Pest control of aphids depends on landscape complexity and natural enemy interactions

Statistics Group project

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Introduction - why is the research relevant?

- Aphids are a **major pest concern**. Biological control is an overlooked tool in aphid control.

- This study attempts to fill a **knowledge gap:** the specific contribution of different Natural Enemy Guilds (NEG) in controlling aphids across a gradient in landscape complexity.

- To isolate the effects of different NEG, enclosures were used on 18 fields of *Brassica oleracea* with varying degrees of landscape complexity.

- **Assumption**: landscape complexity → density and diversity of NEG → aphid population → cabbage biomass

Who are the natural enemies of aphids in the study?

Birds - **B** treatment

parasitoids wasps and syrphid larvae ("flying insects") - **P** treatment

Beetles and spiders ("ground dwellers") **GD** treatment

A wide array of variables

Variables can be divided into:

1. **Independent variables**

- Landscape complexity (% semi-natural habitat at a radius around fields)
- Treatments (= different combinations of NE exclusions)
- Many others

2. **Dependent variables**

- Aphid density
- Aphid population growth (APG)
- Number of parasitized aphids
- Parasitism rate [the proportion of parasitized aphids over total aphids]
- Number of syrphid larvae
- Syrphid fraction [# of syrphid larvae / (# of aphids + # of syrphid larvae)]
- Cabbage biomass (g)

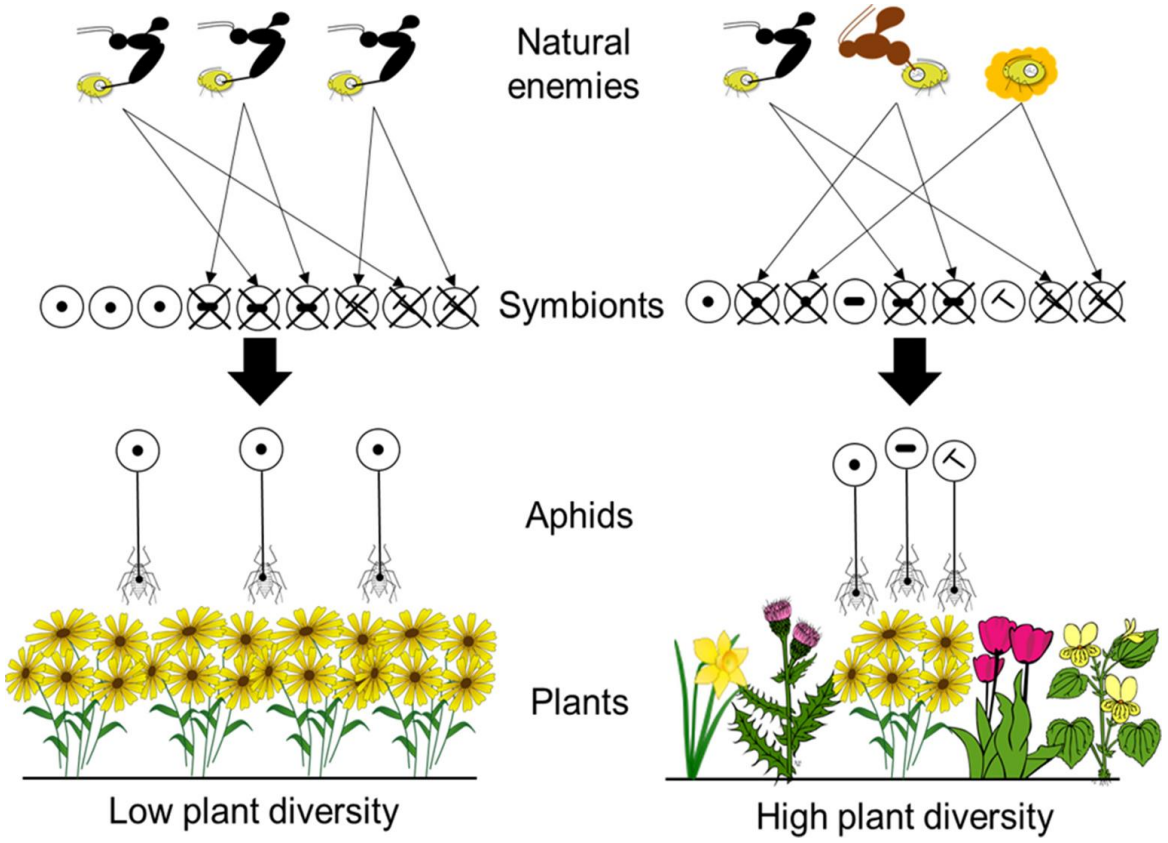
Team Objectives

To **determine**:

1. The effect of natural enemies (NE) on APG across a gradient of Landscape Complexity (LC).

2. The effect of NE on parasitism rate and syrphid fraction across a gradient of LC.

3. The possible interaction between NE and LC. Interaction would imply that the effects of NE guilds are affected by the complexity of the landscape.



