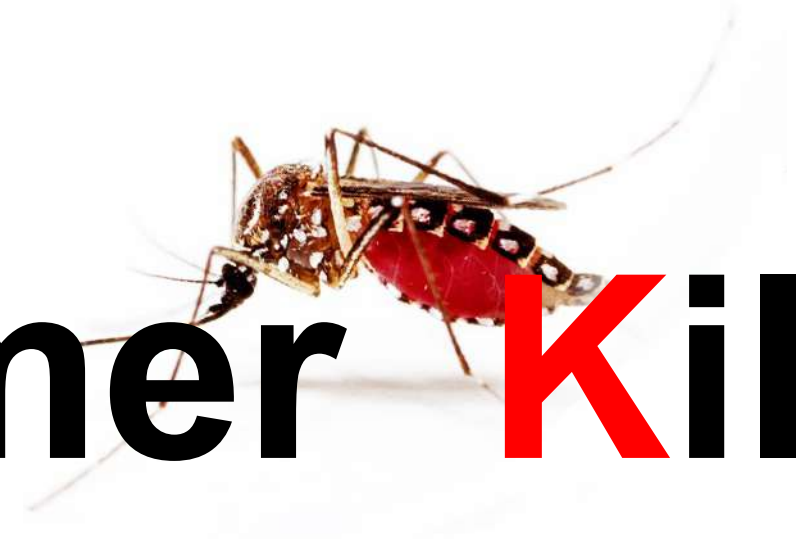
Journal Club in June



Summer Killer

Briefly talk about the host-seeking behavior of *Mosquito*

- Overview of Mosquitoes research

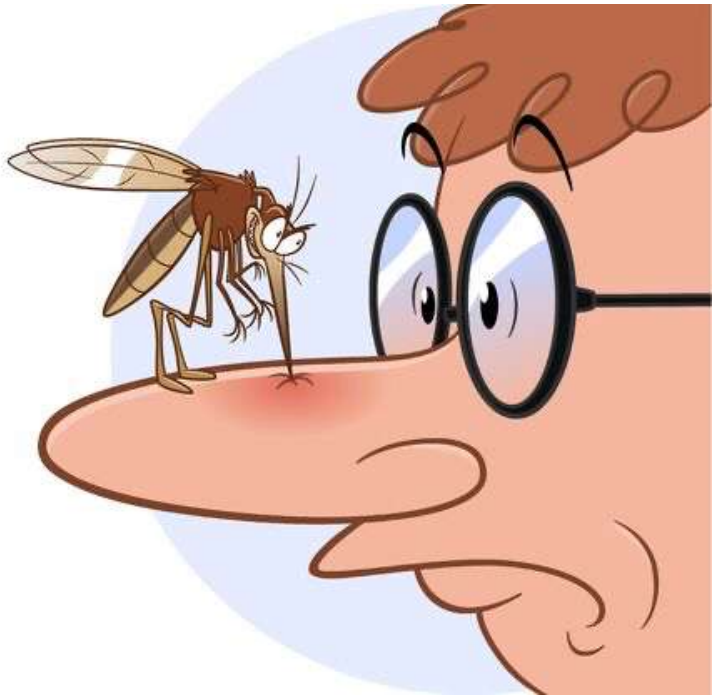
高灿

- How Mosquitoes find us? (sensation & pathway)

張綠宁

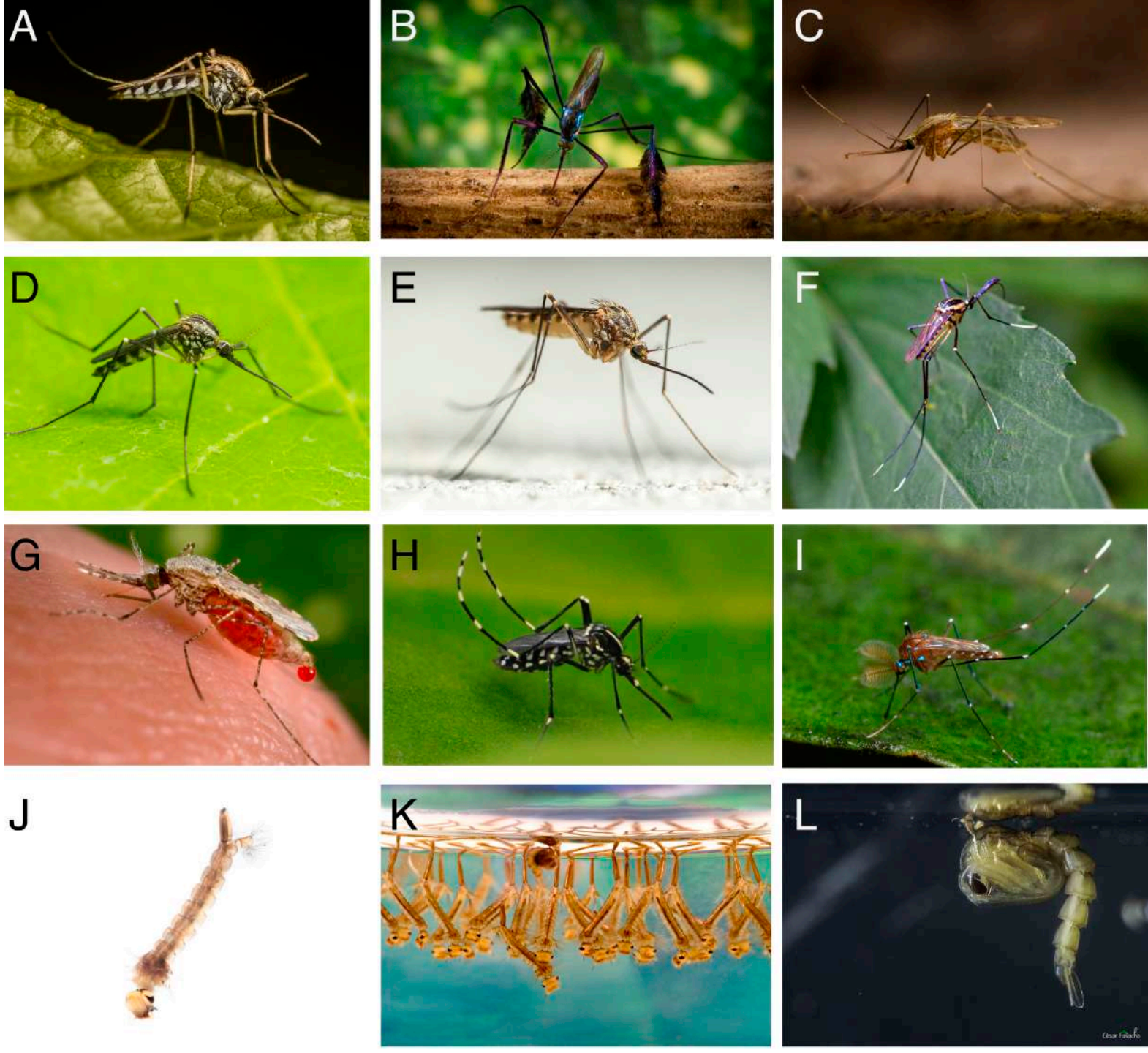
- Why Mosquitoes like us? (preference)

邢丽敏

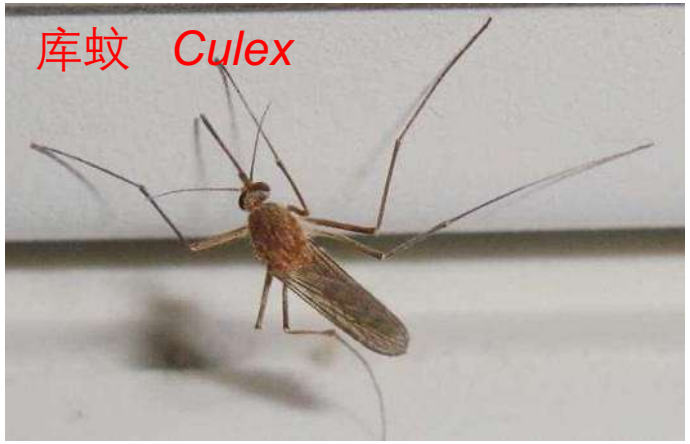


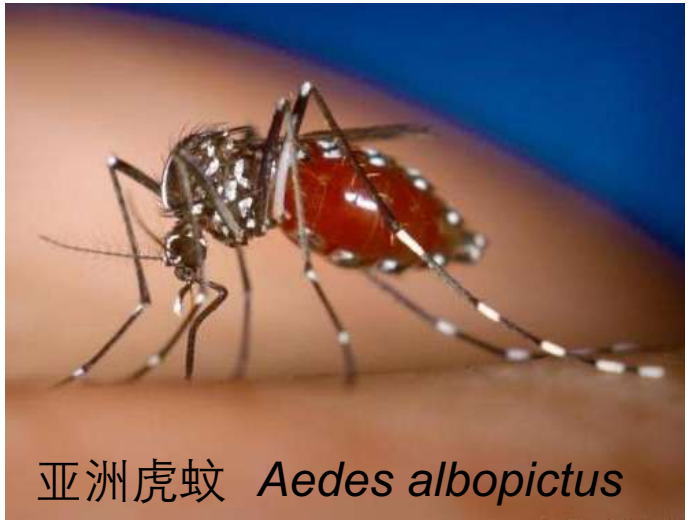
Overview of mosquito research

VG



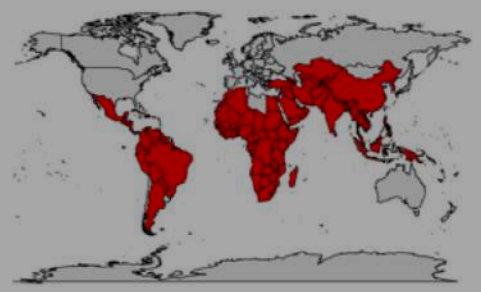
Common mosquito species in China

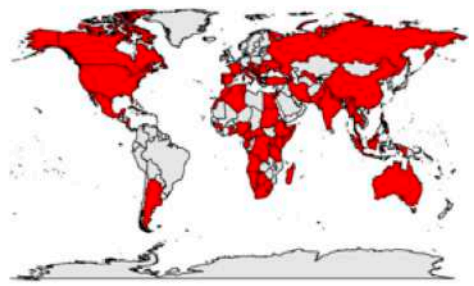




Global distribution of mosquito-borne diseases

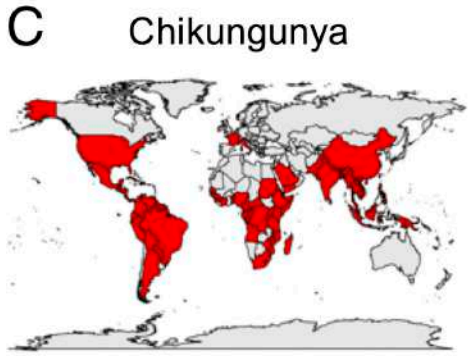
疟疾

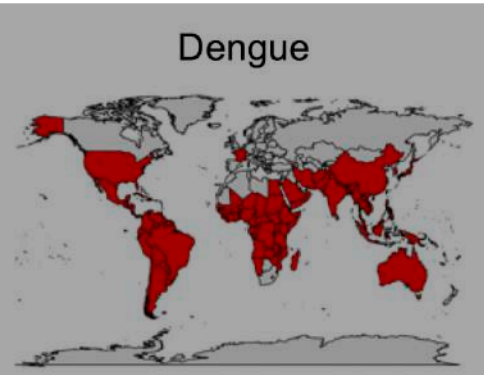




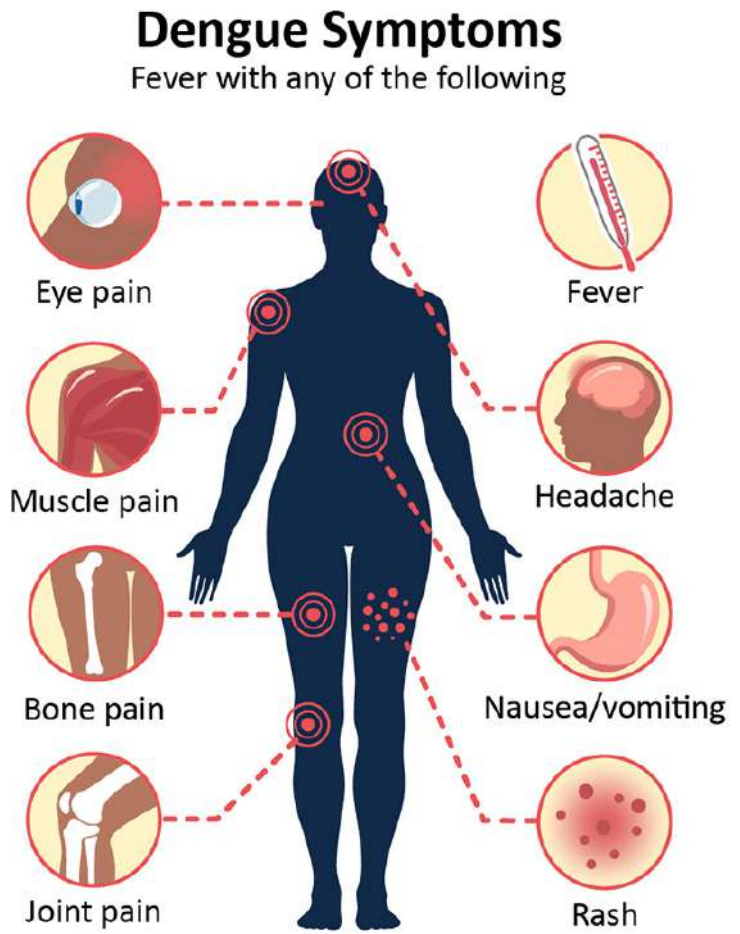
西尼罗河热

基孔肯雅热

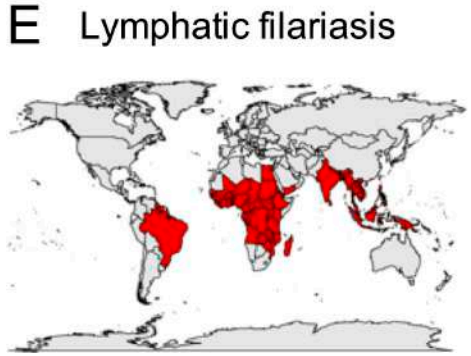


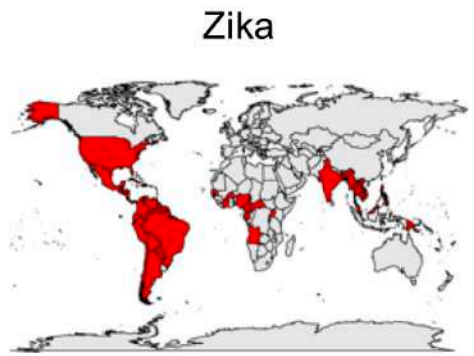


登革热 ➔



淋巴丝虫病





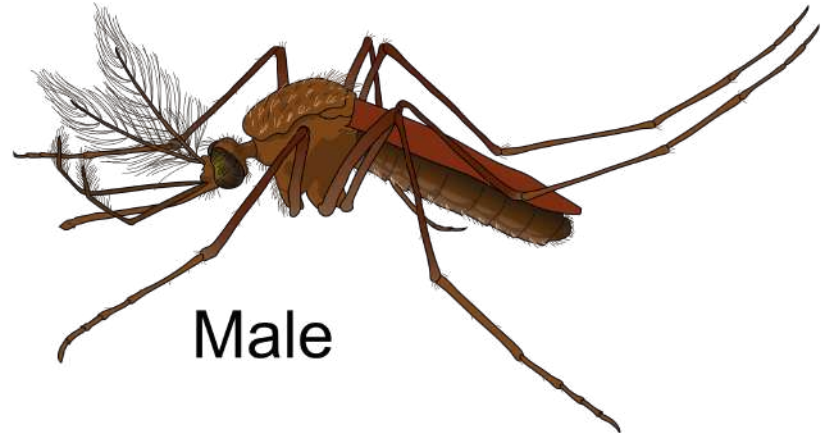
寨卡病毒

Male vs. Female mosquitoes: what's the difference?

Size and appearance

Females are larger than males

Males have finer hairs called flagella on their antennae, compared to the plain, thin antennae of the females



Lifespan and feeding

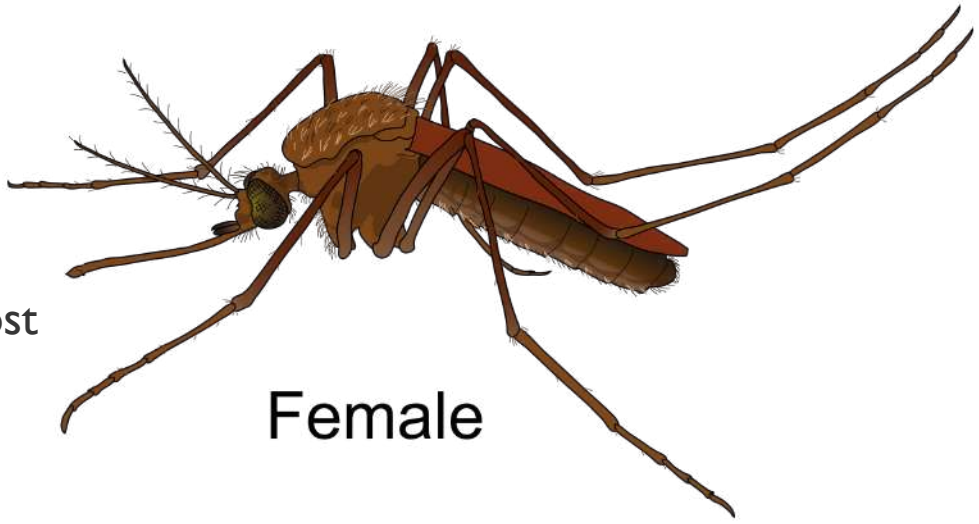
Female mosquitoes live longer than male mosquitoes

Only female mosquitoes need blood

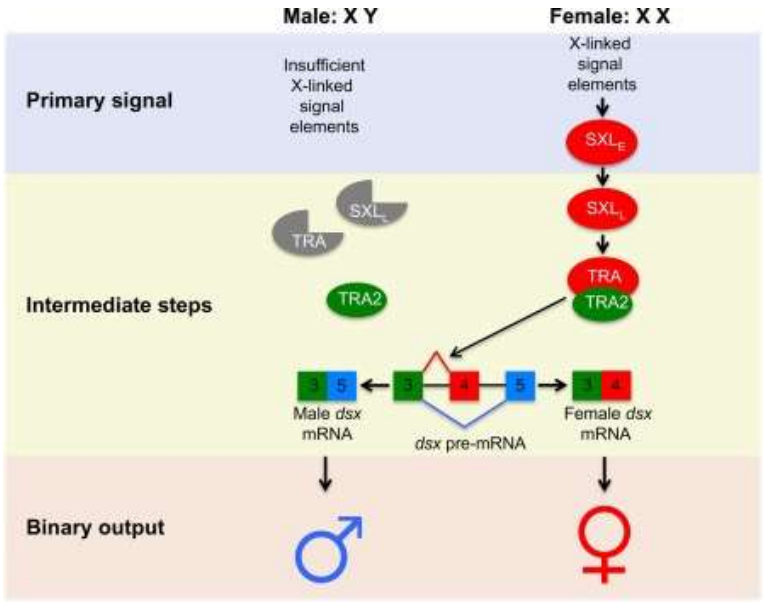
Behavior and mating

Female mosquitoes have specialized sensory receptors to locate host

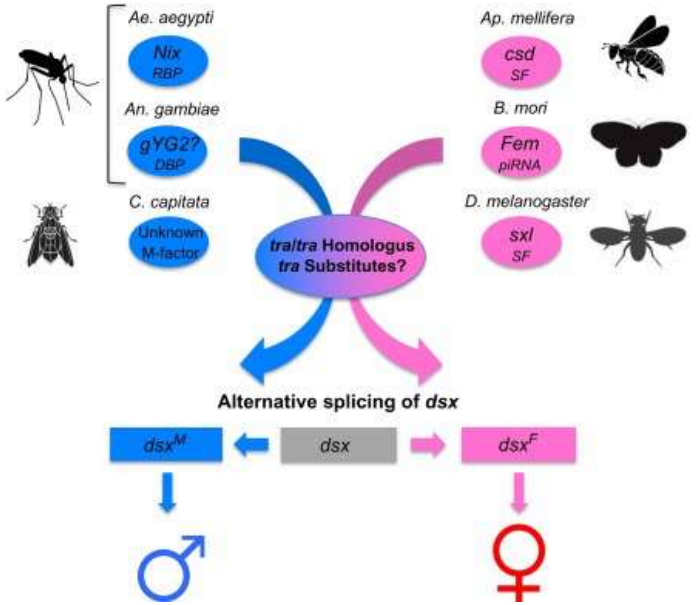
Male and female make different love buzz



Sex determination in mosquitoes



The sex determination pathway in *Drosophila melanogaster*



Comparison of sex determination pathways of holometabolous insects


Science

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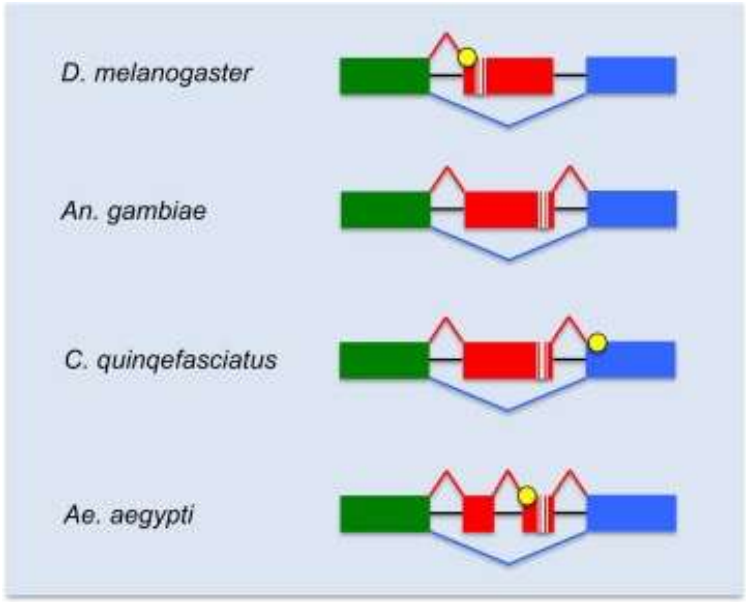
HOME > SCIENCE > VOL. 348, NO. 6240 > A MALE-DETERMINING FACTOR IN THE MOSQUITO AEDES AEGYPTI

REPORT

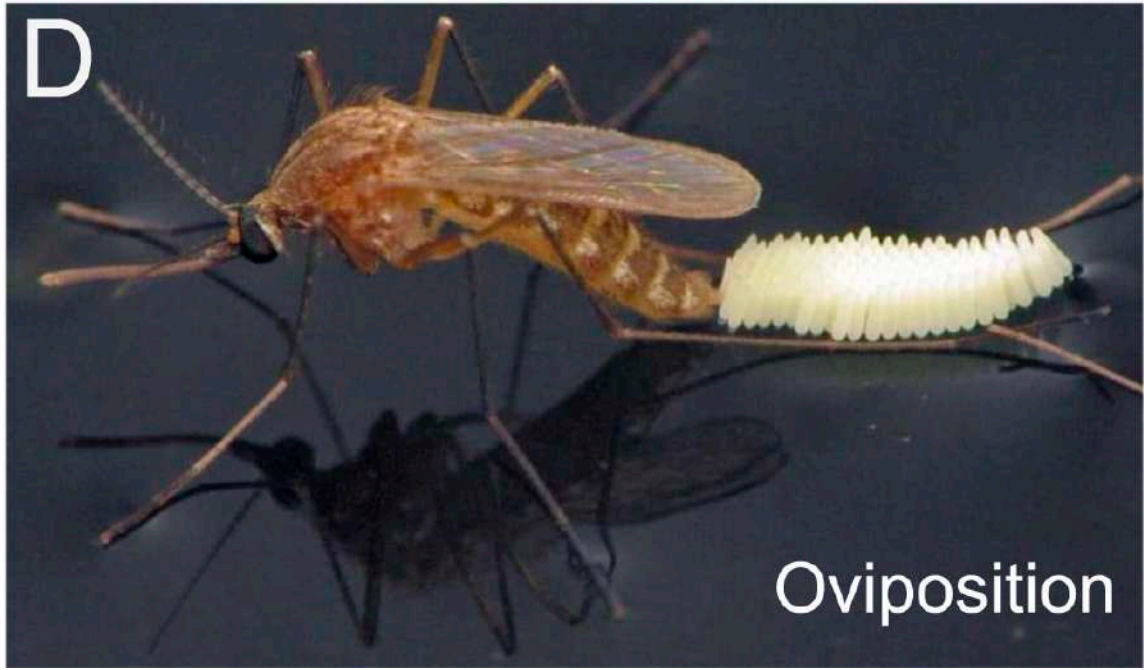
A male-determining factor in the mosquito *Aedes aegypti*

ANDREW BRANTLEY HALL, SANJAY BASU, XIAOFANG JIANG, YUMIN QI, VLADIMIR A. TIMOSHEVSKIY, JAMES K. BIEDLER, MARIA V. SHARAKHOVA, RUBAYET ELAHI, MICHELLE A. E. ANDERSON, [...] ZHIJIAN TU +4 authors Authors Info & Affiliations



Alternative splicing of *doublesex* pre-mRNA in *D. melanogaster* and mosquitoes

Mosquito behaviors



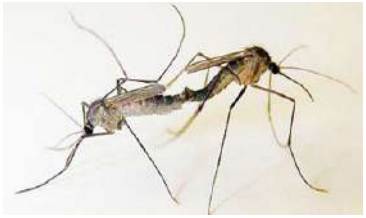
Mosquito life cycle: eggs, larval instars, pupa, and adults

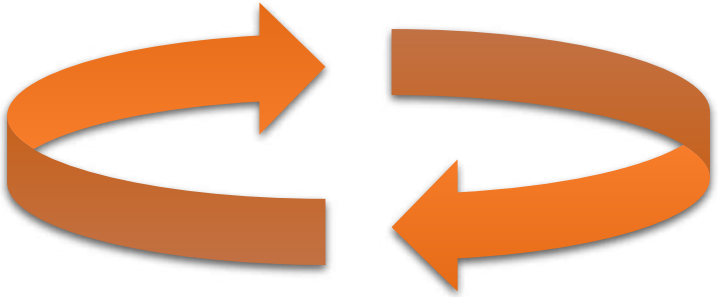
Egg laying behavior

Female biting behavior

embryo

Mating behavior

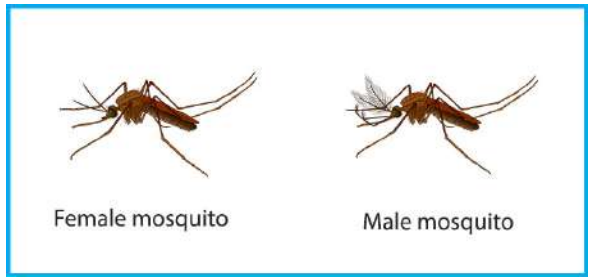




Larva (wiggler)
1, 2, 3 instar

子子

Adult



Eclosion

Pupa (tumbler)

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mosquito

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RESULTS BY YEAR

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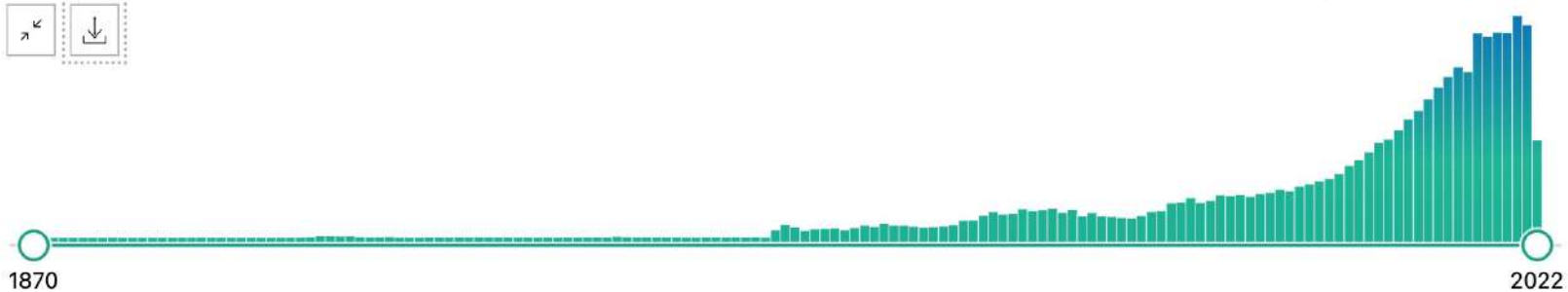

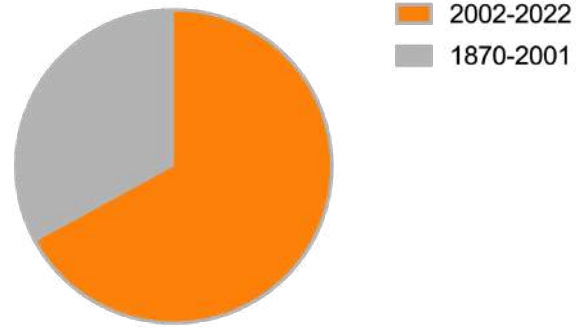

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RESULTS BY YEAR

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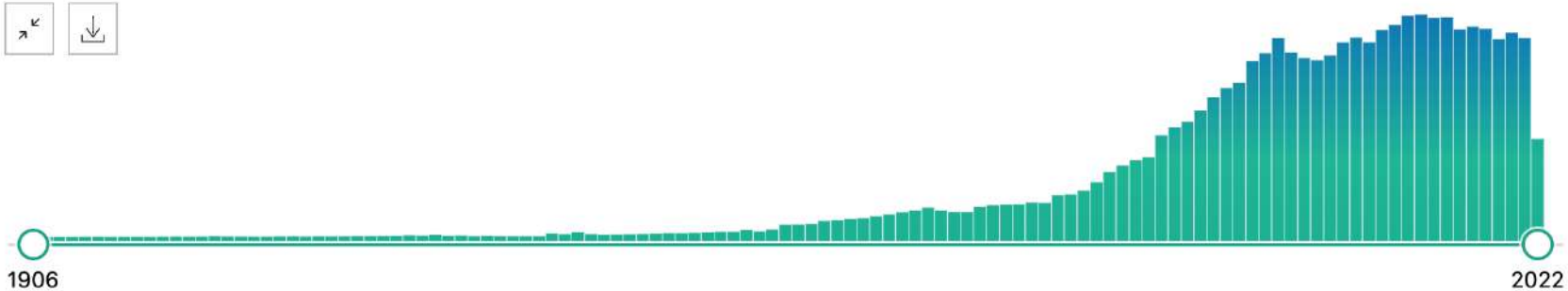

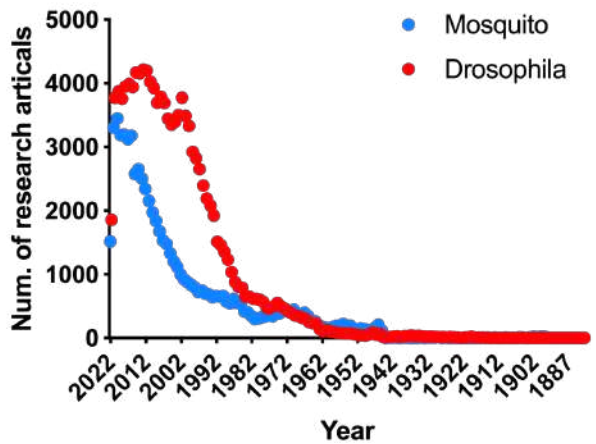

NEWS & COMMENT

Yellow Fever and Mosquitoes

SCIENCE · 2 Nov 1900 · Vol 12, Issue 305 · pp. 692-693 · DOI: 10.1126/science.12.305.692

the present from various quarters, and collections are still coming in almost every week. The work of identifying and describing the specimens was at first entrusted to Mr. E. E. Austen, the dipterist on the staff of the museum, but later he volunteered for active service in South Africa and joined the City Imperial Volunteers. Apart from his duties as a soldier Mr. Austen has, we hear, done useful service in his capacity of naturalist in the South African Field Force. There are not many professional dipterists in this country, and it was therefore fortunate that the director of the museum, Pro- a very wide distribution. Thus one species has been sent from the following widely-separated localities: Japan, Formosa, Hong-kong, Malay Peninsula, India, South and West Africa, North and South America, West Indies and Gibralter. As many of the species are very obscure, photographs of the wings and drawings of various parts are being prepared, and complete figures of the majority of species will also be given in the proposed monograph. The collection and preservation of these tiny and very delicate insects are a most difficult matter, involving unwearied patience and extreme care.

> Science. 1901 Mar 15;13(324):431. doi: 10.1126/science.13.324.431.

A FIELD FOR MOSQUITO THEORISTS

G R S

PMID: 17769848 DOI: 10.1126/science.13.324.431

FULL TEXT LINKS

Science AAAS

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ACTIONS

A FIELD FOR MOSQUITO THEORISTS.

CLIMATIC CONDITIONS ON THE UPPER CONGO.

TO THE EDITOR OF SCIENCE:—The following extracts from letters of Father Grison, a Missionary at Stanley Falls, and Mg'r Roelens, Vicaire Apostolique of the Upper Congo, addressed to the Société Antiesclavagiste of Belgium, may be of interest. G. R. S.

WASHINGTON, D. C.,
February 12th.

At Stanley Falls the climate is very agreeable, but is formidable, as the victims of fever are too numerous. Europeans have very inaccurate ideas of tropical temperatures. I have passed eight years at the equator on the Pacific Coast, and have never seen the mercury above 29° C.

Here the maximum is 32° C. and the nights are deliciously cool. This is our climate all the year.

There is, however, a reverse to this picture. We

J. B. Smith

History of Mosquito Control at Rutgers

The John B. Smith Legacy

New Jersey Agricultural Experiment Station (NJAES)

☐ MAGAZINE ENTOMOLOGY.

☐ CONCERNING CERTAIN MOSQUITOES.

☐ THE MOSQUITO CAM

☐ THE SALT MARSH MC

☐ CONCERNING MOSQ

3

Cite

Smith JB.

Science. 1903 Dec 11;18(467):761-4. doi: 10.1126/science.18.4

PMID: 17844482 No abstract available.

☐ THE LOGICAL BASIS OF THE SANITARY POLICY OF MOSQUITO REDUCTION.

2

Cite

Smith JB.

Science. 1906 Jan 19;23(5

PMID: 17847410 No abs

☐ HOW DOES ANOPHELES BITE?

☐ MOSQUITO EXTERMINATION.

☐ VARIATION IN MOSQUITO HABITS.

1

Cite

Smith JB.

Science. 1907 Feb 22;25(634):311-3. doi: 10.1126/science.25.6

PMID: 17783538 No abstract available.

Share

The mosquito genome: The post-genomic era opens

Chromosome	
X	
2R	
2L	
3R	
3L	

Number of SNPs
2,955
162,335
44,604
102,203
110,743

1

Cite

Share

Mosquito genomics. Highly evolvable malaria vectors: the genomes of 16 Anopheles mosquitoes.

Neafsey DE, Waterhouse RM, Abai MR, Aganezov SS, Alekseyev MA, Allen JE, Amon J, Arcà B, Arensburger P, Artemov G, Assour LA, Basseri H, Berlin A, Birren BW, Blandin SA, Brockman AI, Burkot TR, Burt A, Chan CS, Chauve C, Chiu JC, Christensen M, Costantini C, Davidson VL, Deligianni E, Dottorini T, Dritsou V, Gabriel SB, Guelbeogo WM, Hall AB, Han MV, Hlaing T, Hughes DS, Jenkins AM, Jiang X, Jungreis I, Kakani EG, Kamali M, Kemppainen P, Kennedy RC, Kirmitzoglou IK, Koekemoer LL, Laban N, Langridge N, Lawniczak MK, Lirakis M, Lobo NF, Lowy E, MacCallum RM, Mao C, Maslen G, Mbogo C, McCarthy J, Michel K, Mitchell SN, Moore W, Murphy KA, Naumenko AN, Nolan T, Novoa EM, O'Loughlin S, Oringanje C, Oshaghi MA, Pakpour N, Papathanos PA, Peery AN, Povelones M, Prakash A, Price DP, Rajaraman A, Reimer LJ, Rinker DC, Rokas A, Russell TL, Sagnon N, Sharakhova MV, Shea T, Simão FA, Simard F, Slotman MA, Somboon P, Stegniy V, Struchiner CJ, Thomas GW, Tojo M, Topalis P, Tubio JM, Unger MF, Vontas J, Walton C, Wilding CS, Willis JH, Wu YC, Yan G, Zdobnov EM, Zhou X, Catteruccia F, Christophides GK, Collins FH, Cornman RS, Crisanti A, Donnelly MJ, Emrich SJ, Fontaine MC, Gelbart W, Hahn MW, Hansen IA, Howell PI, Kafatos FC, Kellis M, Lawson D, Louis C, Luckhart S, Muskavitch MA, Ribeiro JM, Riehle MA, Sharakhov IV, Tu Z, Zwiebel LJ, Besansky NJ.

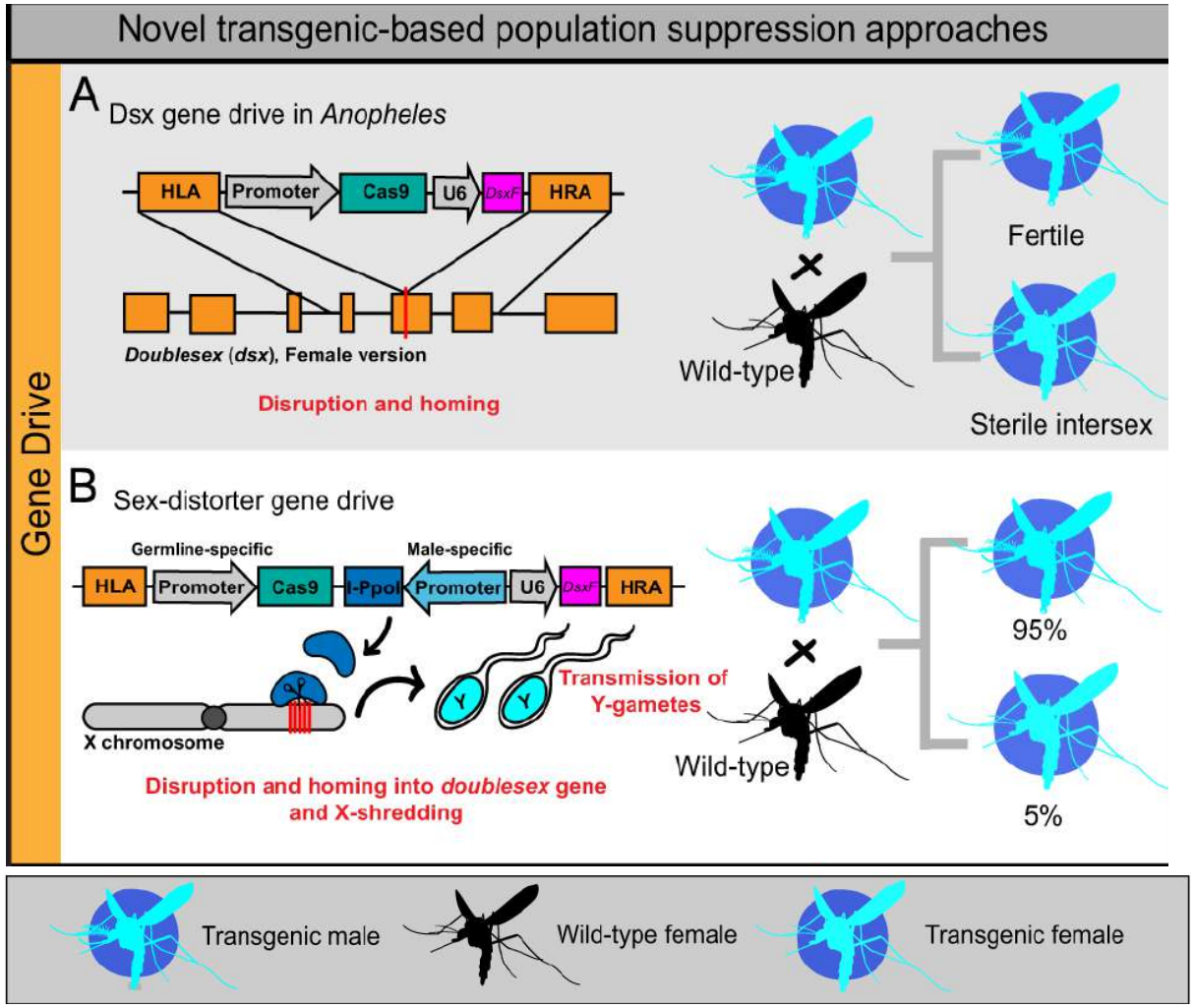
Science. 2015 Jan 2;347(6217):1258522. doi: 10.1126/science.1258522. Epub 2014 Nov 27.

