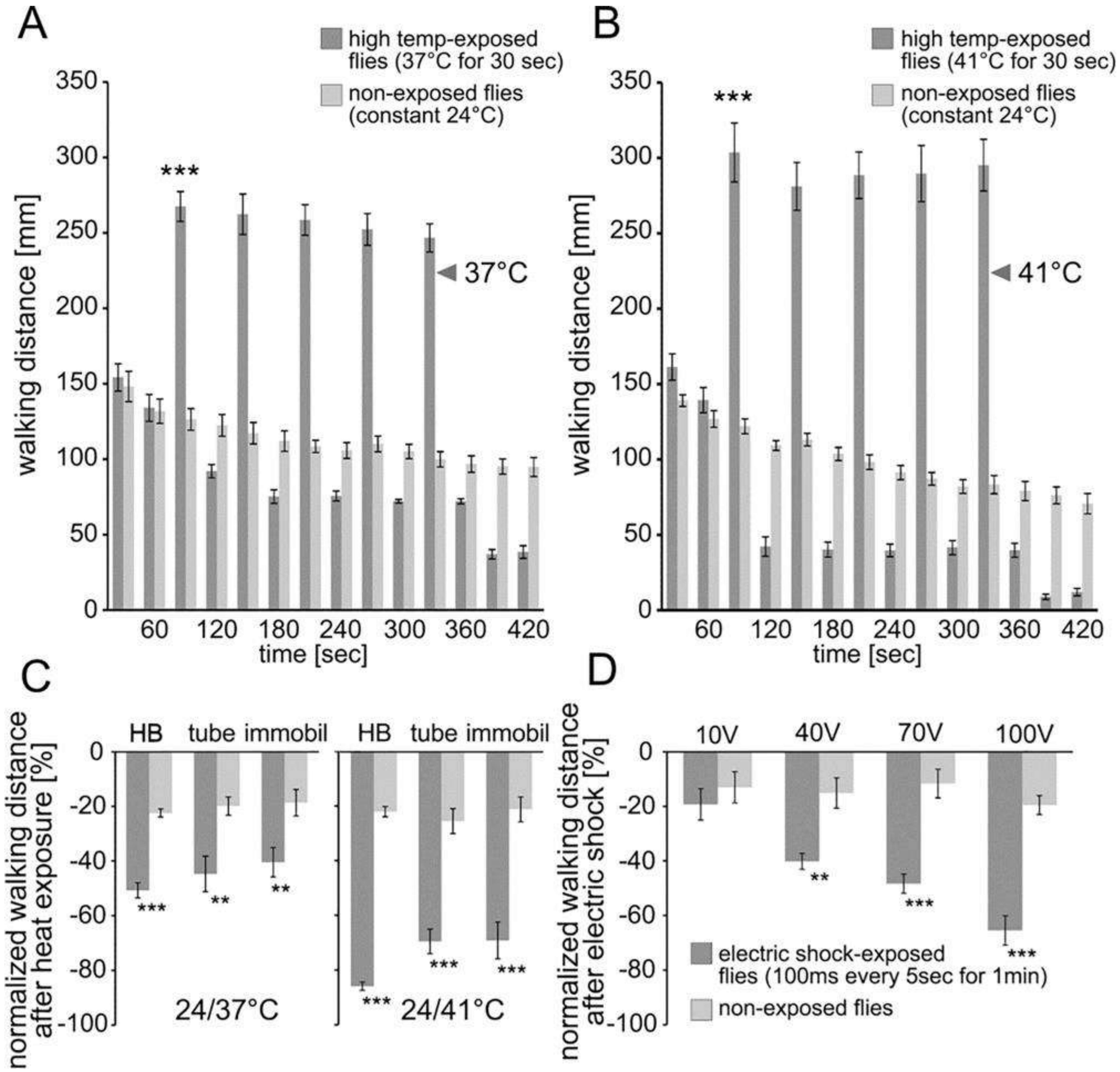
Division of Biological Sciences, University of Missouri, Columbia, Missouri, United States of America

Increase then depression of locomotor activity after high temperature experience.

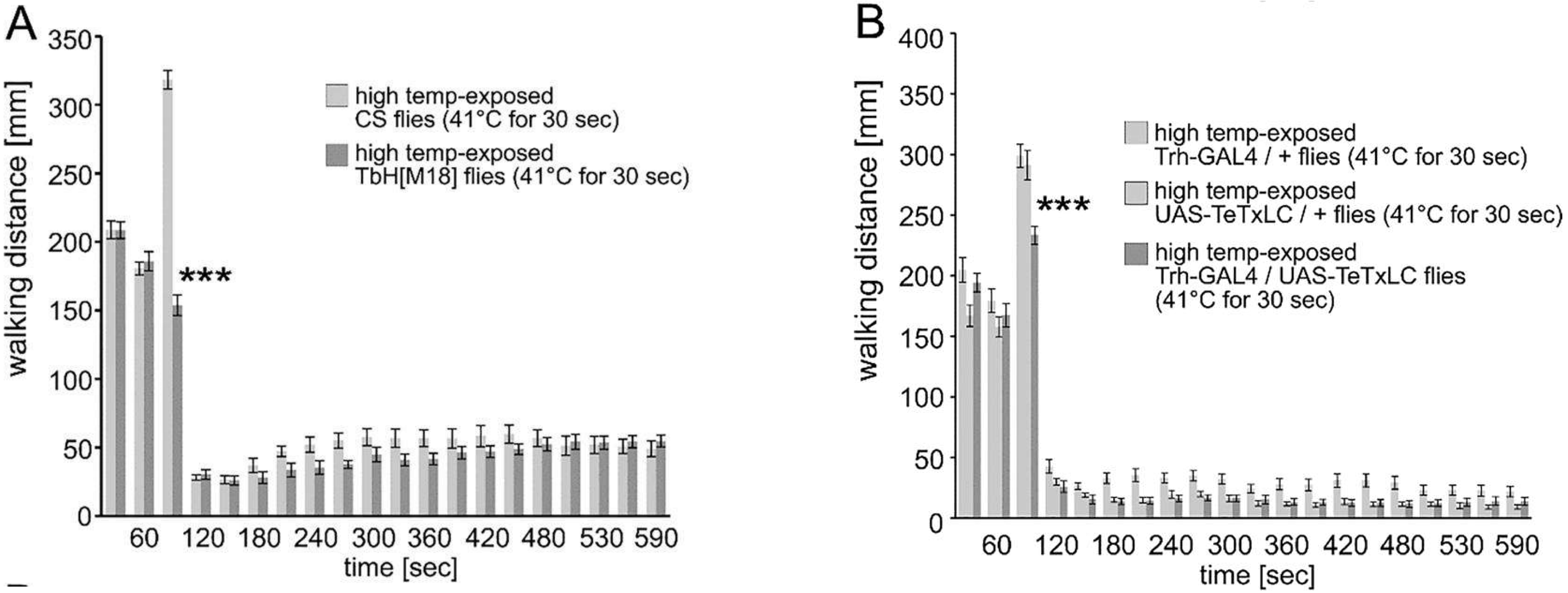




Depressed locomotor activity is not due to fatigue and is a general phenomenon.



The role of octopamine / Tyramine and serotonin in changes of locomotor activity following high temperature exposure.



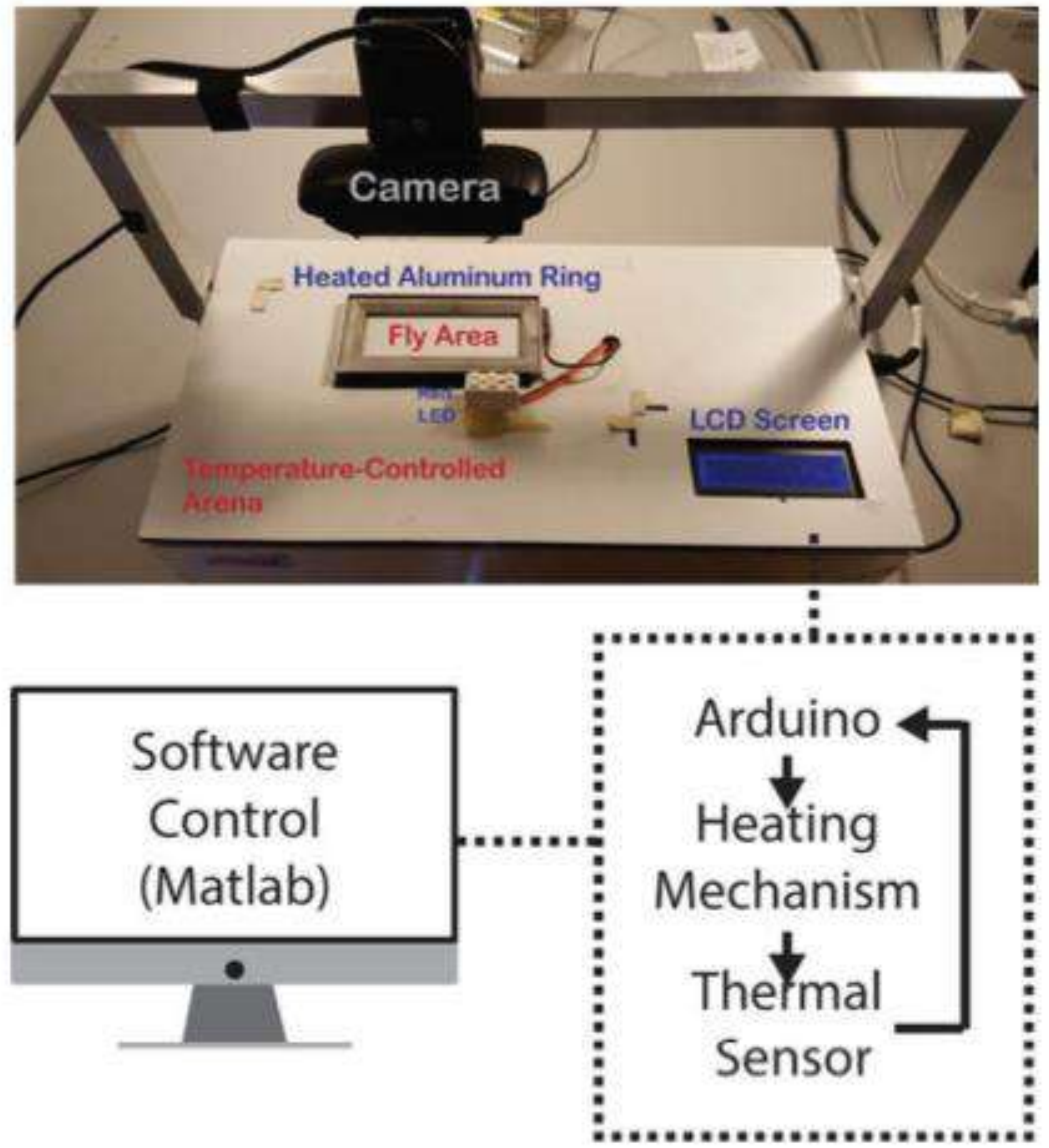
Journal of Experimental Biology

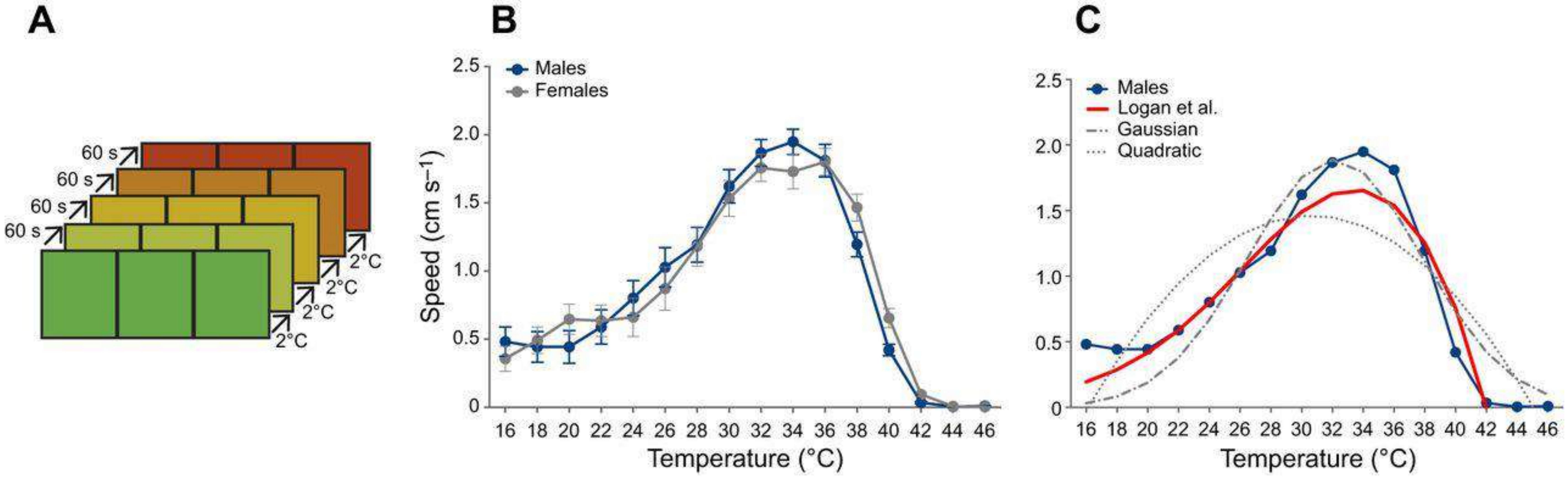
RESEARCH ARTICLE | 22 MAY 2018

Thermosensory perception regulates speed of movement in response to temperature changes in *Drosophila melanogaster* FREE

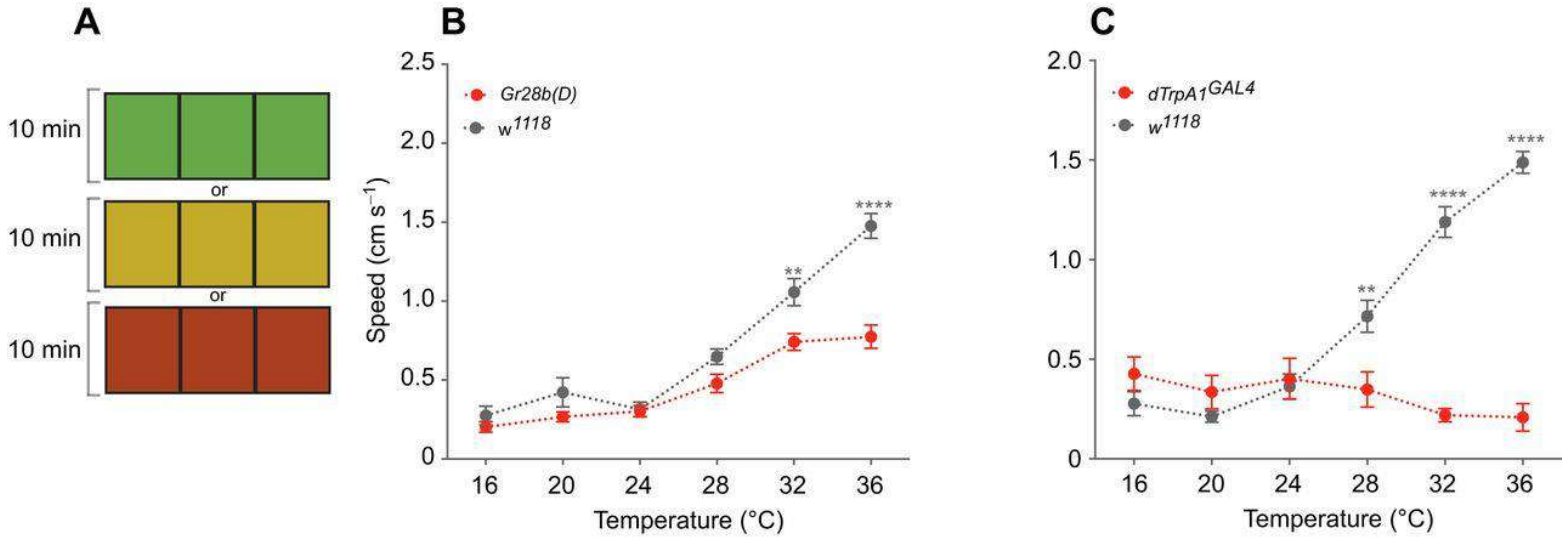
Andrea Soto-Padilla, Rick Ruijsink, Ody C. M. Sibon, Hedderik van Rijn, Jean-Christophe Billeter

Drosophila melanogaster increases speed at increasing temperature following a model based on enzyme-catalyzed temperature performance.





