OP-269 [Pollination and Bee Flora]
Managed pollinators essential for offsetting the declining contribution of native pollinators to fruit yield stability due to changes in breeding-mediated flower traits

Bin Yuan[1], Zhi Chu Huang[2], Xiao Ling Su[2], Xiao Ming Fan[3], Yuan Yuan Lu[1], Yi-bo Luo[4], Fu Liang Hu[1]
[1]College of Animal Sciences, Zhejiang University, Hangzhou 310058, China
[2]Jinhua Academy of Agricultural Sciences, Jinhua 321000, China
[3]Key Laboratory of Cultivation and Protection for Non-Wood Forest Trees, Ministry of Education, Central South University of Forestry and Technology, Changsha 410004, China
[4]State Key Laboratory of Plant Diversity and Specialty Crops, Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China

The global population and food supply requirements are increasing, and the acreage of insect-pollinated plants that serve human well-being has expanded. Pollinators considerably contribute to the current plant yield, which underpins global food security. Breeding aimed at improving fruit traits substantially alters flower traits such as flower anthesis and size. However, the effects of breeding-mediated changes in flower traits on sustainable agroecosystem production via the plant–pollinator relationship remain unclear. As sustainable agroecosystem production directly impacts the United Nations Sustainable Development Goals (SDGs), an economically important oilseed tree (Camellia oleifera) was considered in this study to address the above-mentioned gap in literature, with a focus on the implications for pollinator management and sustainable agroecosystem production. The pollination system of C. oleifera used in this study includes native pollinators (Andrena camellia) and managed pollinators (Apis cerana and Bombus spp.). In this study, we evaluated floral traits, observed pollinator (including native and managed pollinators) preferences, assessed pollinator pollen transfer efficiency, and recorded fruit set data. The results showed that breeding based on fruit traits induced substantial changes in flower anthesis and size, which subsequently affected plant–native pollinator relationships and even pollinator specialization of plants. The changes in anthesis resulted in decreased interactions between plants and pollinators; smaller flowers diminished the attraction of pollinators to plants, whereas larger flowers resulted in a reduction in the pollen transfer efficiency of pollinators. Additionally, the pollen transfer efficiency of pollinators contributed more to plant fruit sets than plant attractiveness to pollinators. Thus, breeding may reduce the contribution of pollinators to plant fruit yield, particularly in large-flowered varieties, which would increase the reliance on managed pollinators for plant yield in future agroecosystems. Overall, breeding-mediated flower trait changes will diminish the contribution of pollinators to sustainable production in agroecosystems, highlighting the importance of managed pollinators in future agroecosystem production. These findings call for knowledge exchange between beekeepers and plant growers to promote the integration of pollination and domestication syndromes in breeding to safeguard future global food security. There also is a need for beekeepers to carefully reconcile the conflicts between native and managed pollinators in future.

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Managed Pollinators are Essential for Offsetting the Declining Contribution of Native Pollinators to Fruit Yield Stability Due to Changes in Breeding-mediated Flower Traits

Presenter: **Bin Yuan**

Supervisor: **Fuliang Hu**

College of Animal Sciences, Zhejiang University, China

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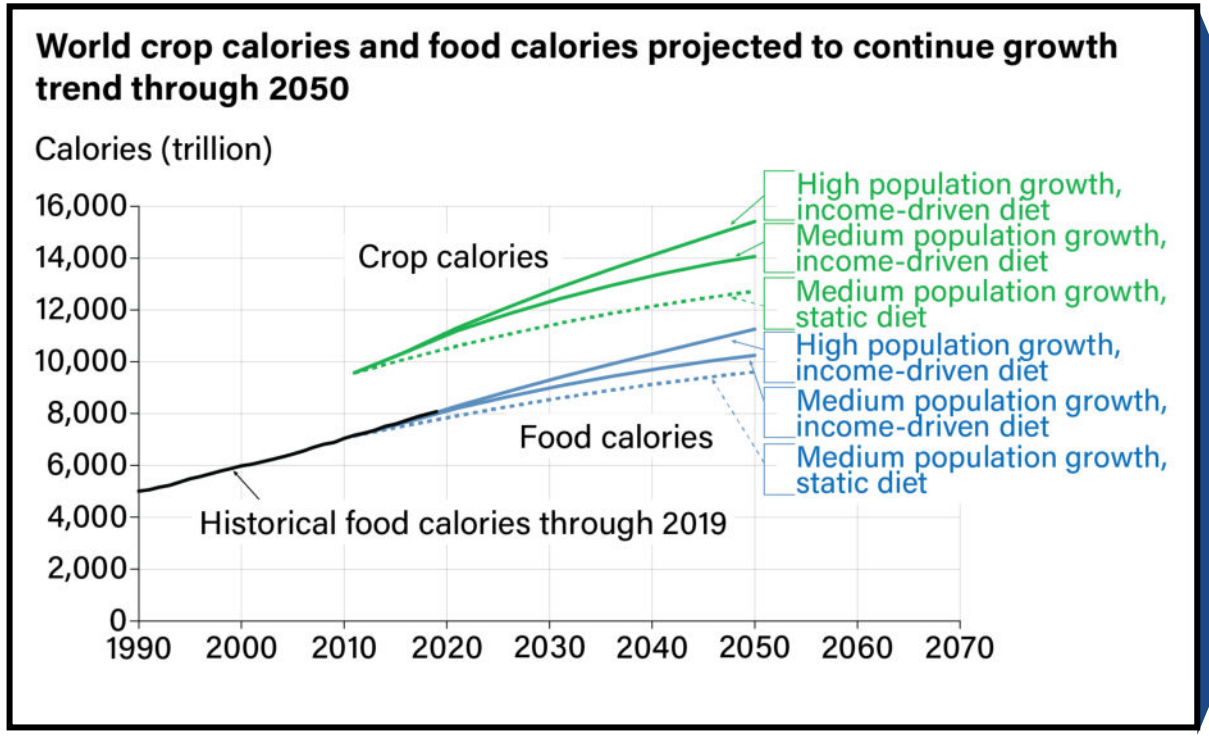
Crop production and pollination crisis



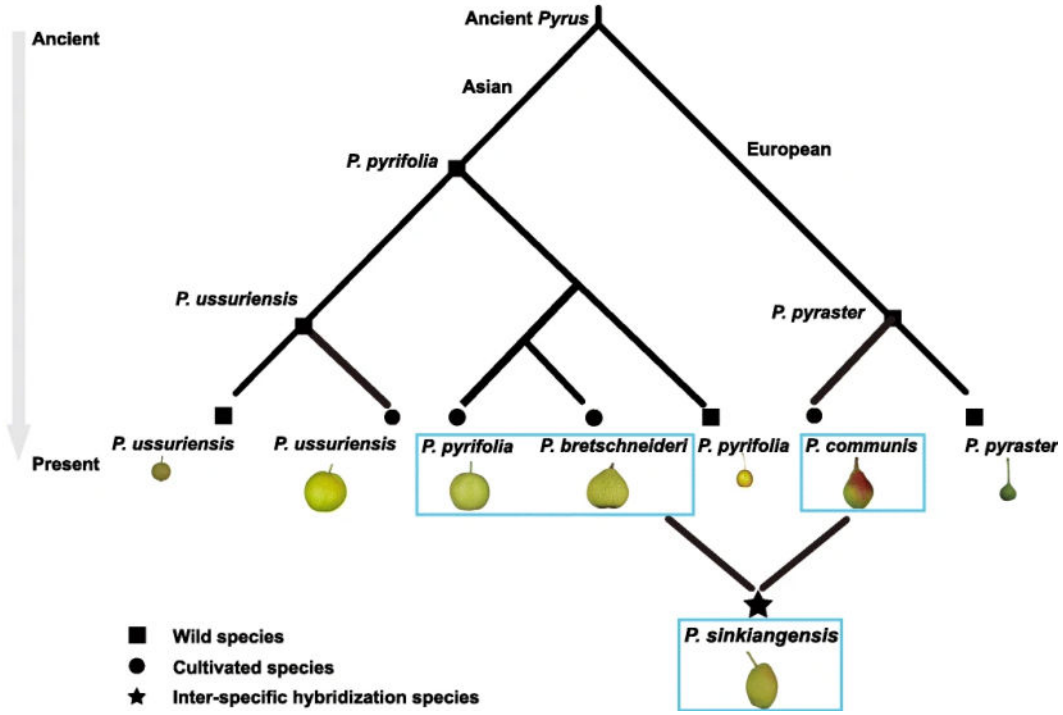
(Sands R. et al. 2023, ERS)

