Researches for *Citrus*

~ ミカンの 香気成分 と 害虫防除 ~

Profiling of VOCs released from individual intact juvenile and mature citrus leaves (Killiny et al., 2016)

- MT 放出＜ 70 %
- 注目物質
  - α-pinene
  - limonene
  - (Z)-ocimene
  - linalool
  - geraniol
  - methyl salicylate (MeSA)

ranking	young	(%)	mature	(%)
1	Sabinene	17.34	Sabinene	21.63
2	*(E)-β-caryophyllene*	12.59	Limonene	19.87
3	Limonene	11.39	δ−3-carene	18.23
4	*(Z)-β-ocimene*	11.31	*(Z)-β-ocimene*	7.36
5	δ－3-carene	8.4	β-myrcene	6.13
6	β-myrcene	4.48	α-thujene	4.42
7	α-pinene	3.84	γ-terpinene	3.5
8	β-elemene	3.7	α-pinene	3.09
9	α-thujene	3.42	α-terpinolene	2.92
10	γ-terpinene	3.29	Linalool	2.65
11	Linalool	3.23	α-terpinene	2.12
12	α-terpinene	1.89	p-cymene	1.45
13	α-humulene	1.68	*(E)-β-caryophyllene*	1.1
14	p-cymene	1.3	β-pinene	1.01
15	α-terpinolene	1.23	β-elemene	0.86
16	Decanal	1.01	Citronellal	0.51
17	*(E)-β-farnesene*	1	α-ocimene	0.42
18	iso-Geraniol	0.91	*(E)-β-ocimene*	0.38
19	Terpendiol	0.78	allo-ocimene	0.35
20	Methyl salicylate	0.73	*(E)-Sabinenehydrate*	0.23

(pink)	monoterpene
(yellow)	monoterpene alc/ald
(light blue)	sesquiterpene
(dark blue)	sesquiterpene alc
(green)	green leaf volatile

Exogenous application of the plant signalers MJ and SA induces changes in volatile emissions from citrus foliage and influences the aggregation behavior of Asian citrus psyllid vector of Huanglongbing (Patt et al., 2018)

- HLB Infected tree
  - MeSA, β-caryophllene ⬆
    - ↳ Attractant of *D.citri* (Mann et al., 2012/ Aksenov et al., 2014/ Martini et al., 2016)

- MJ : higher emission rate

MeSA ⬇: キジラミを分散を防止 ex (ヒメコバチ科、トビコバチ科の寄生蜂)

β-ocimene ⬆, indole ⬆: Attractant of natural enemies

- SA : higher emission rate

MeSA ⬆⬆

β-ocimene, indole : n.s

→ SA付与は好ましくない？(論文中に言及なし)

Attractiveness of Host Plant Volatile Extracts to the Asian Citrus Psyllid, Diaphorina citri, is Reduced by Terpenoids from the Non-Host Cashew (Fancelli et al., 2018)

- VOC preference test
  - [1] Time spent (滞在時間)
  - [2] Number of Entries (選択数)