Research Questions and Hypotheses

1. Does the presence of natural enemies (NE) decrease aphid population growth?

2. Is the effect of NE **complementary** or **antagonist** on the dependent variables (e.g. APG, parasitism rate, syrphid fraction)?

3. Is there a difference in the effect of NE over aphids between complex and simple landscapes?

4. Do parasitism and syrphid presence increase with greater landscape complexity?

5. Is there an interaction between NE and landscape complexity (LC)?

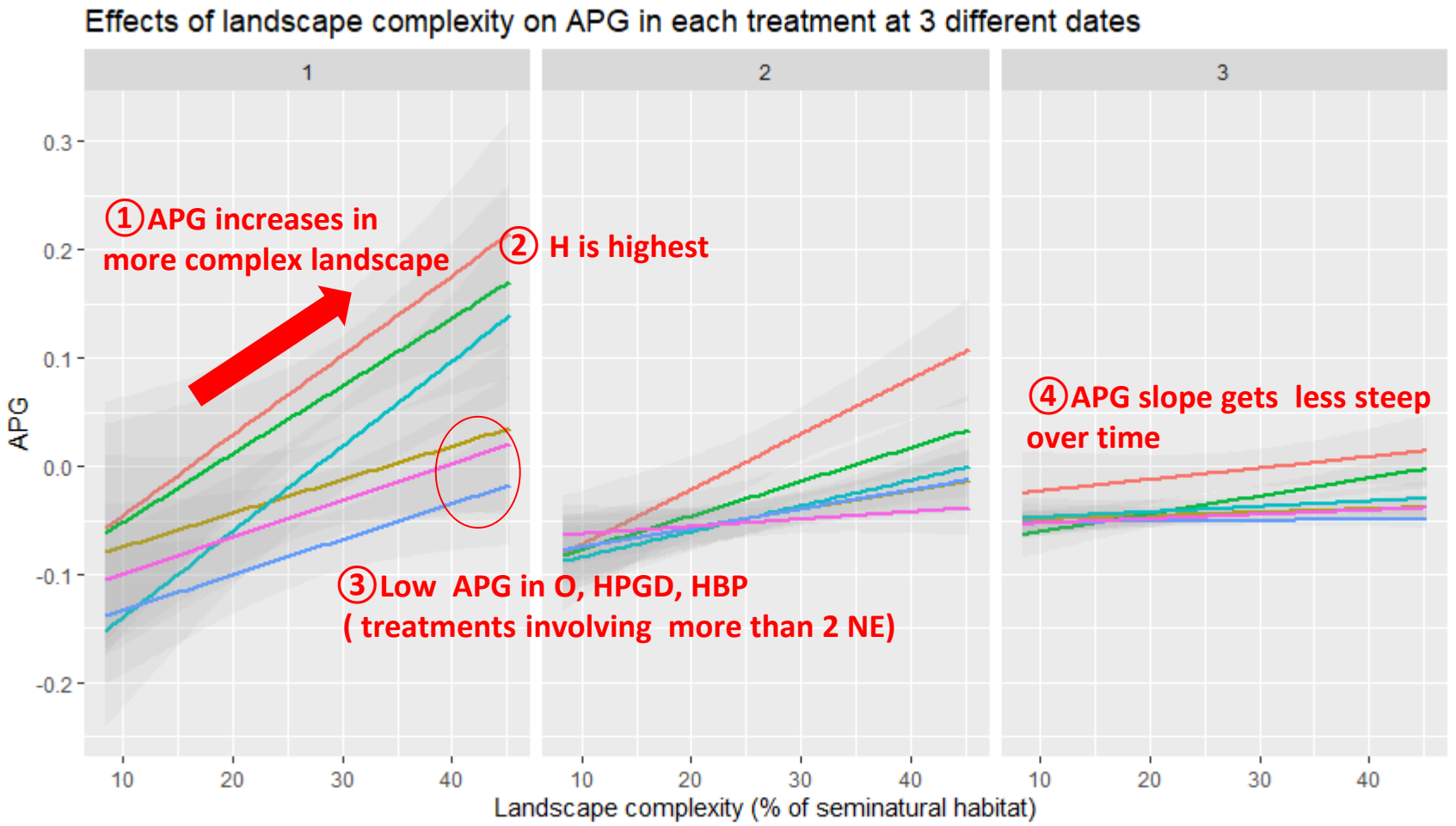
6. Does aphid population growth decrease cabbage biomass?

Methodology using R and excel

RStudio Desktop

1. We calculated **3 new variables** whose formulas were given: APG, parasitism rate and syrphid fraction.
2. We created an excel sheet listing **all the relationships** between the variables that are relevant to assess.
3. We **plotted the major relationships** to outline trends and study the relationships between key variables.
4. We ran a significant amount of **linear models** (lm) to know what model fits best for 6 dependent variables (only 3 in the original study): aphids density, APG, aphids parasitized, parasitism rate, syrphid fraction and biomass.
5. We carried out **ANOVAS** followed by **"post hoc" tests** to highlight significant differences between the models.