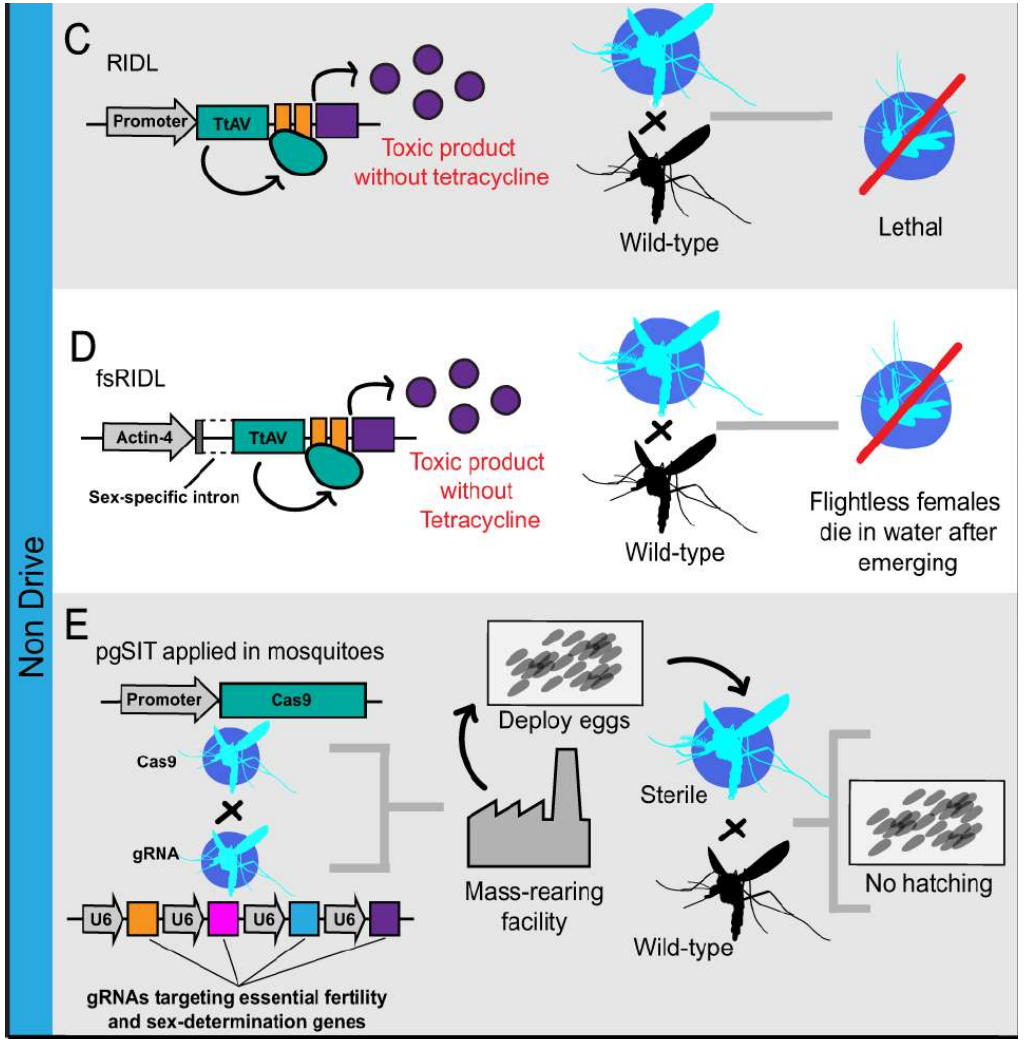
PMID: 25554792 **Free PMC article.**

The main direction of mosquito research

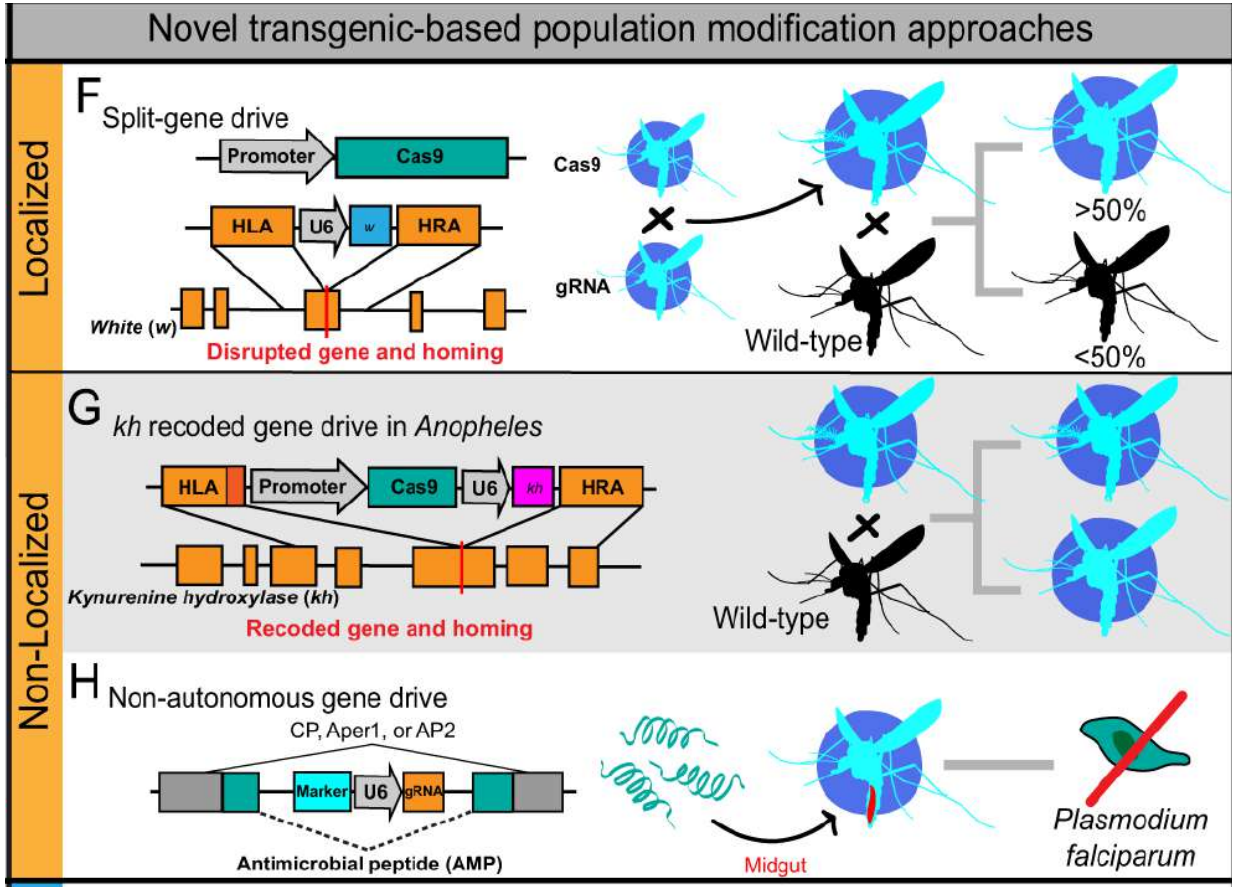
- **Transmission and control of diseases caused by mosquitoes**

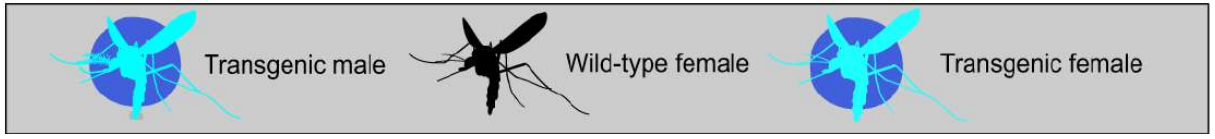
Population suppression

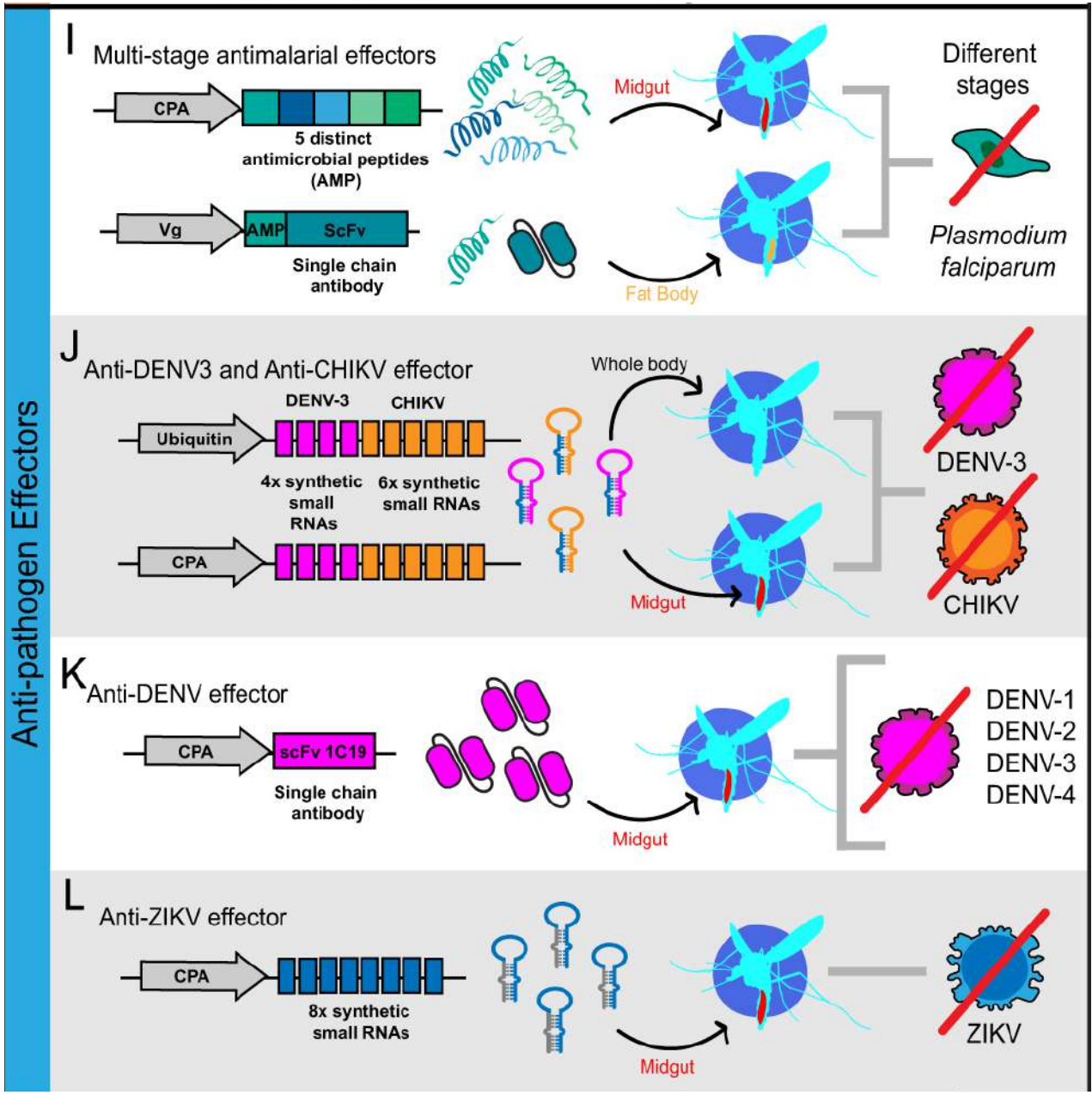


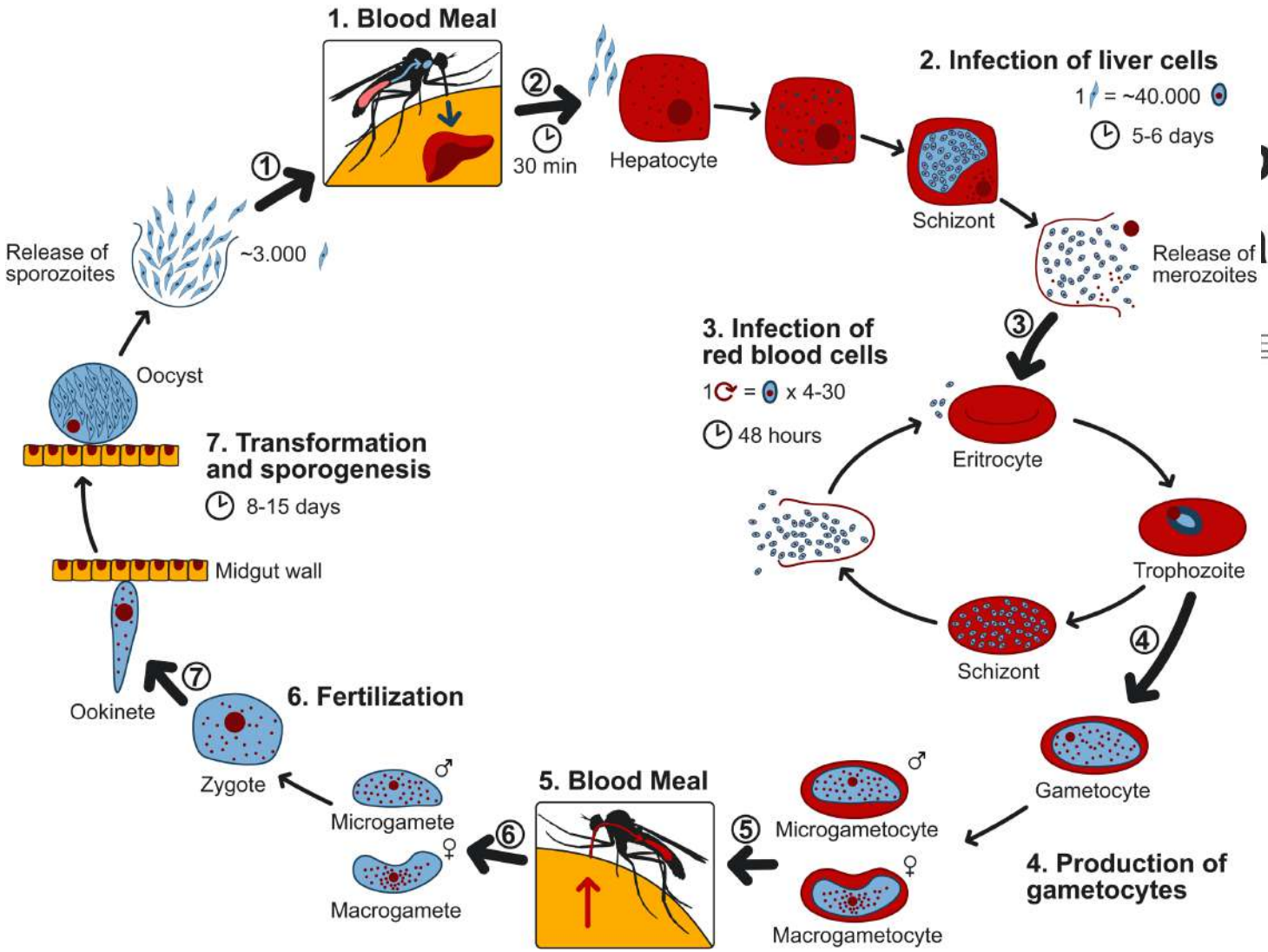


Population modification









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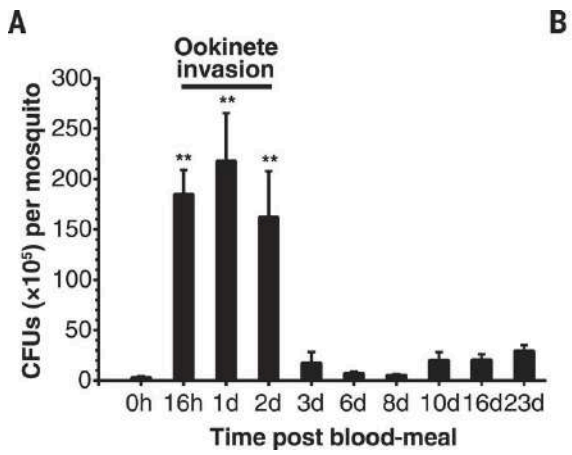
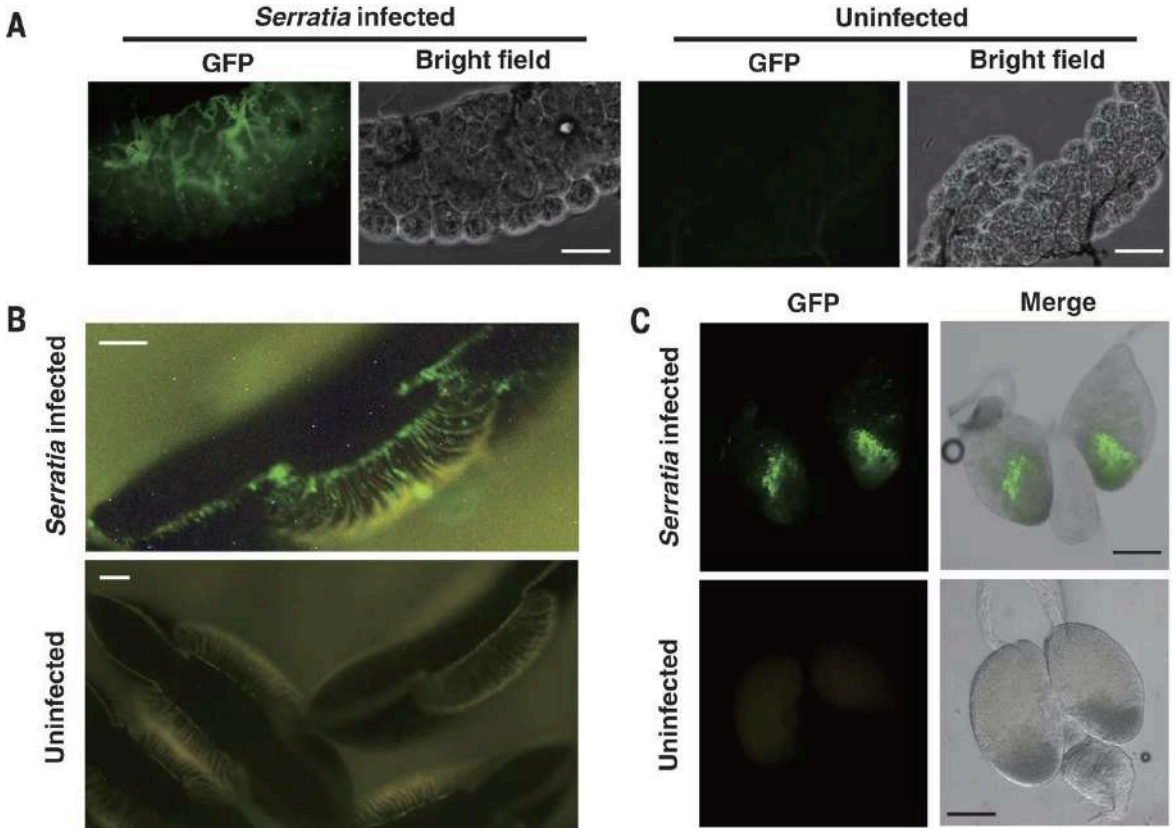
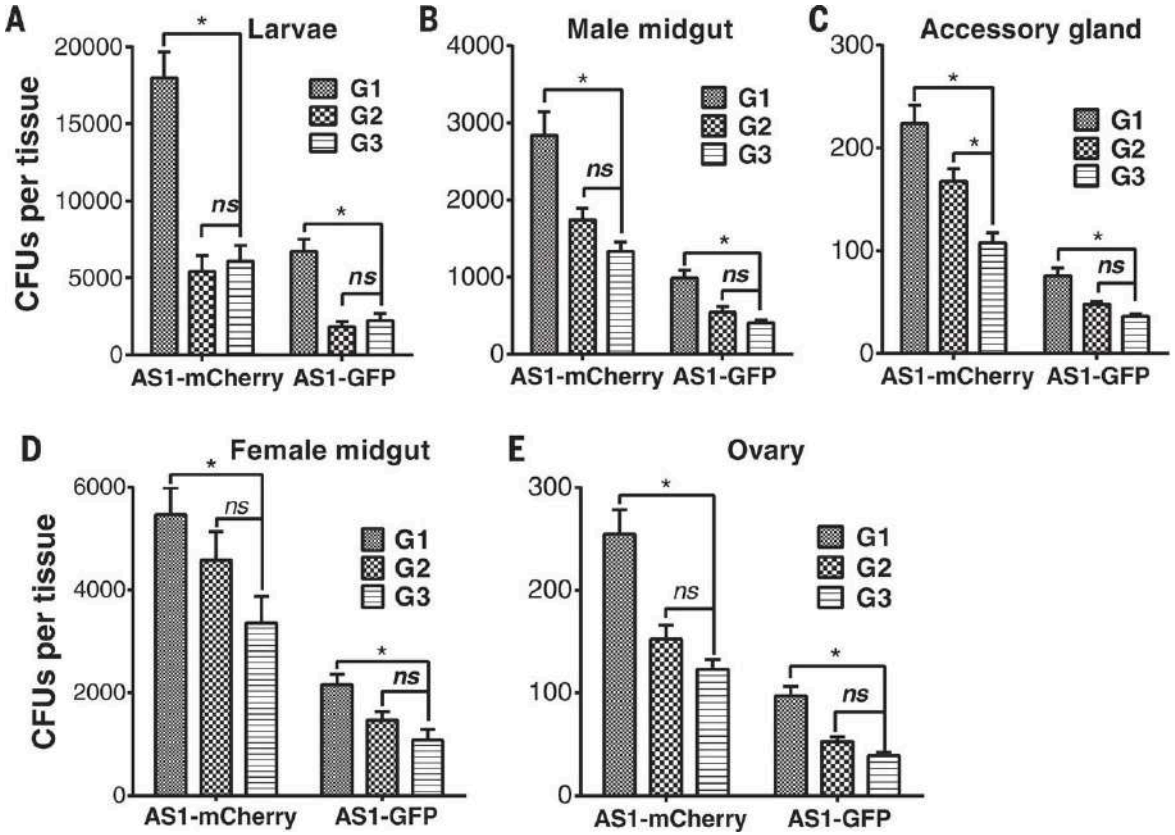
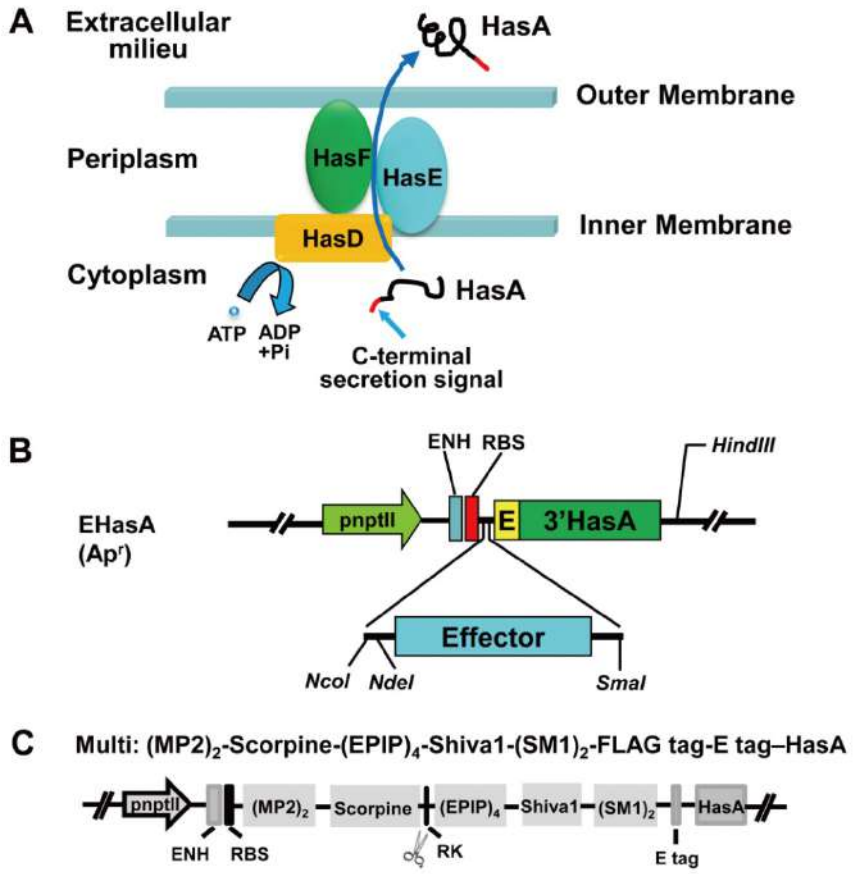


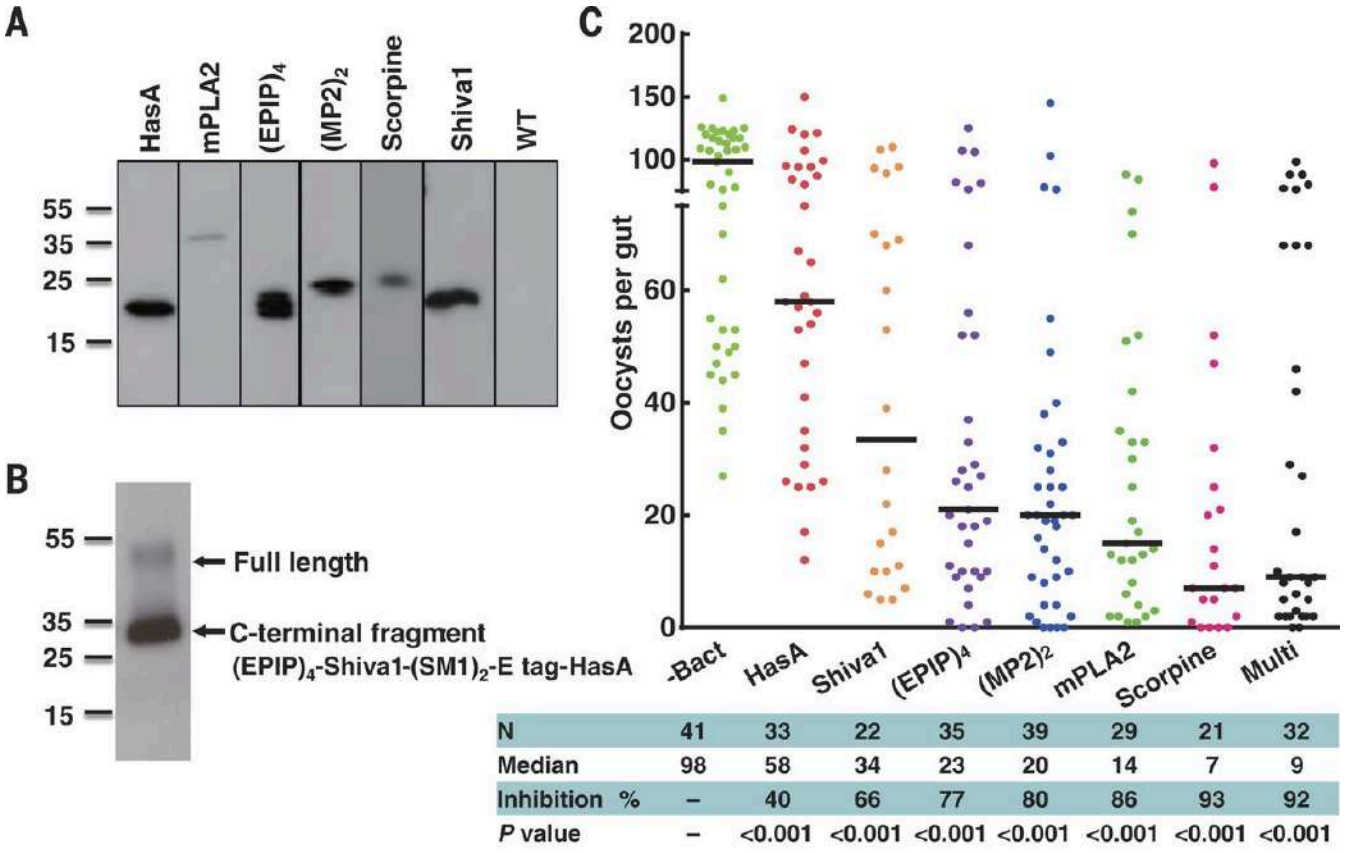
Serratia AS1 bacteria efficiently spread throughout multiple mosquito generations





Inhibition of *P. falciparum* infection of *A. gambiae* by recombinant *Serratia* strains





	-Bact	HasA	Shiva1	(EPIP)4	(MP2)2	mPLA2	Scorpine	Multi
N	41	33	22	35	39	29	21	32
Median	98	58	34	23	20	14	7	9
Inhibition %	–	40	66	77	80	86	93	92
P value	–	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Cell

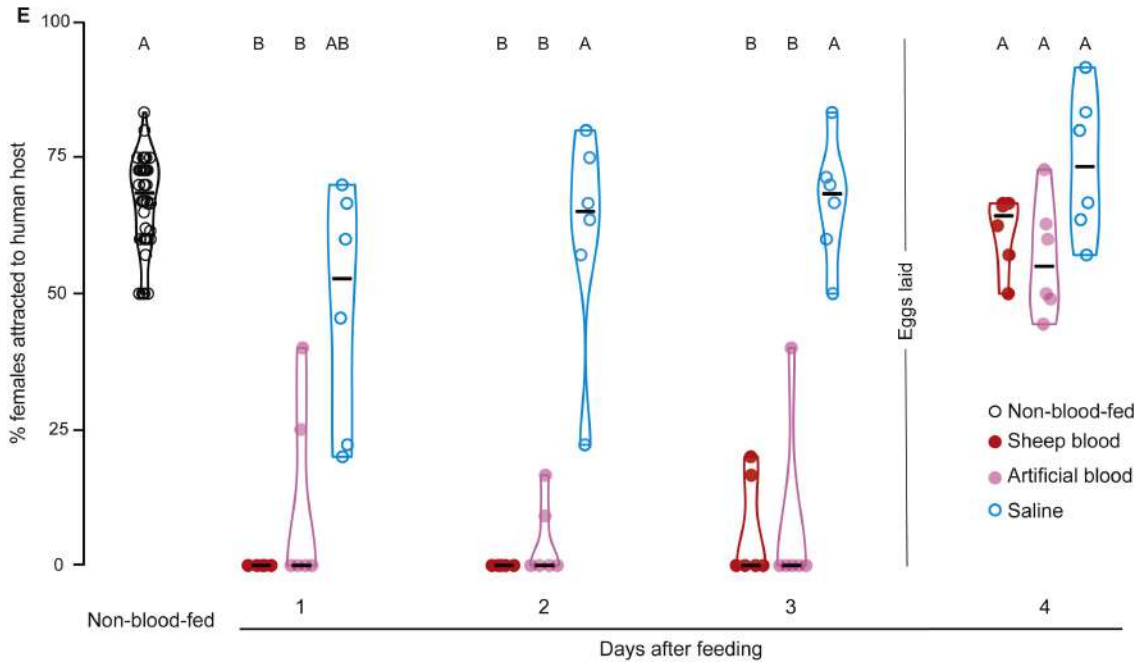
Volume 176, Issue 4, 7 February 2019, Pages 687-701.e5

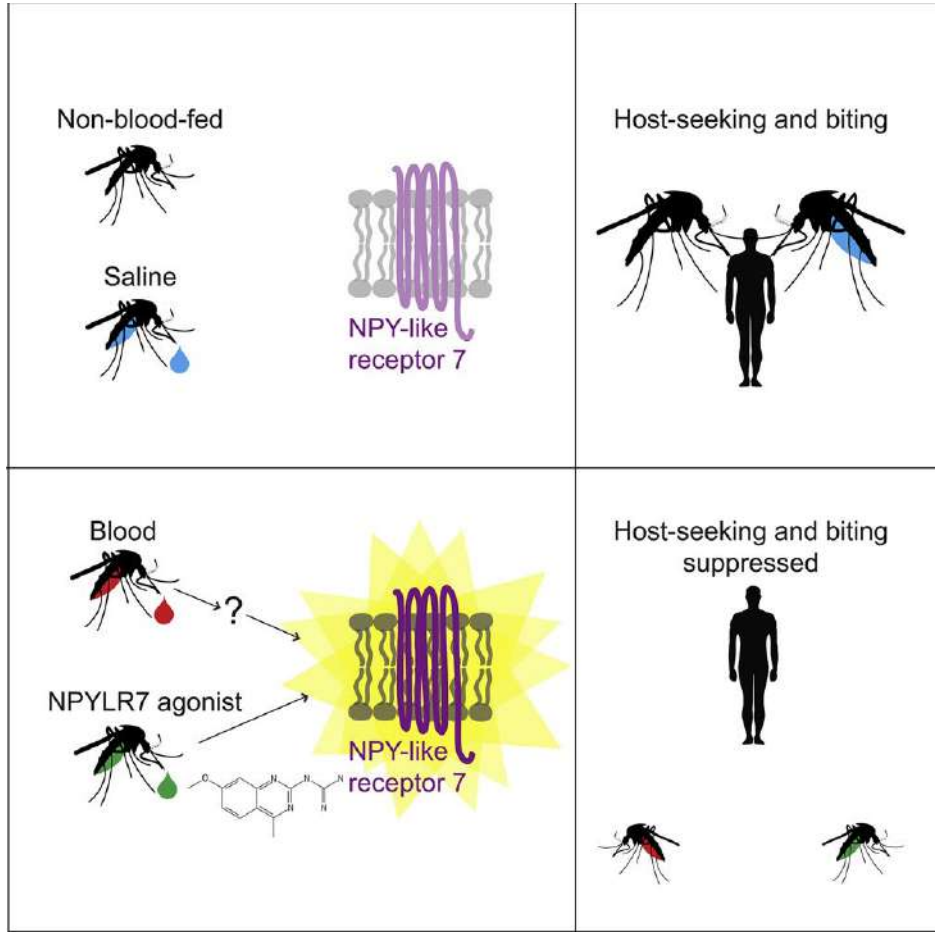
Article

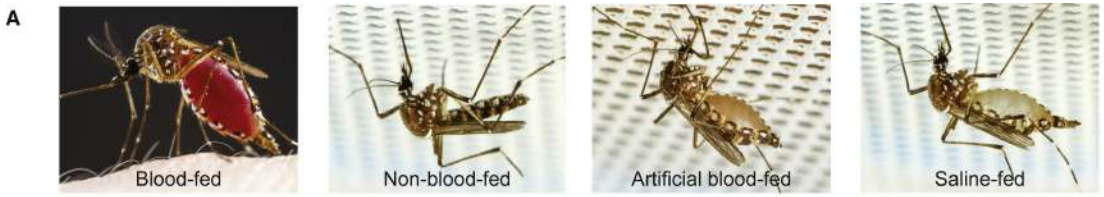
Small-Molecule Agonists of *Ae. aegypti* Neuropeptide Y Receptor Block Mosquito Biting

Laura B. Duvall [1], Lavoisier Ramos-Espiritu [2], Kyrollos E. Barsoum [1], J. Fraser Glickman [2], Leslie B. Vosshall [1, 3, 4, 5]

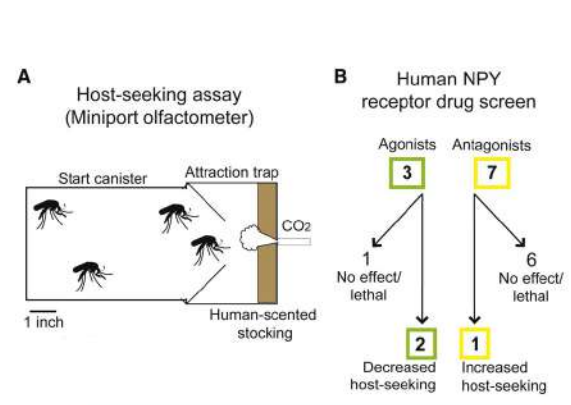
Protein-Rich Blood Meals Induce Sustained Host-Seeking Suppression

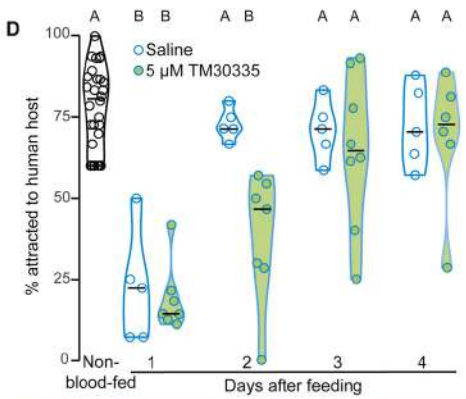


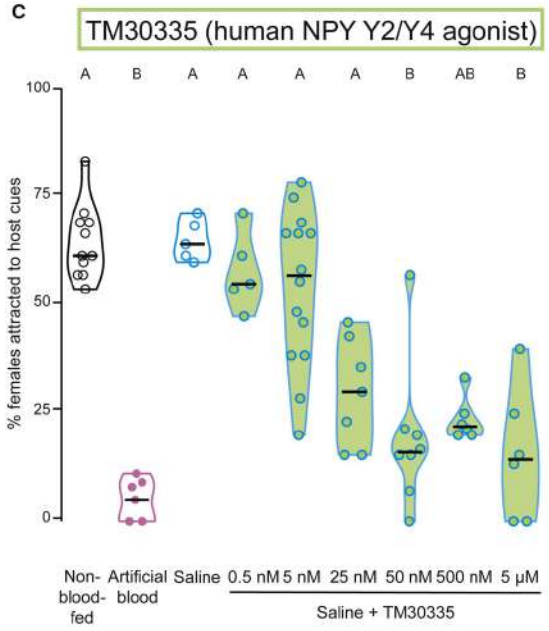


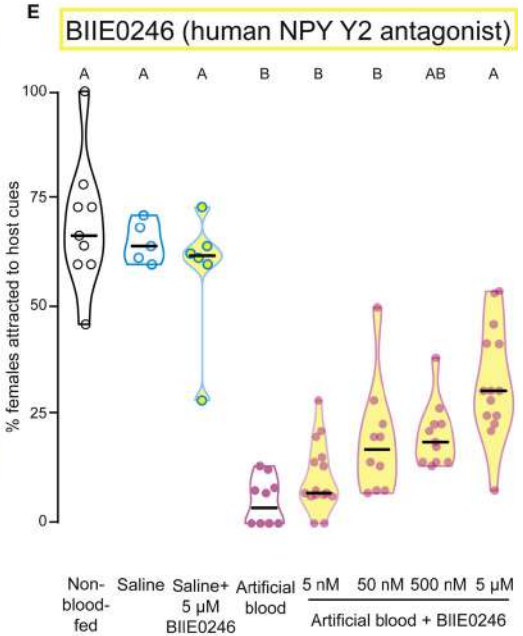


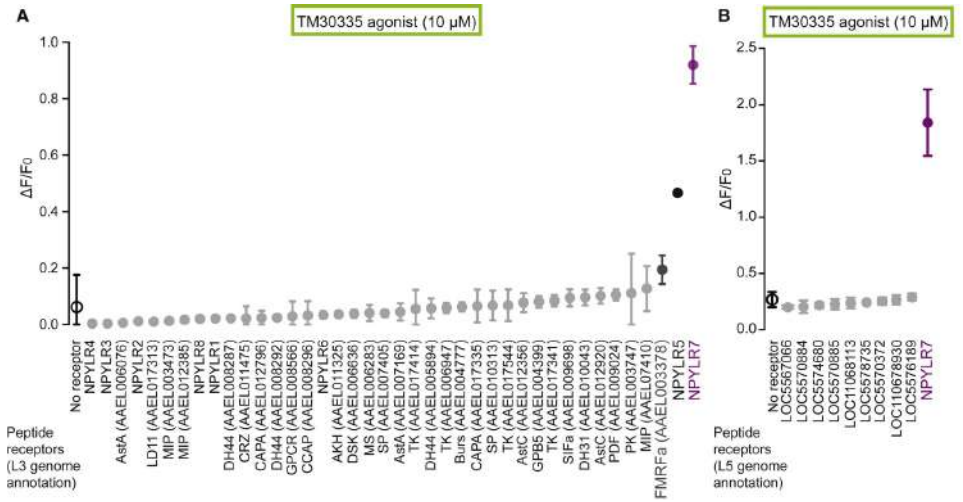
NPYLR7 mutant mosquitoes show abnormal host-seeking regulation

