FiBL
EXCELLENCE FOR SUSTAINABILITY

Research Institute of Organic Agriculture
Forschungsinstitut für biologischen Landbau
Institut de recherche de l'agriculture biologique



Functional Agro-Biodiversity to improve organic orchards

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Functional agrobiodiversity (FAB)

an integral part of a 4-step strategy in organic farming

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mones measures

Inundat  i  biocontrol
(e.g. bact ru cial insects)

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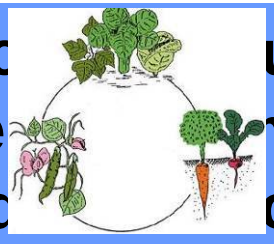
 rac  uding
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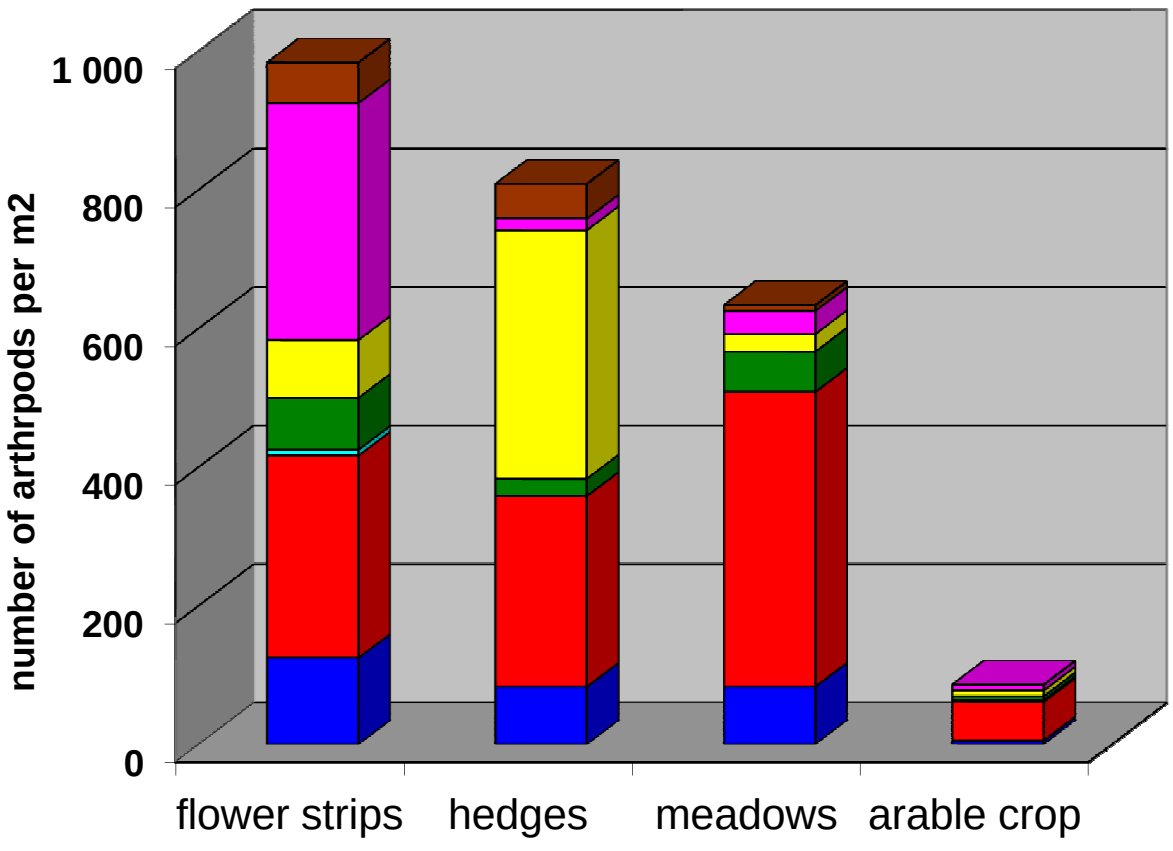
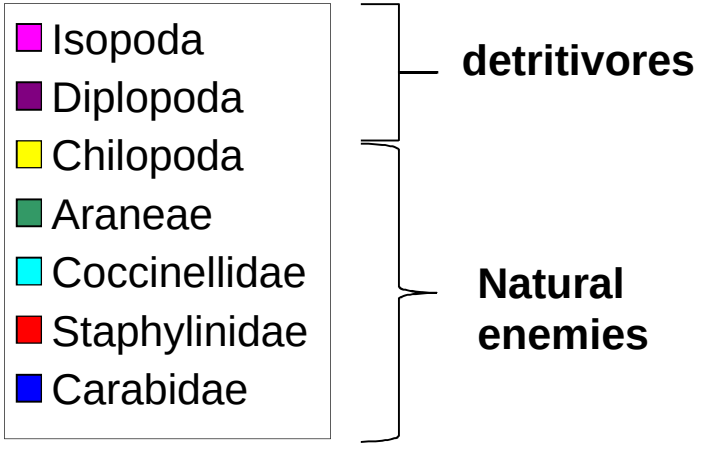
Zehnder et al., Ann. Rev. of Entomology, 2007

Semi-natural and flowering habitats as excellent overwintering sites for most beneficials





(Pfiffner & Luka 2000)

How to optimize an ‘eco-service’ as pest control or pollination?

General biodiversity per se – does NOT enhance automatically *specific functional groups*

To boost *natural enemies* or *pollinators*, tailored measures are needed because they

