

Sampling an ecological network

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Different types of interactions: important to know which type sampled

trophic interactions: direct energy flux (predation)

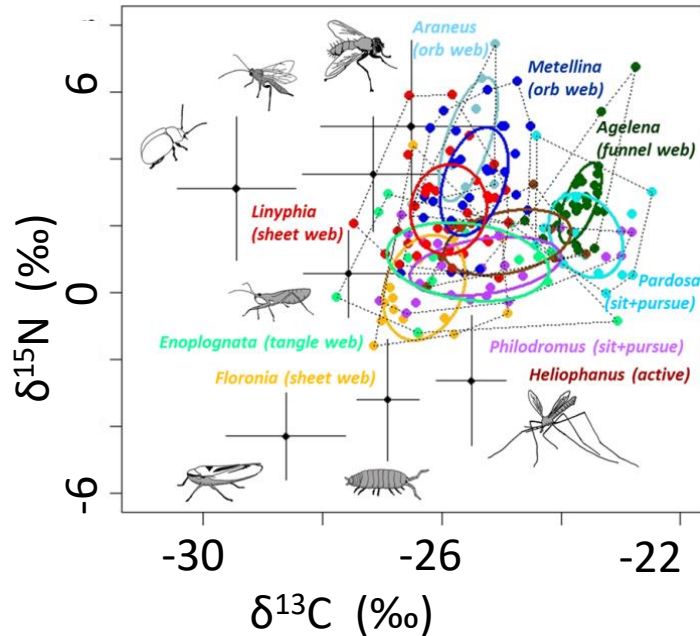


mutualistic



Quantifying species interactions

- indirect methods (e.g. stable isotope analysis, gut analysis, barcoding)



feeding niches of spiders (Sanders *et al.* 2014 *Oecologia*)

$\delta^{15}\text{N}$: changes with trophic position

$\delta^{13}\text{C}$: doesn't change with trophic position

→ position of organisms in $\delta^{13}\text{C}$ – $\delta^{15}\text{N}$ bi-plot isotopic space (a 2-D 'niche space') reveals important aspects of trophic structure and resource use

- mesocosm experiments



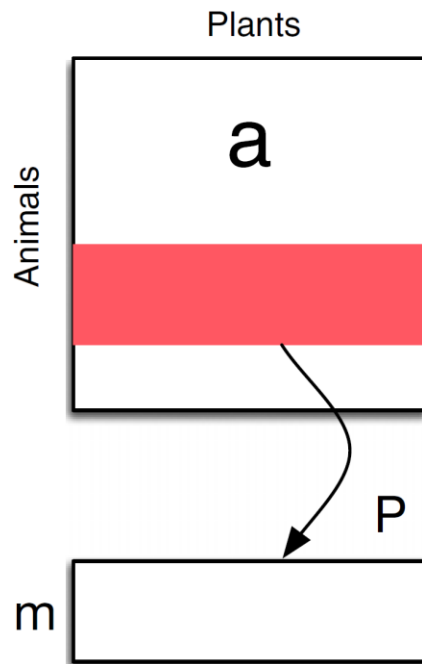
top-down control (Turrini *et al.* 2016 *Ecological Applications*)

- artificial exclusion of pests or predators
- indirect quantification of interaction (i.e., with/without)

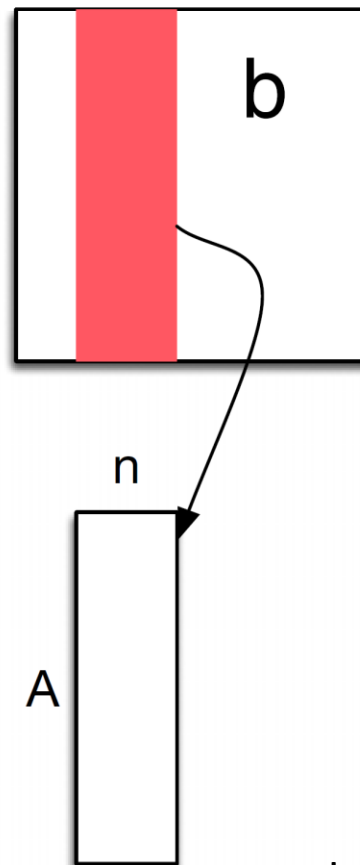
- direct observation in the field, in person or remote (video; pictures)

