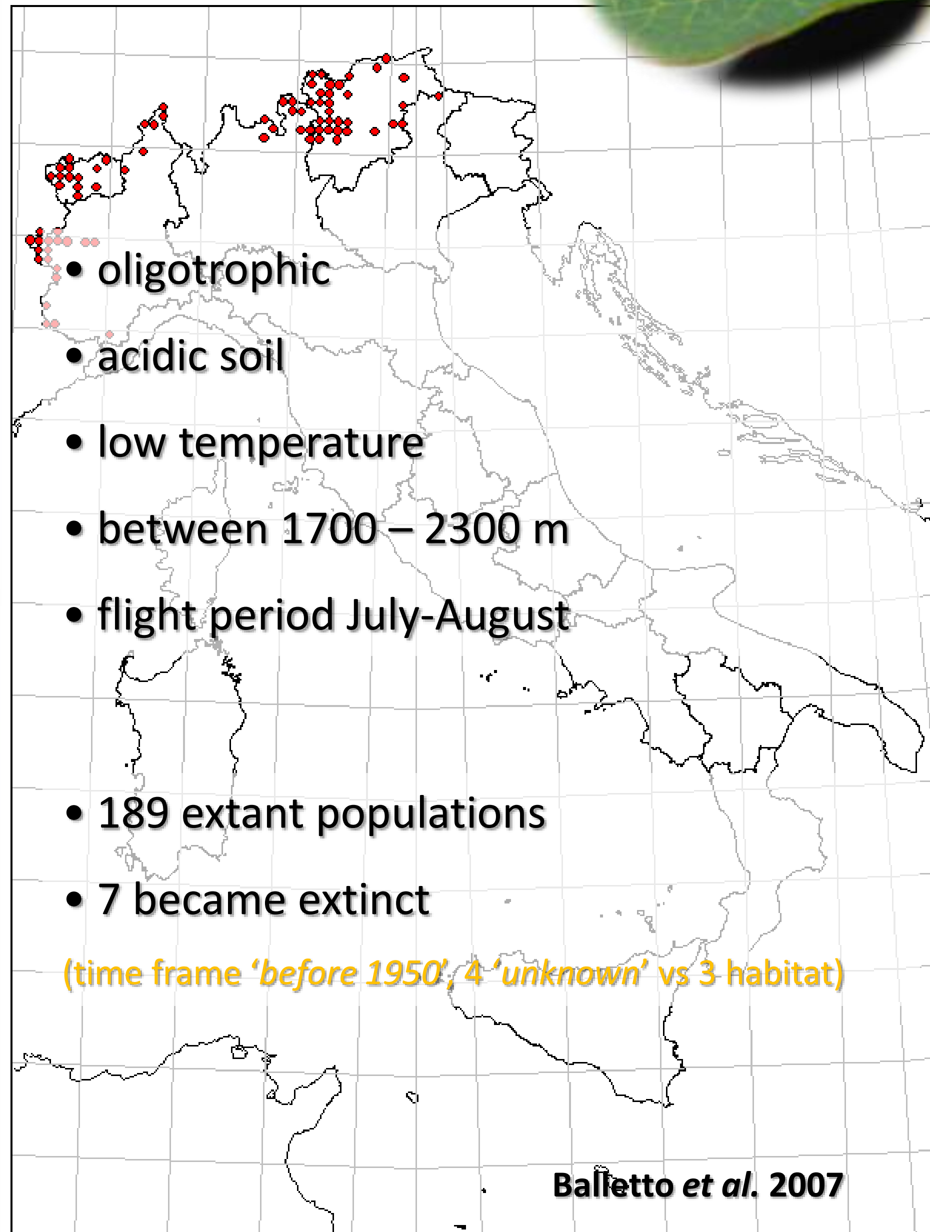
Turin University - Life Sciences and Systems Biology Department

Larval ecology of *Colias palaeno* in the N-W Italian Alps

Future of Butterflies in Europe III – 29-31 March 2012

Cristiana Cerrato

Colias palaeno in Italy



- oligotrophic
- acidic soil
- low temperature
- between 1700 – 2300 m
- flight period July-August

- 189 extant populations
- 7 became extinct

(time frame *'before 1950'*, 4 *'unknown'* vs 3 habitat)

Objectives

Describe the role of biotic and abiotic parameters at a spatial and temporal scale relevant for the caterpillars

Micro-habitat

Micro-climate

Larval host plant condition

→ Survival

Knowledge of the larval needs by target species may be crucial to desing adequate management practice

Habitat quality is often defined on the basis of the requirements of the immature stages, because they are more specific than those of the adults

This is due to the low or absent mobility as well as the longer life time of the immature stages

e.g. Thomas JA (1991) Rare species conservation: case studies of European butterflies. In: Spellerberg IF, Goldsmith FB, Morris MG (eds) The scientific management of temperate communities for conservation. Blackwell Scientific, Oxford, pp 149–197