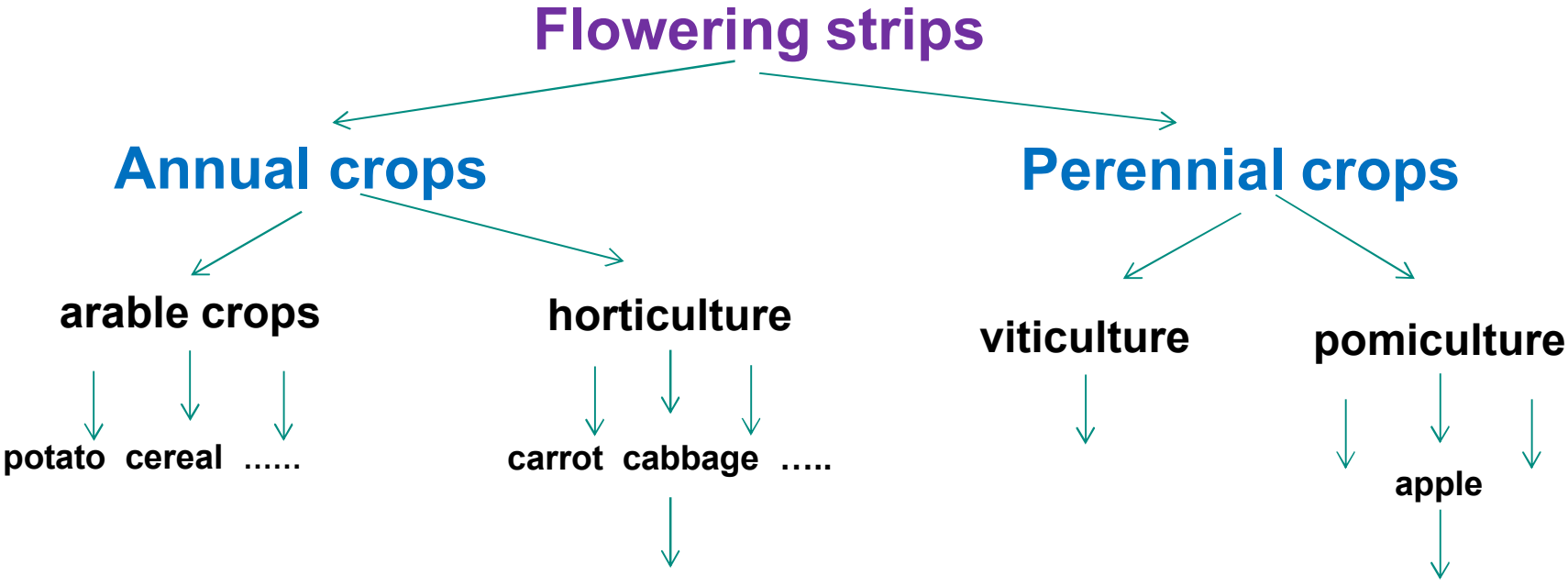
- have their specific requirements on food plants
- possess distinct flower associations
- use different habitat/refugia
- have different action radius in the landscape

Parasitoids and hoverflies need **short-term** corolla flowers as apiacea with shallow, open nectaries

Bumblebees need **long-term** corolla flowers (e.g. fabacea)

Flowering strips tailored to cropping system

in relation to the pest-complex



Screening of plants – a key issue

Main selection criteria for lab- and semi-field tests

1. Attractiveness of plant
2. Accessible food sources
3. No benefit for pests

→ **selective plant mixtures**

Ammi majus

Fagopyron esculentum

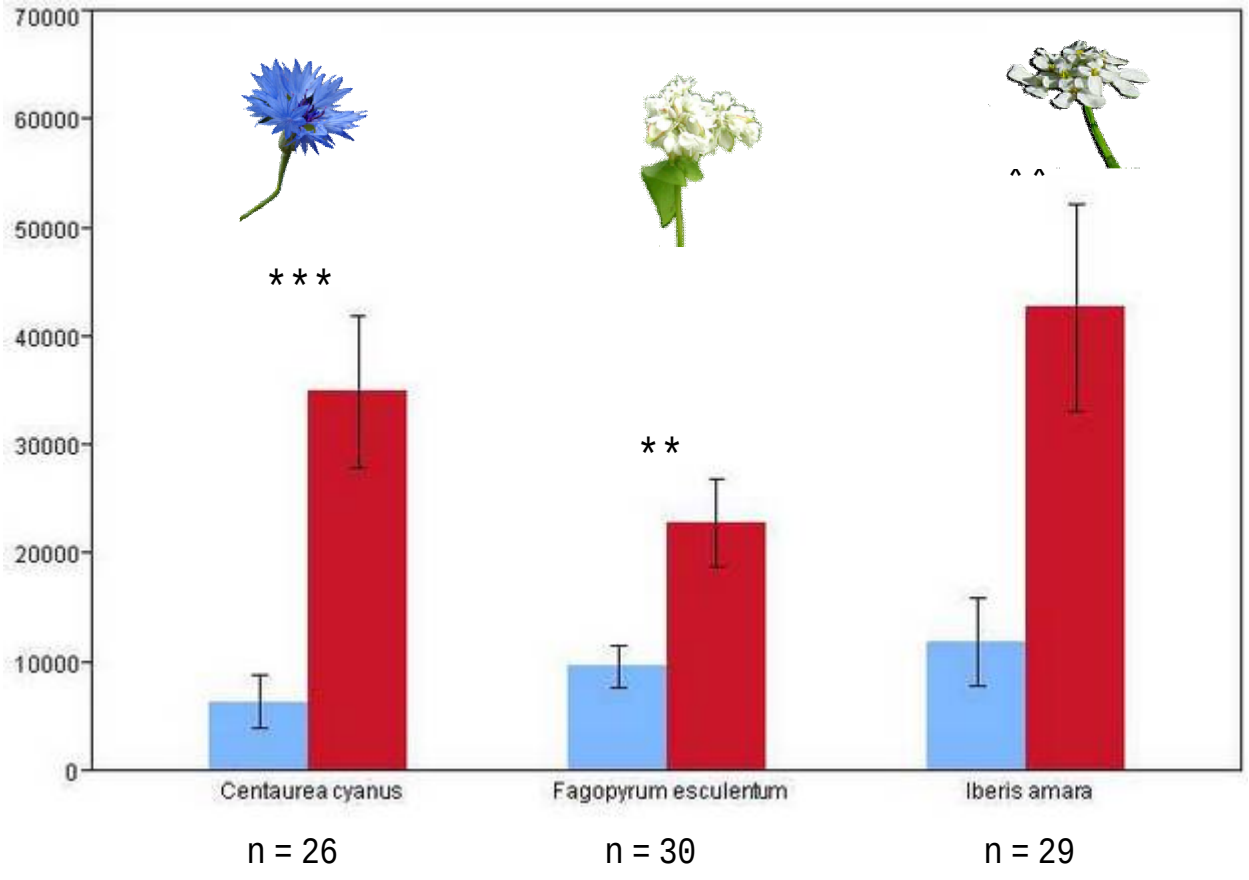
cornflower

Vicia sepium and V. sativa

Daucus carota

Attractiveness of different plant odours for parasitoid (*M. mediator)*

–> visual and olfactoral cues



(Belz et al., 2012)

Impact of flower species on longevity and fecundity of *parasitoid and pest*

- Daily exposition of 30 pest larvae (*M. brassicae)*
- Final dissection of larvae

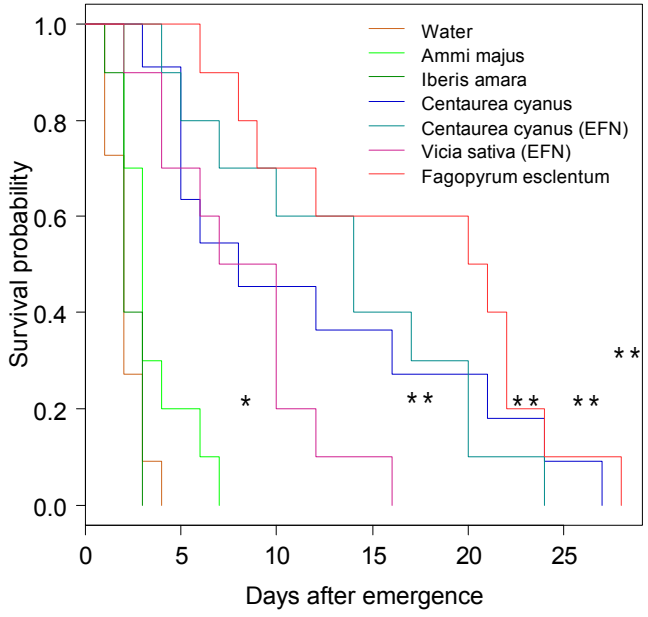
50 cm

100 cm

Release of 2 wasps (♂/♀)
(<24h, unfed)

