Tephritids Gut Microbionts: Diversity, Volatile Emissions and Their Impact on Fly Behaviour

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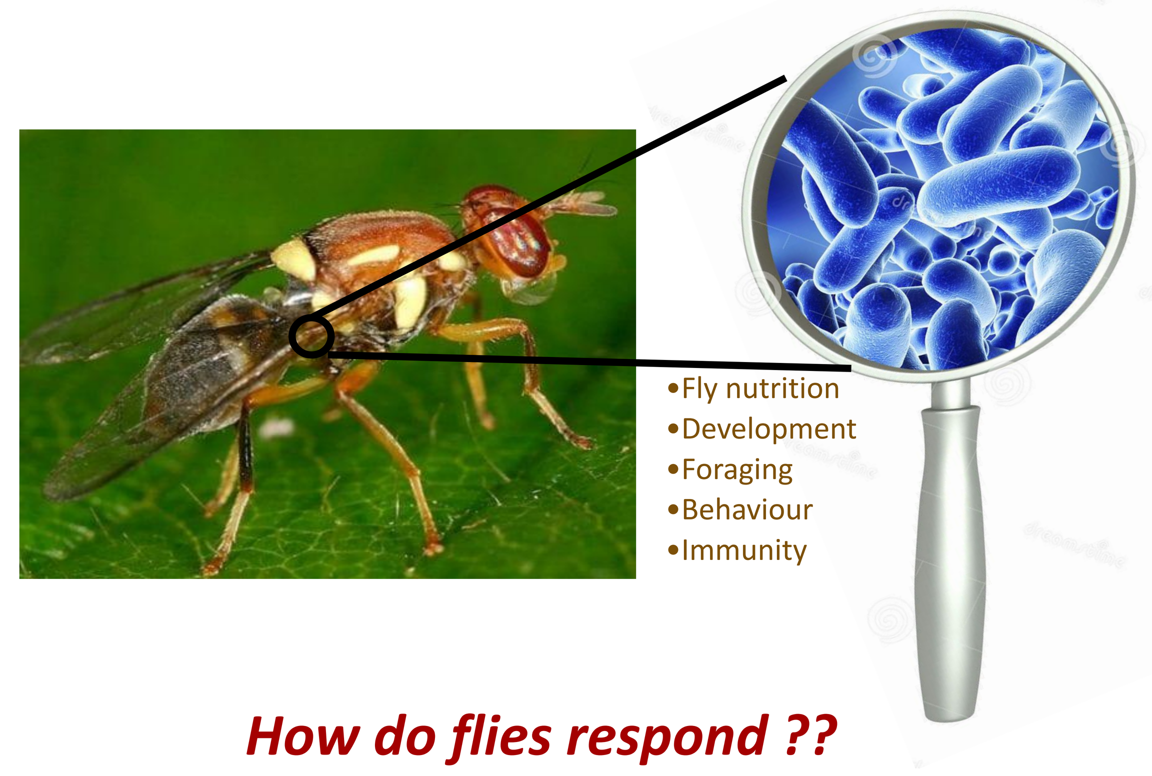
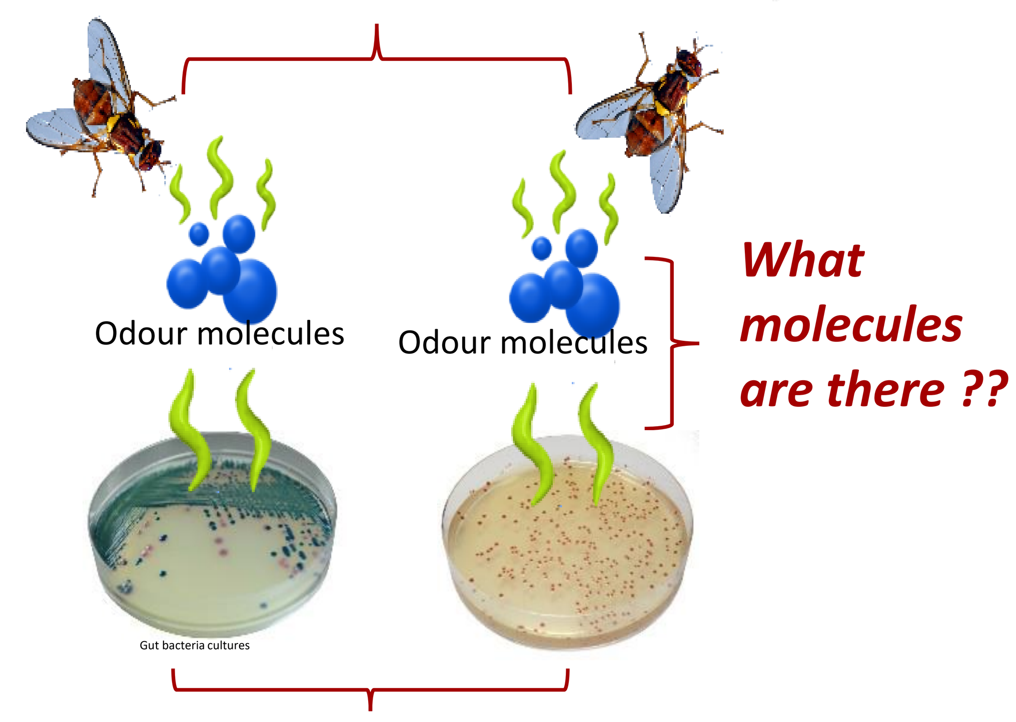
Background

