

A stick insect is camouflaged on a branch with several yellow and orange flowers. The insect's body is brown and segmented, mimicking the appearance of a twig. Its legs are also brown and thin, blending with the branch. The background is a dark, blurred green and yellow, suggesting a natural outdoor setting.

# Fantastic Beasts—— The Master of Camouflage in Nature

Overview of “Cosplay” in nature ——LT

Masters of Camouflage in Insects —— MMZ

Masters of camouflage in other animals and plants ——WR

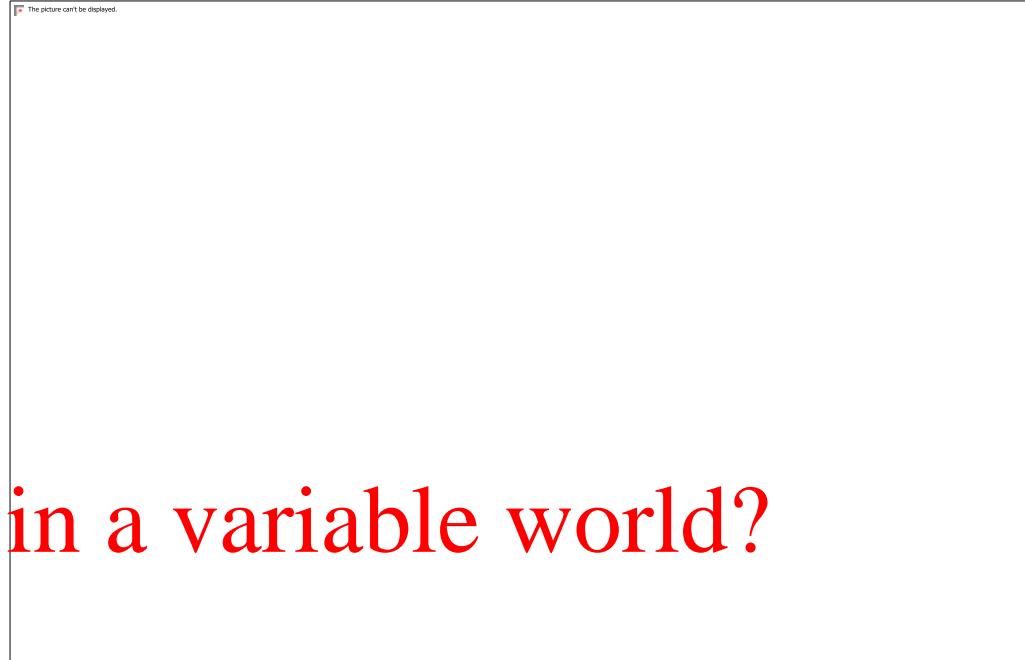
讨论

2025.12.23

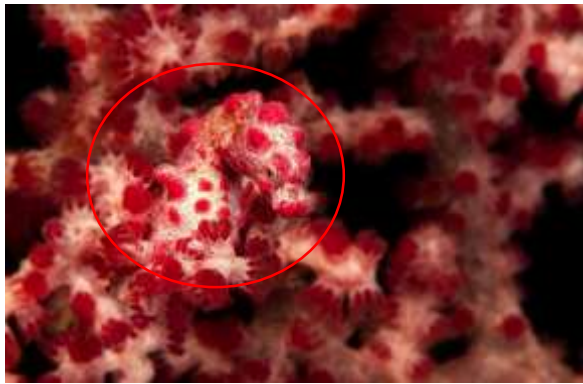
# The White Bone Demon's three disguises



How to hide in a variable world?



# Masters of camouflage in nature



Camouflage strategy——**Survival strategy**

# Interesting cosplay behaviors in nature — — Camouflage



Current Biology  
Magazine

**What is camouflage?** Camouflage is an example of adaptation, whereby animals and even some plants avoid detection or recognition by resembling the general background or specific objects. Among the most striking

# Overview of Camouflage in Nature

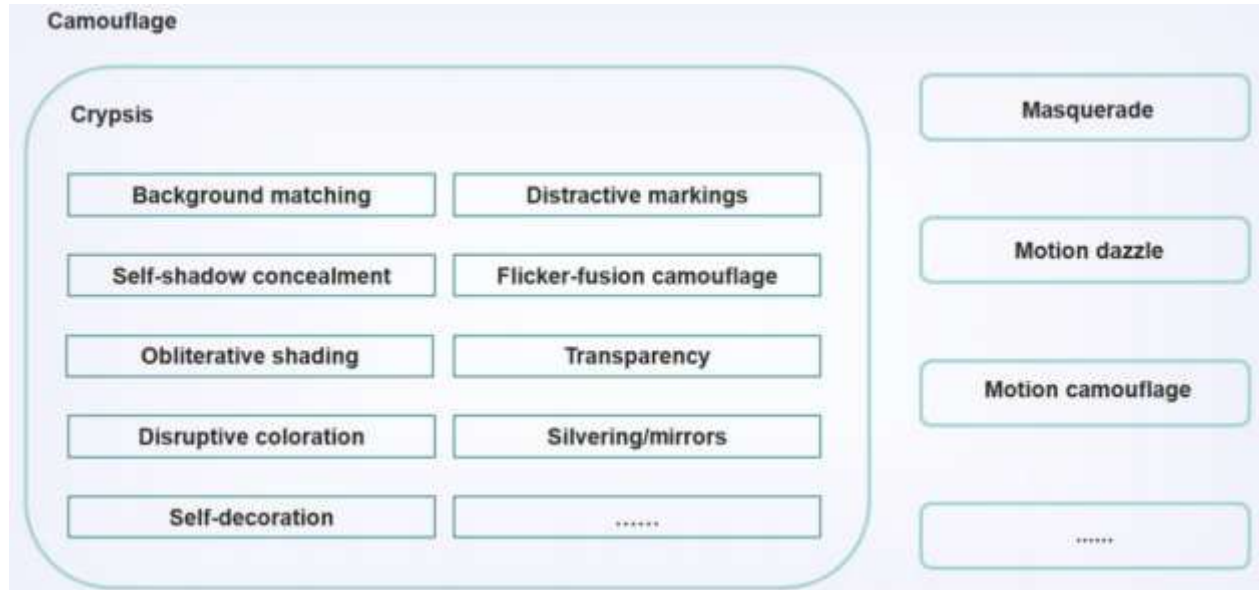
- Types of camouflage — nature's disguise toolkit
- The biological significance of camouflage — the inevitable choice of evolution
- Value extension: from natural camouflage to human innovative applications

# Overview of Camouflage in Nature

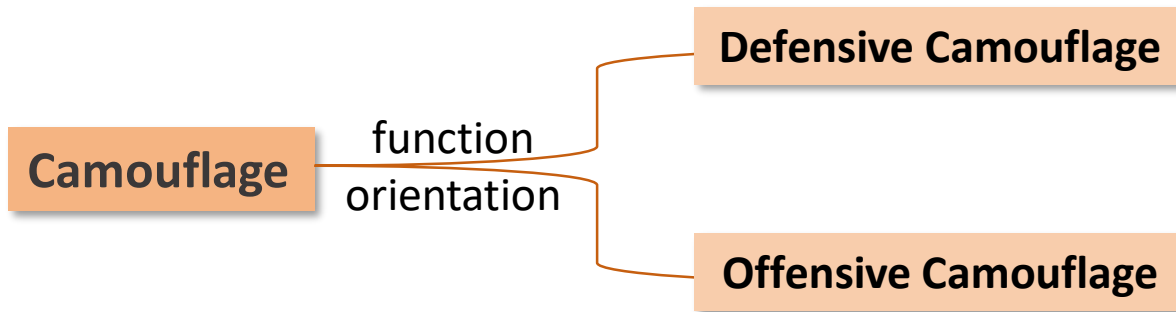
- Types of camouflage — nature's disguise toolkit
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# Types of camouflage

## Morphological camouflage

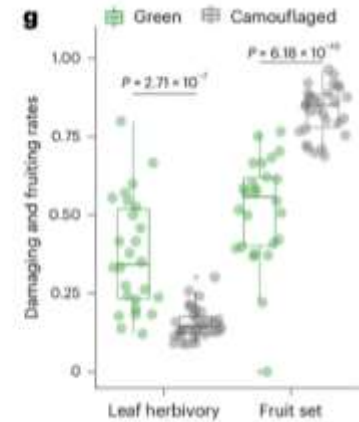
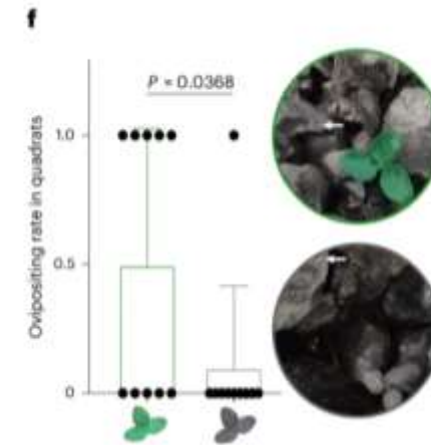
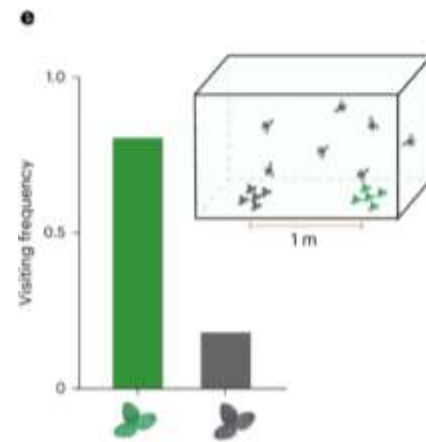
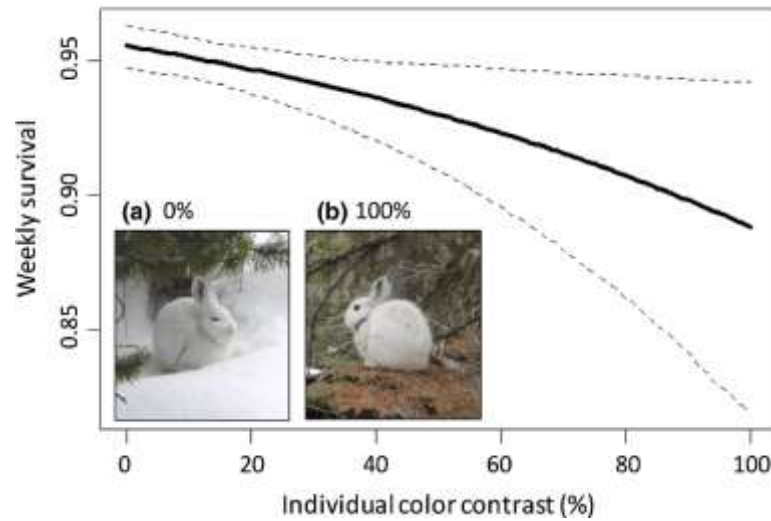


## Morphological camouflage



# Defensive Camouflage — Survival Is the Only Goal

## 1. Protective Coloration : hide in the environment



Zimova, M., et al., *Biological Reviews*, 2018

Zimova, M., et al., *Ecology Letters*, 2016

Han Zhang, et al., *Nature Ecology & Evolution*, 2025

# Defensive Camouflage — — Survival Is the Only Goal

## 2. Morphological Mimicry : Imitation of the shape and environment objects



*Phasmatodea*



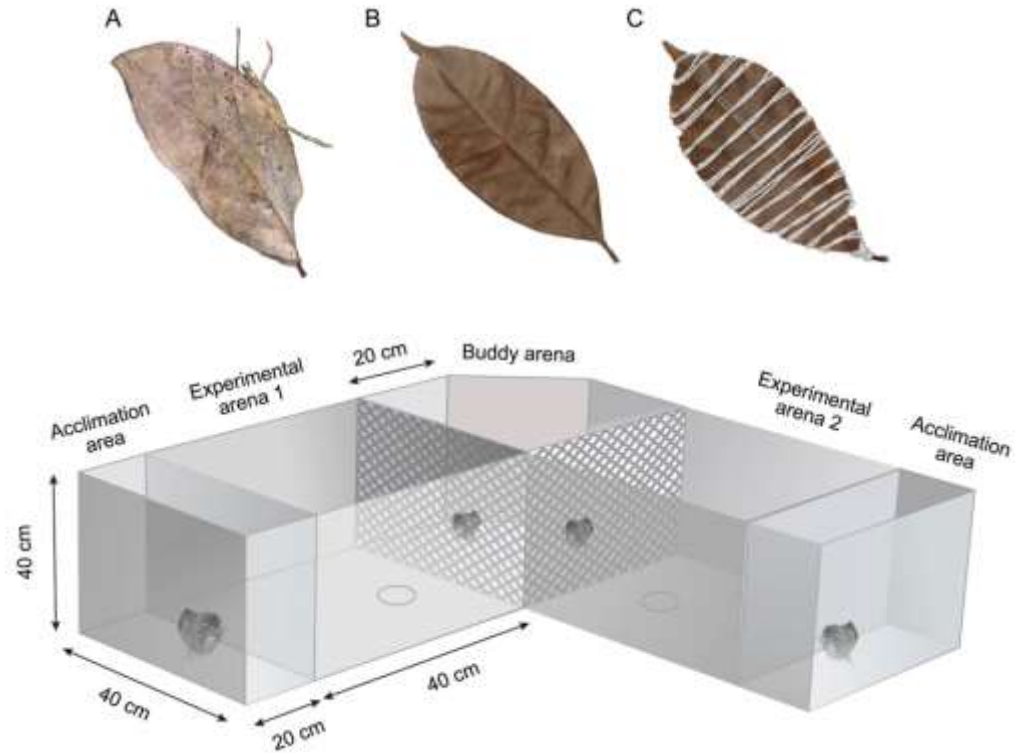
*Kallima inachus*



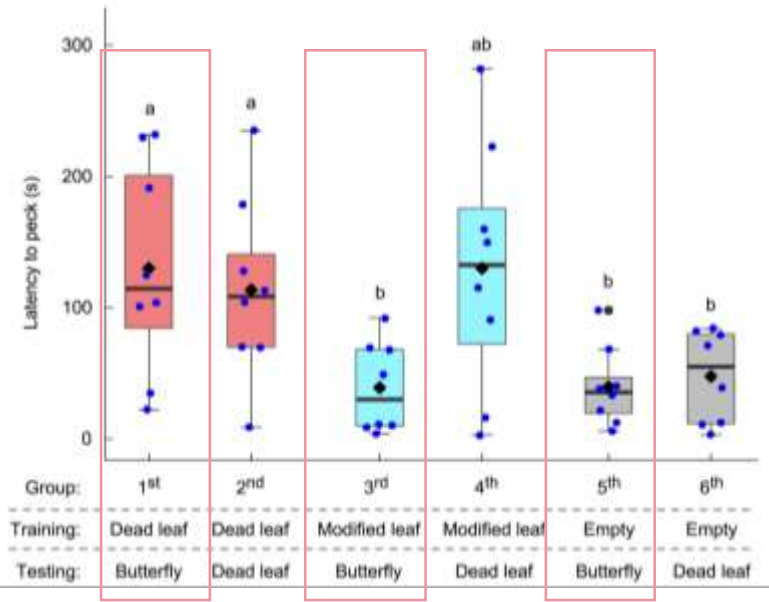
*Lithops N. E. Br.*

# Defensive Camouflage — Survival Is the Only Goal

The defensive function of the *Kallima* butterflies' mimicry

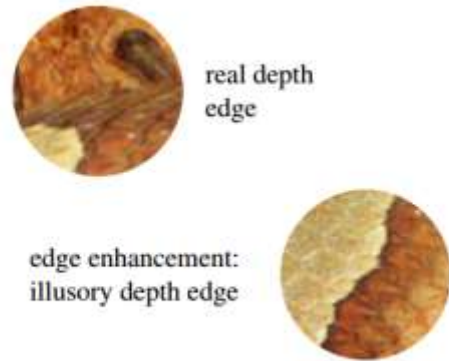


Group	1 <sup>st</sup> (n = 8)	2 <sup>nd</sup> (n = 8)	3 <sup>rd</sup> (n = 8)	4 <sup>th</sup> (n = 8)	5 <sup>th</sup> (n = 8)	6 <sup>th</sup> (n = 8)
Trials						
Experience manipulation trials	Dead leaf	Dead leaf	Modified leaf	Modified leaf	Empty	Empty
Testing trials	Butterfly	Dead leaf	Butterfly	Dead leaf	Butterfly	Dead leaf

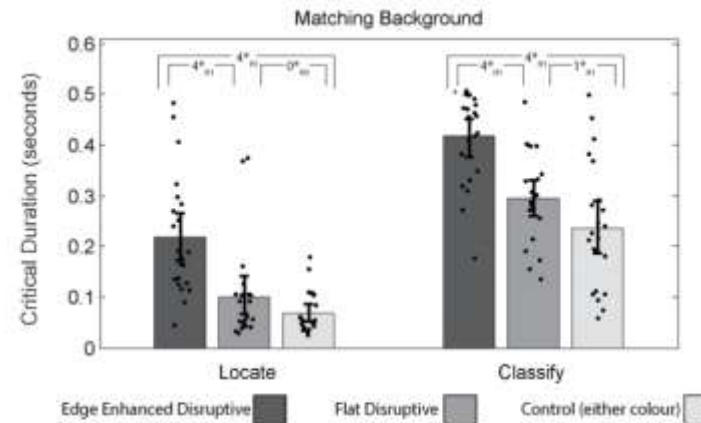
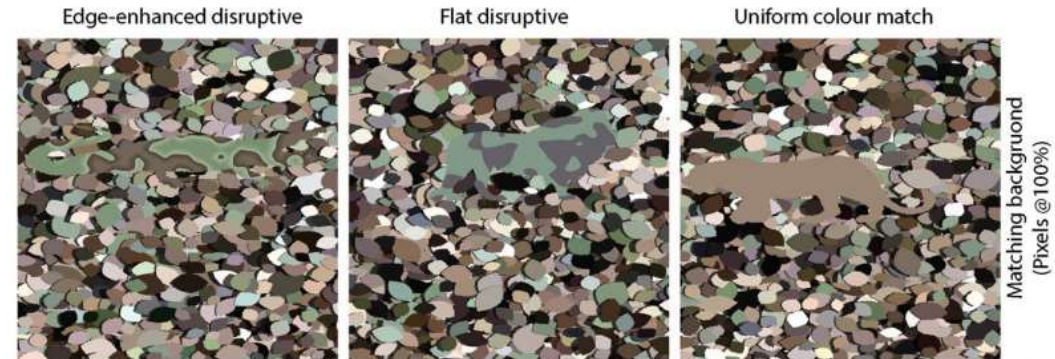