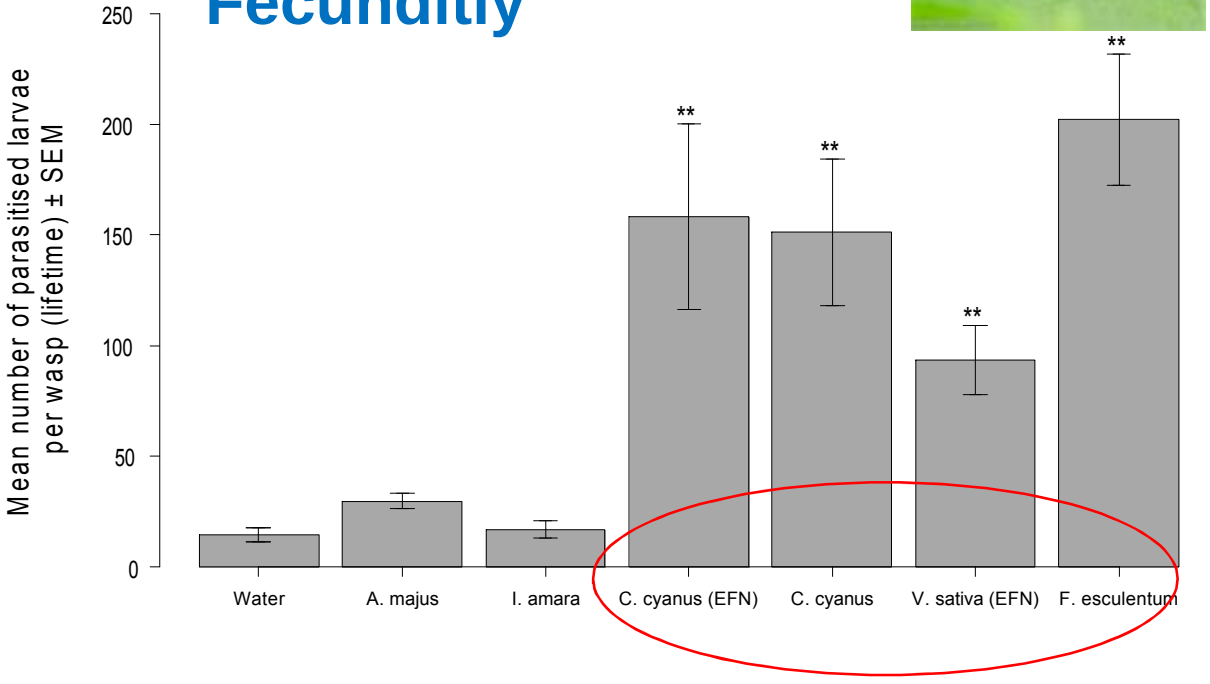
Impact of plants on longevity and fecundity of parasitoid (*M. mediator)*

Longevity



Cox‘ s regression model; Likelihood ratio test p<0.01

Fecunditiy



Linear mixed effect model: **, $p < 0.01$, n = 10

3 best flowers:

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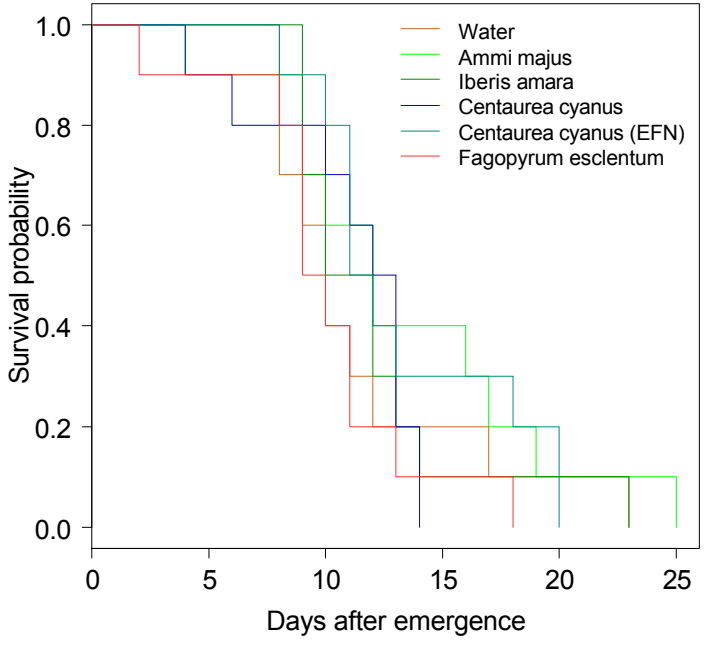
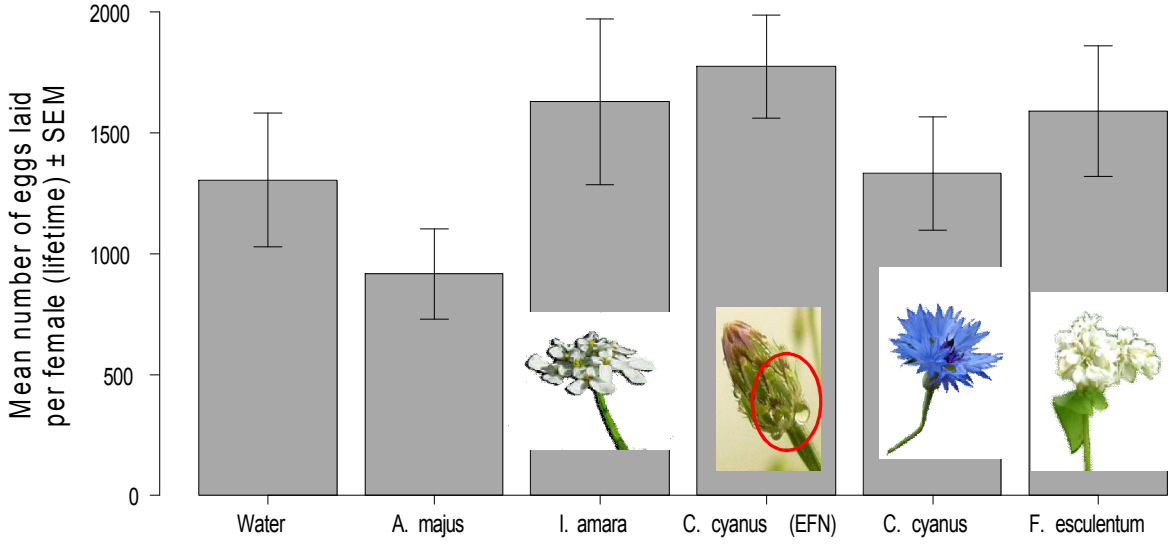
(Géneau et al. 2012)