- Ecologically relevant interactions between insects and associated microorganisms are facilitated by insect olfactory responses to microbial volatile organic compounds (mVOCs), where these act as infochemicals
- The effect of mVOCs on insect behaviour is broad.
- It has been shown that they provide cues for suitable habitat, food, mating, or oviposition sites, and more
- Although many microbial cues are attractive and exploited by insects, they may also negatively affect the insect response, that is, causing deterrence
- The exploitation of mVOCs that signal to insects the suitability of mating, oviposition and foraging, or nearby environmental hazards, is recognised as a possible avenue for pest management
- The fruit flies of the family Tephritidae are globally devastating pests of fruits and vegetables
- Like other insects, the alimentary tract of tephritids, especially the midgut which is the primary site of digestion and absorption, commonly contains a complex biota of diverse microorganisms including bacteria and fungi
- The association between the significant horticultural pest Tephritidae, the true fruit flies, and their gut microorganisms has been well-studied, but there has been relatively little research on the mVOCs of these microorganisms, and how these mVOCs can influence tephritid behaviour.

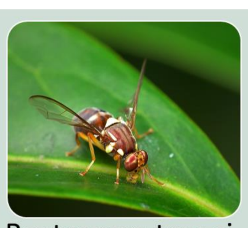




Microbial Diversity in Fruit Fly Gut

Enterobacteriaceae	**Bacillaceae**	**Yersiniaceae**	**Erwiniaceae**	**Vibrionaceae**	**Enterococcaceae**
Citrobacter freundii	*Bacillus anthracis*	*Serratia fonticola*	*Enterobacter agglomerans*	*Vibrio* sp.	*Enterococcus faecalis*
C. koseri	*B. cereus*	*S. liquefaciens*	*Erwinia herbicola*		
Citrobacter sp.	*B. cibi*	*S. marcescens*	*Pantoea agglomerans*	**Phyllobacteriaceae**	**Flavobacteriaceae**
Enterobacter asburiae	*B. pumilis*	*S. odorifera*	*P. dispersa*	*Defluvibacter* sp.	*Flavobacterium* sp.
E. cloacae	*B. subtilis*	*Serratia* sp.			
E. faecalis	*B. licheniformis*		**Saccharomycetaceae**	**Comamonadaceae**	**Streptococcaceae**
E. sakazakii		**Staphylococcaceae**	*Hanseniaspora* sp.	*Delftia acidovorans*	*Lactococcus lactis*
E. amnigenus	**Pseudomonadaceae**	*Staphylococcus aureus*	*Pichia sp.*		
E. hormaechei	*Pseudomonas aeruginosa*	*S. carnosus*	*Candida* sp.	**Hafniaceae**	**Listeriaceae**
Enterobacter sp.	*P. brenneri*	*S. xylosus*		*Hafnia alvei*	*Listeria* sp.
Erwinia amylovora	*P. fluorescens*		**Aerococcaceae**		
Candidatus Erwinia dacicola	*P. libanensis*	**Aeromonadaceae**	*Aerococcus viridans*	**Lactobacillaceae**	**Moraxellaceae**