Influencial factors

Micro-climate

Micro-climatic cooling linked to nitrogen deposition and global warming by advancing plant growth

Optimal temperature and humidity level

Wallisdevries and van Swaay (2006) Global waming and excess nitrogen may induce butterfly decline by microclimatic cooling – Global Change Biology 12: 1620-1626

Physical characteristics of the larval host plant

Bigger leaves and/or bigger plants

Linkage to micro-climate

Zalucki, Clarke and Malcom (2002) Ecology and behaviour of first instar larvae - Annual Revue of Entomology 47: 361-393

Influencial factors

Chemical characteristics of the larval host plant

Nitrogen

Carbon-based secondary metabolites

Throop and Lerdau (2004) – Effects of nitrogen deposition on insect herbivory: Implications for community and ecosystem processes – Ecosystems 7: 109-133
Fisher and Fiedler, (2000): Response of the copper butterfly Lycaena tityrus to increased leaf nitrogen in natural food plants: evidence against the nitrogen limitation Hypothesis – Oecologia 124: 235-241
Stiling and Cornelissen (2007) – How does elevated carbon-dioxide (CO_2) affect plant-herbivore interactions? – Global Change Biology 13: 1823-1842

Phenological asynchrony

Different responses of different trophic levels

Insect phenology must ensure the temporal match of larvae and larval resources
Monovoltine species have a narrow window of opportunity to exploit resources

Singer and Parmesan (2010) ***Phenological asynchrony between herbivorous insects and their hosts: signal of climate change or pre-existing adaptive strategy? –*** *Phil Trans Royal Society*

Where is *Colias palaeno* in the Alps - Sampling design

• 18 study areas in 2 valleys

Val Formazza and Val Bognanco

• Altitudinal gradient

1600-2300 m a.s.l.

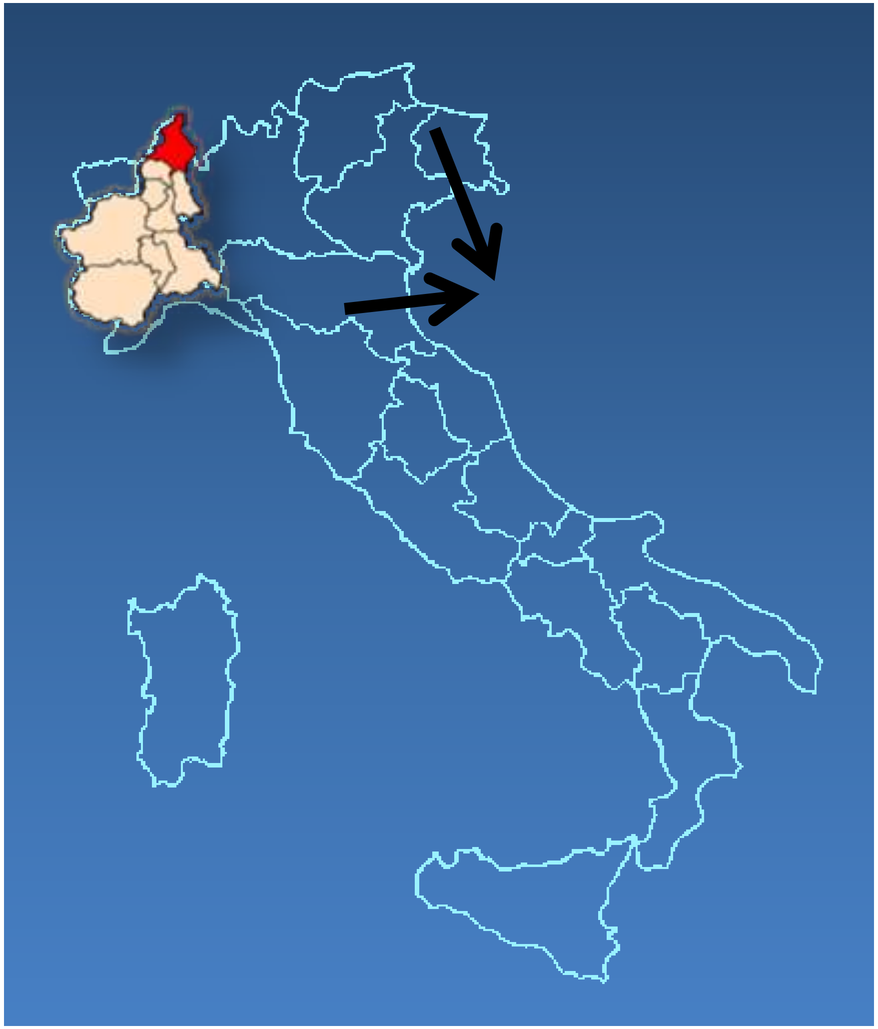
• Dry vs Wet sites

• Sistematically searched for eggs/instars

3 times during the season / 2 hours for visit

Characterized in term of LHP

Random squares 1x1 m (15% minimum coverage by *Vaccinium uliginosum*) -Vegetation structure - Height of herbaceous and shrubs layer - LHP description (height, spring growth, number of leaves, lenght and widht of the apical leaf)