Effects of NE and Landscape Complexity on APG



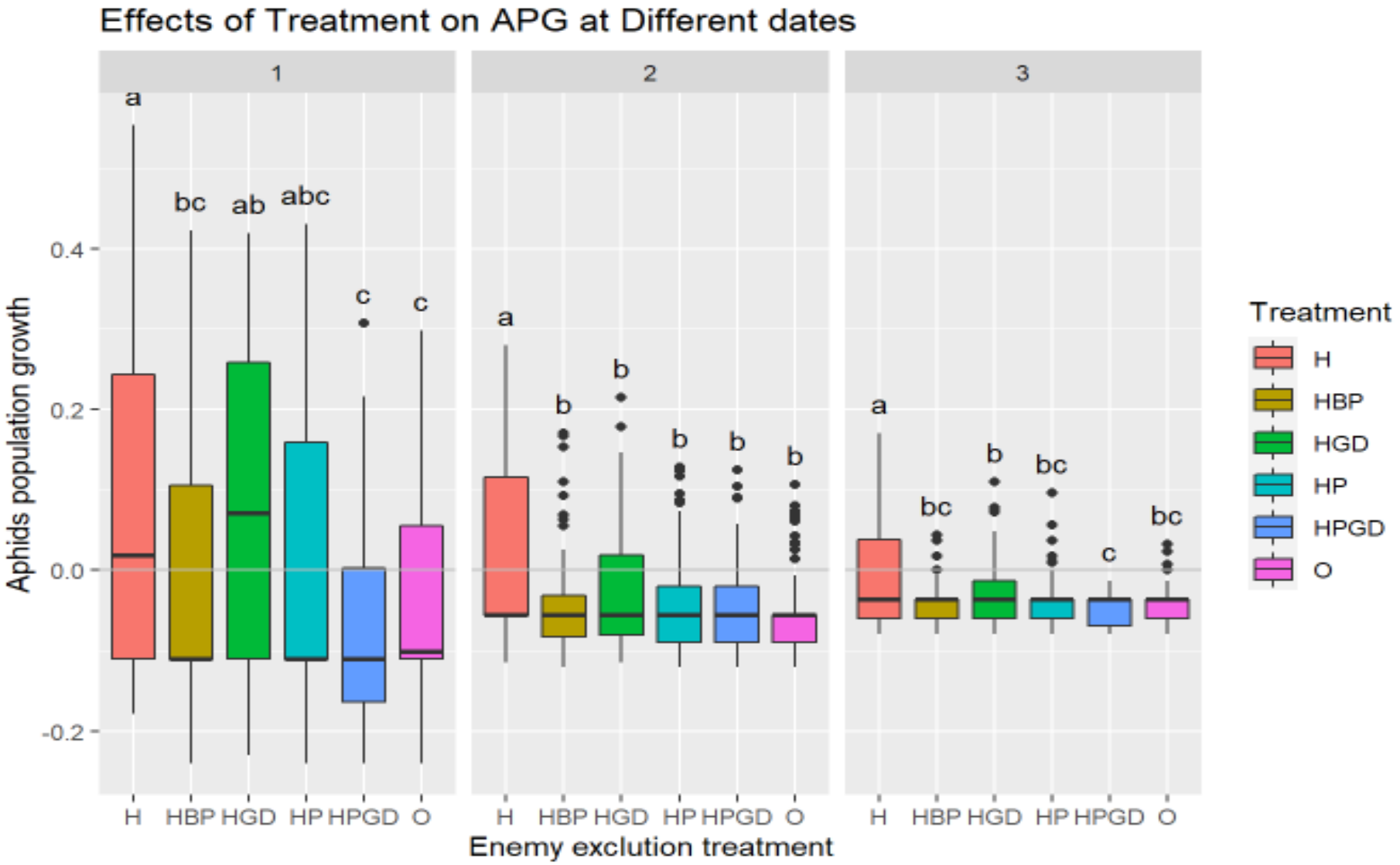
Legend:

- H = herbivores only (all enemies excluded)
- GD = ground-dwellers
- P = flying insects
- B = birds
- O = all enemies.

Effects of enemy exclusion treatments (= combination of NE guilds) on APG at Date 1, 2 and 3

Legend:

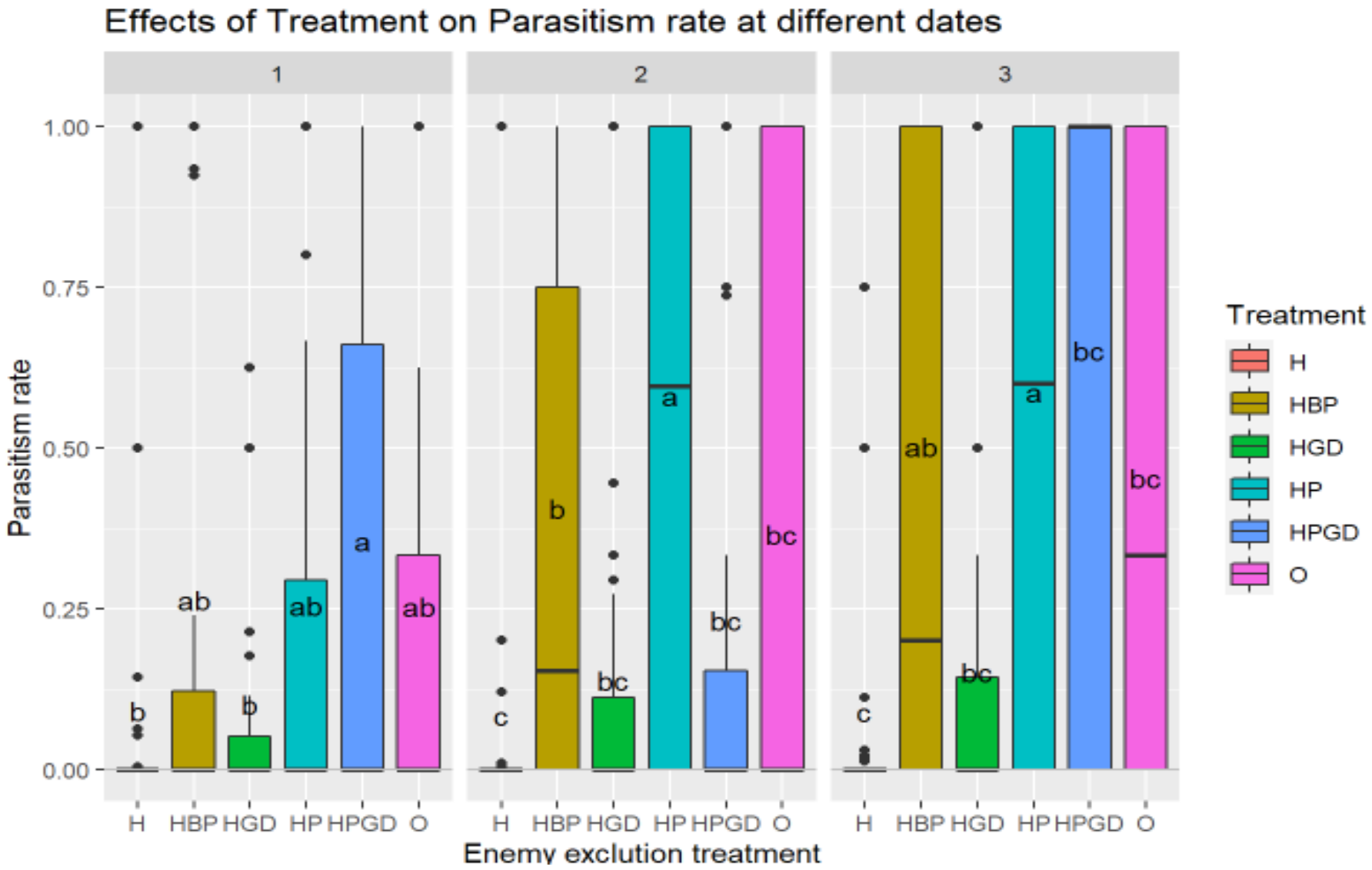
- H = herbivores only (all enemies excluded)
- GD = ground-dwellers
- P = flying insects
- B = birds
- O = all enemies.



Effect of enemy exclusion treatments on parasitism rate at Date 1, 2 and 3

Legend:

- H = herbivores only (all enemies excluded)
- GD = ground-dwellers
- P = flying insects
- B = birds
- O = all enemies.