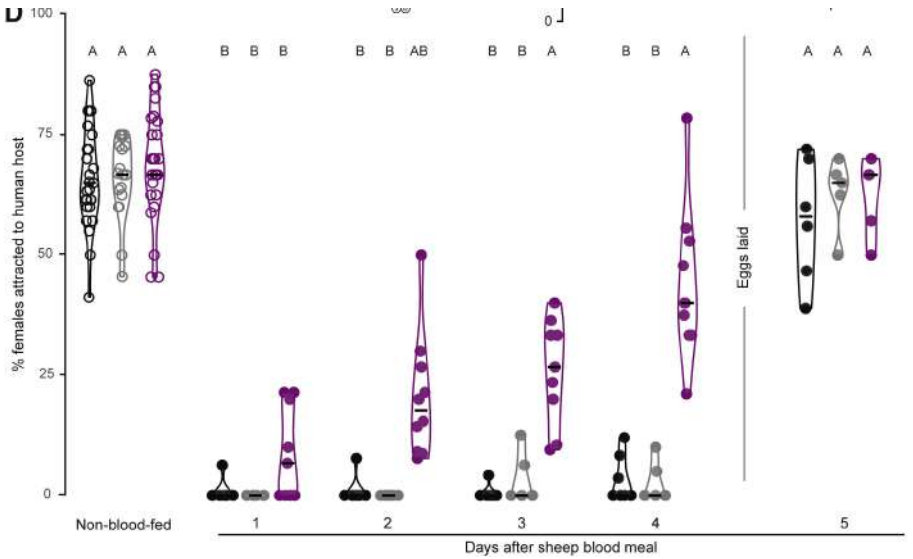




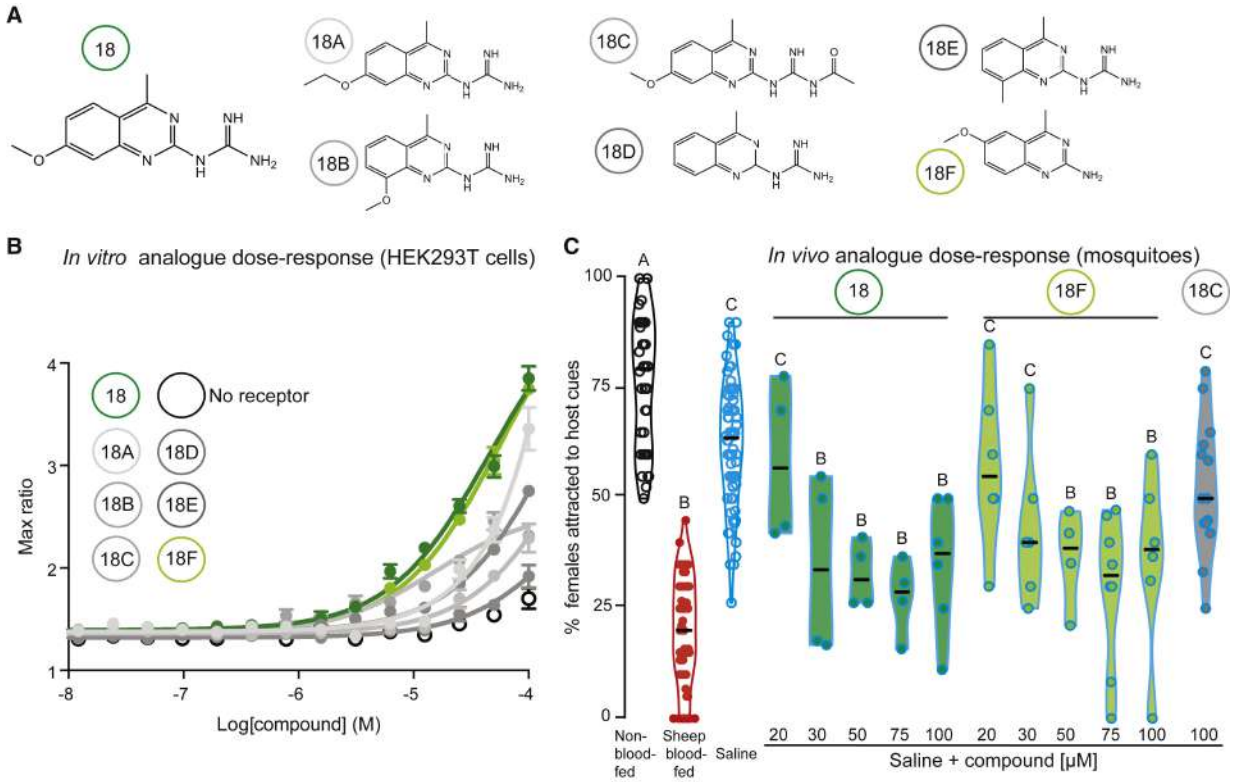


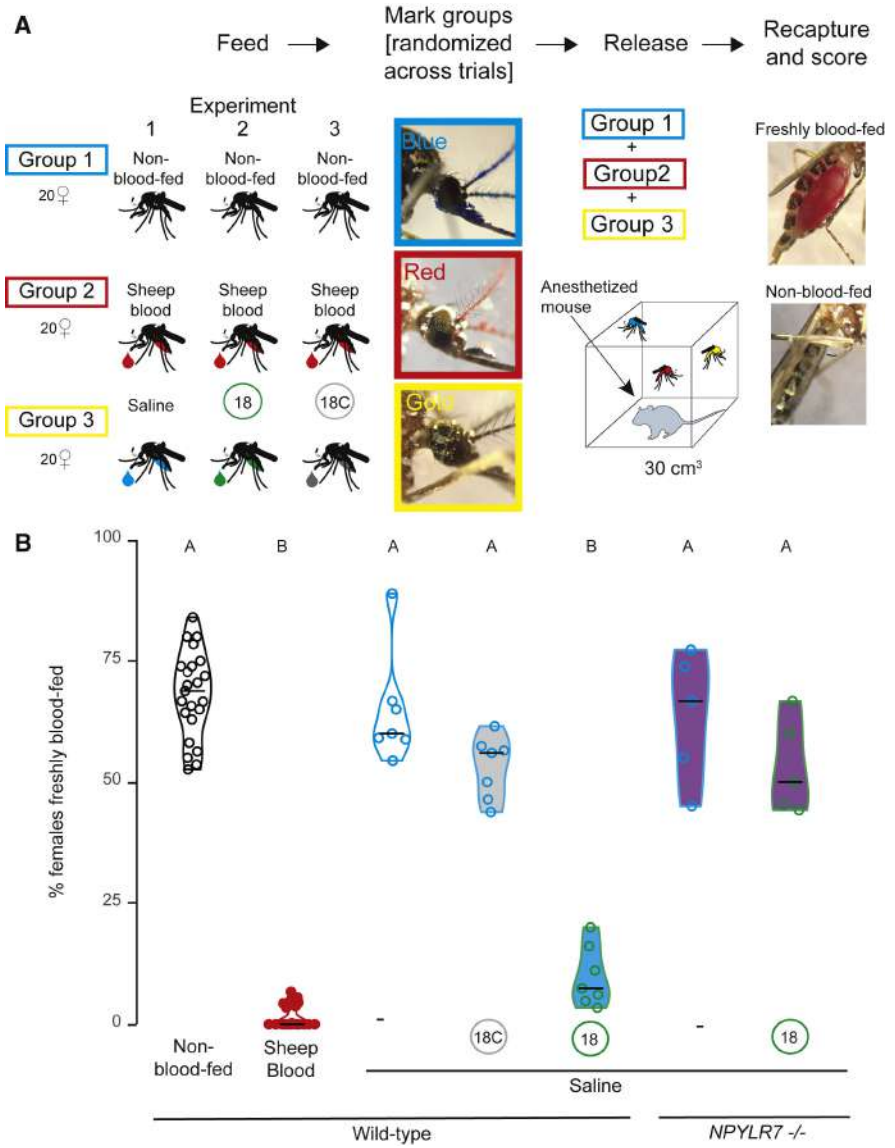






Small-molecule NPYLR7 agonists suppress mosquito host-seeking and biting behavior

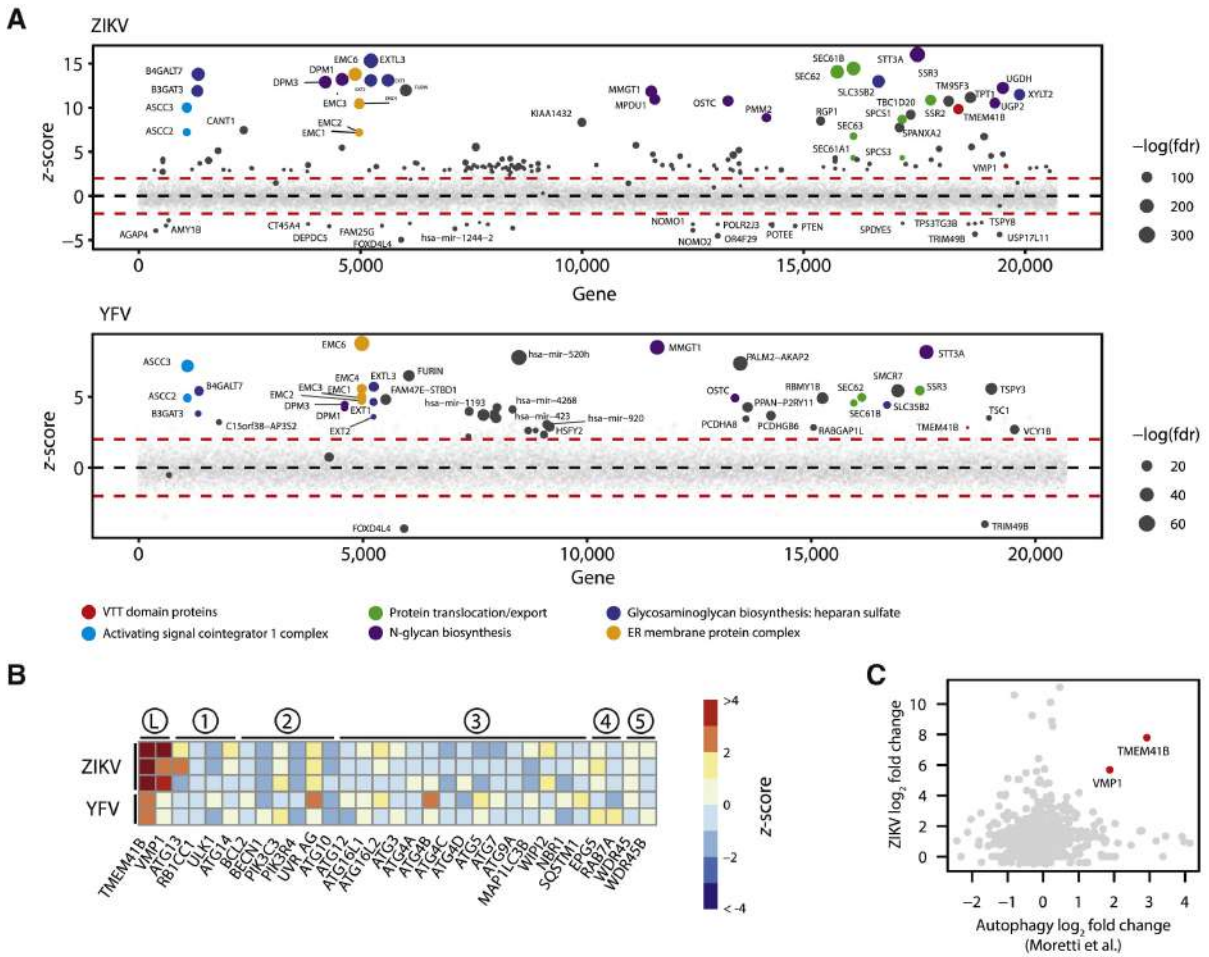


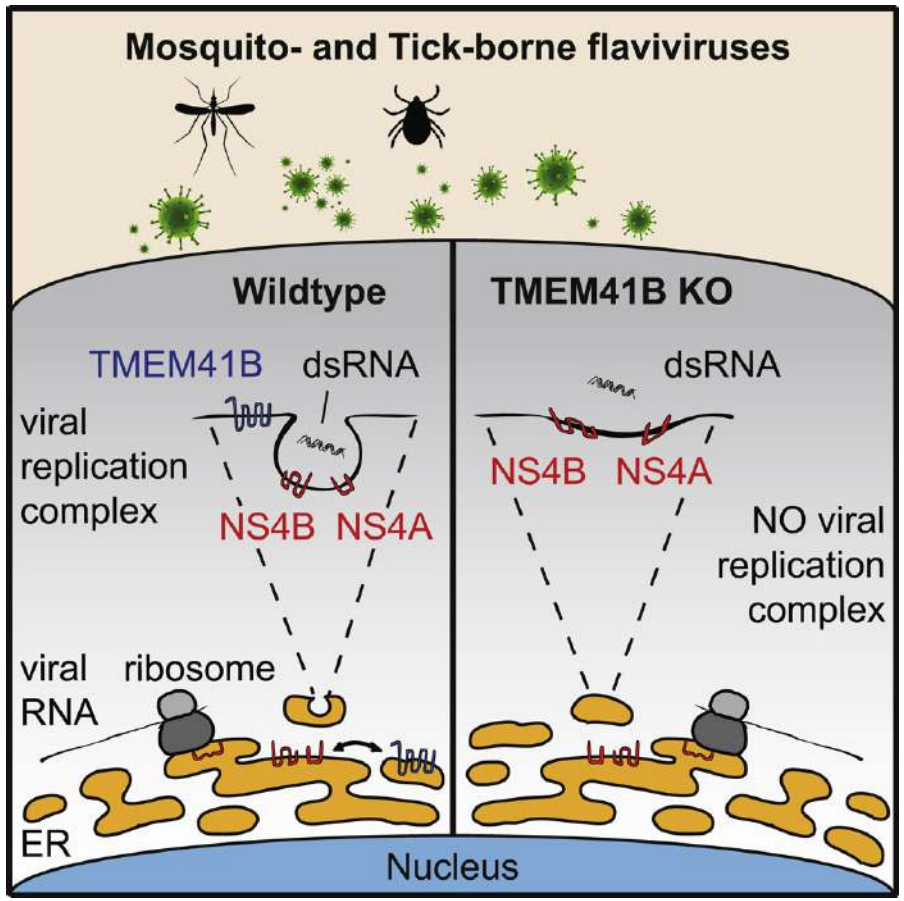


Cell
Volume 184, Issue 1, 7 January 2021, Pages 133-148.e20

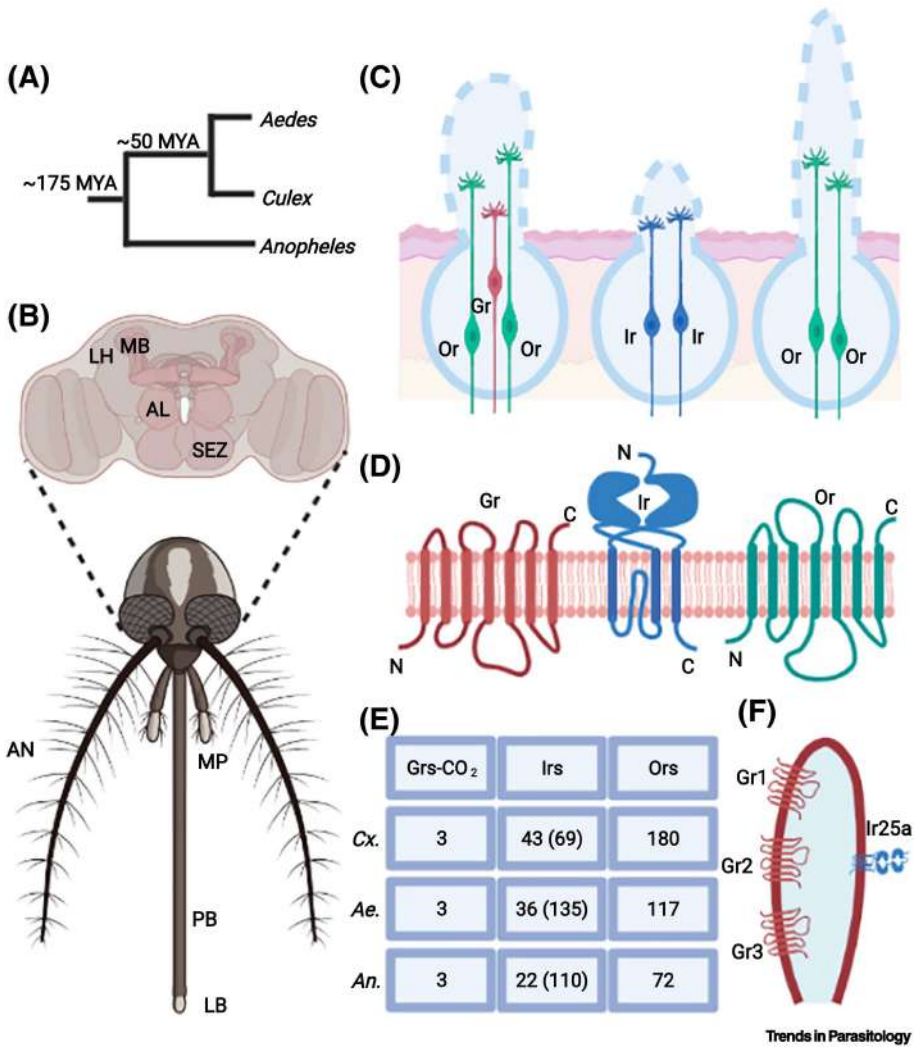
Article

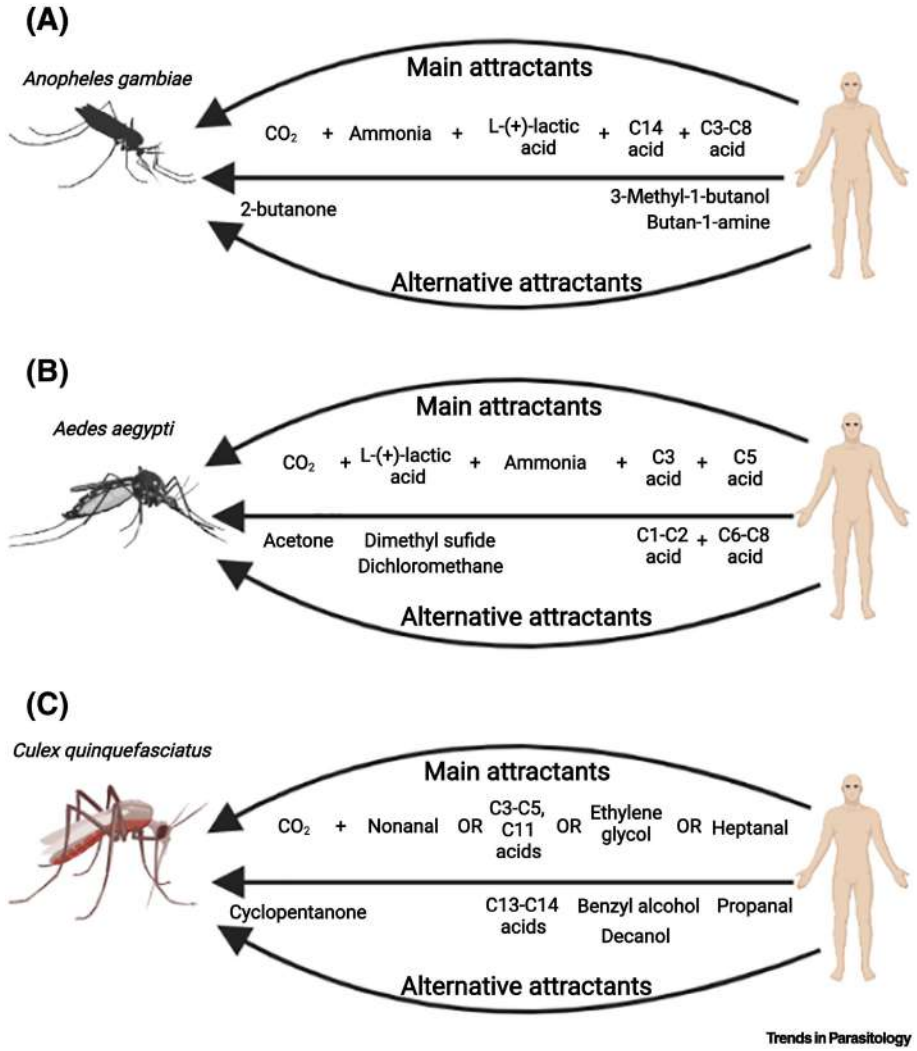
TMEM41B Is a Pan-flavivirus Host Factor





- Mosquitoes host seeking behavior



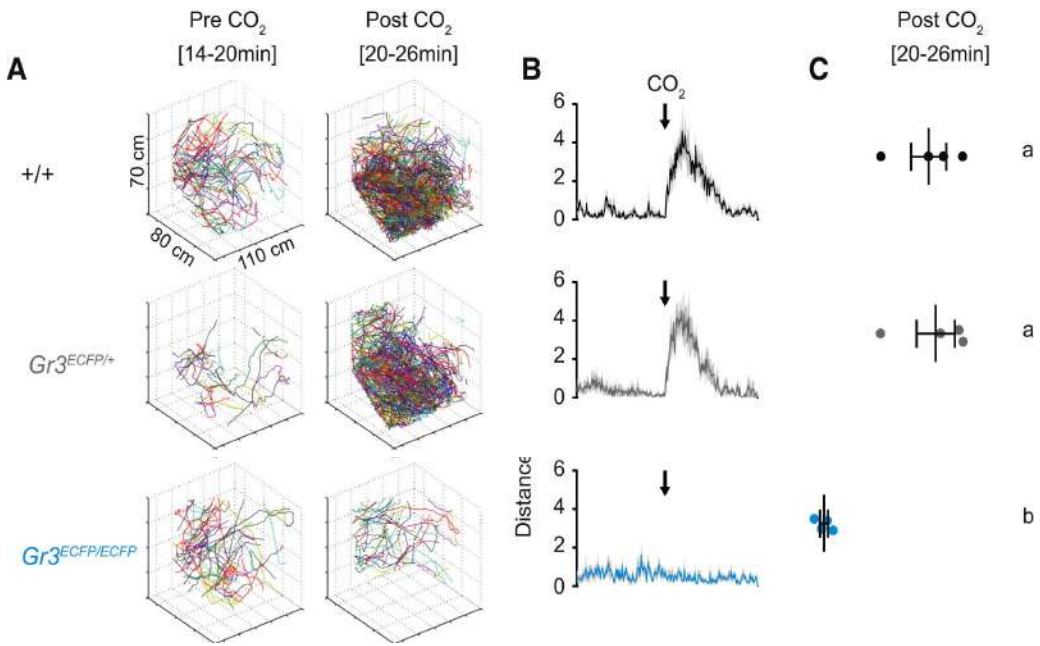


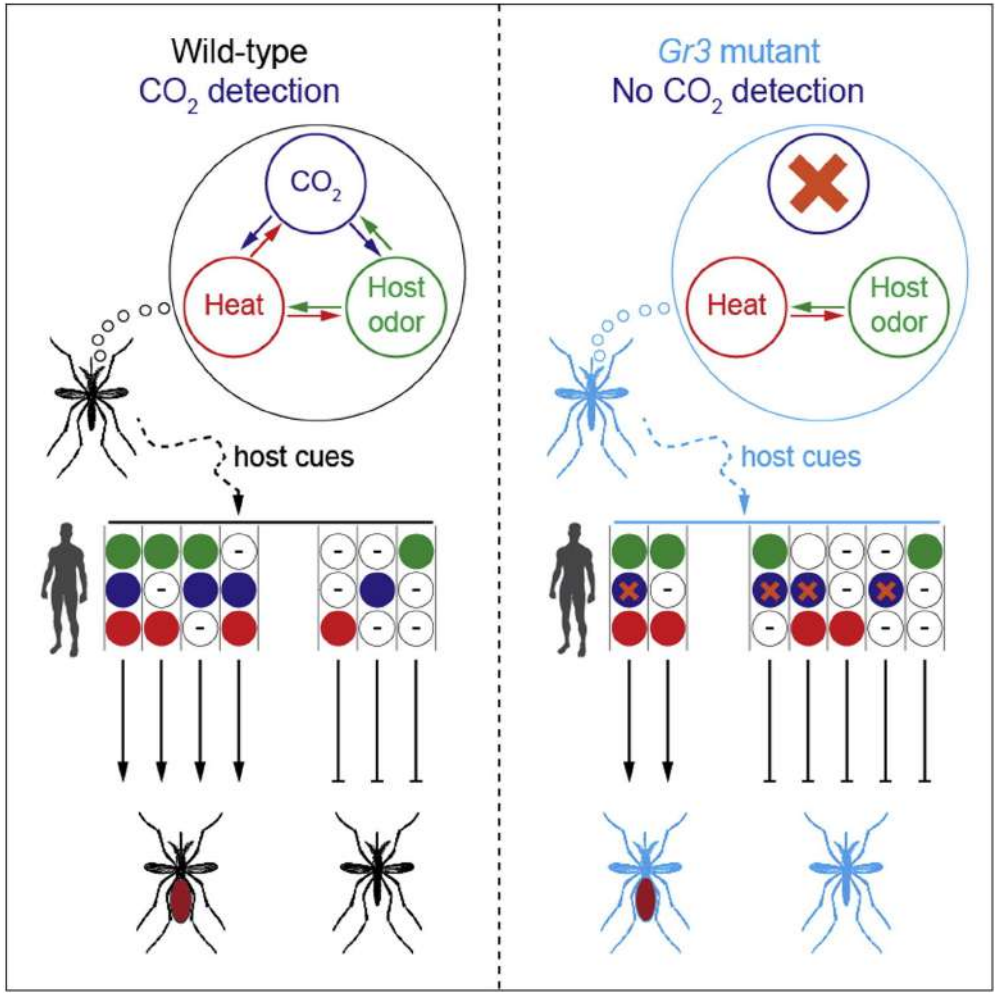
Cell
Volume 156, Issue 5, 27 February 2014, Pages 1060-1071

Article

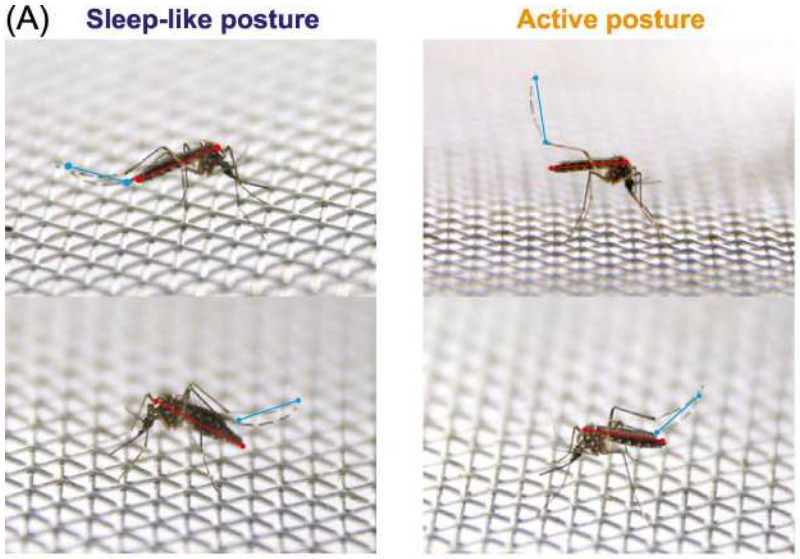
Multimodal Integration of Carbon Dioxide and Other Sensory Cues Drives Mosquito Attraction to Humans

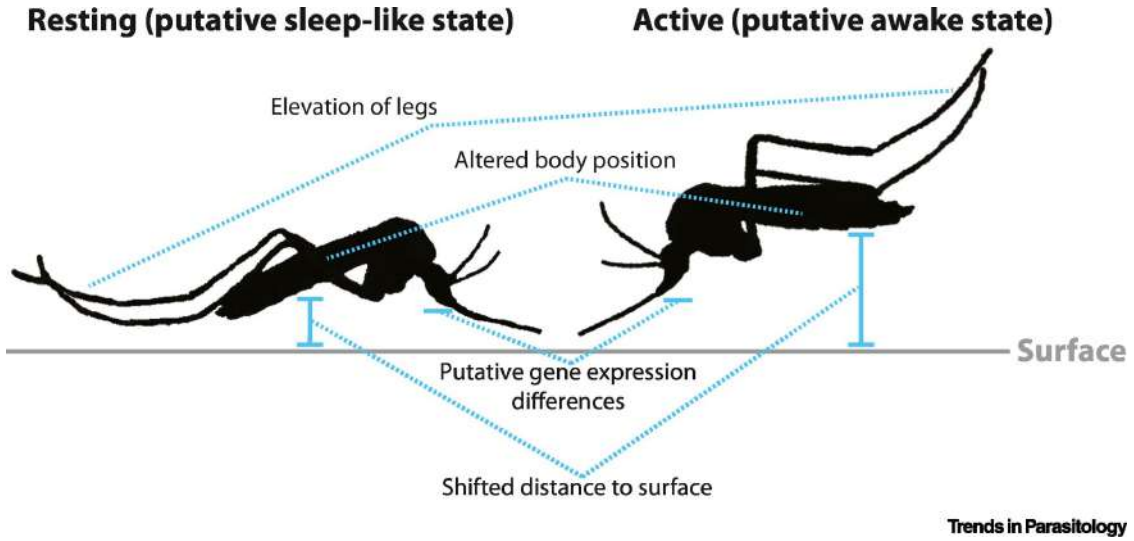
Conor J. McMeniman [1], Román A. Corfas [1], Benjamin J. Matthews [1], Scott A. Ritchie [2], Leslie B. Vosshall [1, 3]





- Sleep, feeding and other behaviors of mosquito





Outstanding Questions

- Does sleep deprivation impact blood-feeding propensity in mosquitoes?
- What effects do human-associated odor blends have on the mosquito sleep-like state?
- How are mosquito immunity and pathogen transmission impacted by sleep deprivation?
- What are the unique gene expression changes associated with mosquito sleep compared with Drosophila?
- What are the interactions between feeding, seasonality, and other factors in relation to mosquito sleep cycles?

Mating behavior of Mosquito

Photograph of *Anopheles gambiae* ss swarm in the VK5 village

Science

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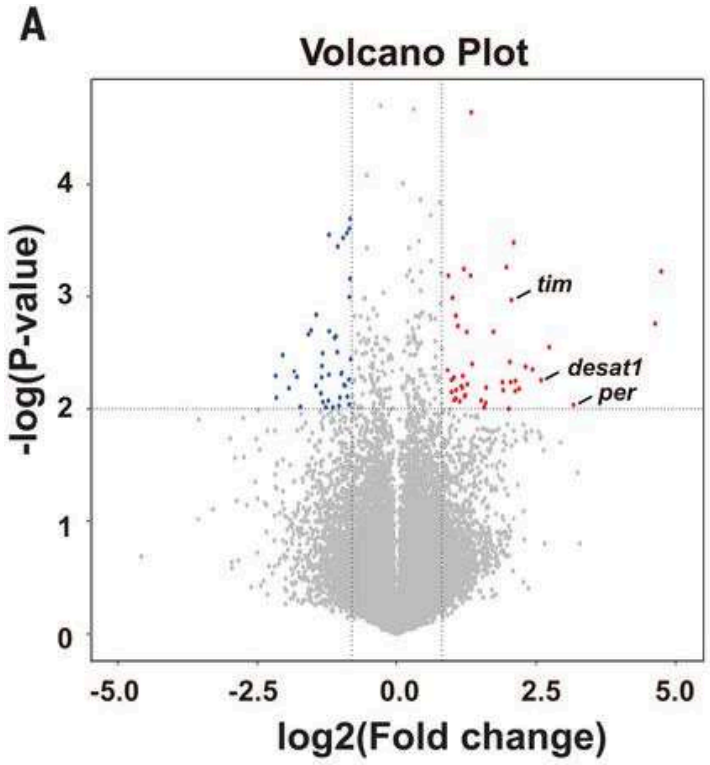
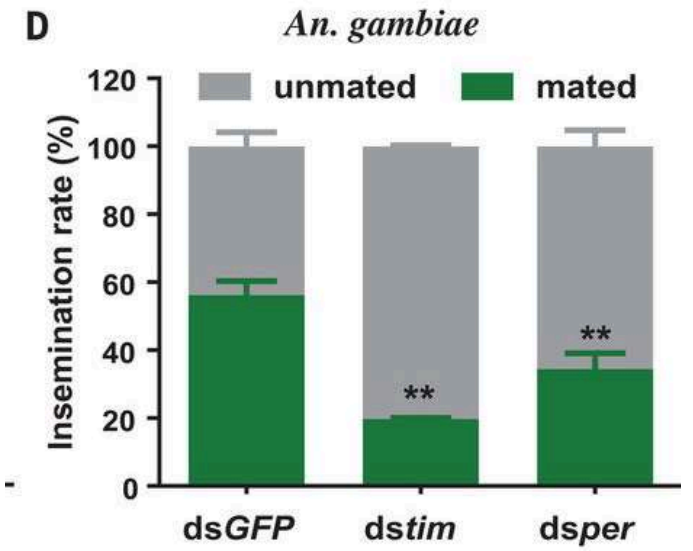
HOME > SCIENCE > VOL. 371, NO. 6527 > CLOCK GENES AND ENVIRONMENTAL CUES COORDINATE ANOPHELES PHEROMONE...

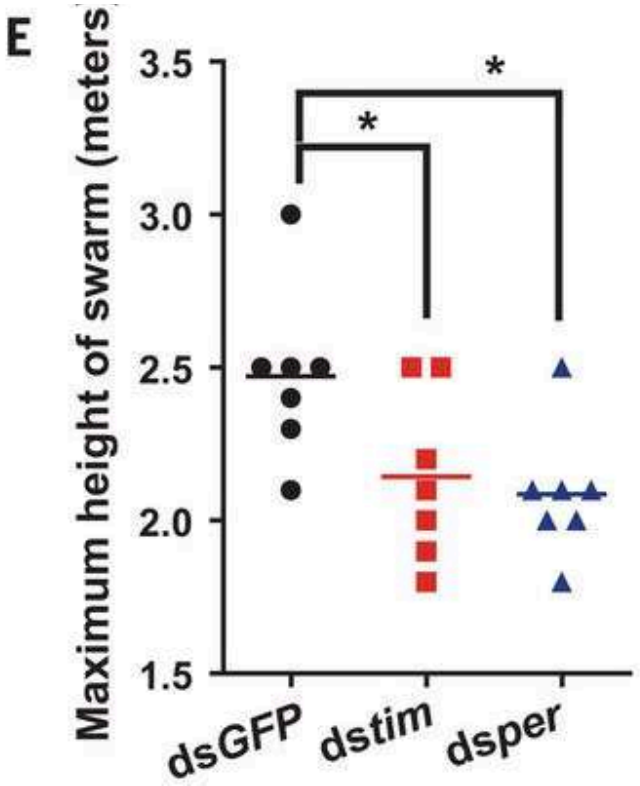
REPORT

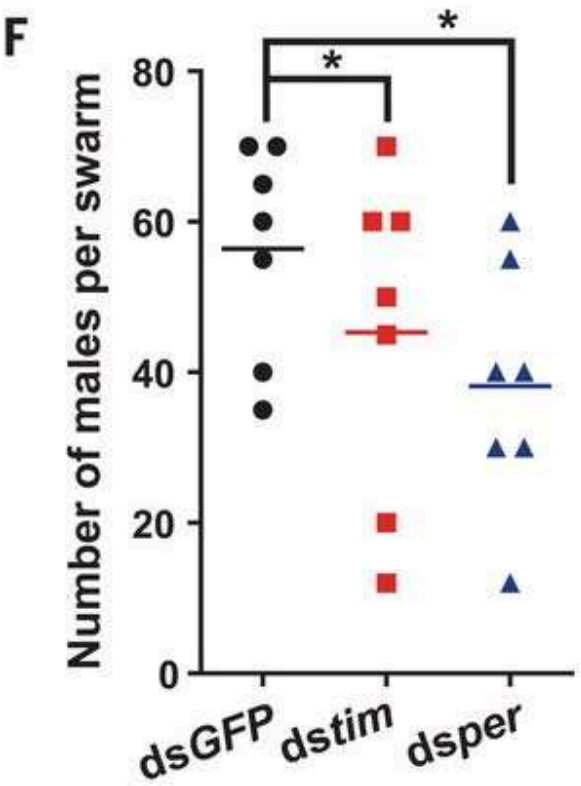
Clock genes and environmental cues coordinate *Anopheles* pheromone synthesis, swarming, and mating

Transcriptome analysis of *An. coluzzii* head gene expression between swarming and non-swarming male mosquitoes