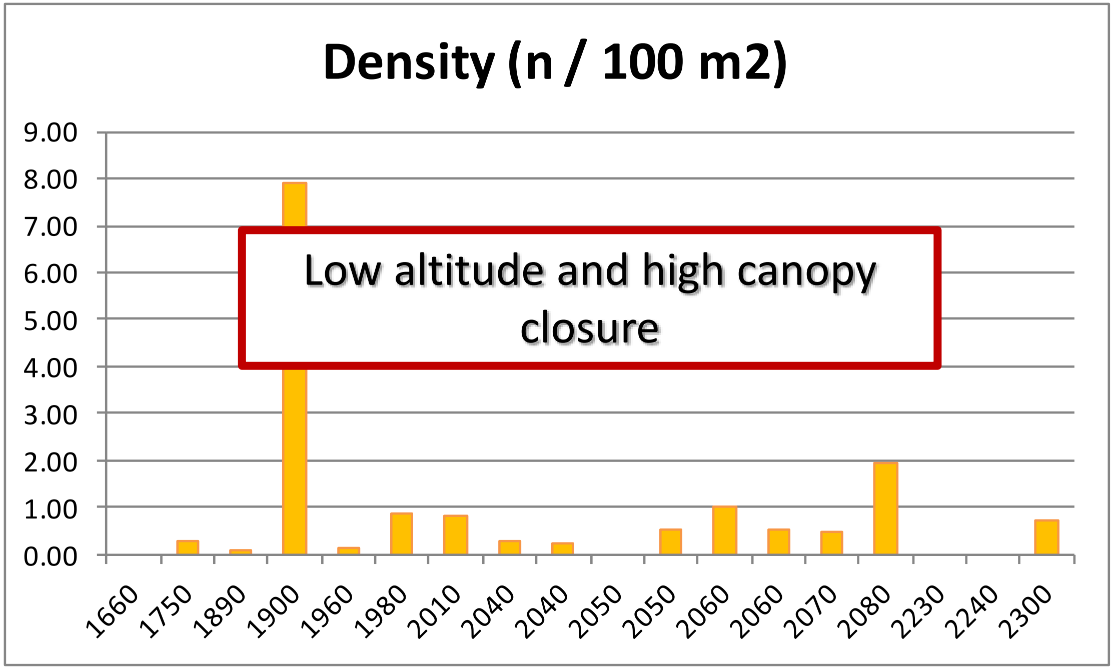


Where is Colias palaeno the Alps?

	dry	humid
occupied	4	10
not occupied	3	1

104 caterpillars in 14 study areas

1. Most sites were occupied (14 vs 4)
2. Low densities



Name: Balma
Habitat: Peat bog
Altitude: 2000 m
Dimension: 1.6 ha
Number of pre-immaginal stages: 100

Name: Erioforo
Habitat: Humid area
Altitude: 2000 m
Dimension: 1.2 ha
Number of pre-immaginal stages: 90

Larval survival - Study areas

Name: Arpa
Habitat: Alpine heathland
Altitude: 1900 m
Dimension: 0.5 ha
Number of pre-immaginal stages: 170

Name: Curzalma
Habitat: Alpine heathland
Altitude: 2300 m
Dimension: 0.3 ha
Number of pre-immaginal stages: 80