- Global food demand continues to rise sharply
- 75% of major crops rely on animal pollination
- Climate change and biodiversity decline destabilize yields

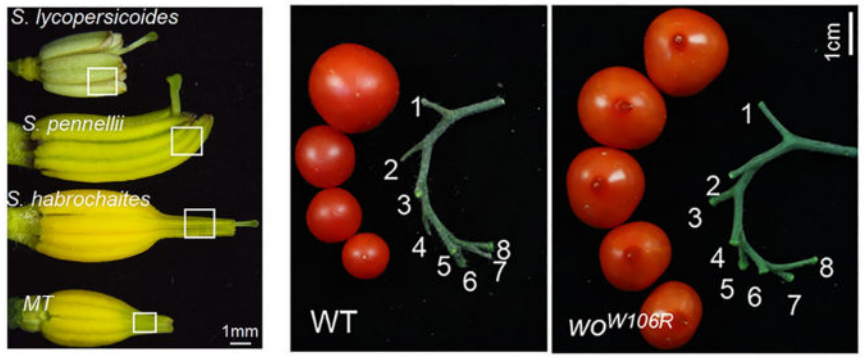
Without reliable pollination, feeding the future population is difficult

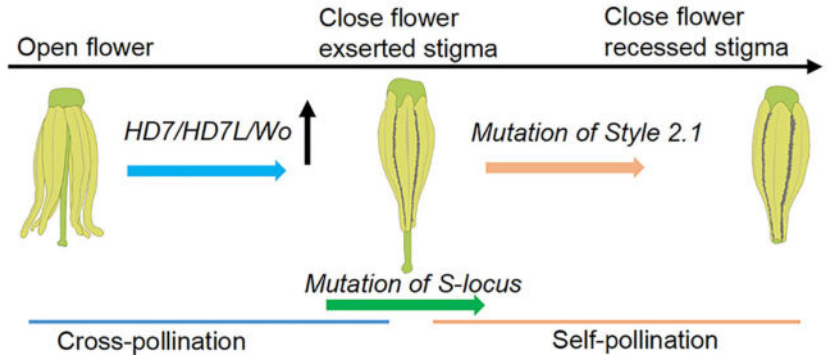
Breeding and floral traits

- Case 1: *Pear (Wu J. et al. 2018, BMC Gen Bio)*



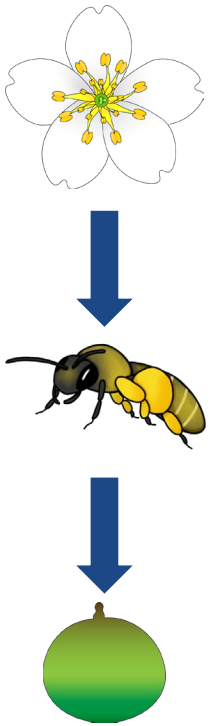
- Case 2: *Tomato (Wu ML. et al. 2024 Science)*





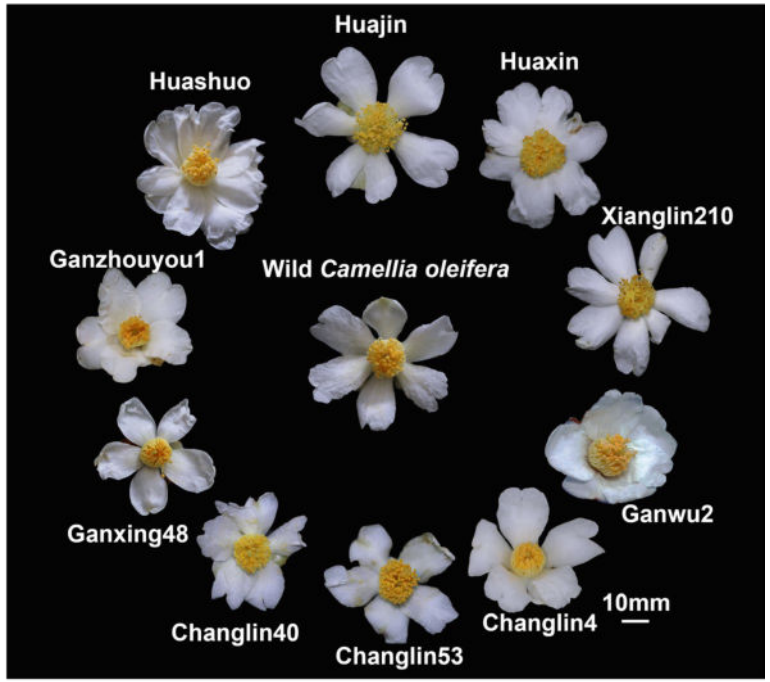
- Breeding enhances fruit traits but unintentionally alters floral traits
- **Such impacts on plant-pollinator interactions are rarely considered in breeding programs**

Objectives



- What flower traits have changed during breeding?
- How do these changes affect pollinator behavior and efficiency?
- What are the consequences for fruit set and yield stability?

Study system and focal pollinators



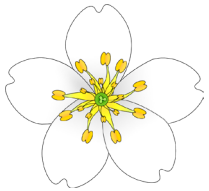
Camellia oleifera

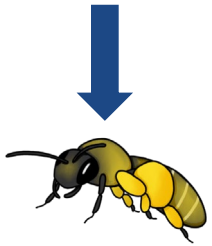
Pollinators

- *Camellia oleifera* (Oil tea), one of the world's top three woody oilseed species
- It has a short breeding history, which makes floral changes easier to detect

This crop provides an ideal system to explore how flower trait changes reshape interactions with the plant and pollinators

- Native pollinator: *Andrena camellia*, a solitary specialist bee of oil tea
- Managed pollinators: *Apis cerana* and *Bombus* spp., rarely interact with oil tea