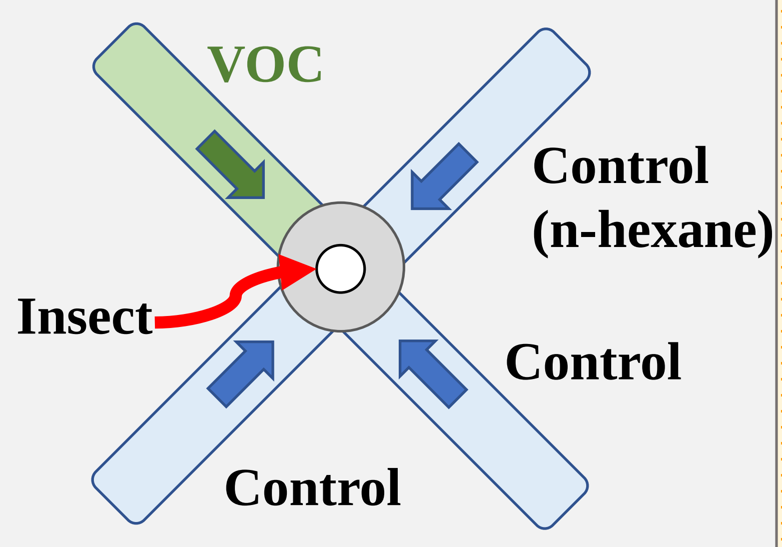
positive control

M. paniculate [1]** attarctive

C. sinensis [1]**[2]* attarctive

negative control

A. Occidentale [1]* repellent



Four-arm olfactometer

Amount of VOC emission

Compounds	M. paniculata	C. sinensis	A. occidentale
α-pinene	63.47±29.08	10.34±1.59	3.63±0.65
camphene	7.14±4.71	10.68±7.28	1.22±0.27
6-methyl-5-hepten-2-one	29.26±20.87	11.15±10.52	1.60±0.48
myrcene		1.08±0.49	1.27±0.29
octanal	12.12±6.99	5.75±3.17	120.14±39.7
(Z)-3-hexenyl acetate	37.03±9.71	19.14±7.53	14.79±7.71
2-ethyl-1-hexanol	54.24±22.26	77.95±50.06	32.25±13.22
limonene	58.55±16.21	61.66±29.99	31.79±11.53
(Z)-ocimene		7.02±2.41	8.59±5.84
(E)-ocimene	6.12±1.95	663.53±423.25	15.03±8.09
linalool+Undecane©	72.52±19.63	129.54±57.58	78.87±13.25
nonanal	126.33±61.08	88.74±49.61	80.63±41.56
DMNT*		13.79±6.21	**55.15±19.59**
(E)-3-hexenyl butyrate			13.33±4.48
MeSA	9.37±3.45	11.84±5.03	24.49±13.82
decanal	627.91±439.65	216.91±115.5	373.37±157.26
benzothiazole			61.41±46.28
indole		27.21±23.88	
tridecane	90.38±39.03	63.01±14.05	98.39±36.36
cis-jasmone		14.64±4.40	
cyperene			48.34±18.16
(E)-caryophyllene		2.27±0.77	2.52±0.72
geranylacetone		773.17±558.73	12.63±3.71
pentadecane		85.83±26.95	109.81±26.94
(*E*,*E*)-α-farnesene			49.55±17.35
TMTT*		3.83±2.06	**31.37±13.91**