Intact central thermal sensing is necessary for flies to increase speed according to temperature changes.



Gr28b(D) gene, encoding a peripheral thermosensor

Disease model

STRESS
2021, VOL. 24, NO. 1, 96–106
https://doi.org/10.1080/10253890.2020.1759547

Taylor & Francis
Taylor & Francis Group

ORIGINAL RESEARCH REPORT

Check for updates

Stress-mediated hyperactivity and anhedonia resistant to diazepam and fluoxetine in *drosophila*

Ana Belén Ramos-Hryb[a,b]*, Mauro Federico Ramirez[a], Cilene Lino-de-Oliveira[b,c] and Mario Rafael Pagani[a]

[a]Instituto de Fisiología y Biofísica (IFIBIO) Bernardo Houssay, Grupo de Neurociencia de Sistemas, Universidad de Buenos Aires, CONICET, Buenos Aires, Argentina; [b]Postgraduation Program in Pharmacology, CCB, Federal University of Santa Catarina, Florianópolis, Brazil; [c]Department of Physiological Sciences, CCB, Federal University of Santa Catarina, Florianópolis, Brazil

Stress

The International Journal on the Biology of Stress

Journal's Impact IF

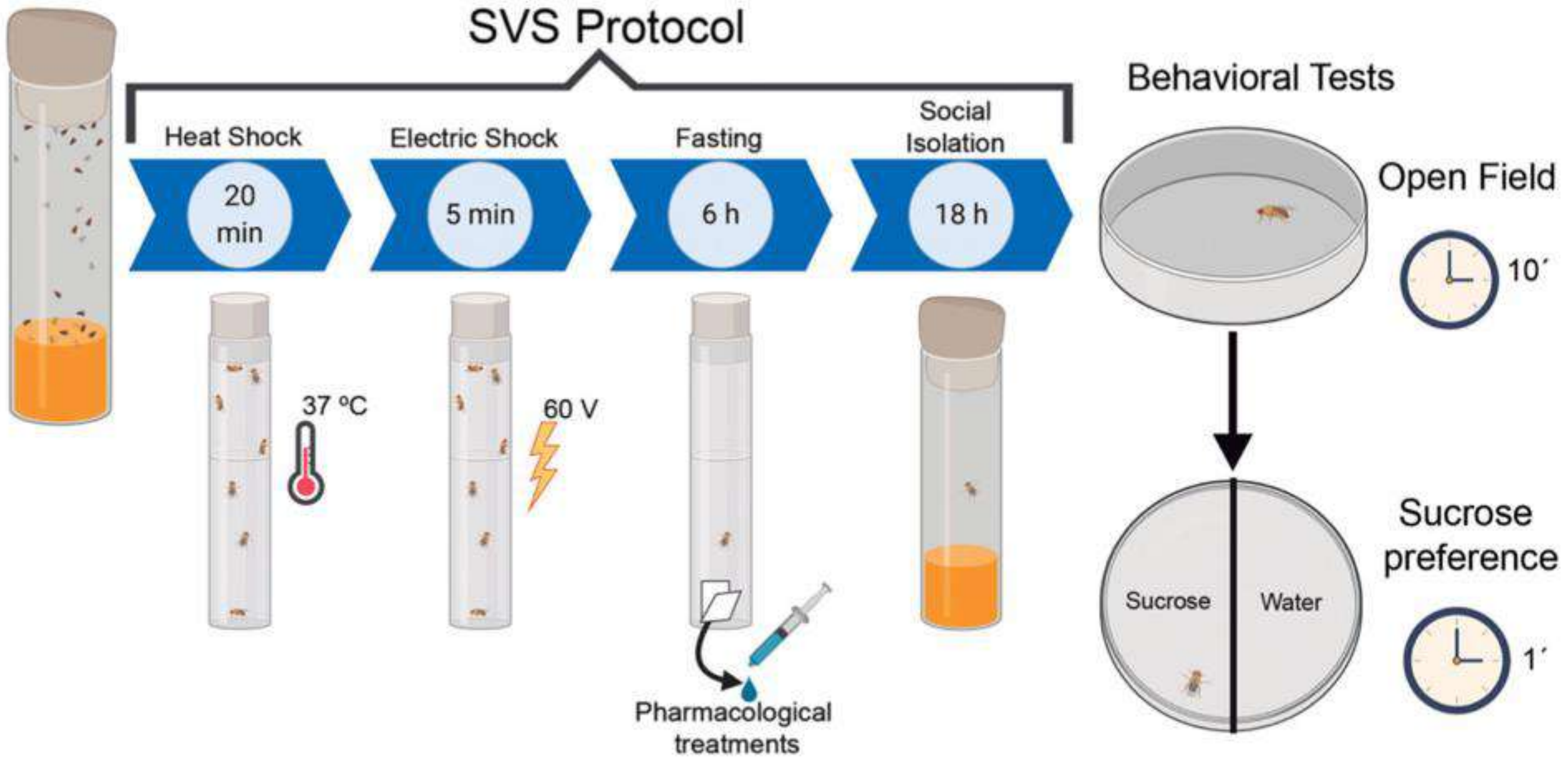
2021-2022

3.493

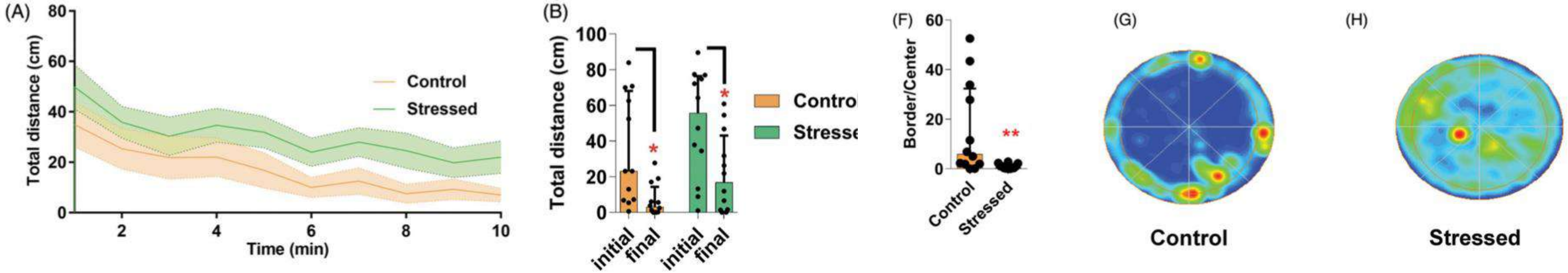
12.6%

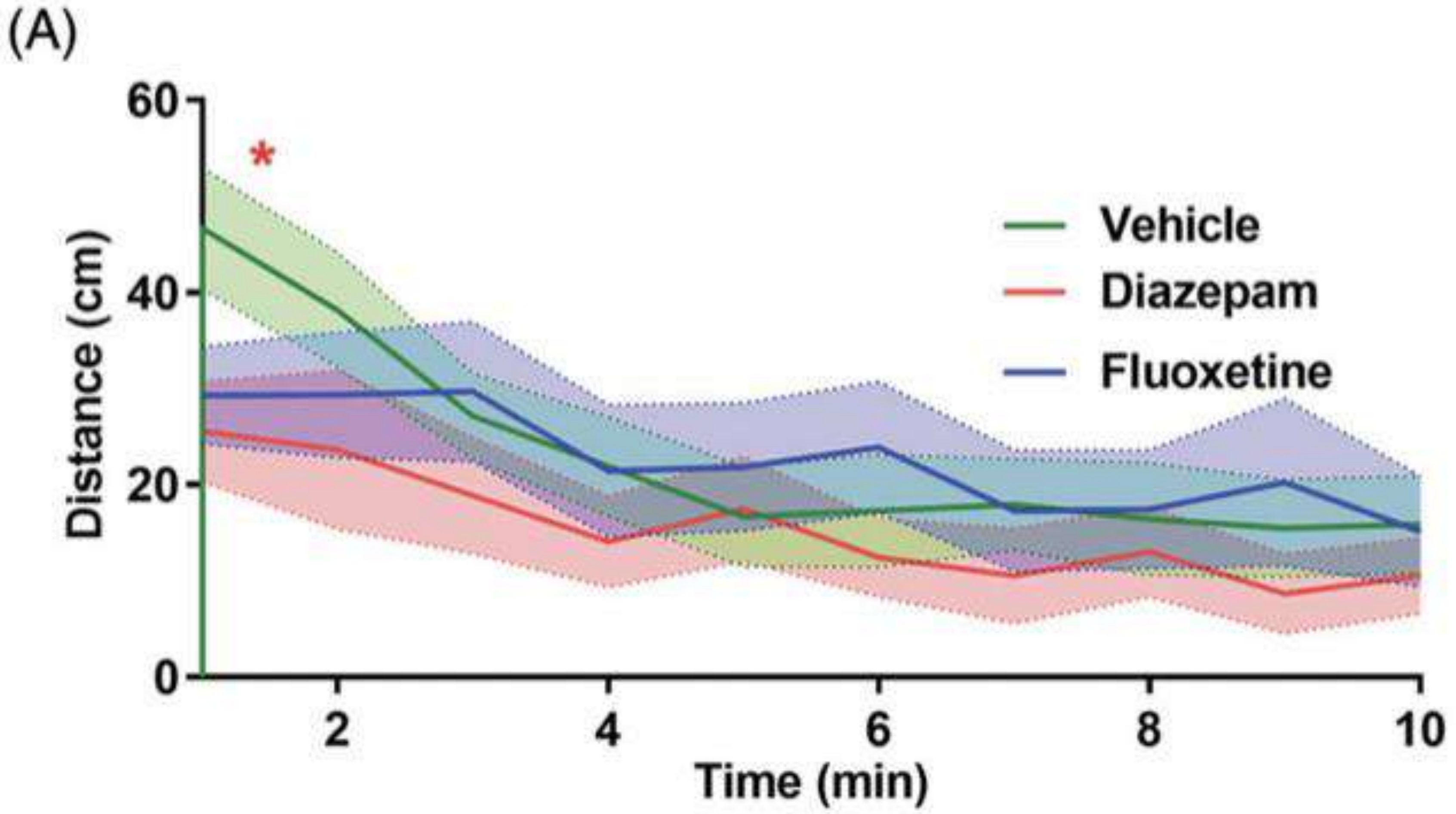
provoke stress-induced phenotypes in Drosophila