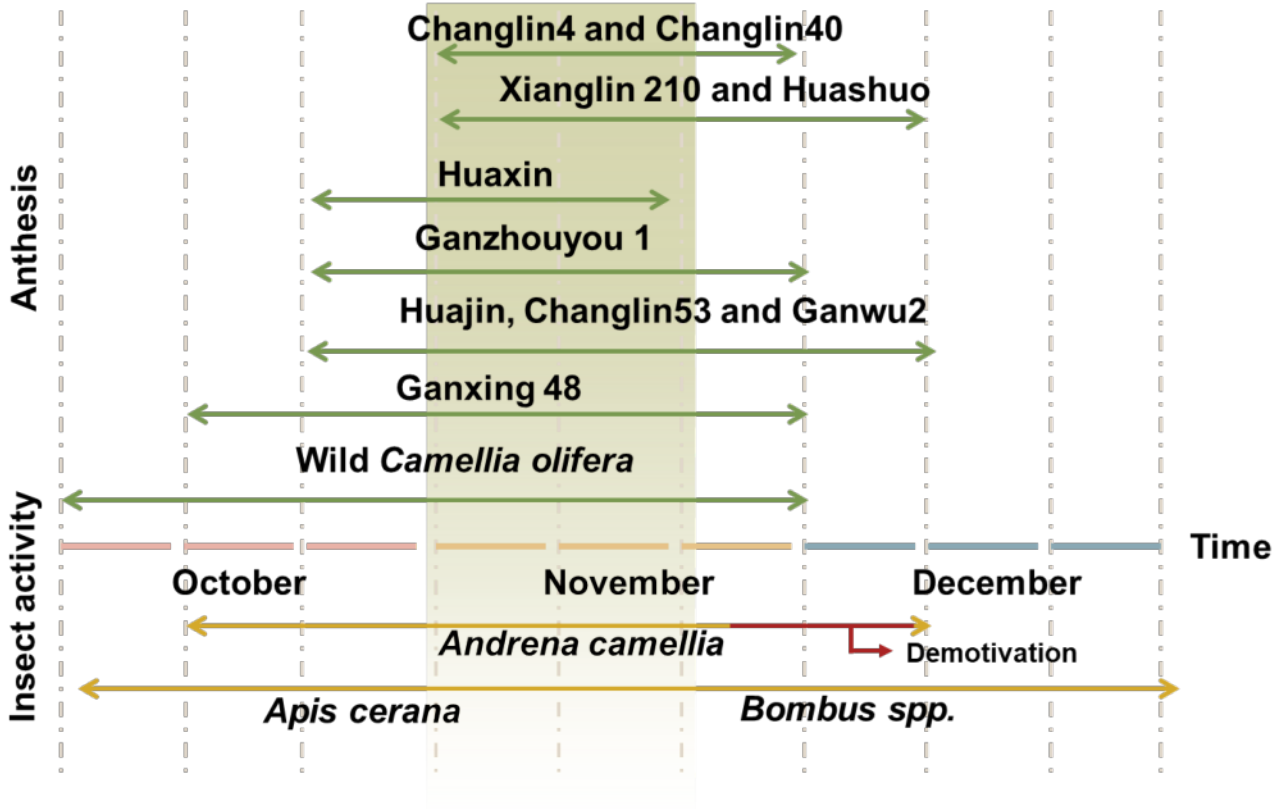




- **Floral traits:** anthesis and phenotype
- **Pollinator behavior:** choice tests, foraging behavior, visitation frequency, stigma contact rate
- **Pollination service:** fruit set under natural and managed pollination conditions, statistical analysis

Floral trait changes associated with breeding

Anthesis:

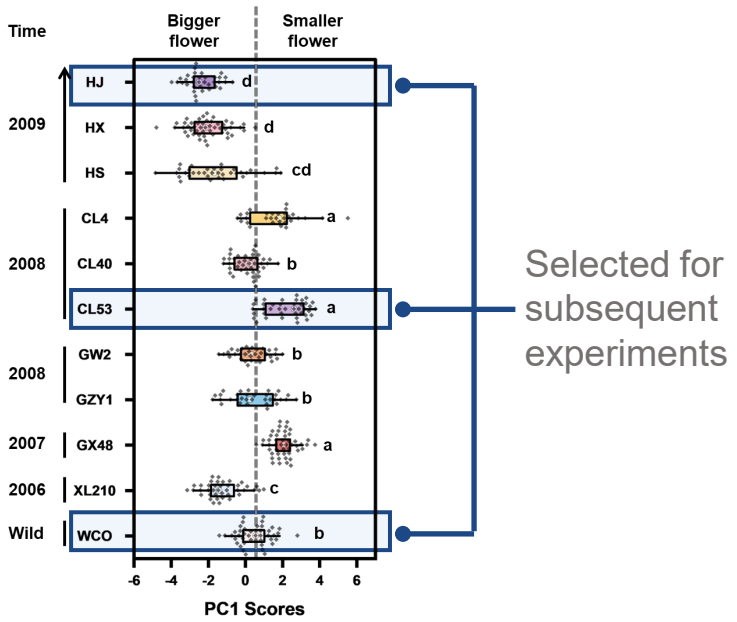


- **A small number of varieties have a change in anthesis**
- Varieties with variations in anthesis are unable to interact with native pollinators

Floral trait changes associated with breeding

Phenotype :

	Component	
	1	2
FWL	**.820**	.246
PL	**.819**	.237
PW	**.747**	.190
AH	.515	.721
ATL	**.759**	
SH	**.777**	-.175
ASRH	.152	-.978



Principal component analysis

- **Flowers, petals, and androecium sizes show common trends in variation**

Floral trait changes associated with breeding

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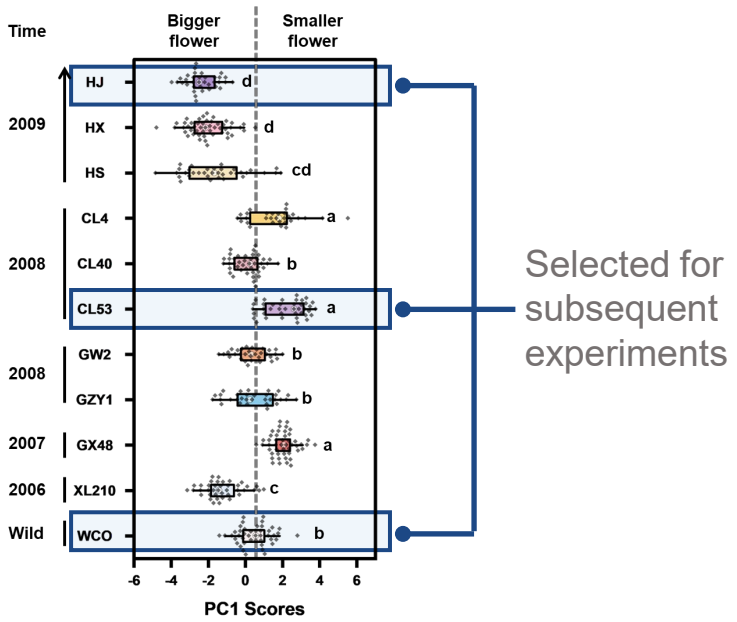
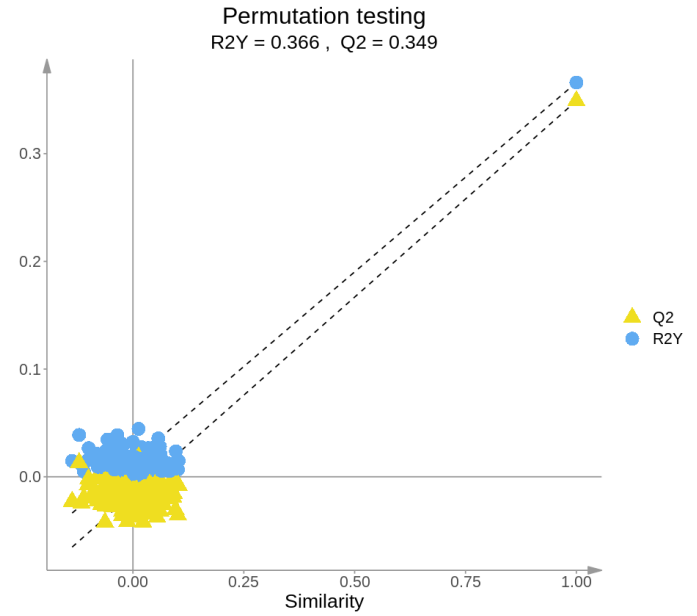