# Defensive Camouflage — Survival Is the Only Goal

## 3. Disruptive Coloration : break the "visual interference" of one's own outline



Edge-enhanced camouflage



# Defensive Camouflage —— Survival Is the Only Goal

## 4. Signal analog : "scare off" or "confuse" predators

### Aposematic Mimicry ( Müllerian mimicry )

The imitated object : toxic and inedible ⚠️

Imitator : toxic or nontoxic

Signal : ⚠️ = toxic

Beneficiary : both



### Batesian Mimicry

The imitated object : toxic and inedible

Imitator : nontoxic

Signal : Shape and color

Beneficiary : imitator



*Danaus plexippus*

*Limenitis archippus*

# Offensive Camouflage— — Take the Initiative to Gain Benefits

## 1. Ambush Camouflage : lie in wait and standby



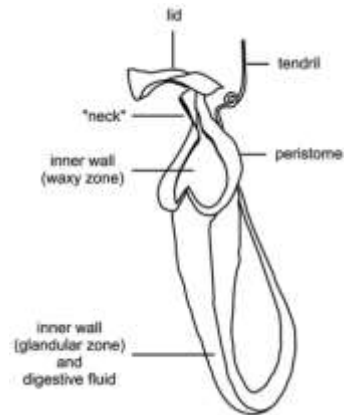
*Panthera pardus*



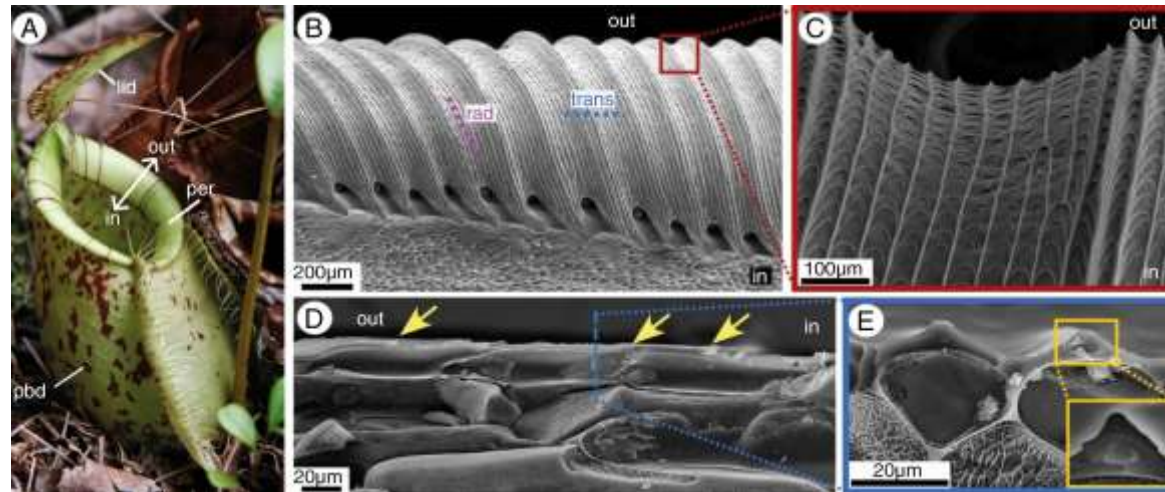
*Ceratophrys ornata*



*Trimeresurus stejnegeri*



*Nepenthes*



# Offensive Camouflage— — Take the Initiative to Gain Benefits

## 2. Aggressive Mimicry : actively attract prey

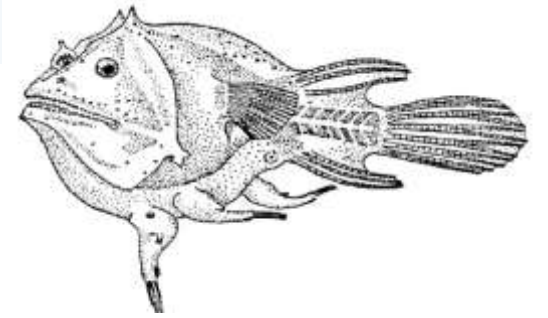
*Lophiiformes*



Hunting for food  
(female)



parasitic males

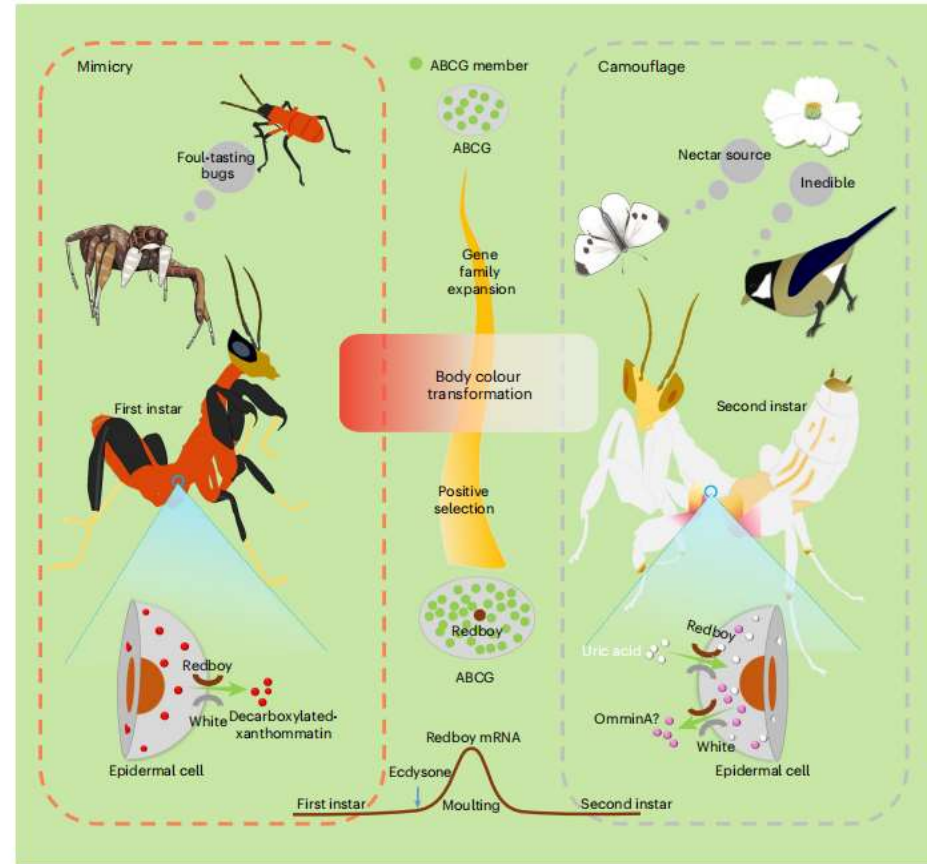


# Offensive Camouflage— — Take the Initiative to Gain Benefits

## 2. Aggressive Mimicry : actively attract prey



*Hymenopus coronatus*

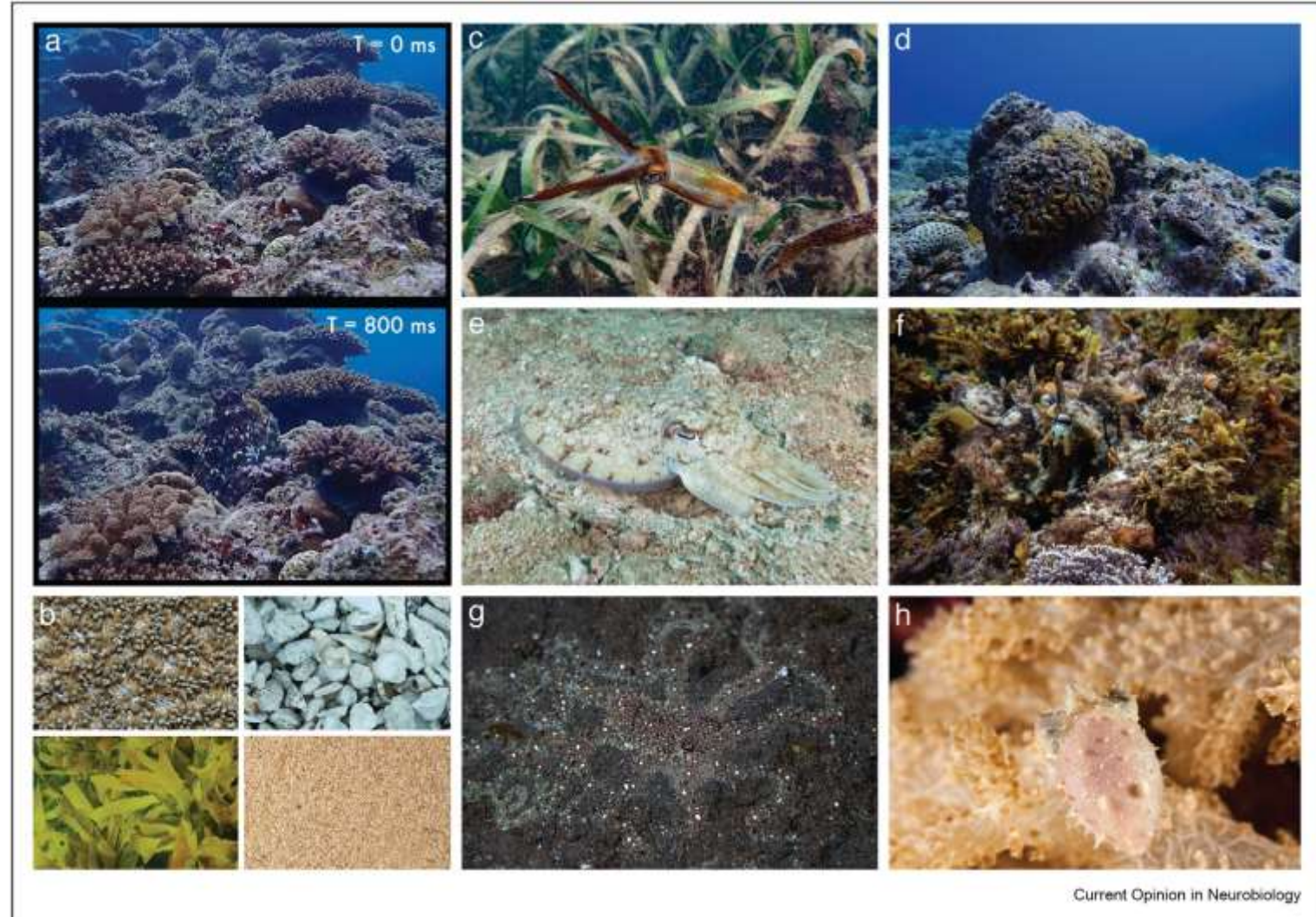


# Offensive Camouflage— — Take the Initiative to Gain Benefits

## 3. Active Camouflage : real-time camouflage

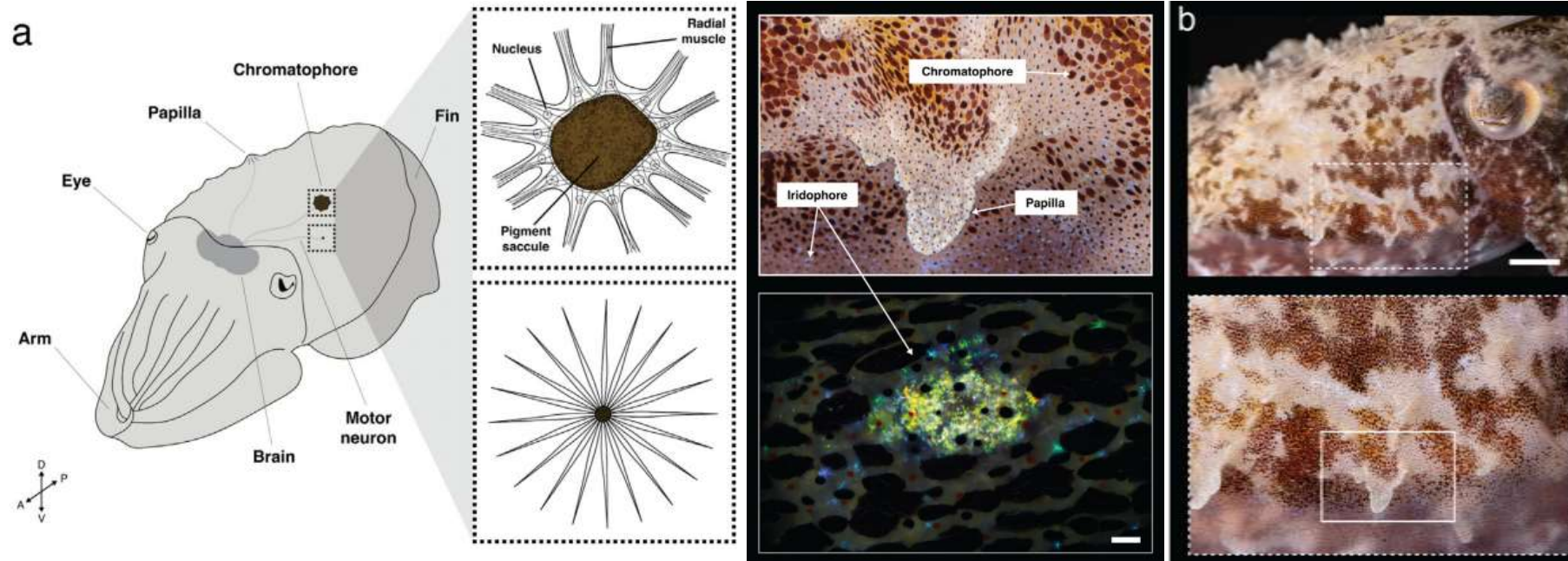


*Thaumoctopus mimicus*



# Offensive Camouflage— — Take the Initiative to Gain Benefits

## 3. Active Camouflage : real-time camouflage



# Overview of Camouflage in Nature

- Types of camouflage — nature's disguise toolkit
- The biological significance of camouflage — the inevitable choice of evolution
- Value extension: from natural camouflage to human innovative applications

# The biological significance of camouflage — —the inevitable choice of evolution

## Individual level

Predator avoidance

Foraging success

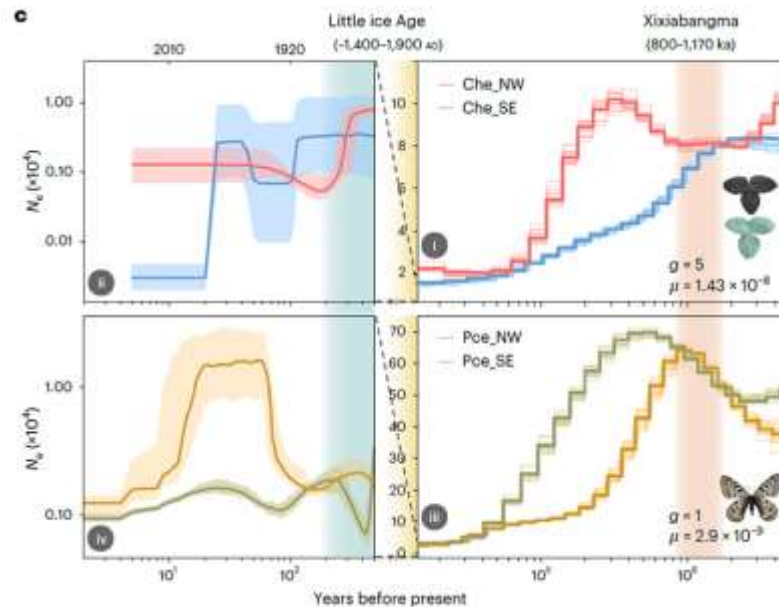


Trends in Genetics

## Species and ecological levels

Interactions among species

Maintaining equilibrium



Han Zhang, et al., *Nature Ecology & Evolution*, 2025

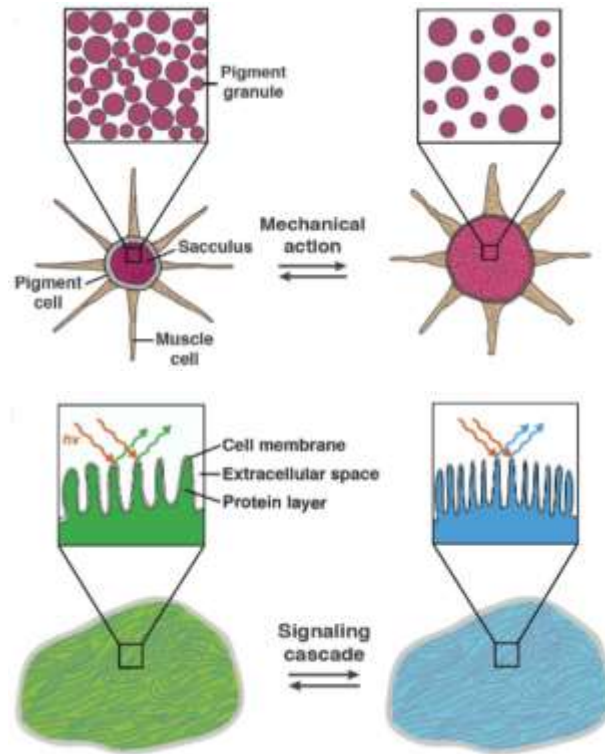
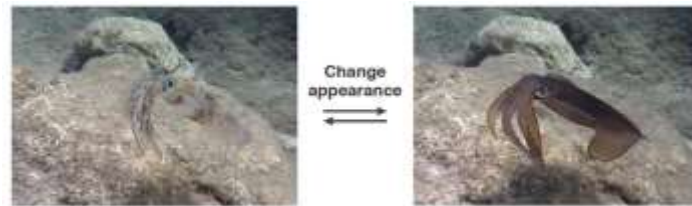
J.C. O'Hanlon, et al., *Behavioral Ecology*, 2015

# Overview of Camouflage in Nature

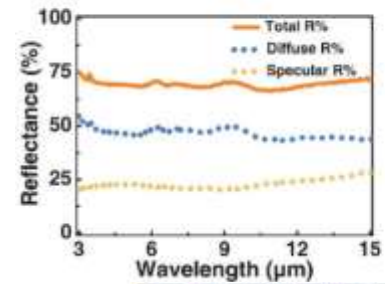
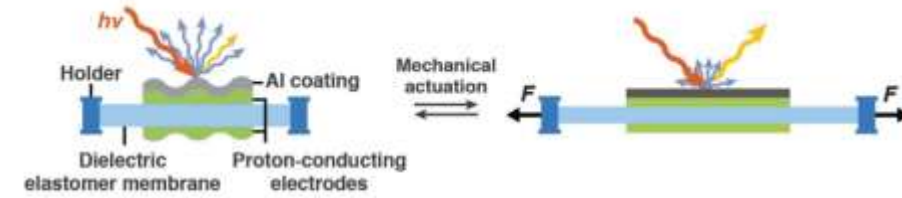
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# Value extension: from natural camouflage to human innovative applications

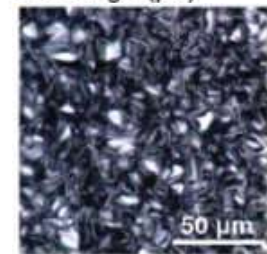
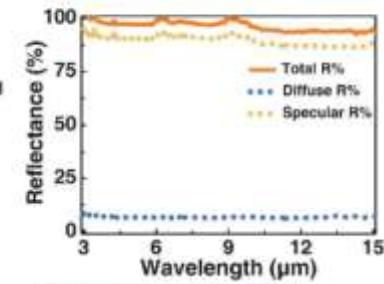
## 1. Military and Materials Science



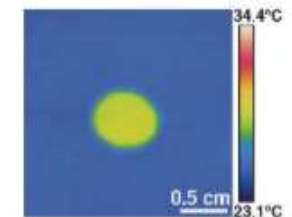
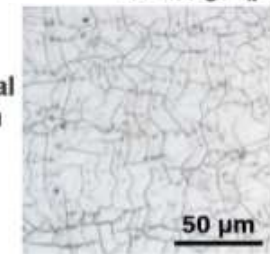
Biological inspiration of *cephalopod*



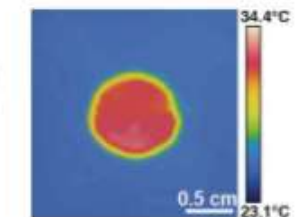
Mechanical actuation



Mechanical actuation



Electrical actuation



Adaptive infrared-reflecting systems

# Value extension: from natural camouflage to human innovative applications

## 2. Cross-disciplinary innovation



Chemical Engineering Journal

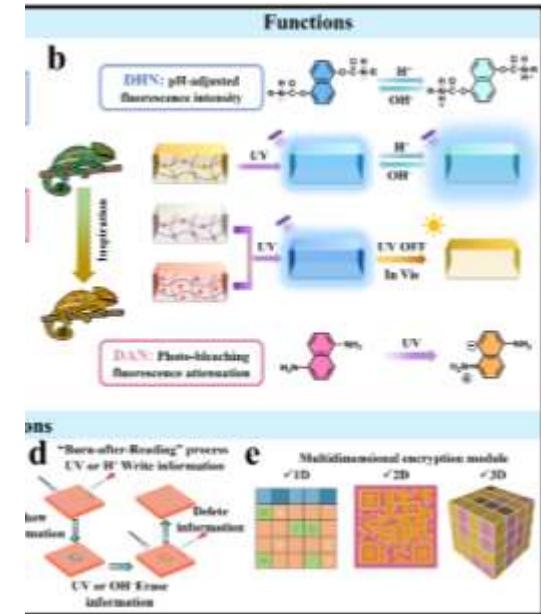
Available online 6 January 2025, 159316

In Press, Journal Pre-proof [What's this?](#)



Chameleon-Inspired adaptive Photoreactive polyurethane films for dynamic secure multidimensional “Burn-after-Reading” encryption 变色龙启发的自适应光响应聚氨酯薄膜用于动态安全的多维“阅后即焚”加密

Wei Bai <sup>a</sup>, Yixin Ji <sup>a</sup>, Ahmed Olalekan Omoniyi <sup>a, b</sup>, Yi Xiao <sup>a</sup>, Wenfei Li <sup>a</sup>, Dongdong Chen <sup>c</sup>, Cunyou Chen <sup>d</sup>, Yang Zhou <sup>e</sup>, Jianfu Zhang <sup>a</sup>



# Take home message

- Camouflage can be classified into protective camouflage and aggressive camouflage based on its function.
- The fundamental purpose of camouflage is to increase the survival rate and the success rate of hunting.
- Camouflage is extremely necessary at both the individual biological level and the ecological level.

# Masters of Camouflage in Insects

## — The Mechanisms of Insect Camouflage

Molz

# The master of mimicry in the insect world



圆掌舟蛾  
(*Phalera bucephala*)



核桃美舟蛾  
(*Uropyia meticulodina*)



枯叶蛱蝶  
(*Kallima inachus*)



苔藓竹节虫  
(*Trychopeplus laciniatus*)



兰花螳螂  
(*Hymenopus coronatus*)



中华蜜蜂  
(*Apis cerana*)



中华马蜂  
(*Polistes chinensis* Fabricius)



长尾管蚜蝇  
(*Eristalis tenax*)



*Ceriana vespiformis*



*Bombylius discolor*

# The master of mimicry in the insect world



hoverfly



长尾管蚜蝇  
(*Eristalis tenax*)



beefly



*Bombylius discolor*

- Mimesis in peppered moth adult and larvae
- Mimicry in syrphid flies (Batesian mimicry)



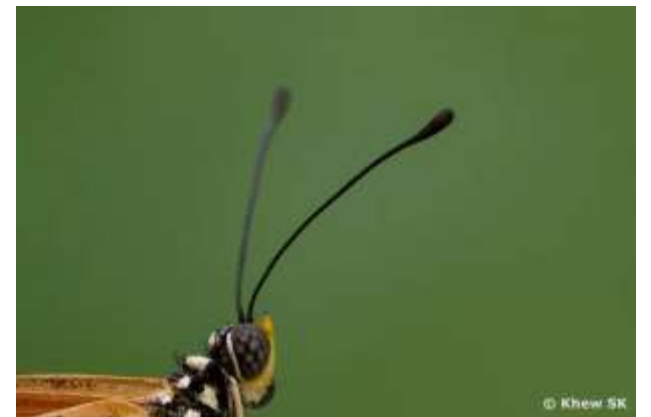
- Mimesis in peppered moth adult and larvae
- Mimicry in syrphid flies (Batesian mimicry)



Can you distinguish between a moth and a butterfly?