Impact of plants on *longevity* and *fecundity* of the pest (*M. brassicae)*





Cox‘ s regression model; Likelihood ratio test p<0.01

Linear mixed effect model: **, $p < 0.01$,

No effect of tested flower -> requirement fulfilled

(Géneau et al. 2012)

In field verification of egg and larval parasitoids

host	parasitoid	family
Mamestra brassicae		
Larvae	*Microplitis mediator*	Braconidae
Egg	Telenomus sp.	Scelonidae
Egg	Trichogramma sp.	Trichogrammatidae
Larvae	*Meloboris collector*	Ichneumonidae
Larvae	Mesochorus sp.	Ichneumonidae
Larvae	Scelionidae sp.	Scelonidae
Pieris rapae		
Larvae	*Cotesia rubecula*	Braconidae
Larvae	*Mesochorus pectoralis*	Ichneumonidae
Larvae	*Cotesia glomerata*	Braconidae
Larvae	*Lochetica westonica*	Ichneumonidae
Plutella xylostella		
Larvae	*Diadegma semiclausum*	Ichneumonidae
Puppa	*Diadegma semiclausum*	Ichneumonidae
Puppa	*Cotesia plutellae*	Braconidae
Larvae	*Itoplectis maculator*	Ichneumonidae
Larvae	Braconidae sp.	Braconidae

(Pfiffner et al. 2003)

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Aspects of successful
implementation into practice

Available seed mixtures a prerequisite

- Seed of indigenous and regional provenance (best case!)
- Certified seeds mixture made by national companies
- CH: Officially recomended mixtures to get the subsidize of AES

Some agronomic relevant aspects

- *Use of suitable mixture* in relation to target: pest control, pollination, soil fertility or nature conservation
- *Sowing in the best season* (spring weediness)

- *Management of perennial strips* necessary for species richness and floweriness – challenge!
- *Soil tillage* advantagous, only mulch/cutting favors grasses
- *Regular control of voles (!) and weeds – flower strips are high quality habitats for voles*

Management, weedcontrol to sustain flowering vegetation

- 6-year field trials on different soil types showed that management may conserve improve flowering vegetation
- Mainly management in *2nd or 3th* year – in relation to vegetation and soil

with mangement
cutting/mulch & soil tillage

without mangement

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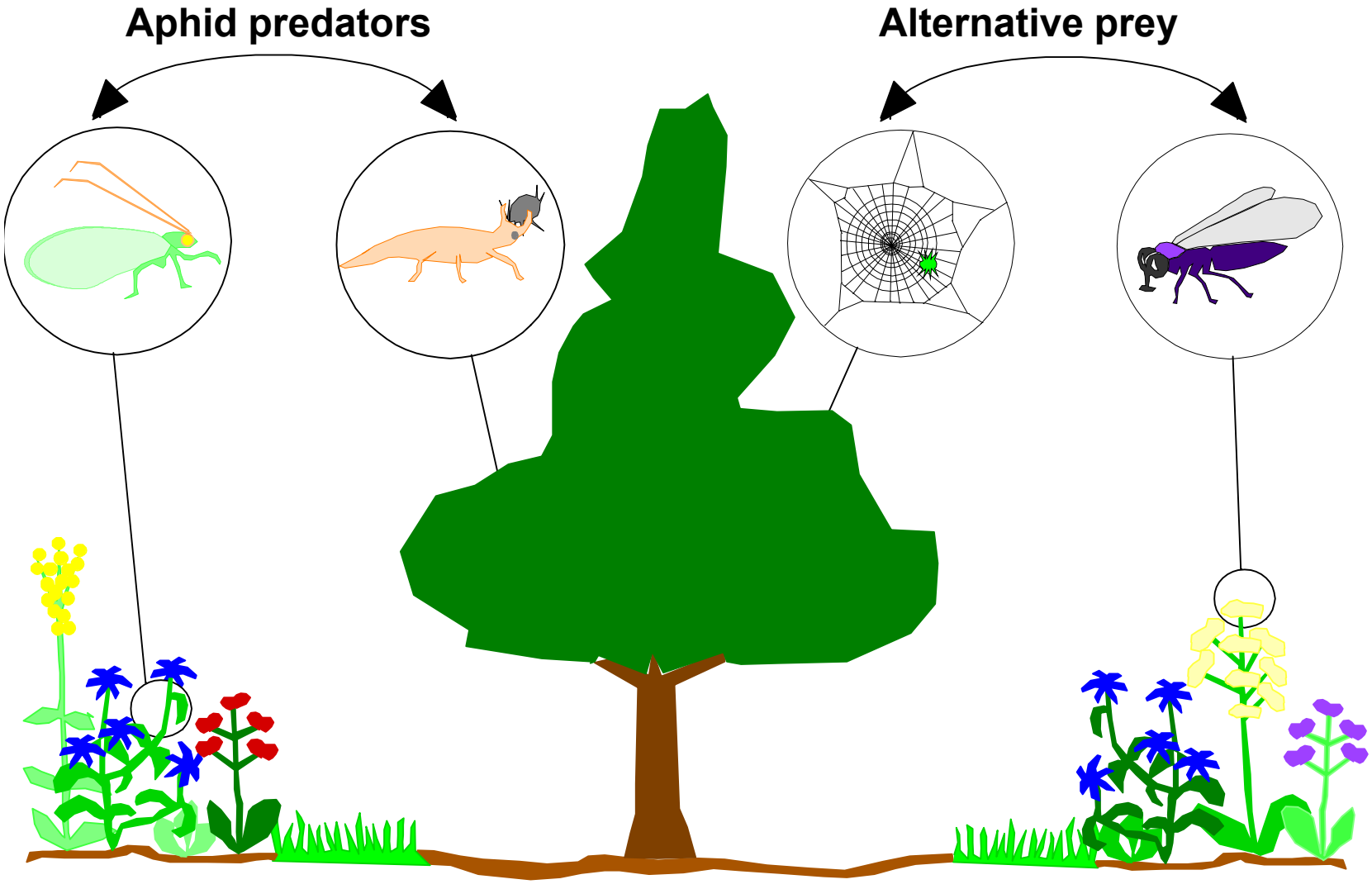
(Uehlinger, G., Schaffner, D. & Pfiffner, L. 2005)


Tailored flower ing strips
to boost natural pest control

Functional agro-biodiversity in orchards – case of aphids – alternative prey/food in flower strip



Flowering plants – testing different mixtures

- Selecting plants enhancing beneficials (fecundity, longevity, densities)
- Without benefit for any pest – selective plant mixtures

