Winged aphids : hosts of choice for parasitoids ?

Jennifer Pirotte – BDIV Seminar, 18th of May 2017

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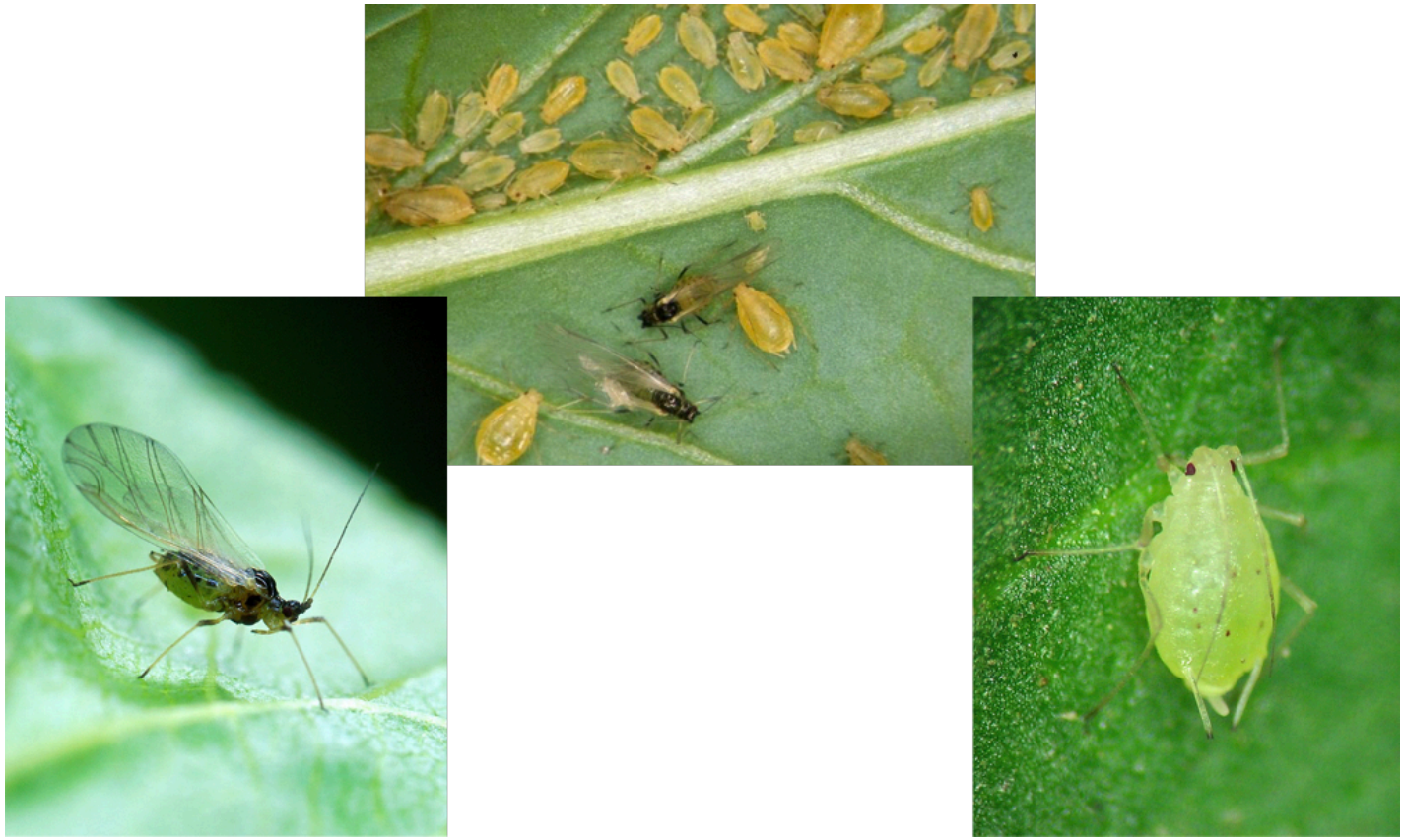
Life history trade-offs

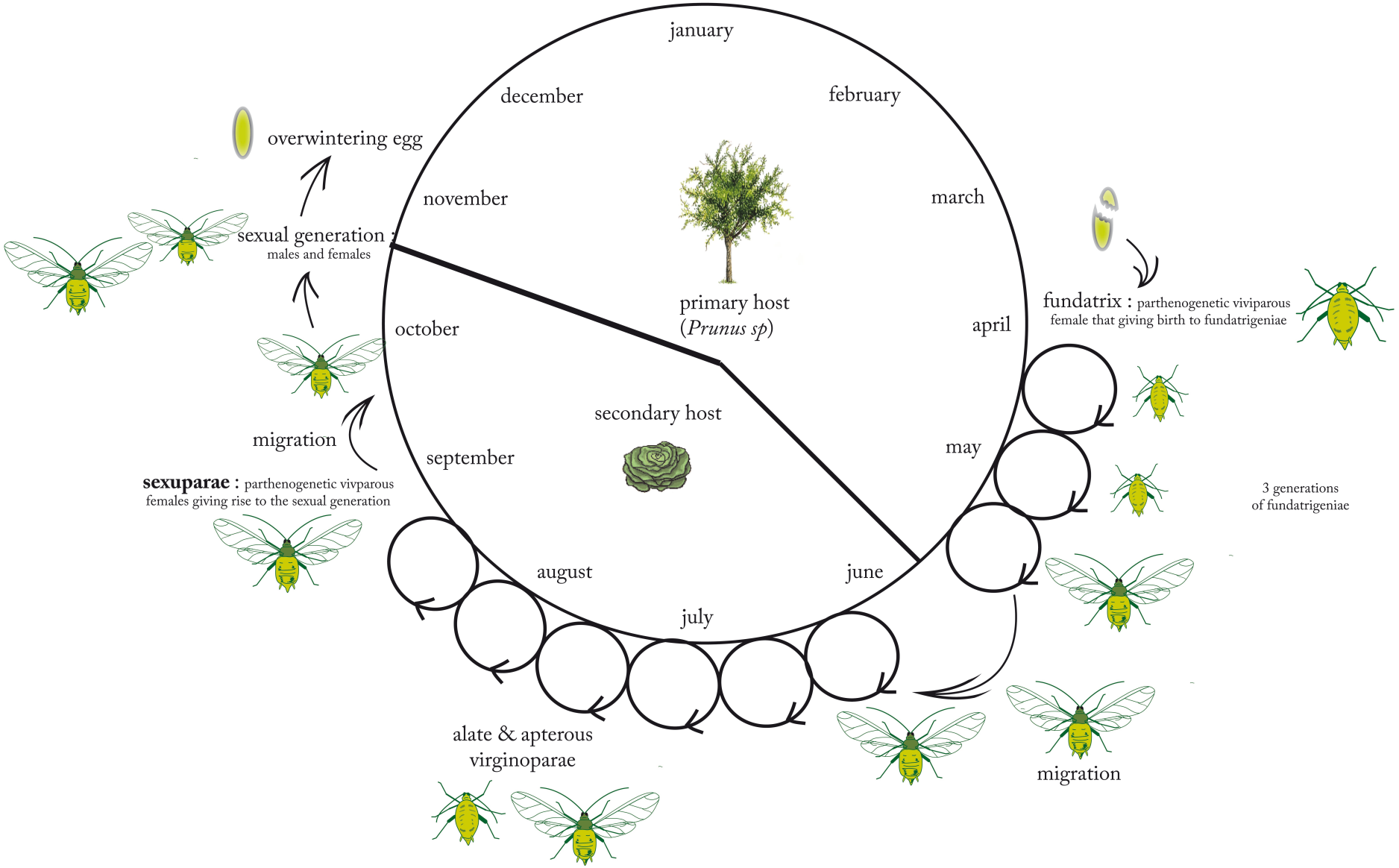
- Life-history traits negatively correlated
- "An increment of resources allocated to one trait necessitates a decrement of resources to another trait" (Zera and Harshman, 2001)
- Numerous examples :
  - Tail loss and reproduction in lizards
  - Immune system and sexual ornamentation in birds
  - Wing polymorphic cricket