# Moth vs. Butterfly: How to tell the difference

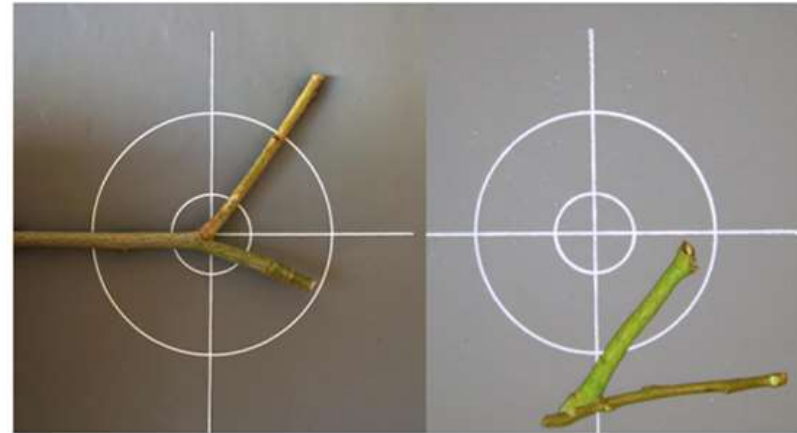


# Mimesis in peppered moth, *Biston betularia* Linnaeus

geometrid moth

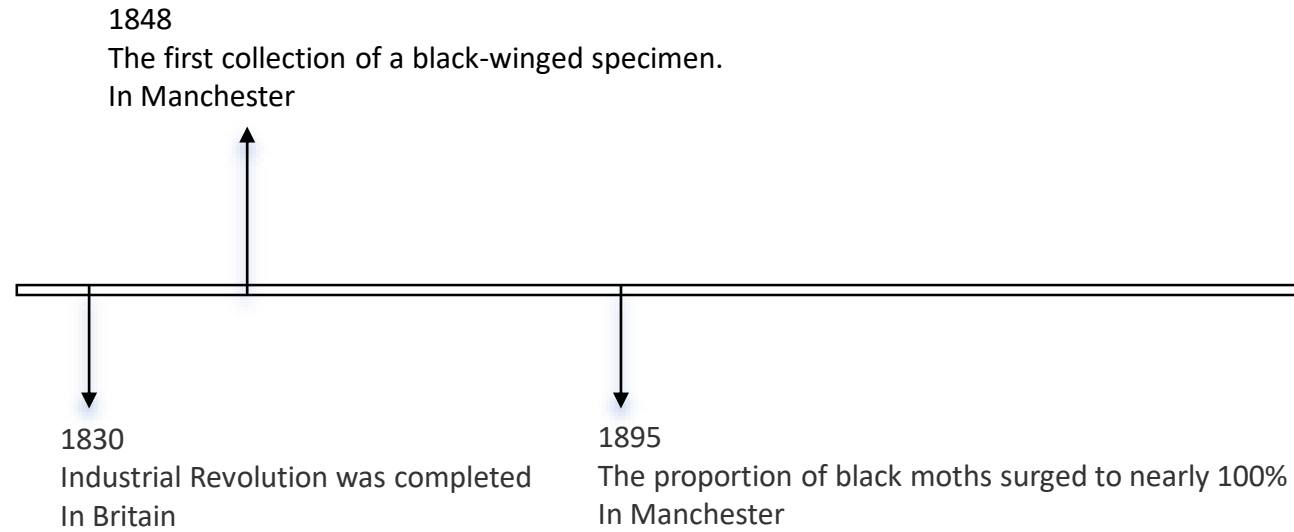


measuring worm



# Body color change of peppered moth population before and after Industrial Revolution

*'typica'*



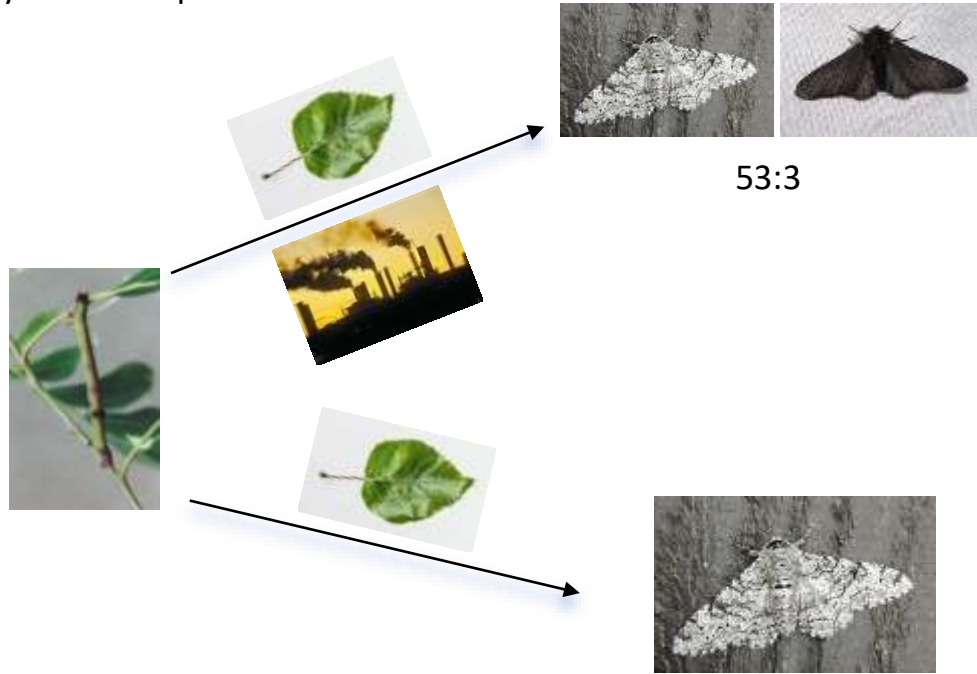
*'carbonaria'*



# Lamarckism vs. Darwinism

## Use and disuse theory

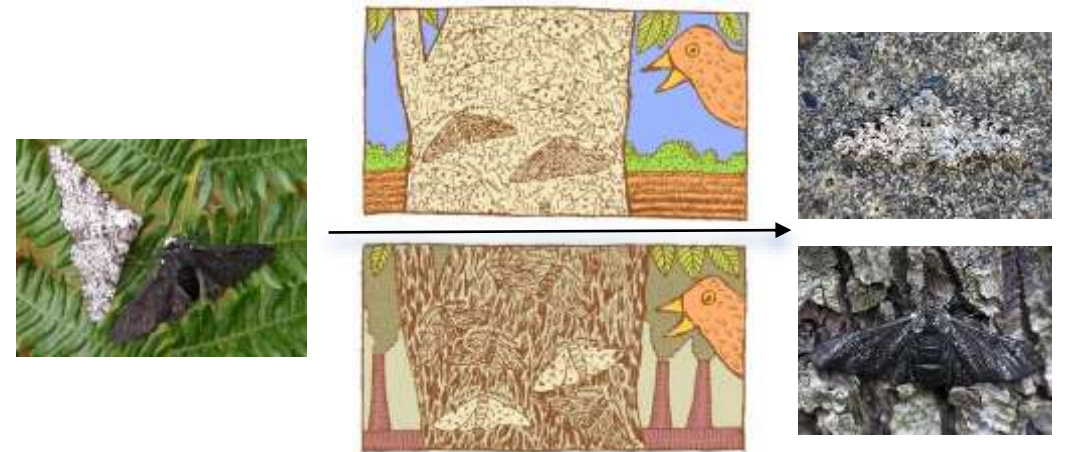
By J.W. Heslop Harrion



**Lack of reproducibility**

## Natural selection

By Niko Tinbergen



**The first experiment on natural selection**

Industrial melanism in the peppered moth is still one of the clearest and most easily understood examples of Darwinian evolution in action

# The genetics of the peppered moth, *Biston betularia*

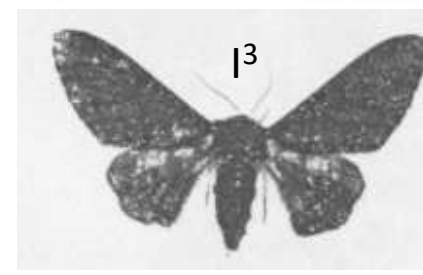
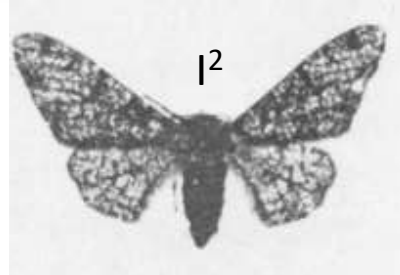
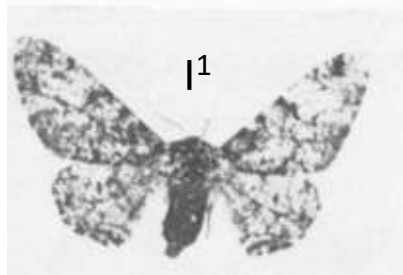
'typica'



'insularia'



'carbonaria'



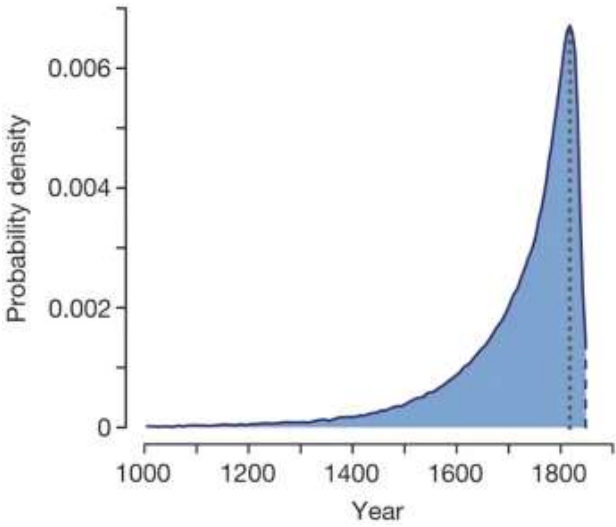
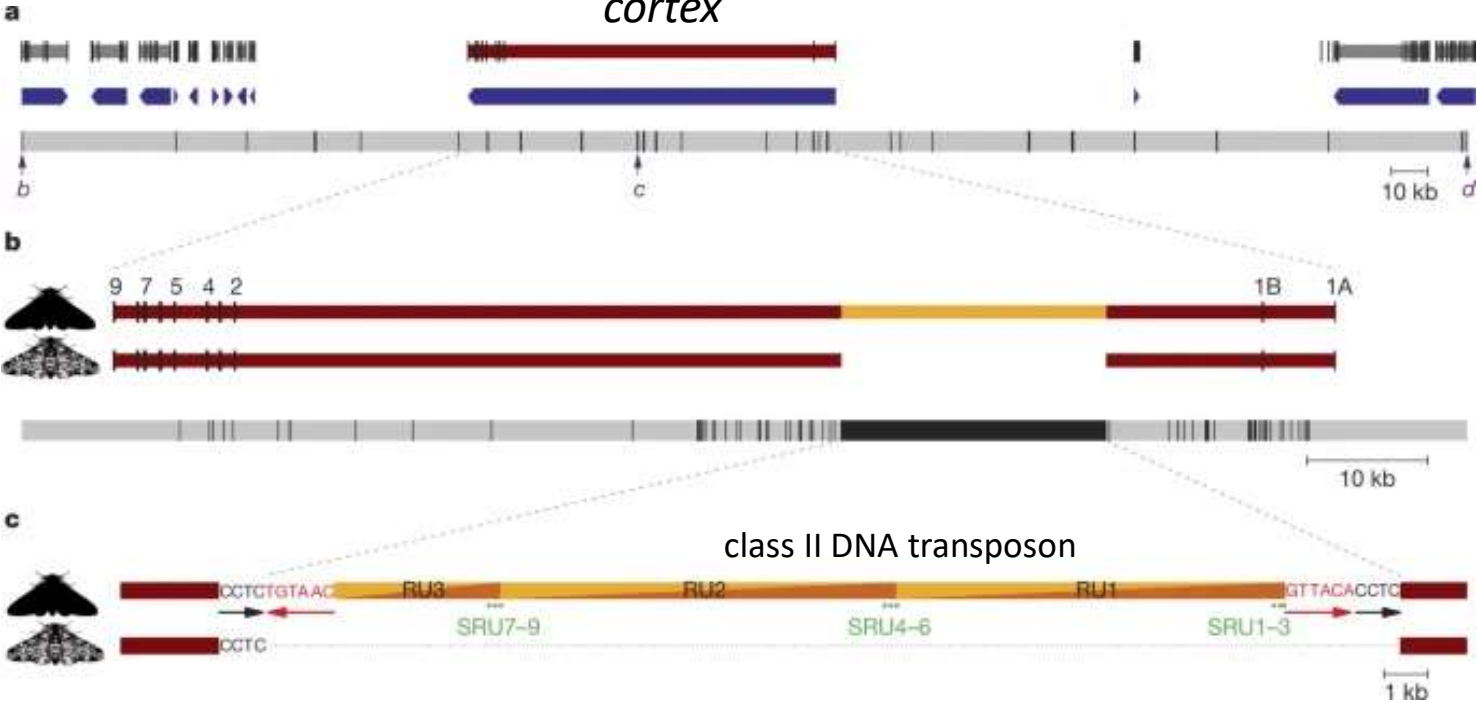
# Multiple alleles regulate body color in the peppered moth

TABLE 1

*Families of Biston betularia used to examine the relationship of I<sup>3</sup> and I<sup>1</sup>*

Family	Parents		Progeny					Total	
	Male	Female	T	1	2	3	C		
B/8/72	I <sup>3</sup> <i>ex</i> Beddau	T <i>ex</i> Oxford		21		27		48	<sup>3</sup> >  <sup>1</sup> >T
B/9/72	I <sup>3</sup> <i>ex</i> Beddau	T <i>ex</i> Oxford		34		25		59	
B/7/73	I <sup>1</sup> <i>ex</i> Beddau	I <sup>3</sup> <i>ex</i> B/8/72	66	55		135		256	
B/6/74	C <i>ex</i> B/9/73	I <sup>3</sup> <i>ex</i> B/4/73	14			20	31	65	C>  <sup>3</sup> >T
B/10/75	T <i>ex</i> Beddau	C <i>ex</i> B/6/74				60	87	147	
B/12/73	I <sup>1</sup> <i>ex</i> Beddau	I <sup>2</sup> <i>ex</i> B/10/72	4	6	6			16	<sup>2</sup> >T
B/10/74	I <sup>1</sup> <i>ex</i> Oxford	T <i>ex</i> Oxford	96	68	26			190	
B/13/75	T <i>ex</i> Beddau	I <sup>2</sup> <i>ex</i> B/8/74	76	10	58			144	
B/11/73	I <sup>1</sup> <i>ex</i> Beddau	I <sup>2</sup> <i>ex</i> B/10/72	17	16	27	14		74	<sup>3</sup> ?   <sup>2</sup> ?   <sup>1</sup>
B/12/73	I <sup>1</sup> <i>ex</i> Beddau	I <sup>2</sup> <i>ex</i> B/10/72	4	6	6			16	
B/11/74	I <sup>2</sup> <i>ex</i> Beddau	I <sup>1</sup> <i>ex</i> B/7/73	58	38	111	44		251	

# A transposable element regulates "carbonaria" in the peppered moth



# Summary 1

- Natural selection has shaped the distribution of body color within peppered moth populations.
- The transposable element facilitated the swift adaptation of peppered moth coloration to environmental changes.

- Mimesis in peppered moth adult and larvae
- Mimicry in syrphid flies (Batesian mimicry)





## Professor Ilik Saccheri

### Professor of Ecological Genetics

[Evolution, Ecology & Behaviour](#)

### Part of

[Institute of Infection, Veterinary & Ecological Sciences](#)

[Faculty of Health and Life Sciences](#)

### Contact

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### About

Research

Research outputs

Teaching

Professional activities

## About

My research is broadly aimed at understanding the factors that maintain genetic and phenotypic variation in natural populations. I study this diverse problem in different species of moths and butterflies, in the context of rapid adaptation to environmental change (industrial melanism and insecticide resistance), conservation biology (response to climate change and habitat fragmentation), and genetic load (inbreeding depression and sex-determination).

I studied ecological science (BSc) at the University of Edinburgh, followed by a PhD on the fitness consequences of small population size and inbreeding at the Universities of Leiden and London, sponsored by the Zoological Society of London. As a postdoc, first at the University of Helsinki and then Leiden, I continued to pursue this research interest in the more complex context of metapopulation dynamics. I moved to a lectureship in Liverpool in 2000 and started to work on the evolutionary genetics of industrial melanism in the peppered moth.

## Evolutionary origins and dynamics of camouflage in moths

Survival to reproduction in many species of moth relies heavily on avoiding detection by bird predators in visually heterogeneous environments. The peppered moth (*Biston betularia*) uses phenotypic plasticity to masquerade as twigs during the caterpillar stage and genetic polymorphism to match light or dark backgrounds as an adult. We study the genetic basis of the recurrent evolution of adult melanism in the context of soot pollution and habitat heterogeneity, and the physiology of slow colour change in the caterpillars.

## Sex-determination mechanisms and inbreeding depression

Inbreeding depression – the reduction in viability and fertility in the offspring of closely related parents – is due to the expression of deleterious recessive alleles in the homozygous state, and has major implications for the evolution of mating systems and the persistence of small populations. The presence of many of these deleterious alleles in natural populations is due to chance (mutation and genetic drift), but others may be maintained by particular selective forces, such as sexually-antagonistic pleiotropy (where the fitness effect of an allele is positive in one sex but negative in the opposite sex) and heterozygote advantage. We are studying this problem in the butterfly *Bicyclus anynana*, that shows extreme male-biased sensitivity to inbreeding due to lethality of homozygous genotypes at the sex-determining locus ([University of Liverpool news](#)).