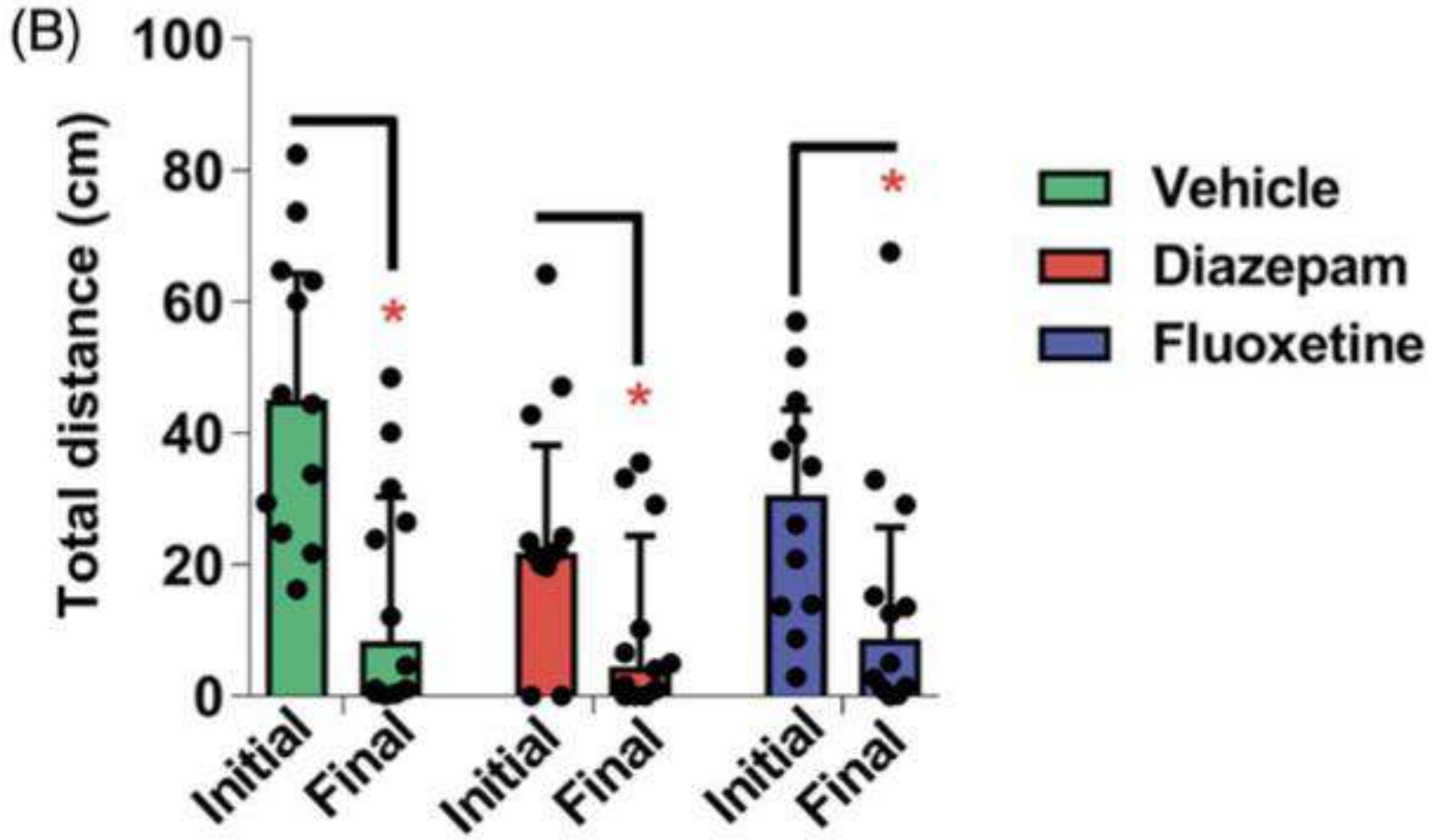
short-term variable stress

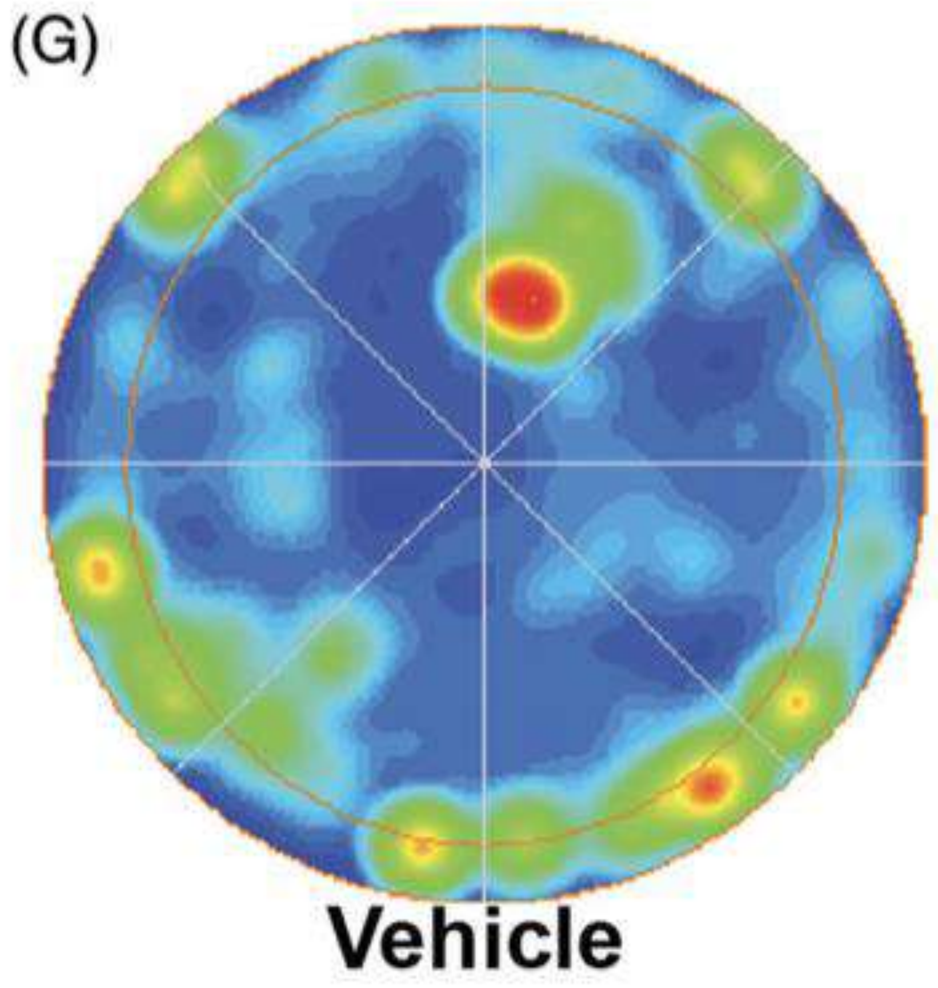


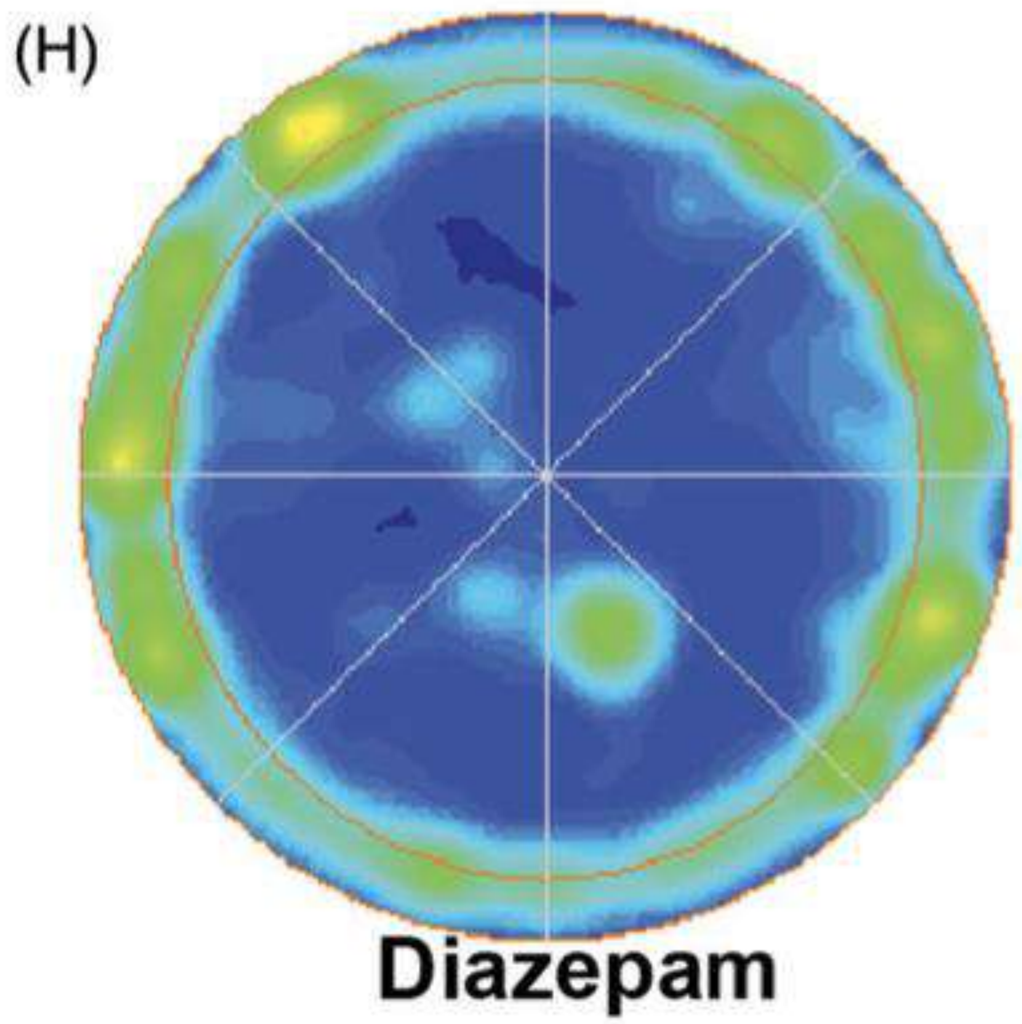
SVS protocol induces hyperlocomotion and centrophilia in adult flies.

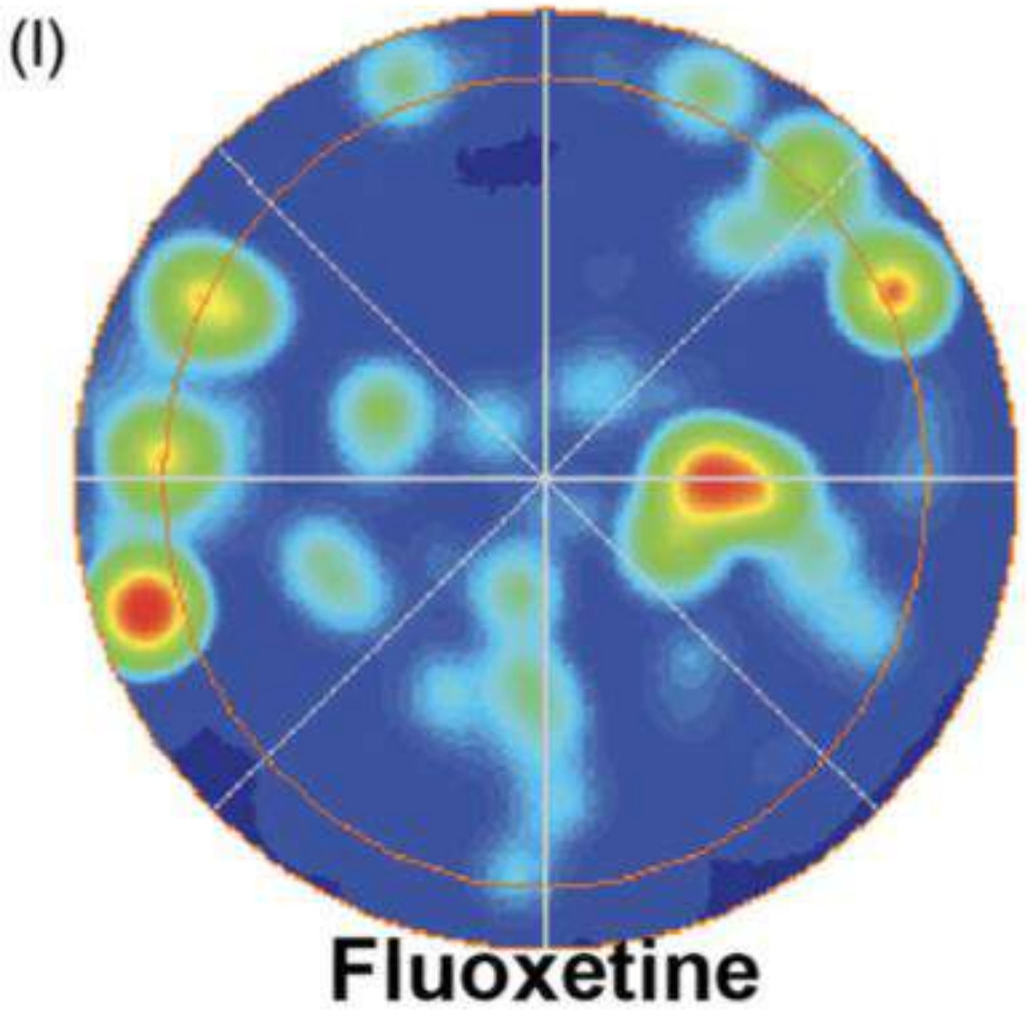






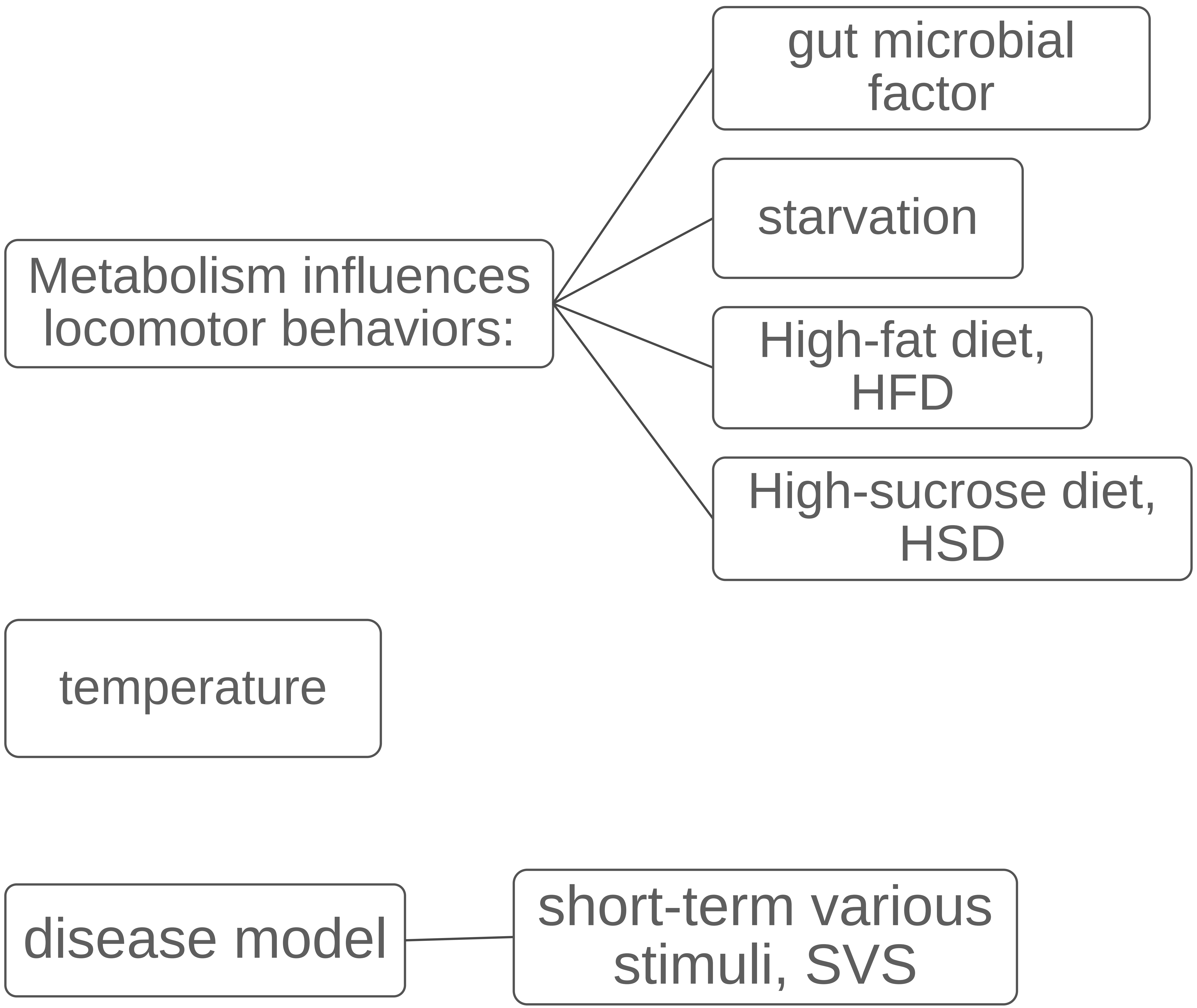






地西泮（安定）

氟西汀（百忧解）

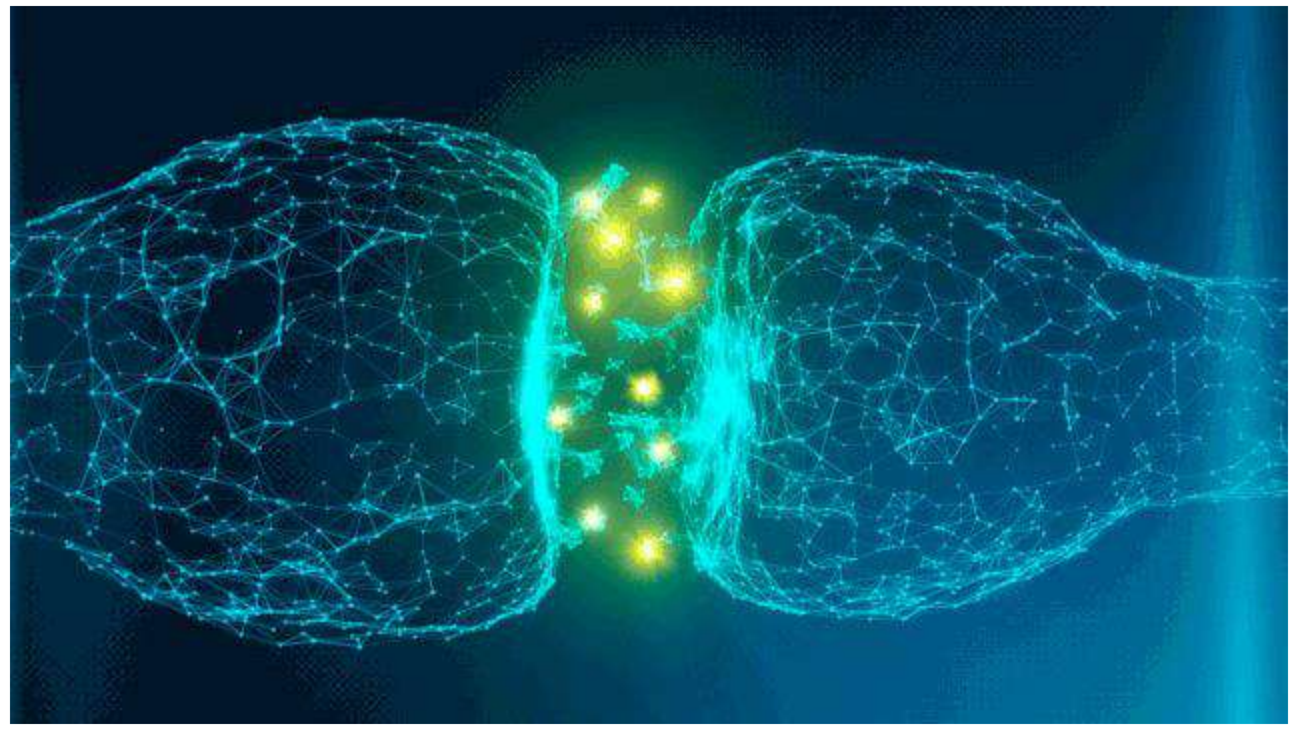

Metabolism influences locomotor behaviors:
gut microbial factor
starvation
High-fat diet, HFD
High-sucrose diet, HSD
temperature
disease model
short-term various stimuli, SVS

The Locomotion Transmitters

The locomotion neurotransmitters of *Drosophila melanogaster*

李小龙 2022-2-24

Neurotransmitter



- What is transmitter?

