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Phylogenetic drivers involved in the diversity of plant volatile profiles shape antixenosis resistance of tomato against *Tuta absoluta*

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Background

Volatile Organic Compounds (VOC) released by plants mediate numerous ecological interactions. For instance, VOC shape antixenosis resistance since they repel/deters herbivore insects. Disentangling ecological and evolutionary sources of variation of VOC may help to elucidate the mechanisms supporting plant protection against pests. Here, we take benefit of the worldwide distribution of tomato to explore VOC diversity in plant lineages with a large range of local adaptations and, in turn, the consequences on plant resistance against a notorious pest, *Tuta absoluta*.

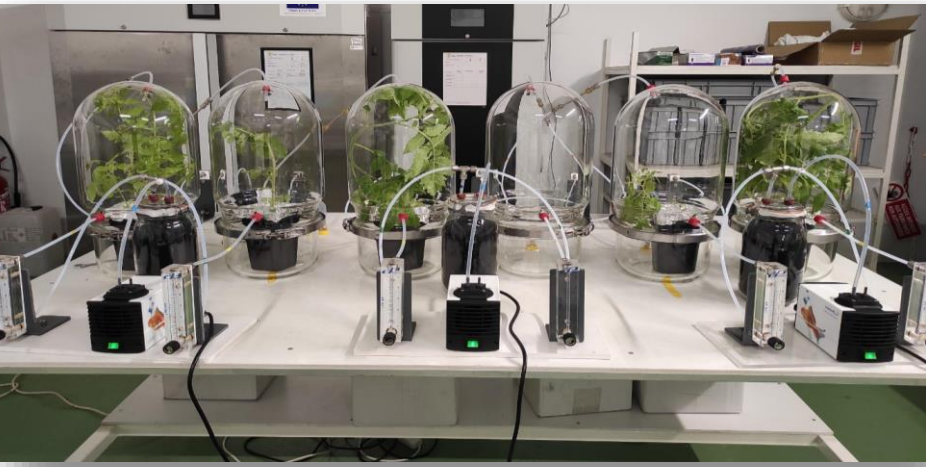
Objectives

- 1/ Compare VOC diversity released by 29 tomato accessions**
 - 5 species with different natural history and niche colonization patterns
 - modern cultivars Vs wild species
- 2/ Study the relationships between VOC diversity and pest repulsion**
 - test correlations between VOC features and antixenosis
- 3/ Investigate the evolution of defensive features in VOC profiles**
 - conduct a phylogenetical approach to compare evolutionary models

Materials & Methods

S. lycopersicum : modern cultivars | *S. habrochaites* : wild species native from Peru and Ecuador | *S. pennellii* : wild species adapted to arid habitats of Andean regions
S. galapagense and *S. cheesmaniae* : wild species endemic from Galapagos

Phenotyping volatilome



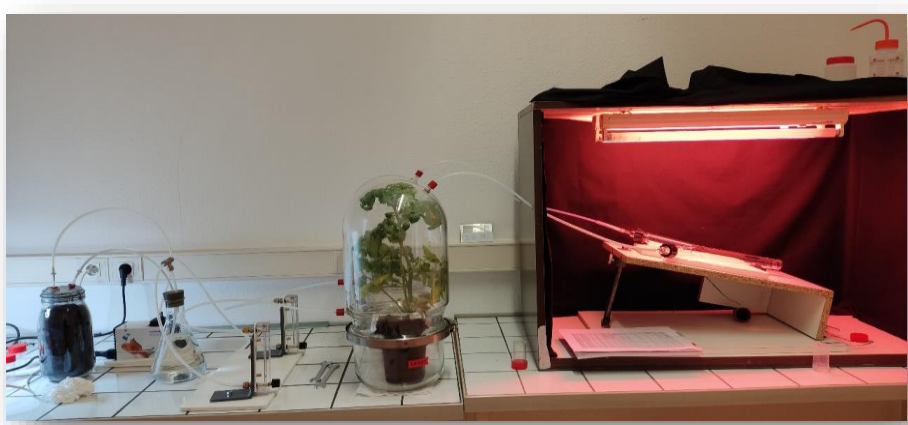
- 266 plants at vegetative stage
- Tenax TA - 30 min - 400ml/min
- Volatile profile analyzed by GC-MS
- Identification : NIST, PubChem