Gras species –> to stabilize drive row	
i Platthalm-Rispengras	Poa compressa
i Harter Schafschwingel	Festuca guestfalica
Flower species – dicods –> offering nectar and pollen	
Brown Knapweed	Centaurea jacea
Queen Anne's lace	Daucus carota
Caraway	Carum carvi
Coomun self-heal	Prunella vulgaris
Bird's-foot Trefoil	Lotus corniculatus
Hedge Bedstraw	Galium mollugo
Chicory	Cichorium intybus
Bush vetch	Vicia sepium

→ Many species of *apiaceae and fabaceae* are valuable nectar and pollen donors

Extrafloral nektaries: valuable additonal nectar-sources

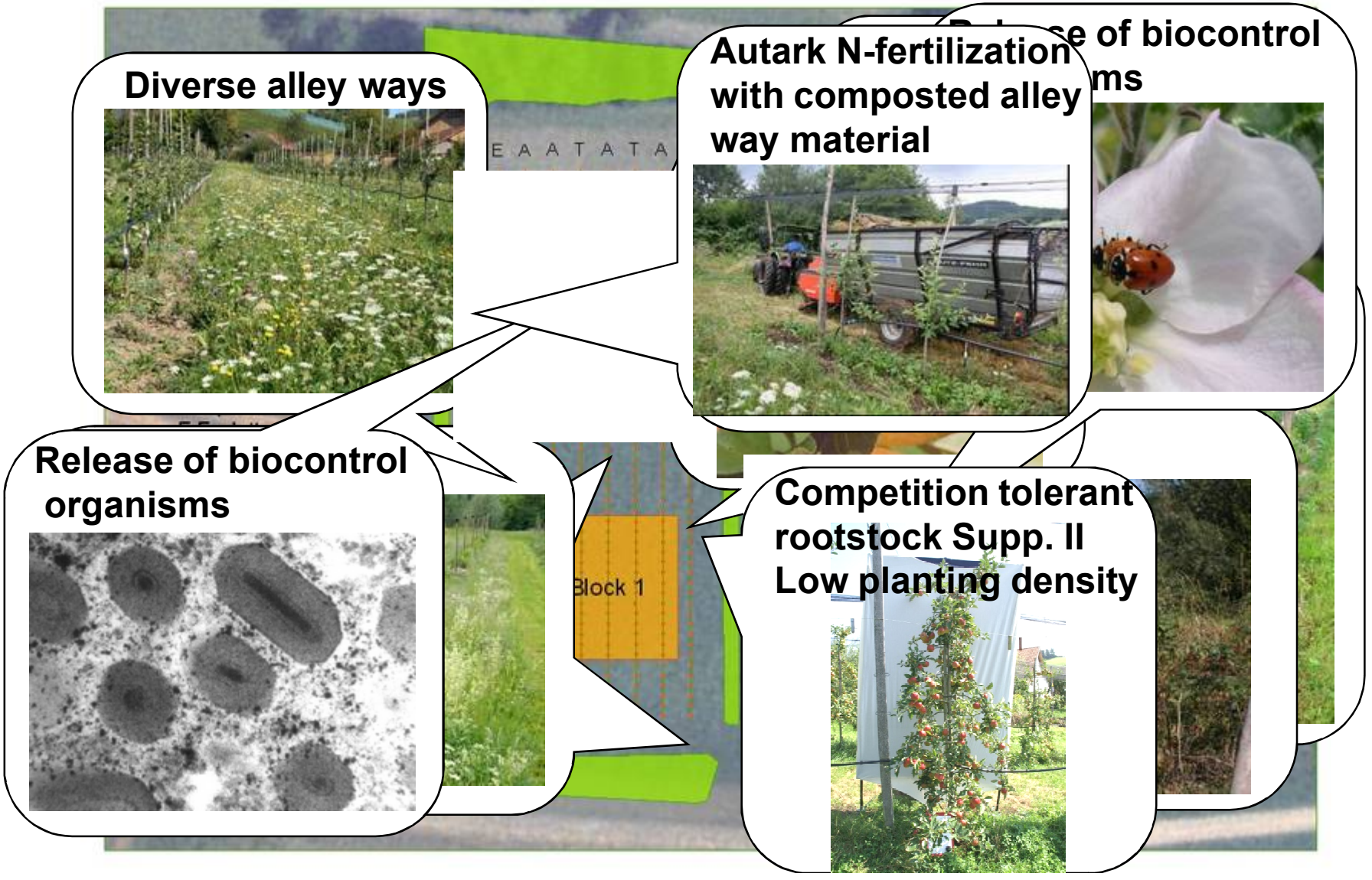
Common vetch:
larval-parasitoid
(Microplitis mediator)

- **Common vetch** *(Vicia sativa)*
- **Bush vetch** *(Vicia sepium)*
- **Cornflower** *(Centaurea cyanus*)
- **Sunflower** *(Helianthus annuus)*