- *A. occidentale*
  - DMNT
  - TMTT

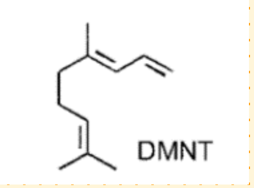
  } homoterpene 放出

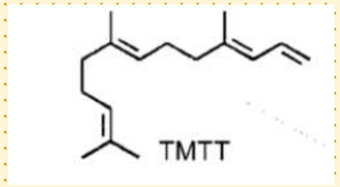
食害行動との関係性が深い成分群

- repellent of Blend*
  - vs *M. paniculate*
  - vs *C. sinensis*

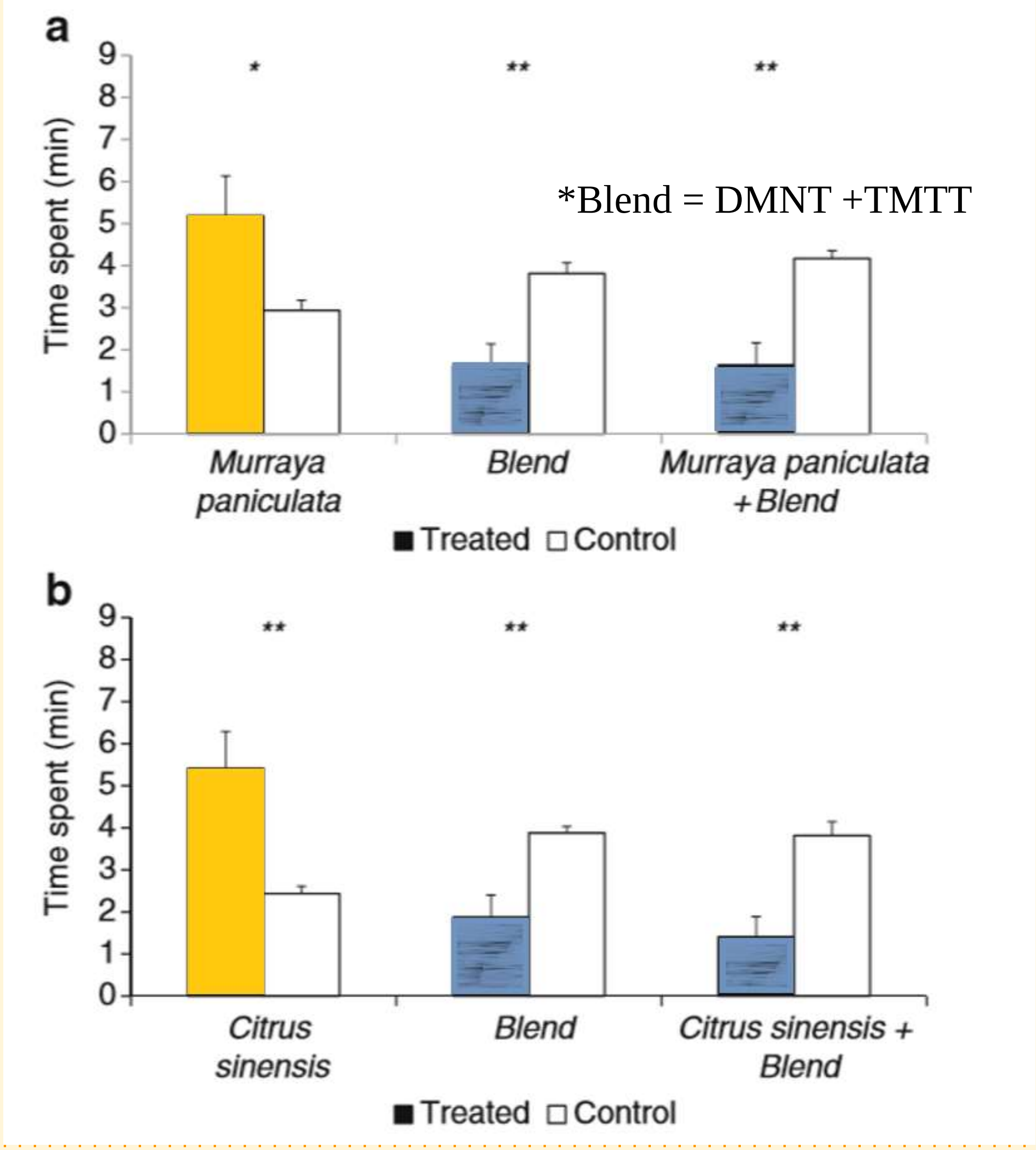
Blend の忌避性 を確認

※ 誘因性のVOC混合でも
忌避性が示される





Amount of VOC emission



- *A. occidentale*
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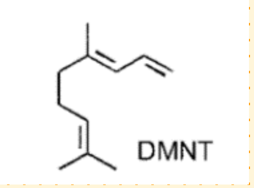
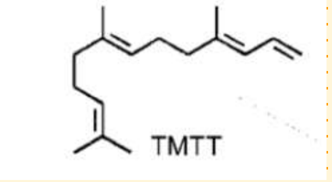




キイロショウジョウバエのSIT制御

- **キイロショウジョウバエ**
  - 300種類以上の農作物に被害を与える重要害虫
  - SIT研究のモデル生物

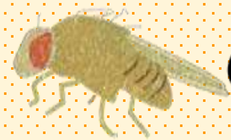
- SIT (Sterile Insect Technique)

去勢した♂個体群を 野外に放ち交配を促す

→ 不妊化により 対象生物の個体密度を減少させる戦略

  - **去勢個体の生存 及び 繁殖競争力**
  - **交配を促す**Sexual Signaling **の強度が重要**

キイロショウジョウバエのSIT制御

BVOCと  の関係性

- α-copaene の誘因性効果は報告されている
  (Citrus, Ginger root)