神经递质（neurotransmitter）是神经元之间或神经元与效应器细胞之间传递信息的化学物质。

Neurotransmitter

Classification：胆碱类、单胺类、氨基酸类和神经肽类等。

Function：

Development,growth, feeding, metabolism, reproduction, homeostasis, and longevity, as well as neuromodulation in learning and memory, olfaction and locomotor control.

The locomotion neurotransmitters of *Drosophila melanogaster*

The locomotion neurotransmitters of *Drosophila melanogaster*

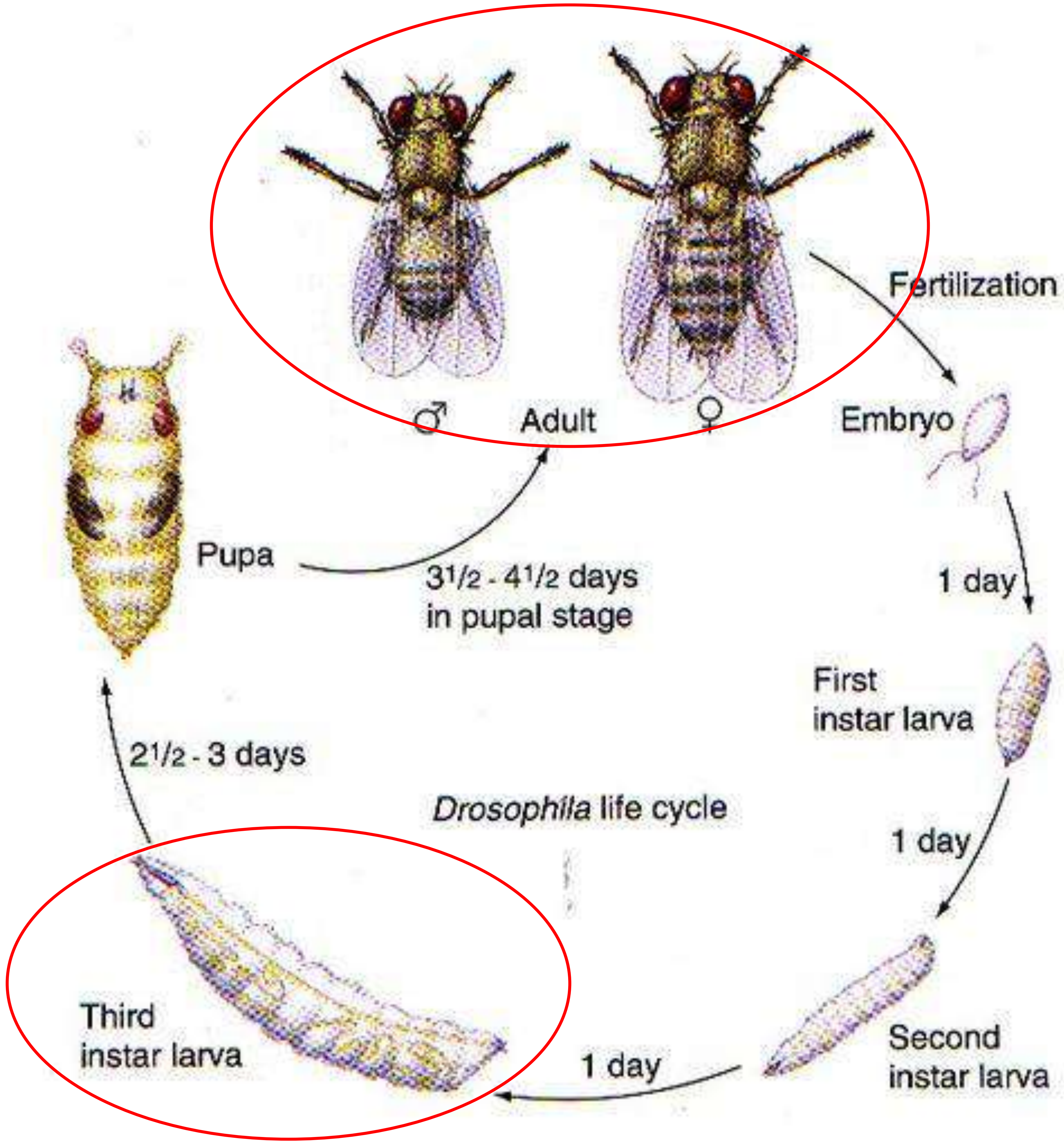
How many **neurotransmitters** are there in Drosophila?

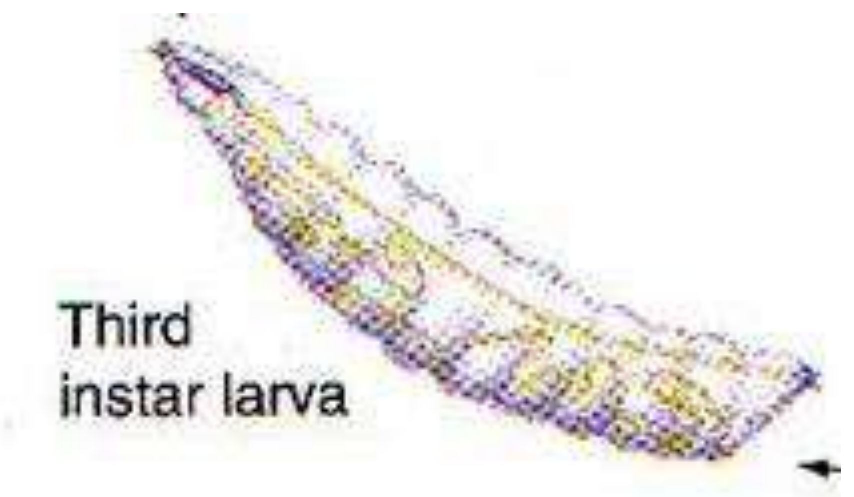
Table 1
Neuropeptides and peptide hormones identified in *Drosophila melanogaster*.

Neuropeptide name[a]	Acronym
Adipokinetic hormone	AKH
Allatostatin A (AstA)	AstA-1 AstA-2 AstA-3 AstA-4
Allatostatin B (AstB; MIP)	MIP-1 MIP-2 MIP-3 MIP-4 MIP-5
Allatostatin C (AstC)	AstC
Bursicon (Burs α)	BURS
Partner of bursicon (Burs β)	PBURS
CAPA-PVK/PK	CAPA-PVK-1 CAPA-PVK-2 CAPA-PK CPPB
CCAP	CCAP
CCHamide	CCH1 CCH2
Corazonin	CRZ
Diuretic hormone 44	DH44
Diuretic hormone 31	DH31
dFMRFamides	dFMRFa-1 dFMRFa-2 dFMRFa-3 dFMRFa-4 dFMRFa-5 dFMRFa-6 dFMRFa-7 dFMRFa-8
Drosulfakinins	DSK-0 DSK-1 DSK-2
Dromyosuppressin	DMS
Ecdysis-triggering hormone	ETH-1 ETH-2
Eclosion hormone	EH
Hugin-pyrokinin	hug-PK hug-γ
Ion transport peptide	DrmITP DrmITPL1 DrmITPL2
Leucokinin	LK
Neuropeptide F	NPF
Neuropeptide F (short NPF)	sNPF-1 sNPF-1$^{4-11}$ sNPF-2 sNPF-2$^{12-19}$ sNPF-3 sNPF-4
NPLP1	MTYamide IPNamide APK VQQ
NPLP2	NEF
NPLP3	SHA VVIamide
NPLP4	YSY
Pigment-dispersing factor	PDF
Proctolin	
Prothoracicotropic hormone	PTTH
Sex peptide[e]	SP
SIFamide	SIFa
Tachykinin-related	DTK-1 DTK-2 DTK-3 DTK-4 DTK-5 DTK-6

Dick R. Nassel, et al., 2010, Prog Neurobiol

Drosophila life cycle





> J Comp Neurol. 2012 Nov 1;520(16):3764-85. doi: 10.1002/cne.23152.

The role of octopamine and tyramine in Drosophila larval locomotion

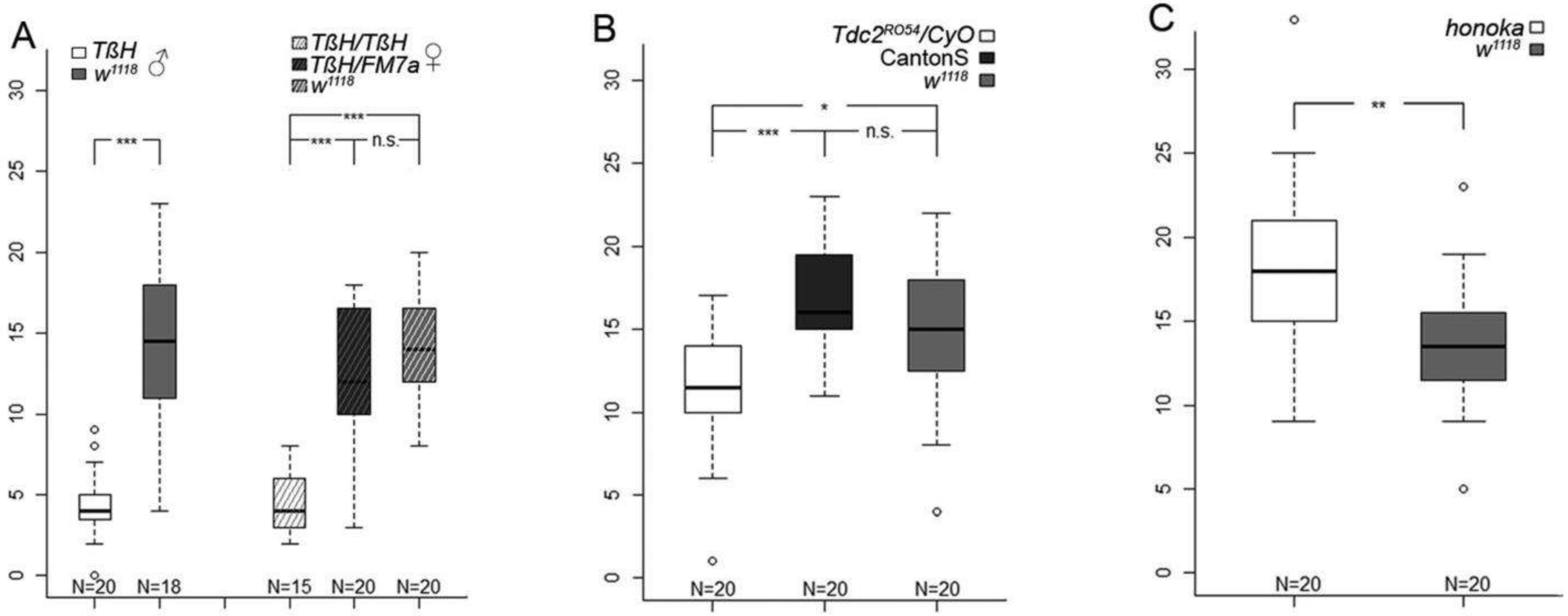
Mareike Selcho [1], Dennis Pauls, Basil El Jundi, Reinhard F Stocker, Andreas S Thum

Affiliations + expand

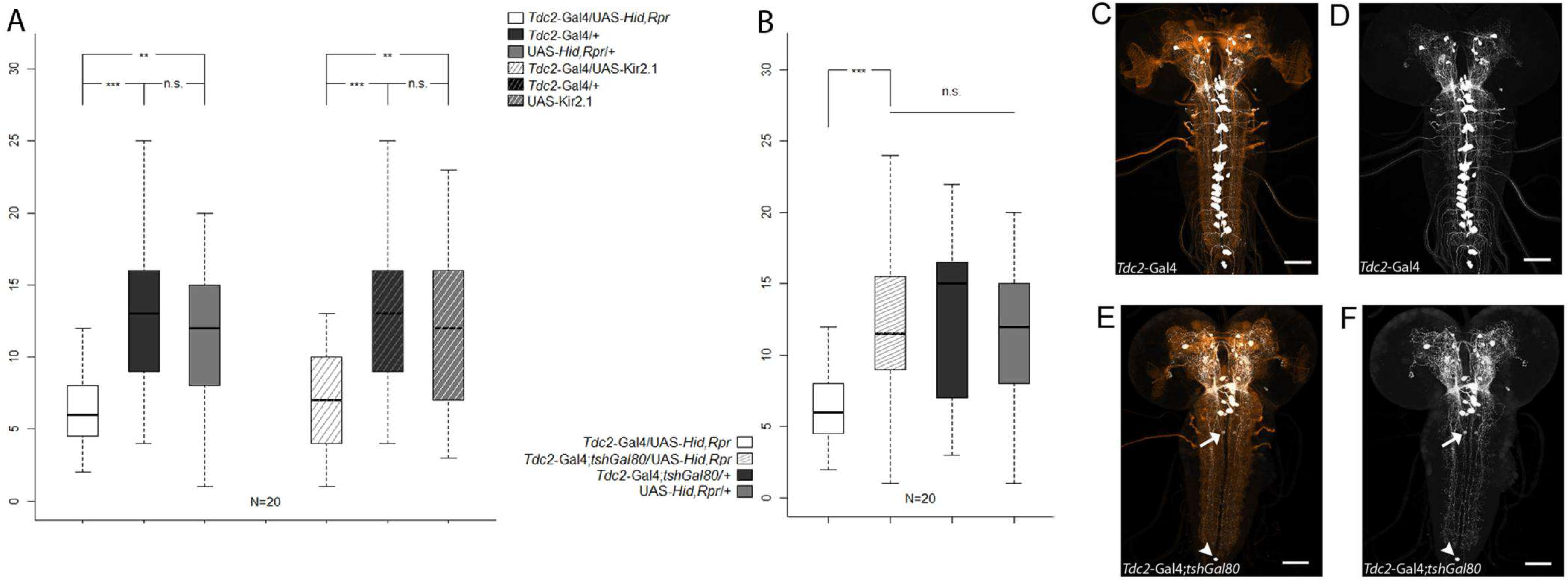
PMID: 22627970 DOI: 10.1002/cne.23152

The role of octopamine and tyramine in *Drosophila* larval locomotion

Tyramine is a biosynthetic precursor of octopamine



Octopaminergic/tyraminergic neurons within the ventral nerve cord are necessary for larval locomotion

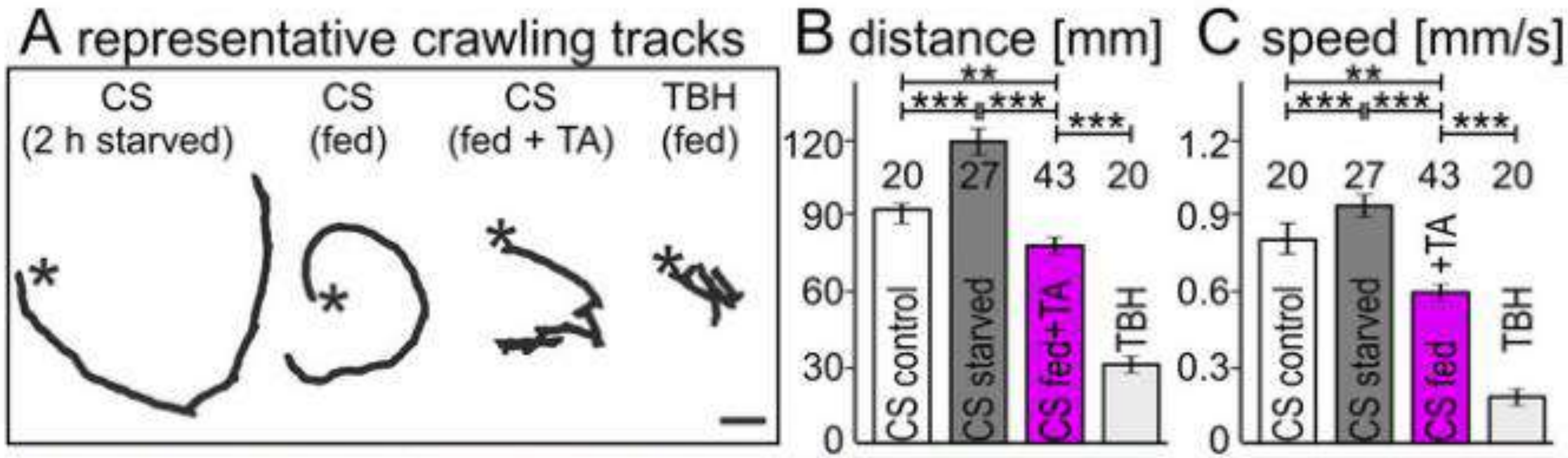


› Proc Natl Acad Sci U S A. 2019 Feb 26;116(9):3805-3810. doi: 10.1073/pnas.1813554116. Epub 2019 Feb 11.