Aphid wing polyphenism

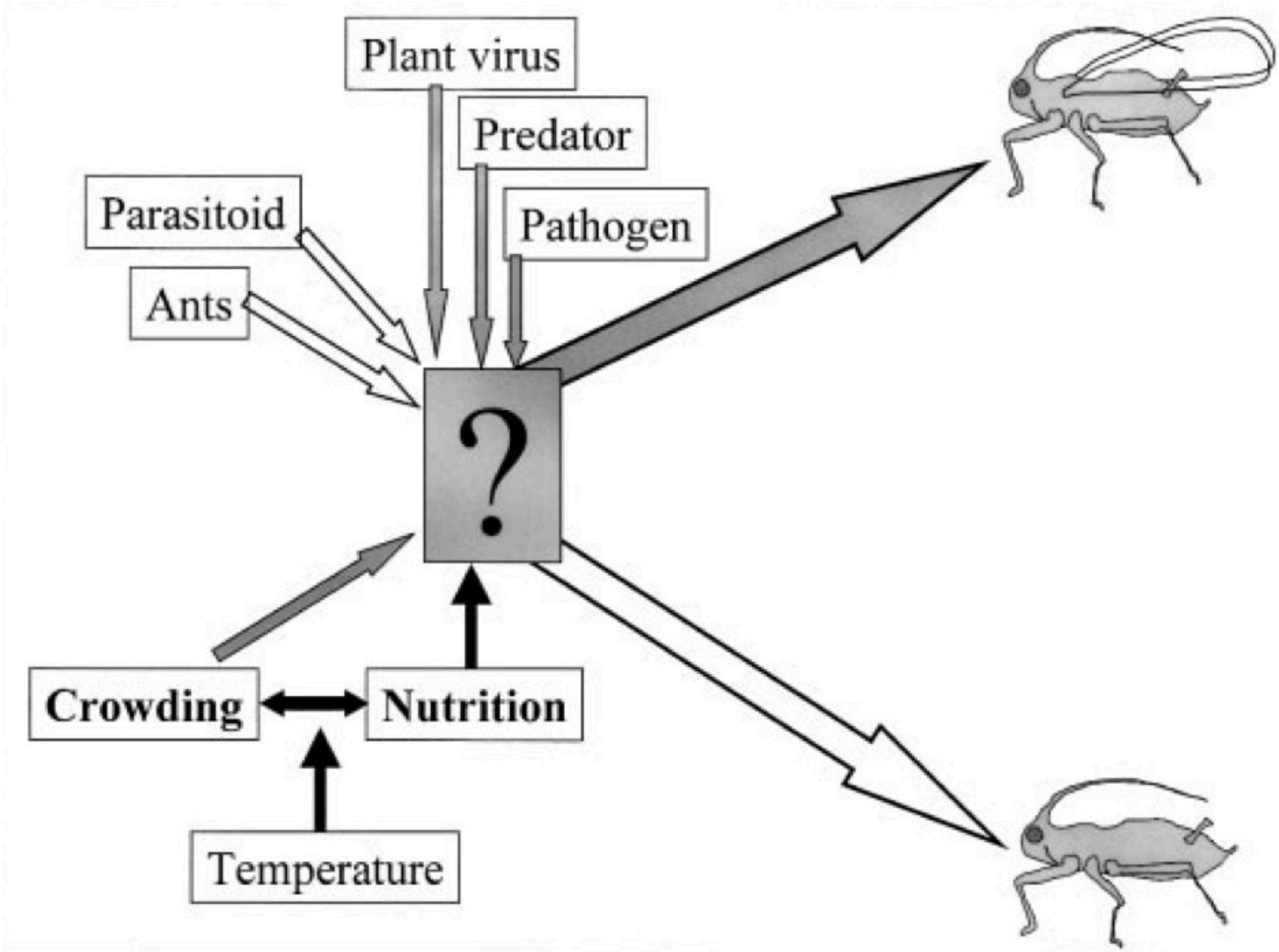
- Polyphenism :"an extreme form of phenotypic plasticity in which a single genotype produces discrete alternative morphologies" (Brisson, 2010)