Larval survival - Study areas

Larval survival - Sampling methods

Micro-climate

Data-logger
Micro-habitat structure

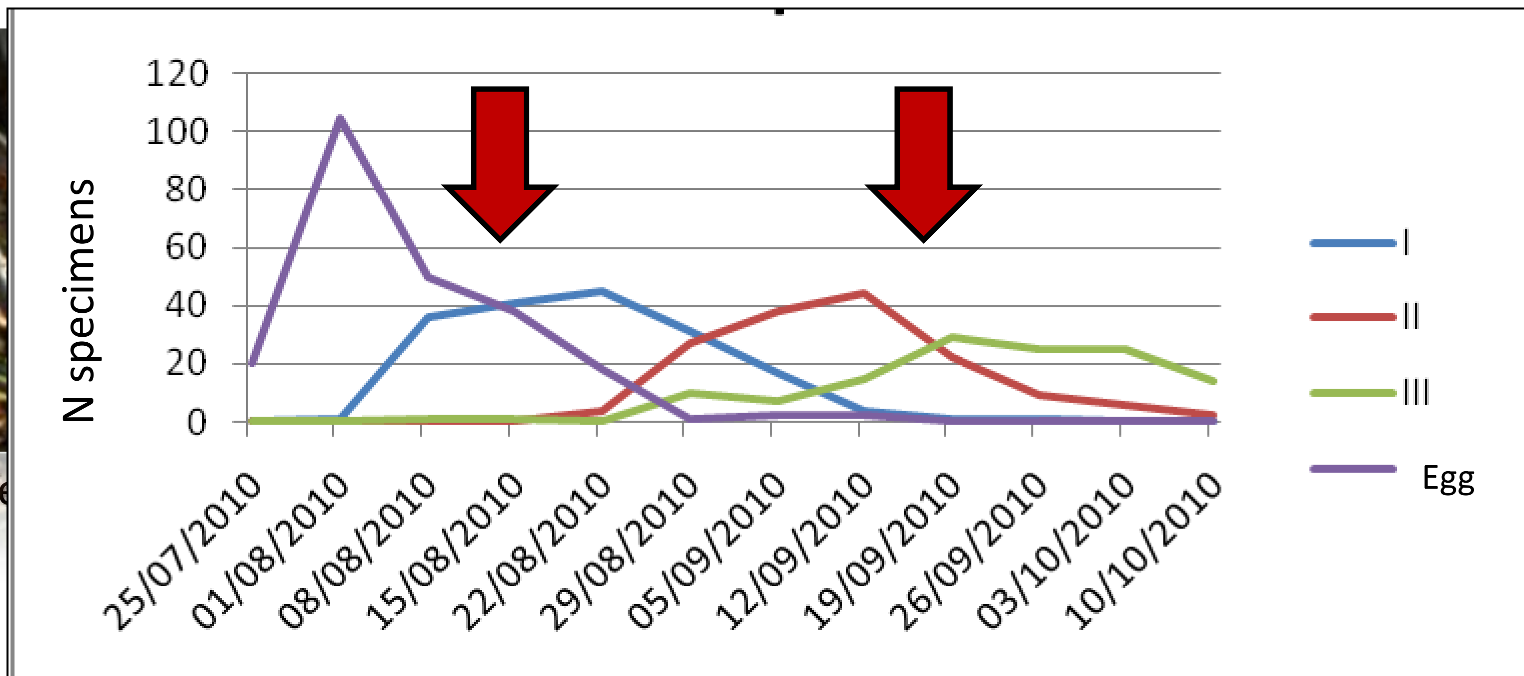
Larval Host Plant

Spatial and temporal sampling

Mid August
Mid September

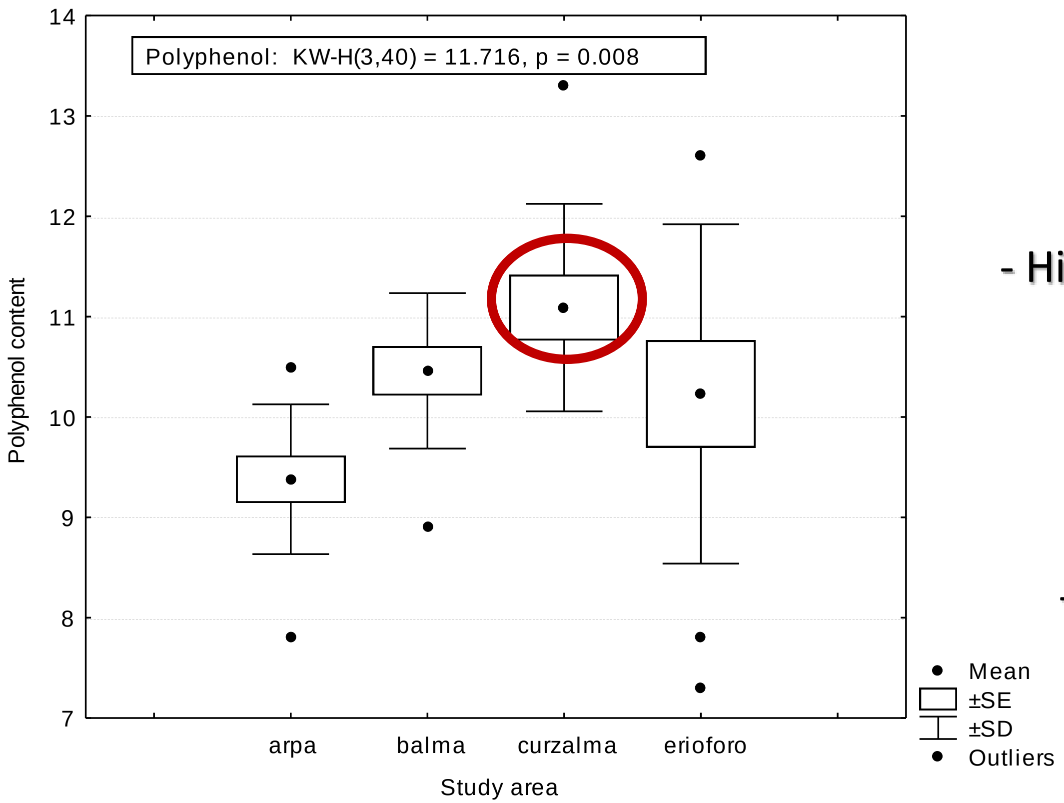
10 sampling points per site in Italy

Life



Larval survival - Main results

Habitat	Altitude	Egg - I	I - II	II - III	Total
Heathland	1900 m	58.6	63.9	54.4	20.4
Humid area	2000 m	44.9	63.2	48.6	13.8
Peat Bog	2000 m	55.0	60.0	39.5	13.0
Heathland	2300 m	48.0	45.5	32.0	7.0