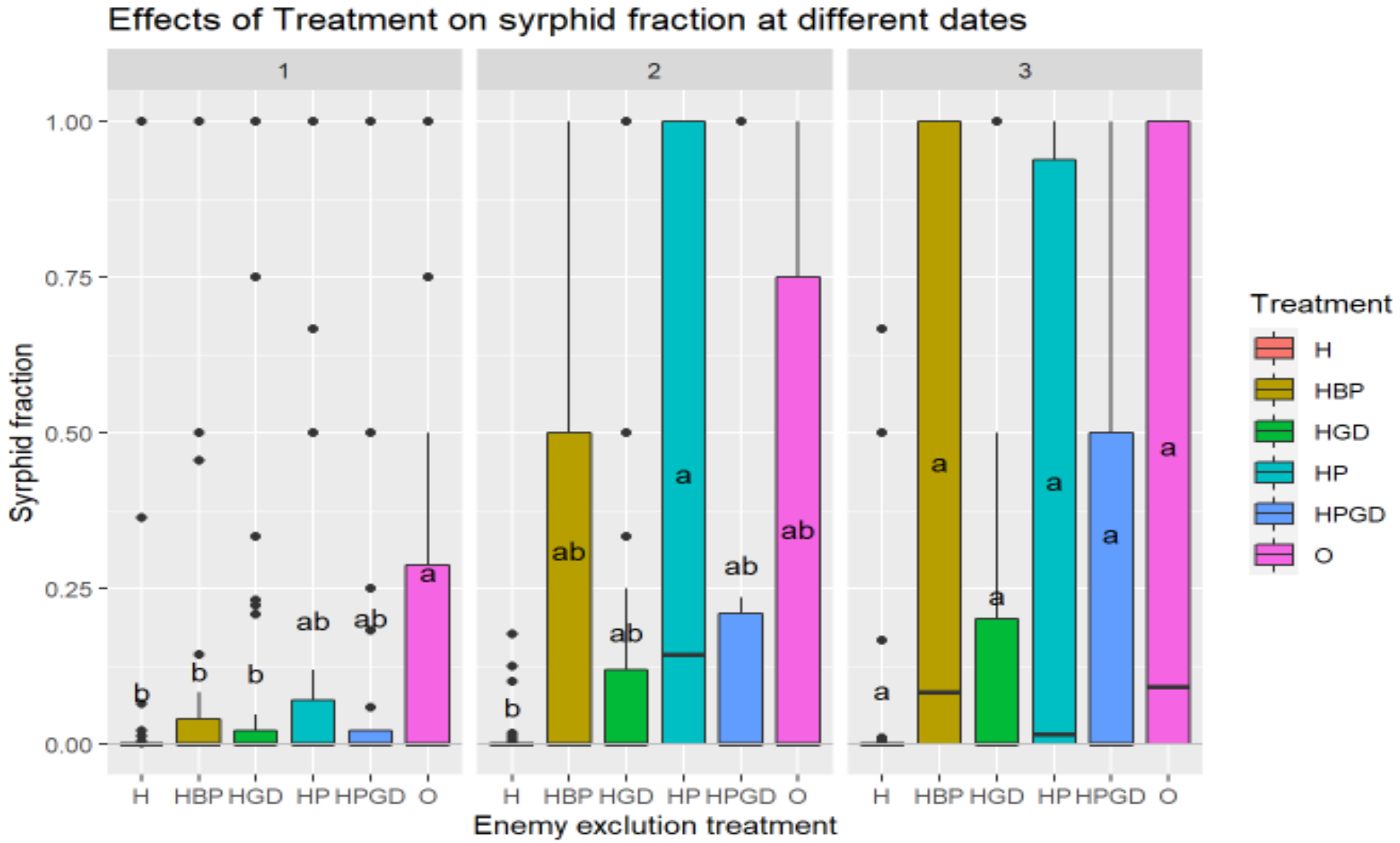


Effect of enemy exclusion treatments on syrphid fraction at Date 1, 2 and 3

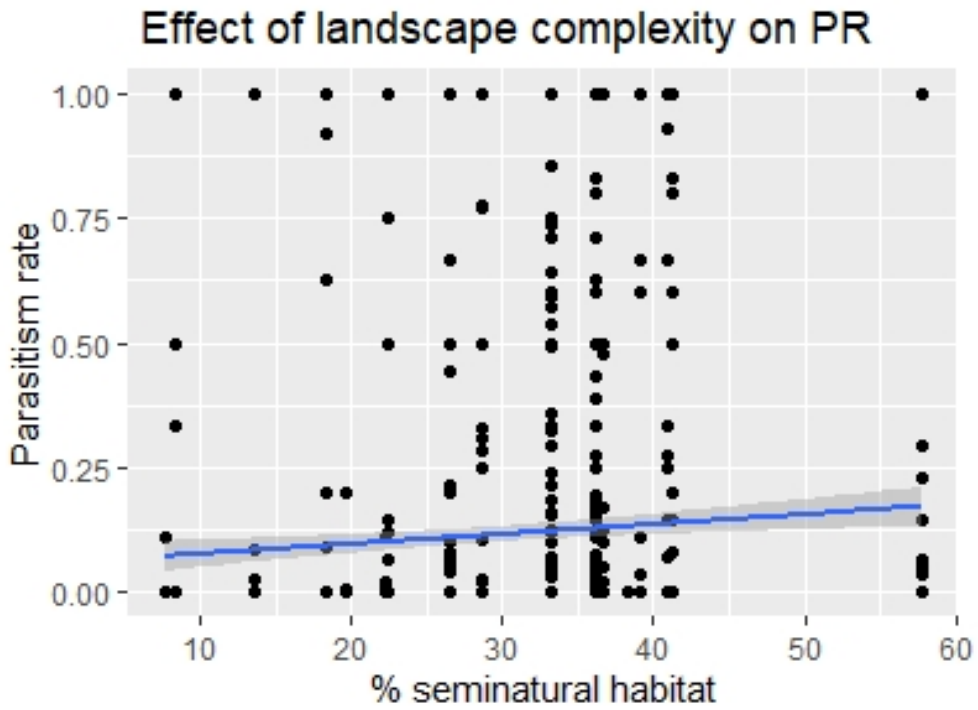
Legend:

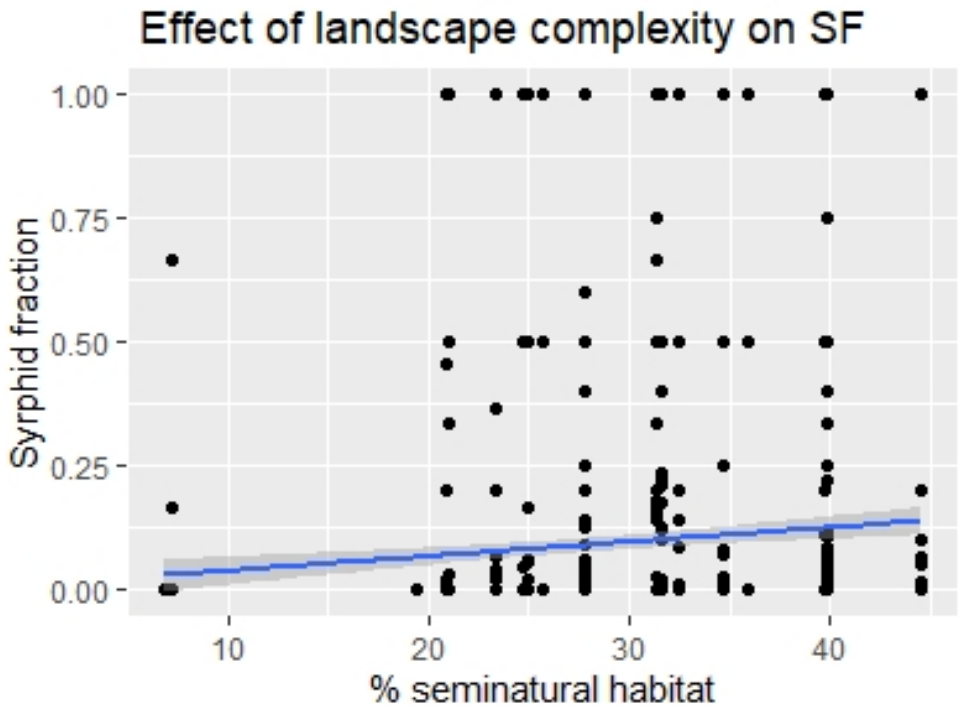
- H = herbivores only (all enemies excluded)
- GD = ground-dwellers
- P = flying insects
- B = birds
- O = all enemies.

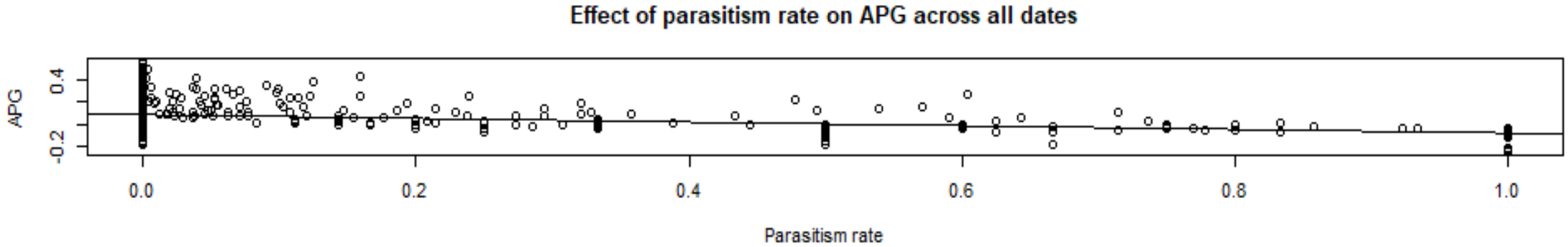
Note: All NaN values have been removed.