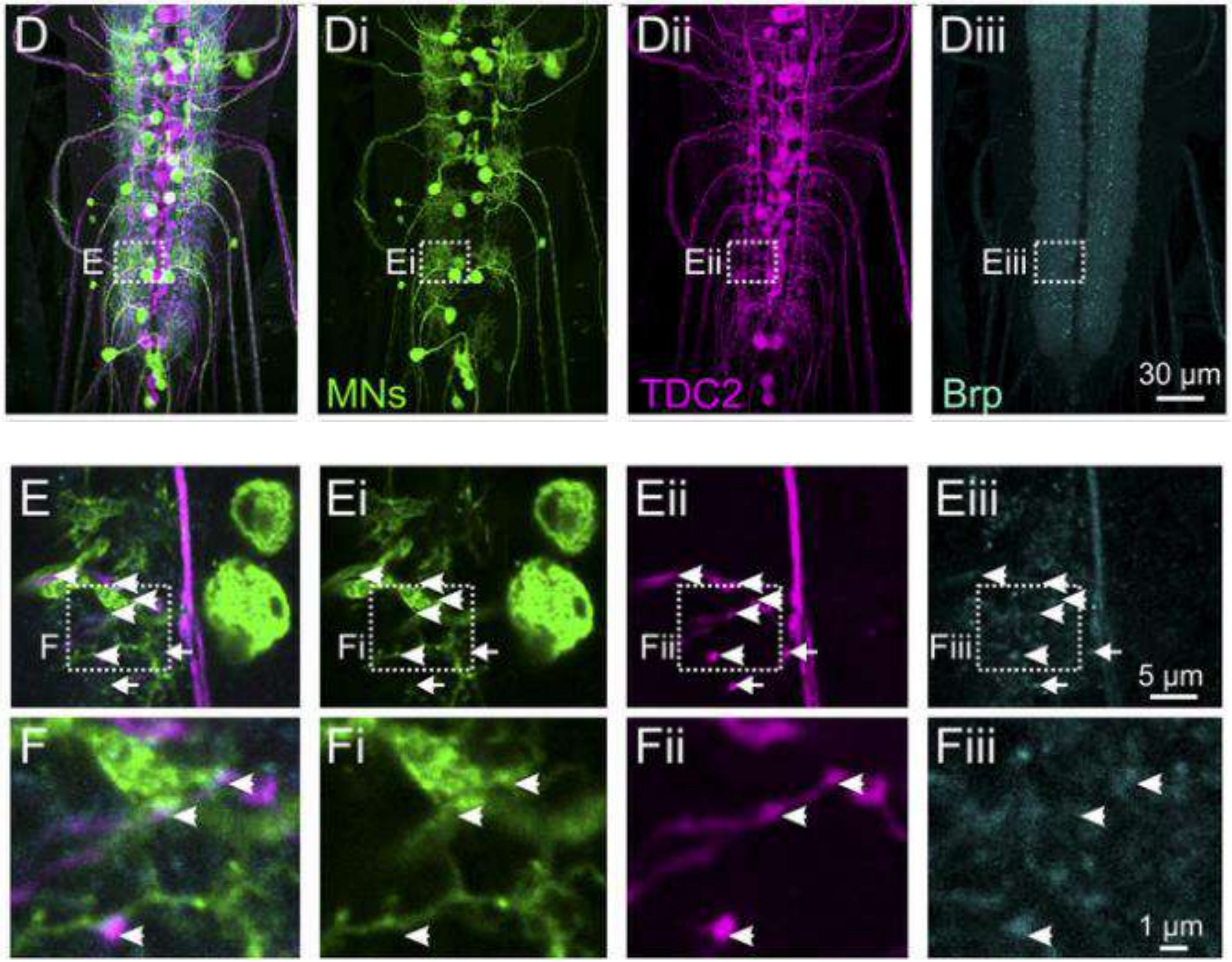
Tyramine action on motoneuron excitability and adaptable tyramine/octopamine ratios adjust *Drosophila* locomotion to nutritional state

Natalie Schützler [1], Chantal Girwert [1], Isabell Hügli [1], Giriram Mohana [2], Jean-Yves Roignant [2], Stefanie Ryglewski [3], Carsten Duch [3]