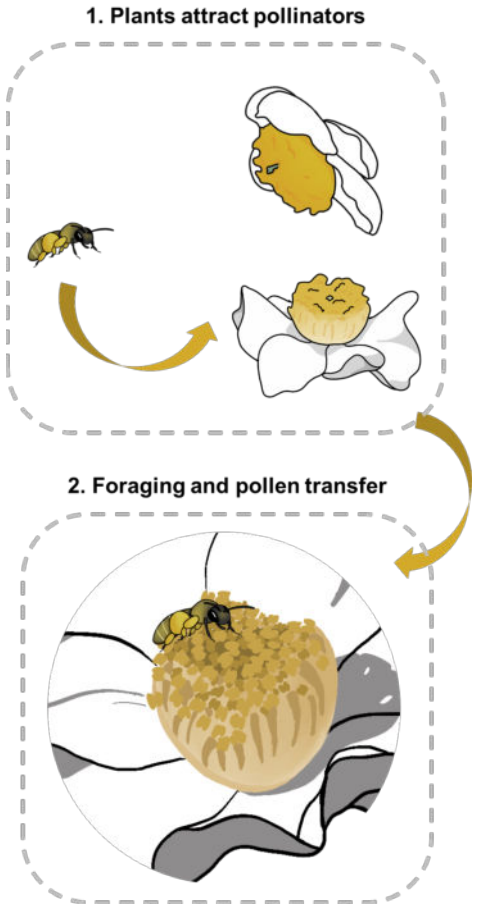
Principal component analysis

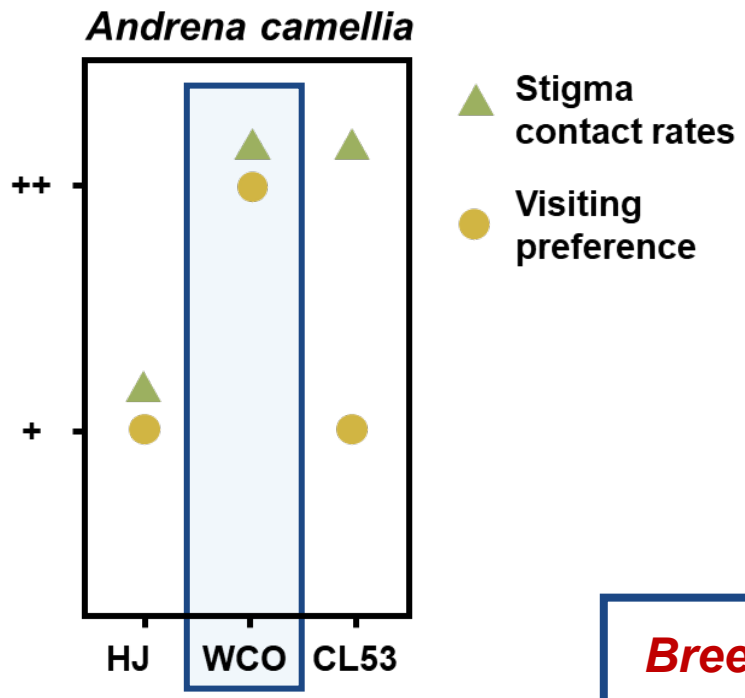


Orthogonal Partial Least Squares Discriminant Analysis

- **Flowers, petals, and androecium sizes show common trends in variation**
- **Breeding resulted in a marked change in flower phenotype, but this change was undirected**

Pollinator preference and efficiency





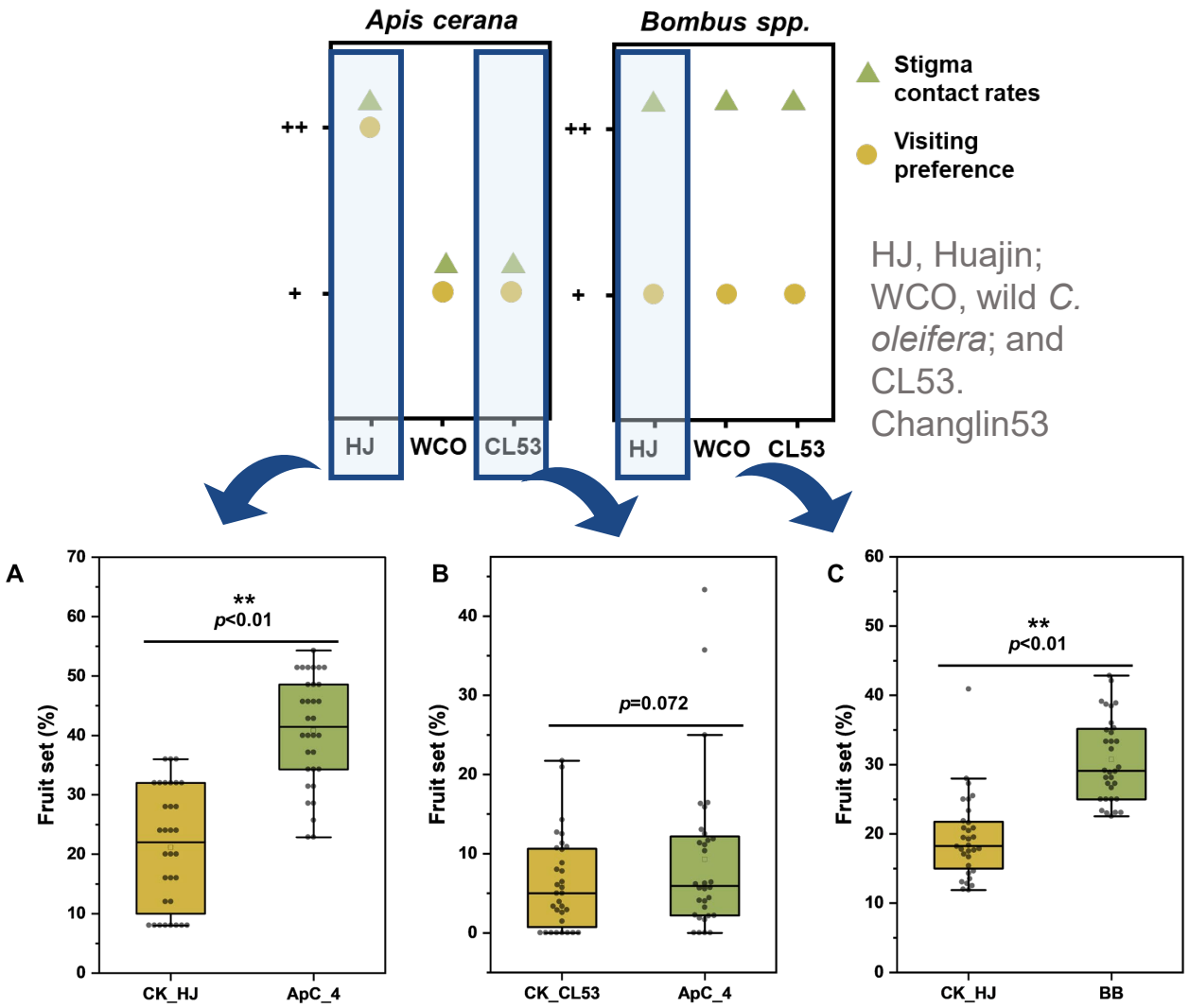
HJ, Huajin; WCO, wild *C. oleifera*; and CL53. Changlin53

- **Small-flowered varieties:** Preference decreased
- **Large-flowered varieties:** Stigma contact rate and preference decreased

Breeding changes plant-pollinator interactions:

- Pollination services from native pollinators are **weakening** in large- and small-flowered varieties

Fruit set under managed pollination



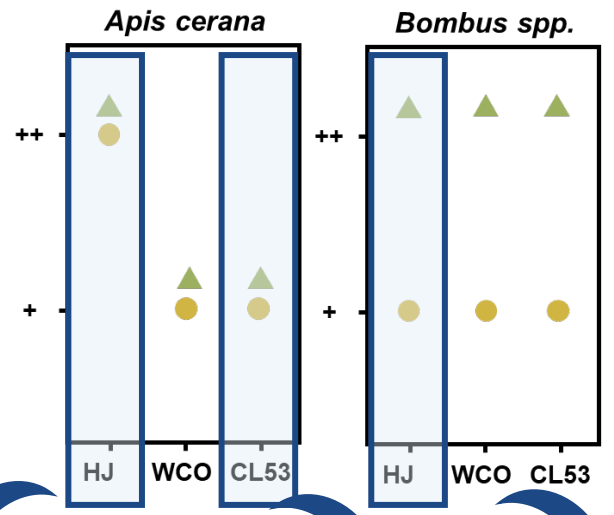
HJ, Huajin; WCO, wild *C. oleifera*; and CL53. Changlin53

(A) Managed *Apis cerana* pollinating Huajin; (B) Managed *Apis cerana* pollinating Changlin53; (C) *Bombus* spp. pollinating Huajin.