Lower survival rate:

- Higher level of polyphenols and tannins

- Higher level of secondary metabolites/nitrogen ratio

- No differences in primary metabolisms among sites

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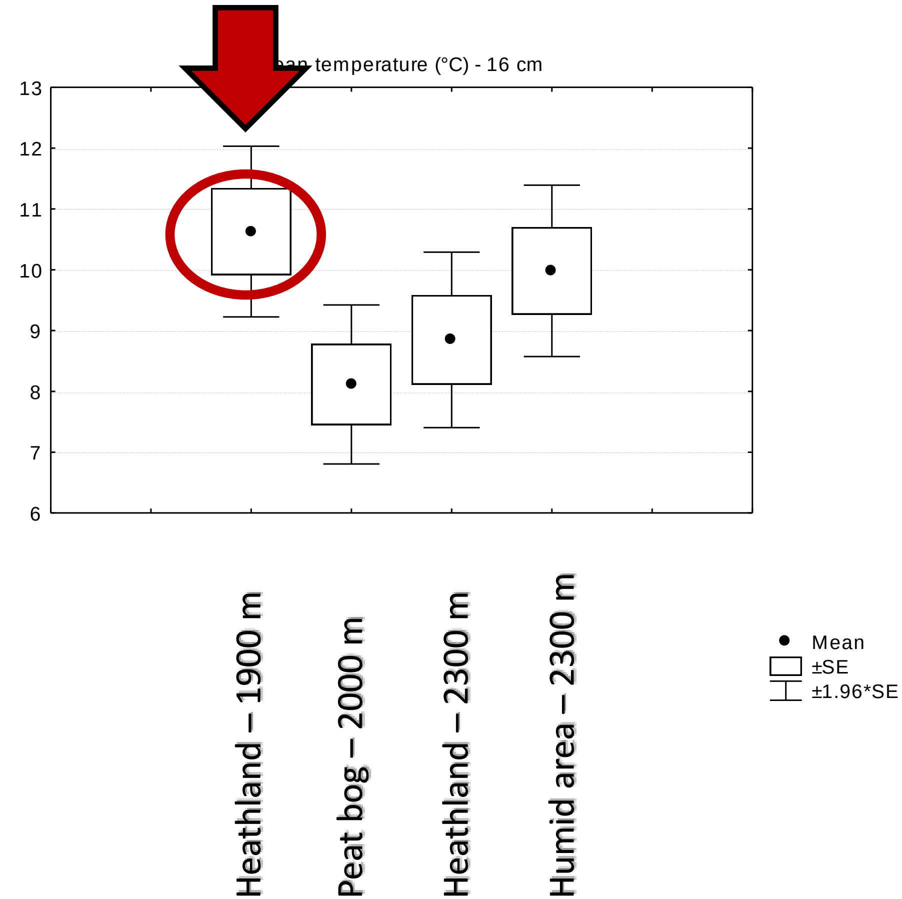


- Higher survival rate: higher near-ground temperatures

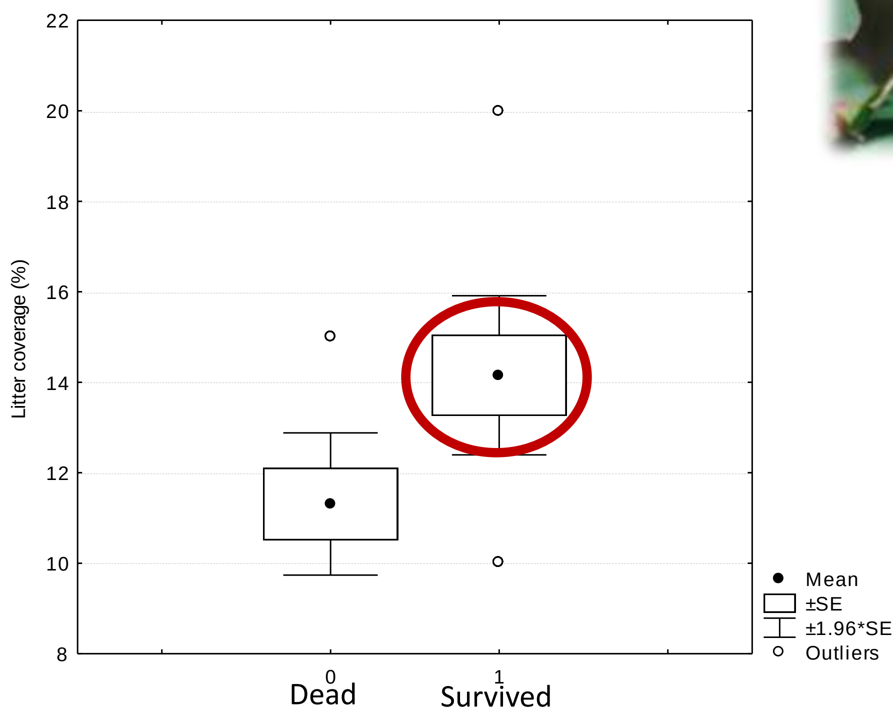
Friedman ANOVA test, N = 22, df = 3, χ^2 = 53.073, $p < 0.0001$