OA and TA Adjust *Drosophila* Larval Locomotion to Nutritional State



TDC2 Neurons Contact MNs in Central Ventral Nerve Cord Neuropils

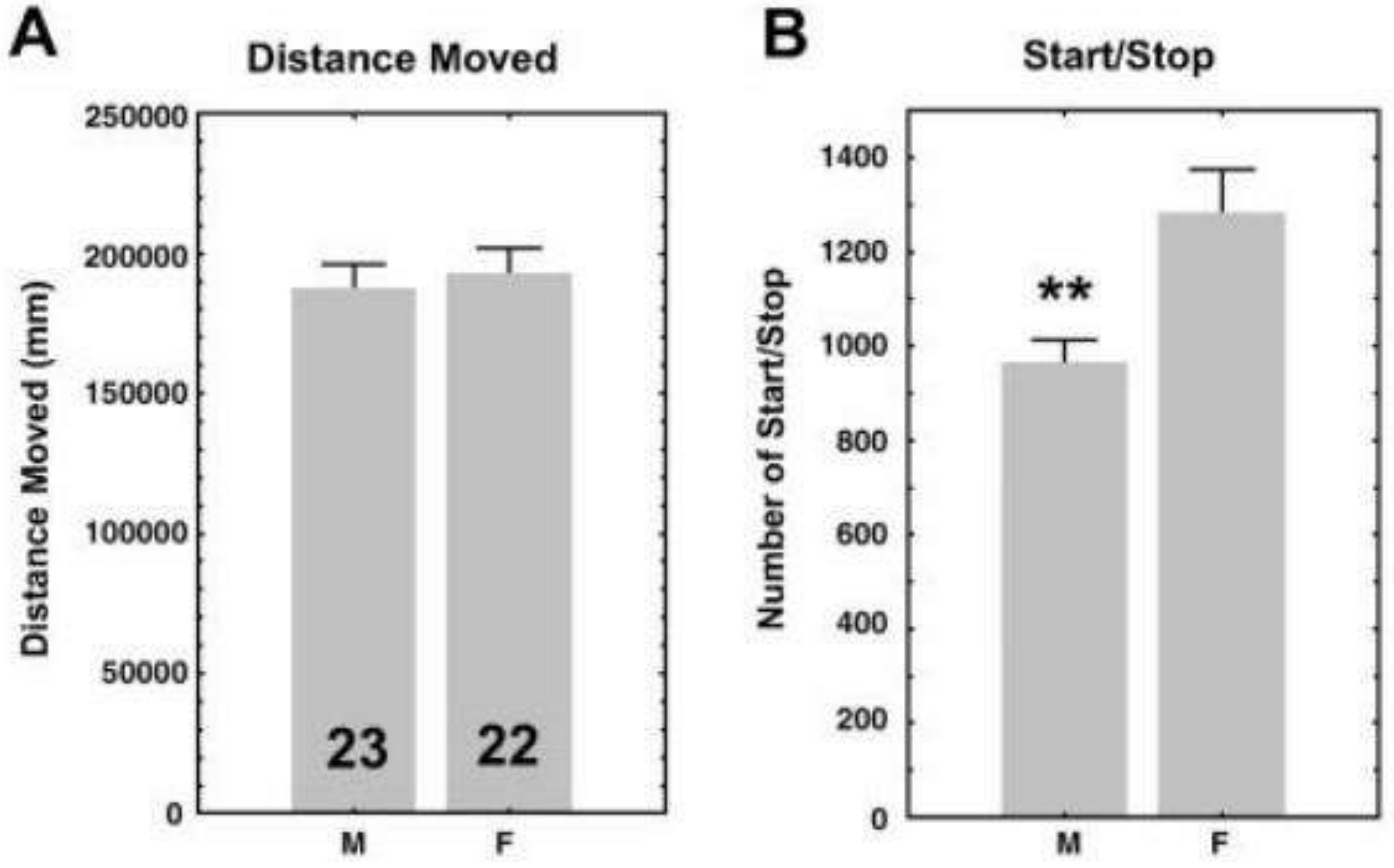


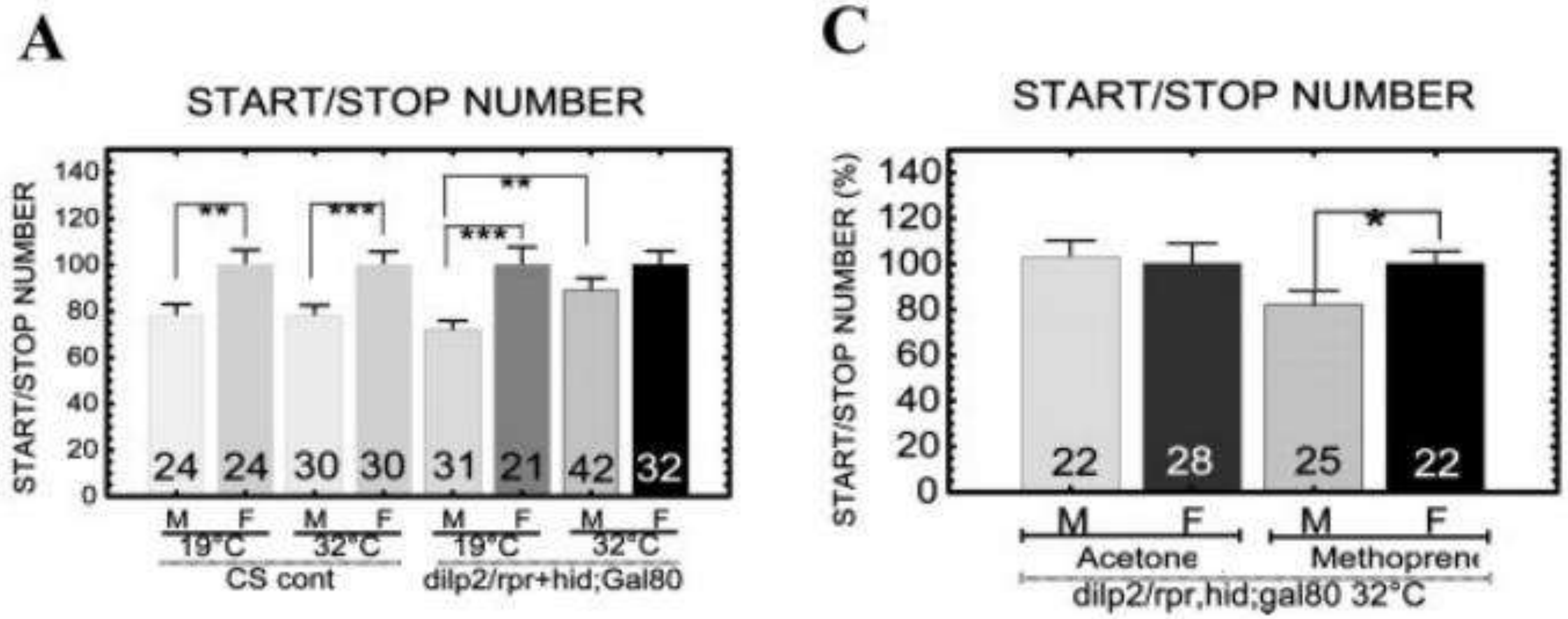
Summary

- **OA and TA are important for *Drosophila* Larval Locomotion**

The locomotion neurotransmitters of adult *Drosophila melanogaster*

Dimorphism is regulated by dilp2 in *Drosophila*

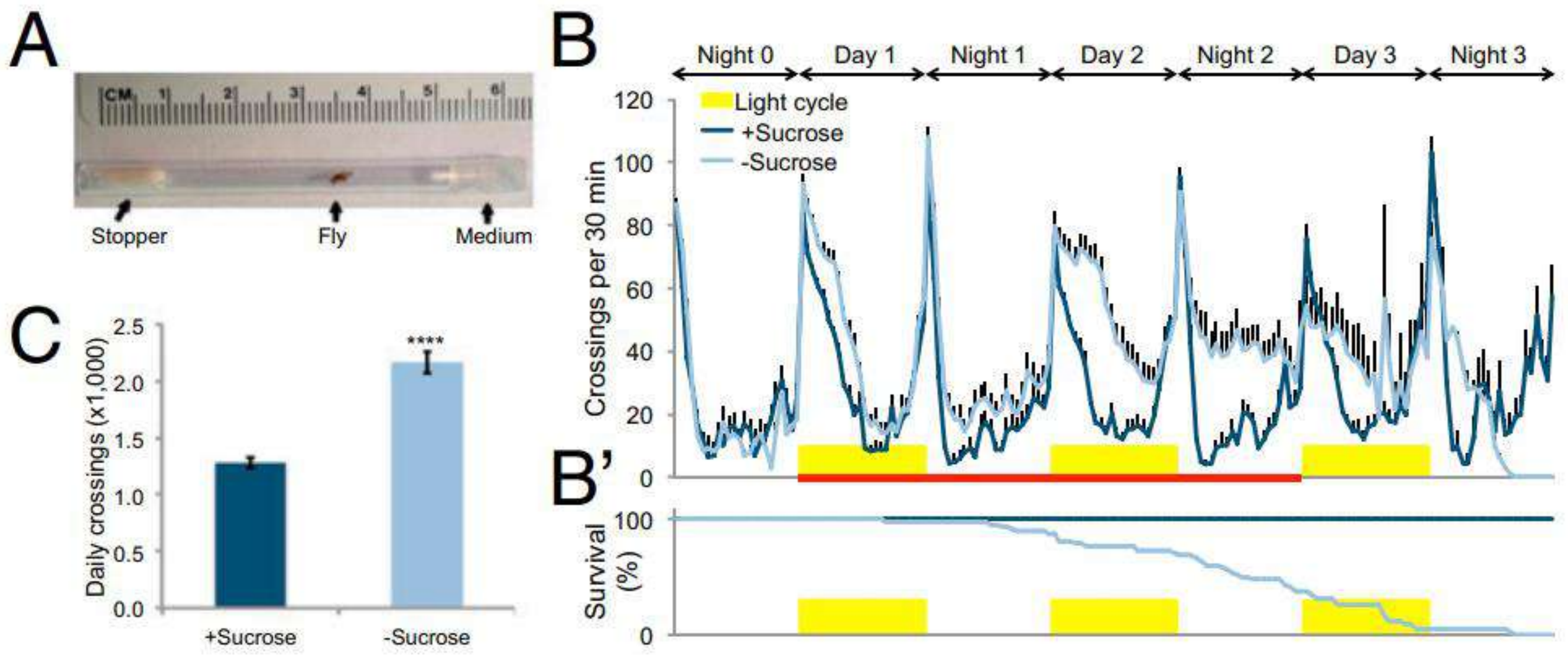


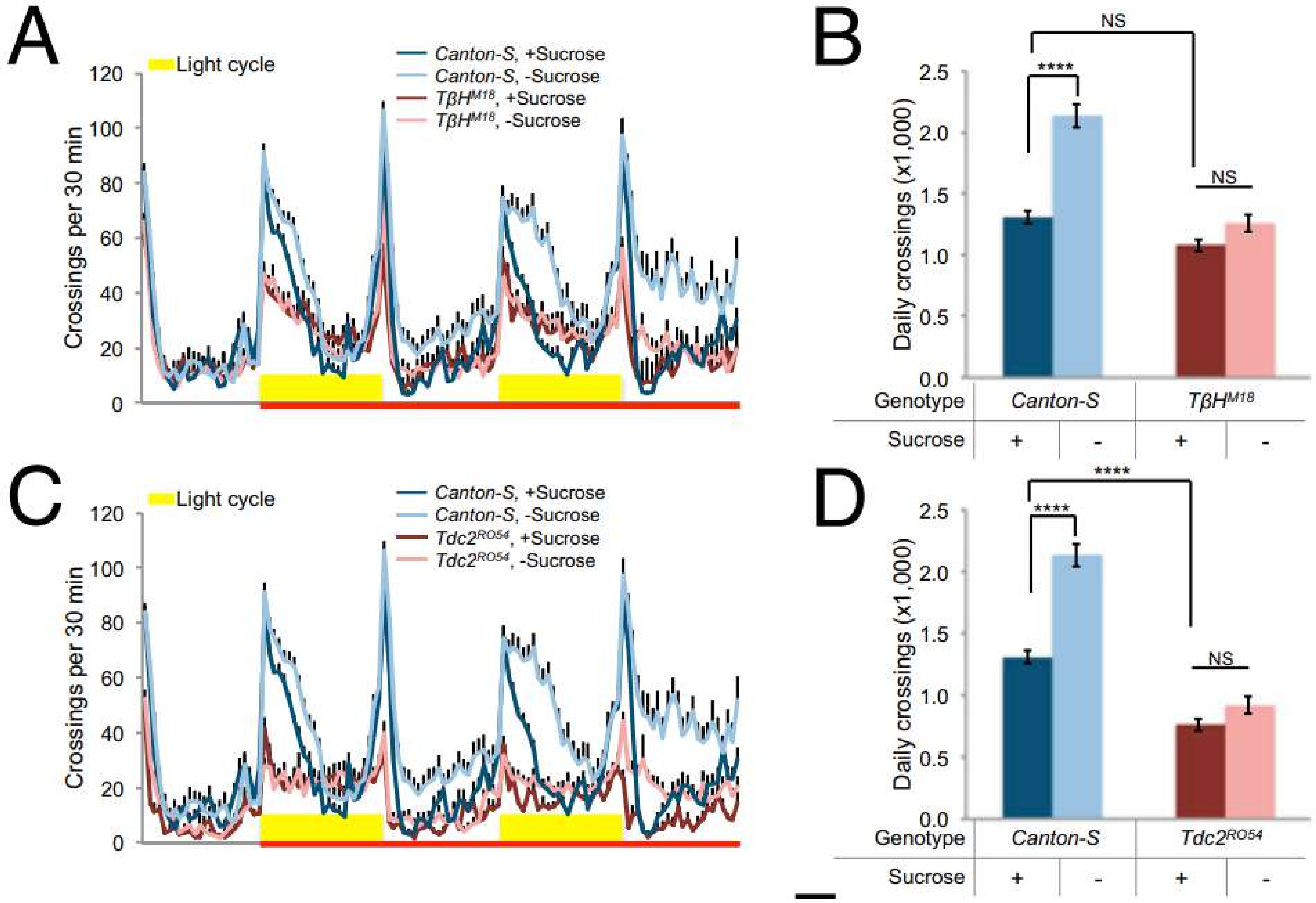


Belgacem YH, et al., 2002, PNAS

Belgacem YH, et al., 2006, J Neurobiol

Octopamine mediates starvation-induced hyperactivity

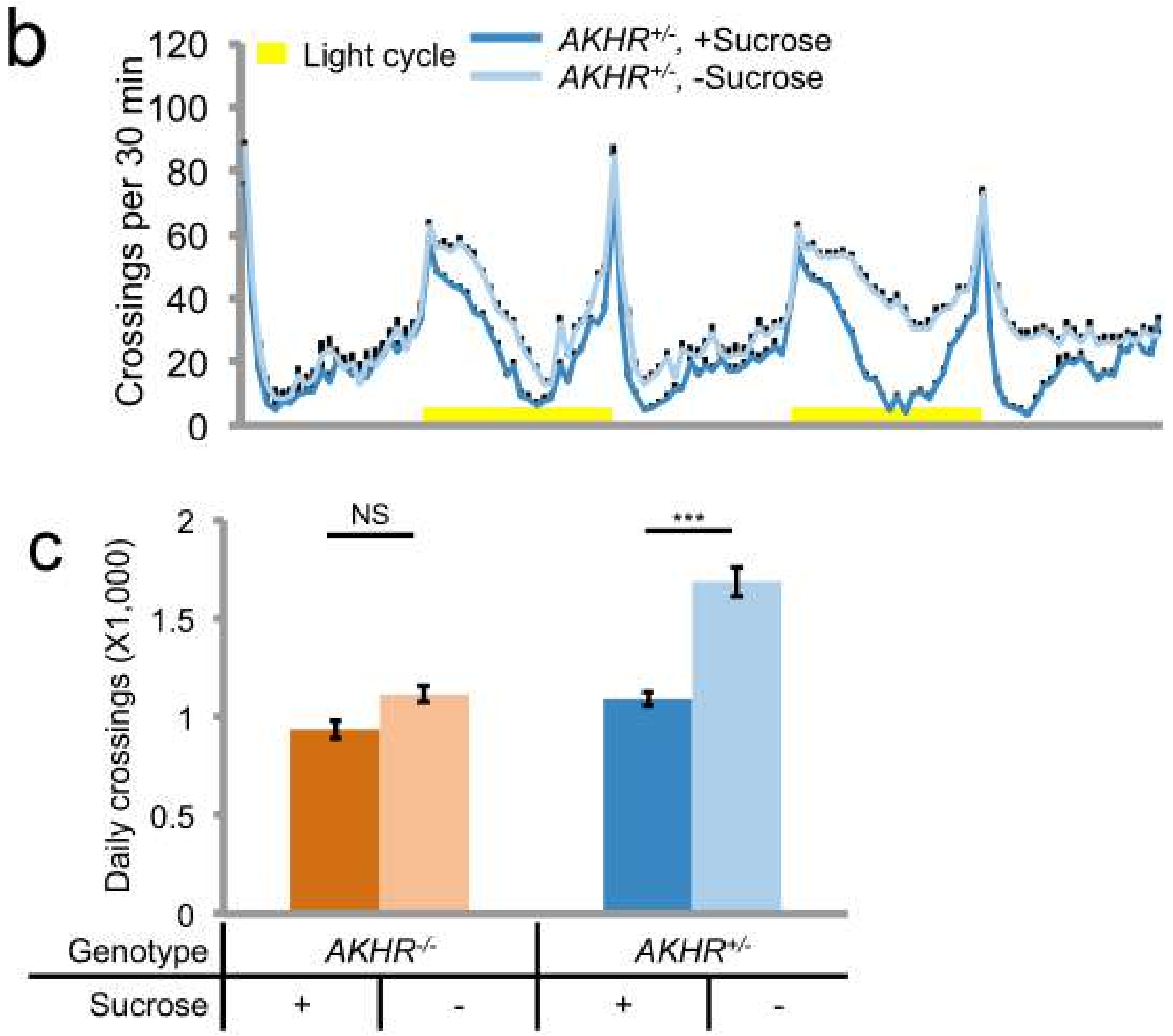




AKH mediates starvation-induced hyperactivity

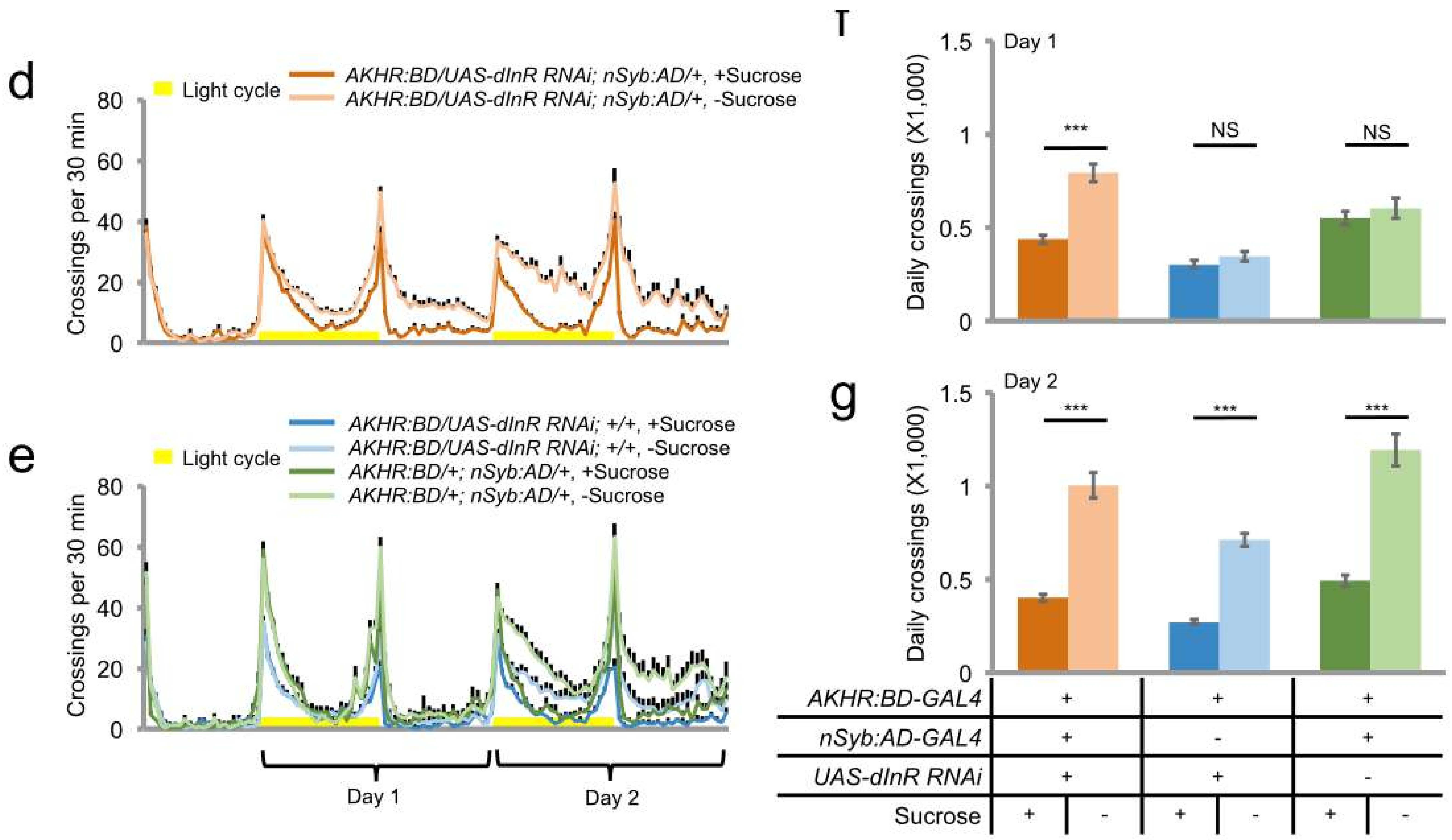
d

Gene name	Gene ID	Putative Ligand	Baseline locomotion (fed)	Locomotion upon starvation	Increase in locomotion (fed vs. starved)	Statistical significance (fed vs. starved)
Control			**865.2(±33.9)**	**1391.9(±77.6)**	**60.8%(±9.0%)**	*******
Adipokinetic hormone receptor	CG11325	Adipokinetic hormone	773.9(±39.0)	897.9(±67.4)	16.0%(±8.7%)	NS
CCHamide-1 receptor	CG30106	CCHamide-1	940.9(±76.9)	1153.1(±73.4)	22.5%(±7.8%)	*
Neuropeptide F receptor	CG1147	Neuropeptide F	1003.0(±44.3)	1265.1(±72.6)	26.1%(±7.2%)	**
Leucine-rich repeat-containing G protein-coupled receptor 1	CG7665	Glycoprotein hormone alpha2/beta5	744.1(±38.9)	939.3(±63.4)	26.2%(±8.5%)	*
Diuretic hormone 44 receptor 1	CG8422	Diuretic hormone 44	719.1(±42.6)	910.2(±72.6)	26.6%(±10.1%)	*
Proctolin receptor	CG6986	Proctolin	734.2(±37.3)	940.3(±84.5)	28.1%(±11.5%)	*
Allatostatin C receptor 2	CG13702	Allatostatin C	766.1(±69.7)	1001.4(±54.9)	30.7%(±7.2%)	*
Cholecystokinin-like receptor at 17D1	CG42301		706.3(±39.7)	925.1(±75.9)	31.0%(±10.7%)	*
	CG10738	Eclosion hormone	686.3(±49.6)	927.6(±73.8)	35.2%(±10.7%)	**
Rickets	CG8930	Bursicon	806.1(±66.4)	1092.3(±68.5)	35.5%(±8.5%)	**
Leucokinin receptor	CG10626	Leucokinin	769.6(±43.1)	1049.9(±75.9)	36.4%(±9.9%)	**
Tachykinin-like receptor at 99D	CG7887	Tachykinin/Drotachykinin	783.3(±58.9)	1074.8(±96.5)	37.2%(±12.3%)	*
Pyrokinin 1 receptor	CG9918	CAPA-PVK/PK	614.8(±29.9)	843.8(±57.0)	37.2%(±9.3%)	***
SIFamide receptor	CG10823	SIFamide	516.3(±31.1)	718.0(±58.3)	39.1%(±11.3%)	**
Myosuppressin receptor 1	CG8985	Myosuppressin/ dromysosuppressin	758.7(±43.3)	1060.9(±62.4)	39.8%(±8.2%)	***
Allatostatin C receptor 1	CG7285	Allatostatin C	855.2(±30.2)	1204.4(±87.8)	40.8%(±10.3%)	***
Corazonin receptor	CG10698	Corazonin	803.3(±32.3)	1157.6(±77.1)	44.1%(±9.6%)	***
FMRFamide Receptor	CG2114	FMRFamide	735.8(±38.6)	1062.4(±81.1)	44.4%(±11.0%)	***
Pyrokinin 2 receptor 1	CG8784	Hugin	732.0(±41.6)	1091.2(±79.3)	49.1%(±10.8%)	***
Myosuppressin receptor 2	CG43745		794.1(±42.5)	1190.0(±71.2)	49.9%(±9.0%)	***
Allatostatin A receptor 1	CG2872	Allatostatin A	828.7(±46.9)	1252.9(±68.4)	51.2%(±8.3%)	***
Torso	CG1389	Prothoracicotropic hormone	723.8(±46.6)	1095.3(±58.1)	51.3%(±8.0%)	***
Allatostatin A receptor 2	CG10001	Allatostatin A	679.7(±44.1)	1039.6(±75.8)	52.9%(±11.1%)	***
Crustacean cardioactive peptide receptor	CG33344		884.3(±61.3)	1356.9(±77.9)	53.4%(±8.8%)	***
Capability receptor	CG14575	CAPA-PVK/PK	959.6(±49.1)	1482.5(±79.4)	54.5%(±8.3%)	***
Pyrokinin 2 receptor 2	CG8795	Hugin	648.1(±28.2)	1018.9(±60.4)	57.2%(±9.3%)	***
Ecdysis-triggering hormone receptor	CG5911	Ecdysis-triggering hormone	990.3(±55.4)	1566.4(±93.7)	58.2%(±9.5%)	***
Pigment-dispersing factor receptor	CG13758	Pigment-dispersing factor	678.3(±27.8)	1099.5(±80.5)	62.1%(±11.9%)	***
Diuretic hormone 31 Receptor	CG32843	Diuretic hormone 31	519.3(±50.3)	857.9(±93.6)	65.2%(±18.0%)	**
Tachykinin-like receptor at 86C	CG6515	Tachykinin/Drotachykinin	749.3(±43.7)	1279.2(±98.1)	70.7%(±13.1%)	***
Short neuropeptide F receptor	CG7395	Short neuropeptide F	820.0(±49.3)	1414.3(±95.7)	72.5%(±11.7%)	***