Theoretical considerations of sampling an ecological network

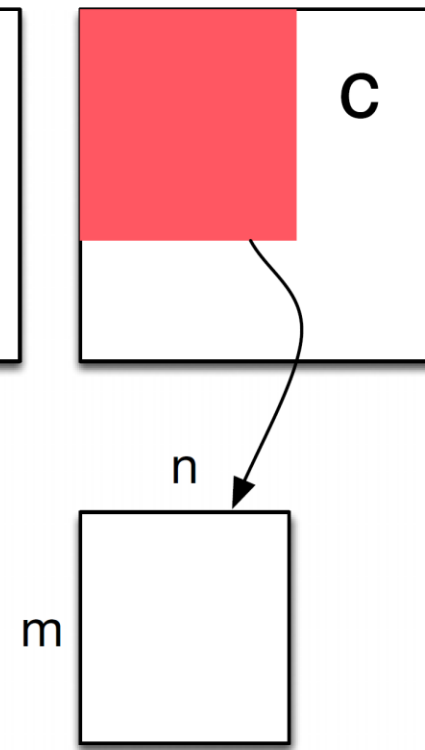
zoo-centric:
one pollinator,
all plants



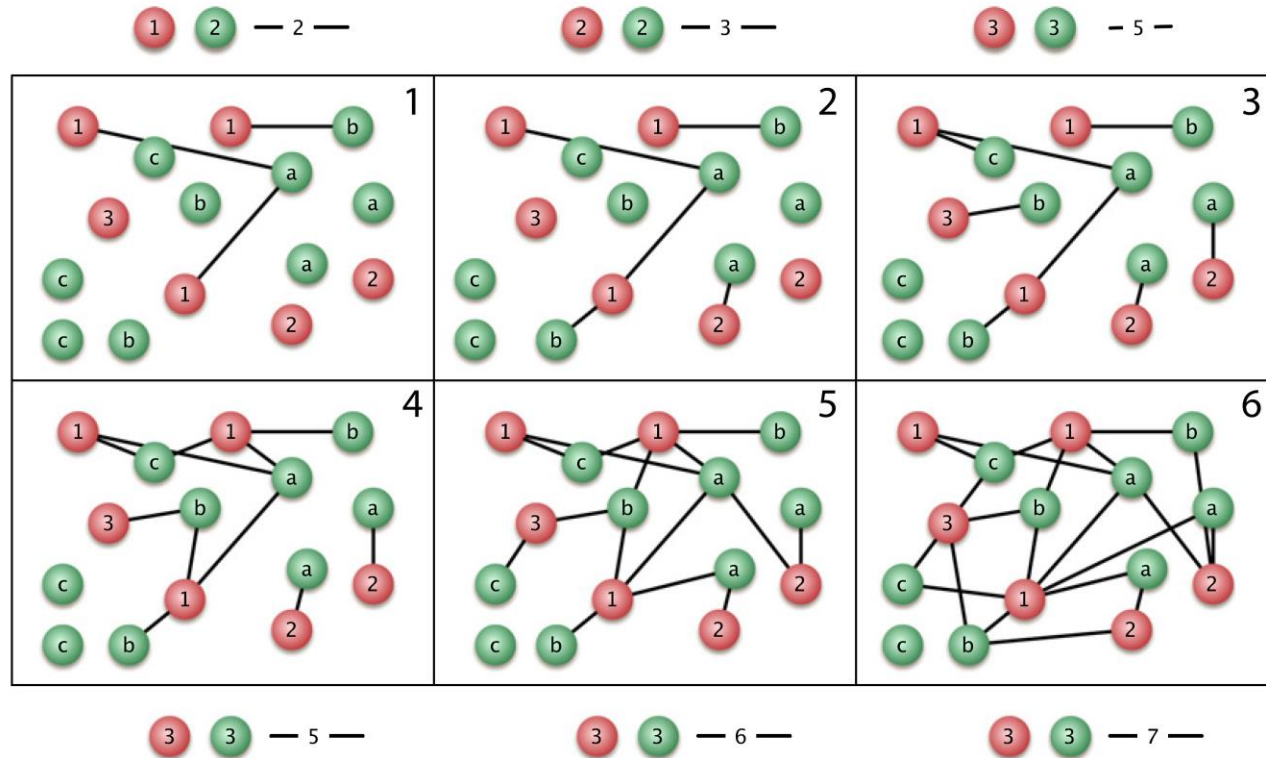
phyto-centric:
all pollinators,
one plant



both:
subset of pollinators,
subset of plants



Sampling effort key for number of interactions sampled



- as sampling effort increases (from Fig.1 to Fig.6), completeness of the network increases
→ standardize it!
- difficulty: forbidden links, i.e. links not observed due to non-occurrences
- interactions among different units of biological organization (e.g., individuals, species)