Phylogenetic analysis

- **DNA Sequencing method:** Single Primer Enrichment Technology [1]
- VCF file with only simple biallelic SNPs (3655 SNPs)
- **Phylogenetic tree:** Maximum Likelihood in RAxML under the GTR + G model

Behavioral assay

- Y-tube olfactometer
- 300 gravid females
- 10 accessions with divergent VOC profile



Results

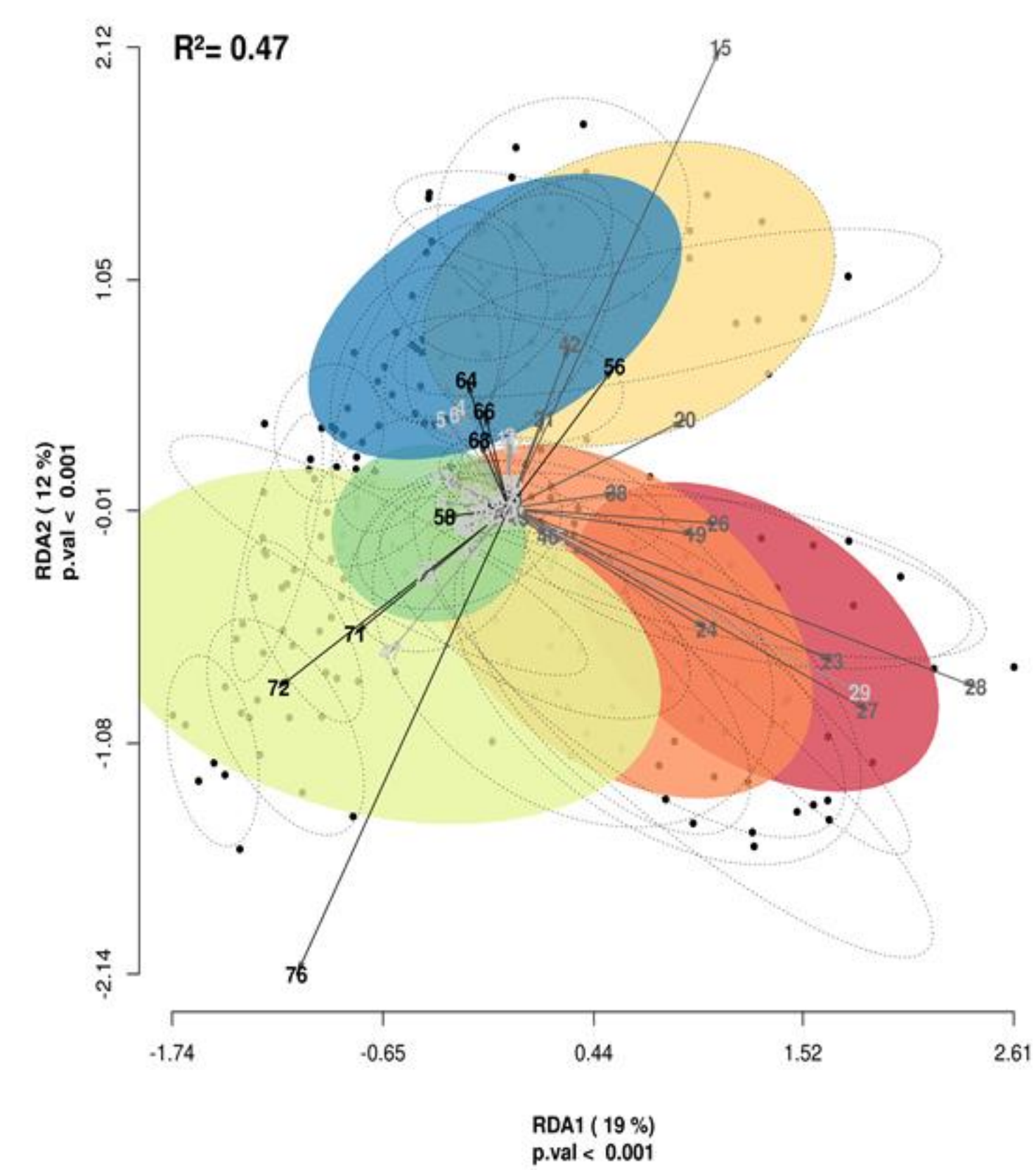


Fig 1 | Redundancy analysis of VOC profiles released by 29 tomato accessions
Dotted lines and coloured ellipses depict tomato accessions and species, respectively. Arrows depict loading scores for the 76 VOC detected

Plant species

- *S. lycopersicum*
- *S. lycopersicum. cerasiforme*
- *S. galapagense*
- *S. habrochaites*
- *S. pennellii*
- *S. cheesmaniae*