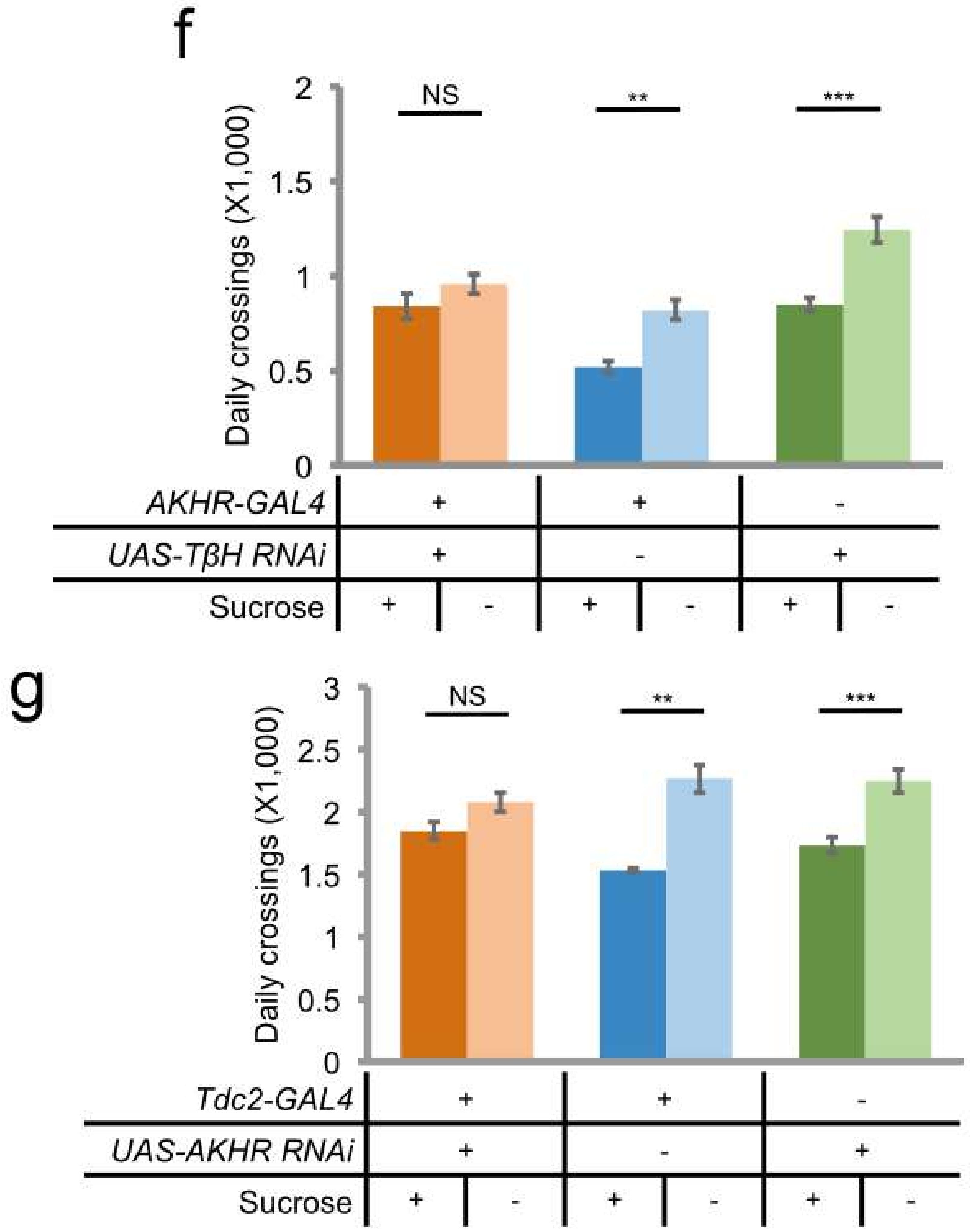
Yu Y, et al., 2016, Elife

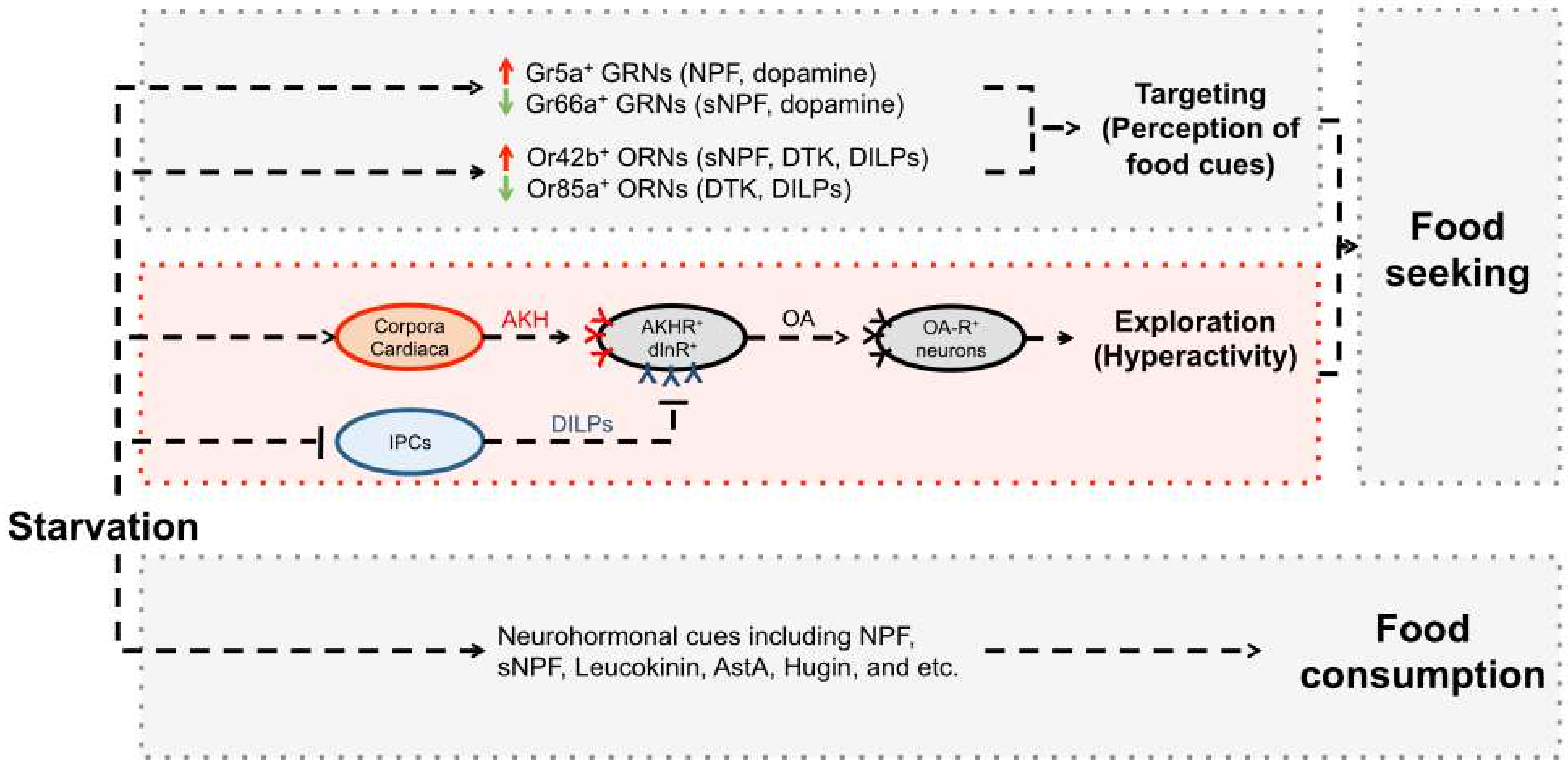
Insulin signaling suppresses starvation-induced hyperactivity via AKHR+neurons



Yu Y, et al., 2016, Elife

Octopamine signaling mediates the effect of AKHR+ neurons on starvation-induced hyperactivity



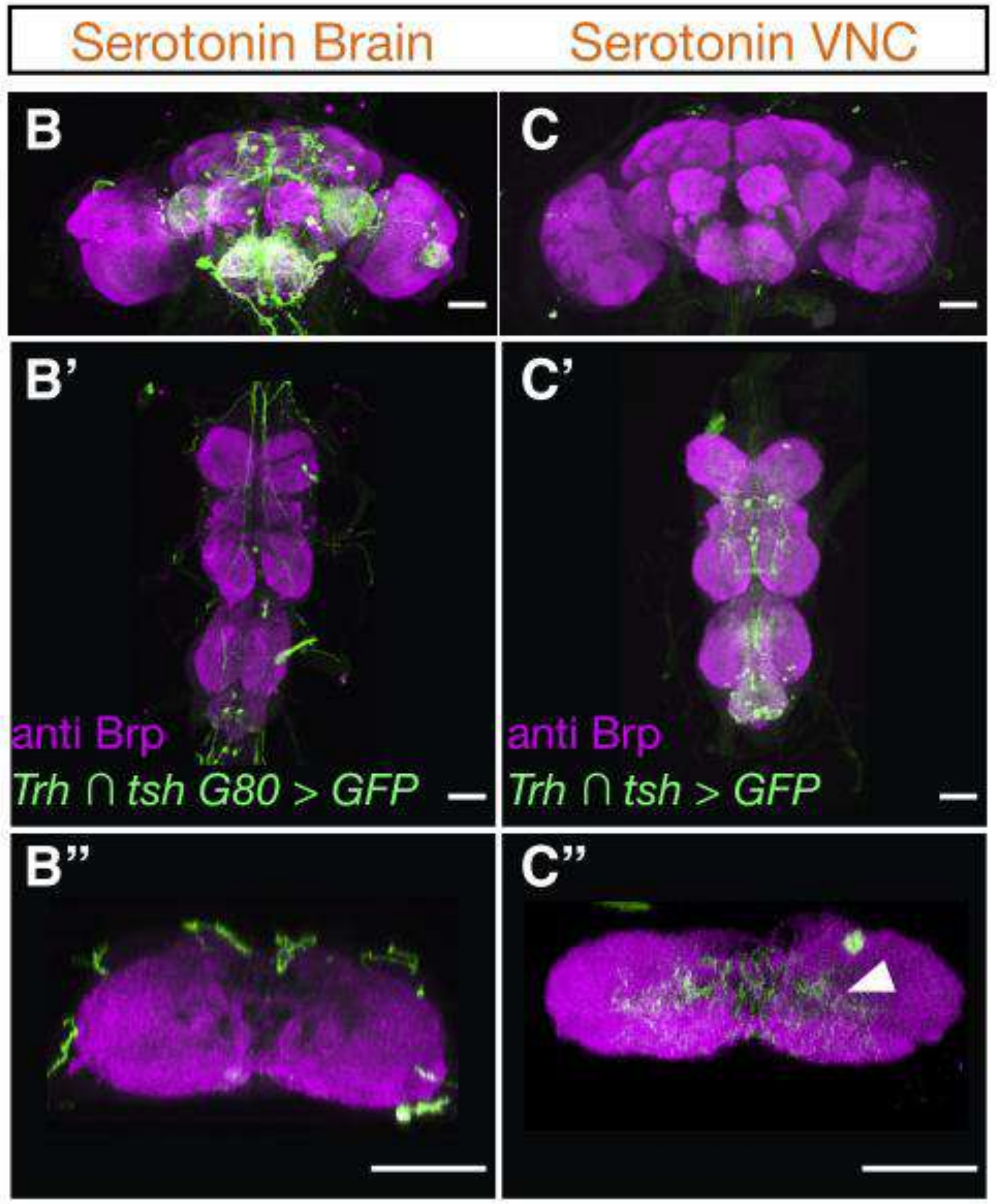


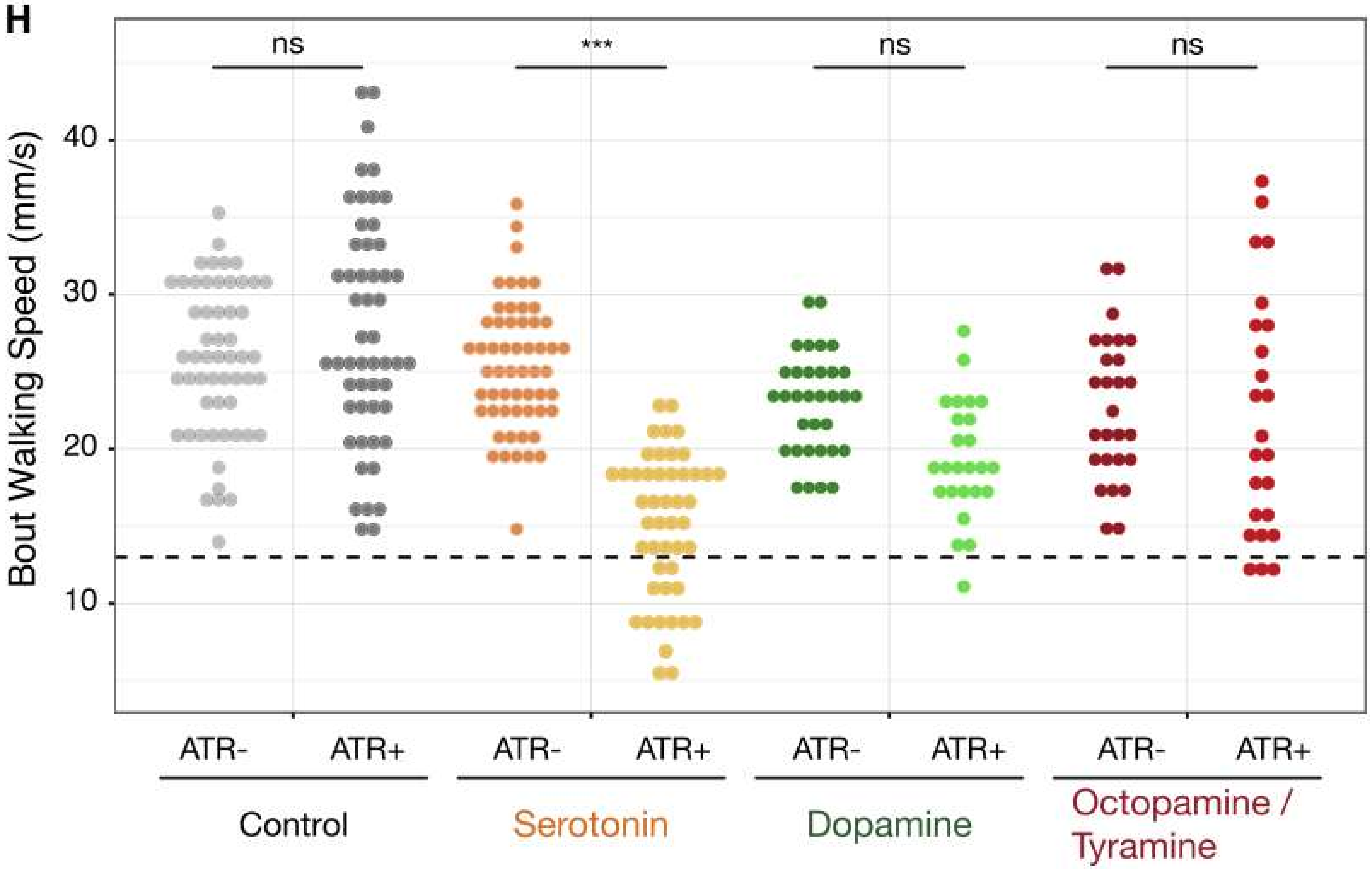
Yu Y, et al., 2016, Elife

Summary

- **OA and TA are important for *Drosophila* Larval Locomotion**
- **Octopamine signaling mediates the effect of AKHR+ neurons on starvation-induced hyperactivity**