Escherichia coli	*P. maltophilia*	*Aeromonas hydrophila*		*Leuconostoc* sp.	*Moraxella* sp.
Klebsiella oxytoca	*P. mucidolens*	*Aeromonas* sp.	**Acetobacteraceae**		
K. pneumoniae	*P. oryzihabitans*		*Asaia* sp. ,	**Microbacteriaceae**	
K. ozaenae	*P. putida*	**Pectobacteriaceae**	*Acetobacter tropicalis*	*Microbacterium* sp.	
K. planticola		*Pectobacterium carotovorum*			
Klebsiella sp.	**Morganellaceae**	*P. cypripedii*	**Brucellaceae**	**Propionibacteriaceae**	
Kluyvera intermedia	*Morganella morganii*		*Ochrobactrum* sp.	*Propionibacterium acnes*	
Lelliottia amnigena	*Morganella* sp.	**Xanthomonadaceae**			
Proteus sp.	*Providencia alcalifaciens*	*Stenotrophomonas* sp.	**Nocardiaceae**	**Bacteroidaceae**	
Proteus vulgaris	*P. rettgeri*		*Rhodococcus* sp.	*Bacteroides fragilis*	
Raoultella ornithinolytica	*P. stuartii*	**Leptotrichiaceae**			
R. terrigena		*Streptobacillus* sp.			

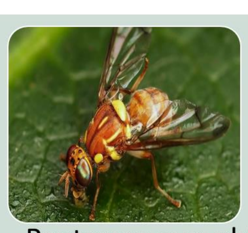
Bacterial Attraction to Tephritids


Bactrocera tryoni

K. Pneumoniae
C. Freundii
E. agglomerans


Anastrepha ludens

S. Aureus
K. Pneumoniae
C. Freundii
E. agglomerans


Bactrcera cucurbitae

K. oxytoca
C. Freundii


Bactrocera oleae

P. Pudita

mVOCs Identified in Attractive Bacterial Volatile Emission

Ammonia Methylamine Dimethylamine trimethylamine 2-methylpropanamine 2-methylbutanamine 3-methylbutanamine indole 1-pyrroline 2,3,4,5-tetrahydropyridine, pyrazine 2,5-dimethylpyrazine 2-methyl-5-isopropylpyrazine	Trimethylpyrazine acetic acid 3-methylbutanal Benzaldehyde phenol Dimethylsulfide Dimethyldisulfide 2-butanone 2-pentanone 2-hexanone 3-hydroxybutanone 2-phenylethanone	2-phenylethanol 2- methyl-1-propanol 3-(methylthio)-1-propanol Ethyl acetate isoamyl acetate isobutyl acetate phenethyl acetate 3-methyl-1-butanol butyl isocyanatoacetate 1-phenyl-2-propanone 2-methylpropanol 2-methylbutanol	3-hydroxy-2-butanone methanol methyl thioacetate 2-butanol 2-heptanone 2-nonanone ethyl tiglate methyl thiocyanate 3-methylbutanol 2-ethylhexanol 2-phenylethanol 3-methyl-1-butanol

Future Works

- As significantly limited records are available on mVOC mediated attraction to fruit flies, individual mVOCs are needed to be extensively studied
- More work needs t explore the diversity of gut associated fungi/yeasts and their effect on fly behaviour
- The understanding of the effect of mVOCs on fruit fly behaviour will broaden the scope to identify lead chemicals to develop chemical lures to contribute in pest management