VOC emissions

- sesquiterpenoid
- monoterpene
- additional classes

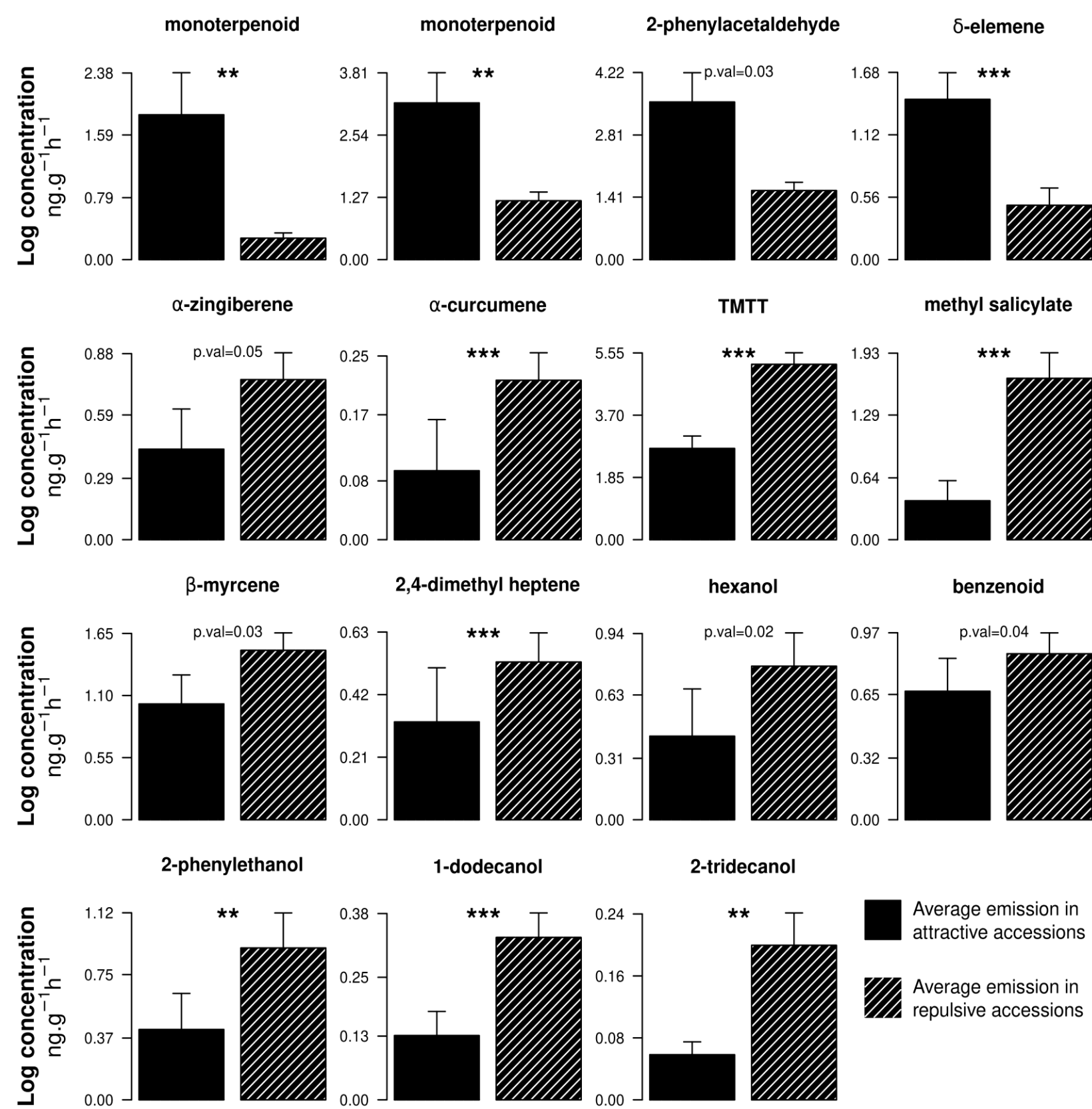