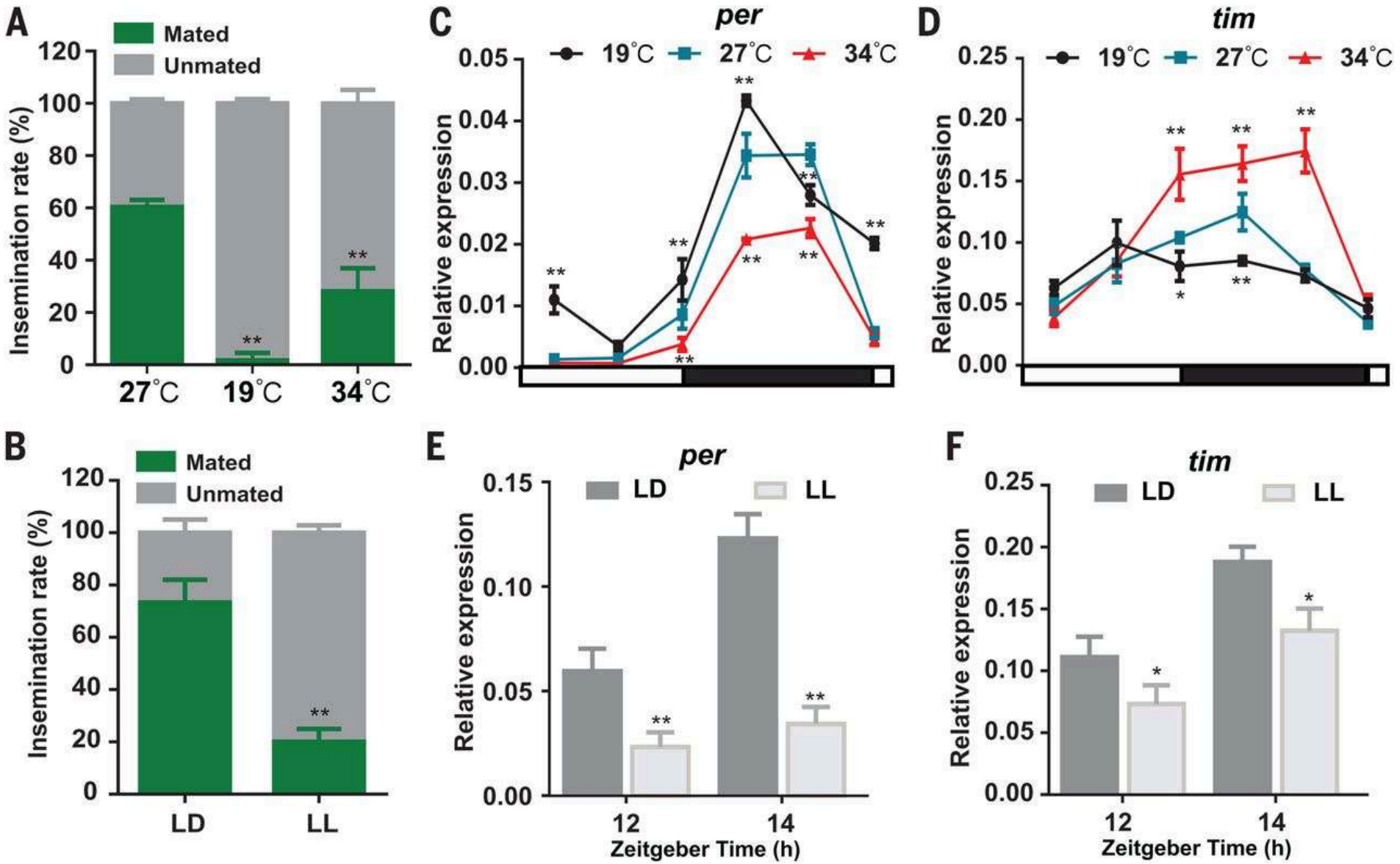




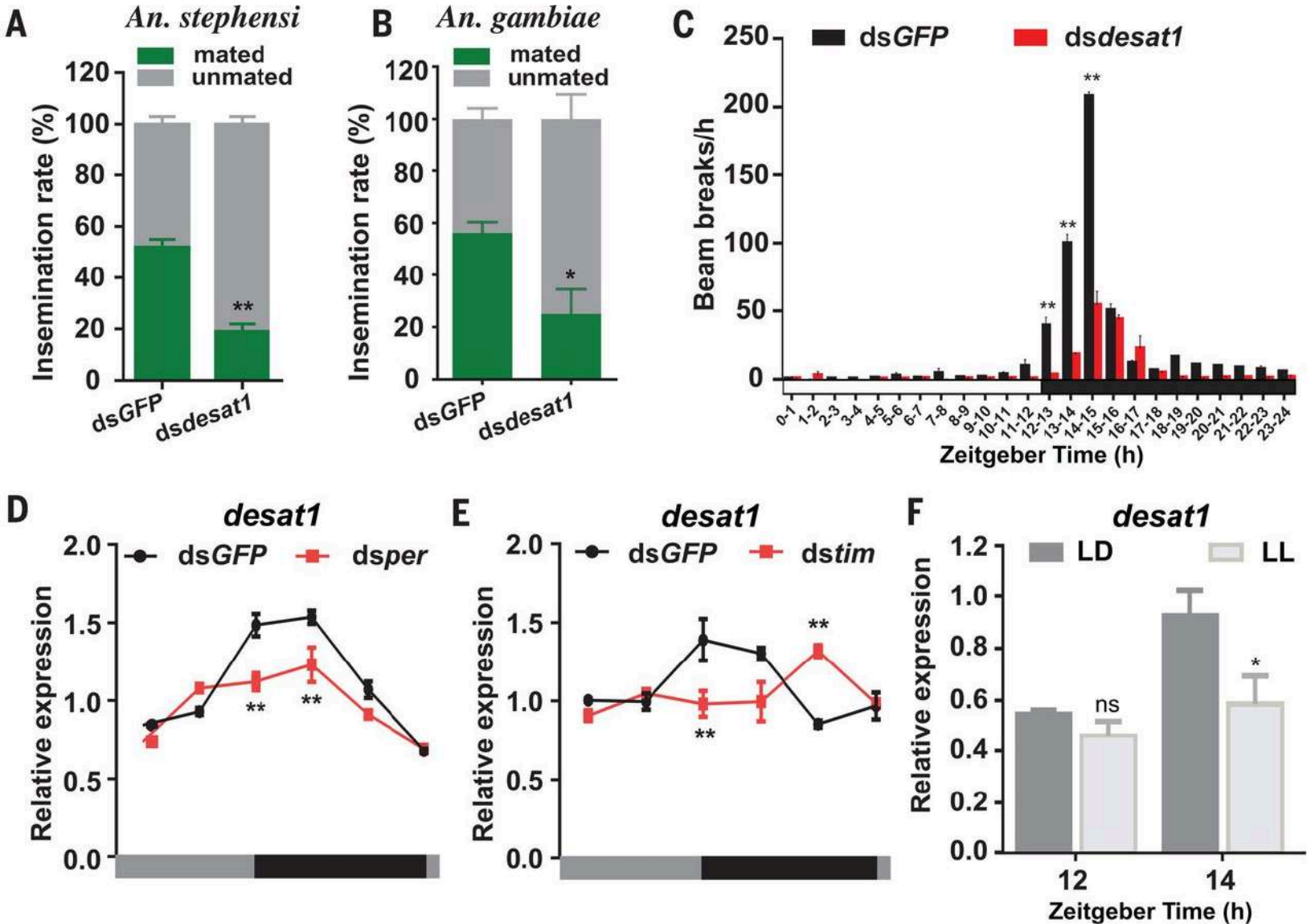




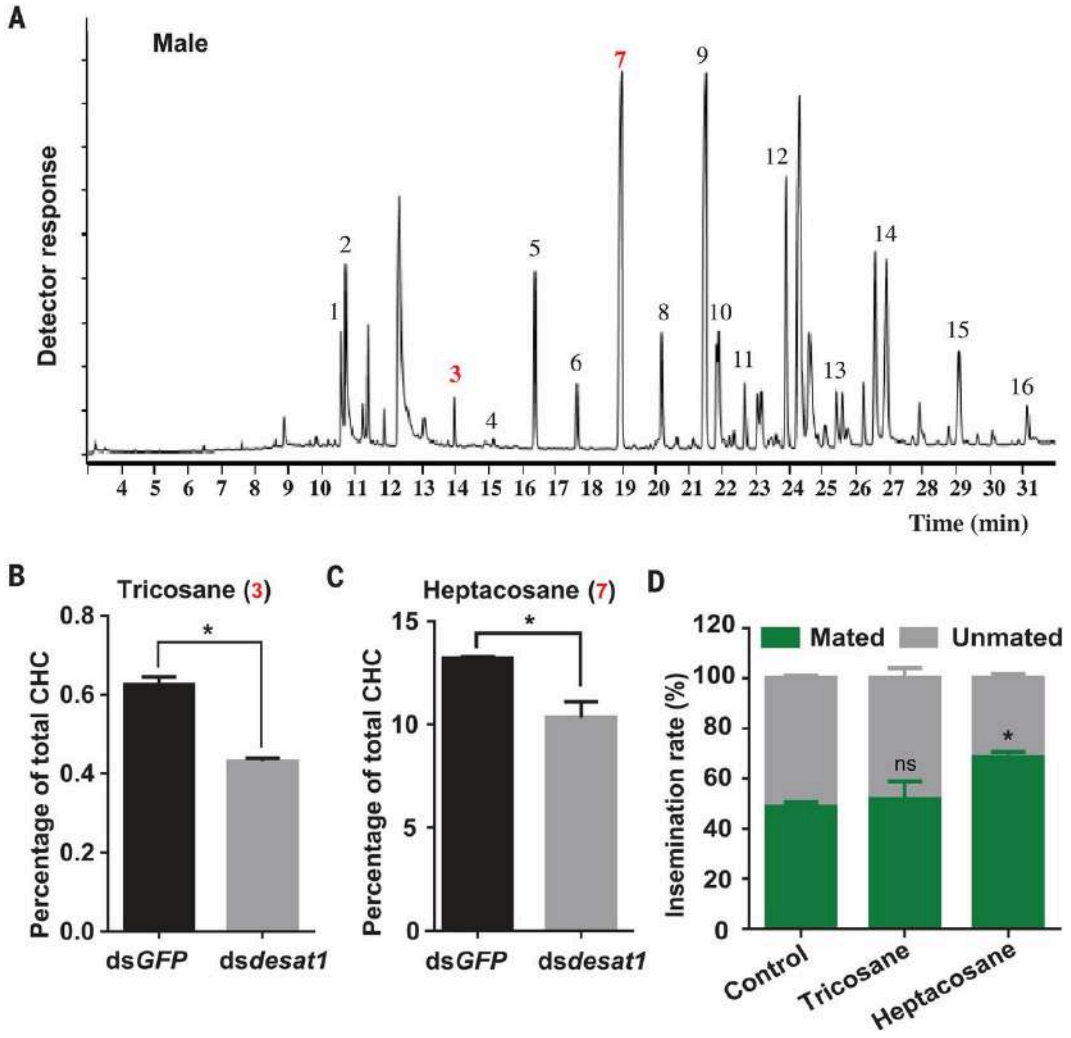
Temperature and light affect mating activity



Desat1 regulates male flight activity and mating.



Silencing of *desat1* changes the CHC profile of male mosquitoes



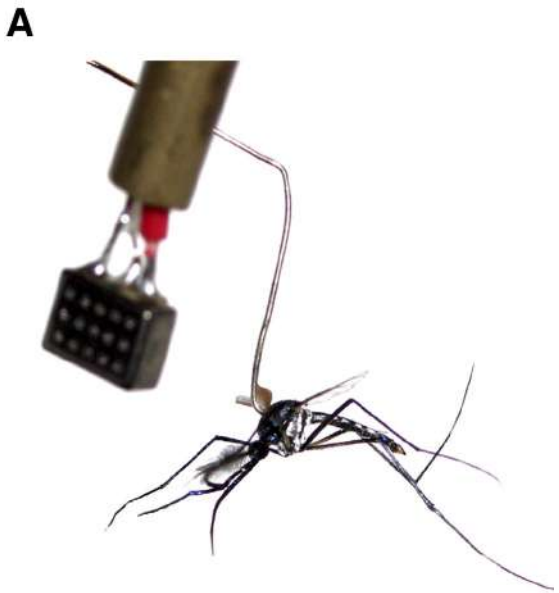
Current Biology

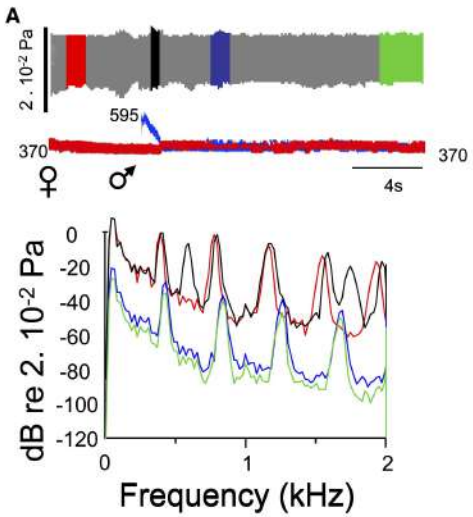
Volume 16, Issue 13, 11 July 2006, Pages 1311-1316

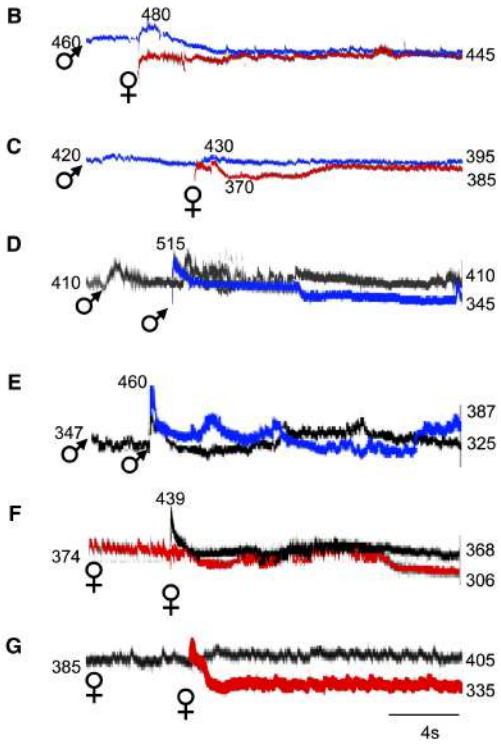
Report

Flying in Tune: Sexual Recognition in Mosquitoes

Gabriella Gibson [1], Ian Russell [2]







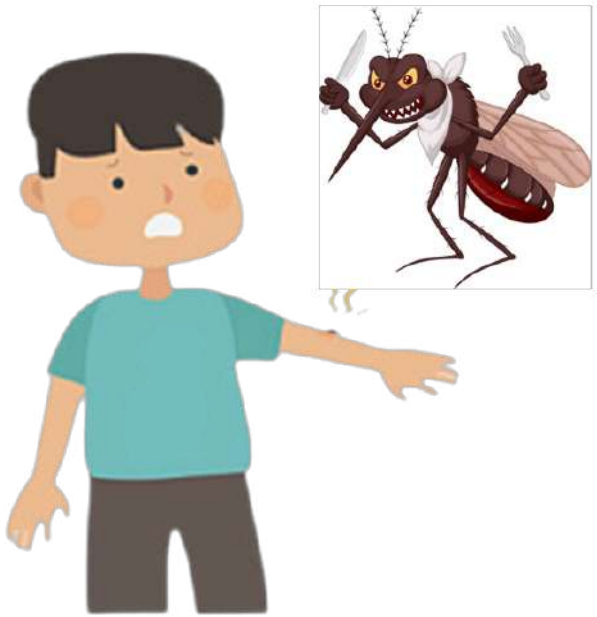
Flight Tones of a Tethered Female and a Tethered Male *Tx brevipalis*

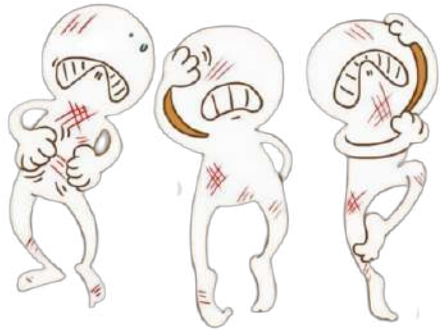
How Mosquitoes Locate a Blood Host

ZYN

2022/07/01

Background

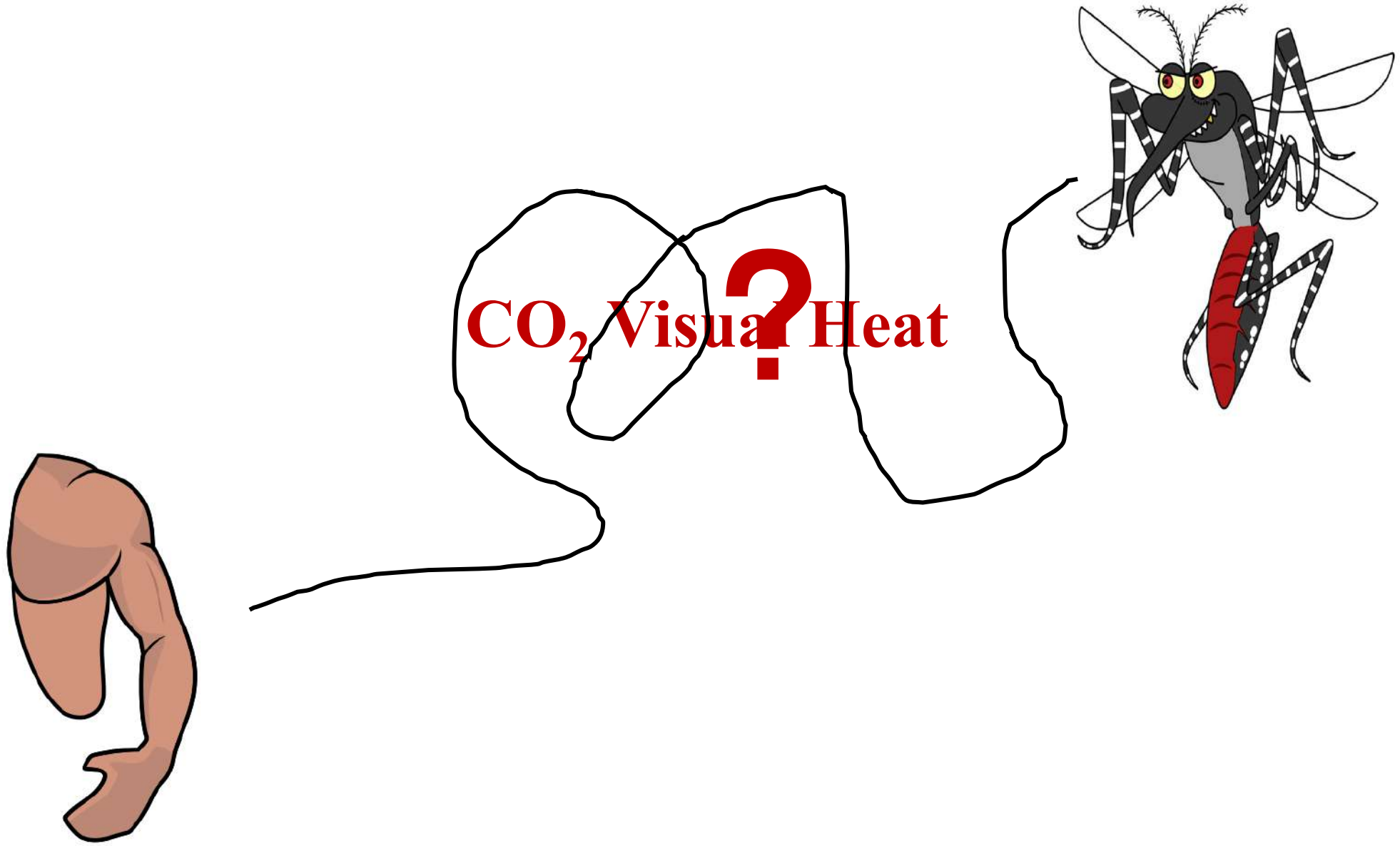




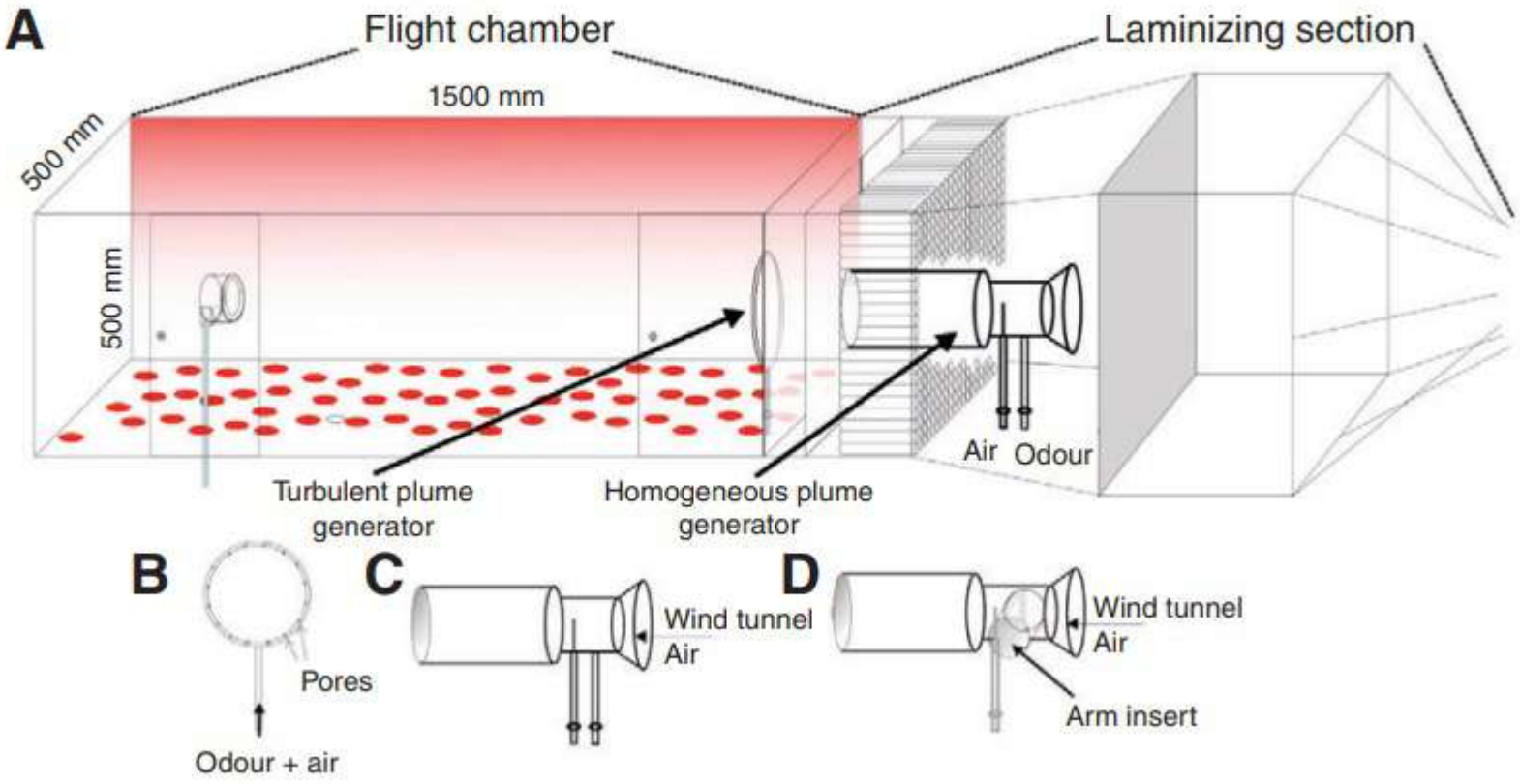
登革热
黄热病
基孔肯雅热
寨卡病毒

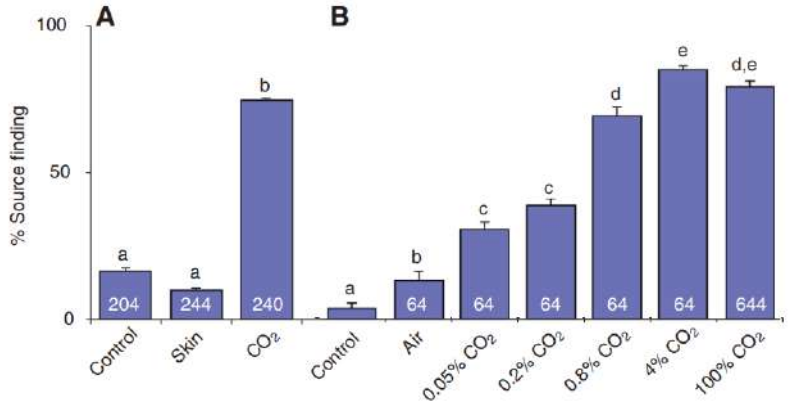
Background

- 登革热
- 黄热病
- 寨卡病毒
- 基孔肯雅热


CO_2 Visual ? Heat

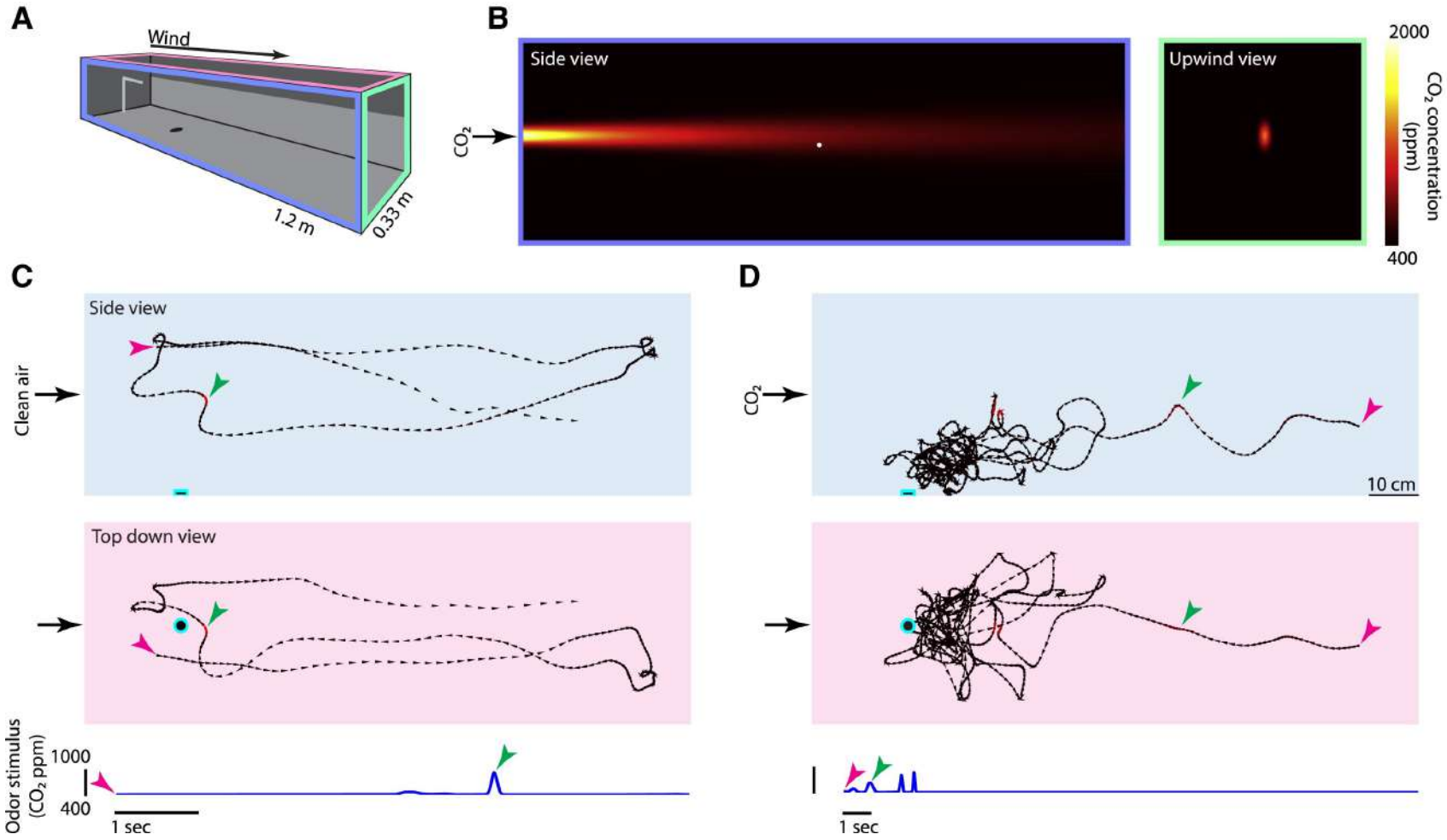
Wind tunnel experiment :CO_2 can attract mosquitoes





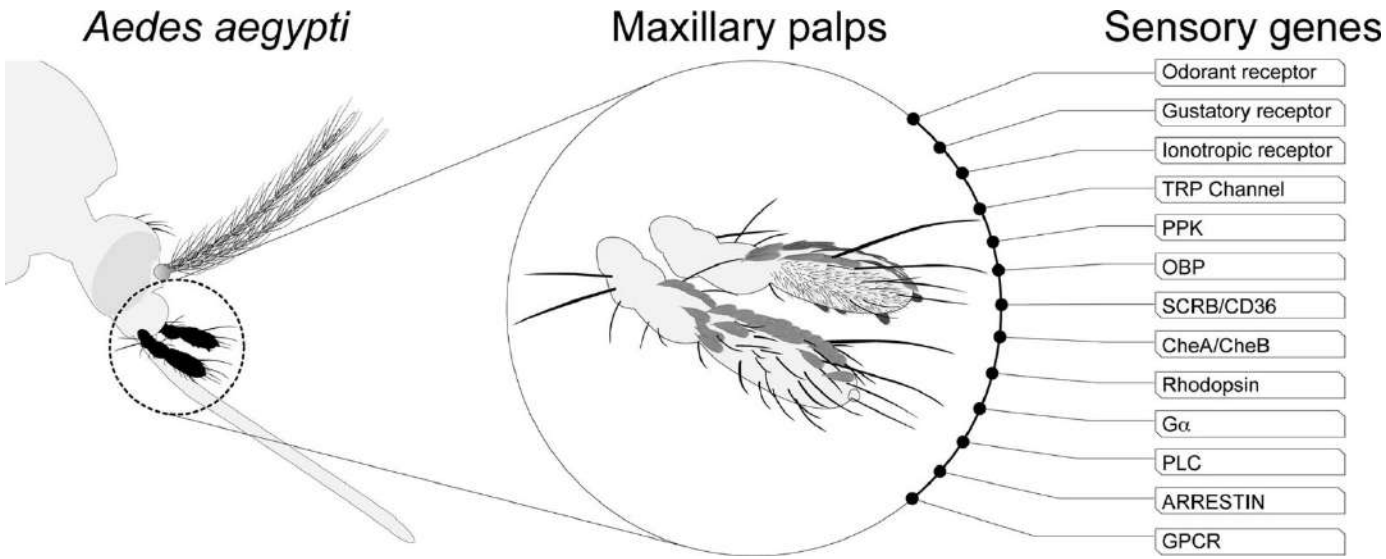
Ring T. Cardé et.al, *Journal of Experimental Biology*, 2011

Odor-gated visual attraction in *Ae. aegypti*

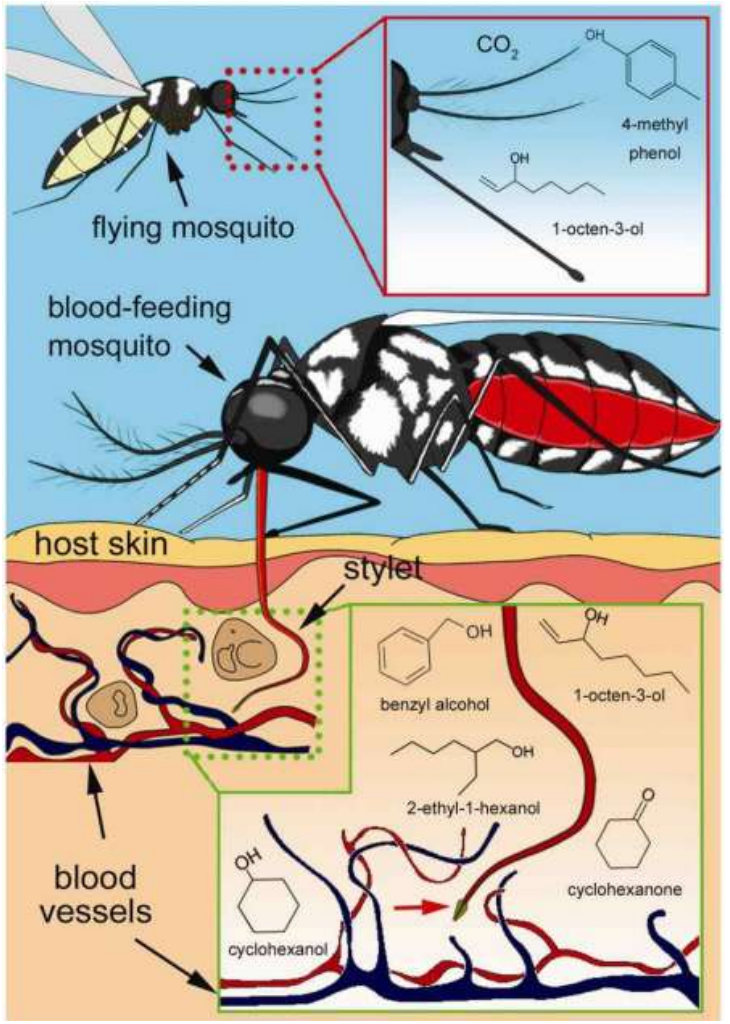


Florisvan Breugel et.al, *Current Biology*, 2015

The maxillary palps of *Ae. aegypti*

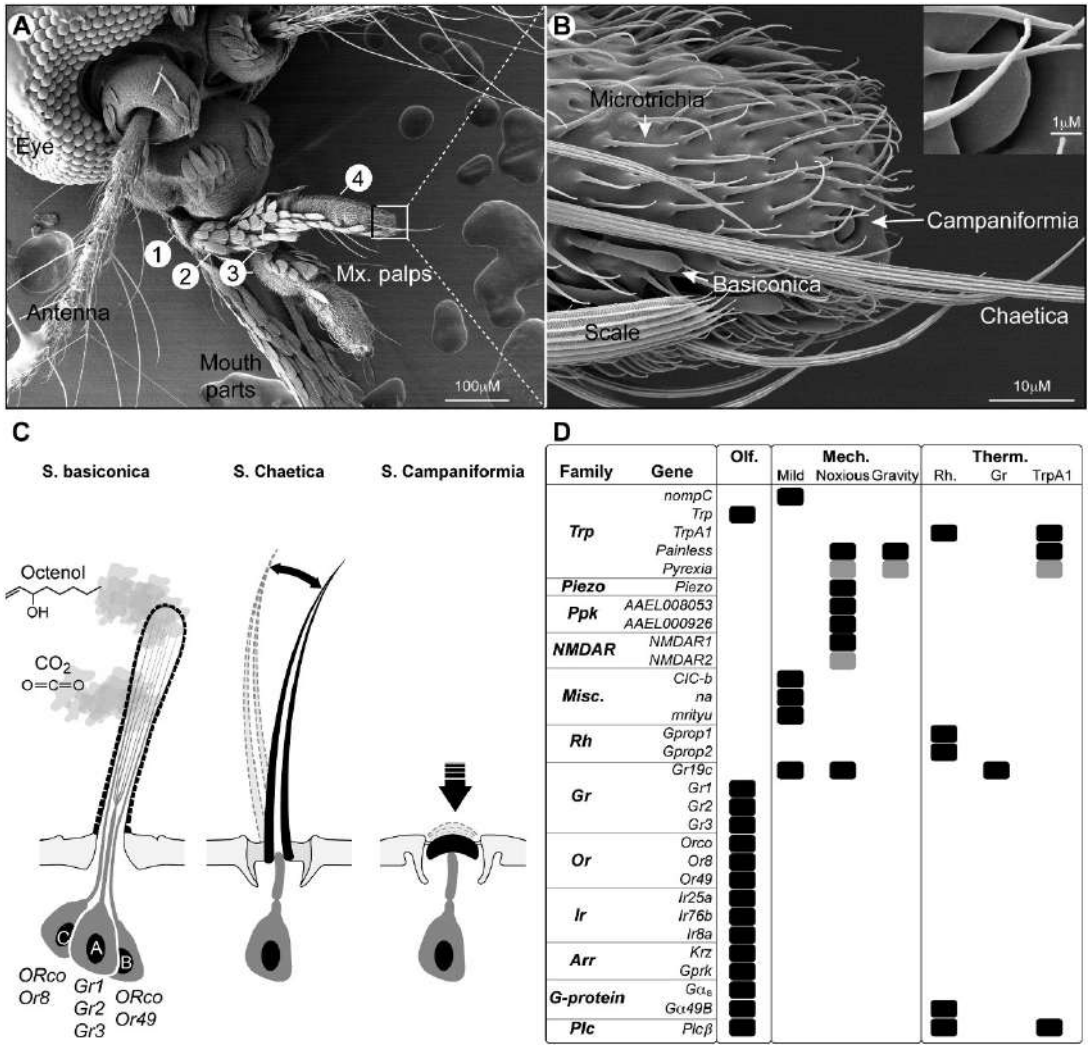


Insect Biochemistry and Molecular Biology, 2014

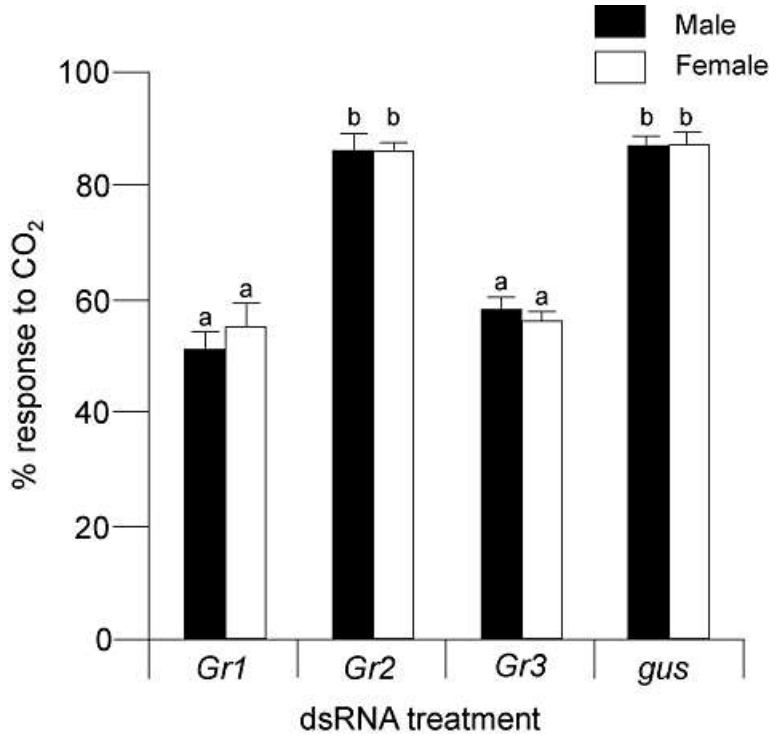


Je Won Jung et.al, *Sci Rep*, 2015

CO2 sensitive G3 gustatory receptors are located in *Ae.aegypti* maxillary palps

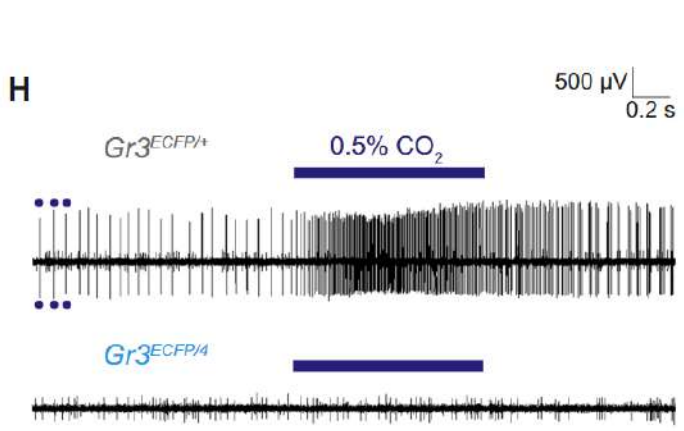


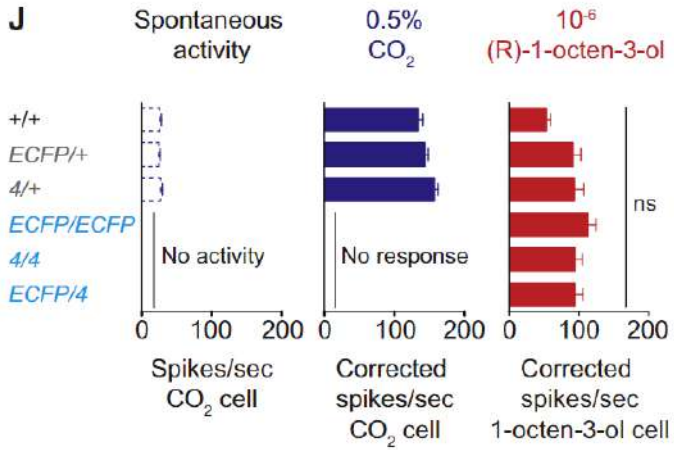
Insect Biochemistry and Molecular Biology, 2014

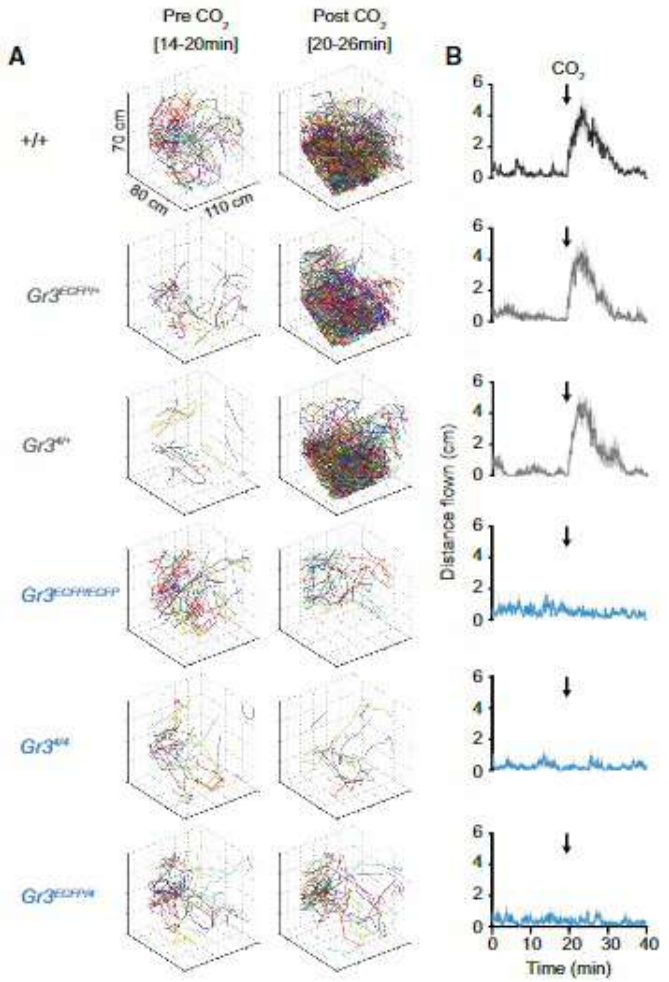


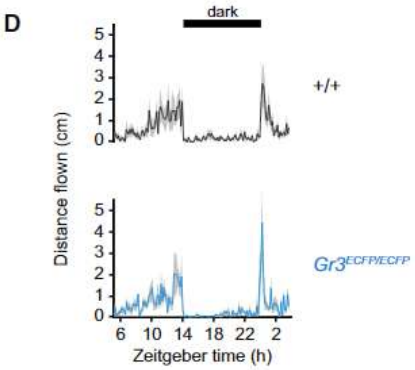
C. N. G. Erdelyan et.al,*Insect Molecular Biology*, 2011