To avoid temporal autocorrelation, we used a subsample of sampling period (2/8 - 5/10): every 3 days mesurements (r <0.5)

Egg - first instar: site and vegetation structure

N dead = 165

N survived = 187

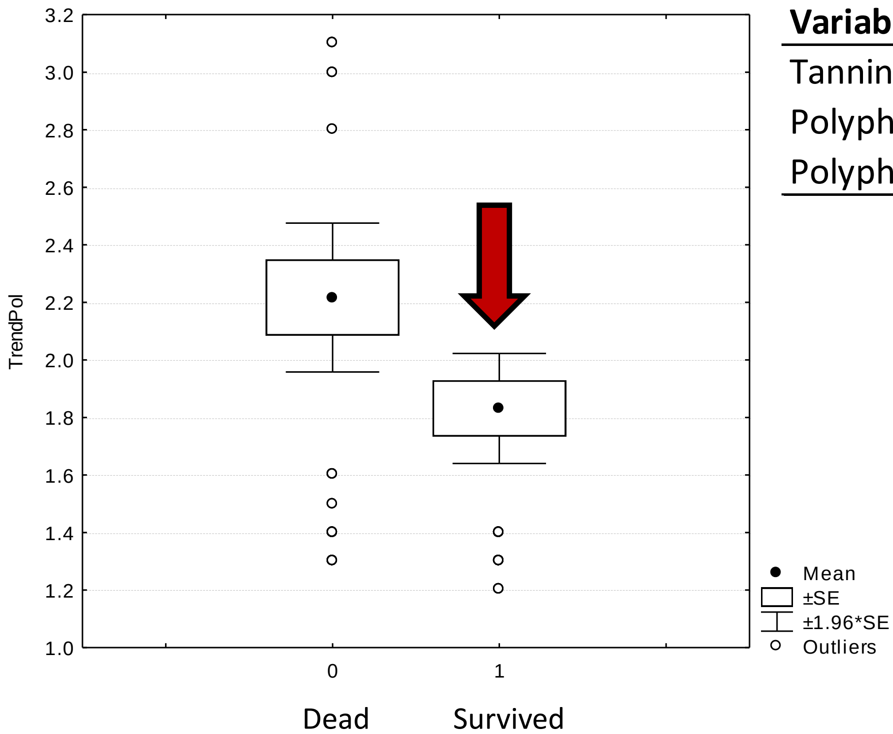


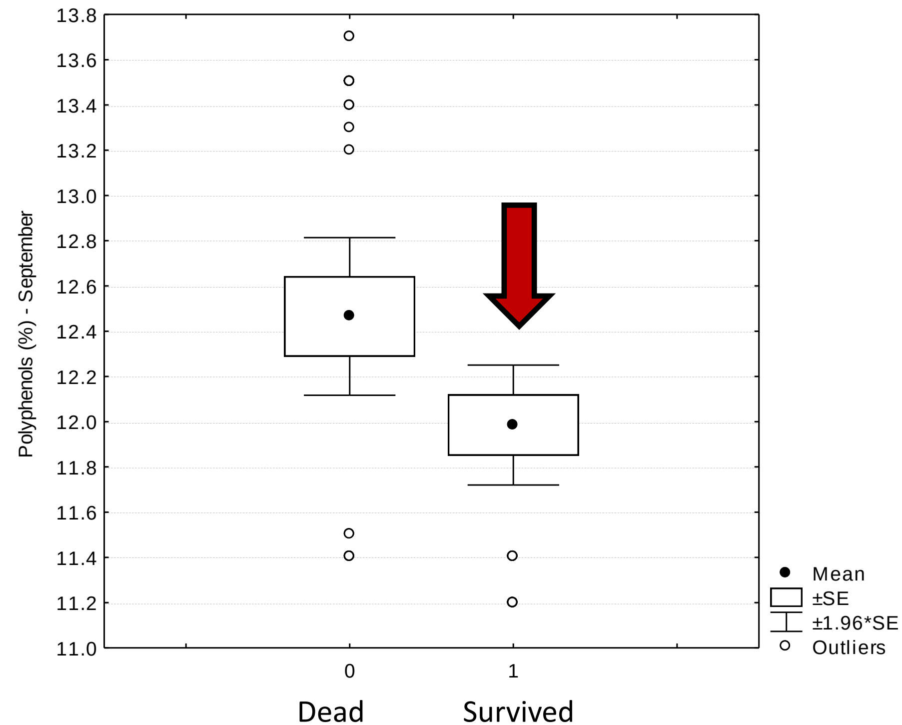
Variable	Dead	Survived
Litter coverage (%)	11.3 (0.8)	14.2 (0.9)