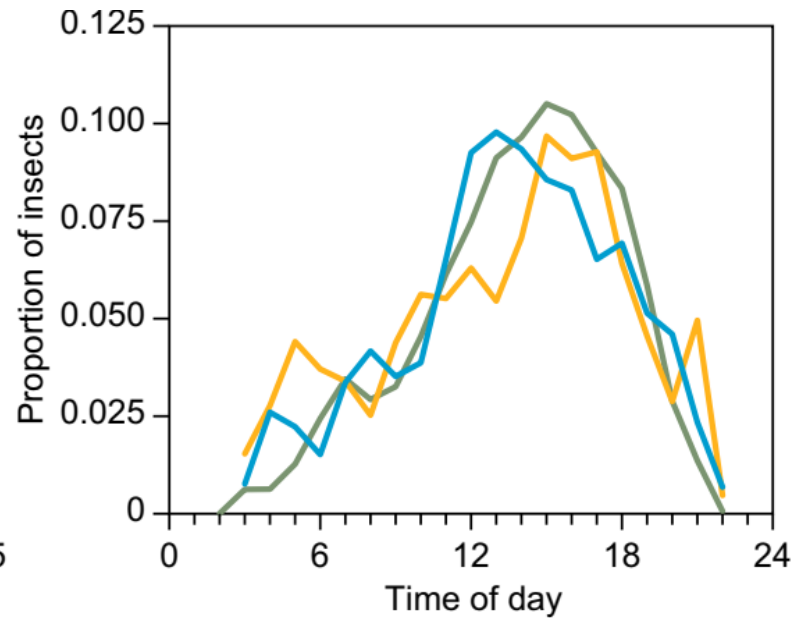
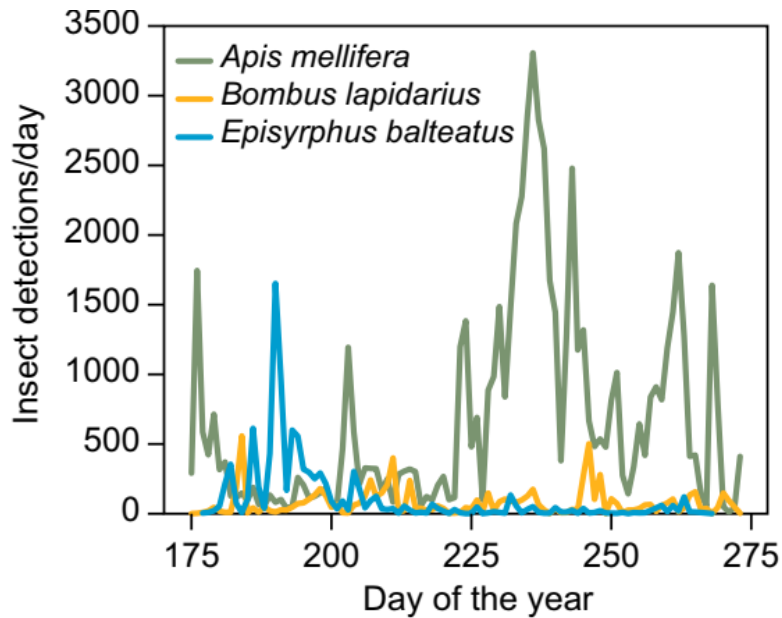
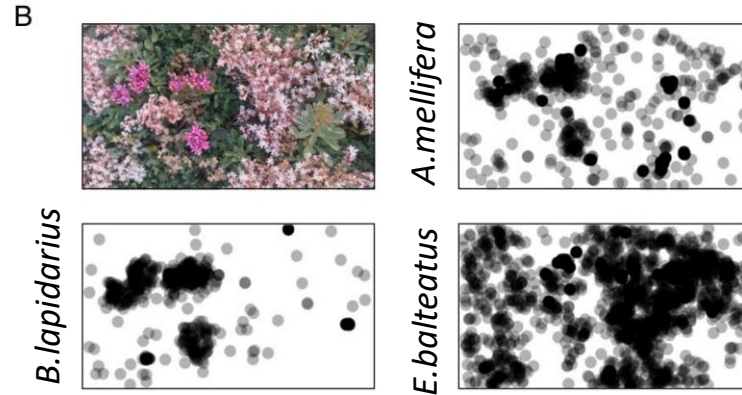
Sampling procedure