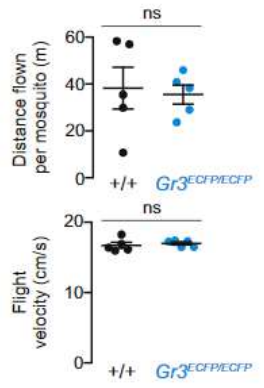
Gr3 mutants are selectively impaired in their response to CO_2





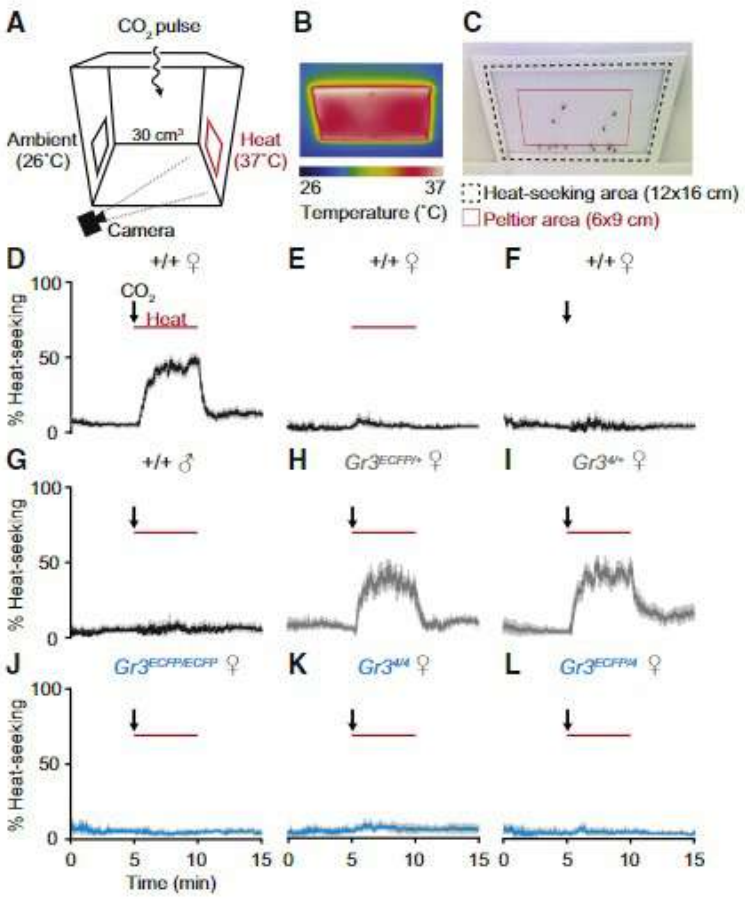


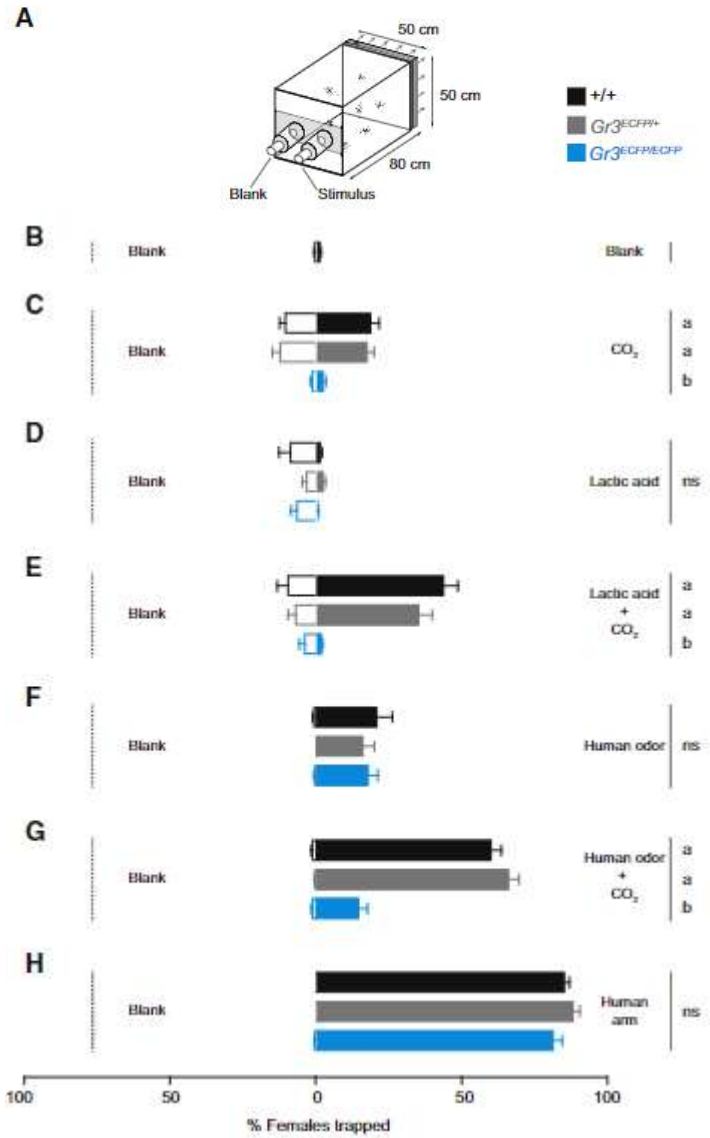




Conor J.McMeniman et.al, *Cell*, 2014

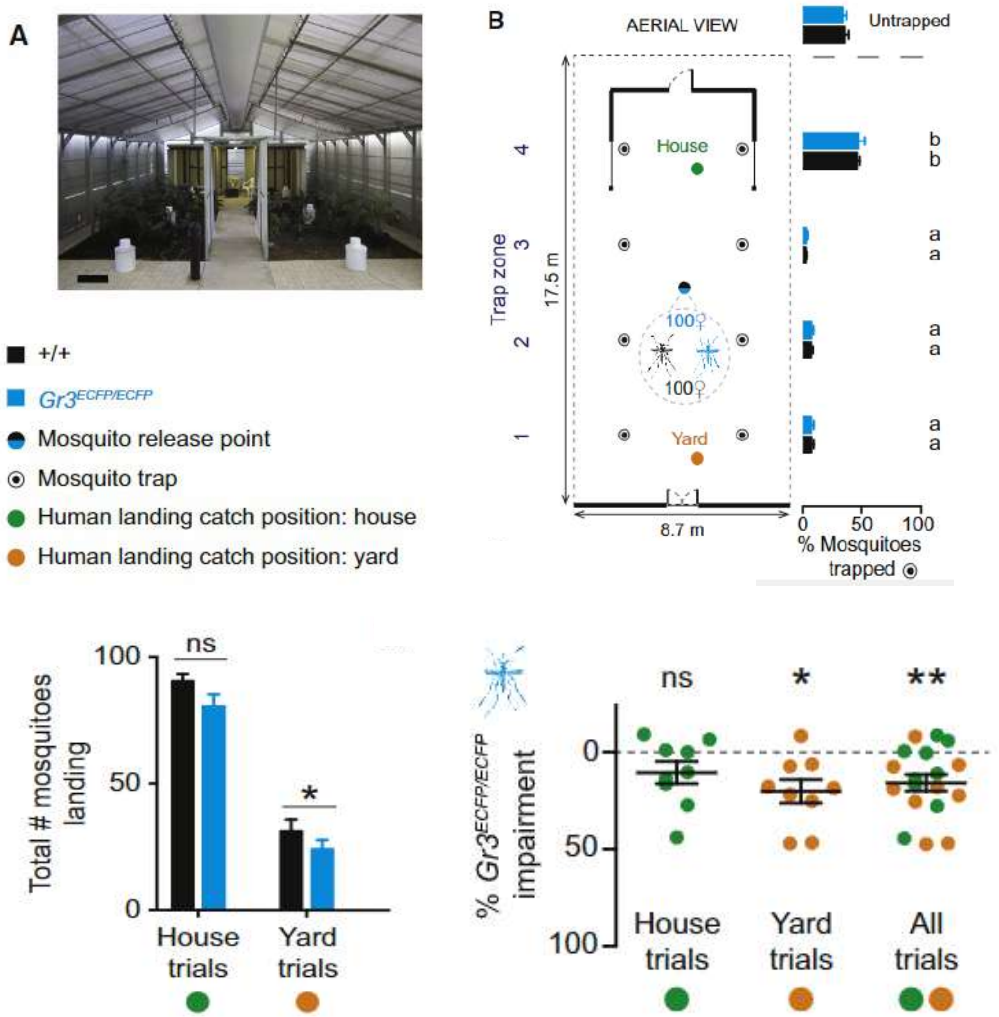
CO_2 detection are required for heat-seeking behavior in female *Ae. aegypti* , and can enhance attraction to Lactic Acid and Human Scent

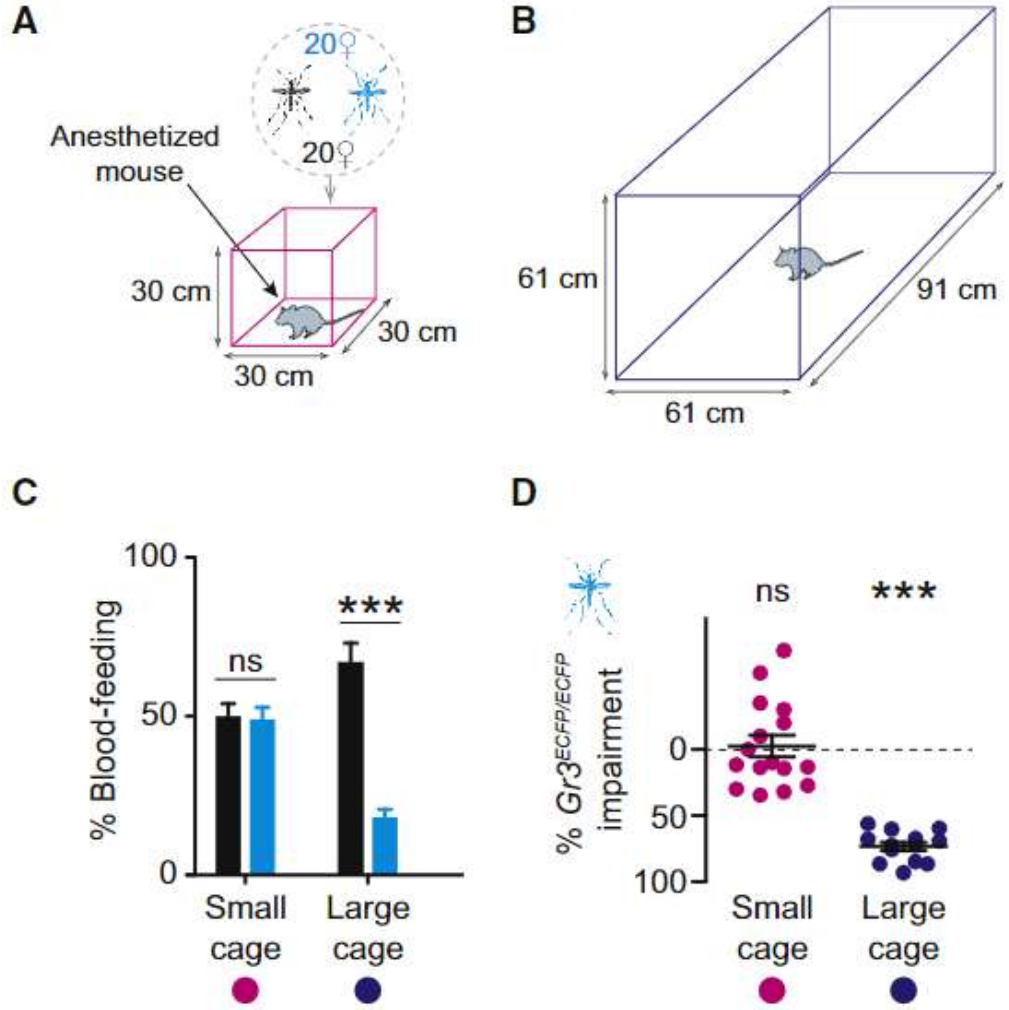




Conor J.McMeniman et.al, *Cell*, 2014

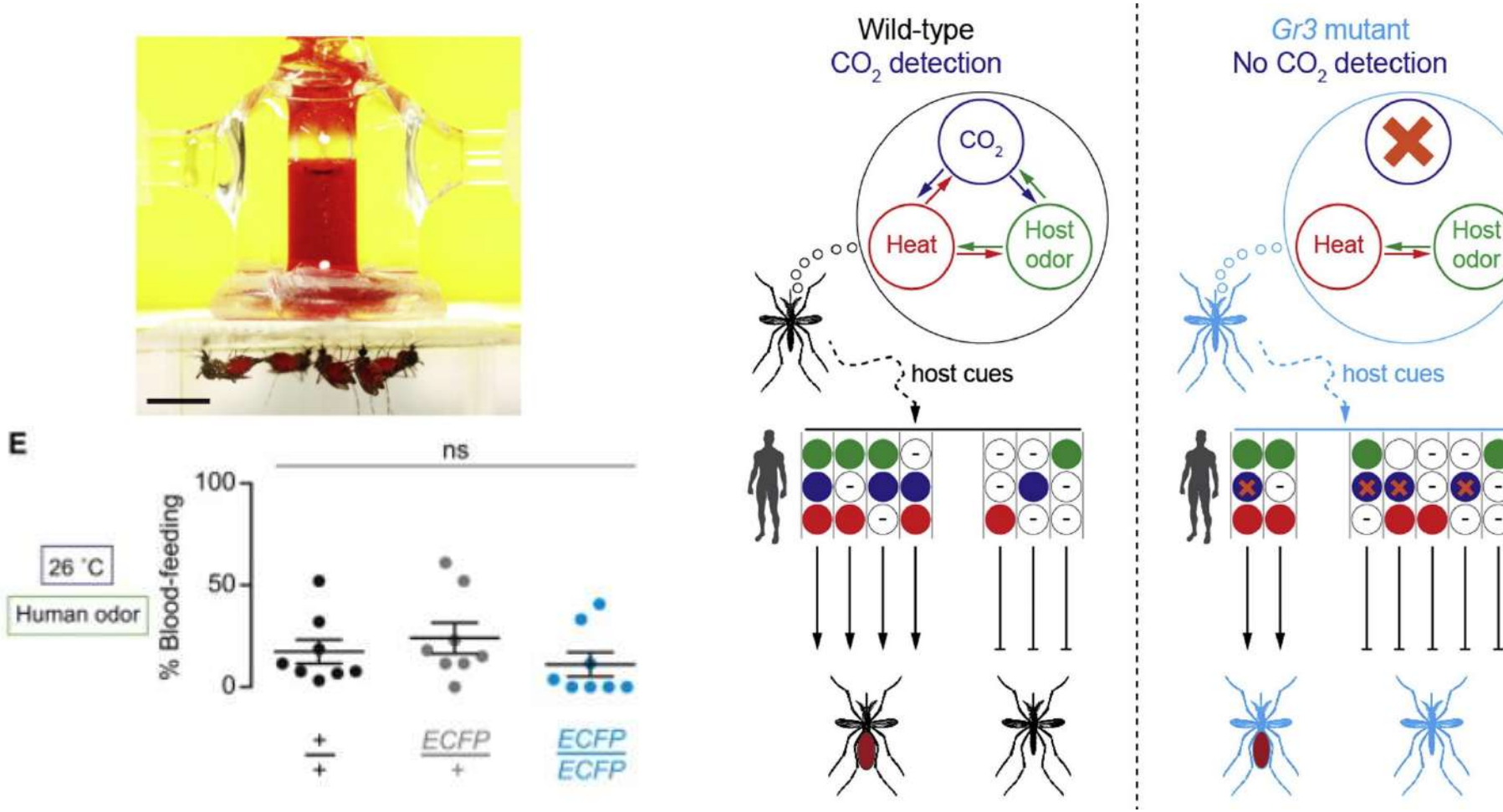
Mosquito Attraction to Humans in a Semi-Field Environment Is Diminished but Not Abolished in *Gr3* Mutants， dependent on Spatial Scale





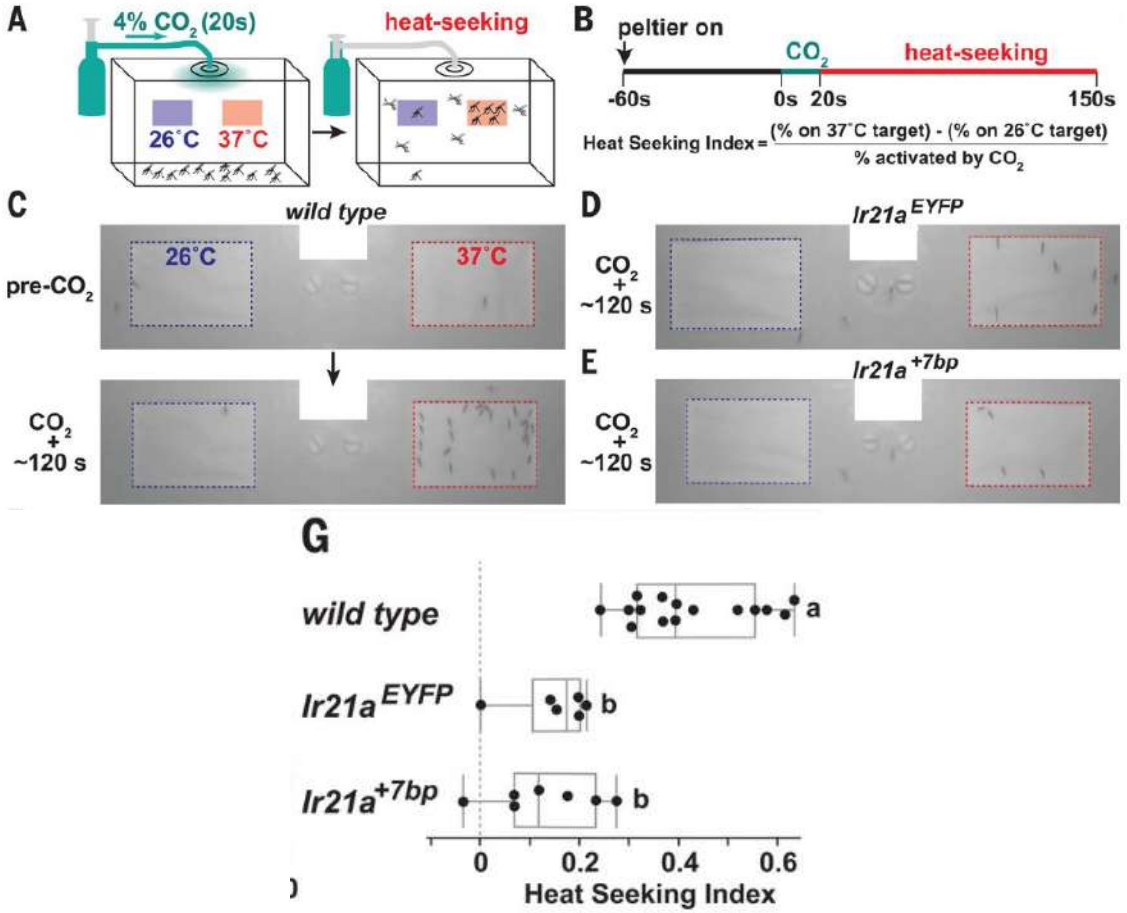
Conor J.McMeniman et.al, *Cell*, 2014

Multiple Host Sensory Cues Combine to Elicit Mosquito

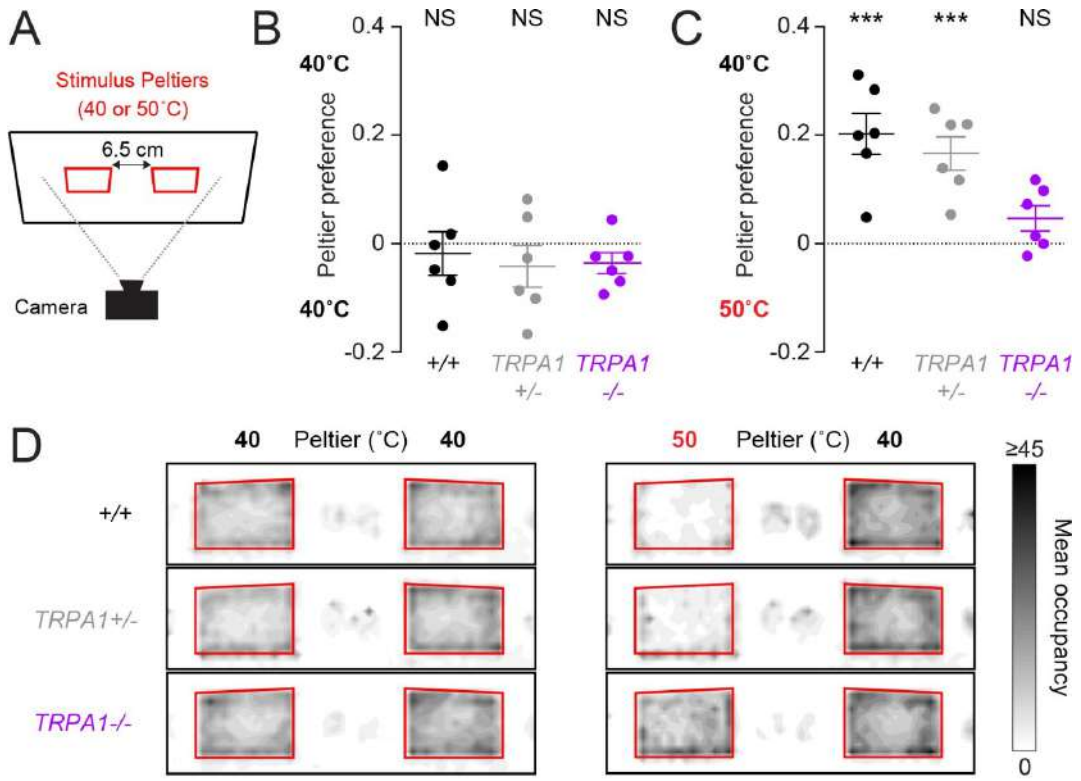


Conor J.McMeniman et.al, *Cell*, 2014

Heat is perceived by the Ir21a receptor and via transient receptor potential (TRPA1) channels

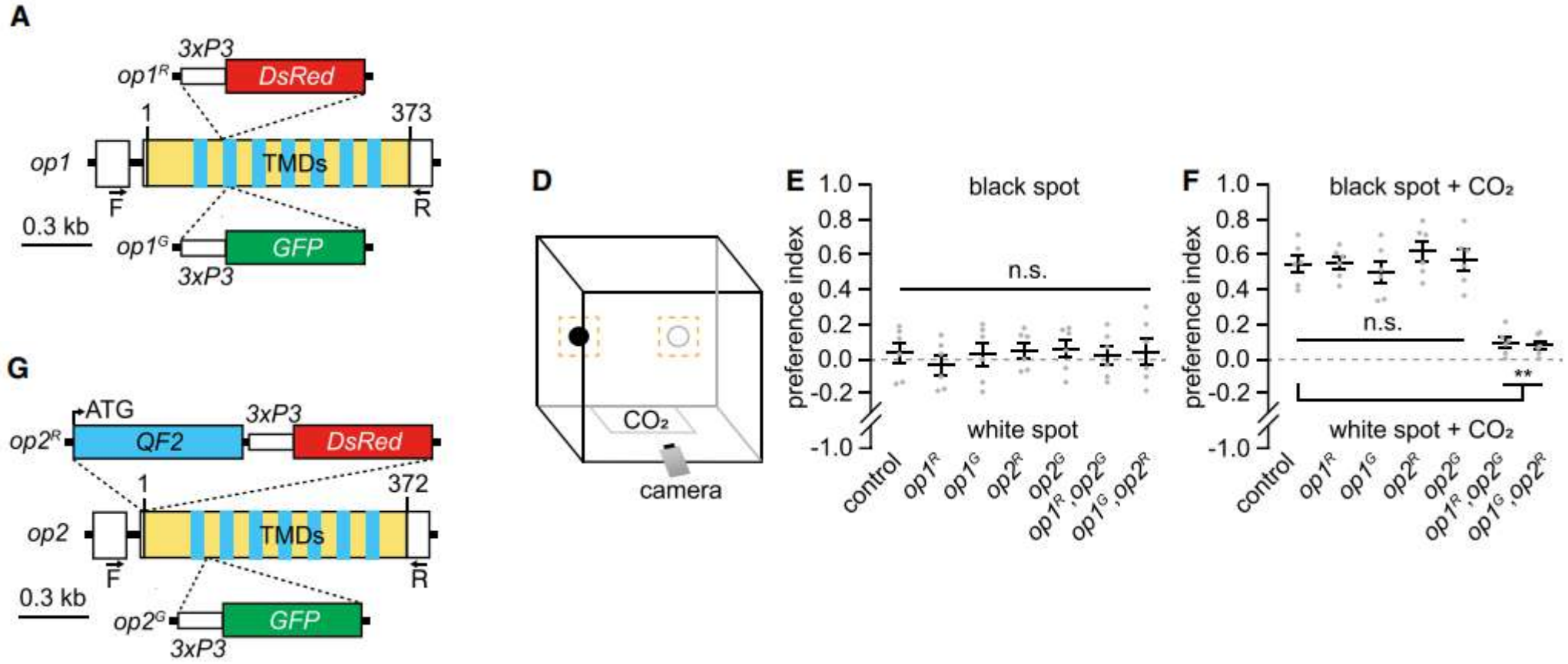


Chloe Greppi et.al, *Science*, 2020



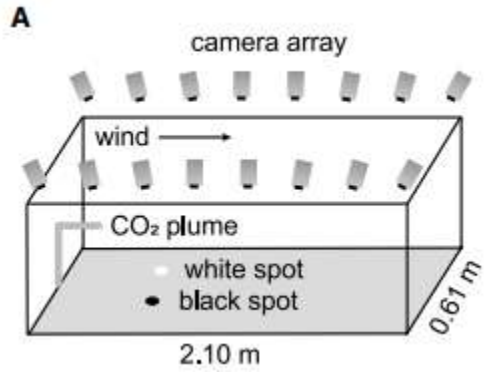
Román A Corfas,*elife*, 2015

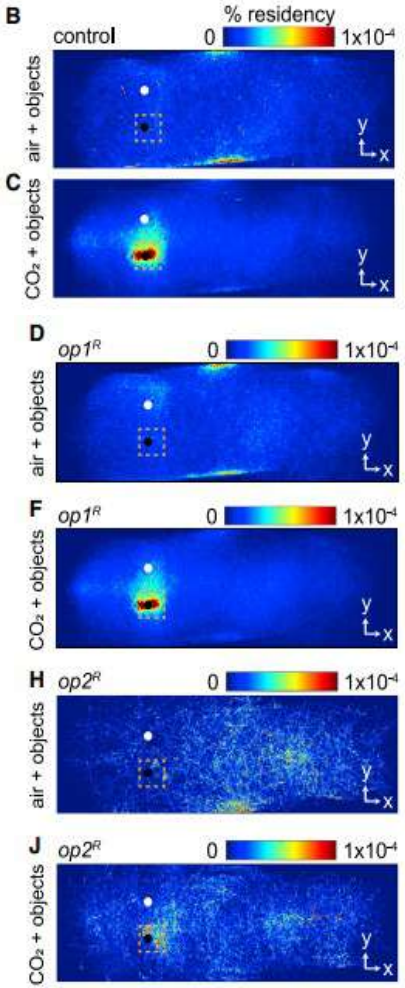
Mutation of both *op1* and *op2* greatly impairs CO_2-induced vision-guided target attraction

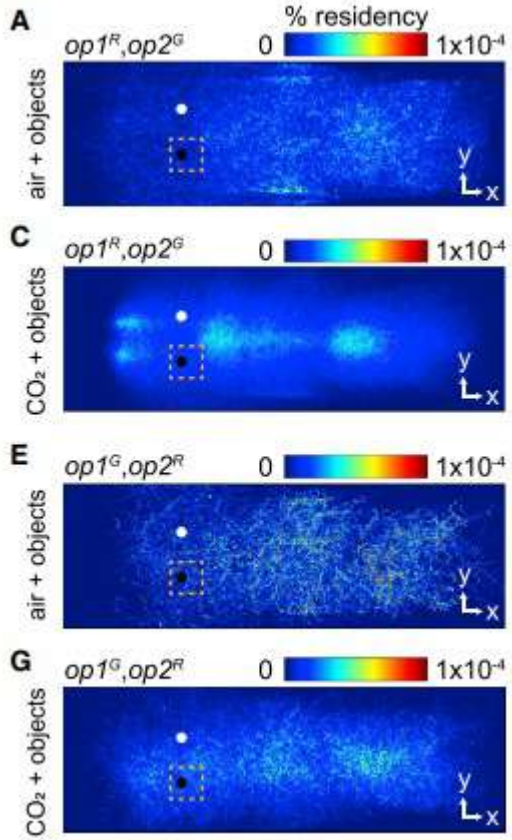


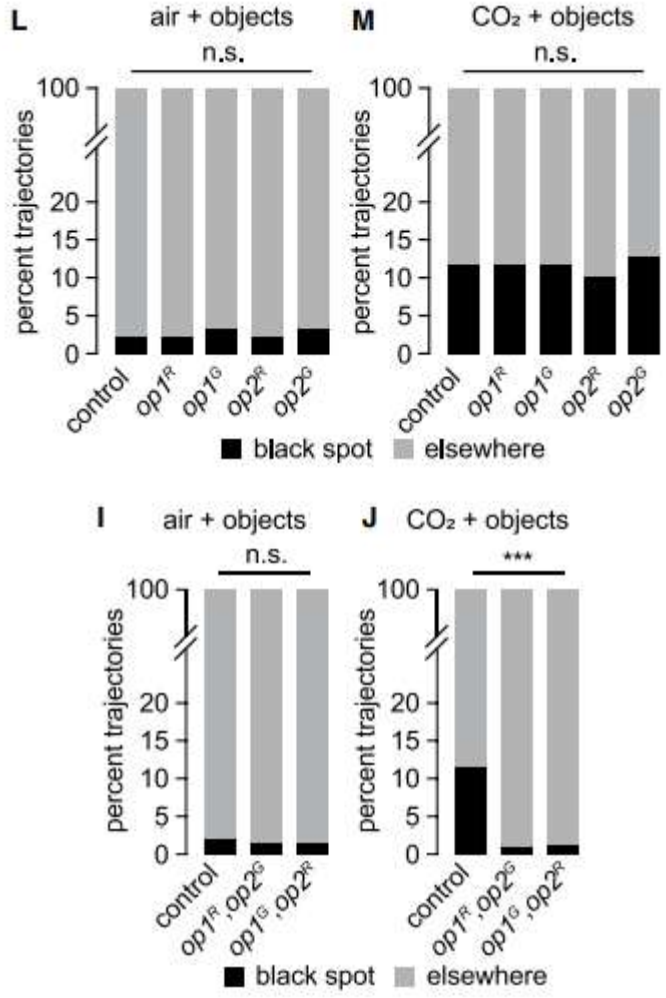
Yinpeng Zhan et.al, *Current Biology* , 2021

Mutation of both *op1* and *op2* greatly impairs CO_2-induced vision-guided target attraction



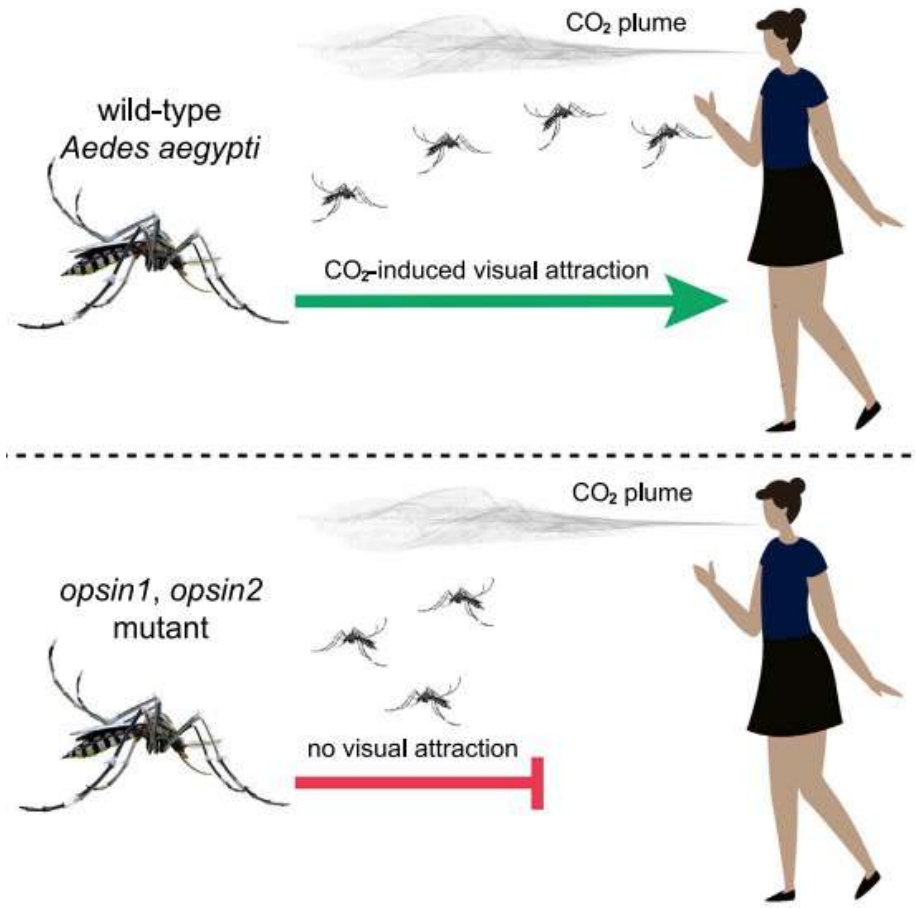






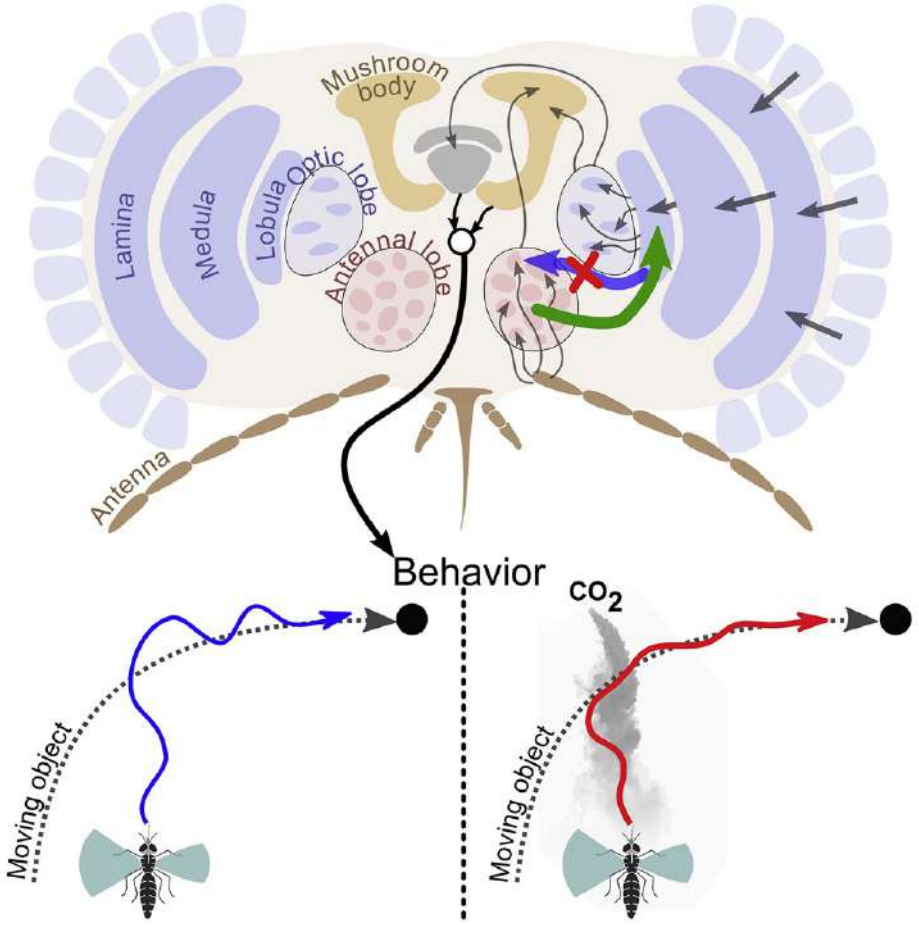
Yinpeng Zhan et.al, *Current Biology* , 2021

Mutation of both *op1* and *op2* greatly impairs CO_2-induced vision-guided target attraction



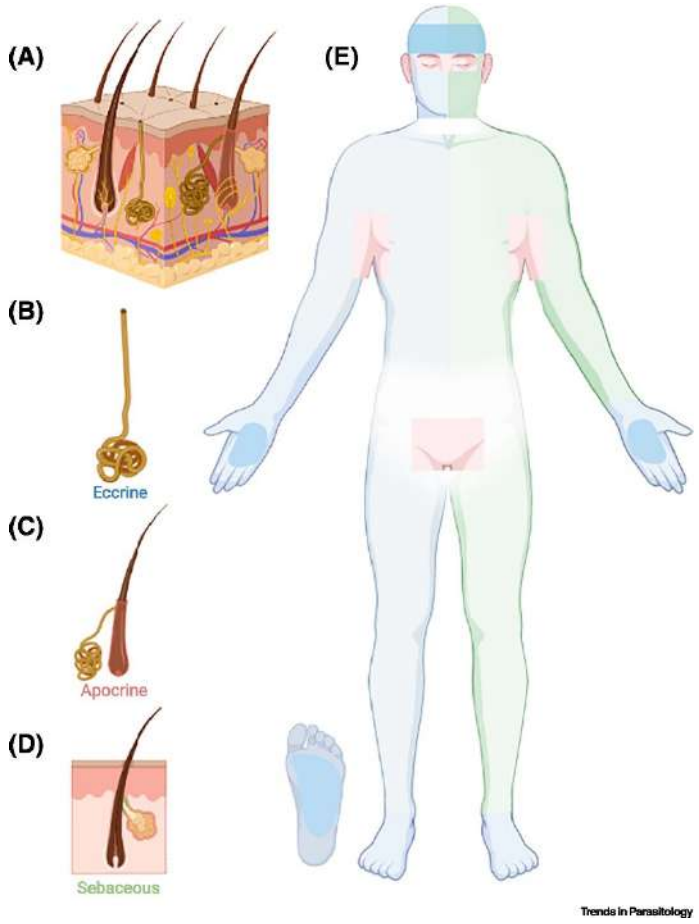
Yinpeng Zhan et.al, *Current Biology* , 2021

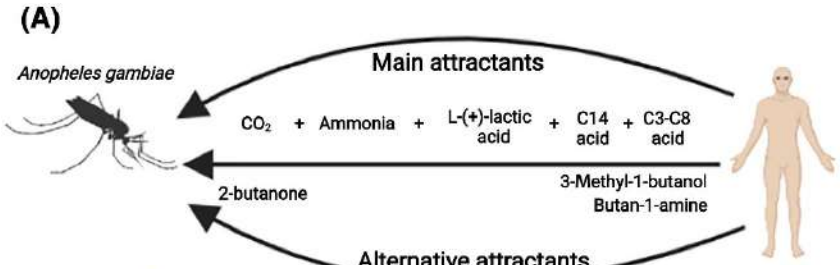
Visual-Olfactory Integration in *Ae. aegypti*