# Mimicry behavior in peppered moth larvae

[nature](#) > [books received](#) > [article](#)

Books Received | Published: 24 July 1890

## The Colours of Animals

[ALFRED R. WALLACE](#)

[Nature](#) **42**, 289–291 (1890) | [Cite this article](#)

**362** Accesses | **4** Citations | **3** Altmetric | [Metrics](#)

exact causes of the adaptation till Mr. Poulton carried out his experiments for several years in succession, and on so extensive a scale that in one year over 700 larvæ of the small tortoiseshell butterfly (*Vanessa urticae*) were observed under various surroundings, and the colours of the resulting chrysalides recorded. In this way pupæ were obtained varying from black to nearly white or metallic golden colours, in each case corresponding more or less closely to the coloured surfaces on which they were suspended. By changing the coloured surroundings at different stages of the process, and by blinding some of the larvæ, it was ascertained that the period of susceptibility is the quiescent stage just before the change to the pupa state, and that in this case vision has nothing to do with the change of colour. By a number of ingenious experiments it was ascertained that

[nature](#) > [communications biology](#) > [articles](#) > [article](#)

Article | [Open access](#) | Published: 02 August 2019

## Adaptive colour change and background choice behaviour in peppered moth caterpillars is mediated by extraocular photoreception

[Amy Eacock](#), [Hannah M. Rowland](#), [Arjen E. van't Hof](#), [Carl J. Yung](#), [Nicola Edmonds](#) & [Ilik J. Saccheri](#) [✉](#)

[Communications Biology](#) **2**, Article number: 286 (2019) | [Cite this article](#)

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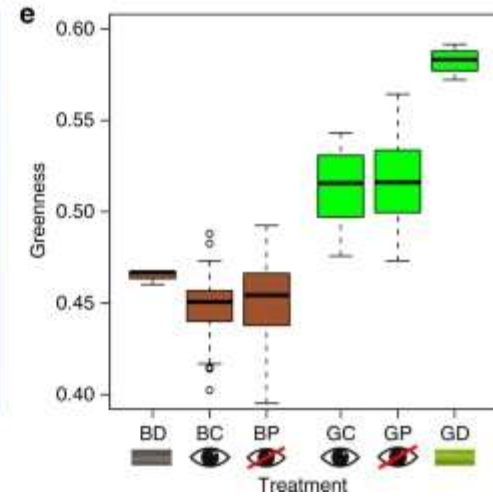
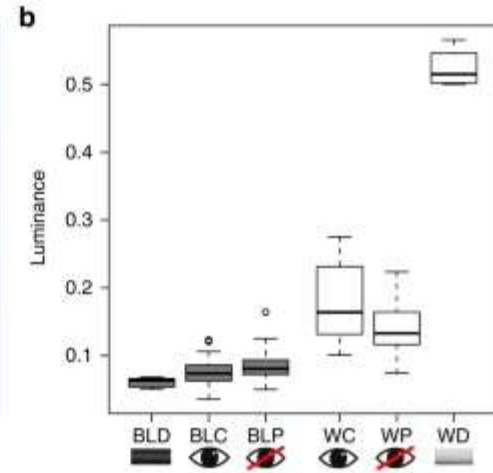


Larvae change in body color after the second instar larval stage

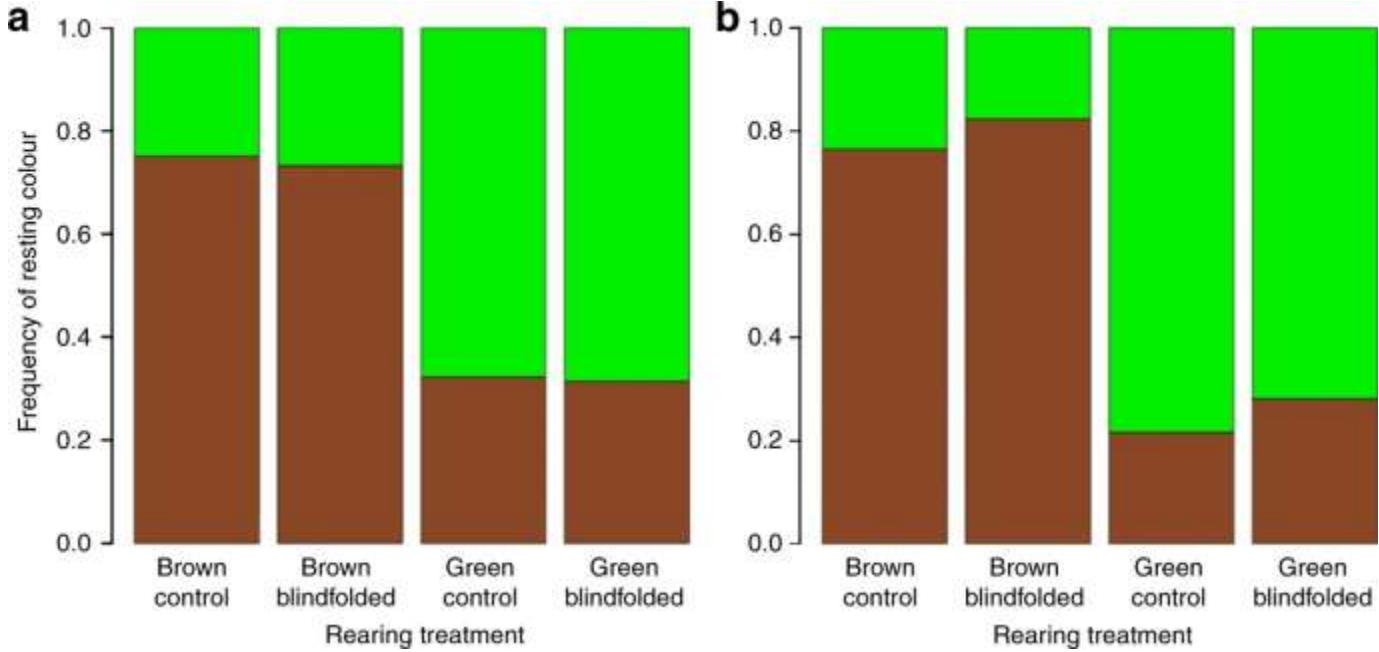
second instar



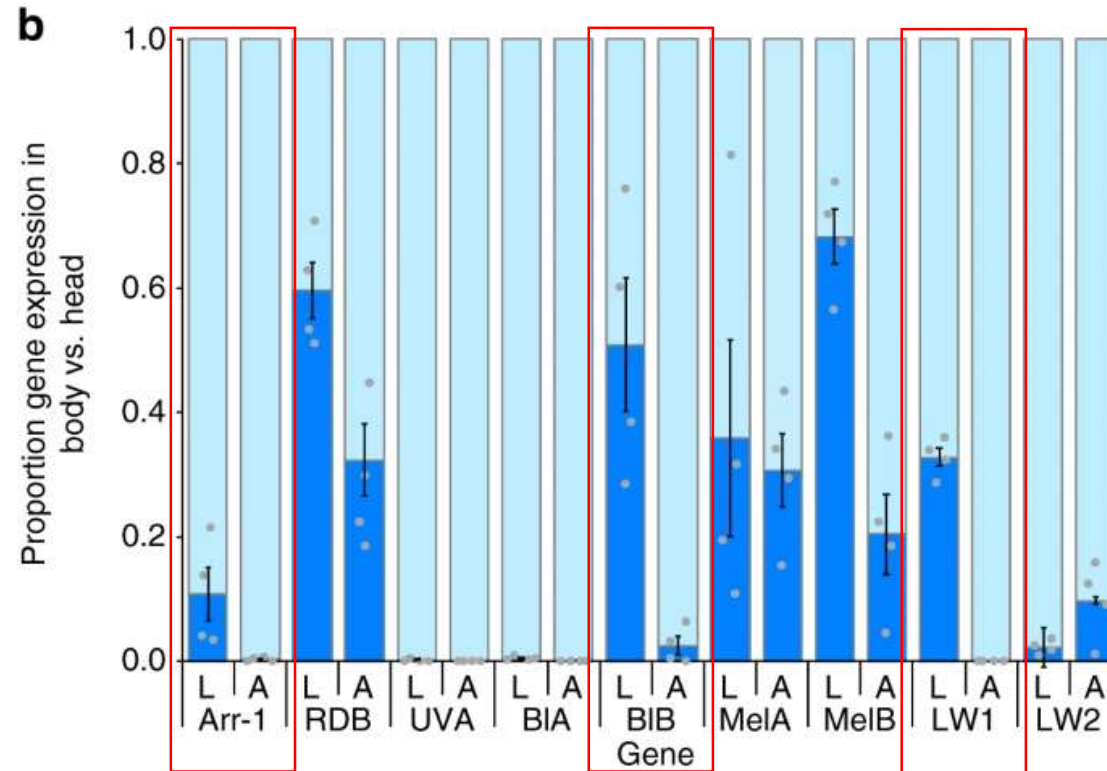
The larvae can gradually change their skin color according to their environment, independent of vision



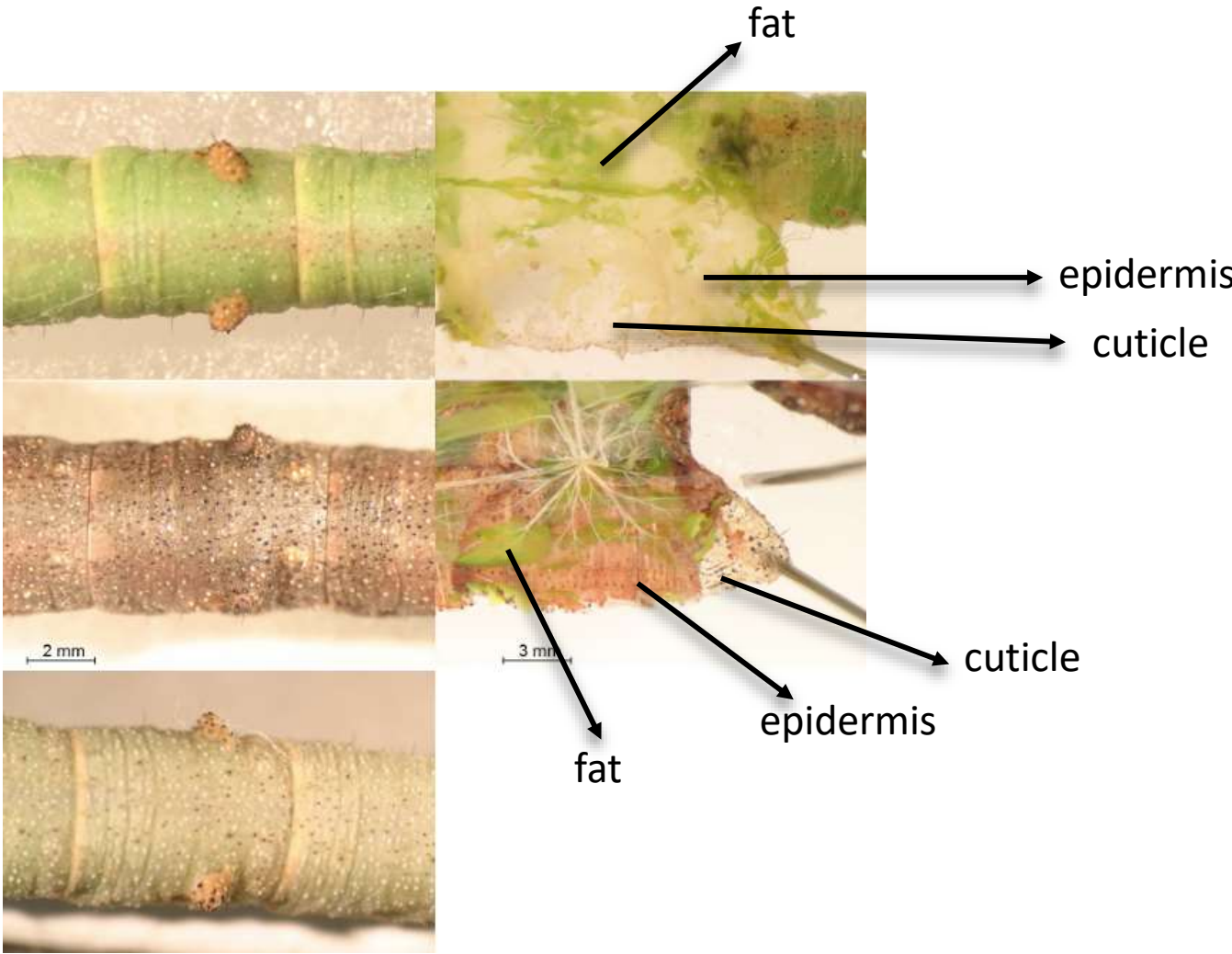
The larvae select environments matching their body color without relying on vision



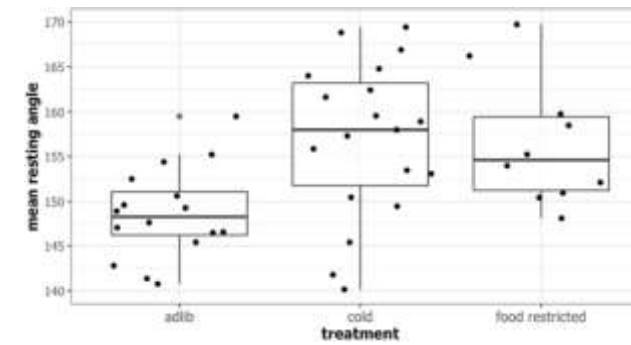
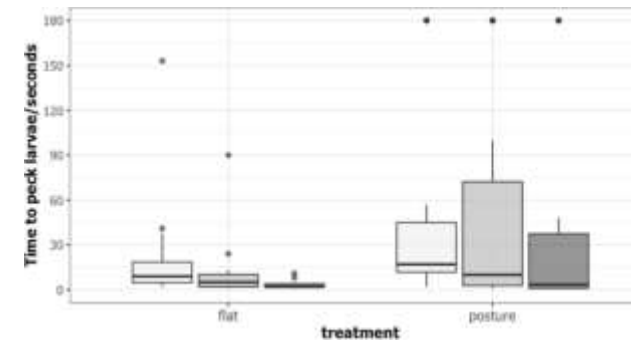
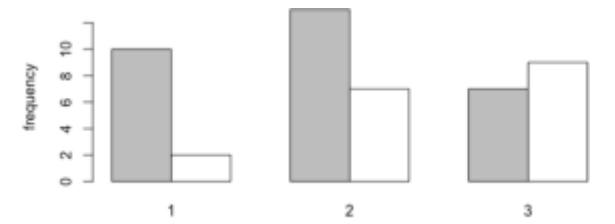
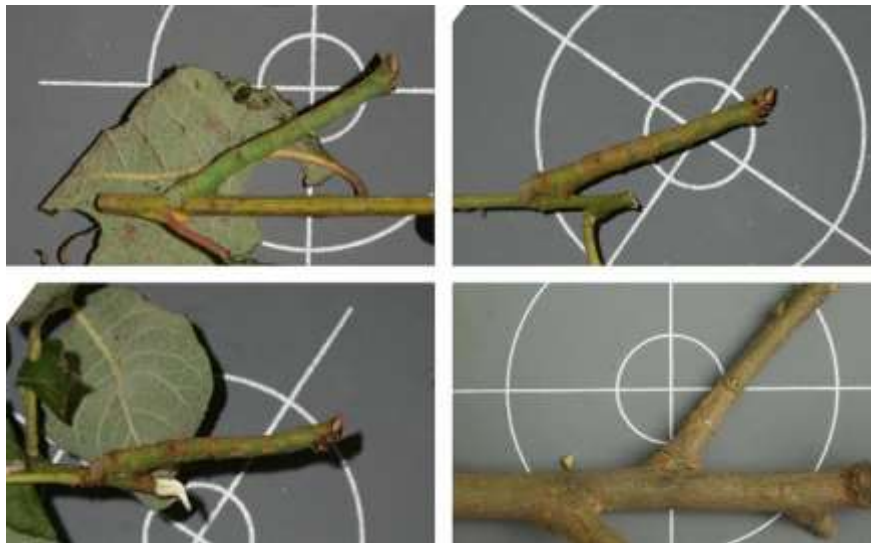
The expression of photosensitive proteins has been detected in the larval skin tissues



# Composition of skin colour in green, brown, and 'white' peppered moth final instar larvae



Larvae presented flat (gray) are more vulnerable to attack than those standing at a posture (white)



## Summary 2

- Peppered moth larvae mimic their surroundings through both coloration and posture.
- This mimicry does not rely on vision.

- Mimesis in peppered moth adult and larvae
- Mimicry in syrphid flies (Batesian mimicry)

How does hoverfly deceive fool predators?



## Tom Reader

Associate Professor, Faculty of Medicine & Health Sciences

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First, I am fascinated by the evolution of animal signals, both visual and acoustic, and in particular by Batesian mimicry and aposematism. My research focuses on trying to explain the evolutionary forces shaping signal variation, both within and among species. I do this using a combination of behavioural experiments, mathematical models and even the odd bit of 3D printing.



Second, I am interested in the conservation of reedbed biodiversity. Reedbeds, both natural and those "constructed" for wastewater treatment, are home to tremendous animal and plant diversity, with many specialist and rare species. One species of special interest to me is the harvest mouse (*Micromys minutus*), which seems to be more of a wetland specialist than it is a creature of arable farmland. We don't really understand the conservation status of this iconic species, or how it has been impacted by recent changes in land-use and agriculture.

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### Mapping the adaptive landscape of Batesian mimicry using 3D-printed stimuli

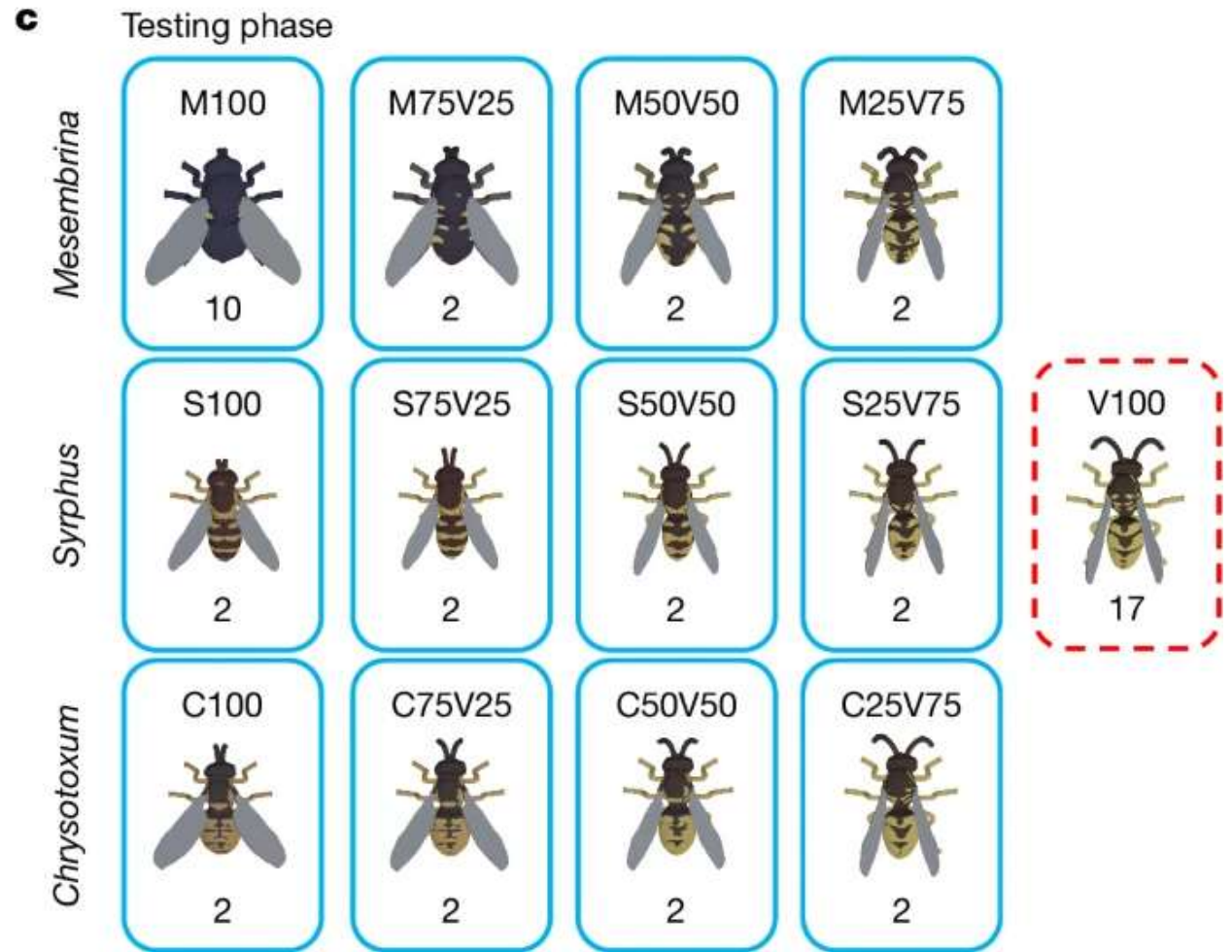
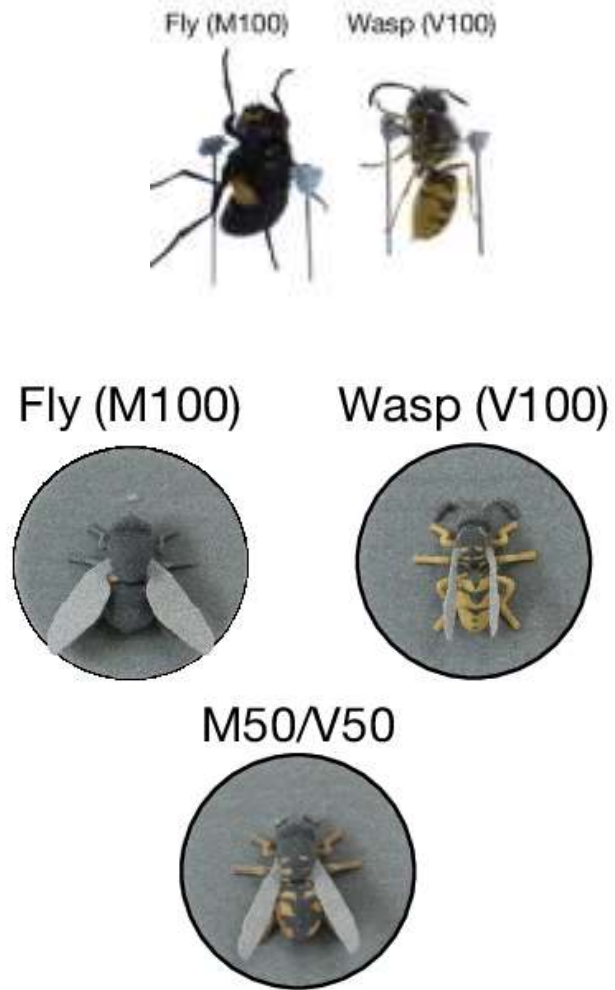
[Christopher H. Taylor](#), [David James George Watson](#), [John Skelhorn](#), [Danny Bell](#), [Simon Burdett](#), [Aoife Codyre](#), [Kathryn Cooley](#), [James R. Davies](#), [Joshua Joseph Dawson](#), [Tahiré D'Cruz](#), [Samir Raj Gandhi](#), [Hannah J. Jackson](#), [Rebecca Lowe](#), [Elizabeth Ogilvie](#), [Alexandra Lei Pond](#), [Hallie Rees](#), [Joseph Richardson](#), [Joshua Sains](#), [Francis Short](#), [Christopher Brignell](#), [Gabrielle L. Davidson](#), [Hannah M. Rowland](#), [Mark East](#), [Ruth Goodridge](#), [Francis Gilbert](#) & [Tom Reader](#) [Show fewer authors](#)