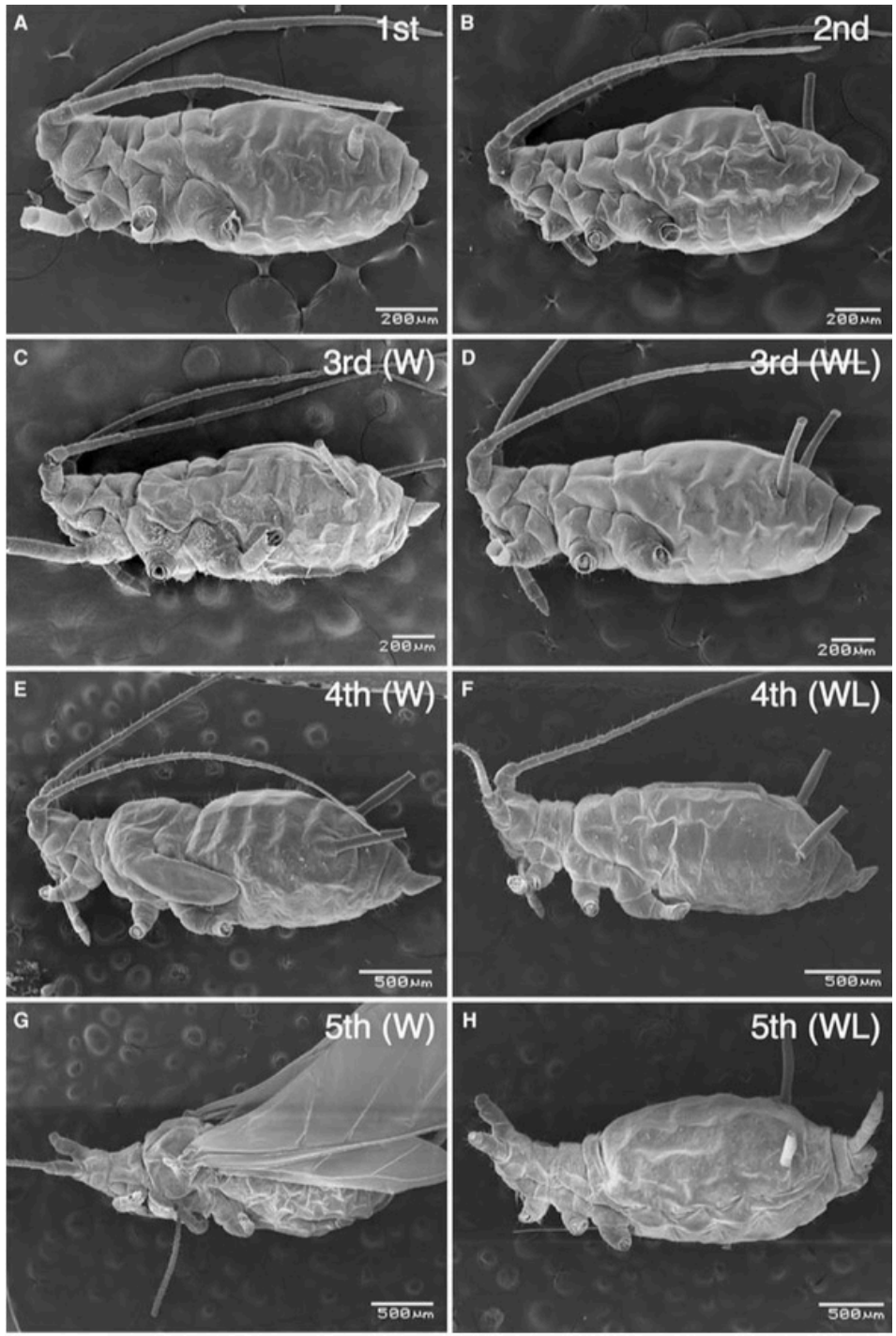
Myzus persicae cycle



Cues and their effect on wing induction



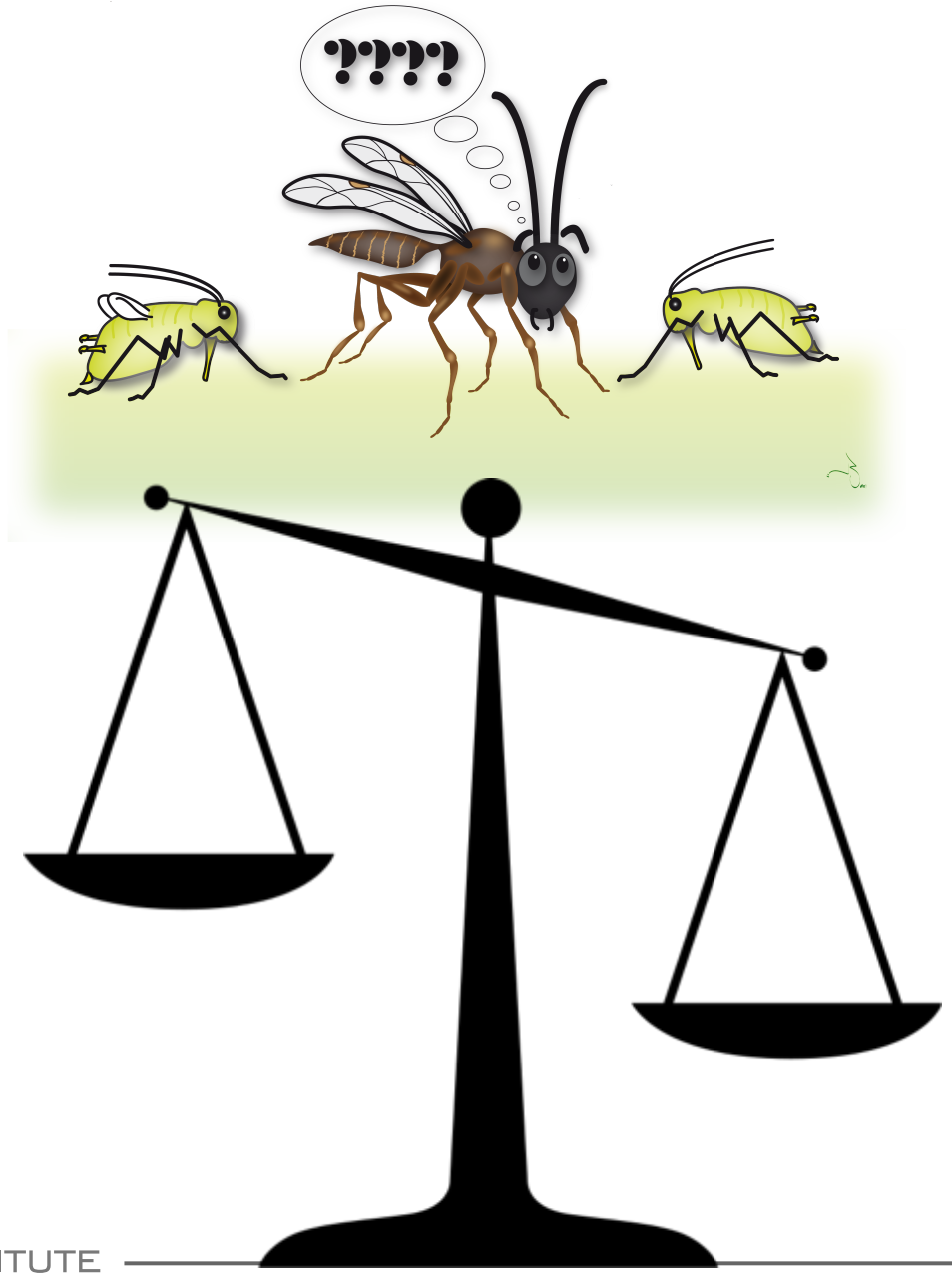
Müller *et al.*, 2001



Ishikawa *et al.*, 2008

Context of the study

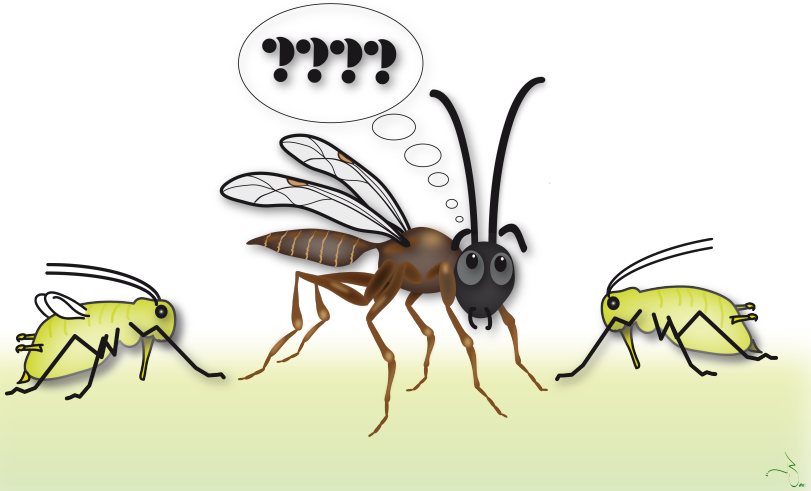
Dispersal



Reproduction

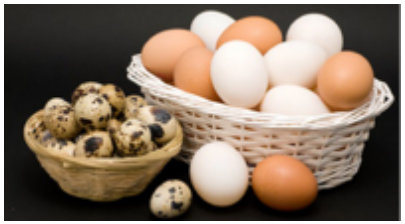
Context of the study

« Escape »
Dispersal in winged hosts favored
(Feng *et al.*, 2007)