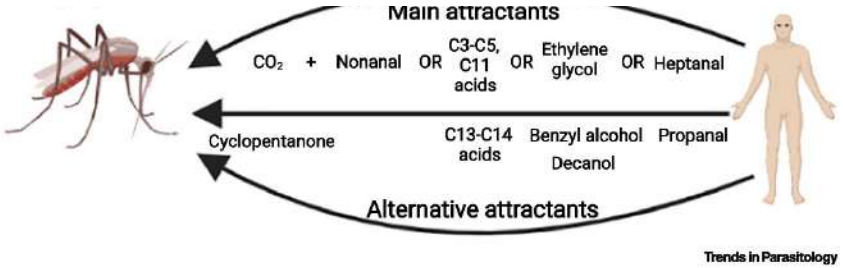
ClémentVinauger et.al, *Current Biology* , 2019

Human odorants attractive to female mosquitoes



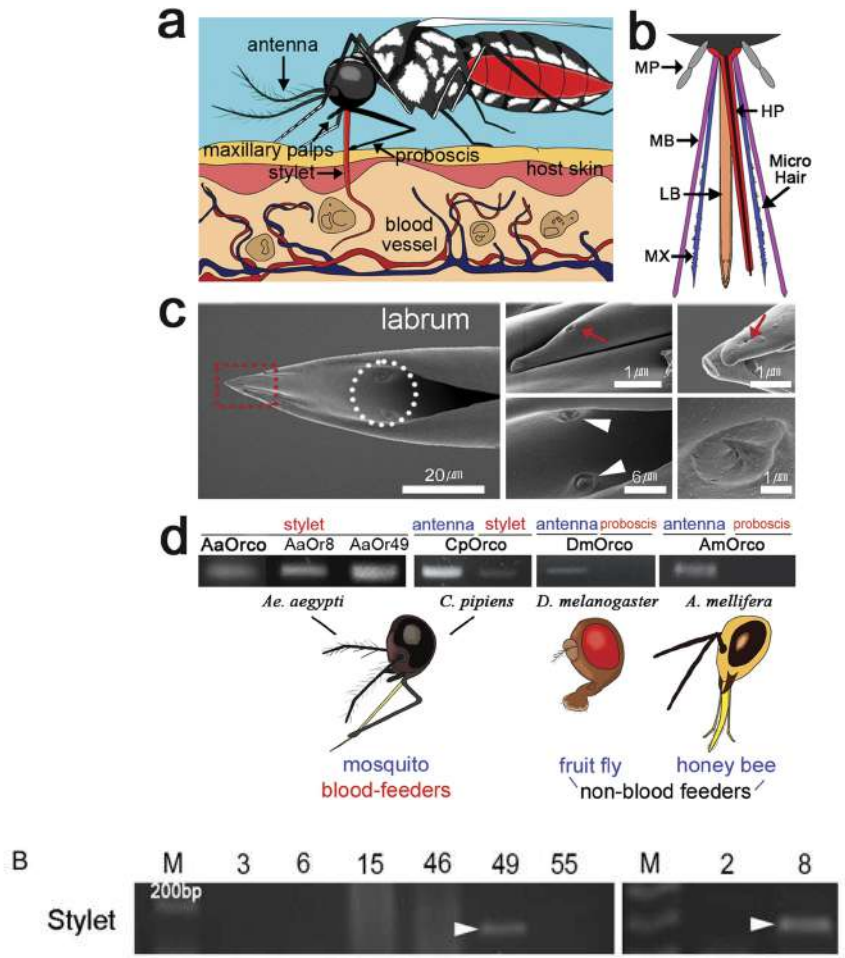


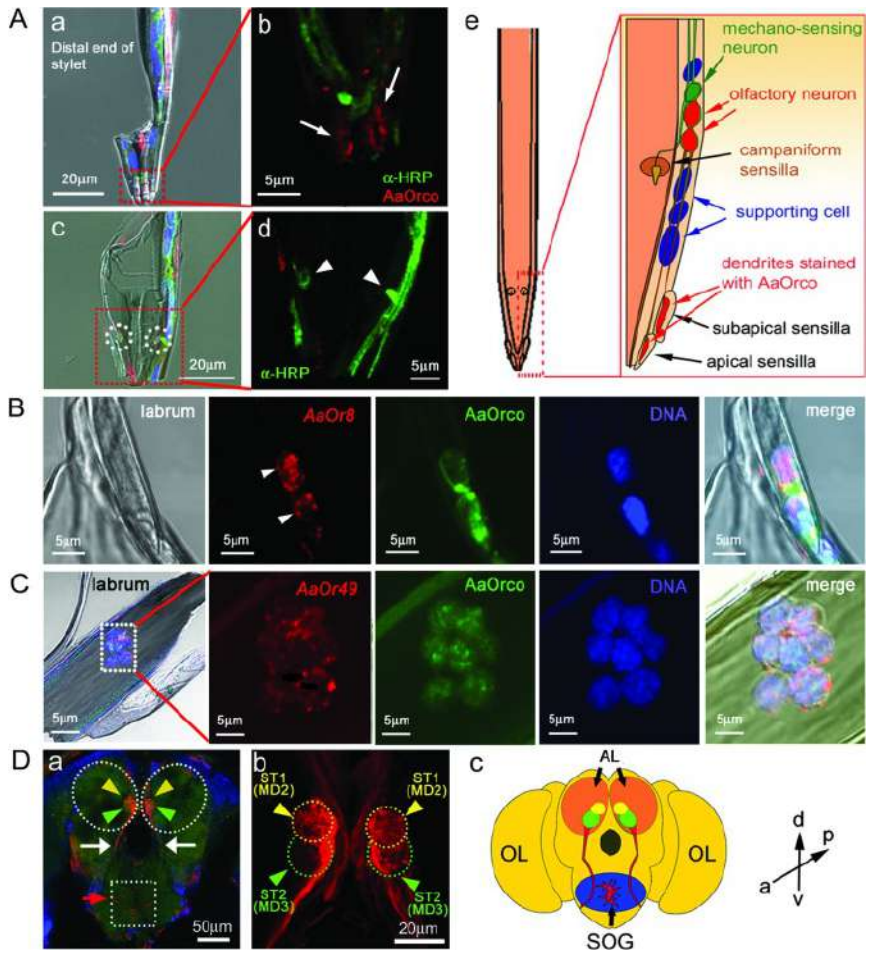
Carbon dioxide	4%	Attraction	Short-range attraction (Y-olfactometer)
Ammonia	0.13 mol/l		
L-(+) lactic acid	Pure		
(C1–C3) carboxylic acid	0.01–1%		
(C5–C8) carboxylic acid	0.01–1%		



Jeffrey A. Riffell et.al, *Trends in Parasitology*, 2022

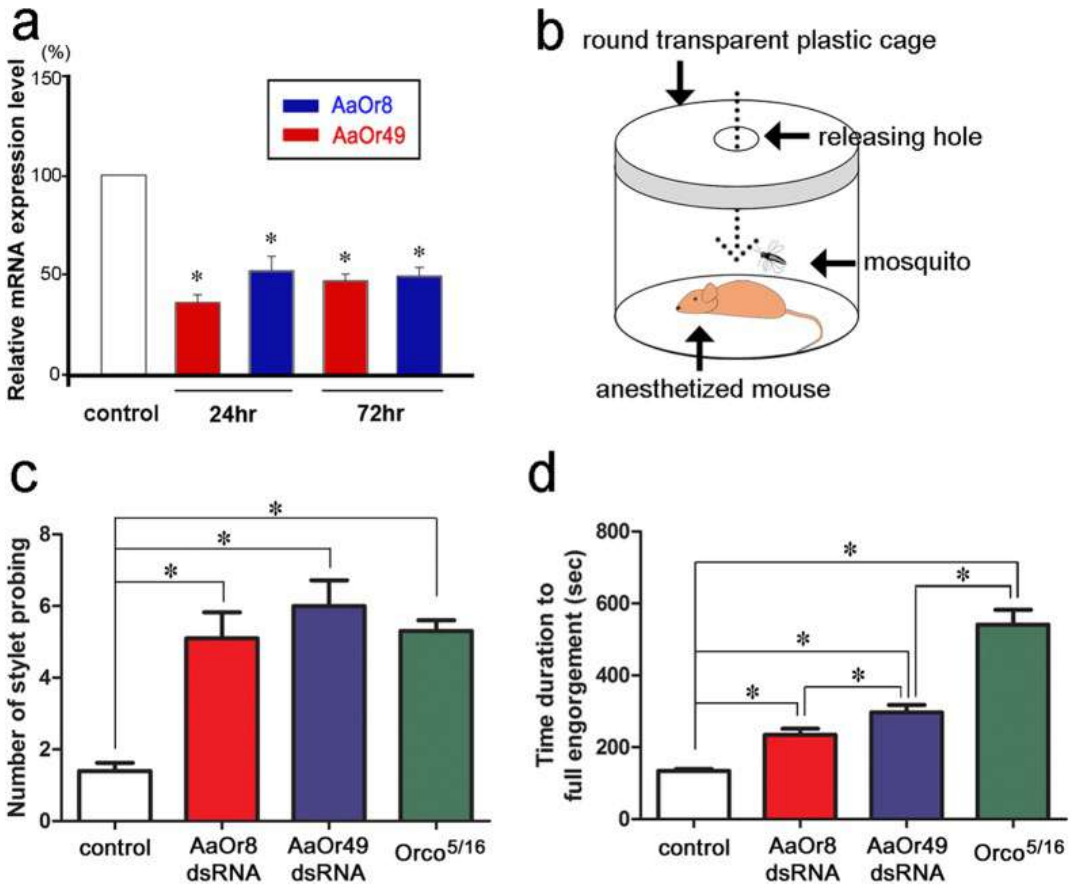
A novel olfactory organ in the mosquito stylet——AaOr8 and AaOr49

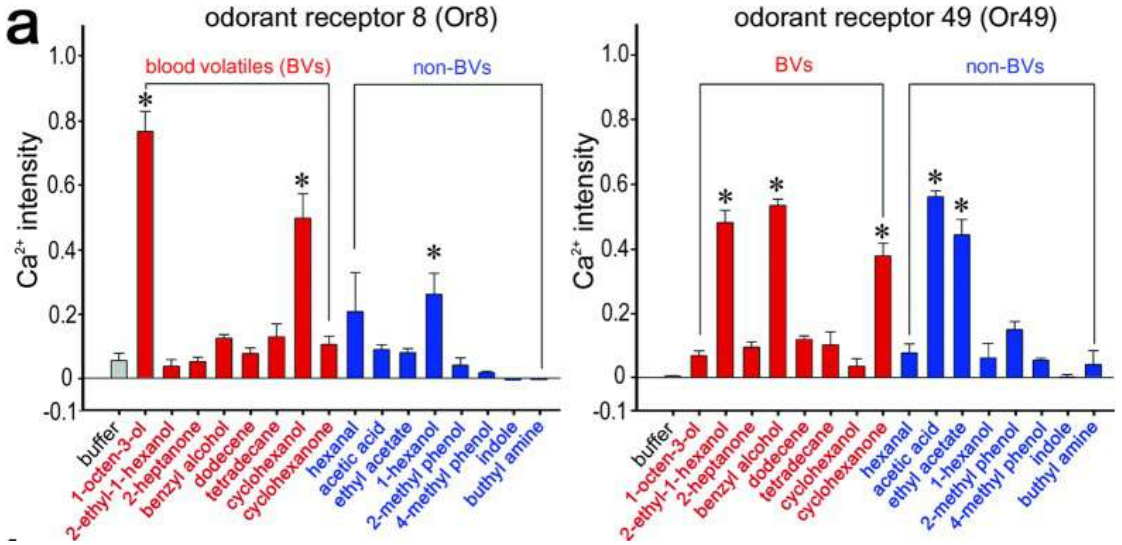




Je Won Jung et.al, *Sci Rep*, 2015

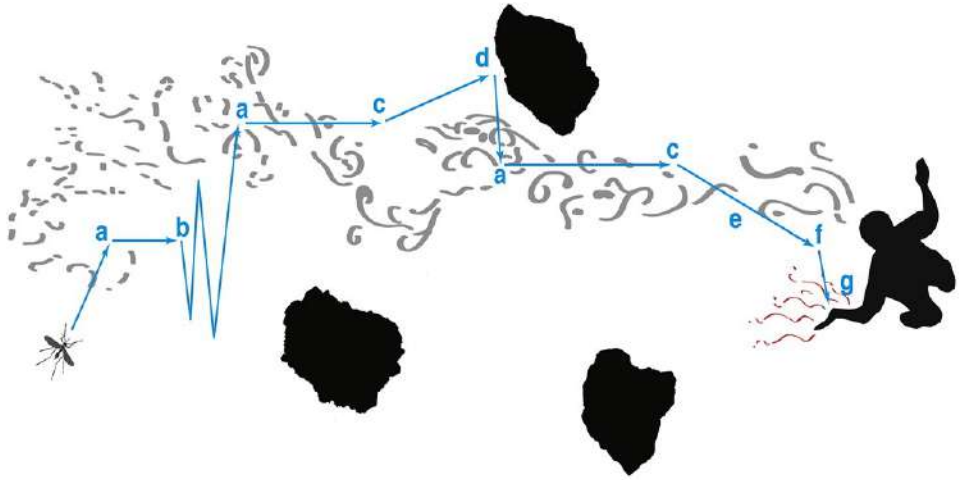
Functional study of AaOr8 and AaOr49





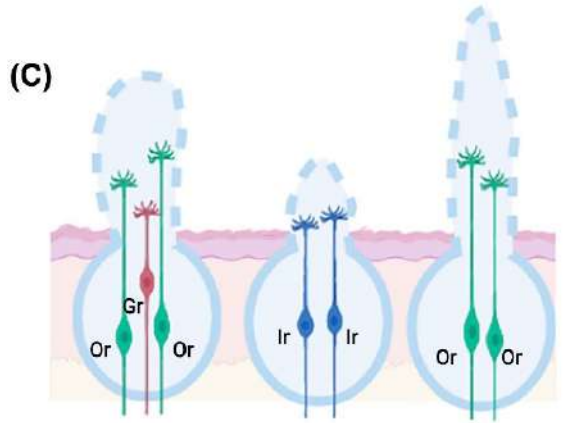
Je Won Jung et.al, *Sci Rep*, 2015

Summary



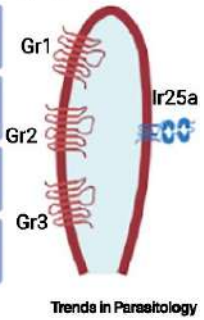
Range		Stimulus - Action pair		
>10 m	a	Encounter CO_2 plume	→	Turn upwind (surge)
	b	Lose CO_2 plume	→	Zigzag crosswind (cast)
5-10 m	c	Recent encounter with CO_2 plume	→	Approach visual feature
	d	Lack of host cues (e.g. heat, moisture)	→	Resume plume tracking
0.01-1 m	e	Host skin voltatiles	→	Follow skin voltatile plume
20 cm	f	Encounter heat plume	→	Continue toward feature, track heat, moisture, and additional odors
~3 cm	g	Sufficient host cues (e.g. heat, moisture)	→	Land, and begin probing

Florisvan Breugel et.al, *Current Biology*, 2015



(E)

	Grs-CO_2	Irs	Ors
Cx.	3	43 (69)	180
Ae.	3	36 (135)	117
An.	3	22 (110)	72



Jeffrey A. Riffell et.al, *Trends in Parasitology*, 2022

Why do mosquitoes prefer humans?

XLM

2022/07/01

Sexual dimorphism of mosquitoes

body size mouthparts
tentacles feeding

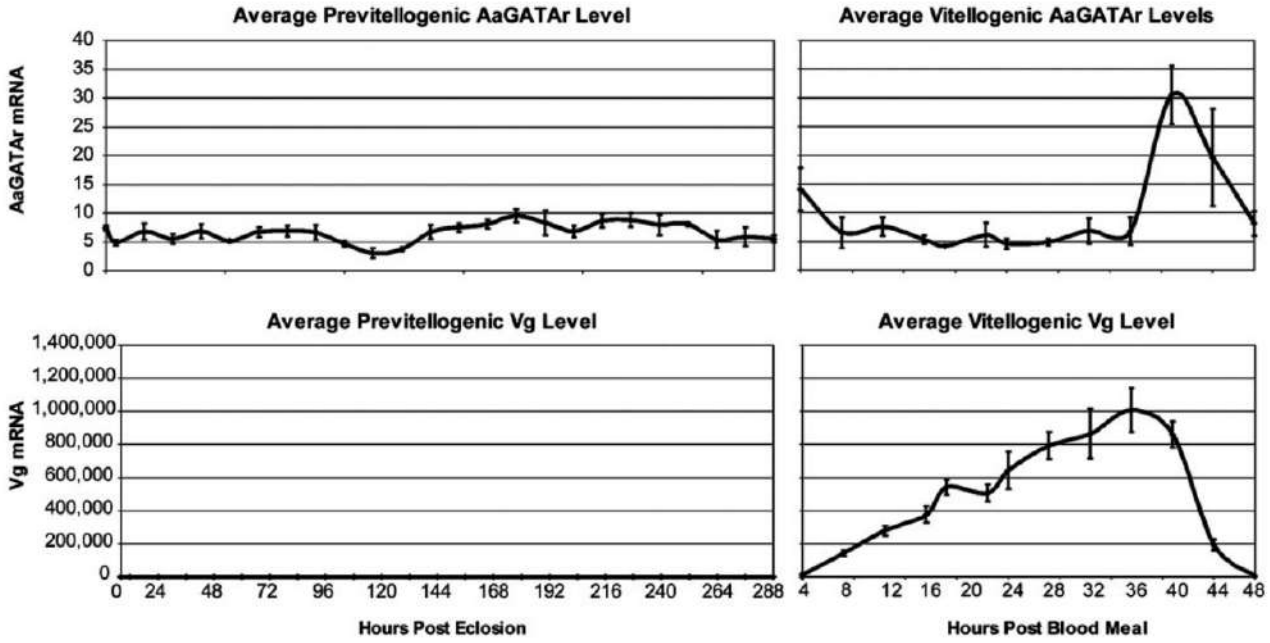
Questions：

- Why do female mosquitoes suck blood, and why don't males?
- Are mosquitoes really biased towards humans? Mechanism?
- Are there certain groups of people that mosquitoes are particularly attracted to?

Why do female mosquitoes suck blood?

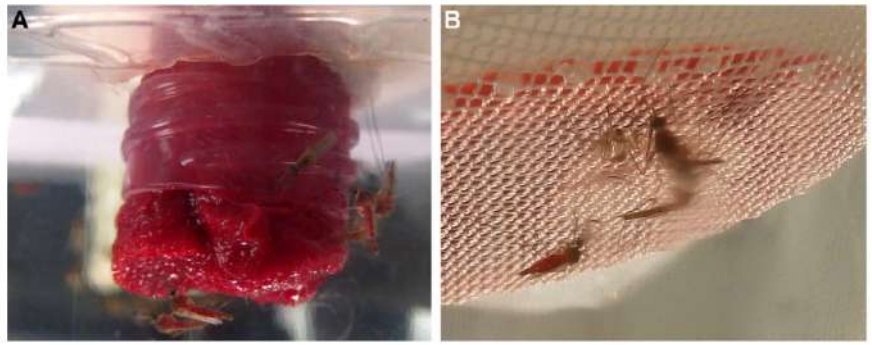
mosquitoes. In general, females of most mosquito vectors need at least one blood meal before they can lay fertilized eggs, and this trait in turn enables them to transfer viral or protozoan infection to their vertebrate hosts (Kelly and Edman, 1992). In nature, females feed on both blood and sugar depending on their availability (Foster, 1995). A sugar meal provides females with enough energy to serve their physiological needs, i.e., it sustains females until they find their hosts and allows an infected mosquito to live long enough to oviposit, bite repeatedly, and to become infective (Van Handel, 1984). However, in the absence of a blood meal, mated females may lack the protein needed to synthesize yolk and develop eggs (Klowden, 1995).

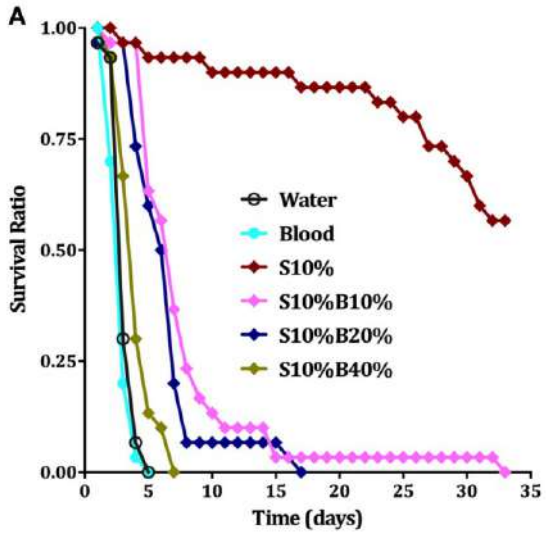
Blood feeding tightly regulates the reproductive cycle in anautogenous mosquitoes. Vitellogenesis (the synthesis of yolk protein precursors) is a key event in the mosquito reproductive cycle and is activated in response to a blood meal. Before blood feeding, *Aedes aegypti* is in a state of reproductive arrest during which the yolk protein precursor genes (*YPPs*) are repressed. The regulatory region of the major *YPP* gene *vitellogenin* (*Vg*) has multiple GATA-binding sites required for the high expression level of this gene. However, a GATA factor (*AaGATAr*) likely acts as a repressor, preventing activation of this gene before a blood meal. Here we report *in vivo* data confirming the role of *AaGATAr* as a repressor of the *Vg* gene at the state of previtellogenic arrest. Using an RNA

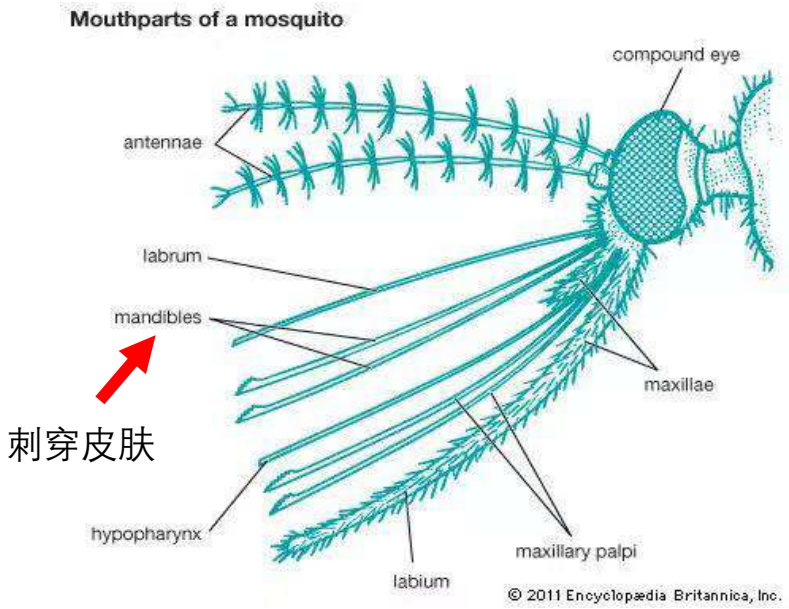


Attardo, G. M., et al., *PNAS., 2003*

Why don't male mosquitoes suck blood?







刺穿皮肤

结构：
shorter mandibles

内部生理：
lack ADA（腺苷脱氨酶）

TABLE 1 | Mean ± SEM of proboscis, mandible, and maxilla lengths (in mm) in male and female *Cx. quinquefasciatus*.

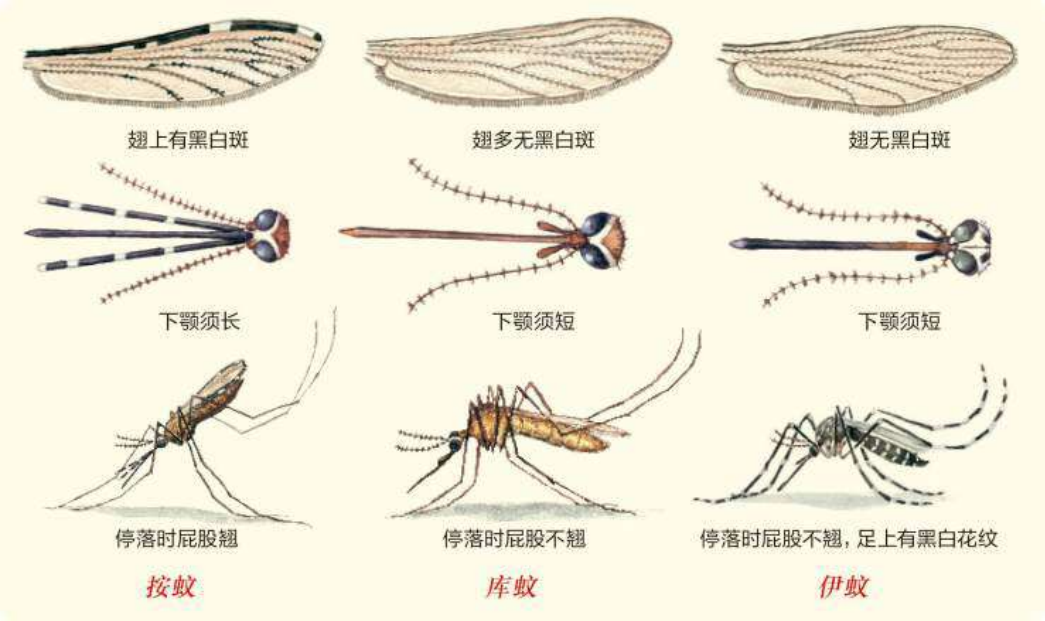
Female			Male		
Proboscis	Mandible	Maxilla	Proboscis	Mandible	Maxilla
2.11 ± 0.02[a]	2.08 ± 0.02[a]	2.04 ± 0.01[a]	2.01 ± 0.03	1.53 ± 0.03[b]	2.00 ± 0.02[a]

Male mosquitoes do not bite，but blood is attractive and lethal

Nikbakhtzadeh, M. R., et al., *Front Physiol.* 2016

Do all female mosquitoes prefer to bite humans ？

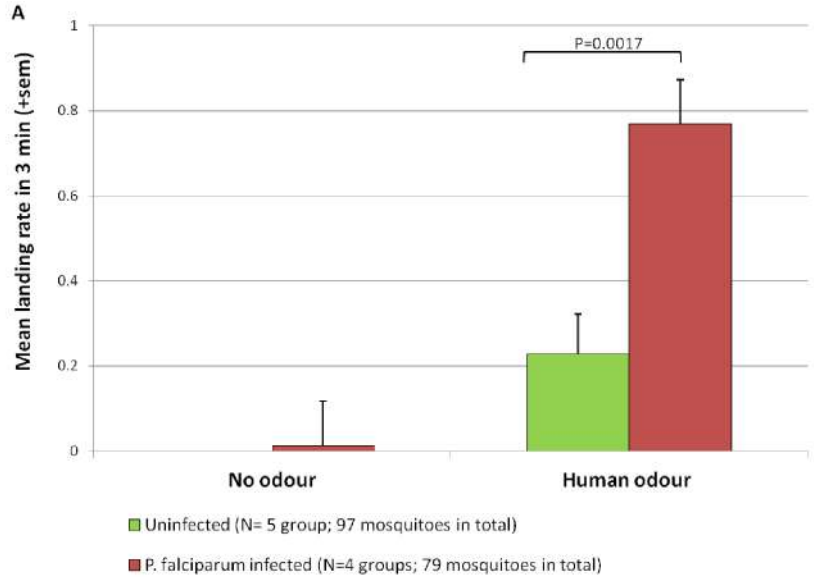
3500-80-10



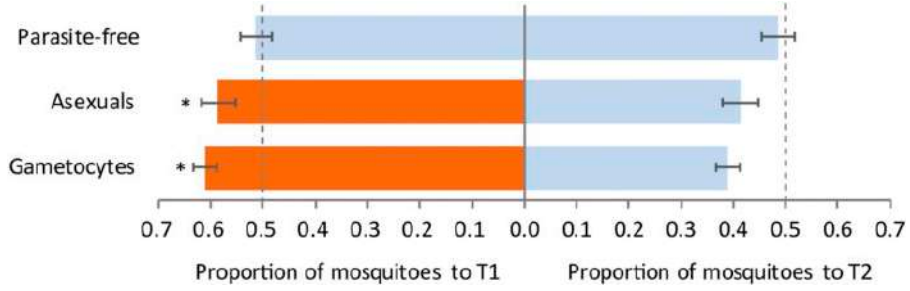
疟疾

丝虫病
流行性乙型脑炎

登革热
流行性乙型脑炎



Renate C ., et al. *Plos one*. 2013

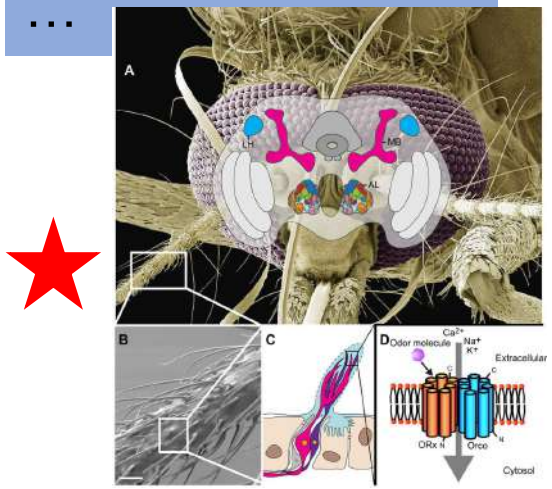


Robinson A, et al. *PNAS*. 2018;

What causes female mosquitoes to prefer humans ？

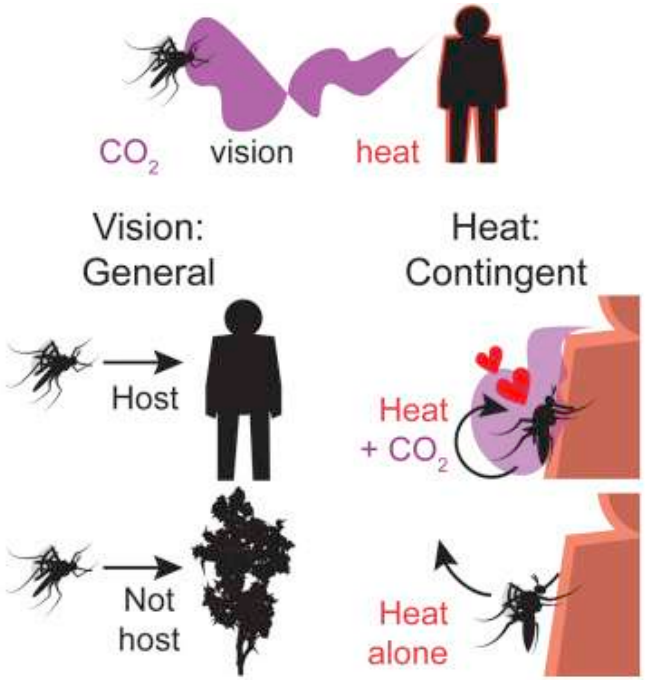
Carbon dioxide

Olfaction:
Lactic acid
Ammonia
Alcohols
Octenol
Aldehydes
Carboxylic acids
Ketones
…



long range

short range



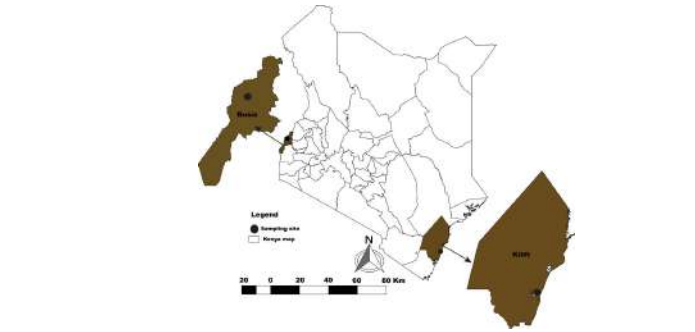
Vision:
Colors
Size
Movement
…

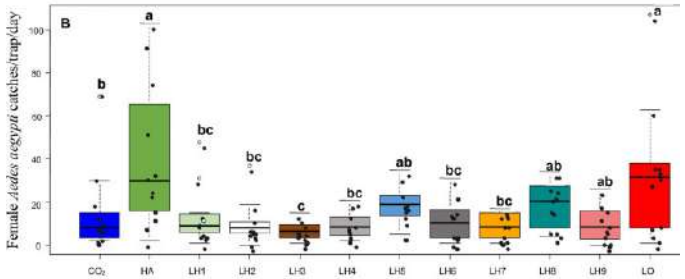
Temperature

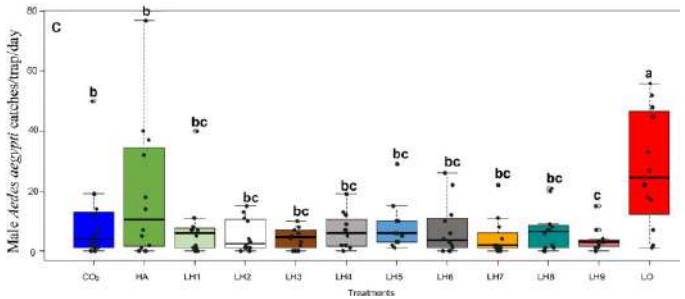
Humidity

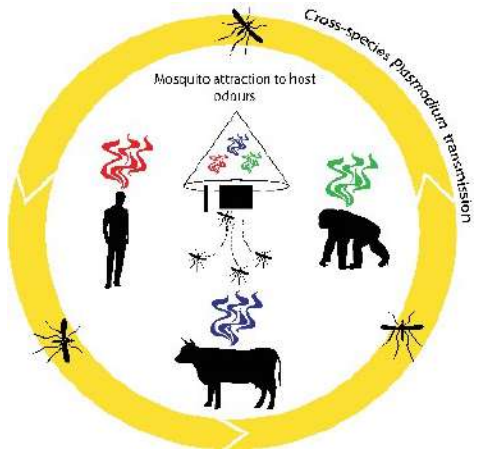
Molly Z.Liu and Leslie B.Vosshall., *Current Biology.* 2019

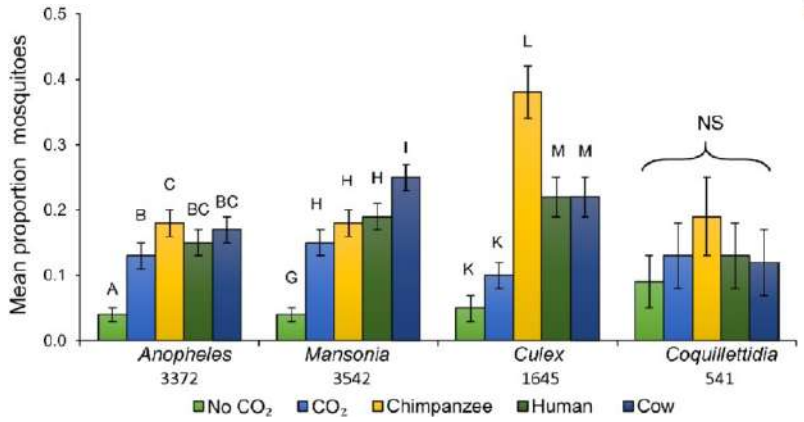
Human, plants and animals differ in their attractiveness to mosquitoes

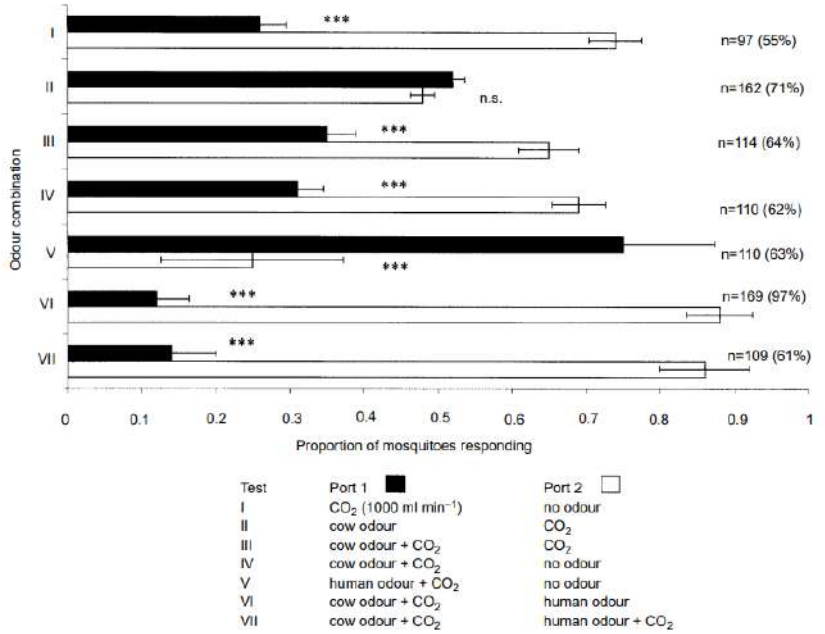












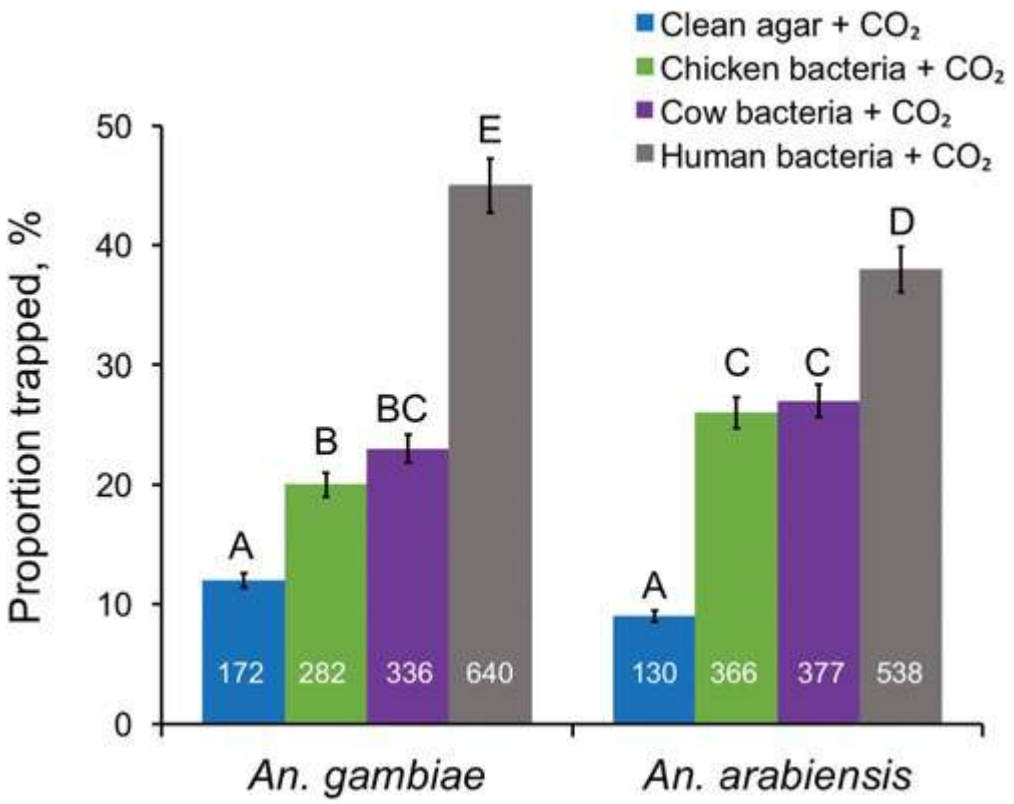
Linalool oxide (LO) : plant-derived odorants
Hexanoic acid(HA) : human-derived odorants

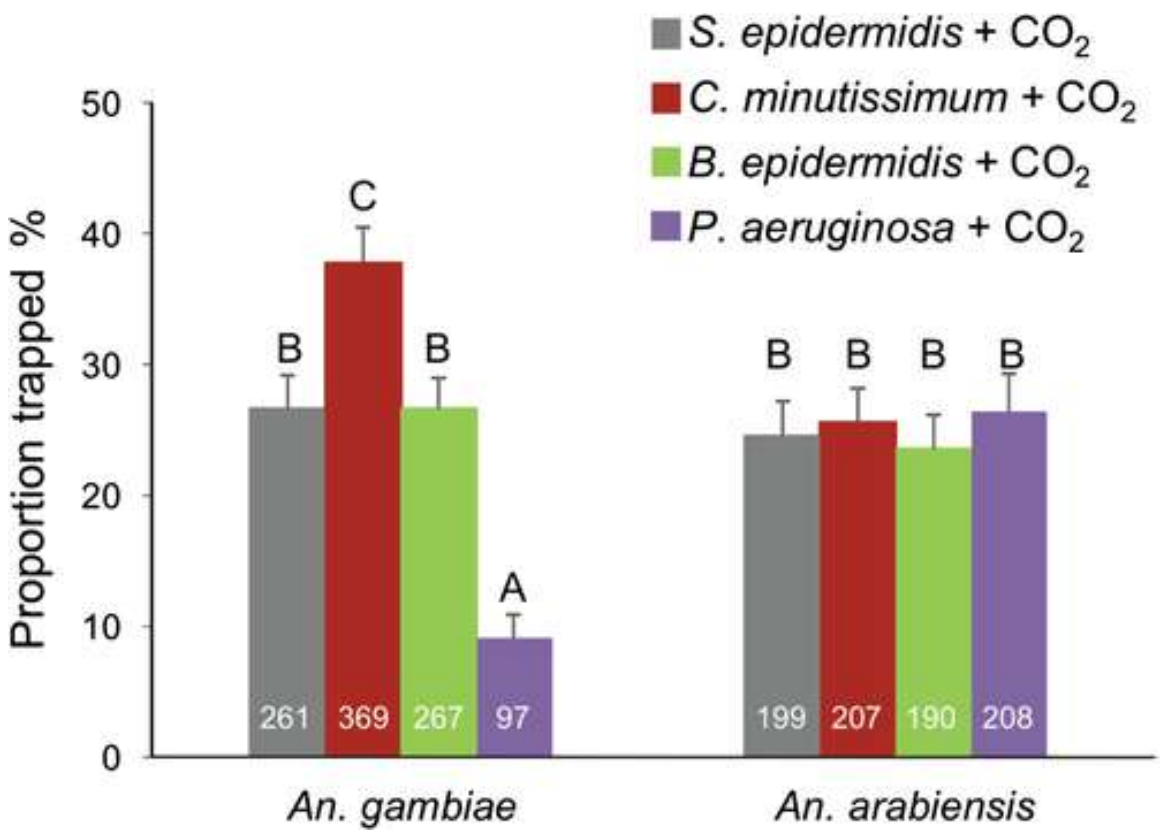
Omondi WP, et al. Acta Trop. 2019

J W Bakker., et al.
Med vet entomol. 2020

H.V. Pates et al.
Bulletin of Entomological Research,2001

Odors from human skin bacteria increase the attractiveness of mosquitoes





An. gambiae : prefers to take bloodmeals from humans
An. arabiensis : feeds on human blood only opportunistically

Busula., et al., *Med. Vet. Entomol*., 2017

What function does smell play in sensing the host ?