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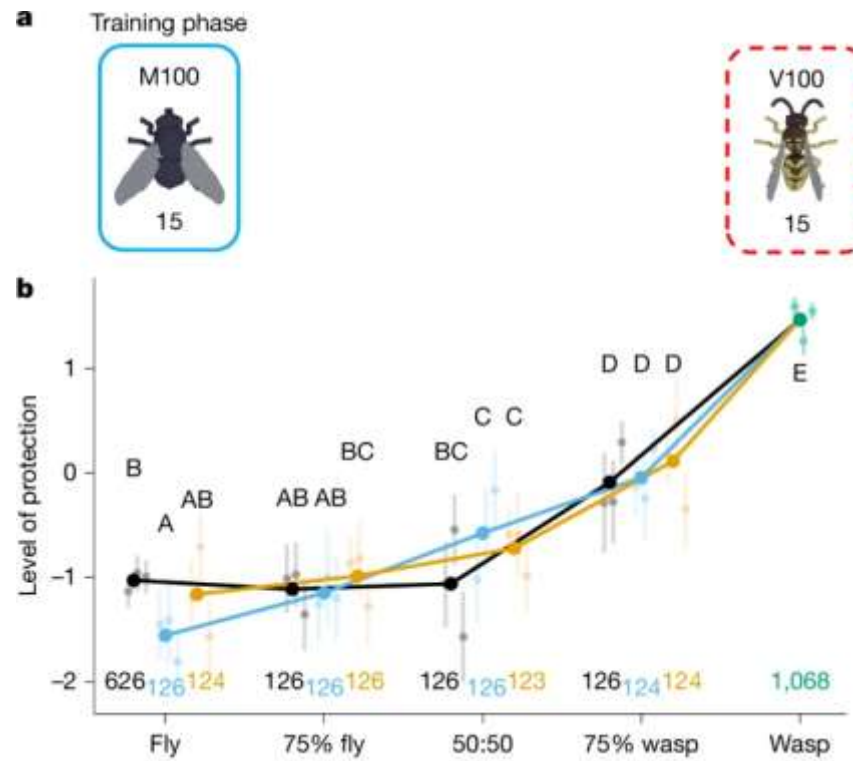
**37k** Accesses | **2** Citations | **228** Altmetric | [Metrics](#)



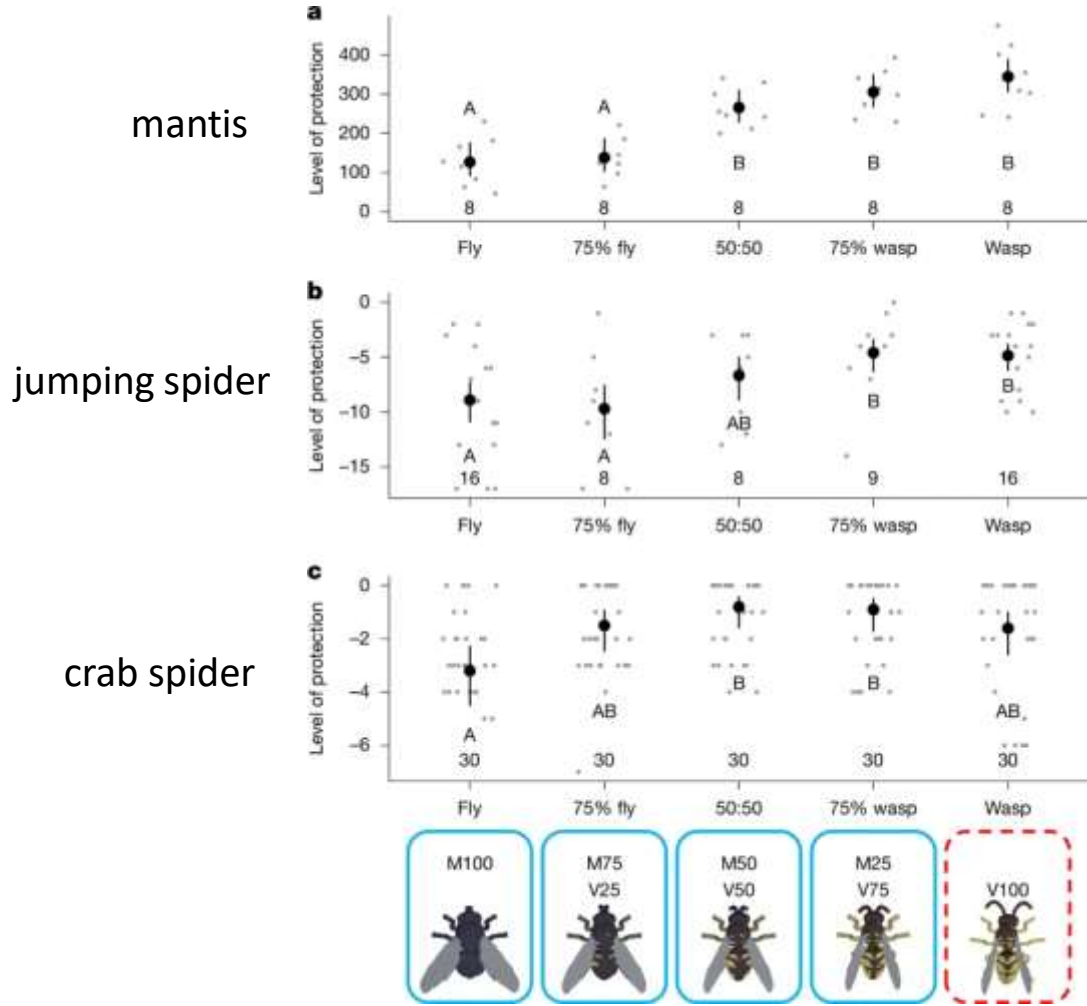
# Models with varying degrees of similarity to the imitated subject in design



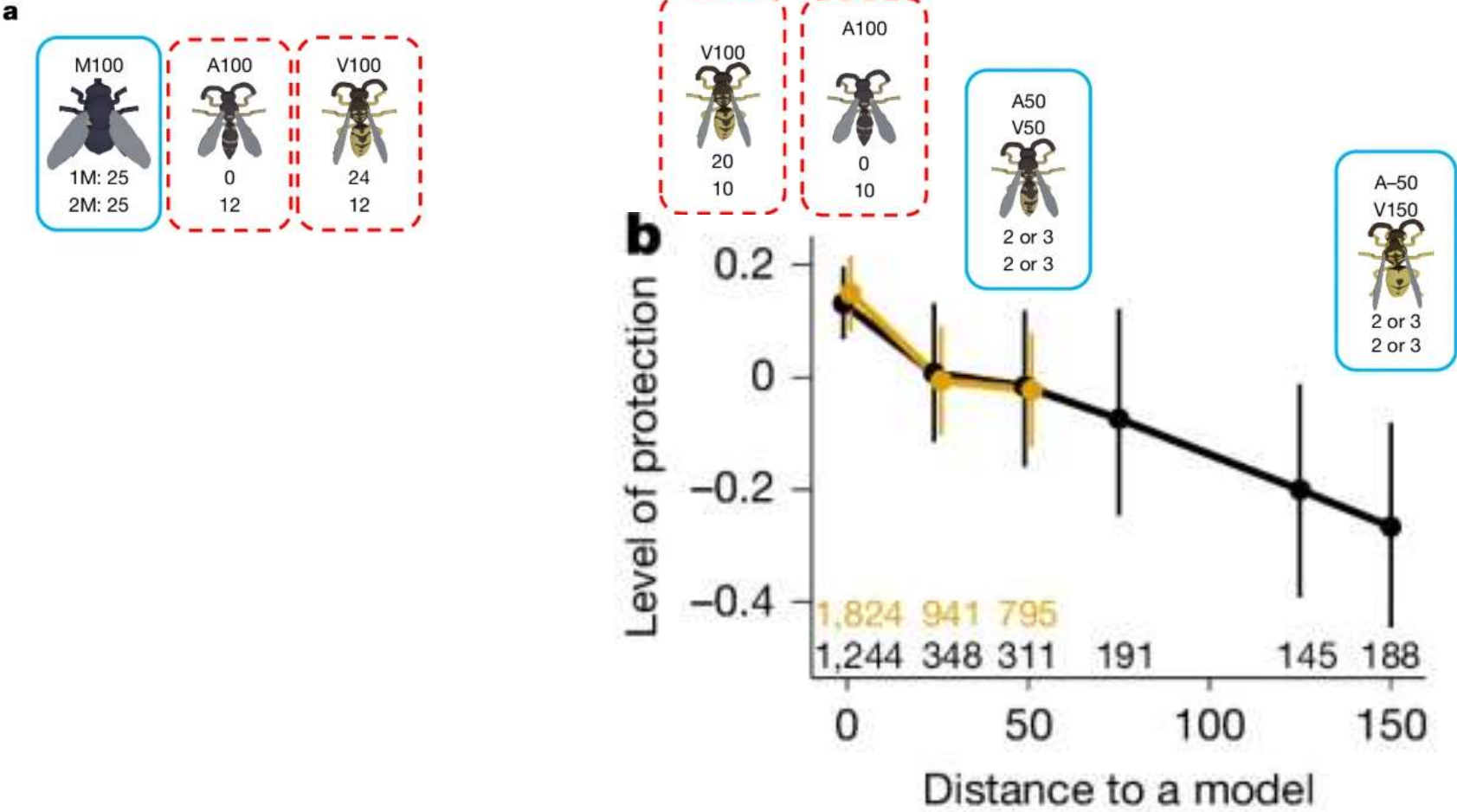
# Samples with stronger imitation capabilities are less susceptible to attack



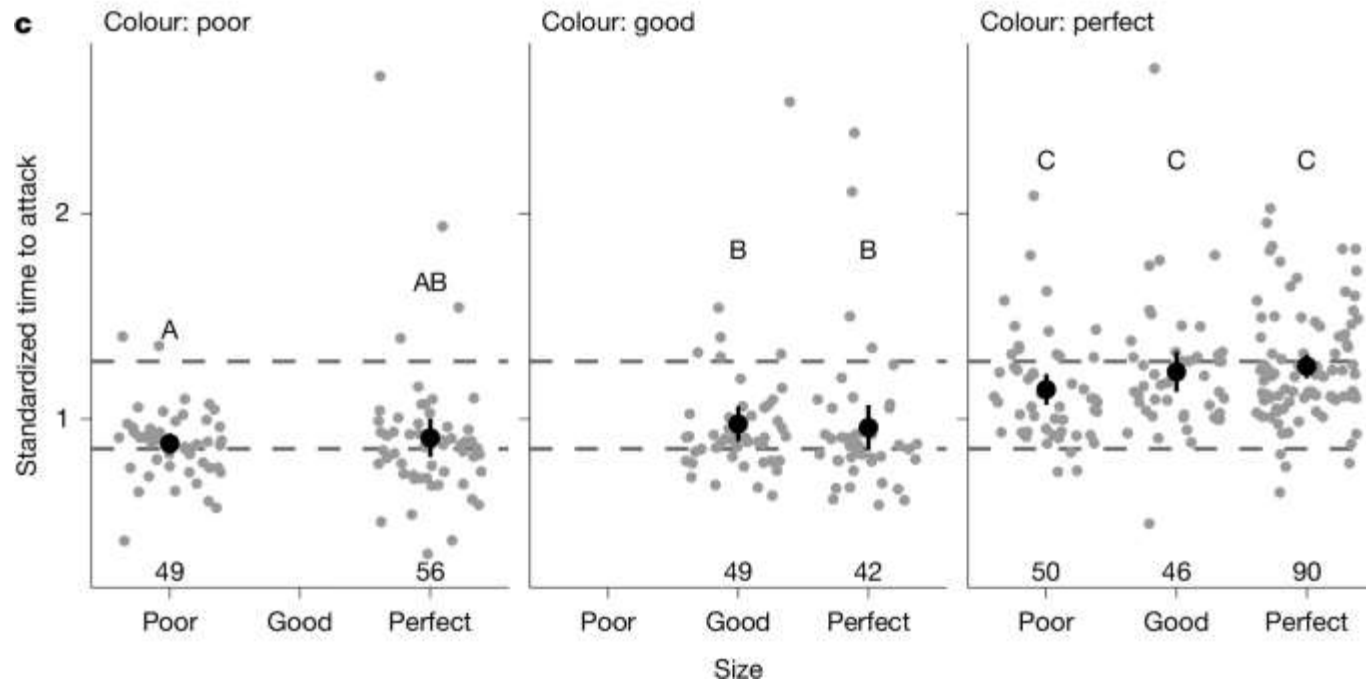
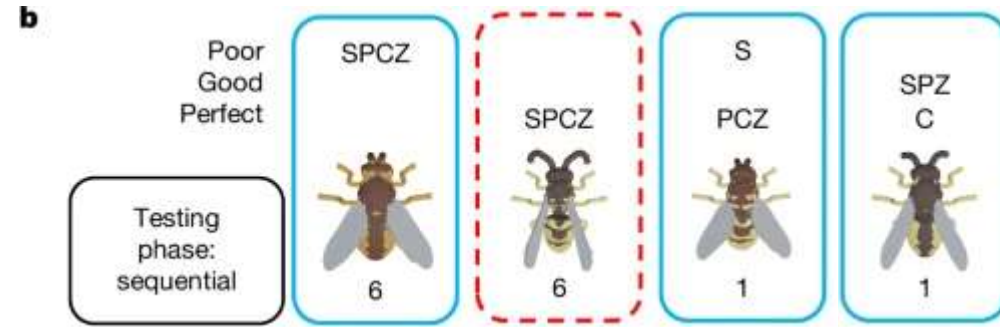
# Invertebrates can also discriminate against mimetic insects to some extent



Species with generalist mimicry do not always have better odds of survival.



# The color of the mimic is the most effective form of mimicry



bioRxiv preprint doi: <https://doi.org/10.1101/2025.02.03.634701>; this version posted February 14, 2025. The copyright holder for this preprint (which was not certified by peer review) is the author/funder, who has granted bioRxiv a license to display the preprint in perpetuity. It is made available under aCC-BY-NC 4.0 International license.

1 Internet images reveal bumblebee-mimicking hoverflies have  
2 evolved to follow flower colour preferences of their models

3

4 James D. J. Gilbert<sup>1</sup>\*, Joseph Craig-Jackson<sup>1</sup>, Lesley Morrell<sup>1</sup>, Francis Gilbert<sup>2</sup>

5 \*To whom correspondence should be addressed: james.gilbert@hull.ac.uk

6 <sup>1</sup> University of Hull, Cottingham Road, Hull, UK HU6 7RX

7 <sup>2</sup> University of Nottingham, UK NG7 2RD

8



#### HIGHLIGHTED FINDINGS



#### Our research

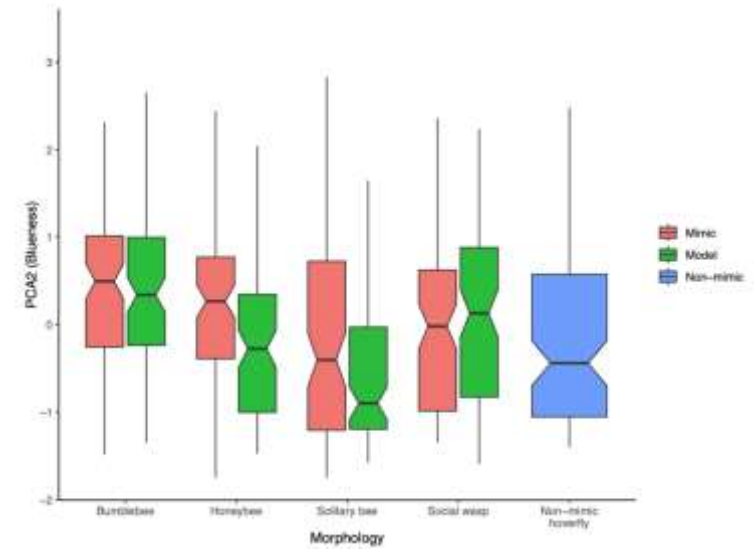
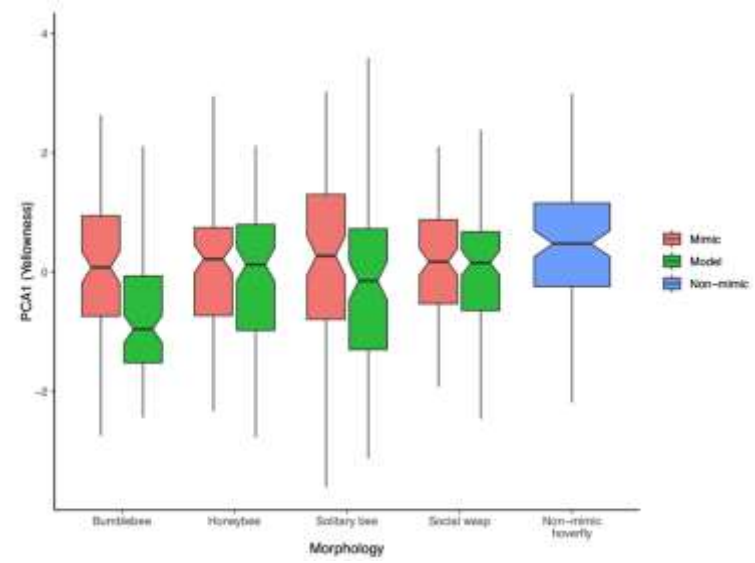
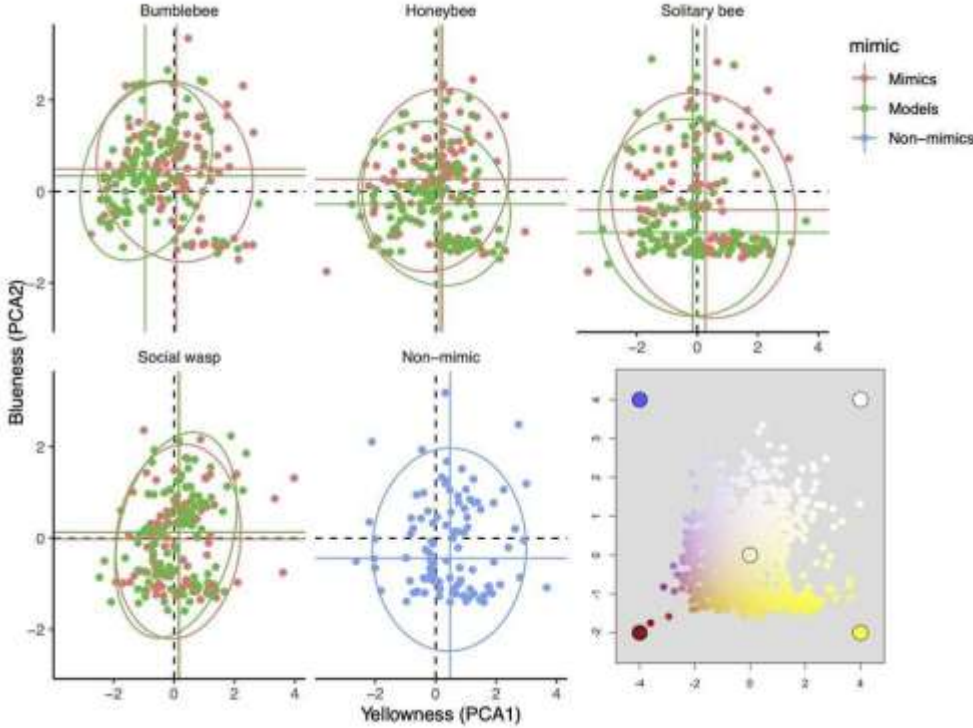
We are interested in arthropod ecology and evolution – particularly reproductive strategies and life histories. We are especially interested in how animals' nutritional ecology affects (and is affected by) the evolution of sociality and parental care.

[My Tweets](#)

Search ...

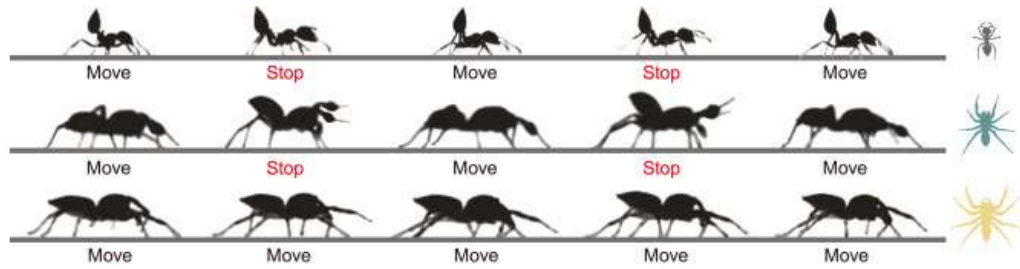
- Nutritional ecology of parental care
- Nutrition and cooperation
- Evolution of parental care in insects
- Mating strategies

# Hoverflies that mimic bumblebees are more attracted to blue flowers than non-mimicking ones



# Imperfect mimicry can still convey a benefit

A



Benefit from locomotor ant mimicry				
Mimetic spider		Less attention		Predator
Ant		Not prey		
Nonmimetic spider		More attention		

# Take home message

- Peppered moth populations rapidly adapt to their environment through transposon element under environmental pressures.
- The skin of peppered moth larvae can sense the environment and develop corresponding coloration.
- The color of hoverflies is an important mimicry characteristic.
- The flower color preferences of mimics tend to match those of their models.