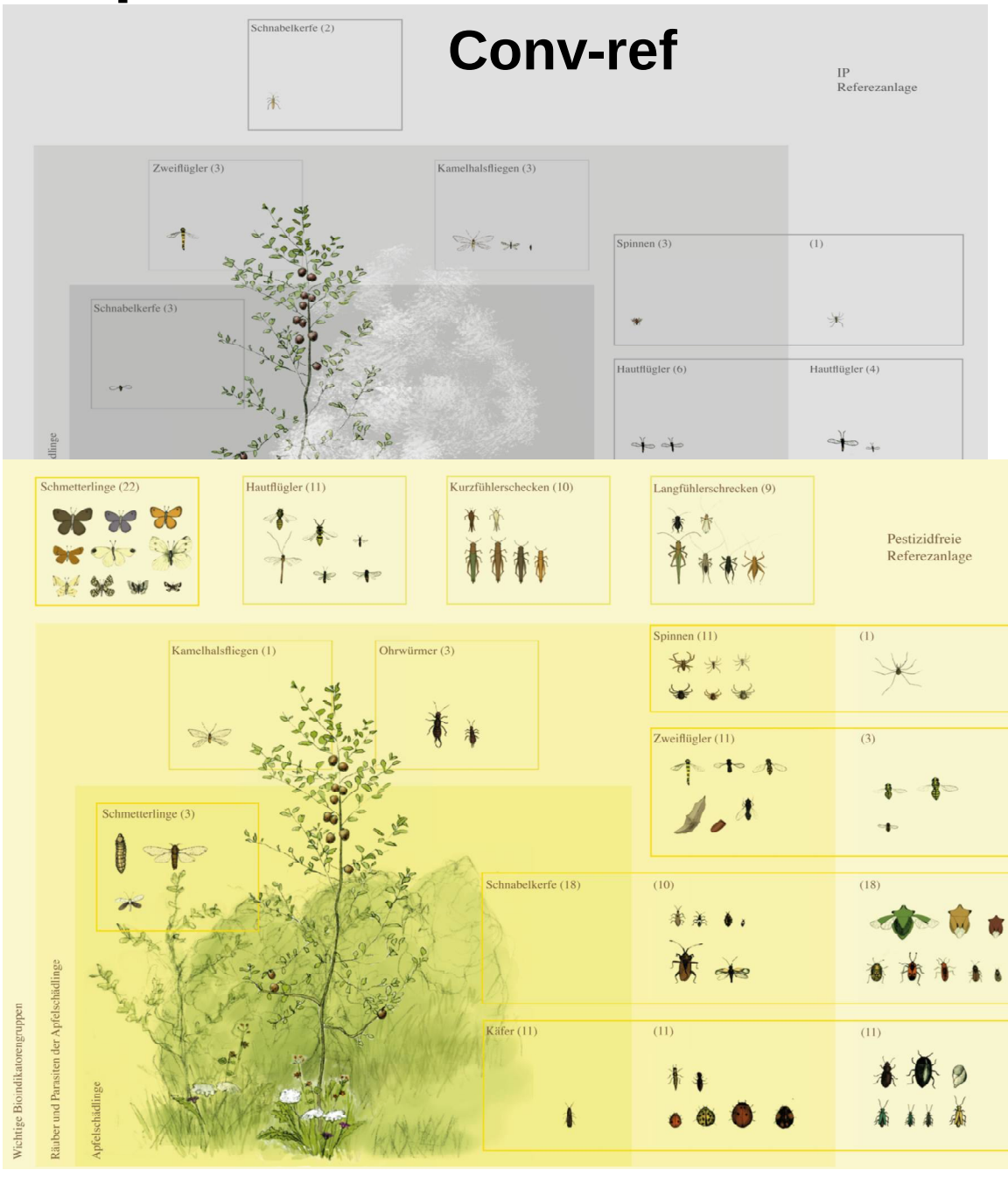
Cornflower

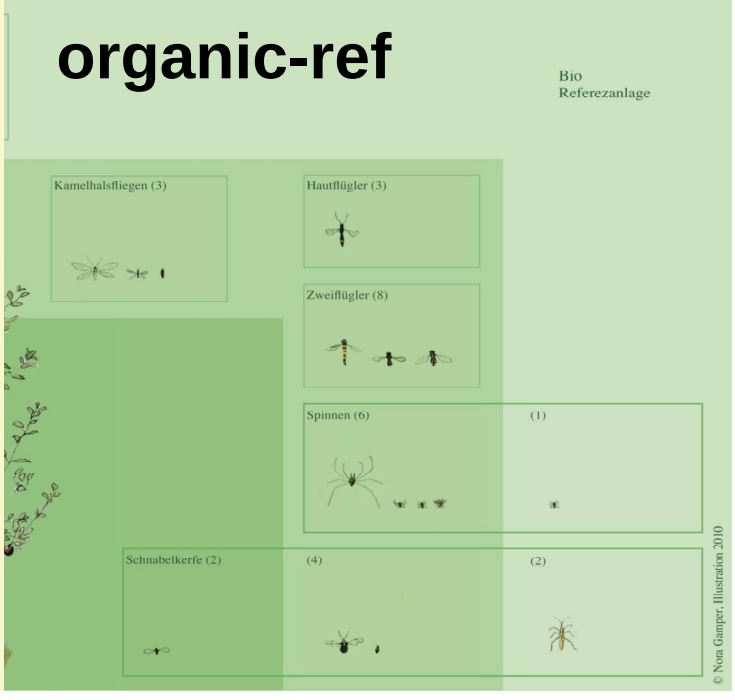
Sustainable Fruit System – FiBL (2006-2016)

- Pesticide-free apple production based on FAB- system design and biocontrol



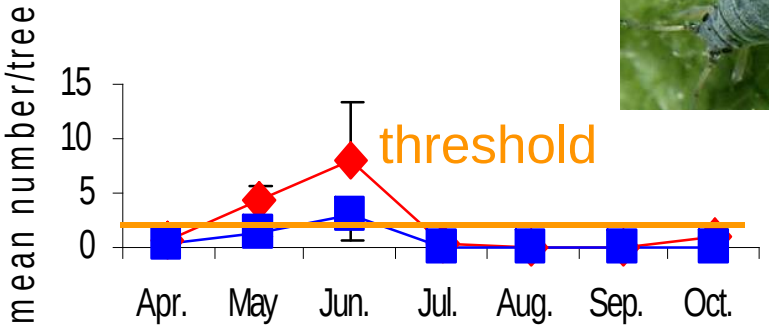
Impact of diversification on arthropods diversity





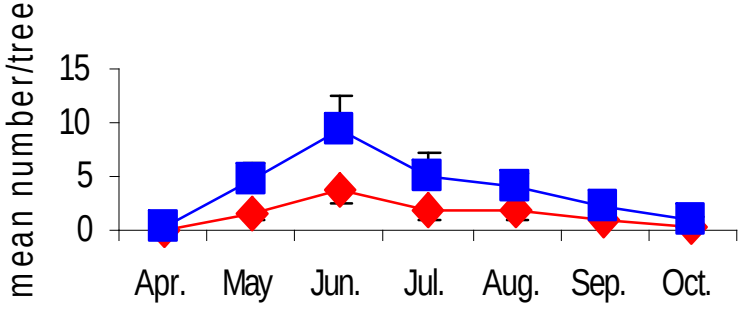
Significant impact of flowering strip on key aphid pest and natural enemy

Dysaphis plantaginea

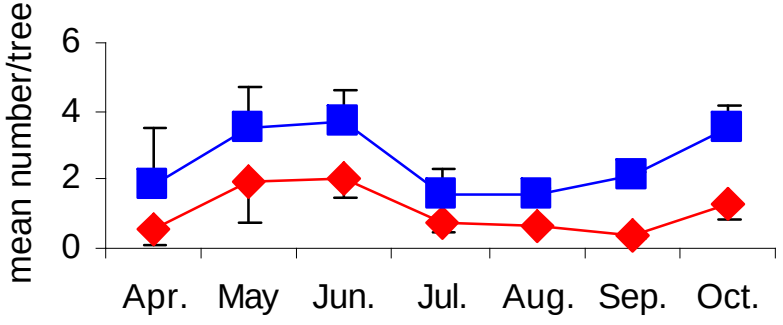


predators

Aphid predators



Spiders



Development of rosy apple aphid, potential prey, spiders, and predators in strip-managed part or control part of an apple orchard

(Wyss, 2005)

Successful implementation of flower strips on-farm

Key aspects

- Tailorded plant mixture and additonal structures (bushes etc.)
- Optimal layout of non-crop features/habitats
- Site adapted management of the strips to sustain high plant diversity, long flowering
- Adapted machinery for mulching the understorey – drive row – tree-row
- Monitoring of pest and natural enemies; risk of voles
- Considering of the plant protection and fertilizer mangement

Thanks to

FiBL staff

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and all the many farmers involved.