Carolyn S. McBride, Ph.D.

orco is a conserved olfactory co-receptor in insects

Neuron. 2004 Sep 2;43(5):703-14. doi: 10.1016/j.neuron.2004.08.019.

Or83b encodes a broadly expressed odorant receptor essential for Drosophila olfaction

Mattias C Larsson [1], Ana I Domingos, Walton D Jones, M Eugenia Leslie B Vosshall

Published in final edited form as:
Nature. 2013 June 27; 498(7455): 487–491. doi:10.1038/nature12206.

orco mutant mosquitoes lose strong preference for humans and are not repelled by volatile DEET

Matthew DeGennaro[1,2], Carolyn S. McBride[1], Laura Seeholzer[1], Takao Nakagawa[1,†], Emily J. Dennis[1], Chloe Goldman[1], Nijole Jasinskiene[3], Anthony A. James[3,4], and Leslie B. Vosshall[1,2]

Leslie B. Vosshall, PhD
Investigator / 2008–2022
Dr. Vosshall is the Robin Chemers Neustein Professor and head of the Laboratory of Neurogenetics and Behavior at The Rockefeller University. In 2022, she became HHMI vice president and chief scientific officer.

INSTITUTION
The Rockefeller University

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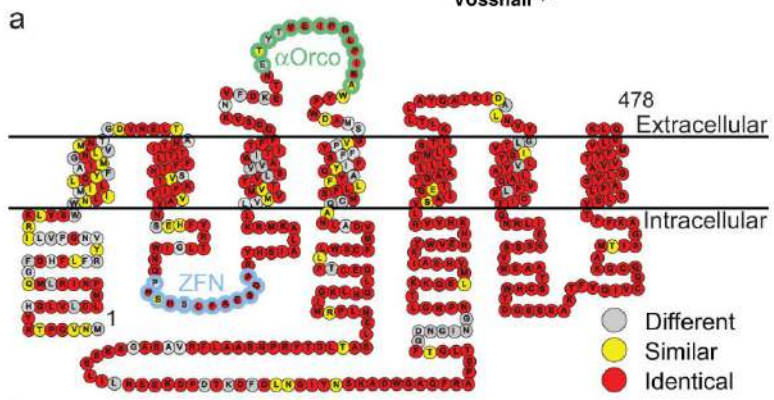
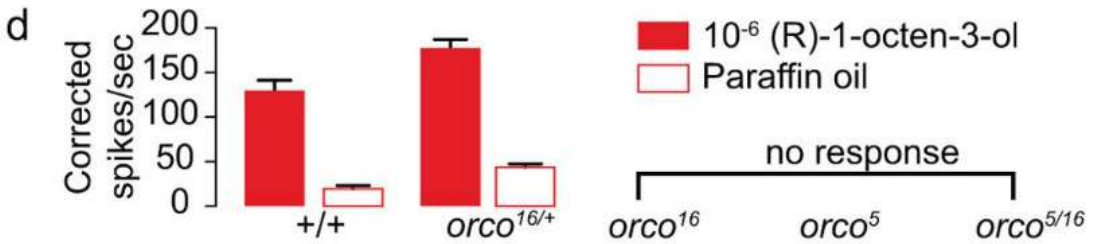
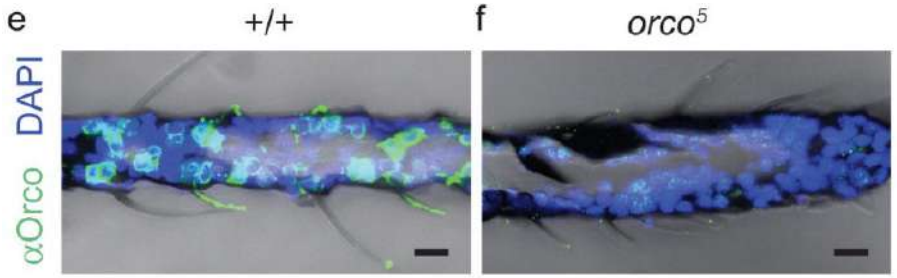
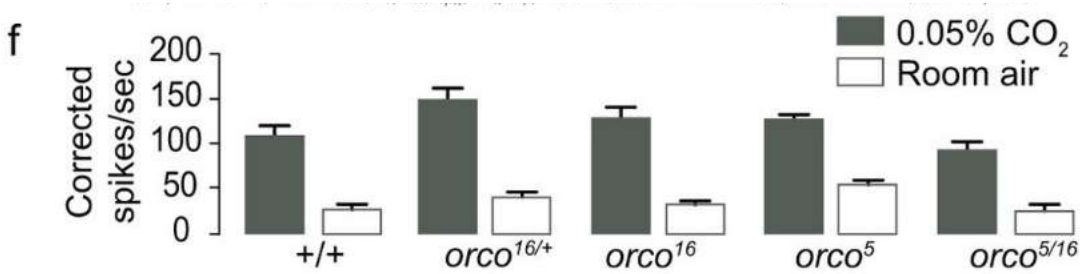
Neuroscience, Molecular Biology



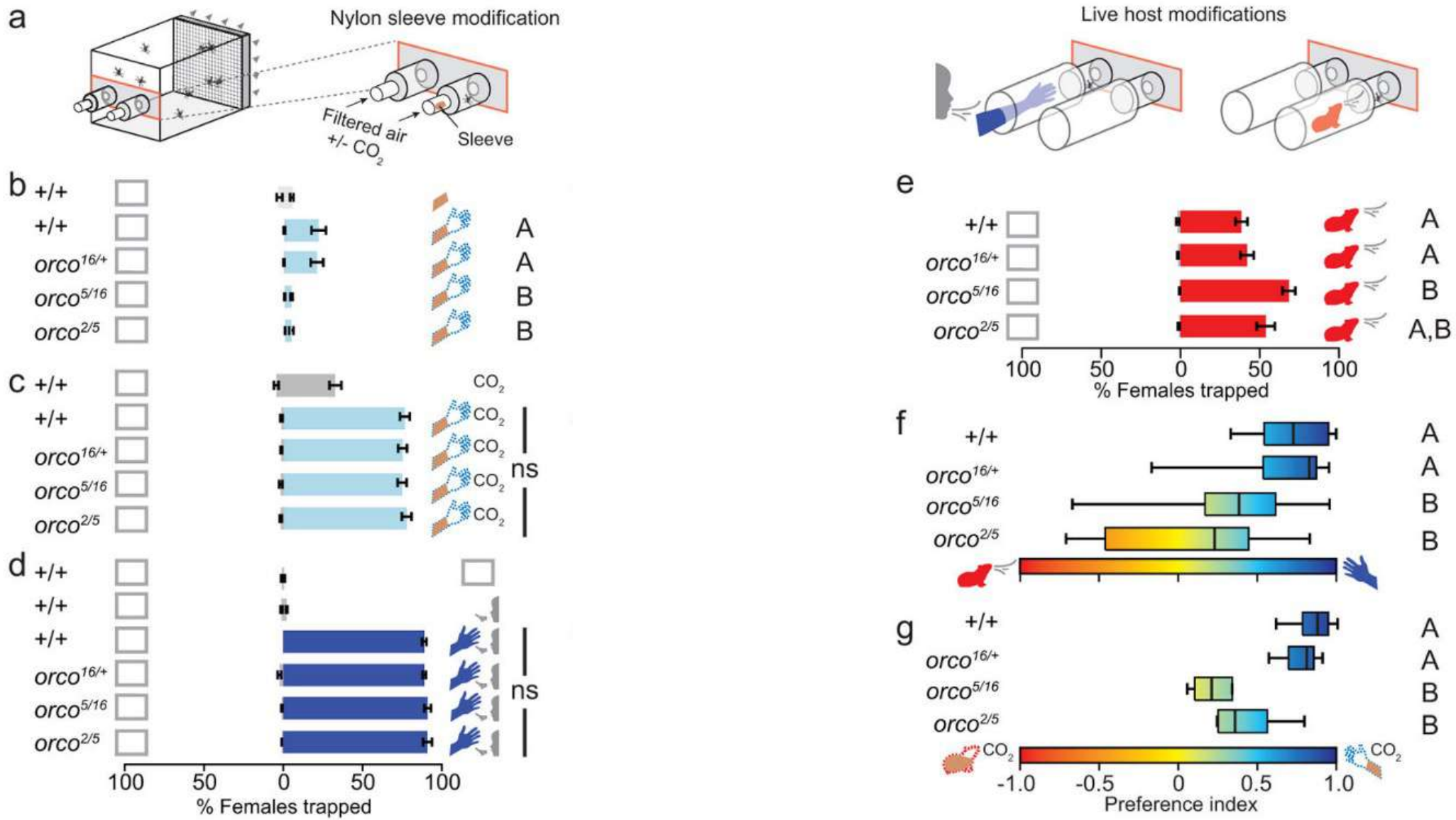




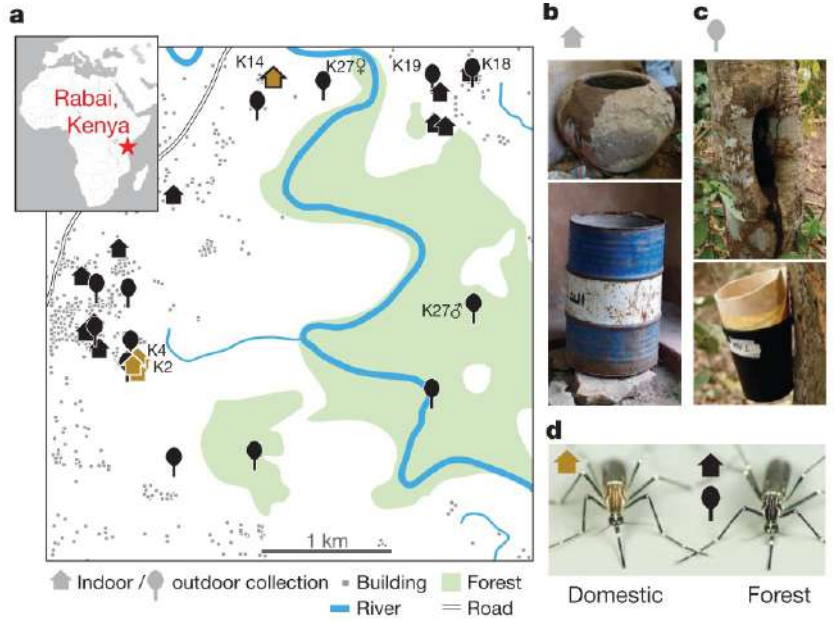


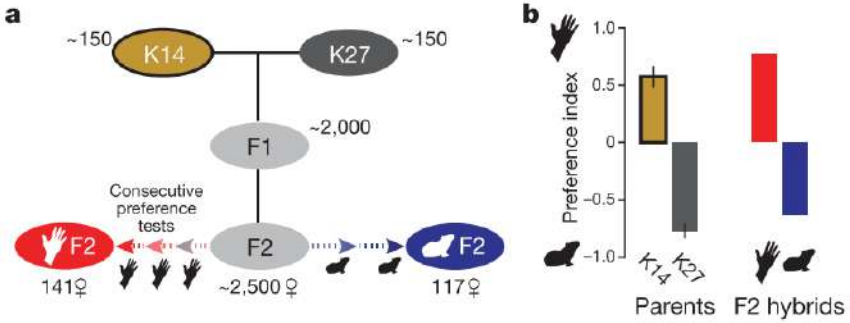
Whether the OR pathway is required for host discrimination ?

orco functions on host detection and discrimination in mosquitoes

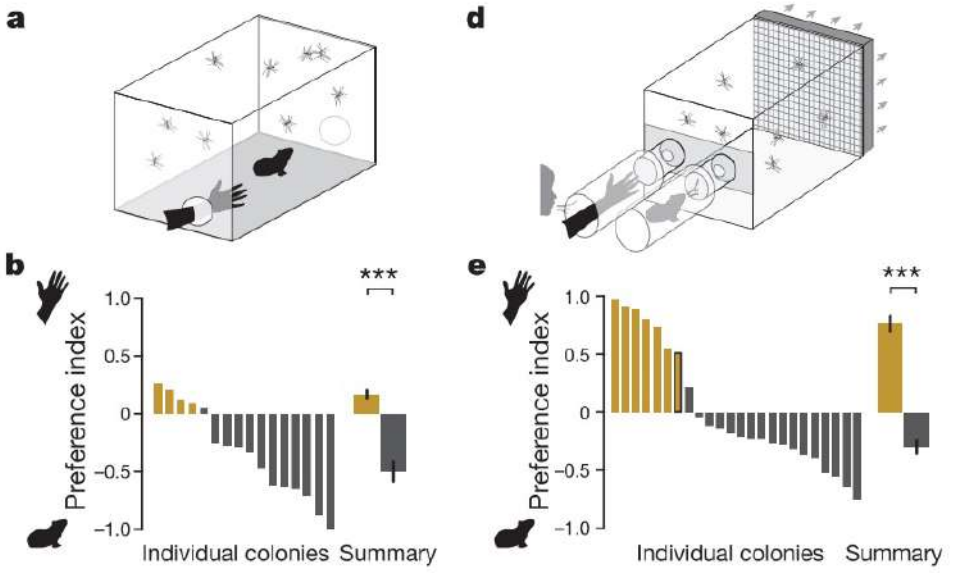


Evolution of mosquito preference for humans linked to or4——which responds to sulcatone, a human odorant

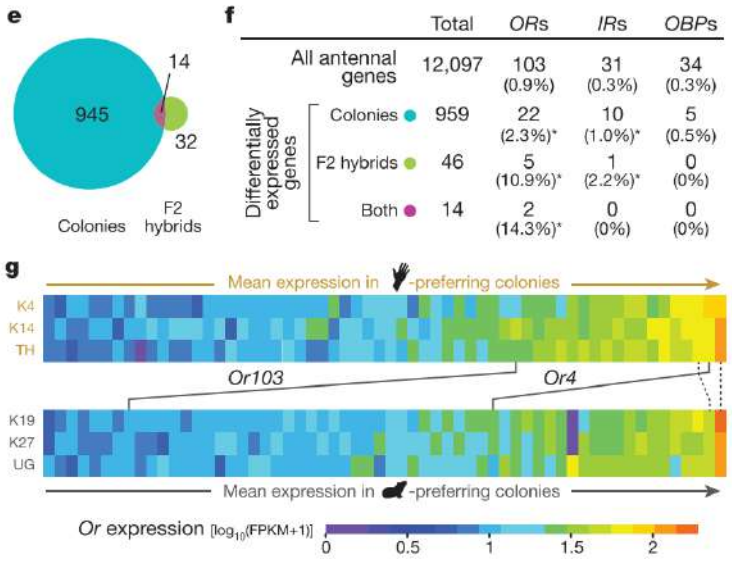


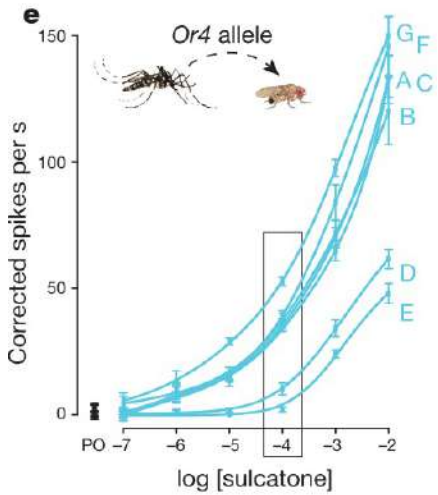


Sulcatone 甲基庚烯酮是一种内源性代谢产物



black—forest
brown—domestic





C. S. McBride, et al. *Nature*. 2014

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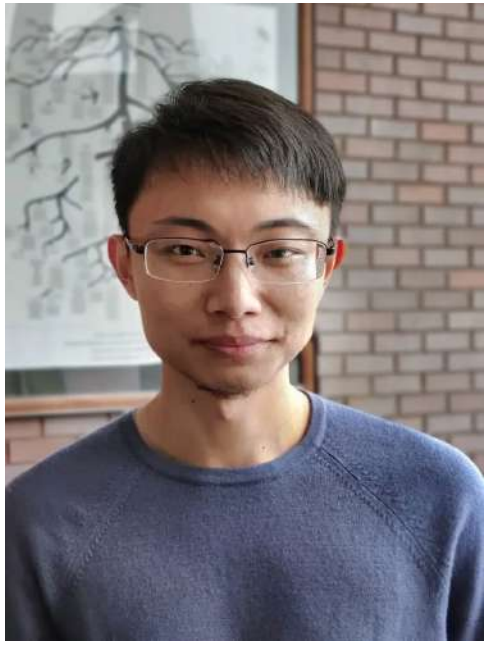
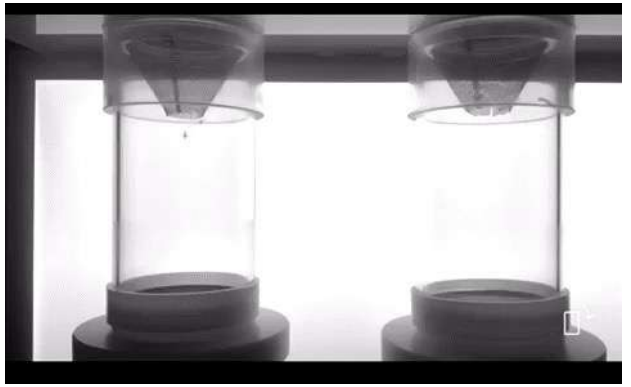
Article | Published: 04 May 2022

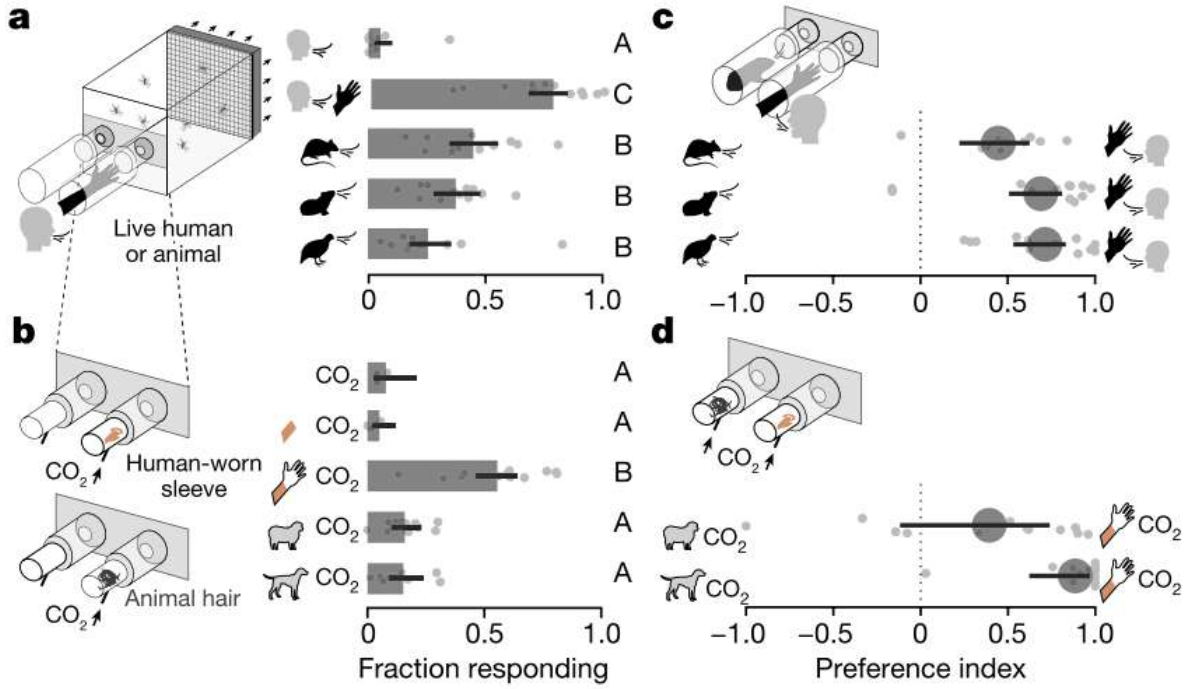
Mosquito brains encode unique features of human odour to drive host seeking

Zhilei Zhao, Jessica L. Zung, Annika Hinze, Alexis L. Kriete, Azwad Iqbal, Meg A. Younger, Benjamin J. Matthews, Dorit Merhof, Stephan Thiberge, Rickard Ignell, Martin Strauch & Carolyn S. McBride

Nature **605**, 706–712 (2022) | Cite this article

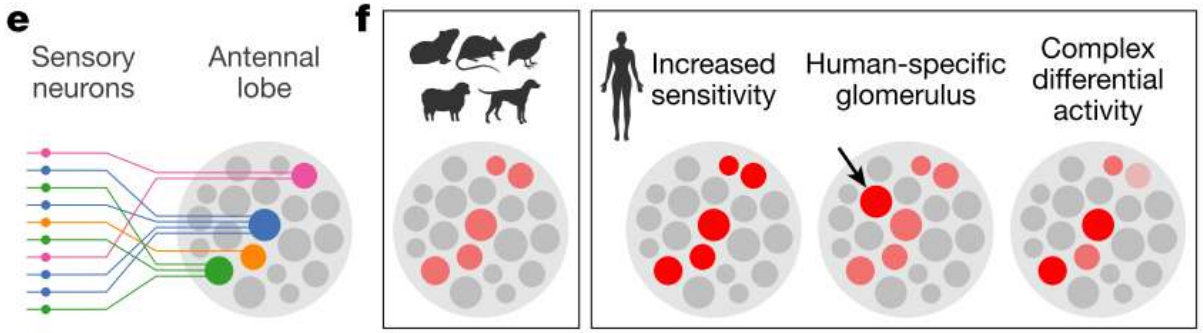


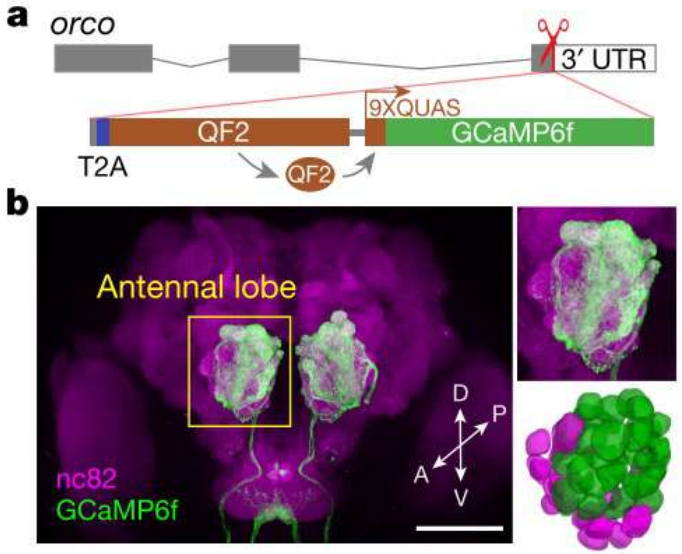


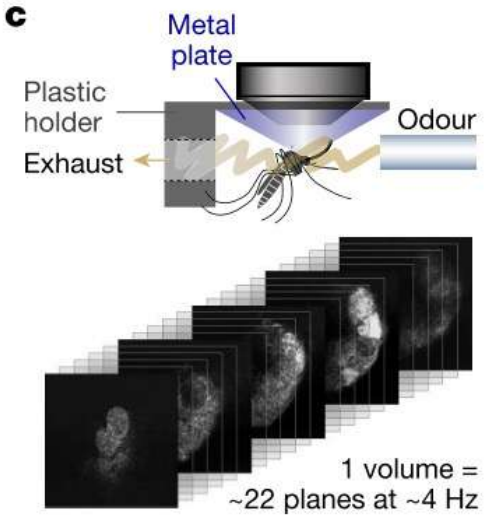


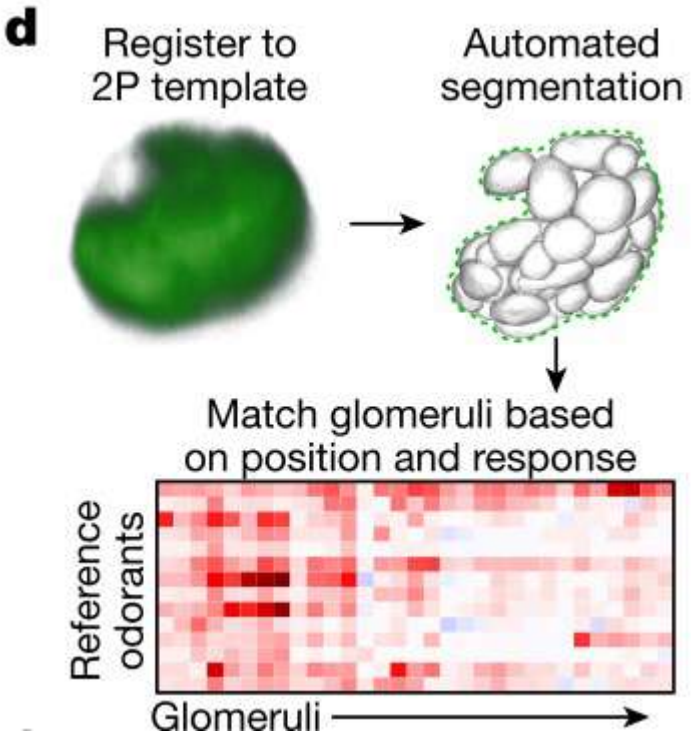
Why human odors make *Aedes aegypti* more interested in us than animals?

Visualizing changes in the glomerulus as they are stimulated by odors

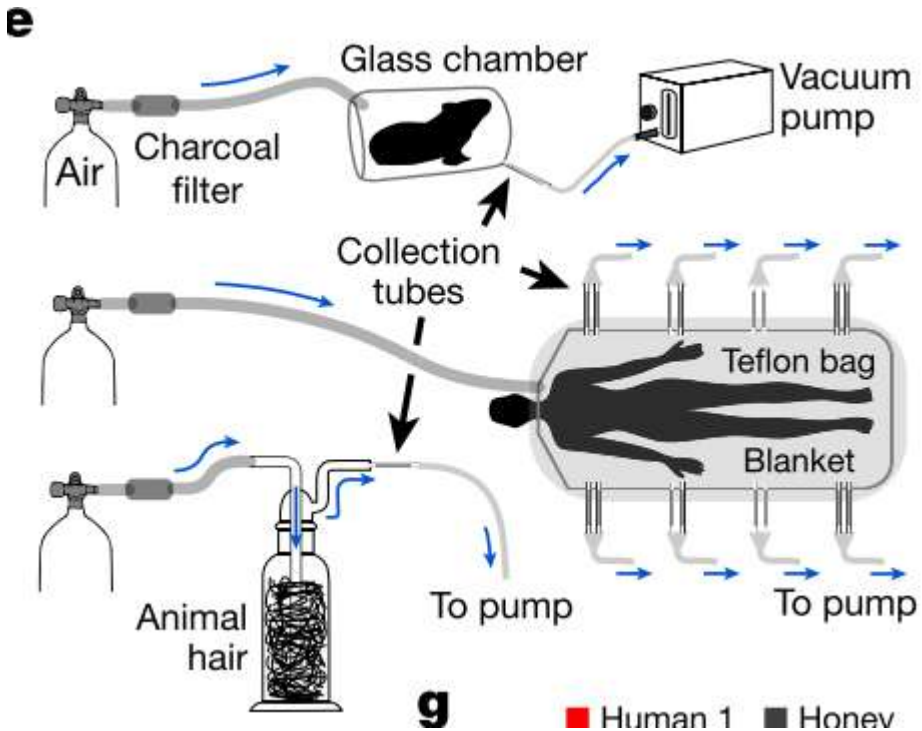


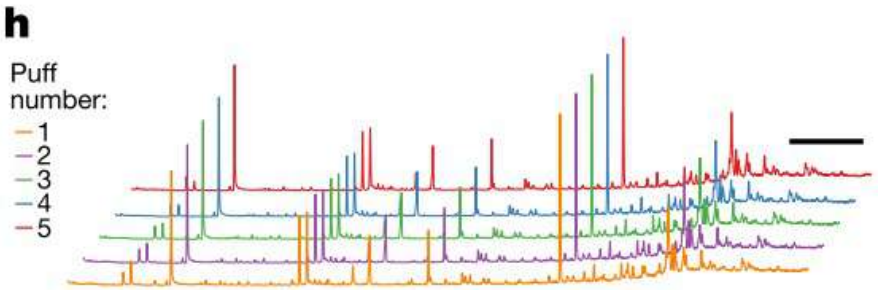




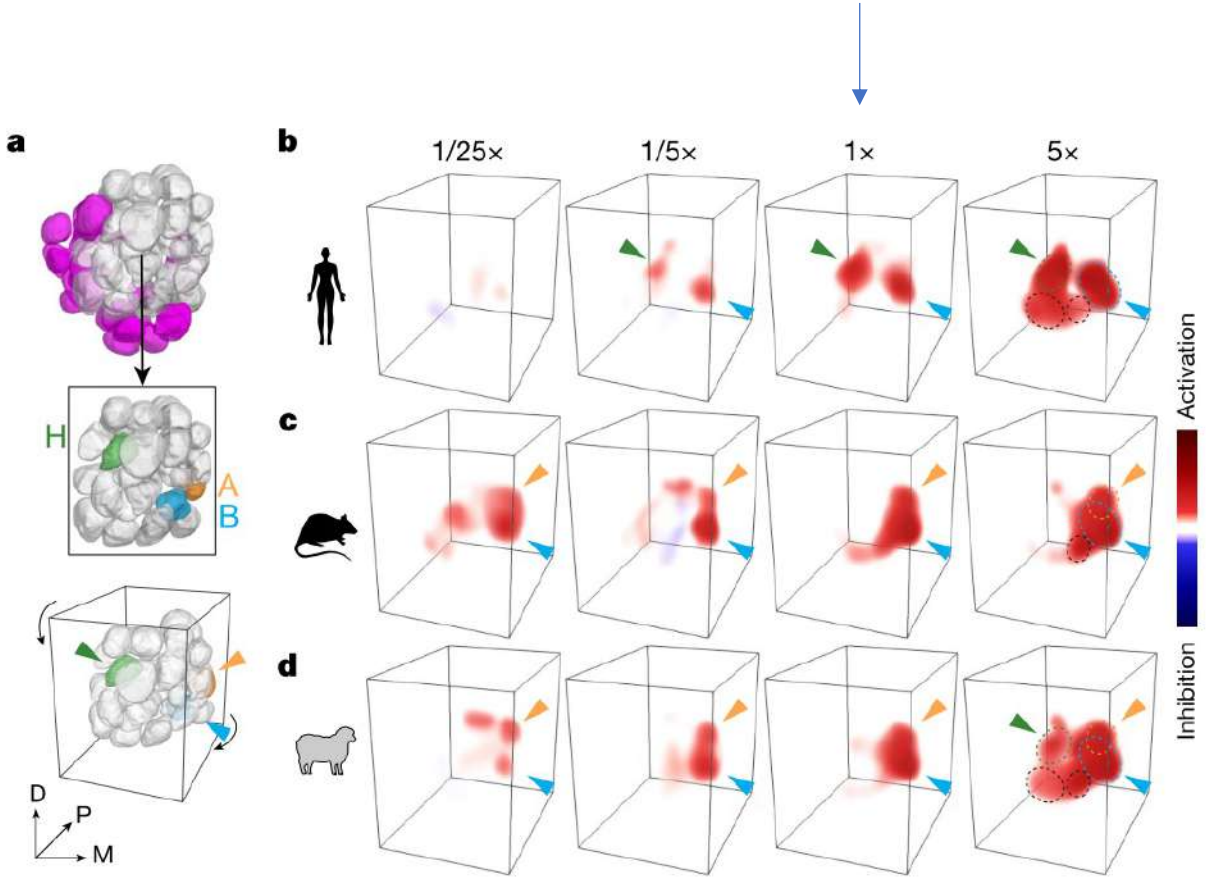


Odor extraction and homogenization

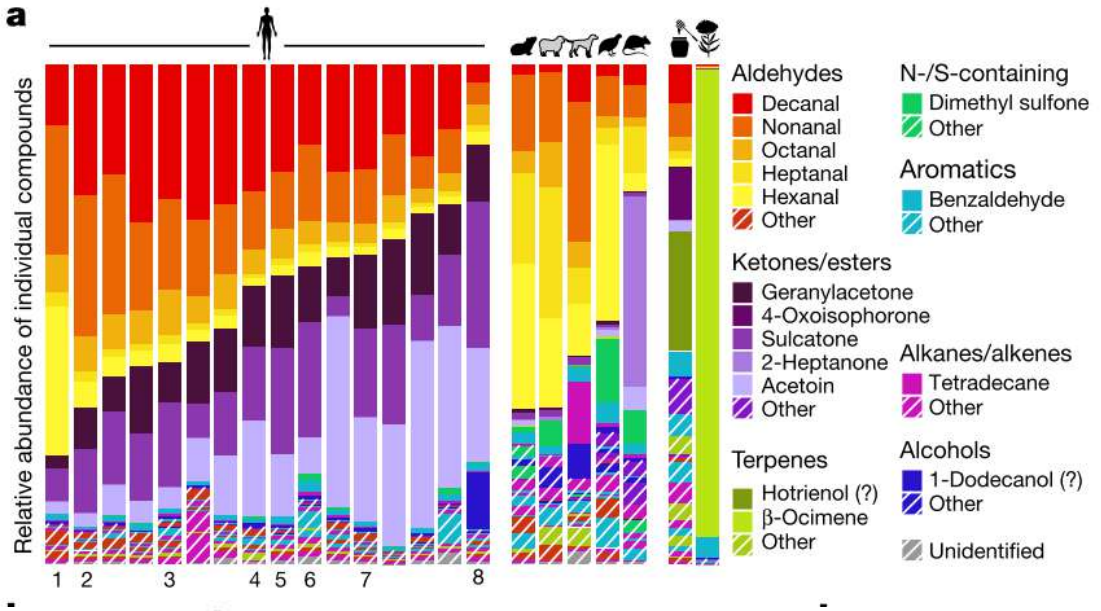


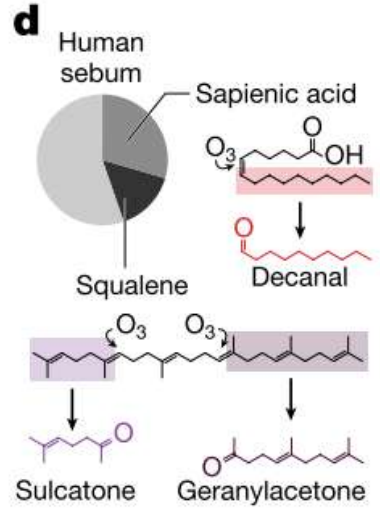


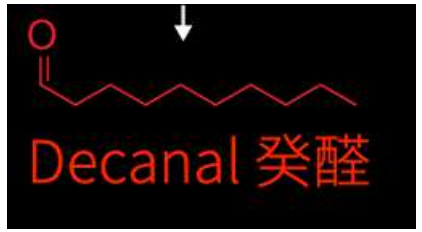
Human odor evokes unique neural responses due to the enriched key compounds



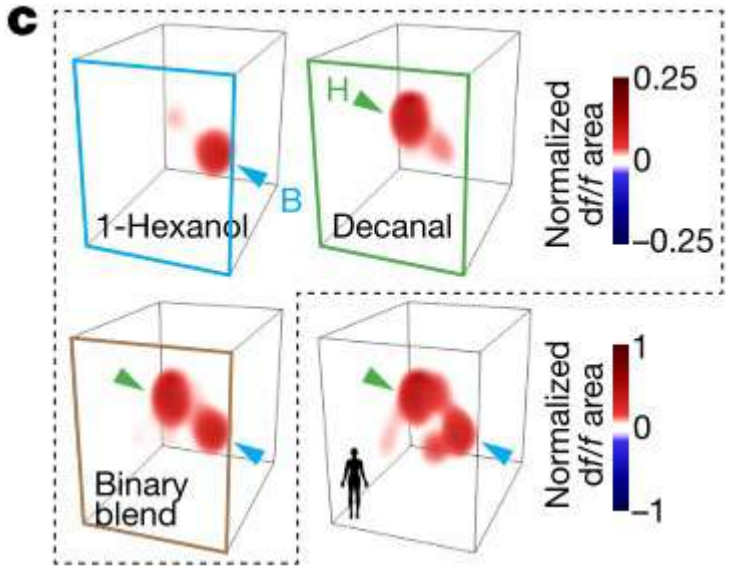
H, human-sensitive glomerulus
A, animal-sensitive glomerulus
B, broadly tuned glomerulus

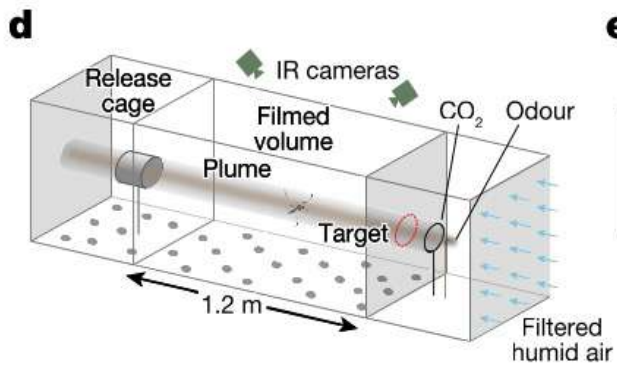


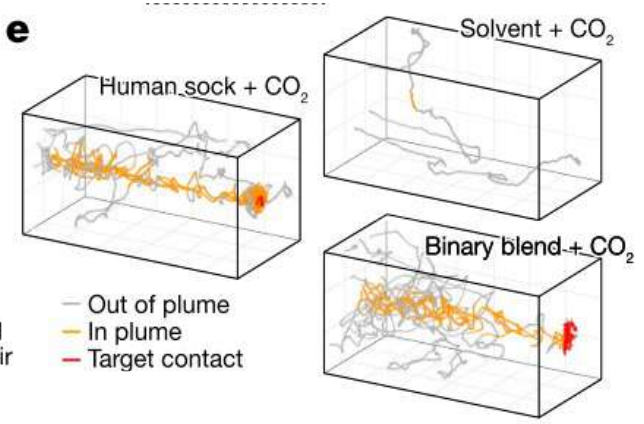


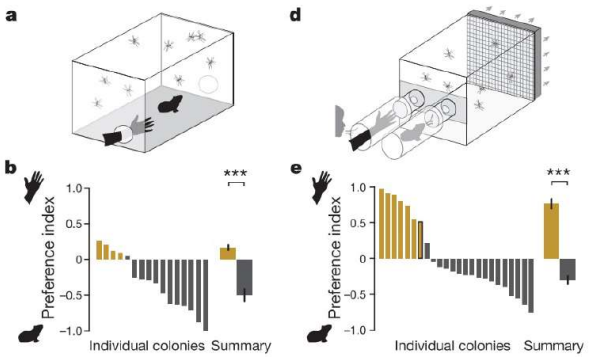


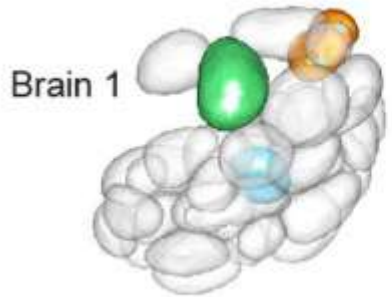
Activation of the H glomerulus enhances host-seeking behavior