# References

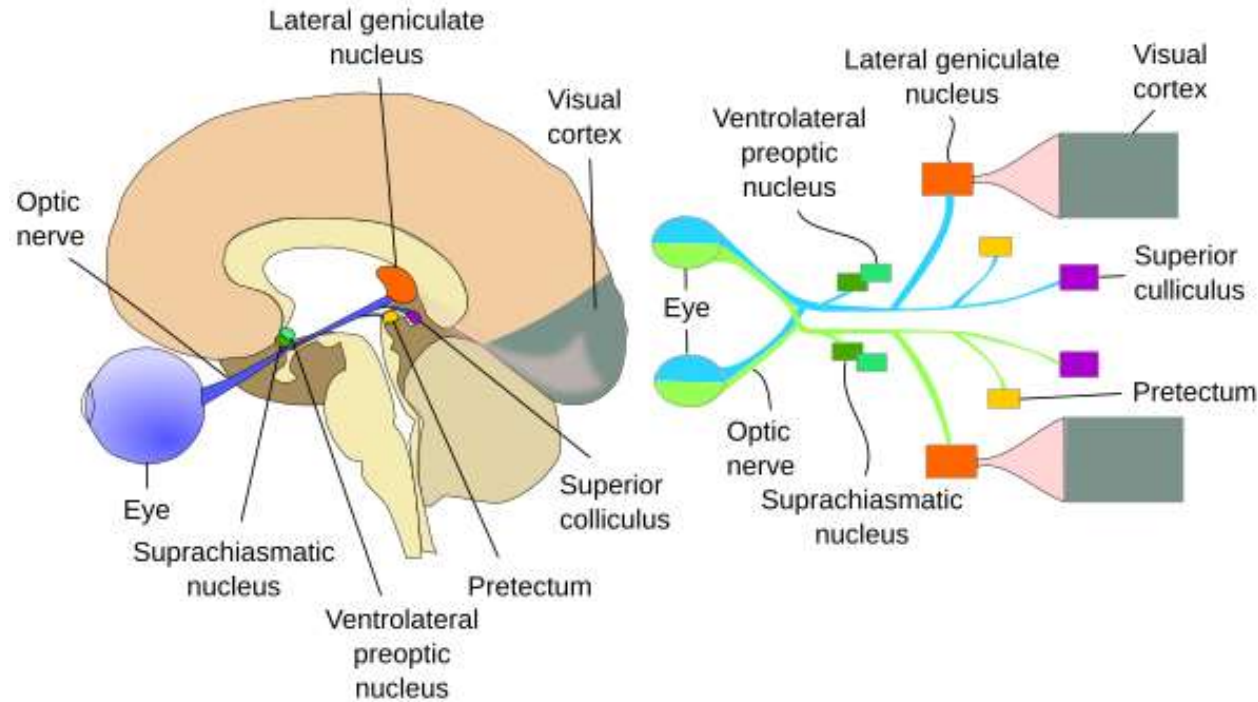
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# Masters of camouflage in other animals and plants

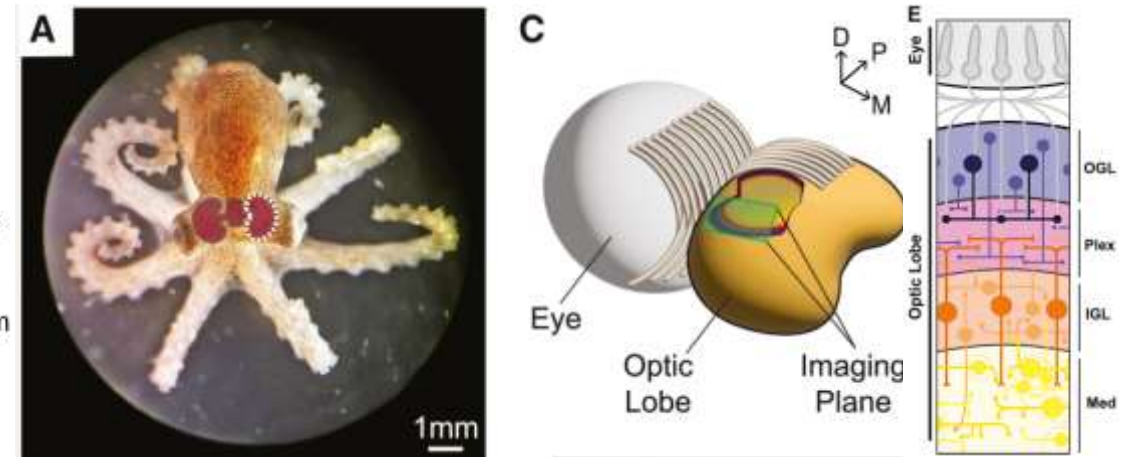
- Camouflage strategies of **Non-aquatic organisms** ?
- How do **aquatic animals** camouflage themselves?
- What are the camouflage strategies in **plants** ?

# The visual pathway is one of the neural bases of camouflage

The visual circuit in mammals



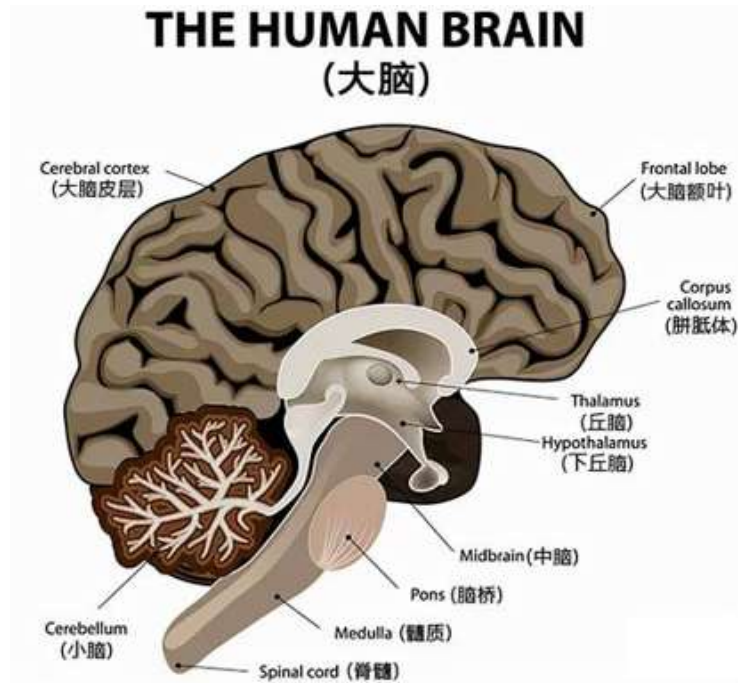
Cephalopod retina



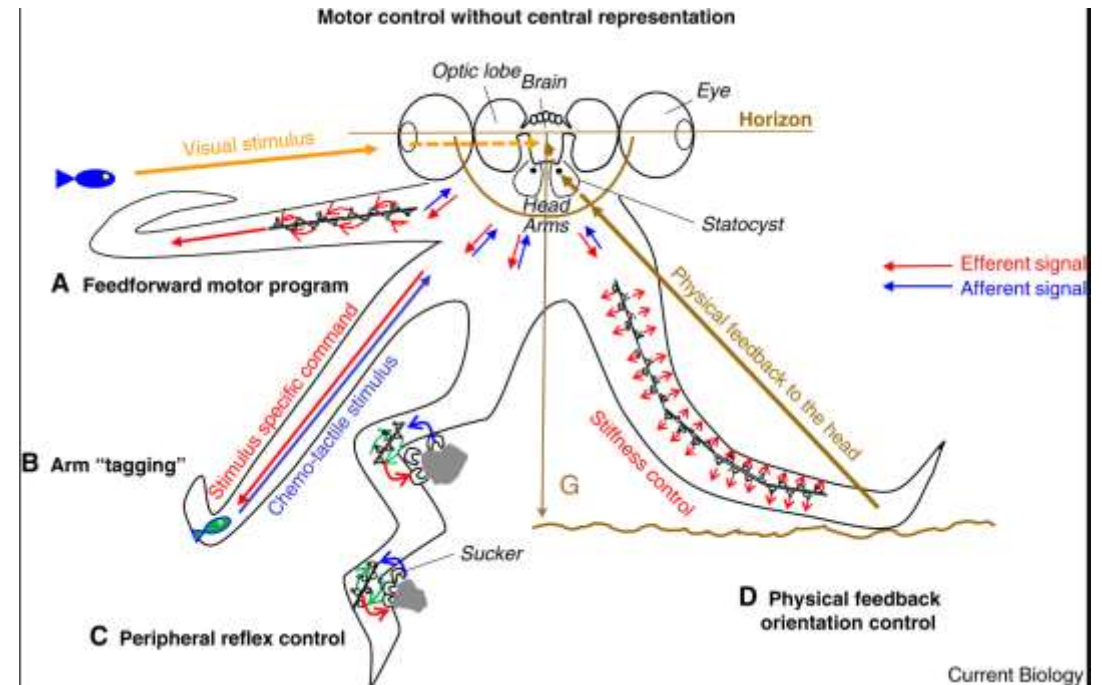
The visual system can extract abstract visual information from complex environmental patterns

( Judit R.Pungor et.al .*Current Biology*.2023 )  
( 《Atlas of plant and animal histology 》 .2017 )

# The neural regulation of camouflage behavior also requires a motor control system and hormonal regulation



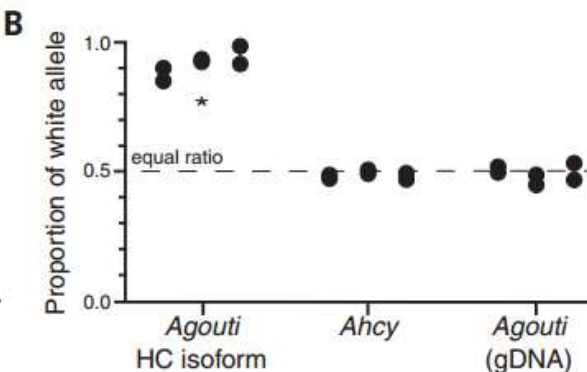
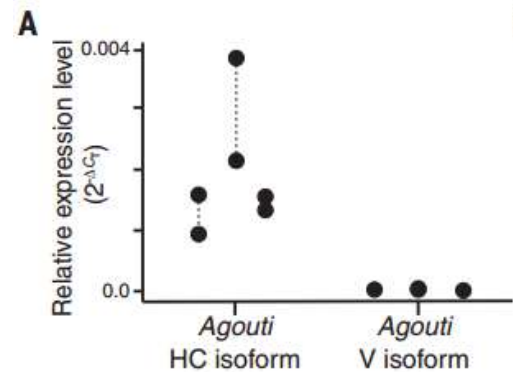
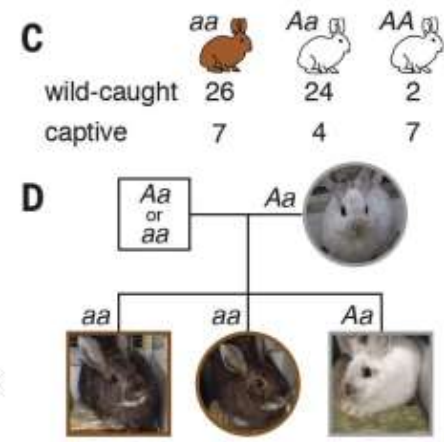
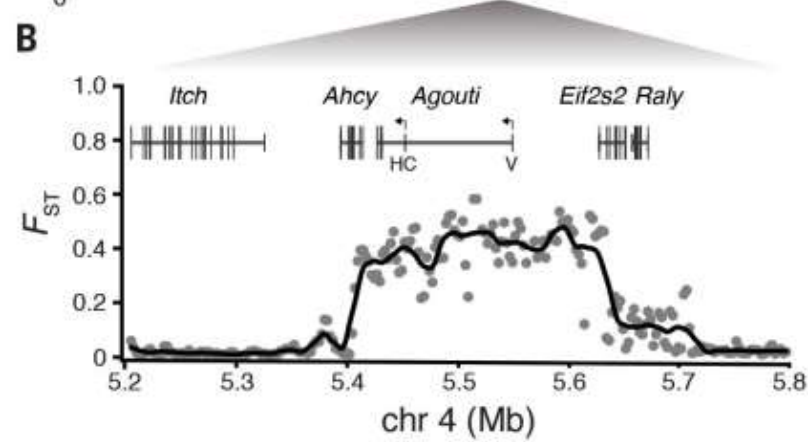
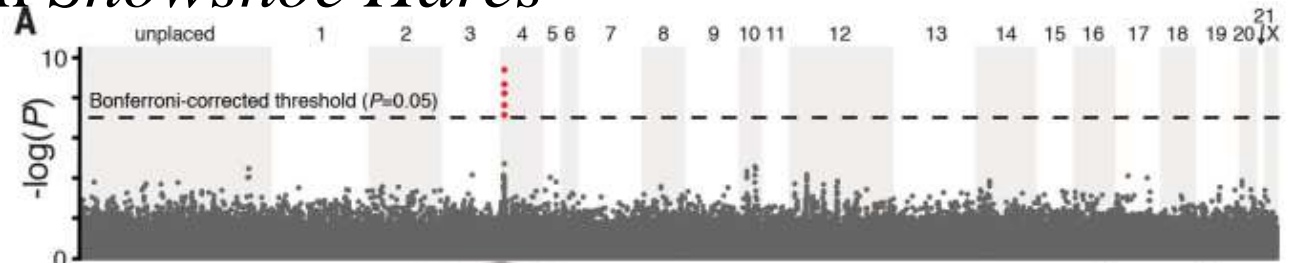
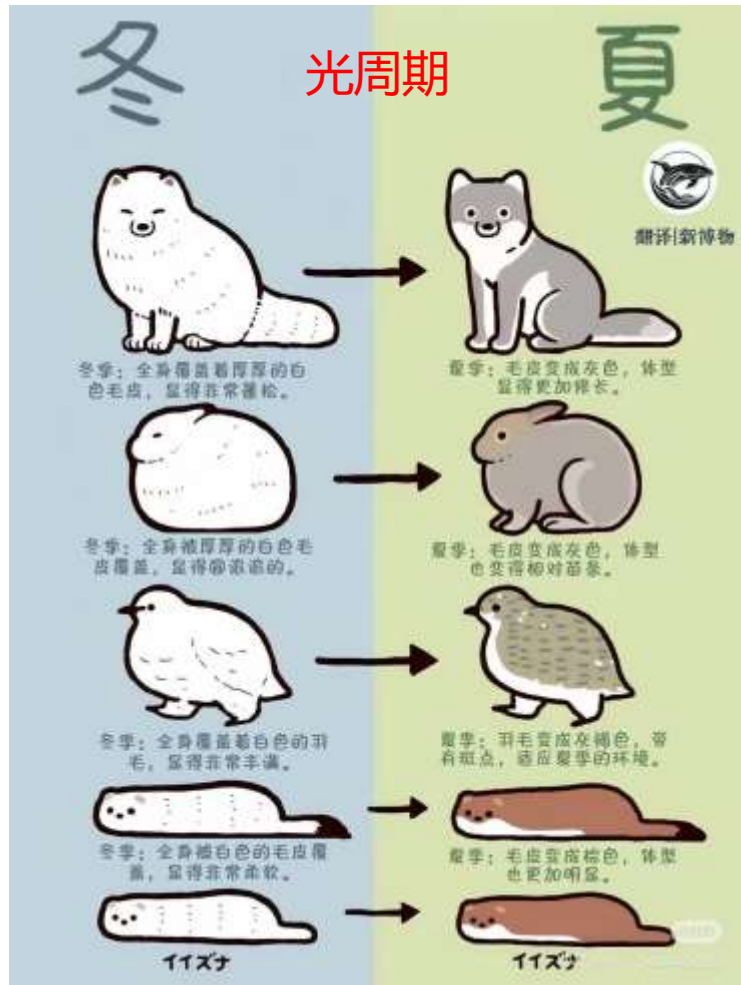
The motion control system of squid



Hormonal regulation: Cortisol, Thyroid hormone

- Camouflage strategies of **Non-aquatic organisms** ?
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# Adaptive introgression underlies polymorphic seasonal camouflage in *Snowshoe Hares*



# The genetic basis for adaptive seasonal coloration in the *Least Weasel*

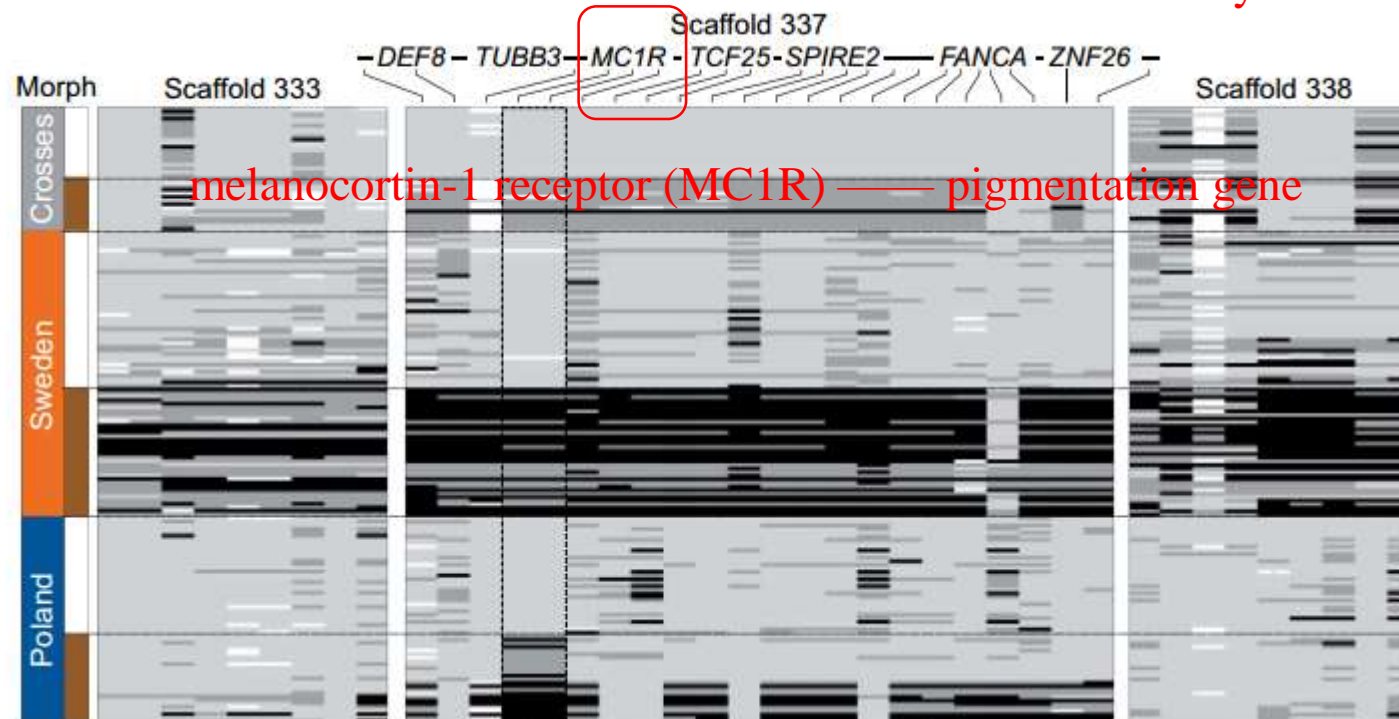


MC1R  $\alpha$ -MSH  $\rightarrow$  dark eumelanin

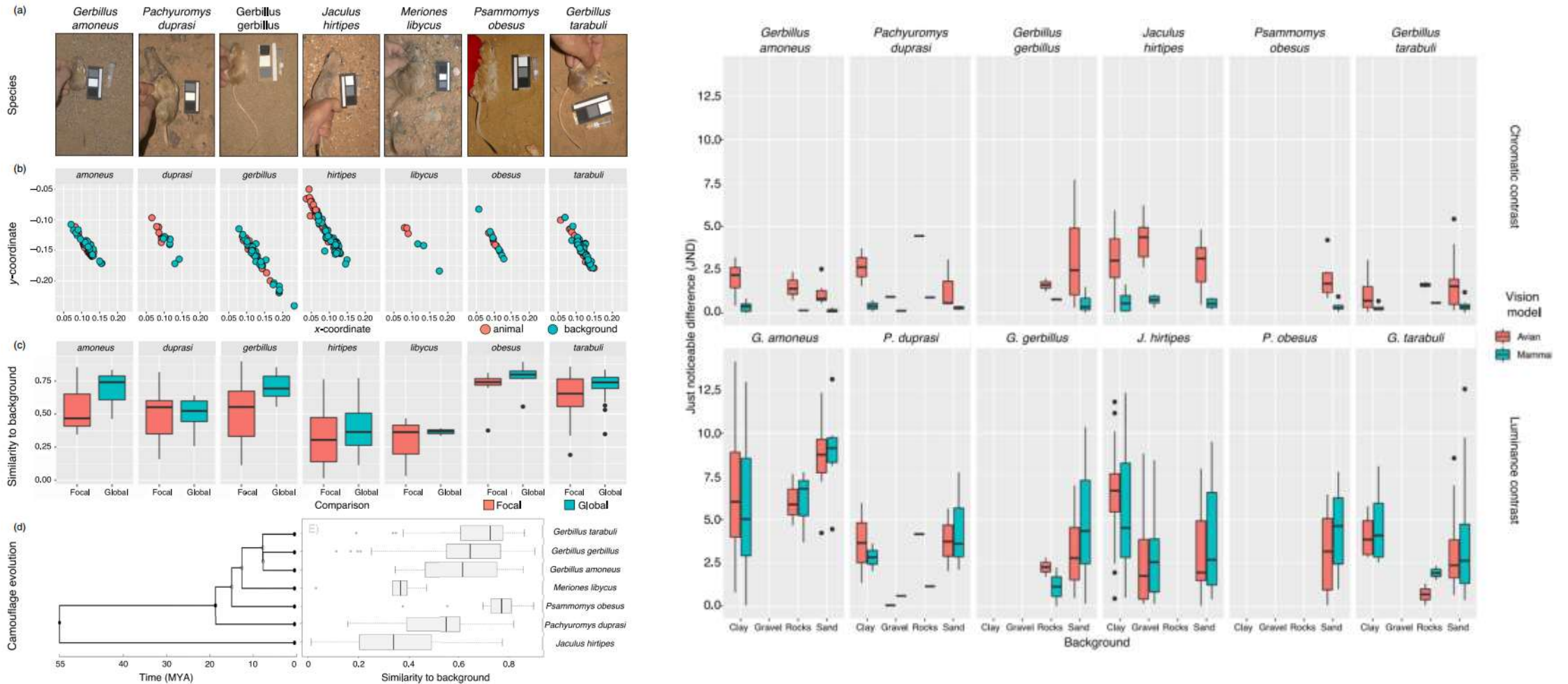
MC1R ASIP  $\rightarrow$  lighter pheomelanin