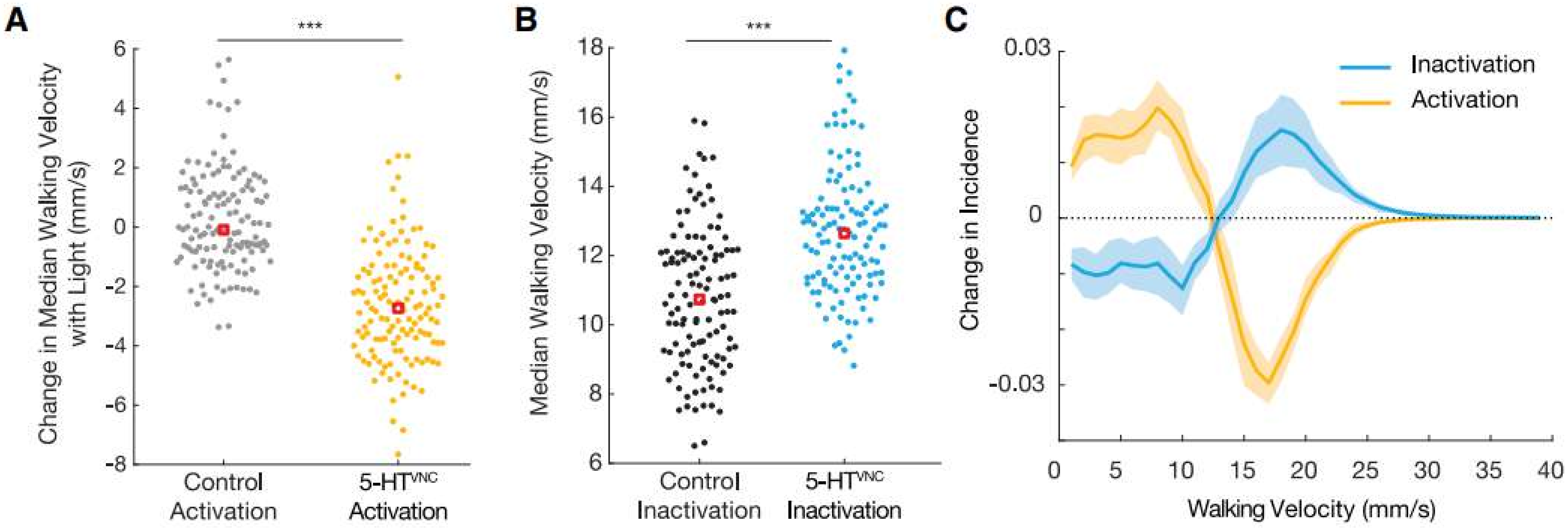
Activation of VNC Serotonergic Neurons Slows Walking Speed





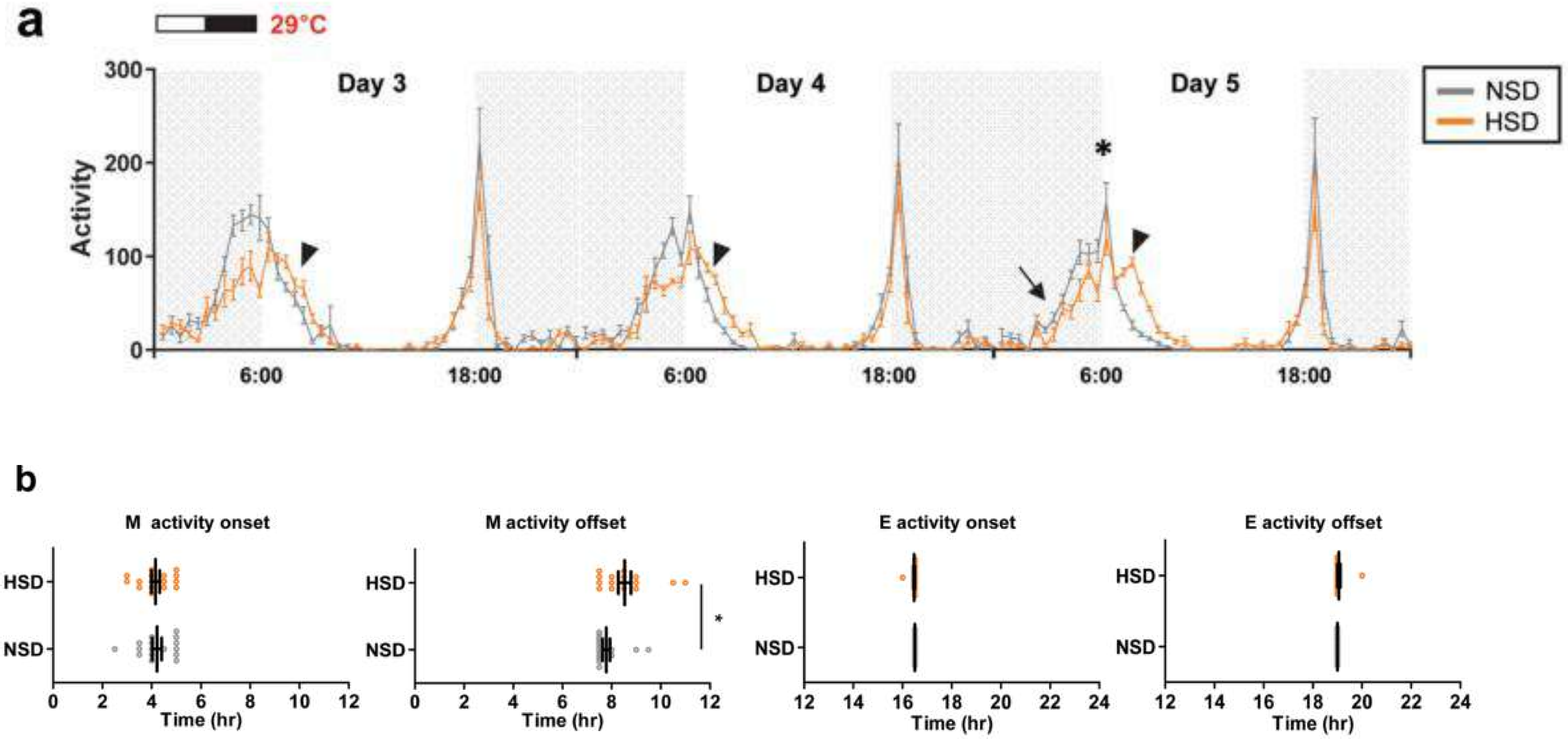
Howard CE, et al., 2019, Curr Biol

VNC Serotonergic Neurons regulate Walking Speed



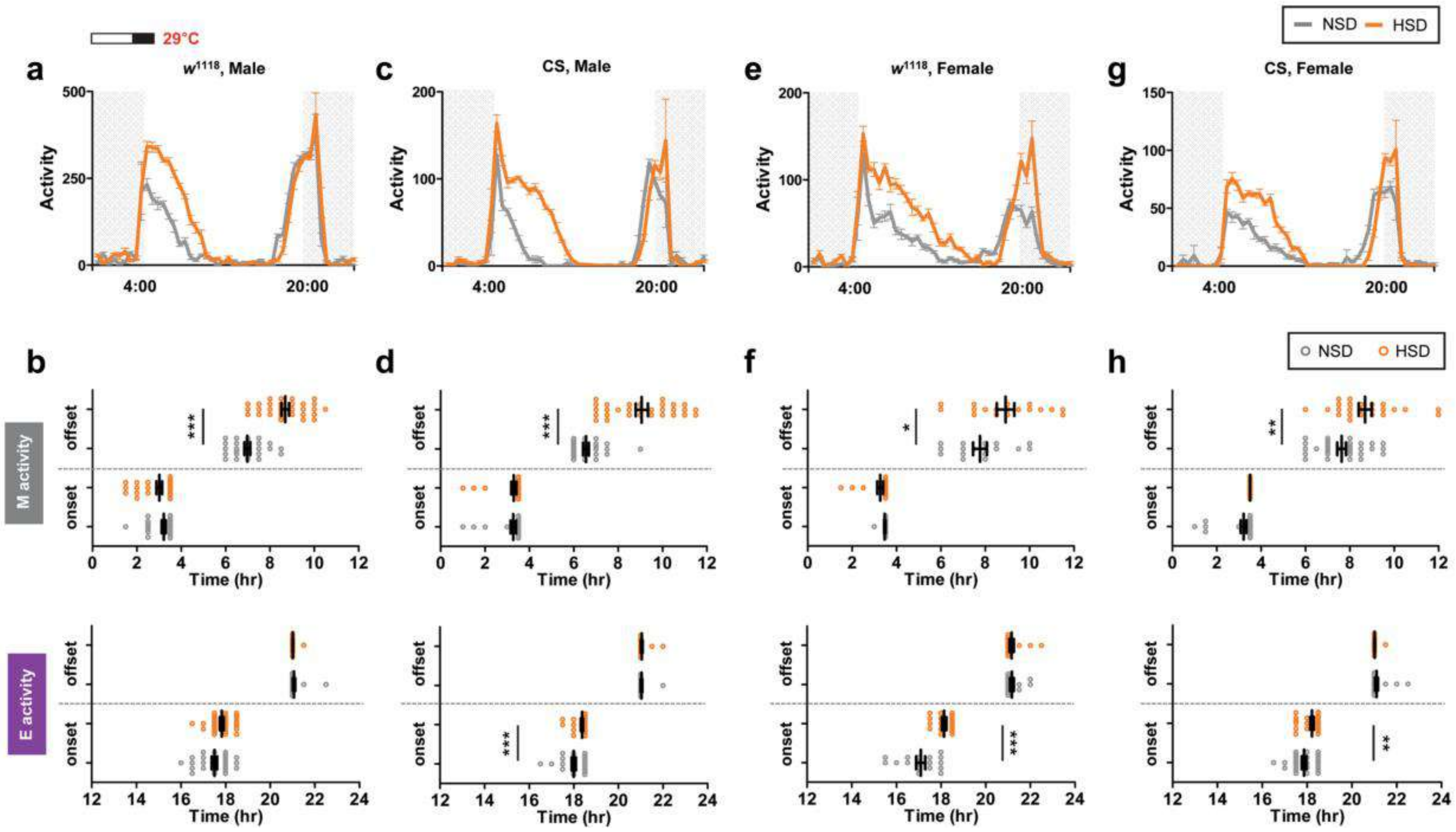
Howard CE, et al., 2019, Curr Biol

HSD extended morning activity but not evening activity



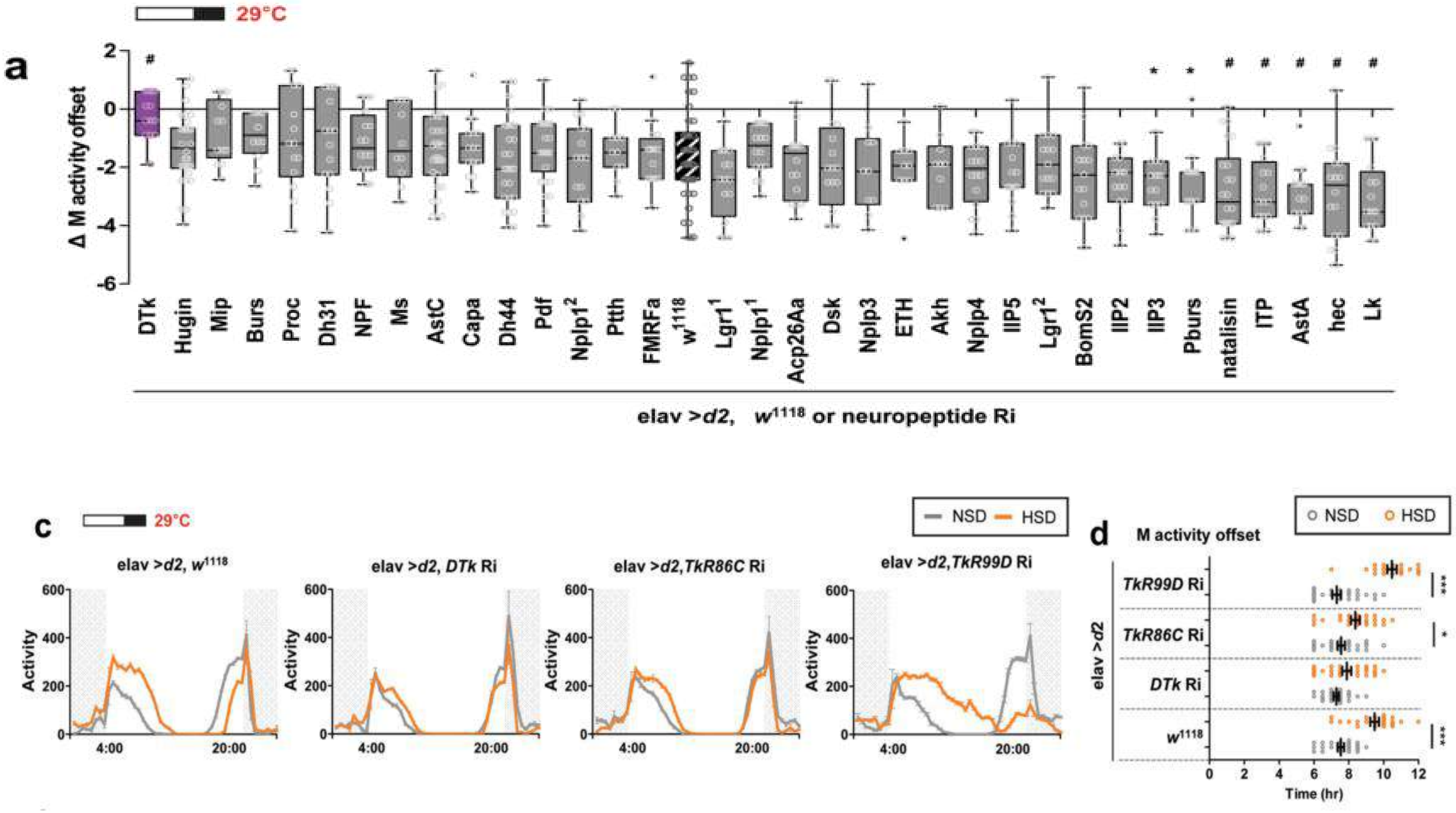
Lee SH, et al., 2019, Commun Biol

HSD extended much morning activity in 16L:8D condition



Lee SH, et al., 2019, Commun Biol

Neuropeptide tachykinin was required for M activity extension in flies on a HSD



Lee SH, et al., 2019, Commun Biol

Summary

- **OA and TA are important for *Drosophila* larval locomotion**
- **Octopamine signaling mediates the effect of AKHR+ neurons on starvation-induced hyperactivity for *Drosophila* adult locomotion**
- **VNC Serotonergic Neurons regulate Walking Speed**
- **Neuropeptide tachykinin was required for M activity extension in flies on a HSD**

Thanks!