- Citrus 中、他成分での繁殖効率上昇の可能性
  linalool, geraniol, *α*-pinene, limonene, *β*-myrcene

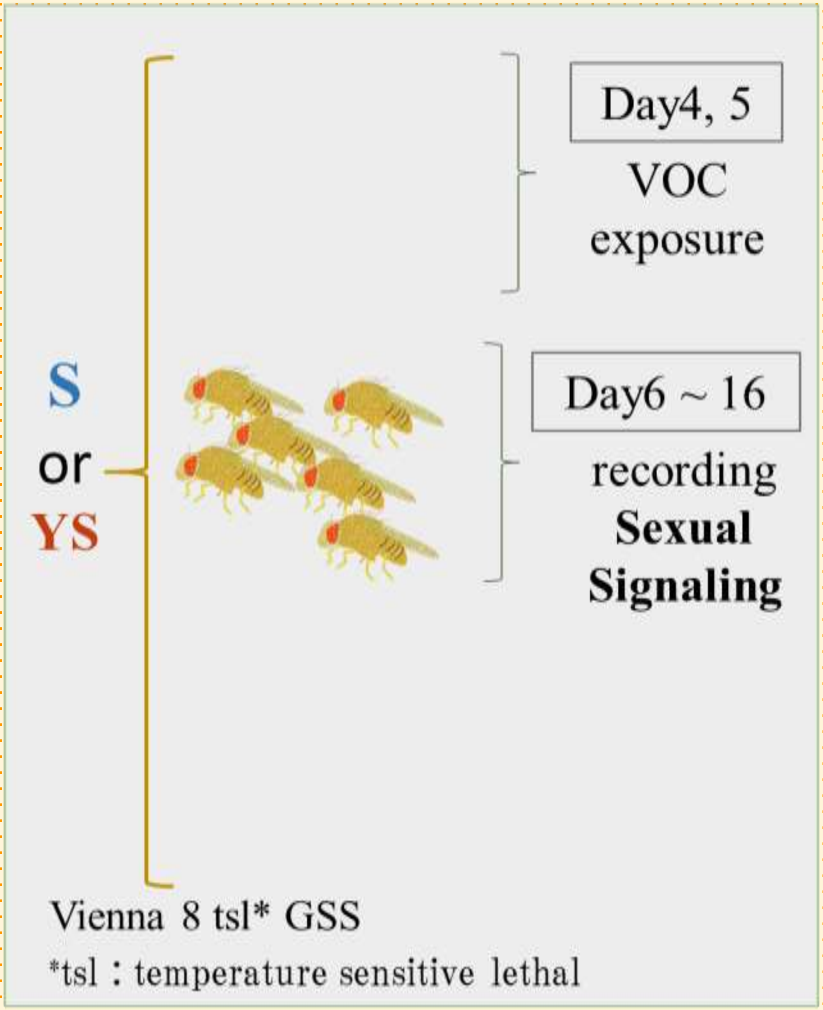
sexual signaling に影響を与える要因

- VOC components
- Nutrients
- Age

キイロショウジョウバエのSIT制御

【Material】

- Exposure to VOCs
  - Control
  - Orange oil
  - Limonene
  - Mixture (5 compounds 1:1:1:1:1)
    (linalool, geraniol, α-pinene, limonene, β-myrcene)
- Nutrients
  - S : Sugar
  - YS : Yeast hydrolysate + Sugar
- Age
  - 6, 8, 10, 16 days