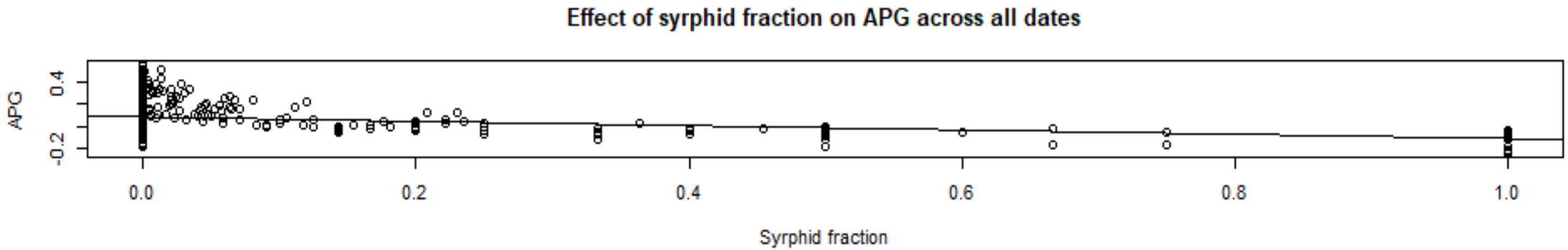


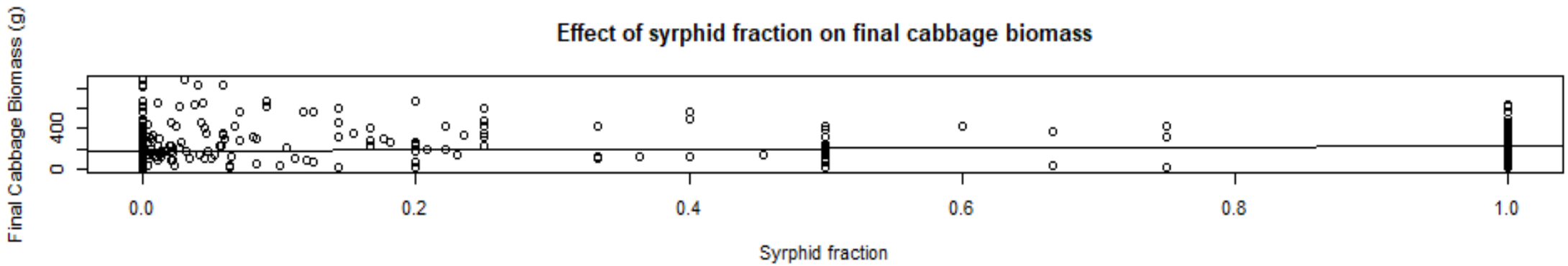
Effect of landscape complexity on PR and SF






Effect of parasitism rate on APG across all dates
APG
-0.2
0.4
0.0
0.2
0.4
0.6
0.8
1.0
Parasitism rate


Effect of syrphid fraction on APG across all dates
APG
-0.2
0.4
0.0
0.2
0.4
0.6
0.8
1.0
Syrphid fraction


Effect of syrphid fraction on final cabbage biomass
Final Cabbage Biomass (g)
0
400
0.0
0.2
0.4
0.6
0.8
1.0
Syrphid fraction

Linear Models comparison based on the AIC index

M = Field management

L = Landscape complexity (% Seminatural habitat)

D = Sampling date

T = Treatment

AP = Aphids parasitized

PR = Parasitism rate

Sy = Syrphid fraction

A = Aphids density

CM = Crop maturity

CT = Crop type

PT = Plot

APG = Aphid population growth

Response	No	Model specification	df	AIC	Rank
Syrphid fraction~	**M1**	**M+L+D+T+M:D+L:D+L:T**	**9**	**1409.151**	**2**
	M2	**M+L+D+T+M:D+L:T**	**8**	**1409.089**	**1**
	M3	M+L+D+T+L:D+L:T	8	1451.763	5
	M4	M+L+D+T+L:T	7	1458.672	
	M5	L+D+T+L:D+L:T	7	1618.325	
	M6	**M+L+D+T+M:D**	**7**	**1428.652**	**3**
	M7	L+D+T+L:T	6	1624.7	
	M8	M+D+T+M:D	6	1432.1	4
	M9	M+D+T	5	1481.405	
	M10	D+T	4	1670.877	
	M11	L+T	4	1661.267	
	M12	M	3	1654.15	
	M13	L	3	1815.628	
	M14	T	3	1688.798	
	M15	CT	3	1755.386	

3 best models for each dependent variable (A)

M = Field management

L = Landscape complexity (% Seminatural habitat)

D = Sampling date

T = Treatment

AP = Aphids parasitized

PR = Parasitism rate

Sy = Syrphid fraction

A = Aphids density

CM = Crop maturity

CT = Crop type

PT = Plot

APG = **A**phid population growth

Response	No	Model specification	df	AIC	Rank
Aphids density~	M2	M+L+D+T+L:D+M:T	8	149319.6	1
	M3	M+L+D+T+M:T	7	149364.4	2
	M1	L+CT+D+PT+T+SF+CM+M	10	150273.9	3

Response	No	Model specification	df	AIC	Rank
APG~	M1	M+L+D+T+M:D+L:D+T:D+L:T+(L:T:D)	11	-19871.81	1
	M2	M+L+D+T+M:D+L:D+T:D+L:T	10	-19870.33	2
	M3	M+L+D+T+M:D+L:D+T:D	9	-19824.13	3

Response	No	Model specification	df	AIC	Rank
BIOMASS~	M13	M+L+T+M:A+L:AP+M:T	8	158068.6	1
	M14	M+L+T+M:A+L:T	7	158671.1	2
	M12	M+L+A	**5**	158974.2	3

3 best models for each dependent variable (B)

M = Field management
L = Landscape complexity (% Seminatural habitat)
D = Sampling date
T = Treatment
AP = Aphids parasitized
PR = Parasitism rate
Sy = Syrphid fraction
A = Aphids density
CM = Crop maturity
CT = Crop type
PT = Plot
APG = **A**phid population growth

Response	No	Model specification	df	AIC	Rank
Aphids parasitized~	M4	M+CT+L+APG	7	78178.6	1
	M10	L+APG	4	78226.79	2
	M1	M+L+D+T+M:D+L:D+T:D+L:T	9	78258.94	3

Response	No	Model specification	df	AIC	Rank
syrphid fraction~	M2	M+L+D+T+M:D+L:T	8	1409.089	1
	M1	M+L+D+T+M:D+L:D+L:T	9	1409.151	2
	M6	M+L+D+T+M:D	7	1428.652	3

Response	No	Model specification	df	AIC	Rank
Parasitism Rate~	M3	M+L+D+T+M:D+L:T	8	3623.658	1
	M2	M+L+D+T+M:D+L:D+L:T	9	3625.303	2
	M1	M+L+D+T+M:D+L:D+T:D+L:T	9	3627.89	3

Discussion: some important findings

Finding #1: In the absence of natural enemies, APG was higher in complex landscape than in simpler ones. Higher APG in complex landscape was compensated by stronger pest control. In fact, parasitism rate and syrphid fraction also increased with increasing landscape complexity.