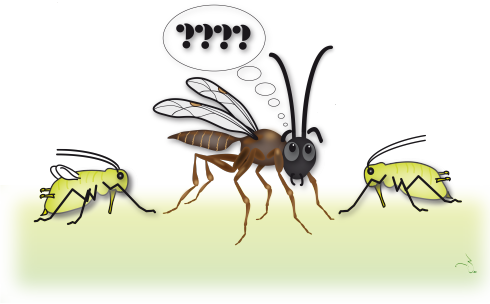
« Avoid »
Females lay more eggs in wingless hosts
(Wyckhuys *et al.*, 2008)

« Fight »
Wing inhibition, no difference in fitness
(Demmon *et al.*, 2004)



« Sit and wait »
Individuals developing in winged hosts have a lower fitness
(Demmon *et al.*, 2004)

Thesis questions



1. Energetic budget of winged/wingless aphids and fitness of parasitoids

2. Impact of host flight on parasitoid fitness

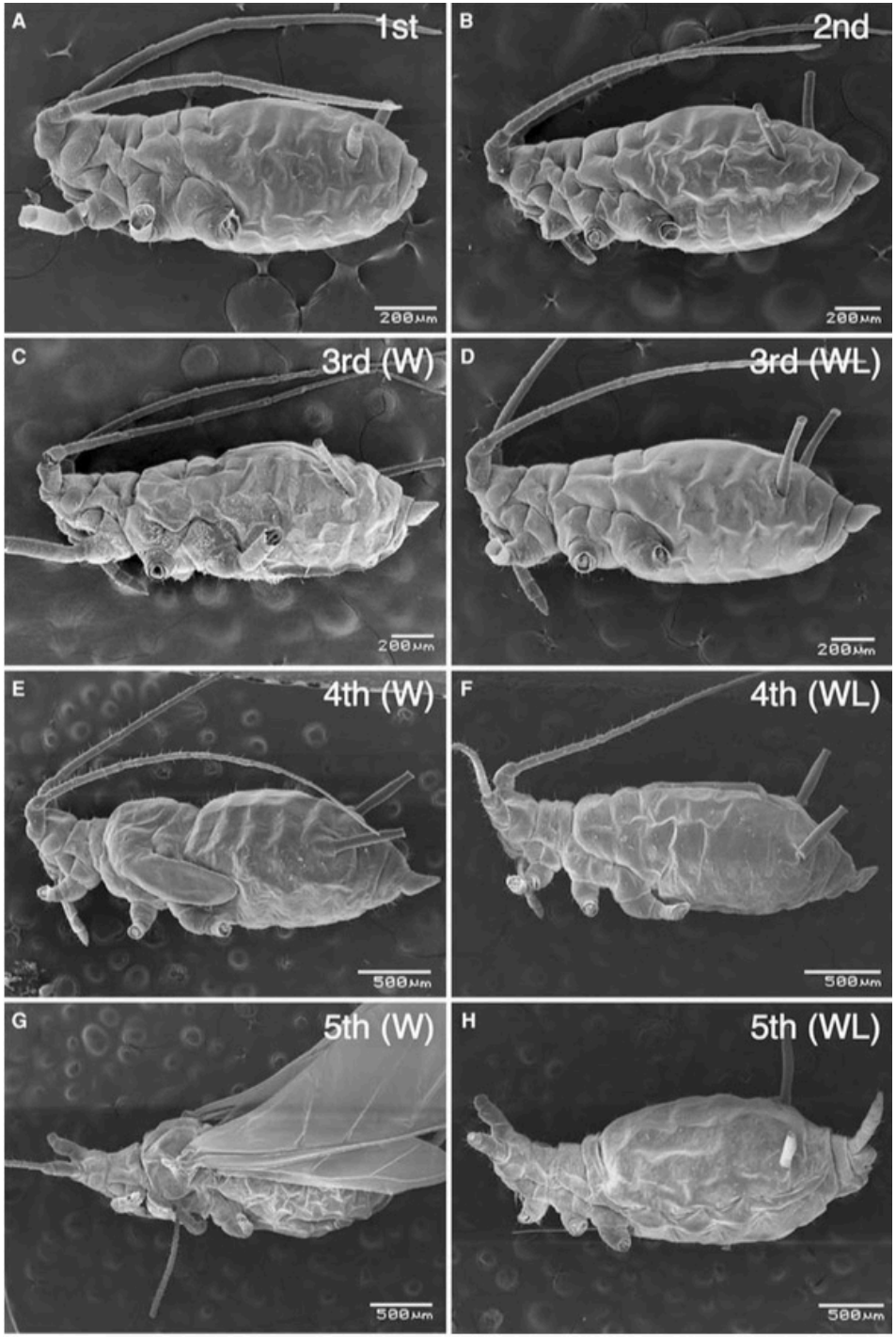
3. Parasitoid's choice and handling time

4. Field experiments

1. Energetic budget of winged/wingless aphids and fitness of parasitoids

- Winged aphids = low quality hosts (Christiansen-Weniger and Hardie, 2000)
- Aphids : allocation of resources in one genotype
- Nutritional status = cue to host quality assessment
- High quality hosts → high fitness for the parasitoid (Li and Mills, 2003)
- Parasitoid fitness also depends on resources quality (Häckermann *et al.*, 2007) and ability to collect resources (Sampaio *et al.*, 2008)
- Host wing inhibition : redirection of resources to parasitoid development ? (Demmon *et al.*, 2004)

Wing inhibition



Wing development

Ishikawa *et al.*, 2008

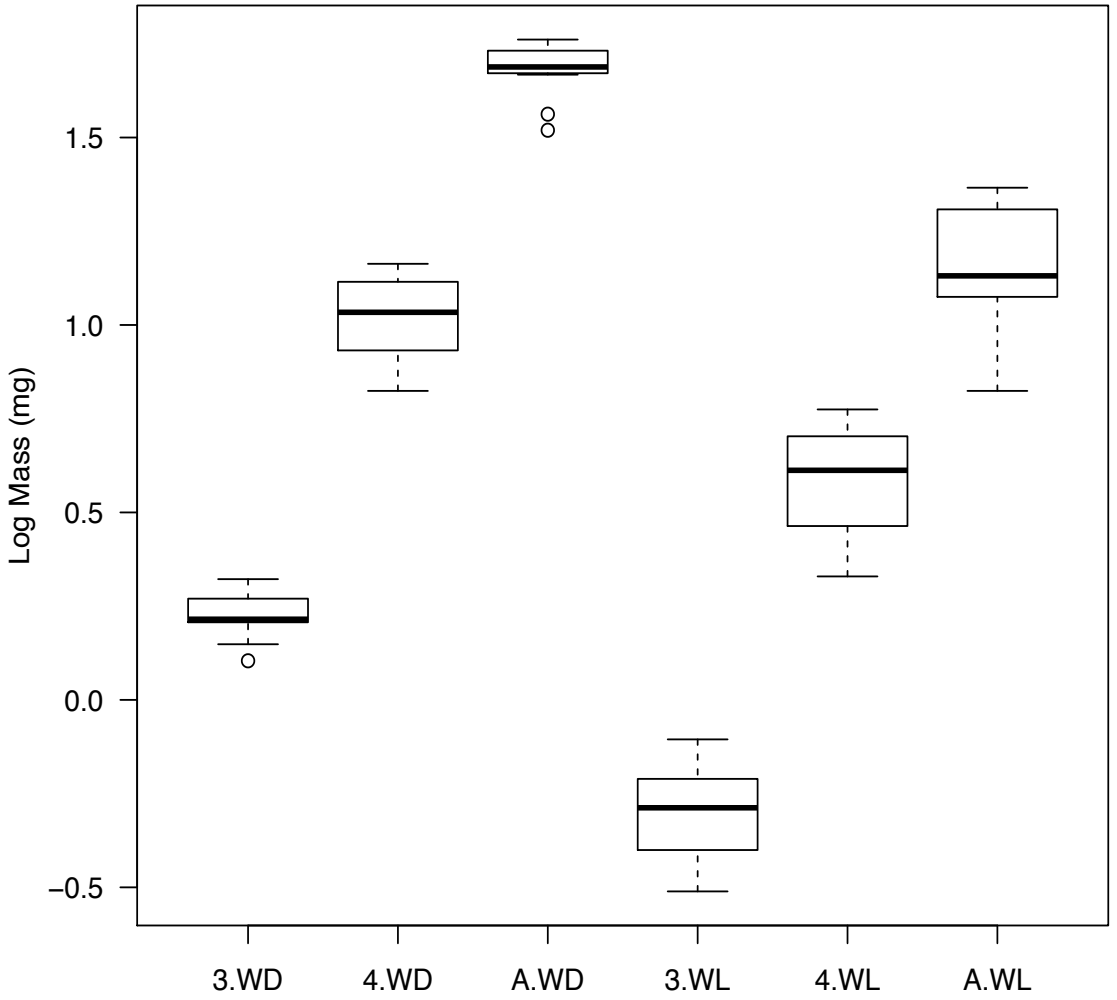
1. Energetic budget of winged/wingless aphids and fitness of parasitoids