Fruit set under managed pollination

Pollinator	Furit set
High preference High stigma contact rate	↑
Low preference High stigma contact rate	↑
Low preference Low stigma contact rate	–

Fruit set depends more on stigma contact rate than on the pollinator preference



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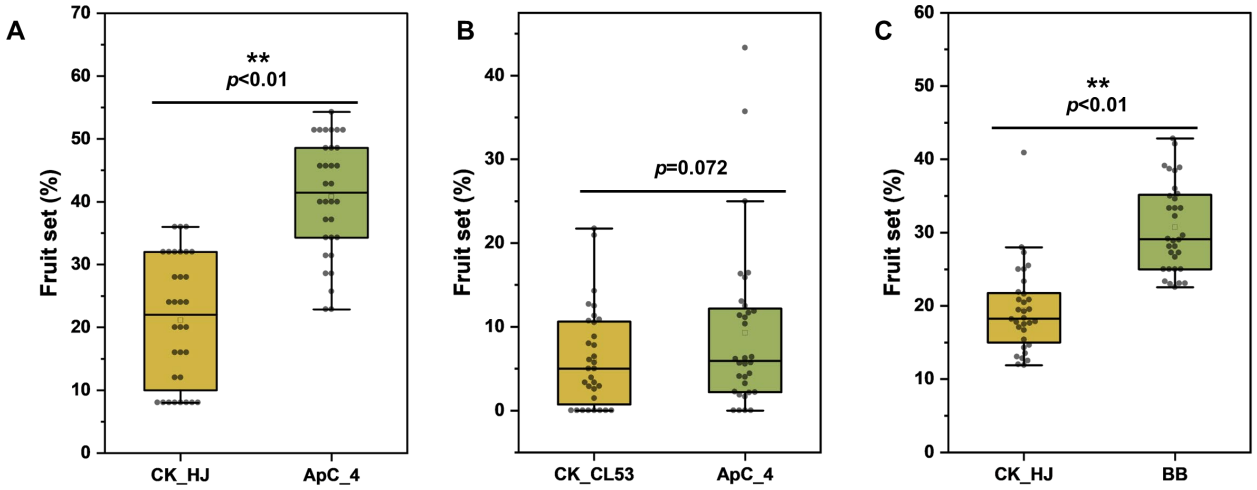
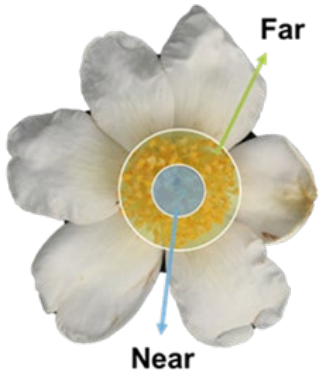
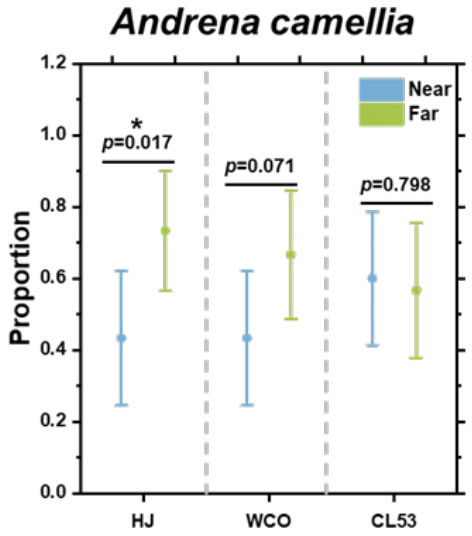


(A) Managed *Apis cerana* pollinating Huajin; (B) Managed *Apis cerana* pollinating Changlin53; (C) *Bombus* spp. pollinating Huajin.

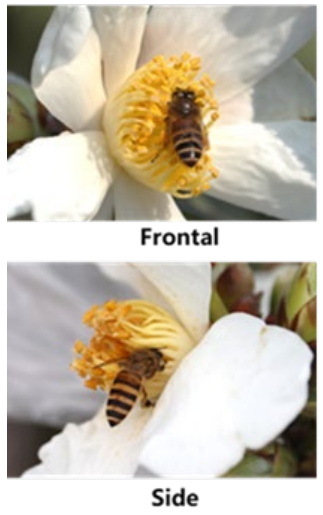
Foraging behaviors of pollinators

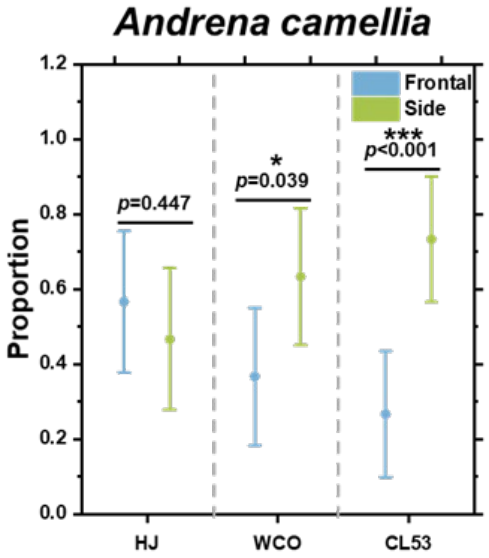
Pollen foraging:





Nectar foraging:





HJ, Huajin; WCO, wild *C. oleifera*; and CL53. Changlin53

Native pollinators show the lowest stigma contact potential on large-flowered varieties, compared with wild and small-flowered ones