Fig 3 | VOC with different emissions between attractive and repulsive accessions
Wilcoxon test : *** p.val < 0.001 ; ** p.val < 0.01

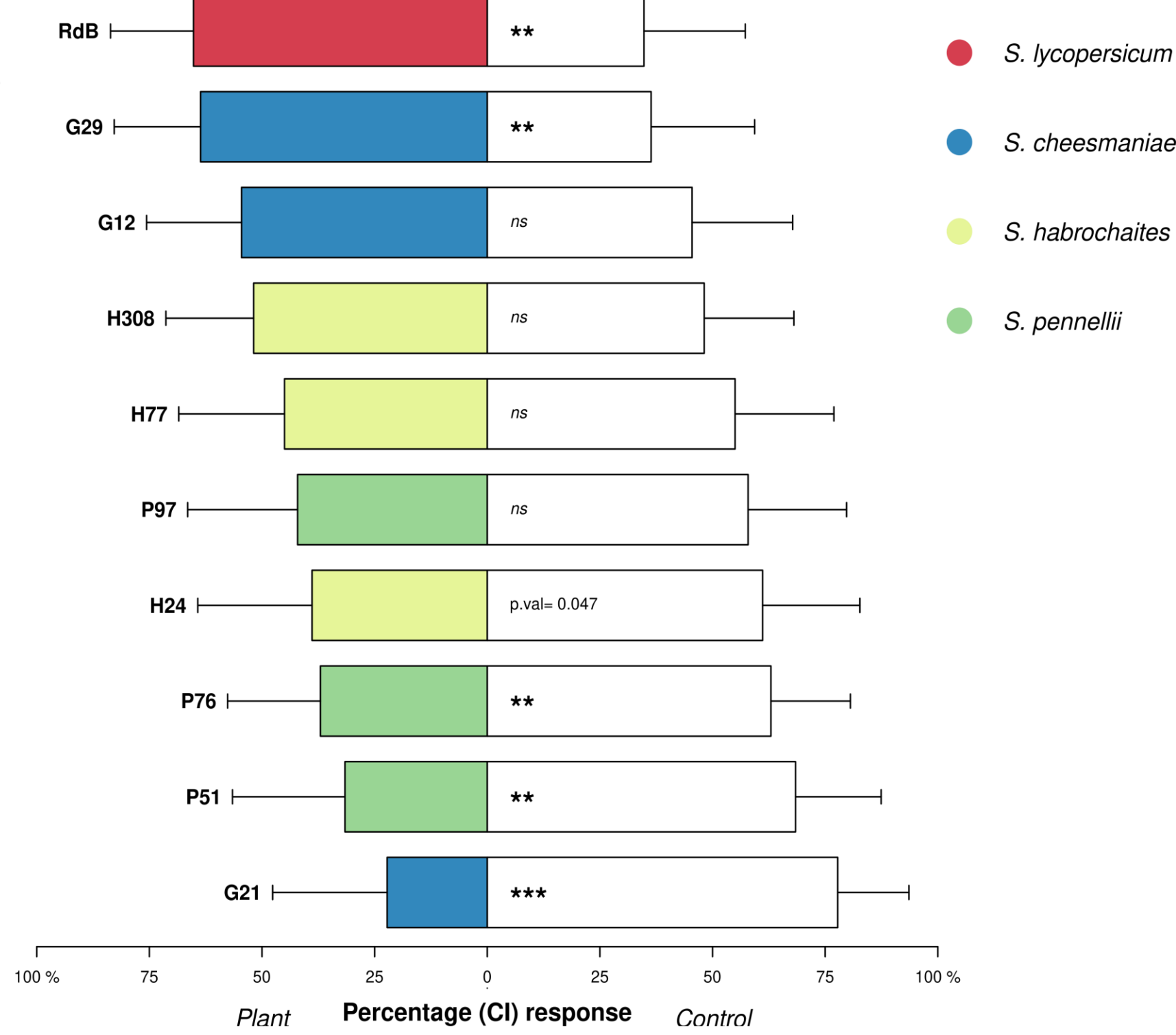
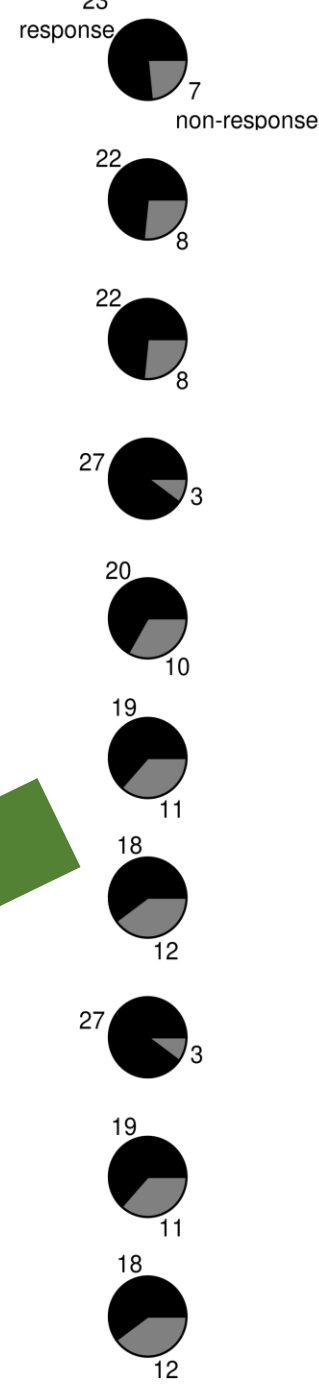