Parameters	Estimate	Standard	Wald	p
Interc	0.516	0.557	0.859	0.354
litter coverage	0.034	0.013	6.598	0.010
shrubs	-0.013	0.007	3.910	0.048
Area: heathland (1900 m)	0.636	0.193	10.799	0.001

First - second instar: secondary metabolites

Variable	Dead	Survived
Tannins (%) - seasonal trend	1.1 (0.1)	0.8 (0.1)
Polyphenols (%) - september	12.5 (0.1)	12.0 (0.1)
Polyphenols (%) - seasonal trend	2.2 (0.1)	1.8 (0.1)

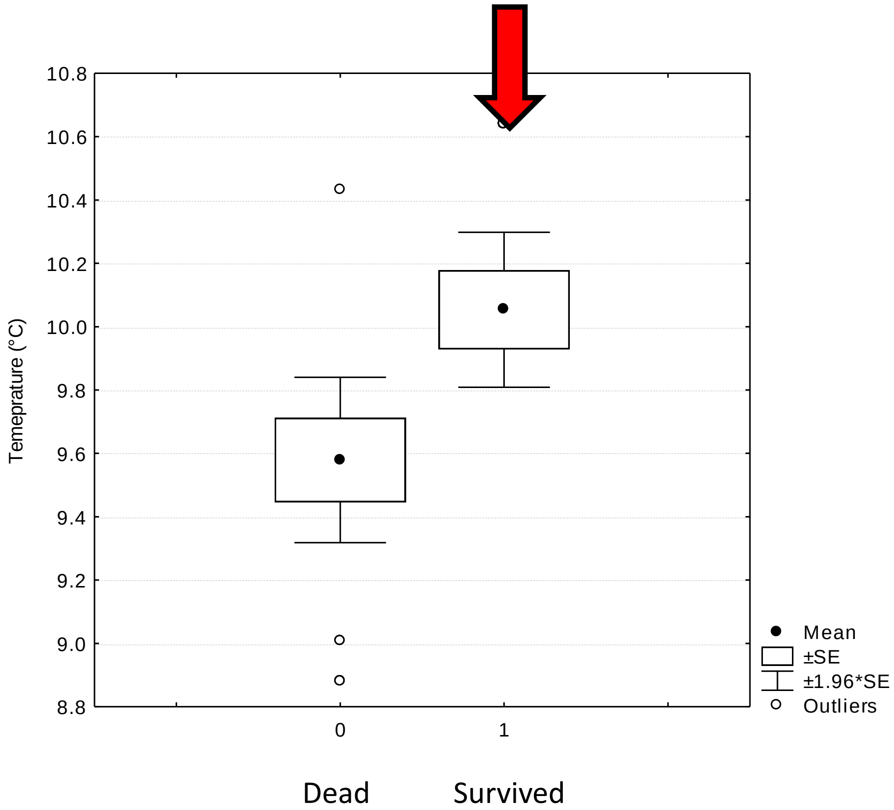




Variable	Z	p-value
Tannins, seasonal trend	2.58	0.009
Polyphenol September	2.35	0.018
Polyphenol, seasonal trend	2.61	0.008

	Estimate	Standard	Wald	p
Interc	0.865	0.290	8.914	0.003
Polyphenols (%) - Seasonal trend	-0.262	0.124	4.437	0.035