How floral traits affect stigma contact rate

***Andrena camellia*：**

1

Flower size —— β = 0.426 *P* = 0.339 ——→ Stigma contact rate

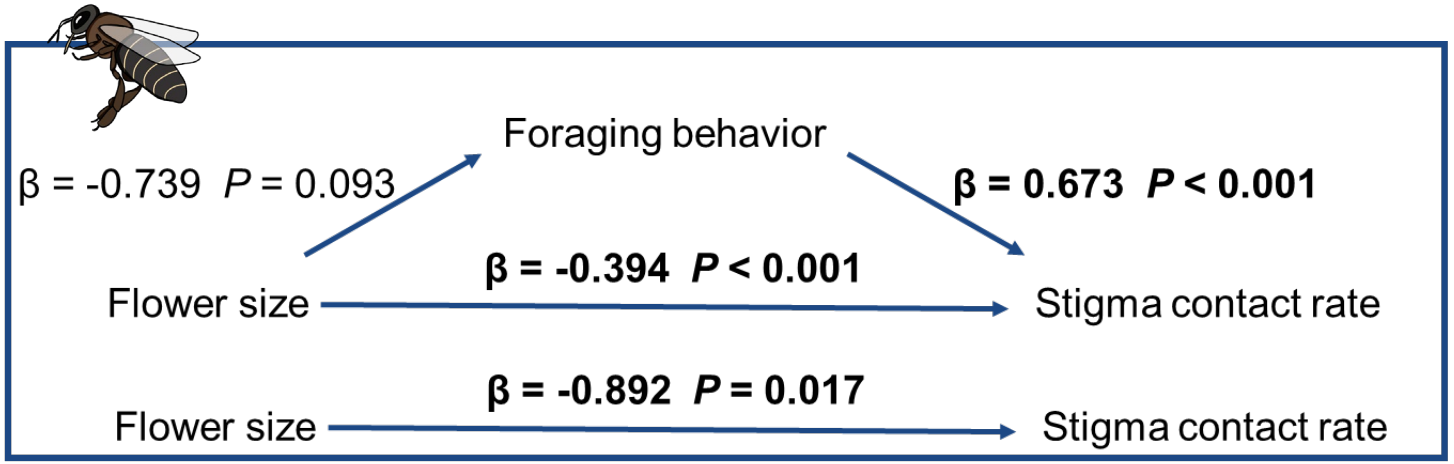
2

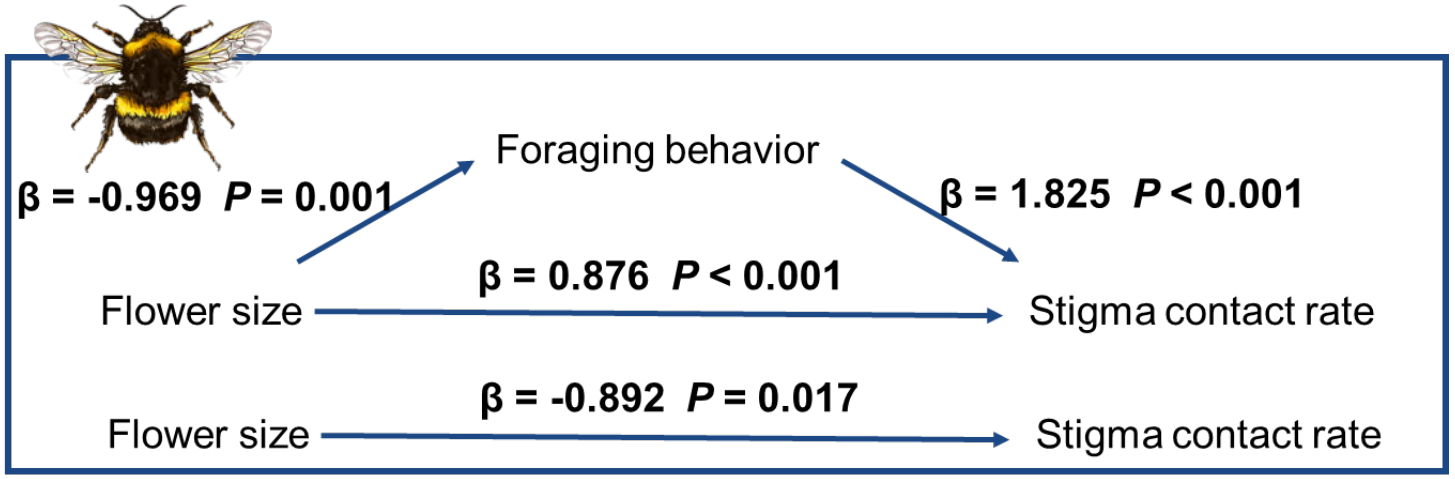
β = 0.756 *P* = 0.082 → Foraging behavior → **β = -1.382 *P* < 0.001**

Flower size —— **β = 1.471 *P* < 0.001** ——→ Stigma contact rate

- Flower trait changes do not directly alter native pollinators' foraging strategies
- **Under the same behavioral strategy, flower traits change the probability of whether an insect can reach the stigma or not**

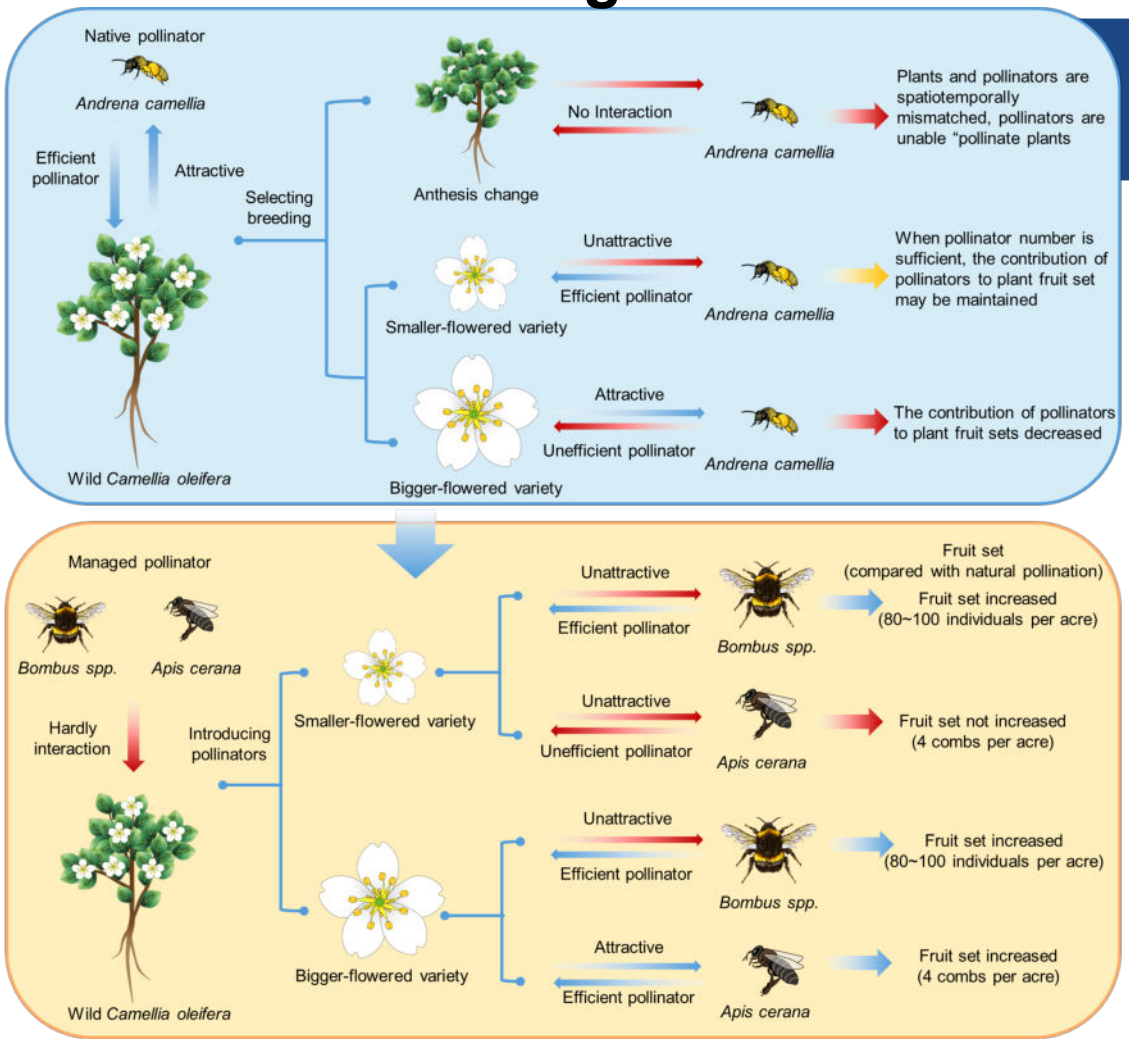
How floral traits affect stigma contact rate





- Changes in floral traits also affect the stigma contact rate of managed bees
- The influence of floral trait variation on stigma contact rate differs across pollinator species