References – most relevant FiBL FAB-papers

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Natural enemy interactions constrain pest control in complex agricultural landscapes

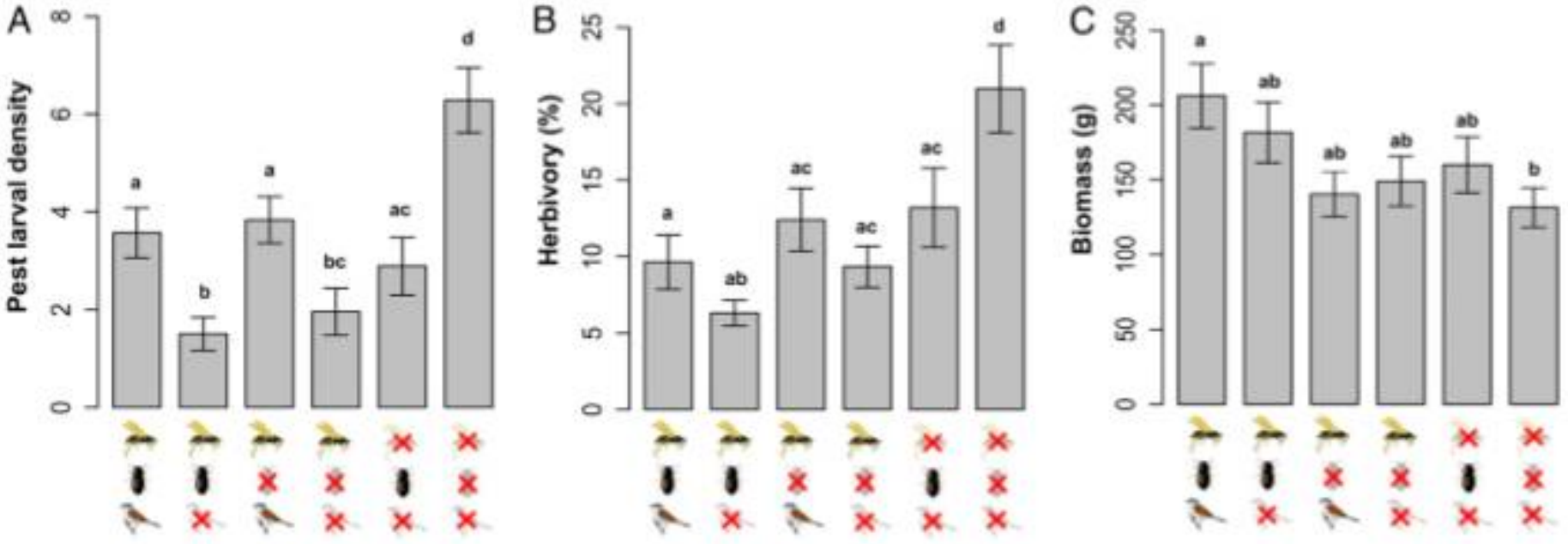
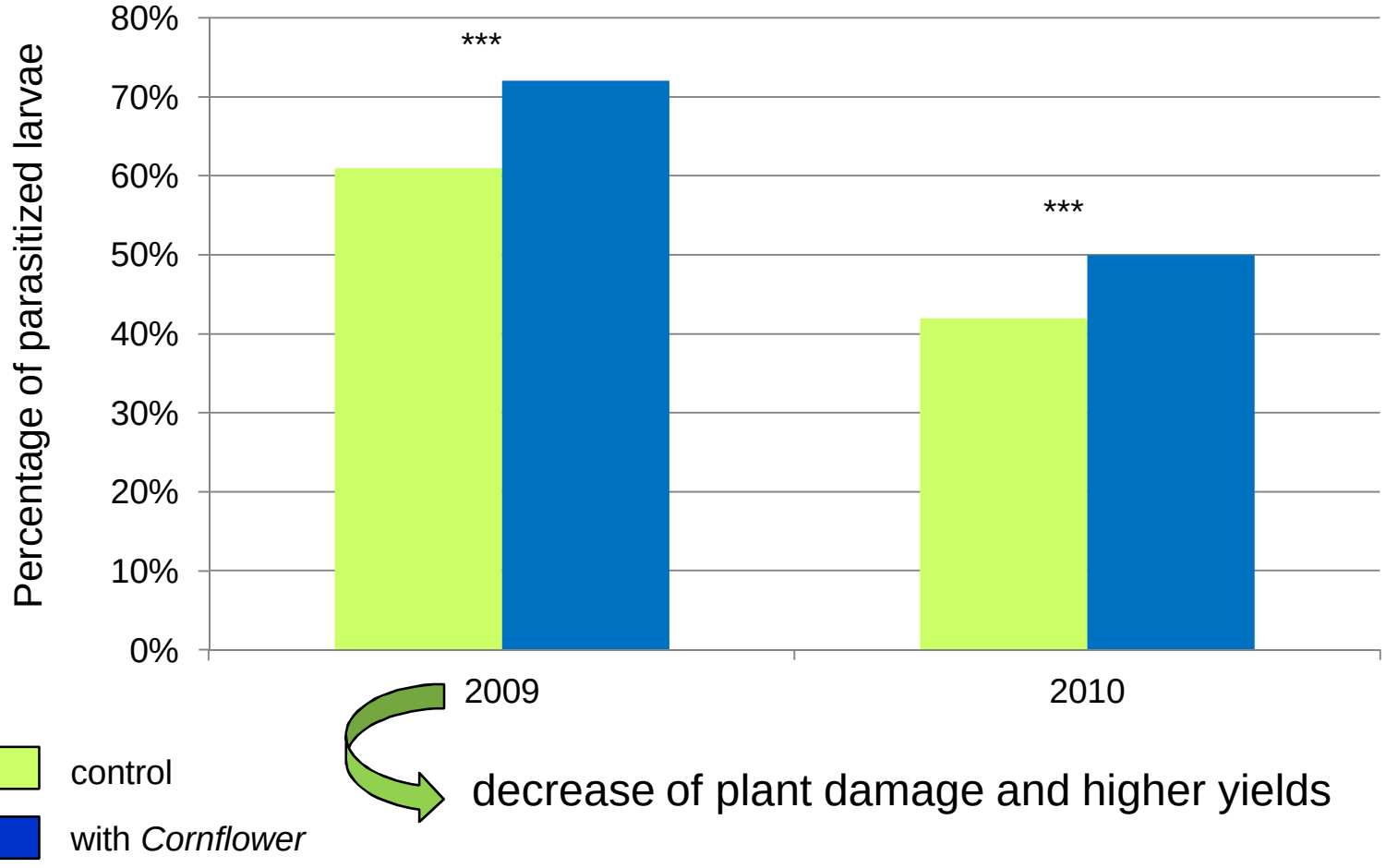


Fig. 1. Effects of natural enemy exclusion on means ± SEM per treatment. (*A*) Pest larval density (individuals per cage), (*B*) herbivory (%) of individual plants, and (*C*) fresh biomass (g) of individual plants. Different letters indicate significant differences among guilds (adjusted *P* values < 0.05). Effects of landscape complexity and interactions were significant in all cases (Table 1, Figs. 2 and 3, and Fig. S2). Crossed-out symbols signify exclusion of corresponding natural enemy functional guilds. Treatments remain accessible to nonexcluded guilds. Guilds of natural enemies are as follows: flying insects, mainly parasitoids, syrphid flies, and predatory wasps (wasp symbol); ground-dwellers, mainly carabid beetles, staphylinids, and spiders (beetle symbol); and birds and other vertebrates larger than 1.5 cm (bird symbol).