Explanation #1: higher availability of resources and overwintering habitats with greater surface area of semi-natural habitat. Benefits both aphids (increased colonization and reproduction) and natural enemies

Discussion

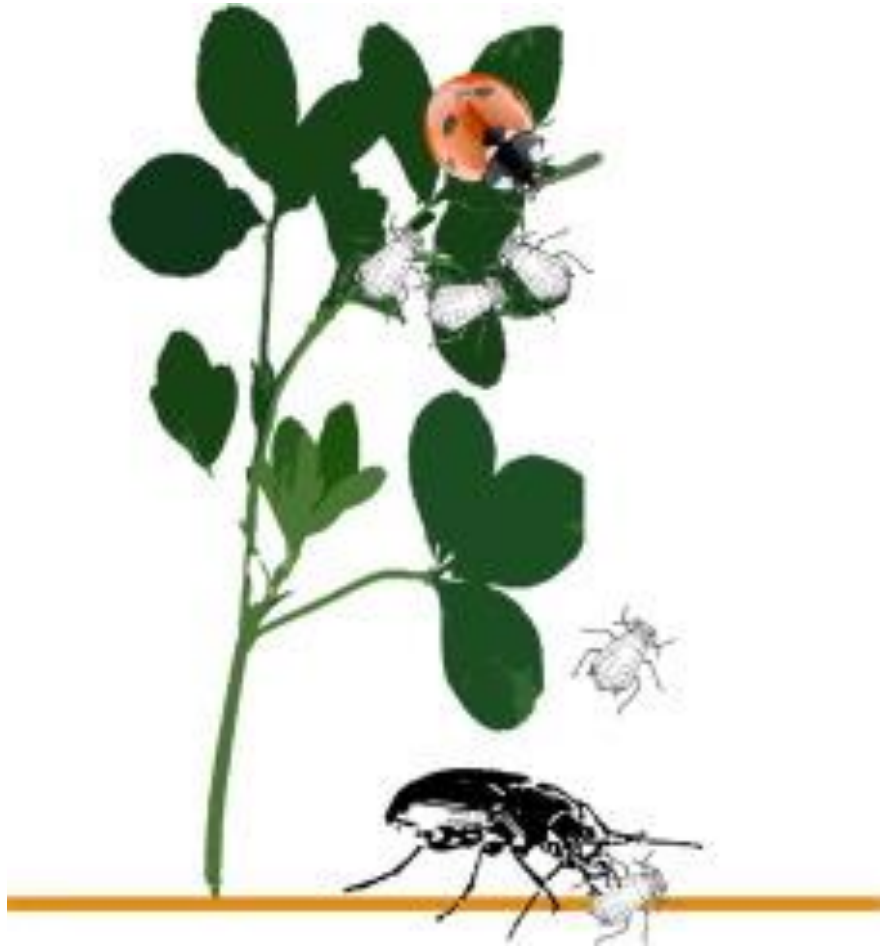
Finding #2: Flying insects (HP treatment) had a stronger control effect than ground-dwellers (GD), especially in complex landscapes. This is reflected with higher parasitism rate and syrphid fraction in complex landscape.

Explanation #2: This finding is consistent with the idea that generalist predators (GD) have a lower impact than specialist predators (flying insect) when prey density is high.

Discussion

Finding #3: There is a complementary effect between flying insects and ground dwellers. Aphid control was stronger in the presence of both guilds than with either guild alone.

Explanation #3 : predation may take place in different places depending on the organism ("spatially segregated foraging"). Aphids may be displaying escaping behavior. Behavior not observed in the field, but some ground dwellers were seen climbing directly on the plants.



Discussion

Finding #4: In some dates, natural enemy rates (parasitism rate and syrphid fraction) are lower in treatments accessible to birds (**O** treatment) than in the other treatments.

Explanation #4: Could be due to predation by birds of parasitized aphids and syrphids.

Conclusion

From the article:

- The interaction between enemy guilds and landscape complexity is **complex**.
- Pest control was always stronger when many different enemies were present, especially in more complex landscapes.
- Pest control of GD and flying insects was complementary, but flying insects provided the strongest contribution to pest control.

More work needed to understand the interactions between natural enemies.

from our work:

- We learned how to run and interpret different statistical tests and models (e.g. anovas, post hoc tests, chi-square test, linear models etc.)
- We now master the art of plotting graphs !