Fig 2 | Behavioral response of *T. absoluta* females in a Y-shaped olfactometer
A dual choice between plants (coloured bar) and control (white bar) [3]
Exact binomial test : *** p.val < 0.001 ; ** p.val < 0.01 ; ns non-significant

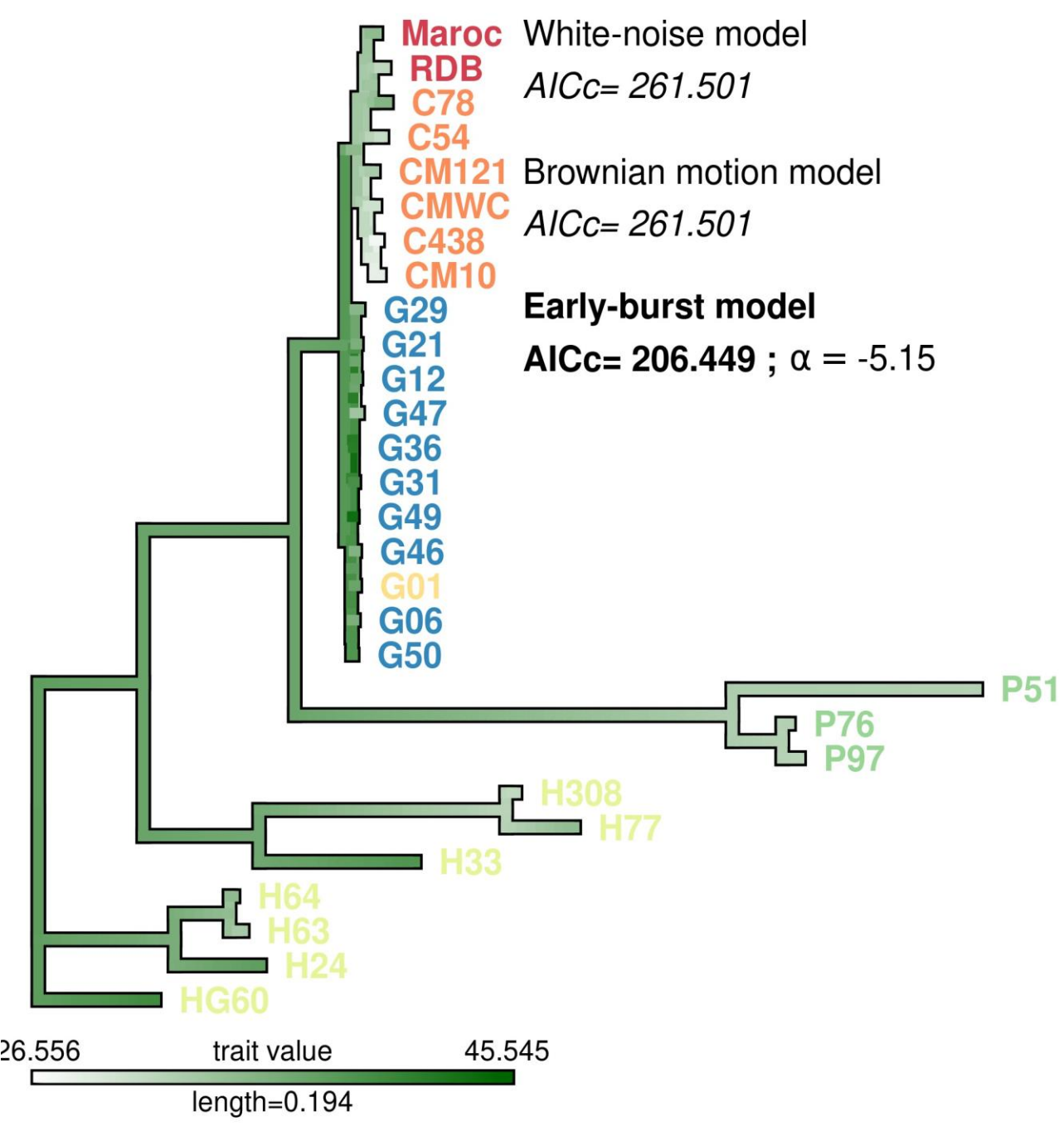
- VOC profiles vary with **inter- and intra-specific diversity**
- The two species endemic from **Galapagos Islands** share similar profiles (*S. cheesmaniae* and *S. galapagense*)
- **Wild species** : rich profiles with higher emissions of sesquiterpenoids [2]
- **Modern cultivars** : poor profiles dominated by monoterpenoids

- Among 76 VOCs, **15 compounds** differ between attractive and repulsive accessions
- **Attractive** accessions release **monoterpenoids**
- **Antixenosis** resistance relies on **sesquiterpenoids** like α-zingiberene, α-curcumene [3] or TMTT.