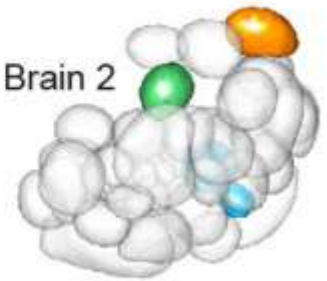




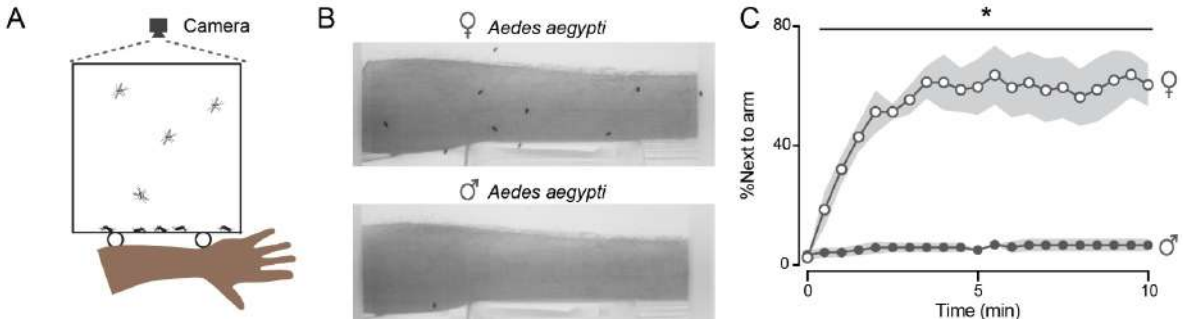


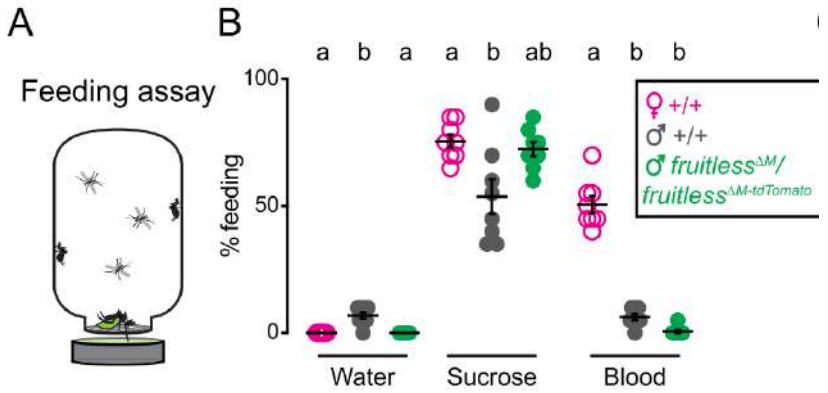


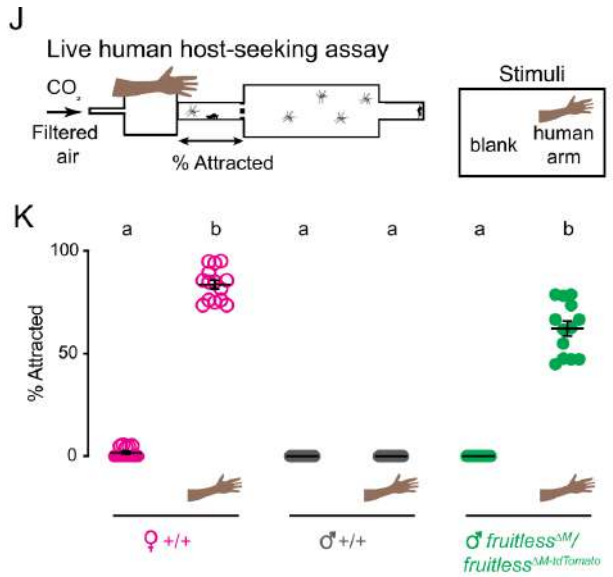


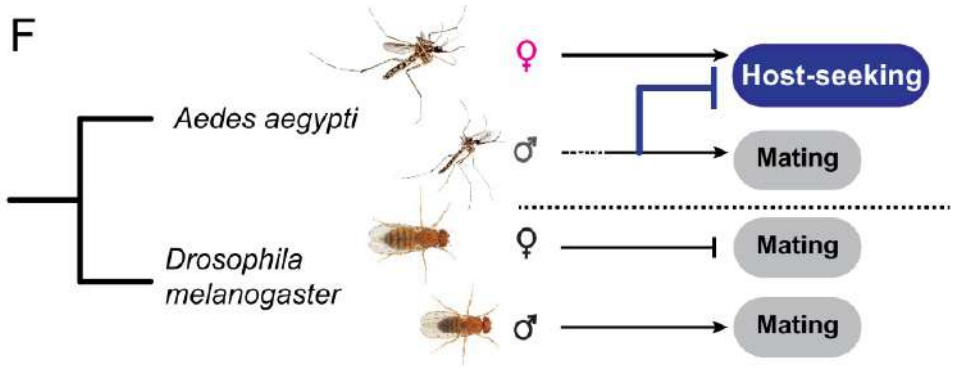


fruitless mutant male mosquitoes gain attraction to human odor







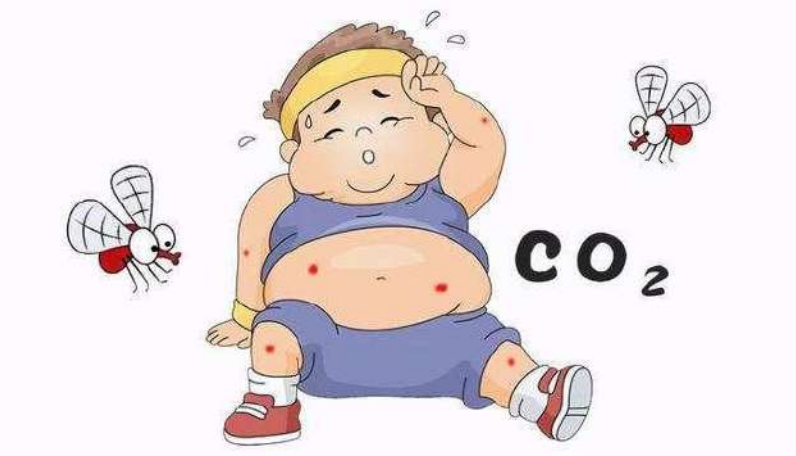


N. S. Basrur, et al. *Elife*. 2020

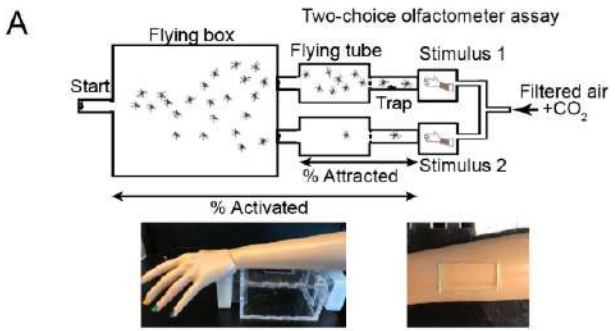
Conclusions：

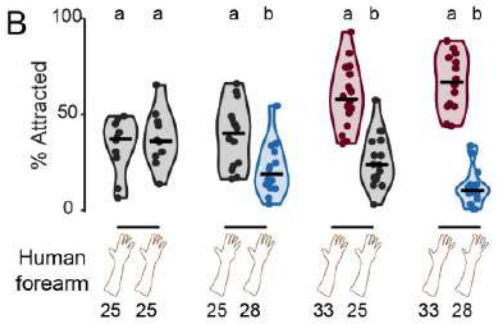
- Sexual dimorphism of mosquito bloodsucking behavior
- *ocro* functions on distinguishing humans and animals
- *or4*：evolution of mosquito preference for humans
- The response of H glomerulus to key compounds participates mosquito preference for humans

What types of people do mosquitoes prefer ？

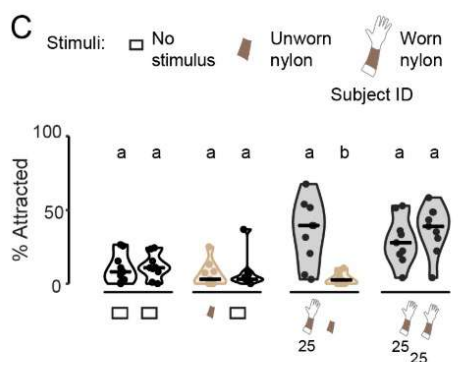


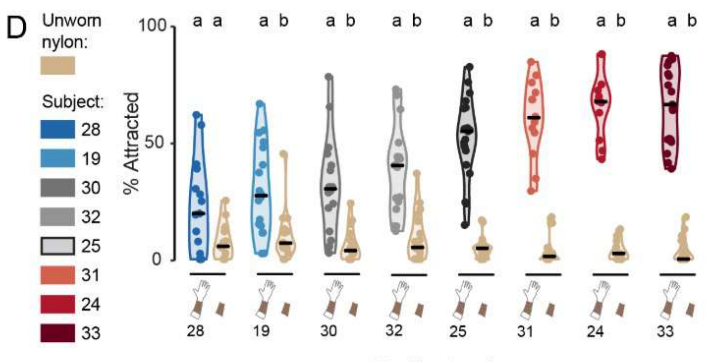
Mosquitoes show strong preferences for individual humans

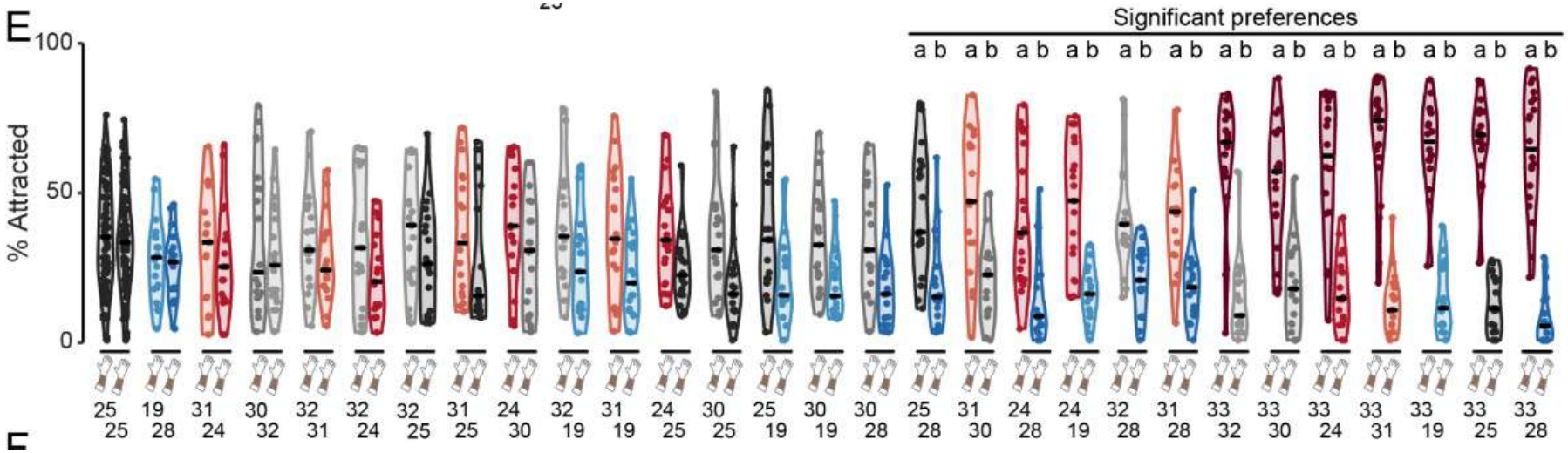




33>>25>28





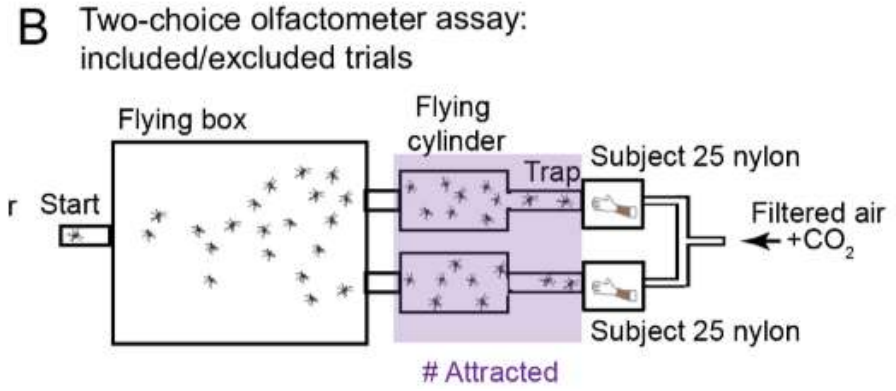


What sensory mechanisms do mosquitoes rely on to detect these interindividual differences in skin odor?

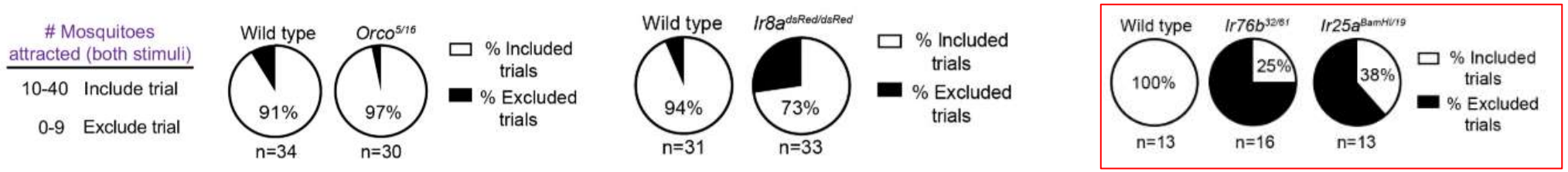
M. E. De Obaldia,. et al. 2022
Leslie B. Vosshall

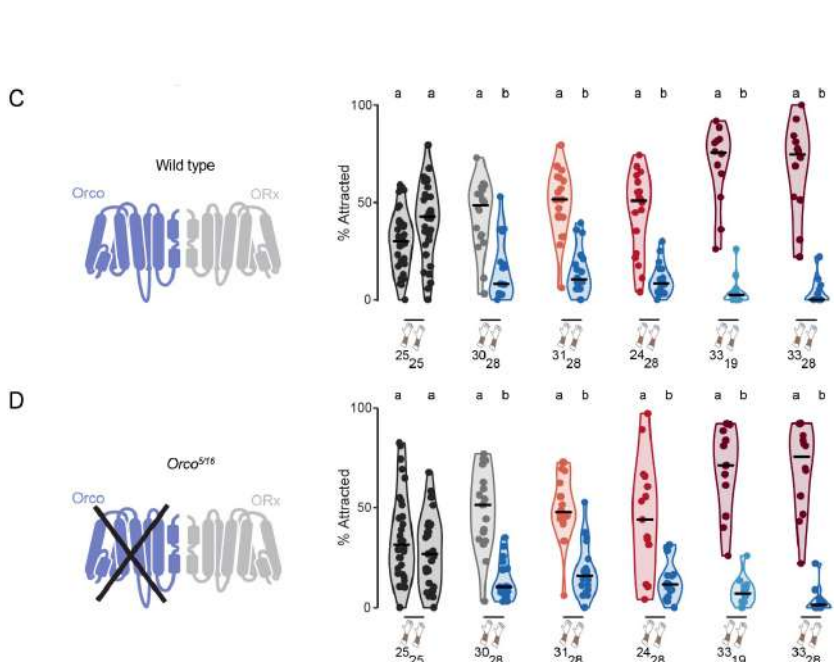
- Mosquitoes use two large multigene families to detect olfactory cues that each encode odor-gated ion channels, the **odorant receptors (ORs)** and the **ionotropic receptors (IRs)**

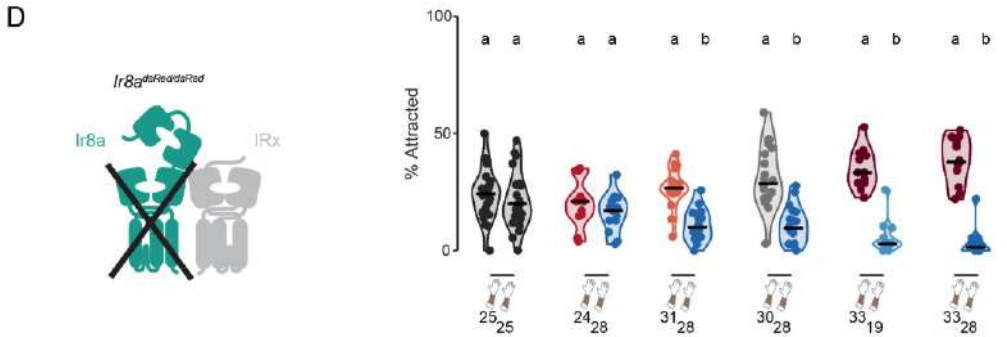
	ORs	IRs
Number of co-receptors	1—orco	3—Ir8a, Ir76b, Ir25a
Ligand-selective	116	132
Responsive molecule	esters, alcohols, ketones, aldehydes	carboxylic acids and amines

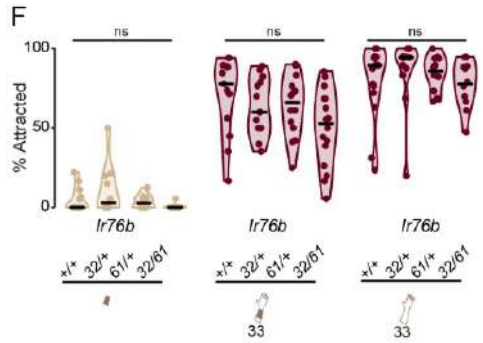


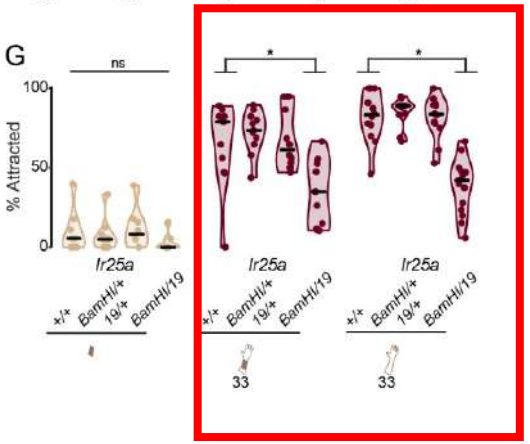
Orco and Ir co-receptors mutant mosquitoes retain individual human preferences

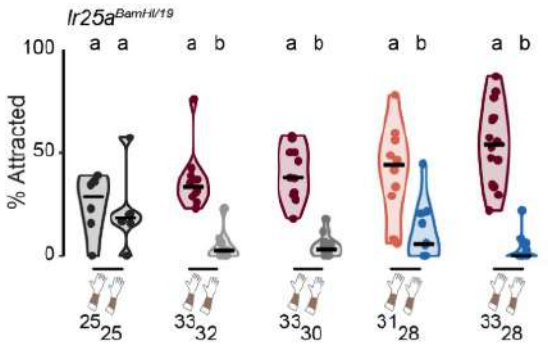










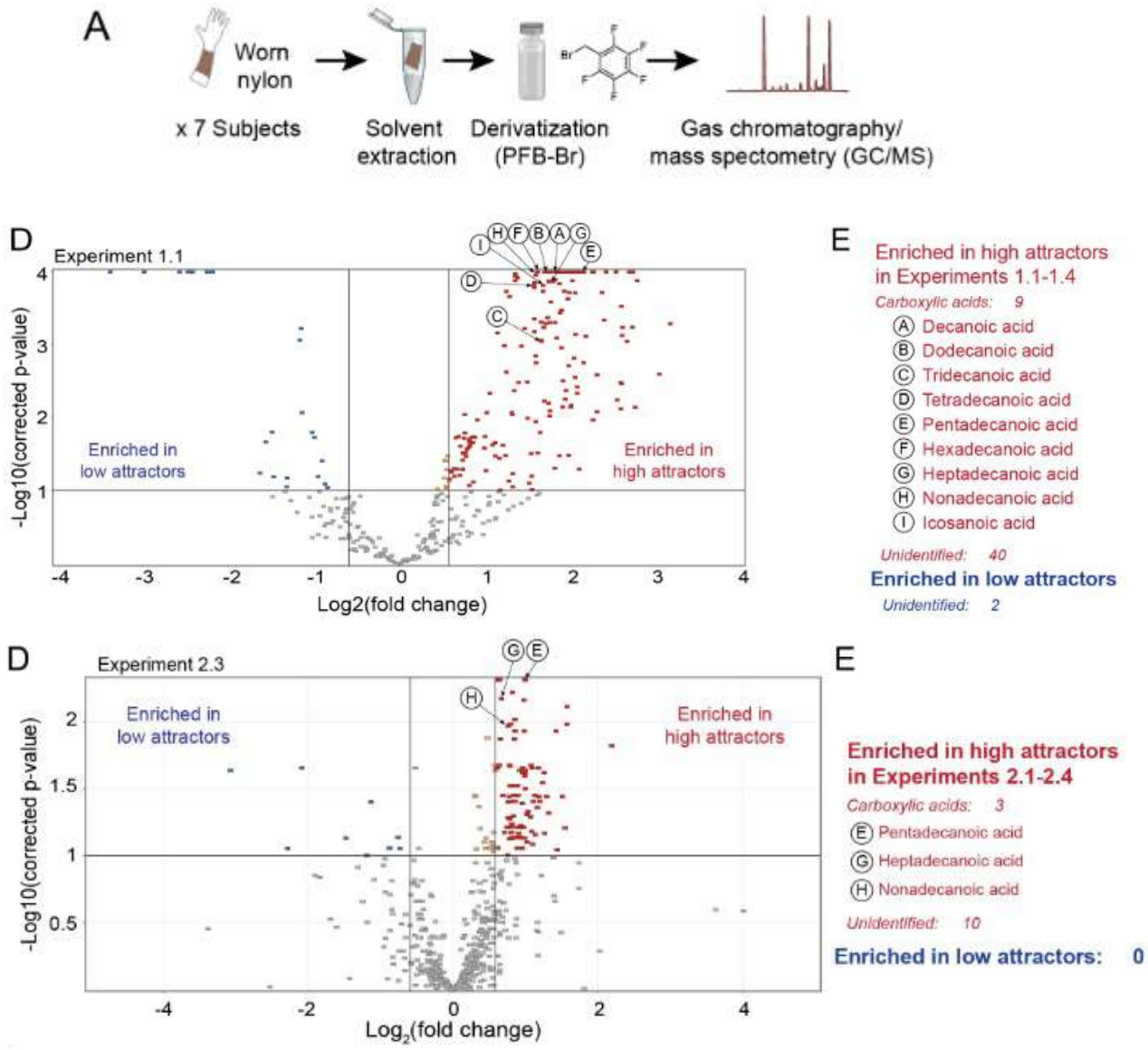


Mosquitoes have evolved highly redundant sensory systems to sensing humans

Carboxylic acids are enriched in the highly mosquito attractive humans

Acidic compounds:

pentadecanoic,
heptadecanoic,
nonadecanoic acids



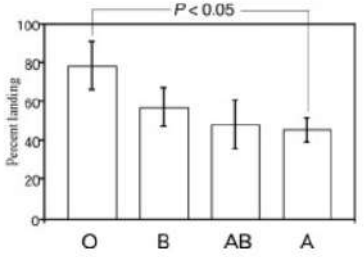
Are mosquitoes really attracted differently to blood types?

Table 1 Mean Number of Bites in Each Group

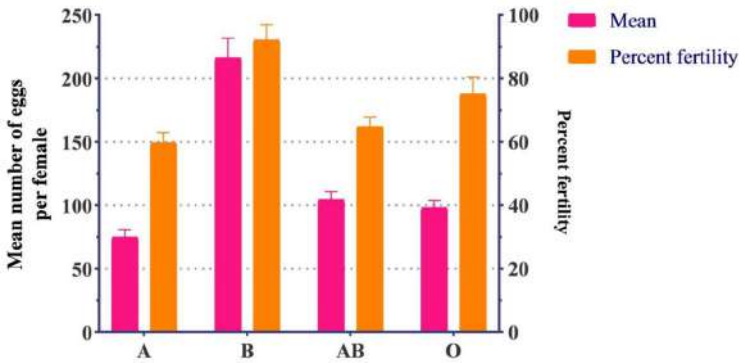
Blood group	No. of subjects	Mean No. of bites*
O	42	5.045
A	41	3.276
B	14	4.250
AB	5	3.280
A+B+AB	60	3.503

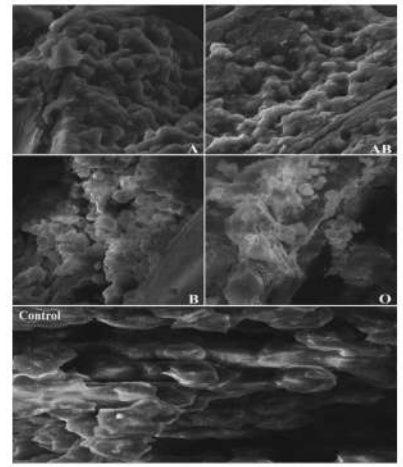
* For each subject exposed more than once the average value was used.

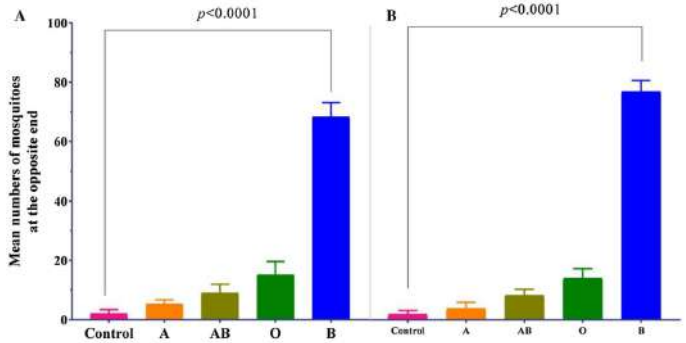
C. S. Wood, et al. Nature. 1972



Shirai., et al., 2002

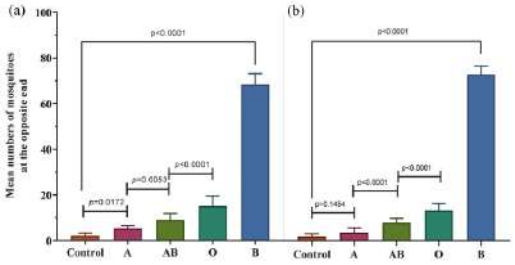






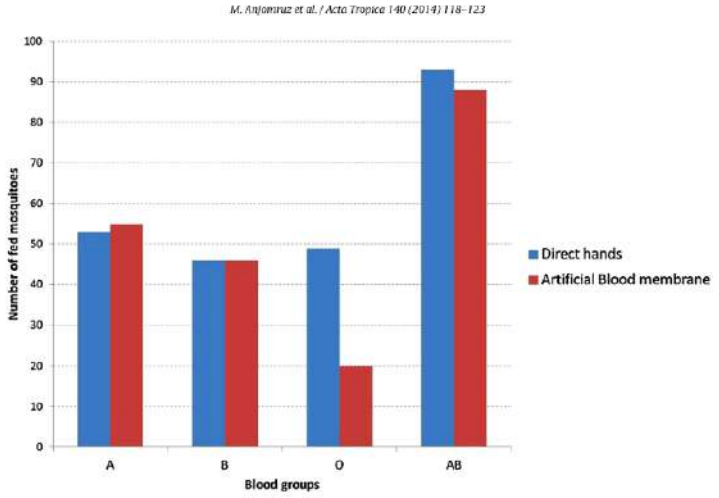
Aedes aegypti

Anopheles stephensi



S. A. Khan, et al. *Scientific reports.* 2021

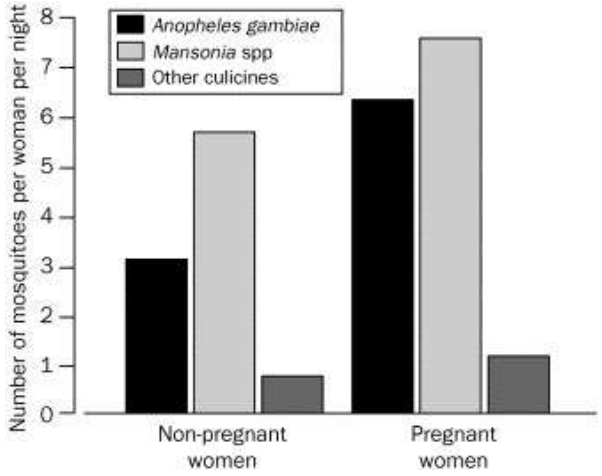
Pest Manag Sci. 2022



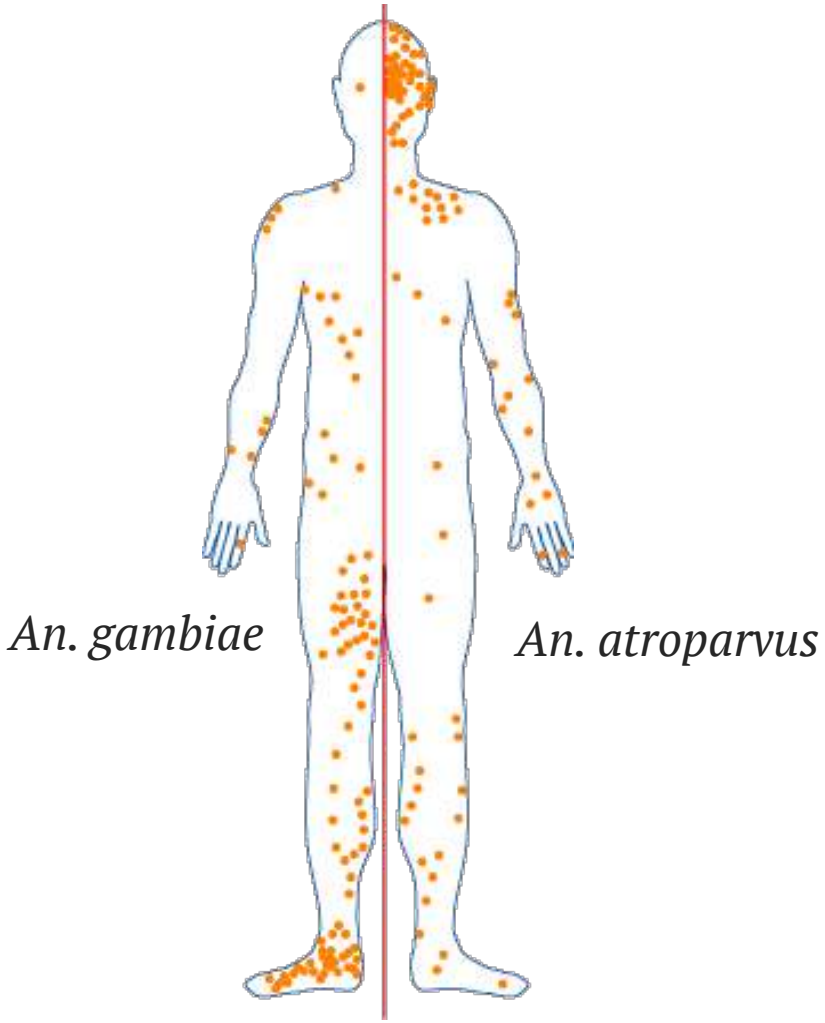
preference of *An. stephensi* to different blood groups was as follow AB > A > B > O whereas it is almost the opposite for *An. gambiae*, O > B > AB > A. In another study it was shown that *Aedes albopictus* preferred to land on human skin of blood group O and then in decreasing order on B, AB, and A blood groups (Shirai et al., 2004).

M. Anjomruz, et al. *Acta Trop*. 2014

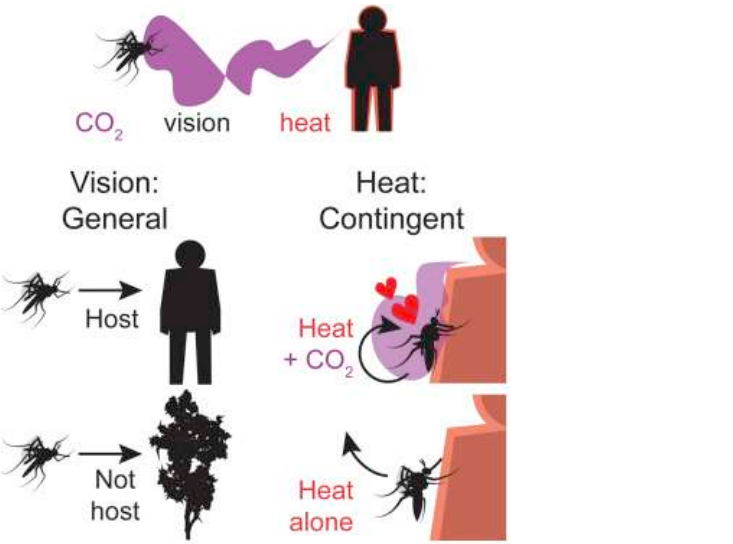
Different influencing factors of mosquito attraction

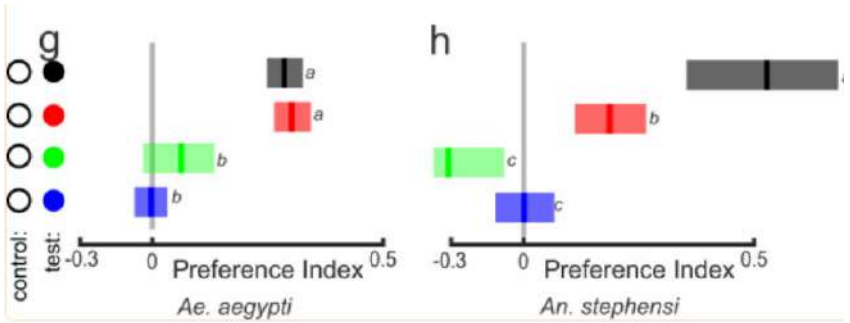


Lindsay, S. et al. *The Lancet* , 2000



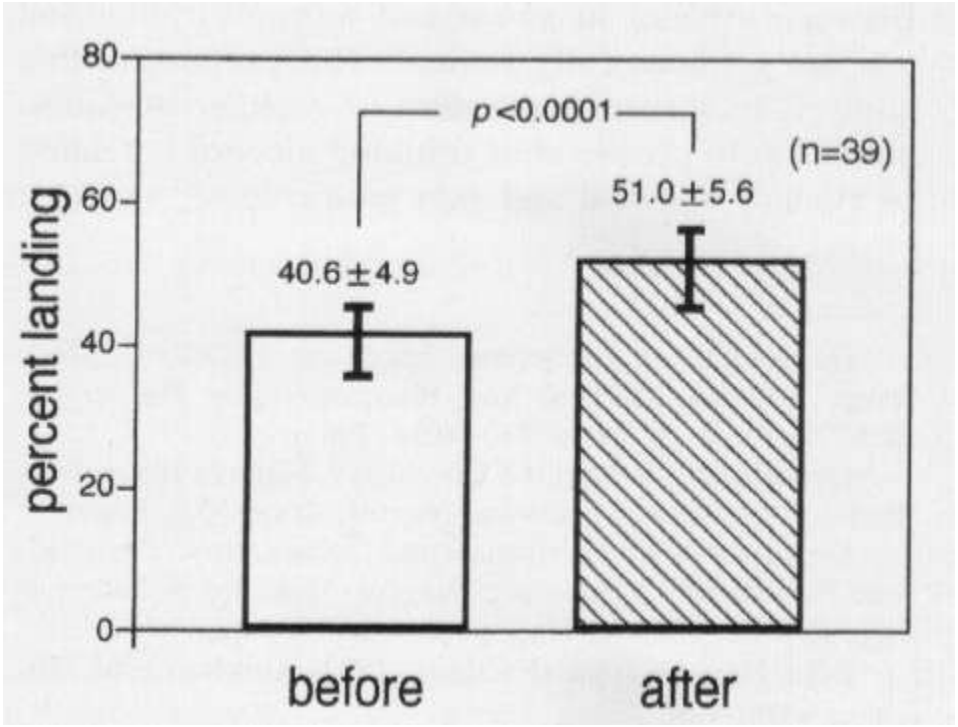
Enserink, M., *Science*., 2002



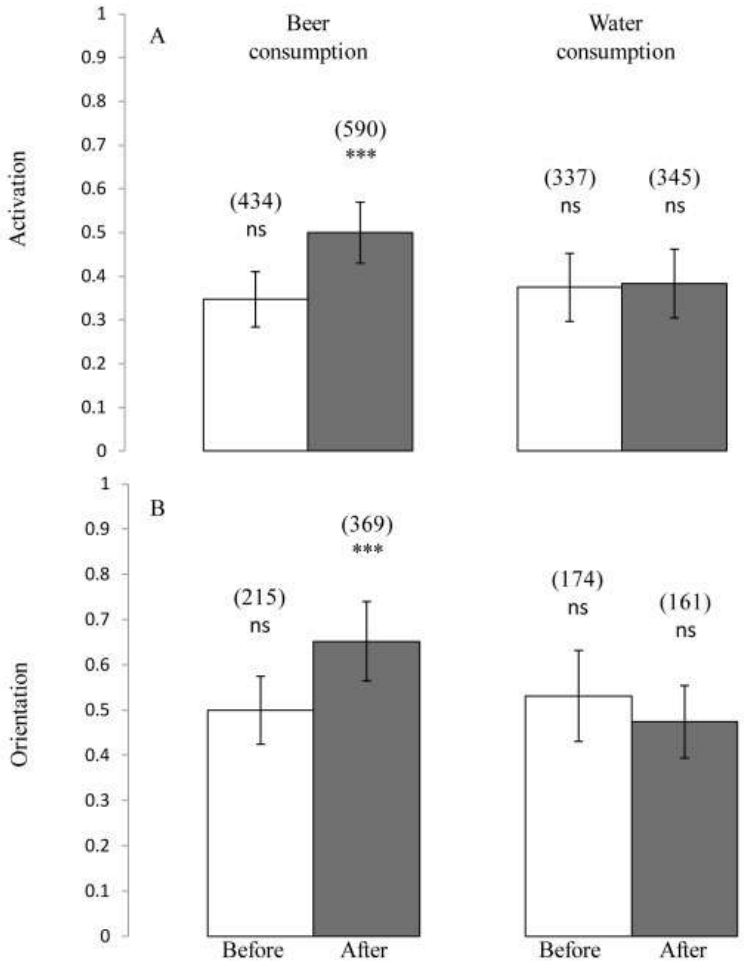


Diego et al. *Nat Commun*. 2022

Alcohol consumption increases human attractiveness to mosquitoes



O Shirai., et al. 2002



Thierry Lefèvre., et al. *PLoS One*. 2010

Conclusions：

- Sexual dimorphism of mosquito bloodsucking behavior
- *ocro* functions on distinguishing humans and animals ； *or4*
- The response of H glomerulus to key compounds participates mosquito preference for humans

- Mosquitoes have evolved highly redundant sensory systems to track humans
- Individual differences in mosquito attractiveness were associated with carboxylic acids
- The evidence for “blood type theory” is scant
- Many factors can affect the attractiveness of mosquitoes

THANK YOU!