- Lipids are important as a maintenance energetic source and for oogenesis (Rivero and Casas, 1999)
- Proteins are also required for reproduction (Rivero and Casas, 1999)
- Glycogen reserves are needed for flight (Amat *et al.*, 2012)
- Sugar sources used in maintenance or in egg production (synovigenic) (Jervis *et al.*, 2008)
- Lipids = constraint for oviposition behaviour as no lipogenesis in parasitic wasps (Vissers and Ellers, 2008)
- Sugar sources can be found in the adult life (Jervis *et al.*, 2008)

1. Energetic budget of winged/wingless aphids and fitness of parasitoids

- Material and methods:
  - ✦ Protocol as in Foray *et al.* (2012) based on colorimetric assays
  - ✦ Aphids (*Myzus persicae)* collected in high density rearing, within 3h after molting
  - ✦ 3 stages : 3rd, 4th and adult, 2 morphs : WD, WL
  - ✦ Generalized linear model with mass as the first explanatory variable

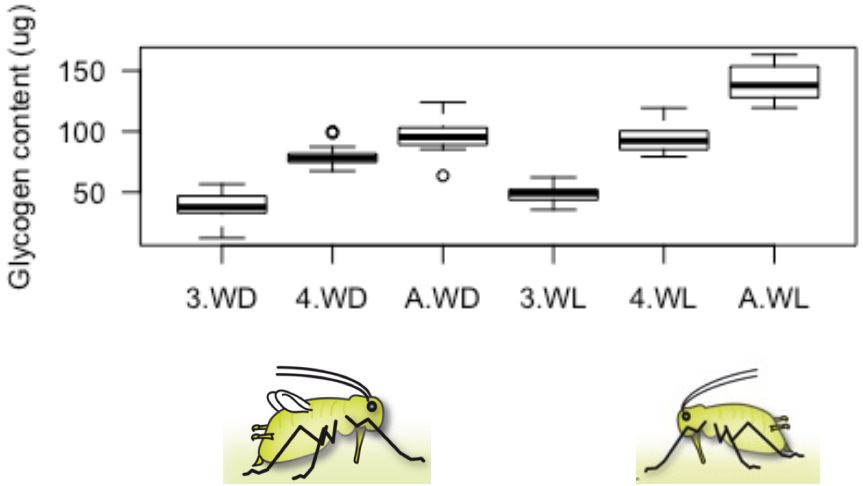
1. Energetic budget of winged/wingless aphids and fitness of parasitoids

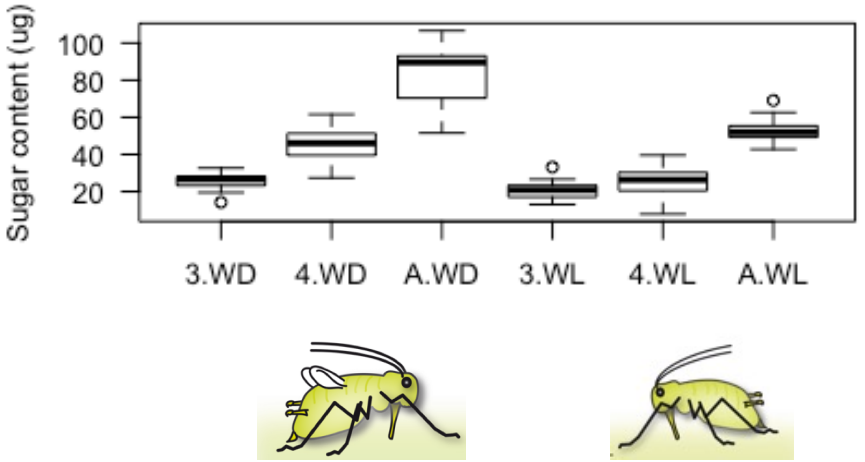


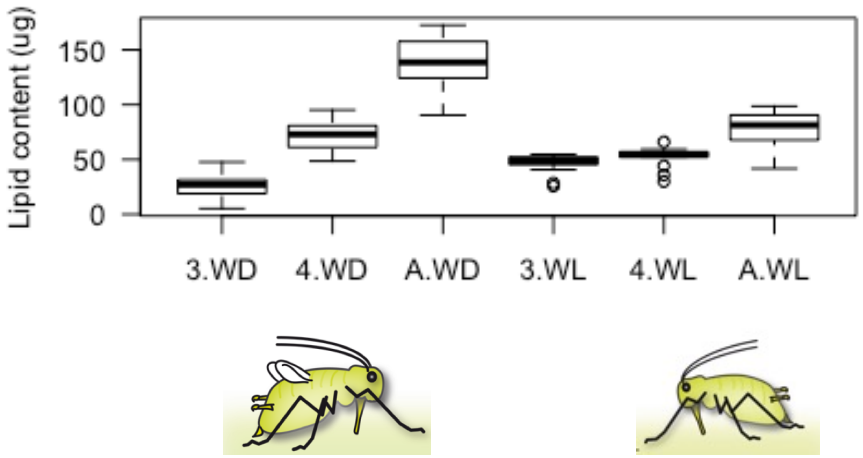
1. Energetic budget of winged/wingless aphids and fitness of parasitoids