Analysis of pest parasitism *under field conditions*

(parasitoid *Microplitis mediator)*



generalized linear mixed-effects model, p = 0.0001

Balmer *et al. 2014*

Wildblumenmischungen

Welche Wildblumen? Wert Nützlinge, nachhaltige Etablierung
Anteil Gräser – welche? GL für eine ‘stabilen’ Bestand

Gräser		keimfähige Samen/m²	keimfähige Samen/m²
i Platthalm-Rispengras	Poa compressa	199.8	200.0
i Harter Schafschwingel	Festuca guestfalica	221.6	221.8
Wildblumen		keimfähige Samen/m²	keimfähige Samen/m²
i Wiesen-Flockenblume	Centaurea jacea	20.3	16.6
i Wilde Möhre	Daucus carota	23.0	18.8
i Wiesen-Kümmel	Carum carvi	17.3	14.1
i Kleine Brunelle	Prunella vulgaris	16.1	13.2
i Gewöhnlicher Hornklee	Lotus corniculatus	15.1	12.3
i Wiesen-Labkraut	Galium mollugo	14.9	5.0
i Gewöhnliche Wegwarte	Cichorium intybus	15.3	12.2
i Zaun-Wicke	Vicia sepium		12.5
			9.8

- **Standardmischung** ab 10 kg: Fr. 28.80/kg
- **Deluxe-Mischung** mit V. sepium Fr. 65.00/kg

Achieved milestones: in FAB FiBL-Research

Agronomic-technical level *(since 2000 to onwards)*

- *Knowledge about tailored flower strips* for vegetable and orchards to significantly improve pest management
- *Available management techniques* to conserve a minimum floral quality in orchard (management of botanical quality)

Farm-level

- *Useful tools to assess sustainability on-farm: Point Score System, SMART, RISE*
- *Training courses, integration of FAB in farmers advice for a better acceptance*

Agro-political level – Swiss State legislation

- *State legislation integrate this Novel FAB-element for natural enemies and bees for 2015 – Great Success (!!)*

FAB a tool to improve natural pest control

Big bottleneck in many agricultural landcapes
Lack of food resources (nectar, pollen) and shelter, refugia

Poor in food resources

Rich in food & habitat resources

Intensive agriculture – loss of biodiversity

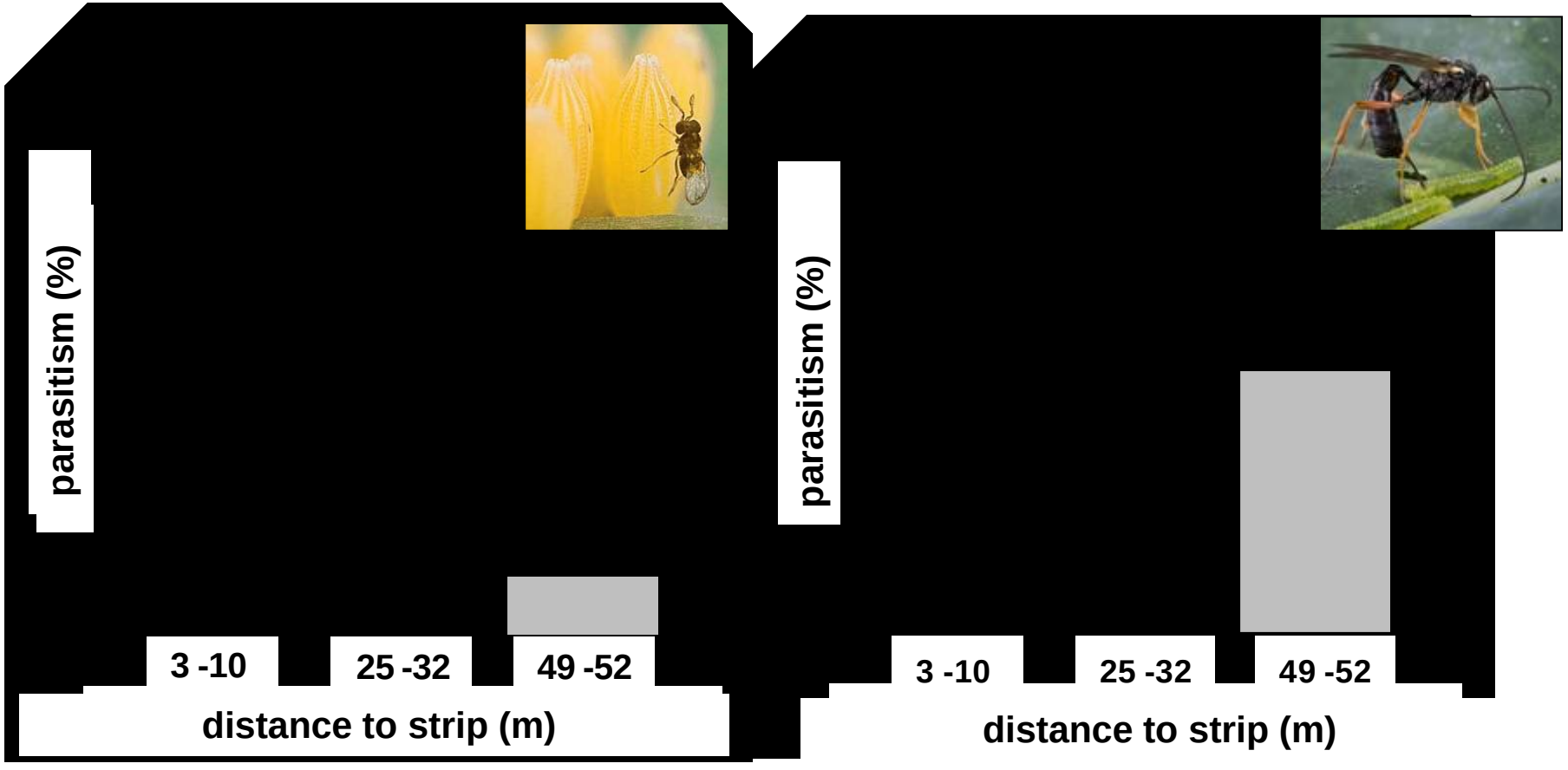
On the landscape level

- Larger fields
- Loss of non-crop elements
- Reduction of flowering elements

On the field level

- exessive use of agrochemicals
- heavy machinery
- simplification of crop rotation
- fewer crop species/varieties

Impact on field parasitism in relation to distance of flowering strip (pest *M. brassicae*)



Spill over into crop up to 30-50m

(Luka et al., 2009)