Second - third instar: temperature



N dead = 77

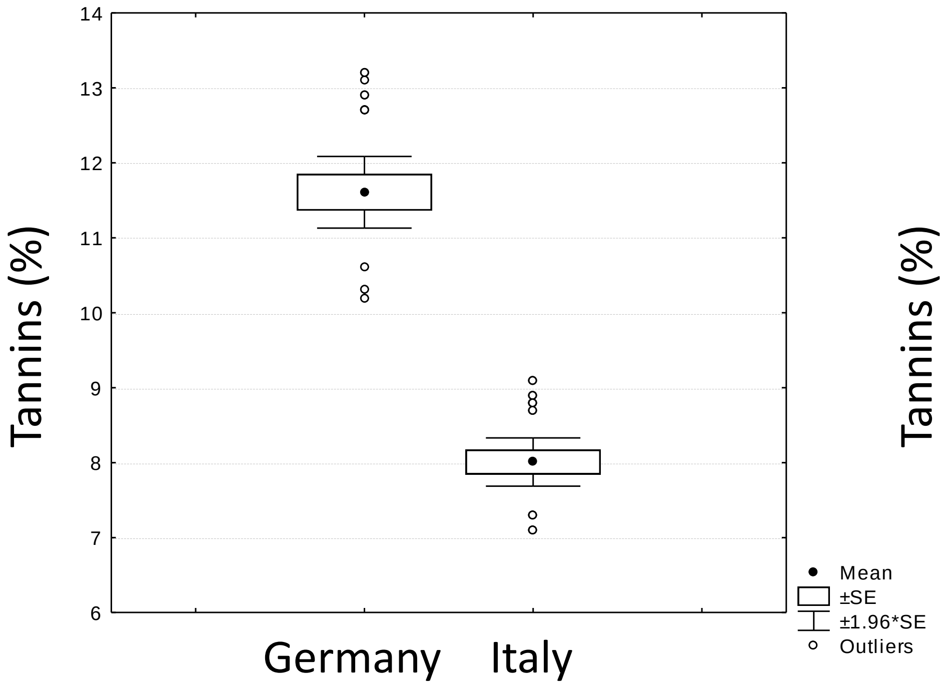
N survived = 67

II - III instar	Mean (SE)
Dead	9.6 (0.1)
Survived	10.1 (0.1)

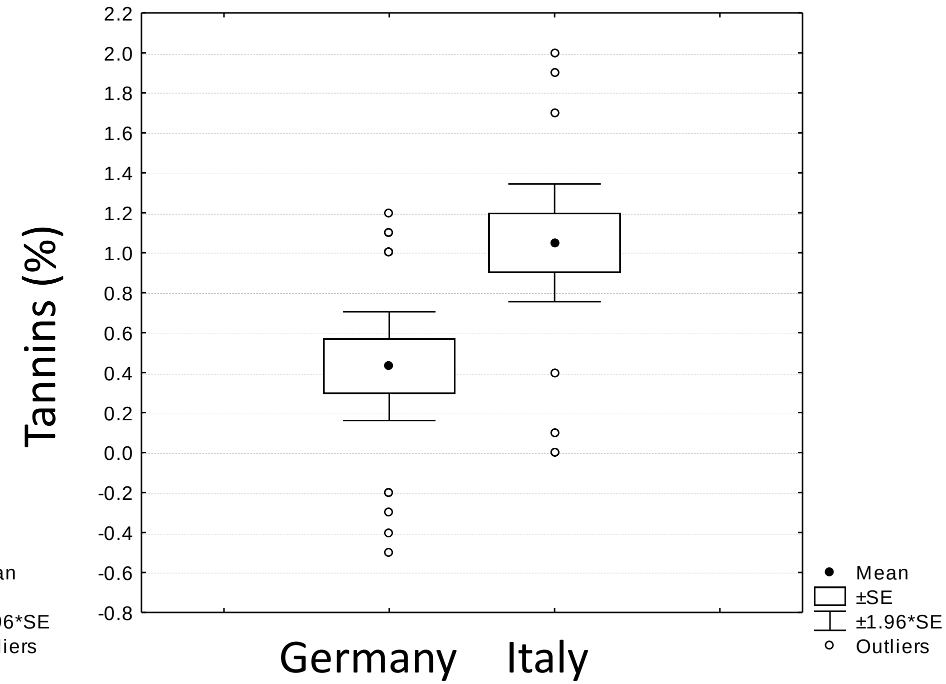
	Estimate	Standard	Wald	p
Interc	3.997	1.561	6.552	0.010
Temperature	0.393	0.157	6.218	0.013

Colias palaeno - Comparison with german sites

First sampling



Seasonal trend



	Germany		Italy		M-W Test	
	Mean	SE	Mean	SE	Z	p-value
Tannins (First)	11.61	0.24	8.01	0.16	7.455	0.000
Polyphenols (First)	15.55	0.29	10.29	0.20	7.589	0.000
Tannins (Second)	12.04	0.25	9.06	0.22	6.560	0.000
Polyphenols (Second)	15.75	0.29	12.51	0.28	6.242	0.000
Diff Tannins	0.43	0.14	1.05	0.15	-2.961	0.003
Diff Polyphenols	0.20	0.17	2.22	0.20	-6.107	0.000

Secondary metabolites: higher in Germany

Seasonal trend: higher in Italy

Colias palaeno - Conclusion

1. Higher density and survival rate near the timberline

2. Different parameters (vegetation structure, secondary metabolites, temperature) are important for different immature stages

3. Possibility of phenological asynchrony

Aknowledgements

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Thanks for your attention!