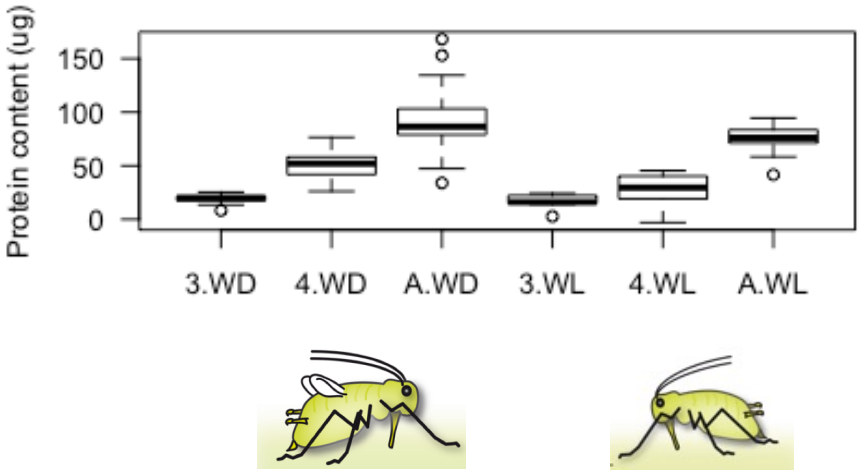
- Winged heavier than wingless at all stages (stage: $p < 0{,}0001$; morph: $p < 0{,}0001$)
- >< Braendle *et al.*, 2006; Brisson, 2010; Shi *et al.*, 2010; Xu *et al.*, 2011)
- High/low density? (differences in fecundity : Groeters and Dingle, 1989)
- Winged more resistant to starvation (Braendle *et al.*, 2006; Brisson, 2010)
- Same rearing method: similar weight (Tsumuki *et al.*, 1990; *Acyrthosiphon pisum*) or winged heavier (Newton and Dixon, 1990; *Sitobion avenae*) except at adult stage

1. Energetic budget of winged/wingless aphids and fitness of parasitoids









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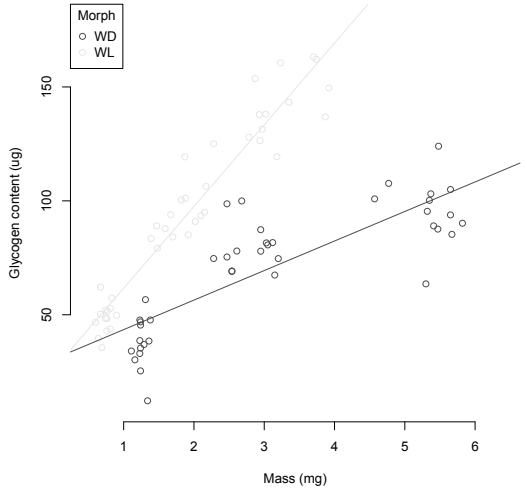
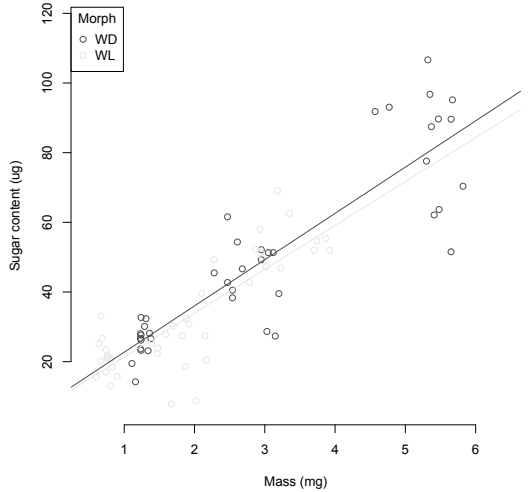
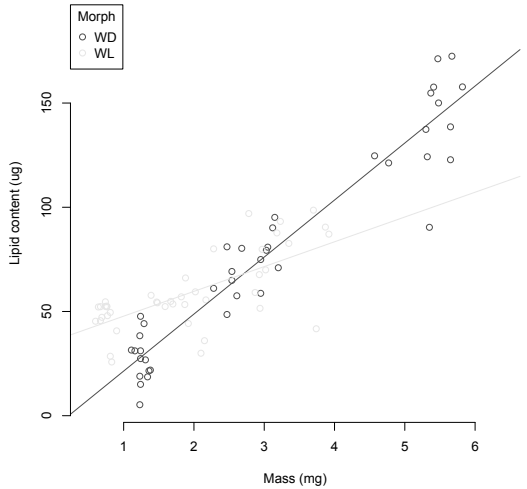
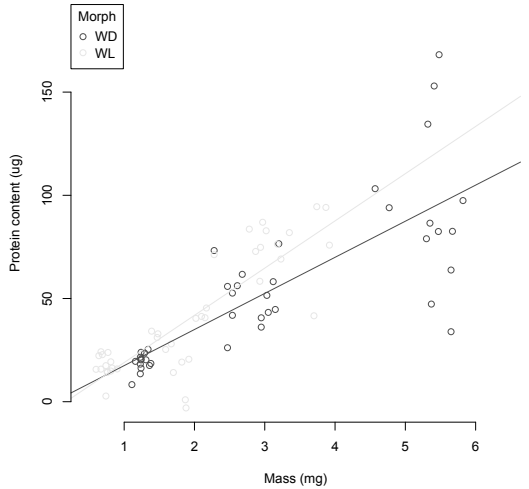


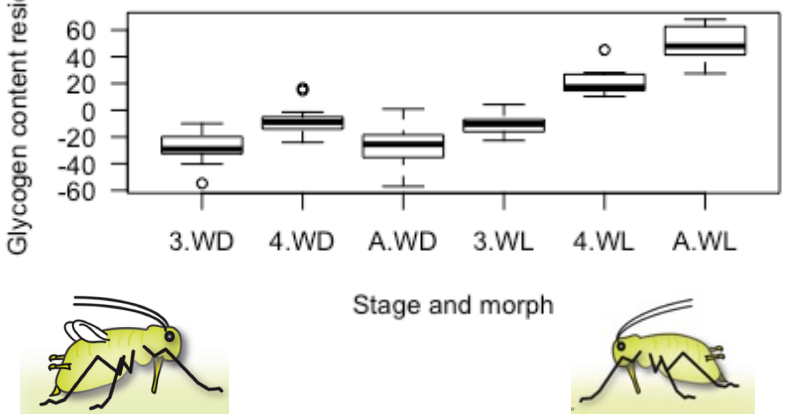




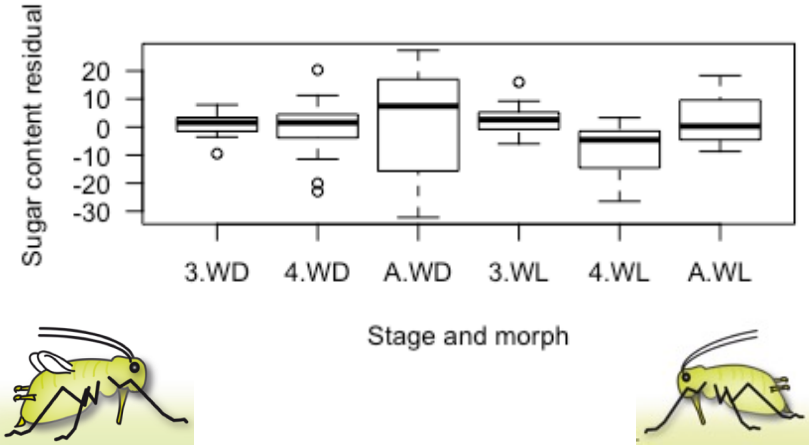


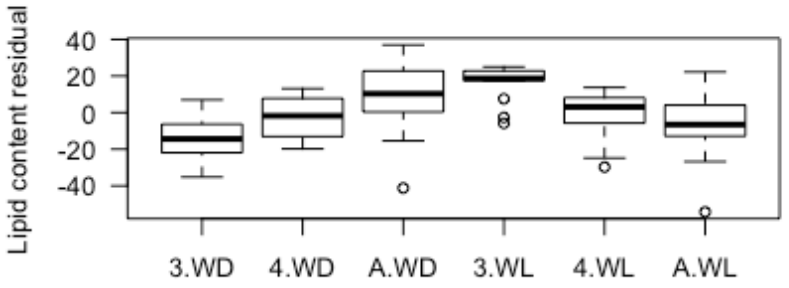
1. Energetic budget of winged/wingless aphids and fitness of parasitoids