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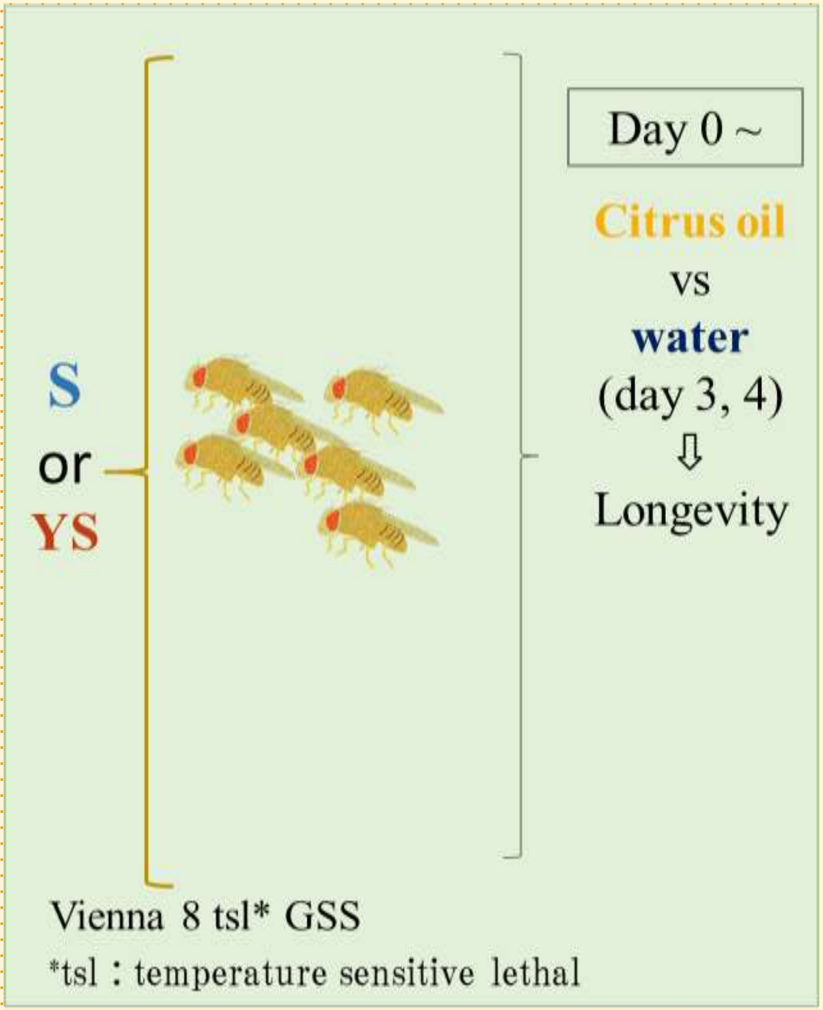