leucine and lysine at residue 101

E



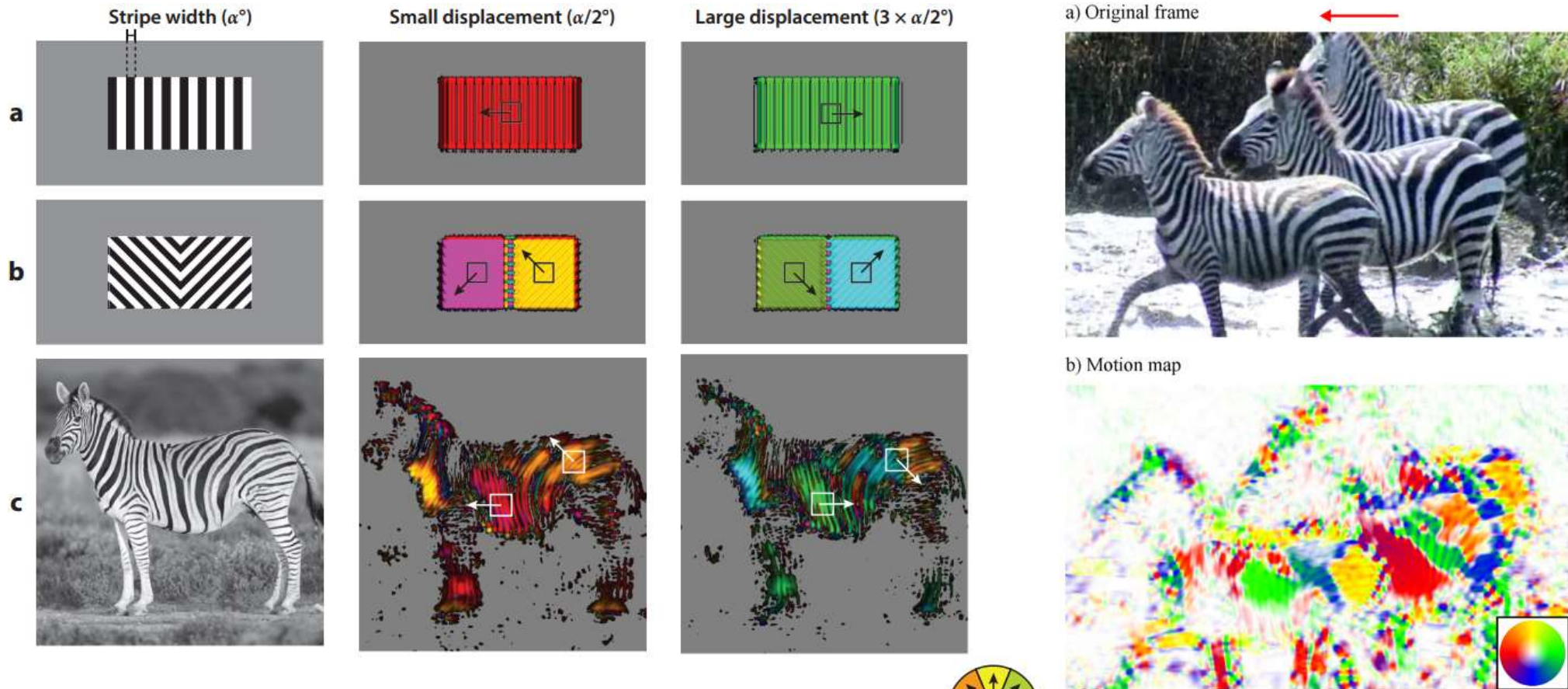
# A generalist camouflage tactic——Animal-to-background similarity was generally high at global scale in *Sahara–Sahel desert rodents*



Predation, as top-down selection pressure, appears to drive phenotype–environment convergence and a generalist or compromise camouflage tactic

( Ossi Nokelainen et.al .*J Anim Ecol.*2020 )

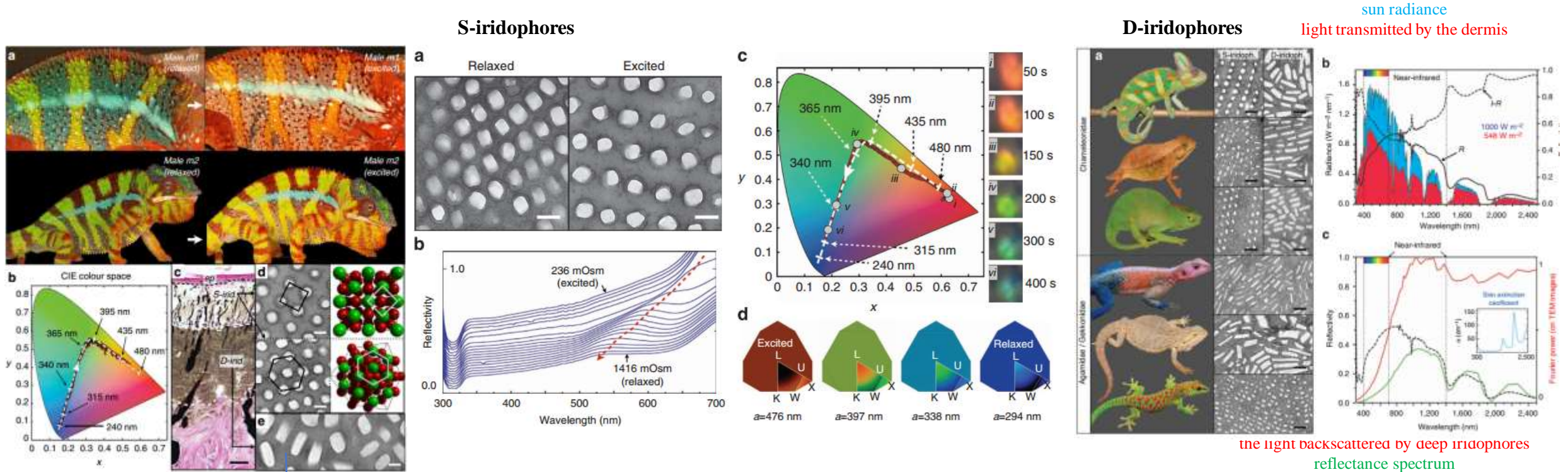
# Biases in motion extraction—potentially leading to biases in overall motion perception and, consequently, disrupting detection—do occur for moving patterned targets



( Julie M. Harris et.al .*Annu. Rev. Vis. Sci.* 2025 )

( Martin J. Howa and Johannes M. Zanker .*Zoology*. 2014 )

# Photonic crystals cause active colour change in chameleons

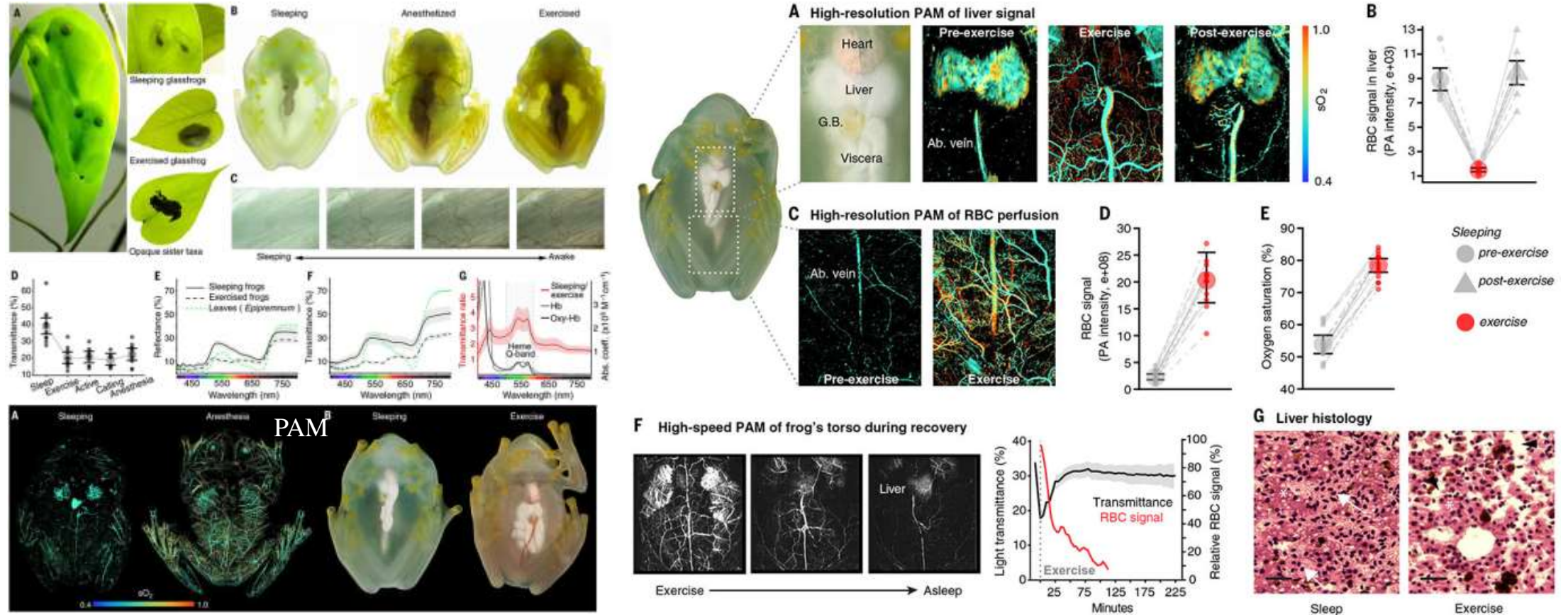


small close-packed guanine crystals<sup>19</sup>

*Panther chameleons* rapidly change colour (hue) by actively tuning the photonic response of a lattice of small guanine nanocrystals in S-iridophores

( Je'ré'mie Teyssier et.al .*Nature Communications*. 2015 )

# Glassfrogs conceal blood in their liver to maintain transparency

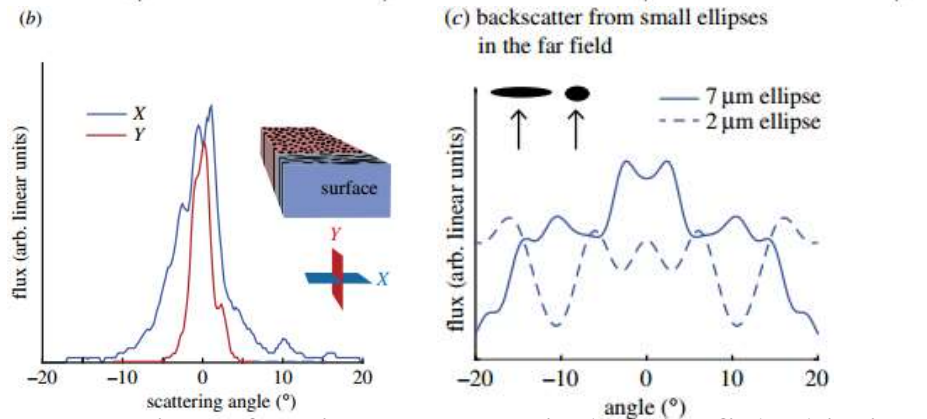
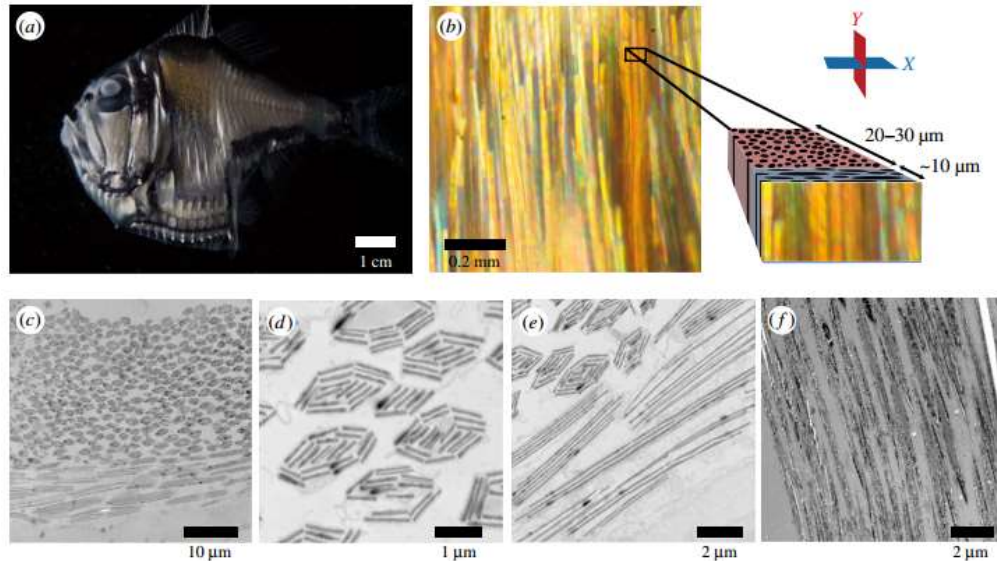


Mirrored sacs that contain reflective **guanine crystals** and attenuate over 80% of the incident visible light

( Carlos Taboada et.al. *Science*. 2022 )

- Camouflage strategies of **Non-aquatic organisms** ?
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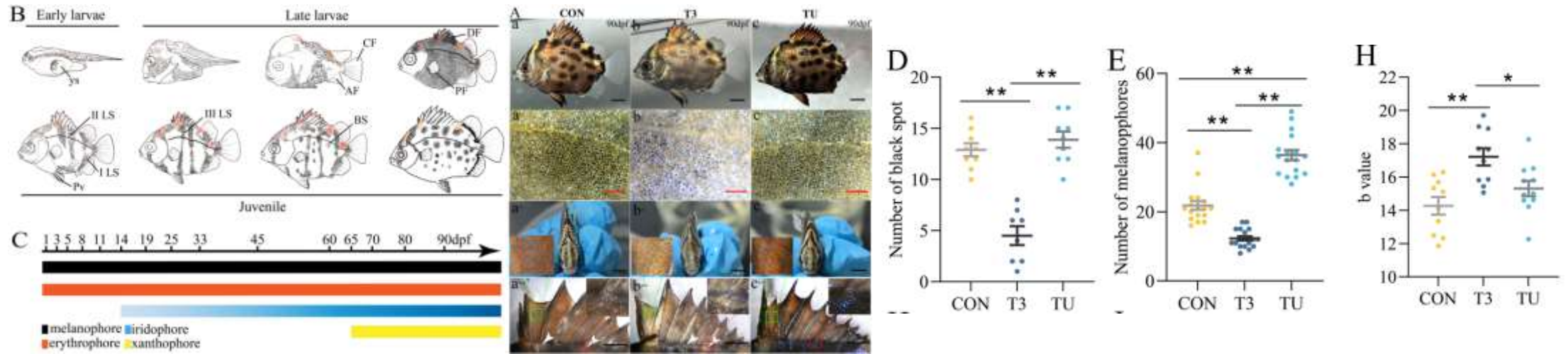
# Scattering and reflecting from *Hatchetfish* scales contributes to camouflage



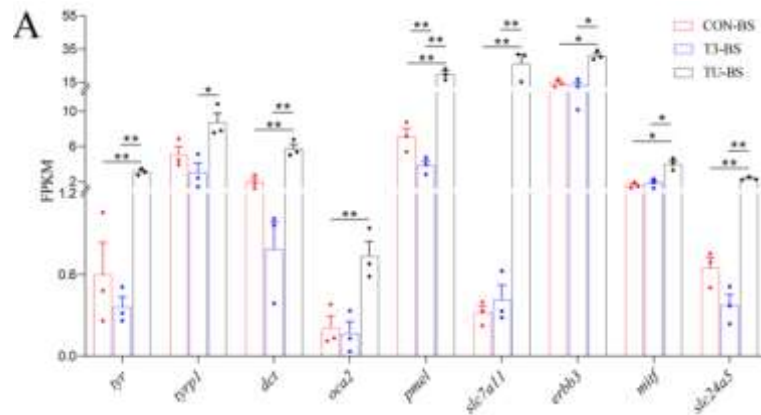
The composite refractive structure in hatchetfish skin increases camouflage from all viewing angles when illuminated either by ambient light and/or by a predator's searchlight

( Eric I. Rosenthal et.al. The Royal Society .2017 )

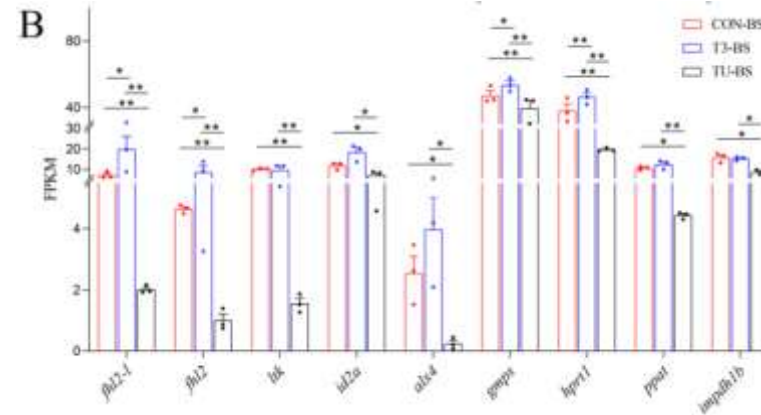
# Thyroid hormones repress melanophores formation and promote the proliferation of xanthophore and iridophore in *Spotted scat*