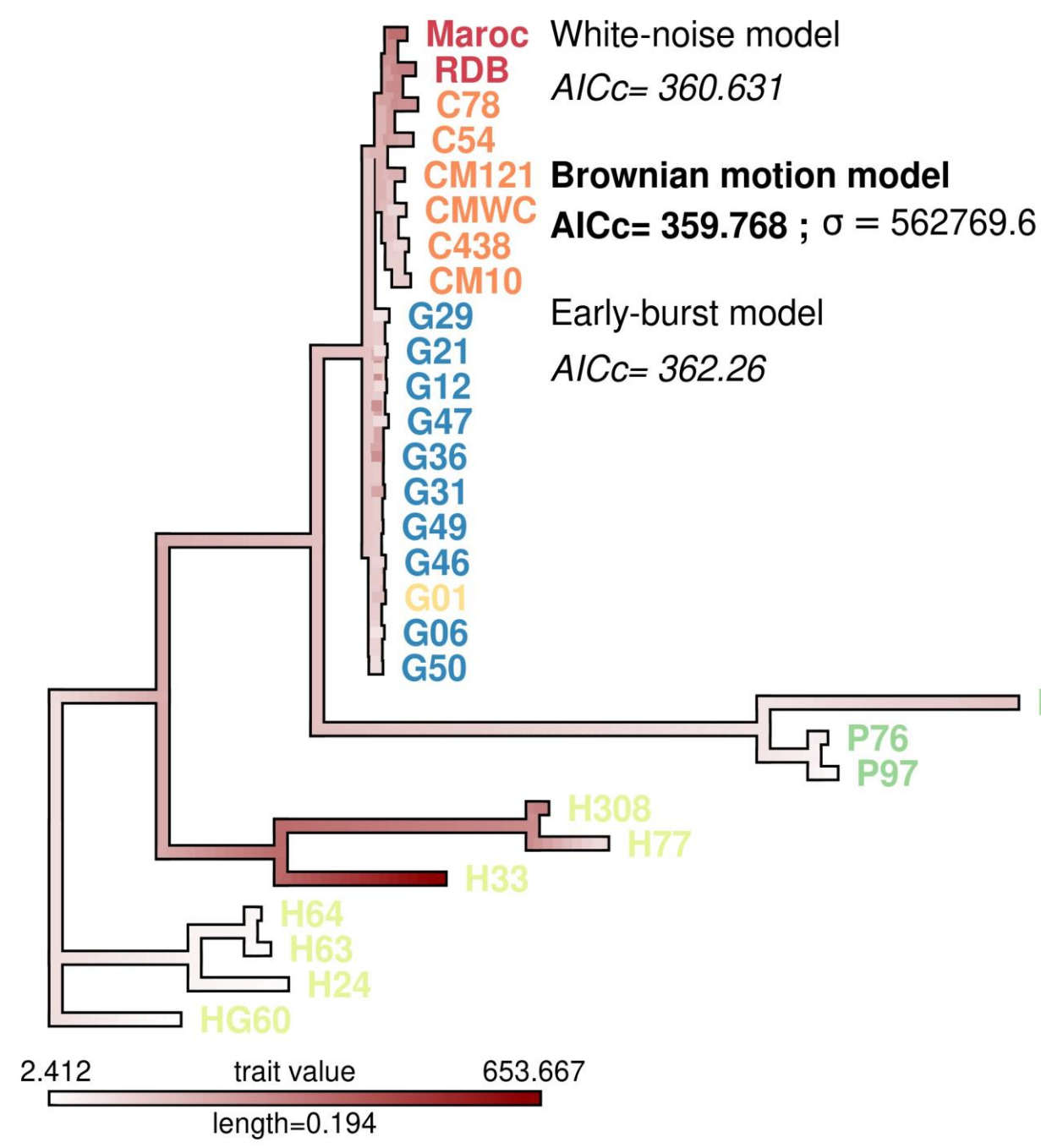
- **Intra-specific variations** of VOC affect pest behavior
- **2 attractive accessions** including RdB (modern cultivar)
- **4 repulsive accessions** among wild relatives : H24, P76, P51, G21