キイロショウジョウバエのSIT制御

結果：栄養条件 & VOC

- 【YS】全香気組成の暴露で Sexsual Signaling 活性化
- 【S】Mixture 暴露のみ Sexsual Signaling 活性化

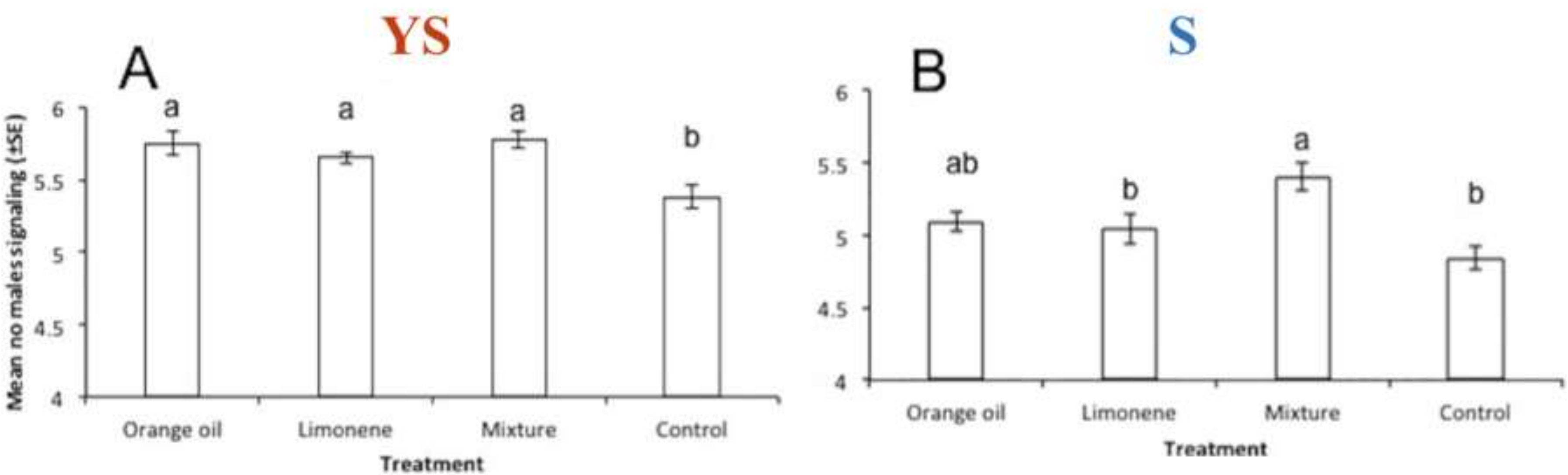

Fig 1. Effects of exposure to citrus compounds on male sexual signaling. Overall levels of sexual signalling activity (mean number of males signalling through the ages of 6 to 10 days old and 16 days old) of Vienna 8 GSS sterilized males medflies that were exposed during day 4 and 5 of adult life to orange essential oil, limonene, and a mixture of 5 pure compounds (limonene, linalool, myrcene, α-pinene and β-myrcene 1:1:1:1:1 ratio) or left unexposed (control) fed on (A) yeast hydrolyzate & sugar (YS) and (B) sugar only (S). On each day of age, observations took place hourly from 07:00 to 20:45 hours in 10 cages (replicates) containing 10 males each. Values on y-axis are mean numbers (±SE) of males signalling per cage per hour observation. Means followed by the same lowercase letter are not significantly different (P>0.05, Tukey's HSD test).

S: Sugar
YS: Yeast hydrolyzate + Sugar

キイロショウジョウバエのSIT制御

結果：栄養条件 & VOC

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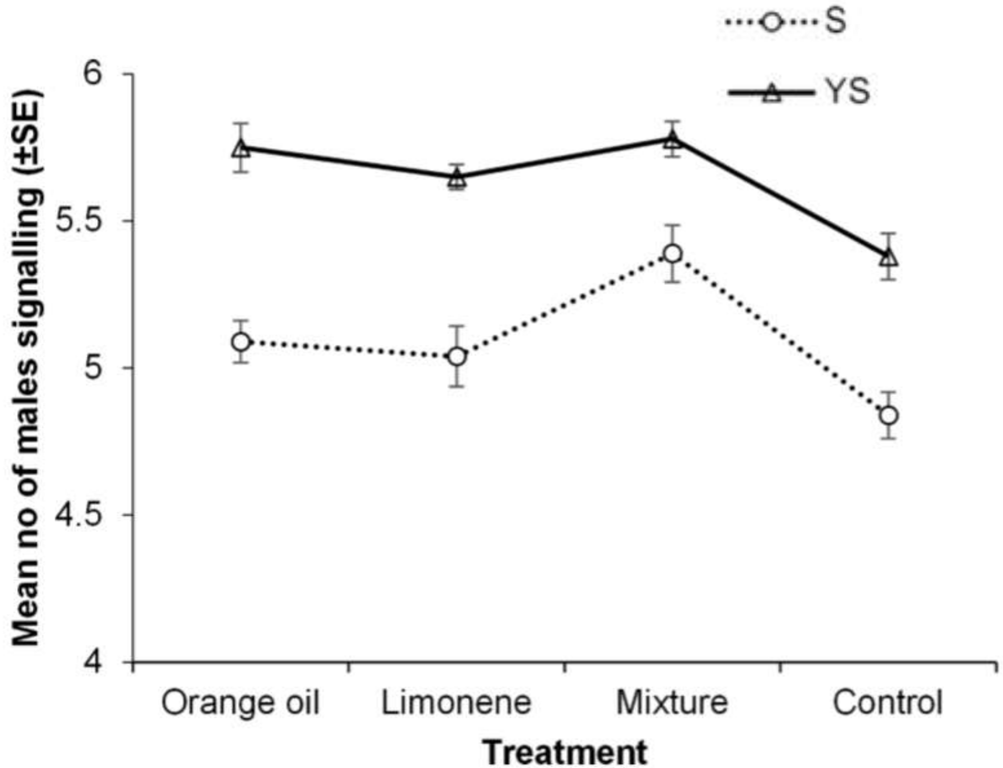
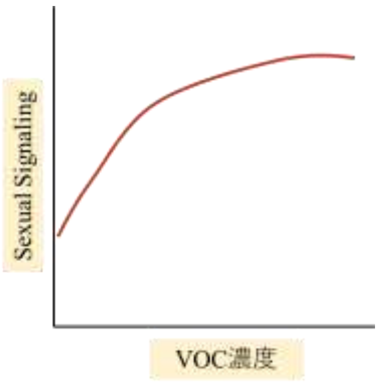