Gene associated with melanogenesis



Gene associated with iridophore



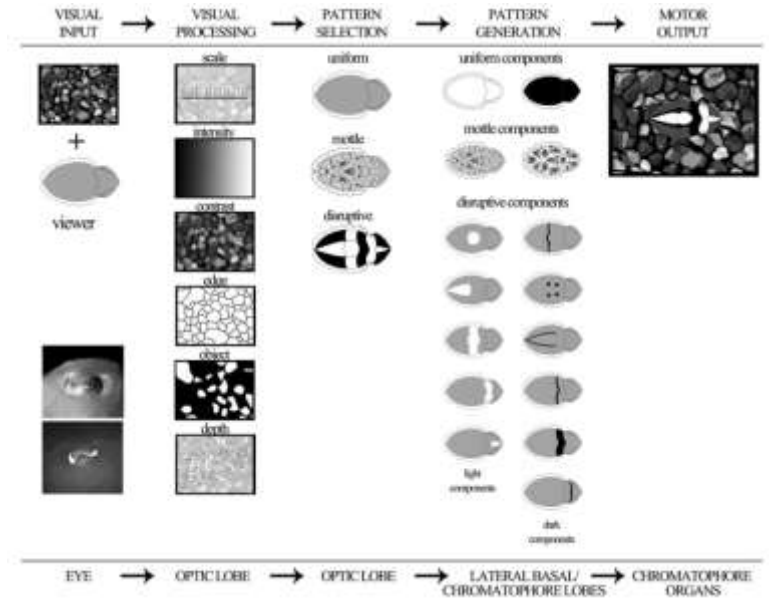
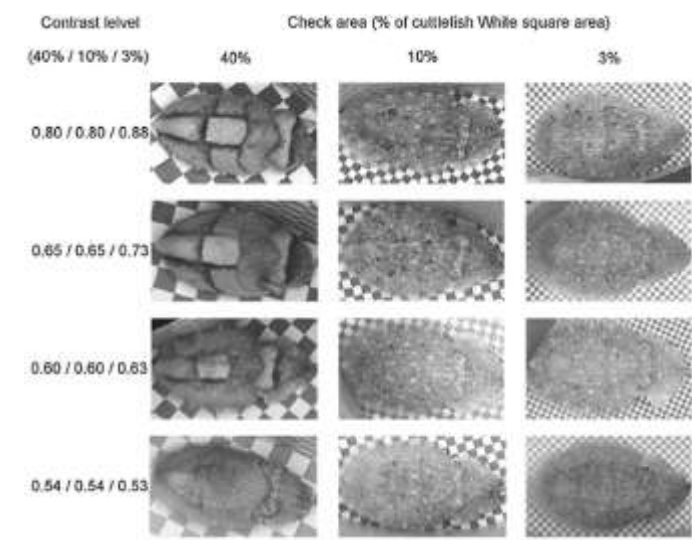
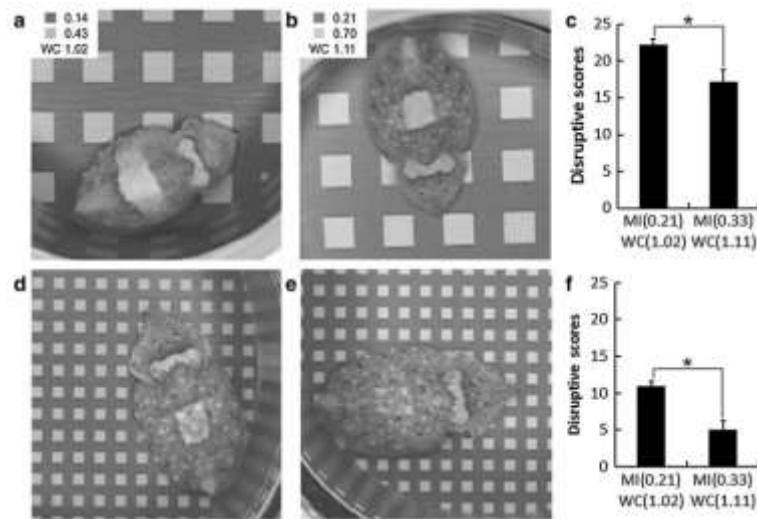
# Visual perception mechanisms that regulate rapid adaptive camouflage in *cuttlefish*

Vision → Brain → (camouflage) Motor control



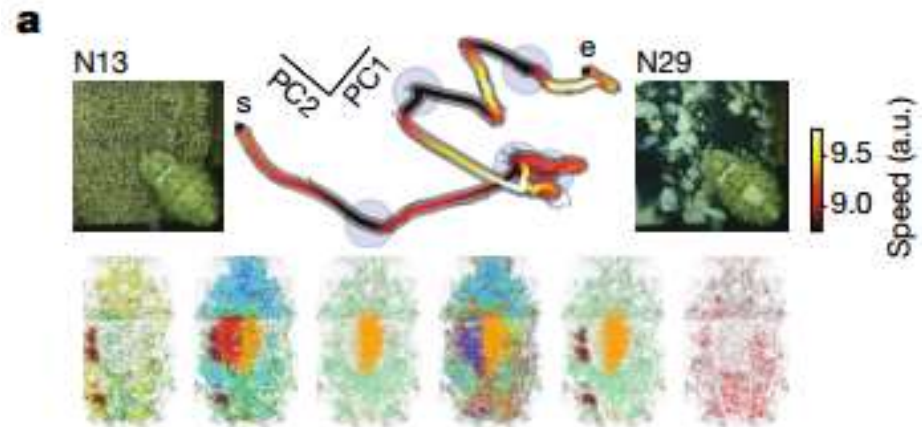
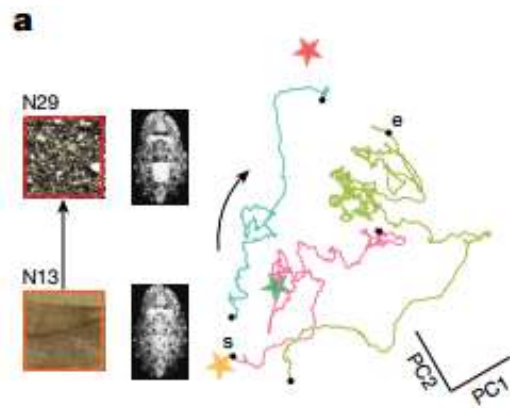
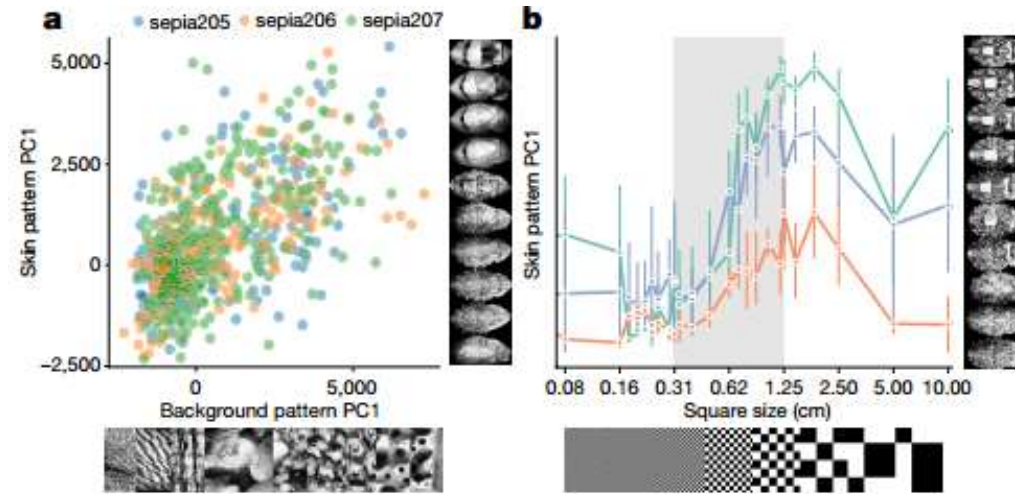
Low background **intensity** tends to evoke stronger disruptive patterns

The **contrast** of the benthic background



( Chuan Chin Chiao et.al .J Comp Physiol A .2015 ) **No vision - photosensitive cells**

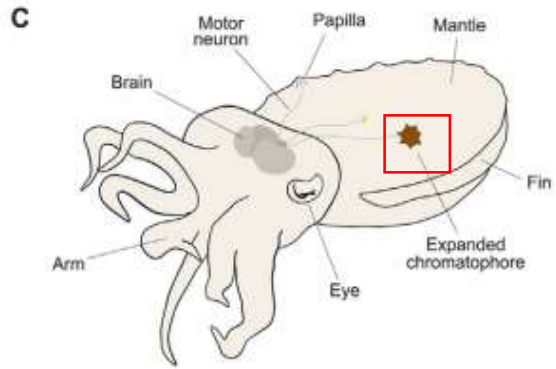
# The dynamics of pattern matching in camouflaging *cuttlefish*



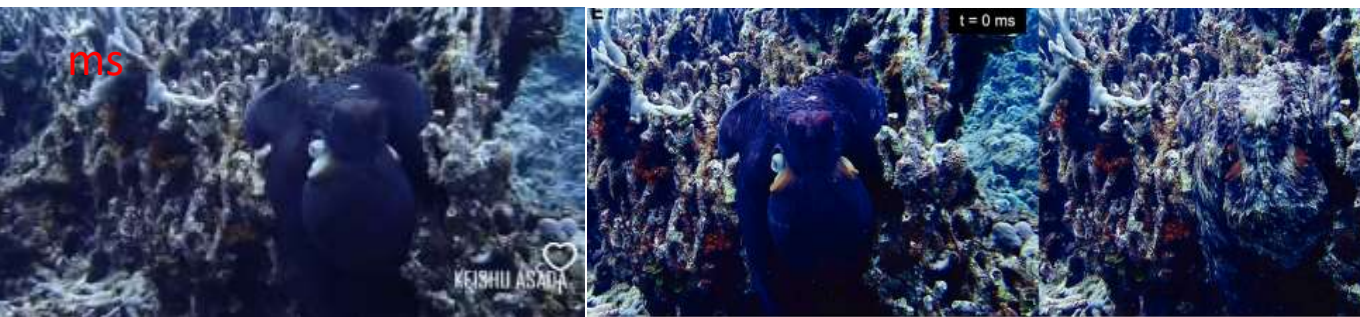
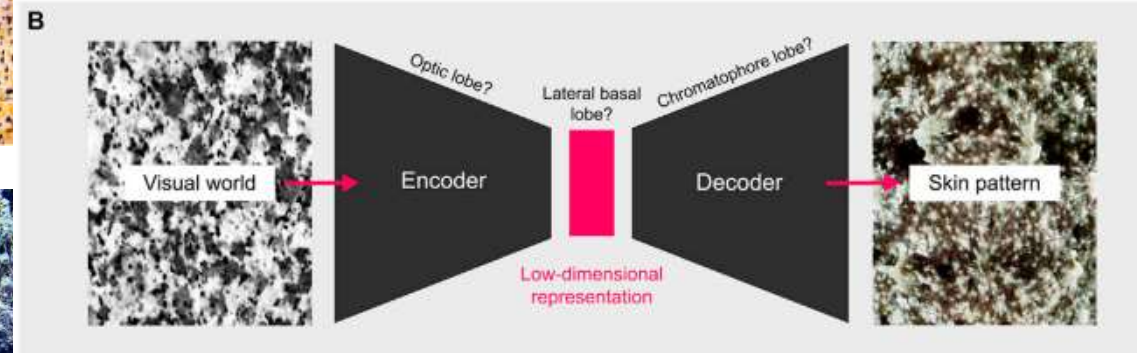
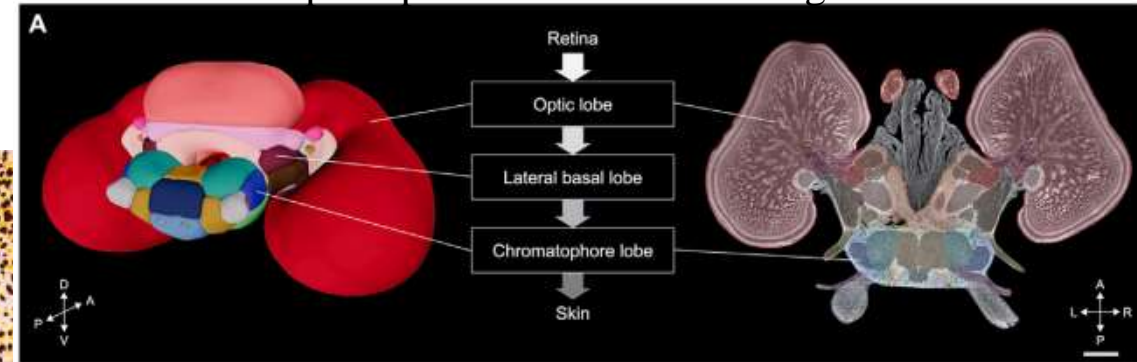
( Theodosia Woo, Xitong Liang et.al .*Nature*.2023 )

# Neural control of cephalopod camouflage

chromatophores (Yellow/Red/Brown)  
and papillae



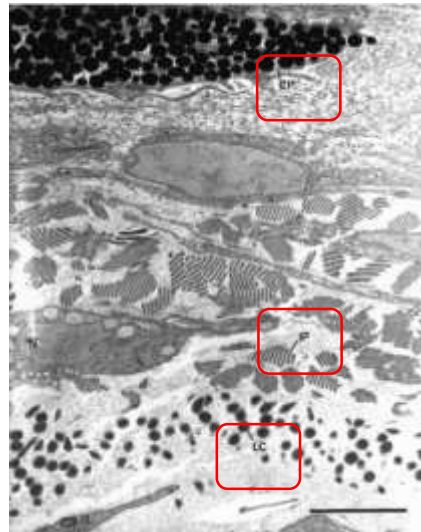
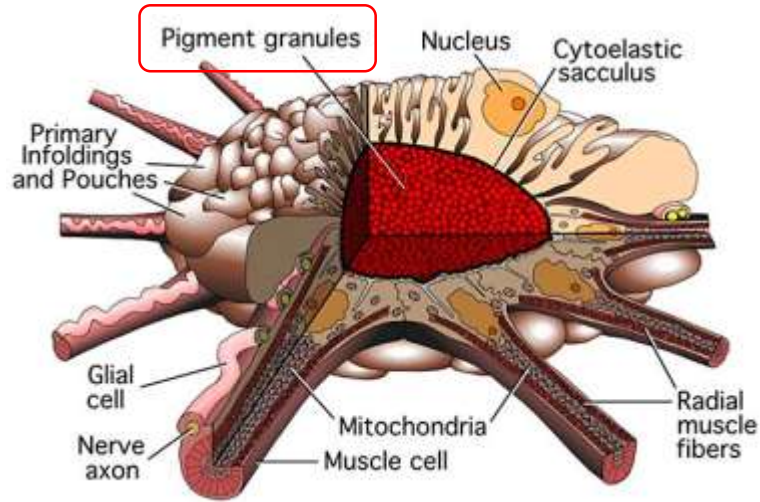
The cephalopod brain and camouflage control



( Tessa G. Montague .*Current Biology* .2023 )

# Chromatophores, which are neuromuscular organs innervated directly from the brain, and not under any kind of hormonal control

## chromatophores and reflecting cells and skin muscles



### Under the skin

**Chromatophore**  
When the cell is relaxed, the pigment forms an ectoplasmic dot in the center. By pulling the radial muscles, the chromatophore is stretched into a larger disc and the colour is visible.  
Orange-yellow, Red-orange, Black-brown

**Iridophore**  
Iridophores generate iridescent colours using stacked crystals of melanin granules (proteins) as they project. By altering the angle of the iridophore, the colour changes.  
Pink, Yellow, Green, Brown, Blue, Silver

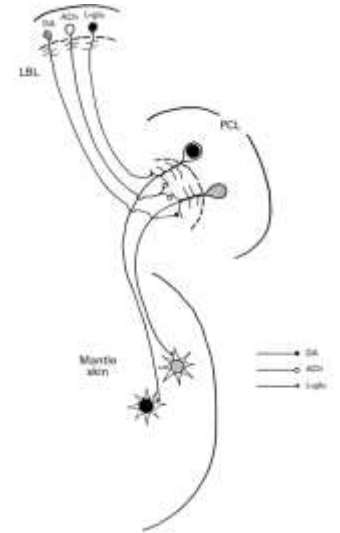
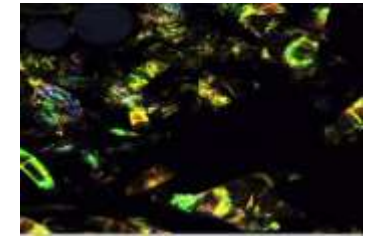
**Leucophore**  
Leucophores use the same proteins as iridophores, but instead of stacking them in plates, the crystals are arranged on the surface of the cell. Squaring or flattening the cell controls how much light is reflected.  
Cell body, Nucleus, Transparent refractive granule

**Mirror granules**  
The guanine crystals are actually transparent, but by arranging them in tiny beads they act like crushed glass and form a white base.

**Top layer**  
Stacked layers of chromatophores contain the three basic pigments. Reds, yellows, browns and black colours are all produced here.

**Middle layer**  
The iridophores create interference patterns to generate shimmering, metallic patterns, and are also used to create blue and green colours.

**Base layer**  
Leucophores are white. White is used as a danger signal by many octopuses, but this layer is also used as a 'base coat' to modify the colours of the chromatophores above.

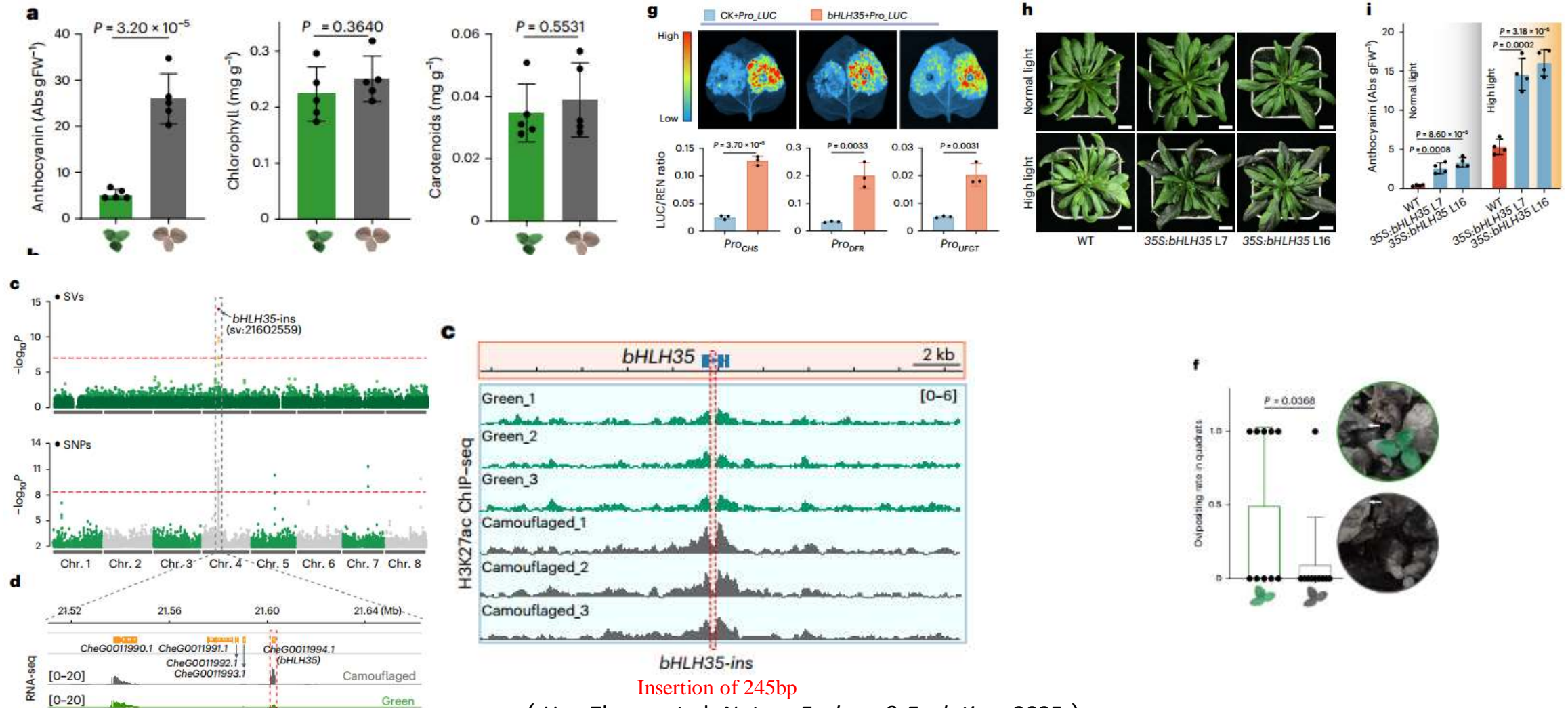


- There are apparently no pigmentary blues or greens in cephalopods.
- Octopus vulgaris has yellow, orange, red, brown and also black chromatophores.

- Each chromatophore organ comprises an elastic sacculus containing pigment, to which is attached a set of obliquely striated radial muscles, each with its nerves and glia.
- When excited the muscles contract, expanding the chromatophore; when they relax, energy stored in the elastic sacculus retracts it.

- Camouflage strategies of **Non-aquatic organisms** ?
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- What are the camouflage strategies in **plants** ?

# Leaf camouflage is due to a transposon insertion in the *bHLH35* gene, which acts as an enhancer and leads to anthocyanin accumulation in the leaves



( Han Zhang et.al. *Nature Ecology & Evolution* .2025 )

# Take home message

- The essence of camouflage is an adaptive strategy.
- Among non-aquatic animals, the camouflage strategies are diverse, including: coat color camouflage, texture camouflage, color camouflage, transparent camouflage etc. Involving the photoperiodic changes of hair scales, the regulation of pigment cells and the reflection of structural colors.
- Among aquatic organisms, some fish use iridines to reflect light. They can also regulate the activity of melanocytes by using thyroid hormones produced by the HPA axis. In octopus , they rapidly change color through pigment cells , reflex cells and skin structure.
- The camouflage strategies of plants usually include changing colors and shapes to adapt to the environment.