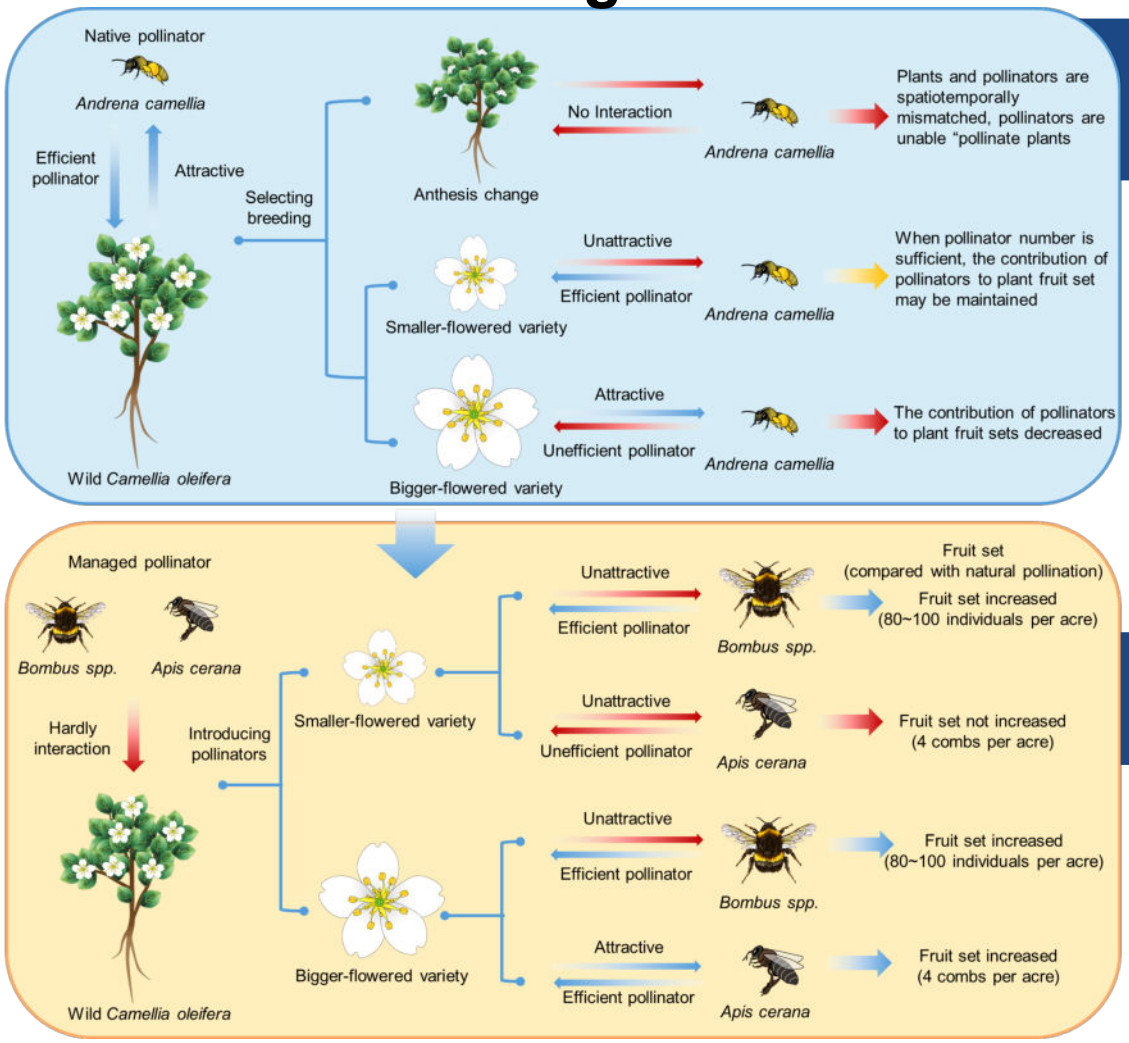
Take-home message



Breeding has altered flower traits, weakening the contribution of native pollinators to fruit set

- Widespread flower trait changes induced by breeding negatively affect pollination services of native pollinators, particularly when such changes reduce the potential for pollinators to contact stigmas during foraging

Take-home message



Breeding has altered flower traits, weakening the contribution of native pollinators to fruit set

- Widespread flower trait changes induced by breeding negatively affect pollination services of native pollinators, particularly when such changes reduce the potential for pollinators to contact stigmas during foraging

Managed pollinators can partly compensate for this loss

- Flower trait variation also alters plant–managed bee interactions, but choosing appropriate managed pollinator species can help stabilize crop yield

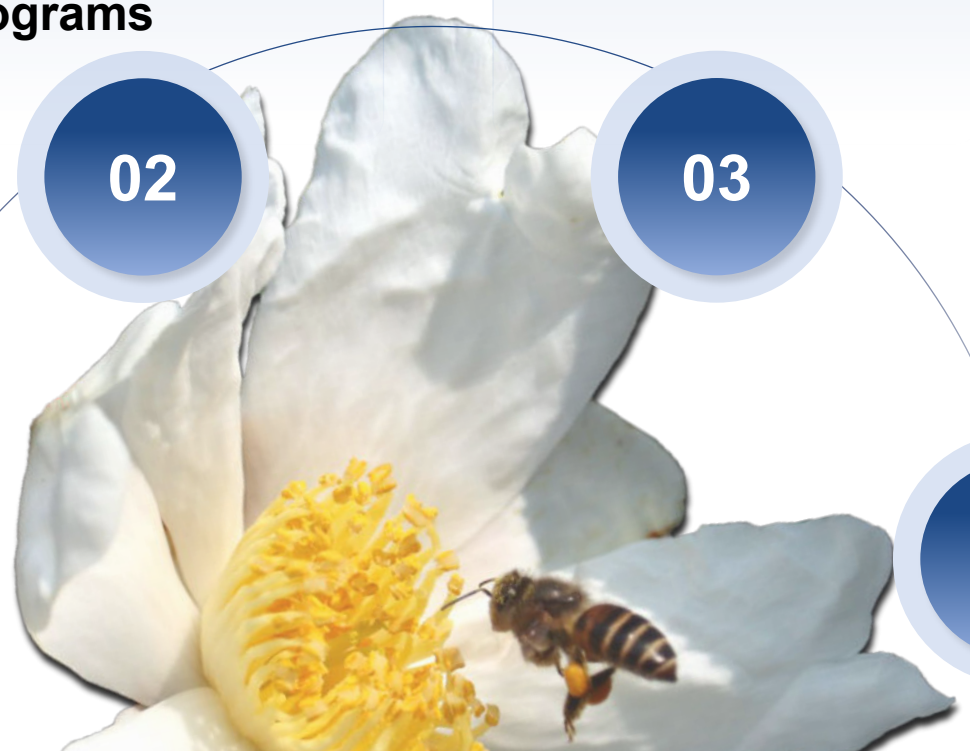
Outlook

01 Managed pollinators will continue to be essential for yield stability

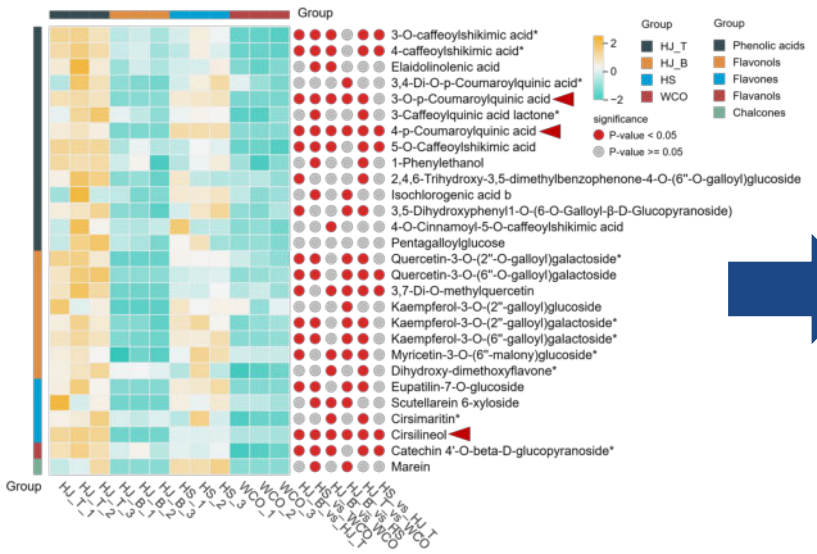
02 Pollination syndromes must be integrated into breeding programs