但し,
Mixture ：上昇率 低

[個人的見解]

活性化上限？

→ 濃度相関*も
見てみたい



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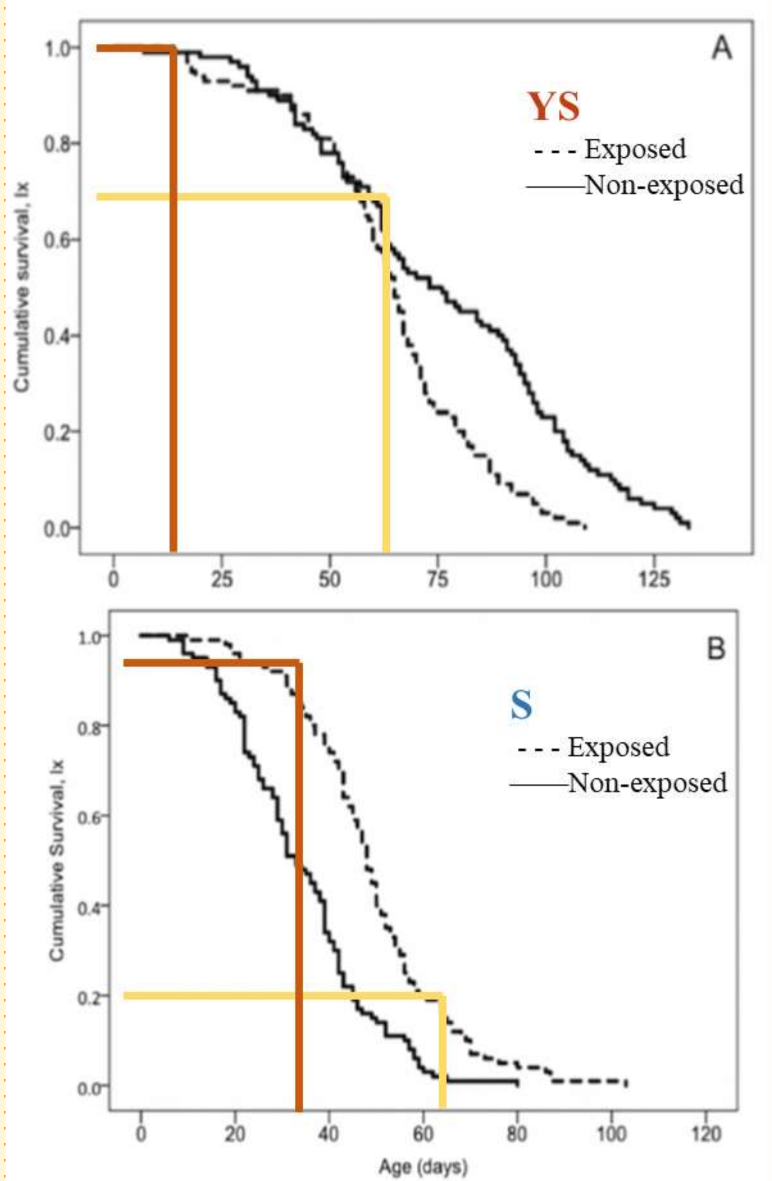

まとめ

Sexual Signaling…

- Nutrients : YS群　**up↑**
- VOC : Exposure群 **up ↑**
- YS*VOC : **up ↑↑**

×

Age

◇繁殖殖効率の維持は 最長50~60days

- 自然環境で長寿命個体は存続困難
- 同齢での生存率は YS > S

→ YS群利用の方が　SIT戦略上 好ましい

（cost-effectiveの観点は未検討）