Stage:morph
(p < 0,0001)

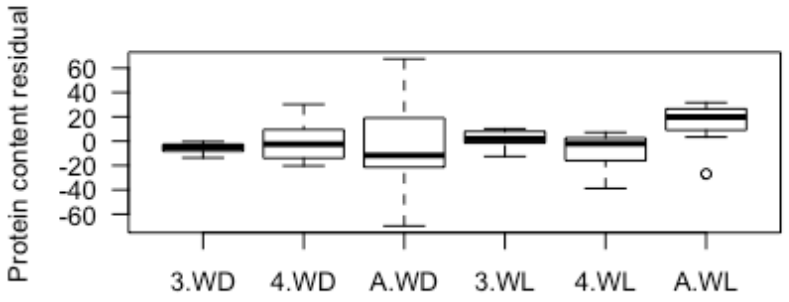


Morph (p = 0,01)





Stage:morph
(p < 0,0001)

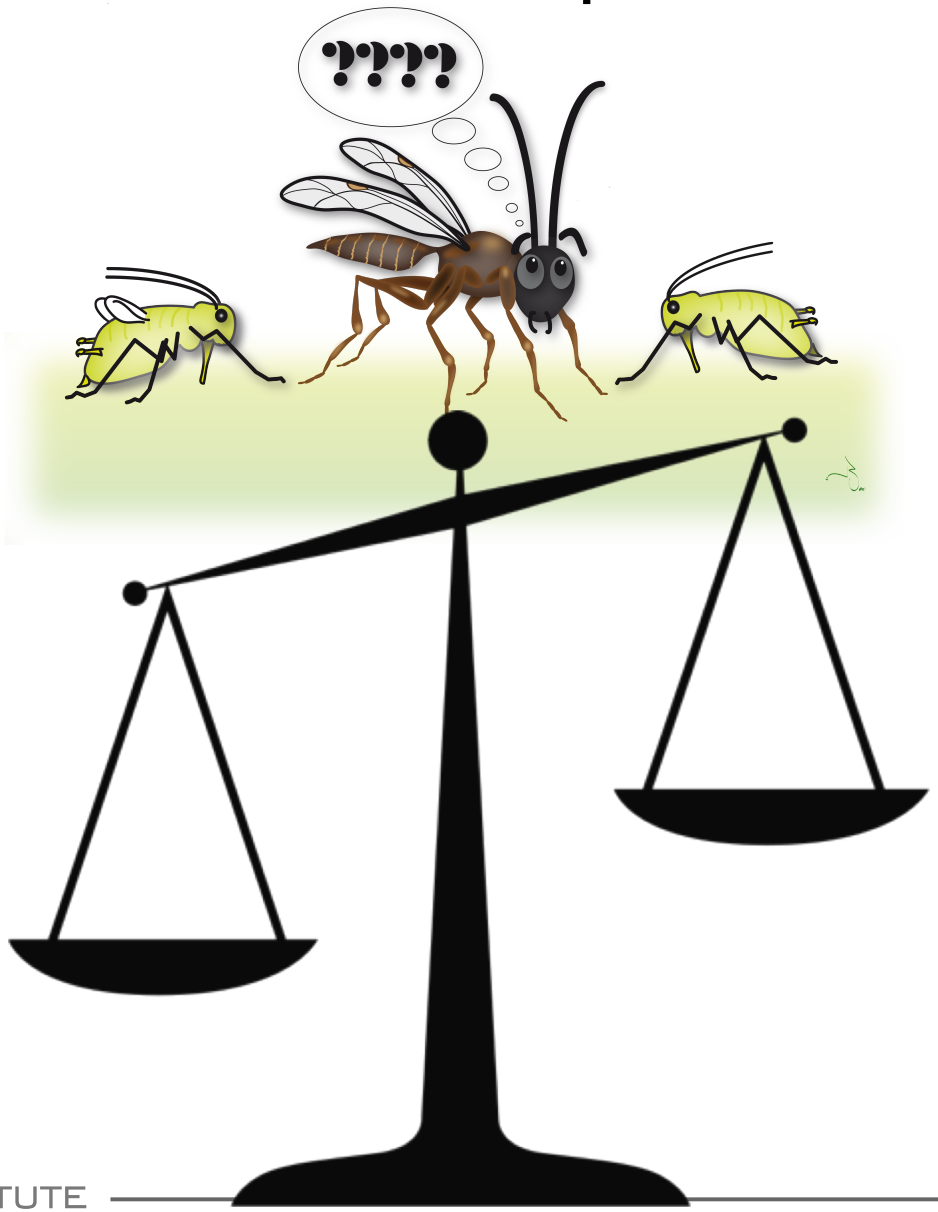


Stage (p < 0,0001)

1. Energetic budget of winged/wingless aphids and fitness of parasitoids

- Glycogen content increases with age but decreases in WD adults : glycogen needed for wing development (Tsumuki *et al.*, 1990)
- Glycogen content higher in WL (Shi *et al.*, 2010; Xu *et al.*, 2011)
- Lower gene expression linked to sugar metabolism in WD (Yang *et al.*, 2014)
- Lipid content increases with age in WD : storage for future flight (Cockbain, 1961)
- Lipid content higher in WD (Itoyama *et al.*, 2000; Shi *et al.*, 2010; Xu *et al.*, 2011)
- Higher gene expression linked to lipid metabolism in WD (Yang *et al.*, 2014)
- High protein content in WL adults: provide higher fecundity (Shi *et al.*, 2010, Xu *et al.*, 2011)
- More protein synthesis in WL (Yang *et al.*, 2014)

1. Energetic budget of winged/wingless aphids and fitness of parasitoids



Lipids (except at 3rd stage)
Proteins
Sugars

Glycogen

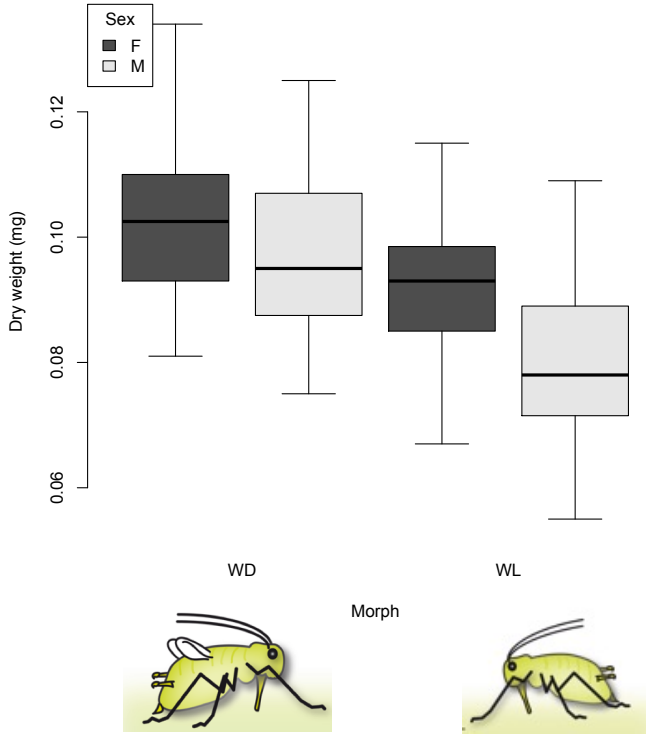
1. Energetic budget of winged/wingless aphids and fitness of parasitoids