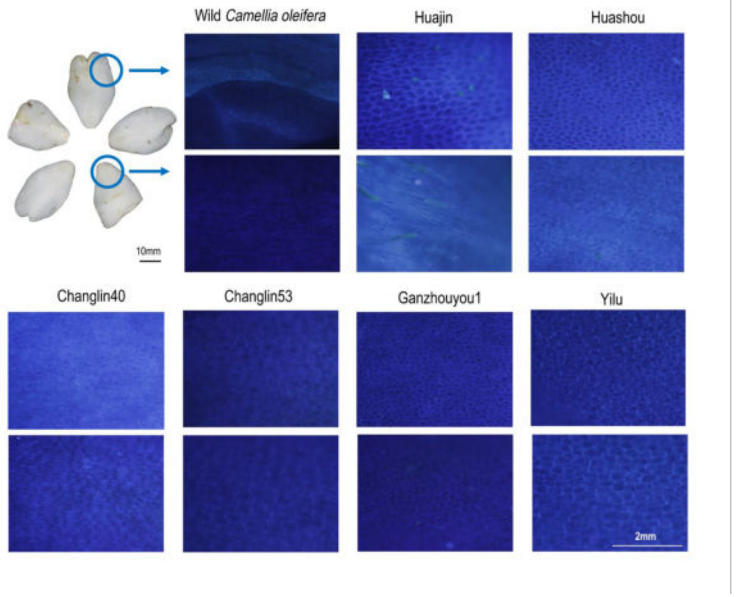
03 Building stronger bridges between apiculturists and plant breeders

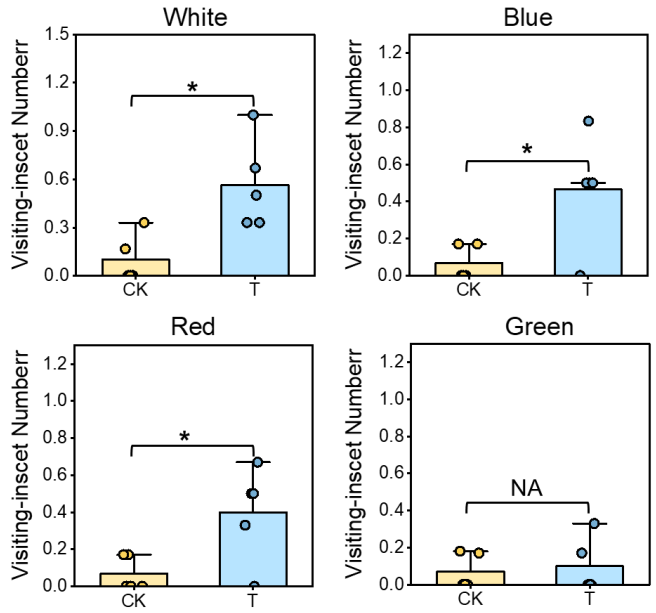
04 Further research should focus on the link between flower and fruit traits



Extension: Petal fluorescence as a novel floral signal



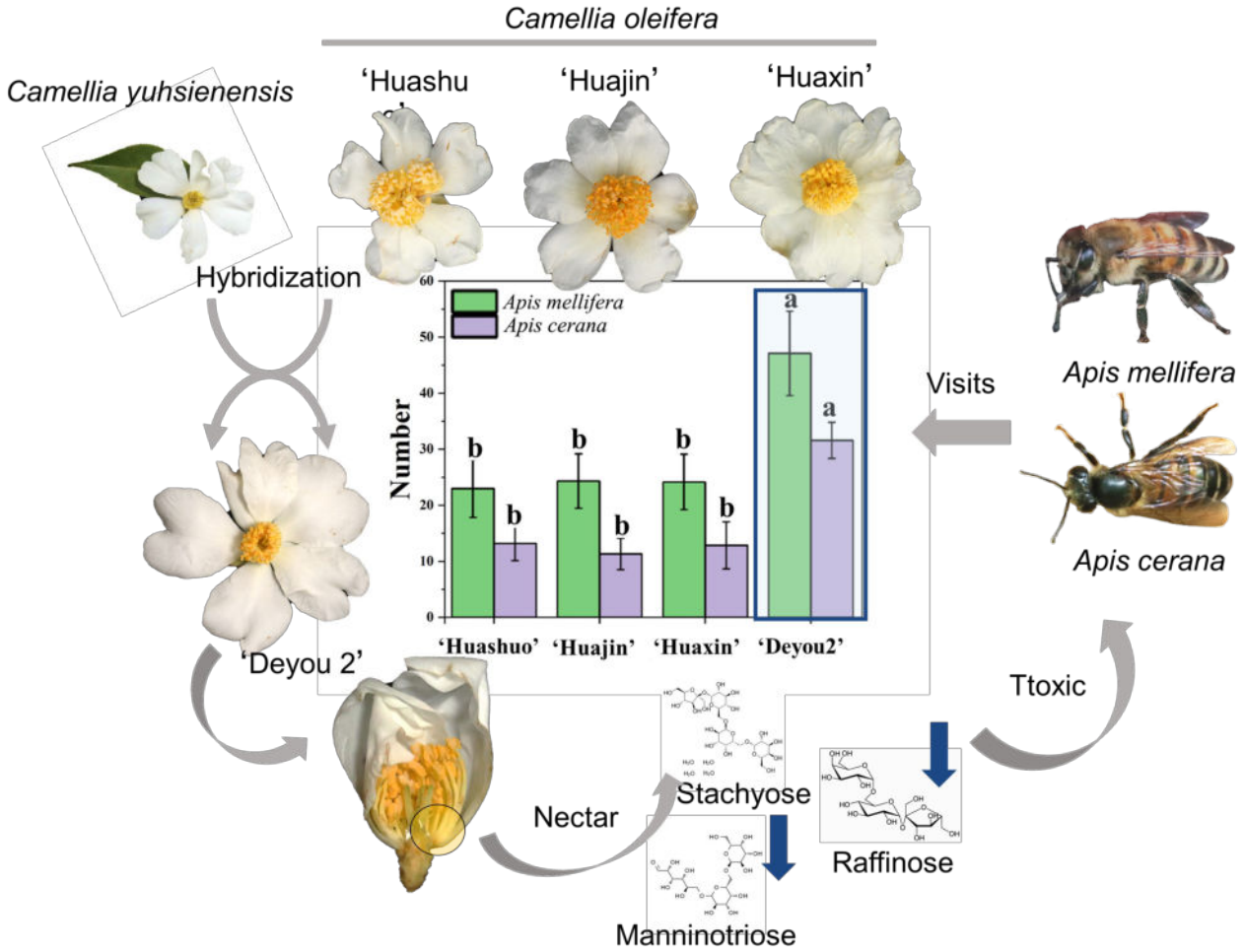




- Breeding affects the metabolites of the petals
- New variety petals show blue fluorescence absent in wild types
- Blue fluorescence effectively attracted honeybees on the white background

Breeding can even transform “anti-bee” flowers into honeybee-attractive flowers

Extension: Distant hybridization alters plant-pollinator interactions



- Distant hybridization produced varieties that both attract honey bees and show lower toxicity to their larvae

Distant hybridization: A promising solution to the pollination deficit by modifying plant-pollinator interactions

Acknowledgements：

Funding:

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Contact:

Bin Yuan

College of Animal Sciences, Zhejiang University

Email: yuan_bin322@zju.edu.cn ;

yuan_bin322@163.com

My website: https://cookie-flea-311.notion.site/binyuan

ORCID: 0000-0002-2238-5277

Research Gate: https://www.researchgate.net/profile/Bin-Yuan-27

Currently seeking PhD opportunities in bee behavior, pollination ecology, and chemical ecology

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Thank You

Presenter: **Bin Yuan**

College of Animal Sciences, Zhejiang University, China

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