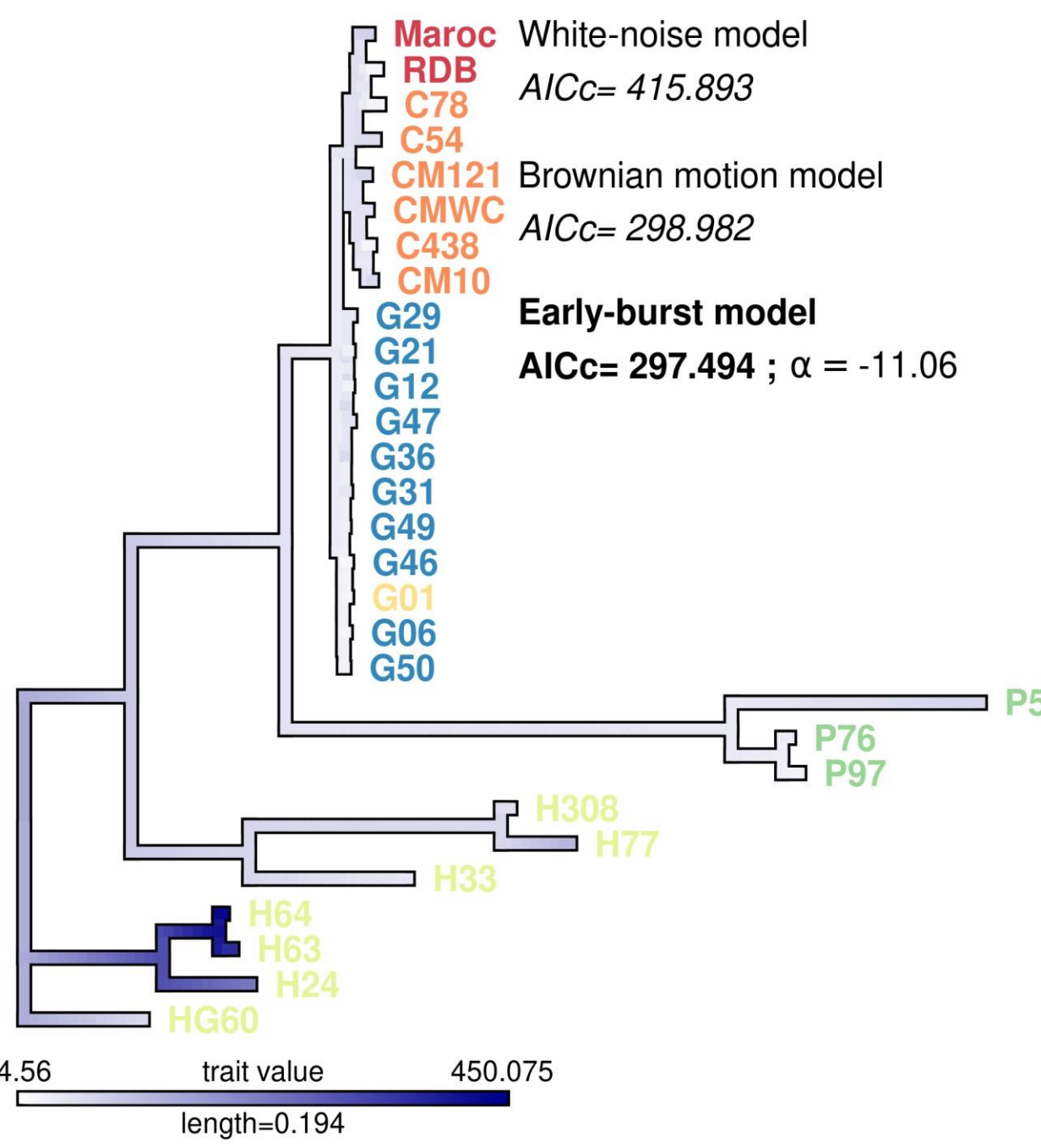
VOC richness (# compounds)



Monoterpenoid emission



Sesquiterpenoid emission



• *S. lycopersicum*

• *S. lycopersicum. cerasiforme*

• *S. galapagense*

• *S. habrochaites*

• *S. pennellii*

• *S. cheesmaniae*

- **Ecological diversity** of VOC arise from **phylogenetic conservatism**
- 'Random-walk' changes make **monoterpenoid emissions** proportional to the extent of shared ancestry
- In line with **adaptive radiation** during plant-insect co-evolution [4], **defensive features of VOC** (richness, sesquiterpenoid) decrease exponentially with diversification

Take home messages

- In opposition to convergent evolution, natural history and phylogenetic conservatism explain ecological diversity of tomato VOC profiles
- In wild tomato, antixenosis resistance against *T. absoluta* relies on VOC richness and sesquiterpenoid emission
- VOC-mediated plant defences are reduced in modern cultivars. This is in line with side-effects of domestication on natural plant defences [5]

Partnerships & Funding



References

- [1] Barchi *et al.*, 2019, [2] Bleeker *et al.*, 2009, 2011
[3] Subramani *et al.*, 2021,
[4] Ehrlich and Raven (1964) ; Fraenkel (1959),
[5] Fernandez *et al.*, 2021

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