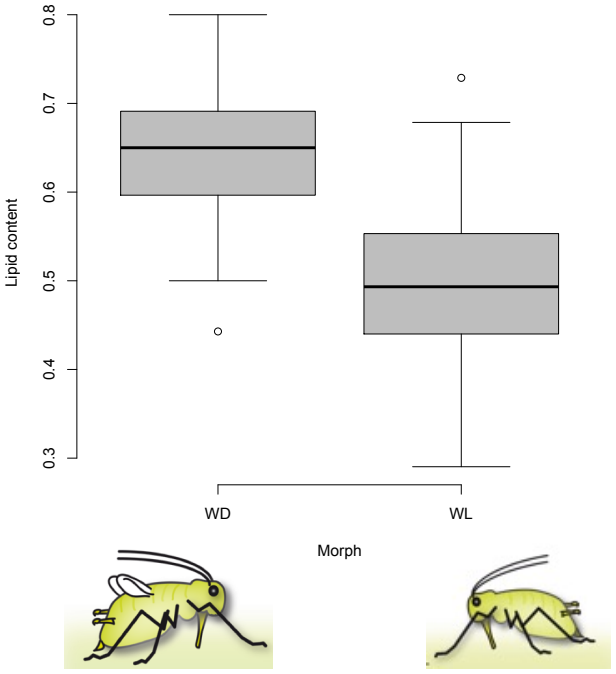
	No-choice experiment	Choice experiment
Number of aphids	5 aphids	10 aphids
Aphid stage	3rd	3rd
Aphid/parasitoid species	*Myzus persicae* / *Aphidius colemani*	
Time of exposition	2h	4h
Number of phenotypes	1	2 (50/50)
Number of experiment	2	1
Parameters measured	- Tibia size - Egg load - Fresh weight - Dry weight - Lipid content	- Tibia size - Fresh weight - Egg load - (Egg volume) - Wing loading

1. Energetic budget of winged/wingless aphids and fitness of parasitoids

No-choice 1		
	Morph	Sex
Tibia	ns	ns
Egg load	ns	-

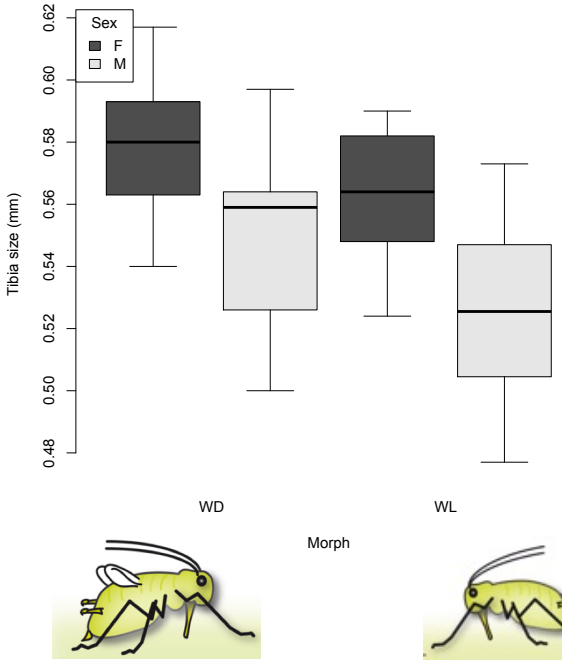
No-choice 2		
	Morph	Sex
Fresh Weight	p < 0,0001	p < 0,0001
Dry weight	p < 0,0001	p < 0,0001
Lipid content	p < 0,0001	ns

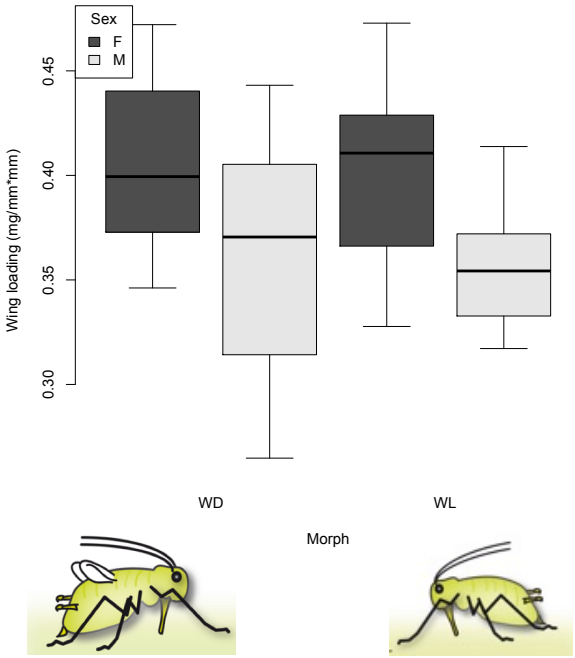




1. Energetic budget of winged/wingless aphids and fitness of parasitoids

Choice		
	Morph	Sex
Tibia	p = 0,004	p < 0,0001
Egg load	ns	-
Fresh weight	ns	p = 0,001
Wing loading	ns	p = 0,002





1. Energetic budget of winged/wingless aphids and fitness of parasitoids

- Winged aphids = interesting source of lipids
- Important for egg production (Rivero and Casas, 1999) as no lipogenesis (Vissers and Ellers, 2008)
- *Aphidius colemani* is synovigenic (Jervis *et al.*, 2001)
- Do not host feed at adult stage (Romeis *et al.*, 2003)
- All nutrient for reproduction are acquired during larval development (Romeis *et al.*, 2003)
- Higher lipid content when emerging from winged hosts
- Wing inhibition does not lead to arrest of lipid accumulation
- Host quality is not fixed as host continues to feed (Mackauer, 1986)
- Females are usually bigger and heavier (Häckermann *et al.*, 2007)

1. Energetic budget of winged/wingless aphids and fitness of parasitoids

- Effect on tibia and fresh weight not consistent through experiments
- High variability, more samples needed, type of experiment?

No-choice 1		
	Morph	Sex
Tibia	ns	ns

No-choice 2		
	Morph	Sex
Fresh Weight	$p < 0{,}0001$	$p < 0{,}0001$

Choice		
	Morph	Sex
Tibia	$p = 0{,}004$	$p < 0{,}0001$
Fresh weight	ns	$p = 0{,}001$

	WD, F	WD, M	WL, F	WL, M
No-choice 1	19	10	12	15
No-choice 2	30	31	47	39
Choice	26	9	25	8

1. Energetic budget of winged/wingless aphids and fitness of parasitoids

- Effect of morph on egg load never significant
- Egg volume ? → reproductive effort (Le Lann *et al.*, 2012)
- No effect of morph on parasitism rate, mortality rate nor emergence rate (data not shown)
- Conditions of the experiment or no preference ?
- Choice experiment with video recording in progress…

Thanks for your attention !