Sampling conditions: influence community sampled

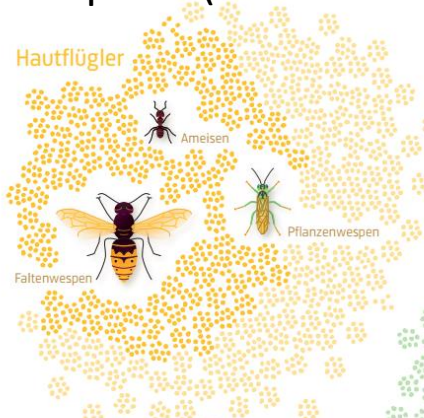


Direct observations: Deep learning and computer vision

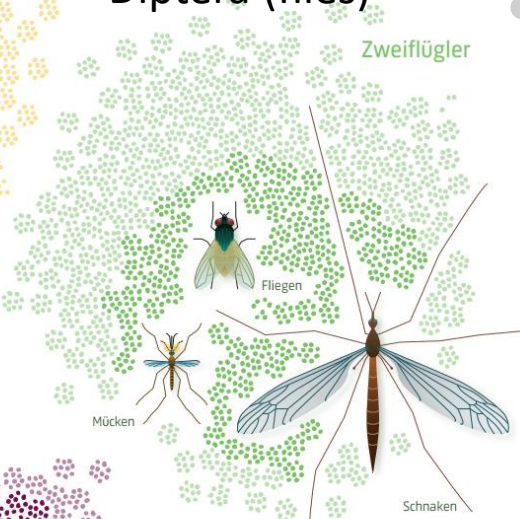


Overview insect flower visitors in Switzerland

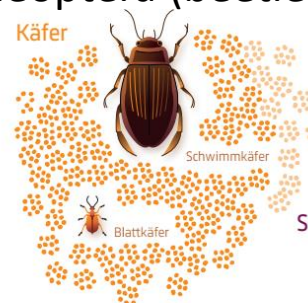
Hymenoptera (bees and wasps)



Diptera (flies)



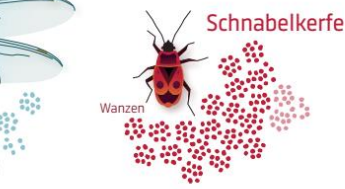
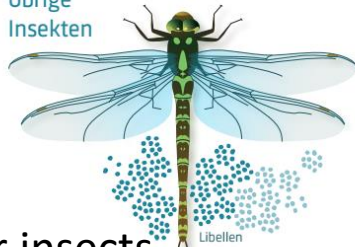
Coleoptera (beetles)



Lepidoptera (butterflies & moths)



Übrige Insekten



Hemiptera

other insects

- Legende
- 10 Insektenarten
 - In der Literatur erwähnte Arten
 - Zusätzlich geschätzte Arten (Maximalwert)

- 10 species
- species known to occur (literature)
- additional species estimated to occur

→ ~up to 60'000 insect species in CH



Order Hemiptera: Suborder Heteroptera (true bugs)

- mouthparts adapted for sucking the juices of plants or animals
 - mostly herbivores or predators
- forewing divided into a hard basal part and a membranous apex
- when at rest slightly overlapping folded



Order Hemiptera: Suborder Homoptera (leafhoppers and aphids)

- hemimetabol
- mouthparts adapted for sucking the juices of plants
- all are herbivores, usually not visiting flowers
- leafhoppers have their wings folded, which looks like a roof of a house



leafhoppers



aphids

Order Coleoptera (beetles)

- order with diverse functional groups, i.e., predators, herbivores, and pollinators
- predators: usually crawl on the ground, see picture → not in a flower
- herbivores: usually sit (and feed) on leaves and the stem of a plant (see picture)
- **pollinators: usually visit the flower and are covered with pollen**



predatory beetle:
predation of a slug



herbivorous beetle:
beetle eating a leaf



pollinating beetle:
beetle visiting a flower

Order Diptera (flies)

- only **one pair of membranous wings**, hindwings reduced to balancing organs
- syrphids, which are important pollinators, typically fly/stand still in the air like a helicopter
- very species rich order
- not all are pollinators (e.g. mosquitos)



Order Hymenoptera (bees)

- two pairs of membranous wings
- usually hairy body
- more than 600 wild species in Switzerland, domesticated species: honeybee
- **pollinators**



- bumblebee (*Bombus sp.*)
- large (up to ~3 cm) and hairy



- honeybee (*Apis mellifera*)
- very abundant
- medium size (~1.3 cm)



- wild bee
- small to medium sized

Order Lepidoptera (butterflies)

- two pairs of wings
- about 230 diurnal species and 3400 nocturnal species (moths)
- often pollinators



Pieris brassicae
(Large white butterfly)



Inachis io
(Peacock)

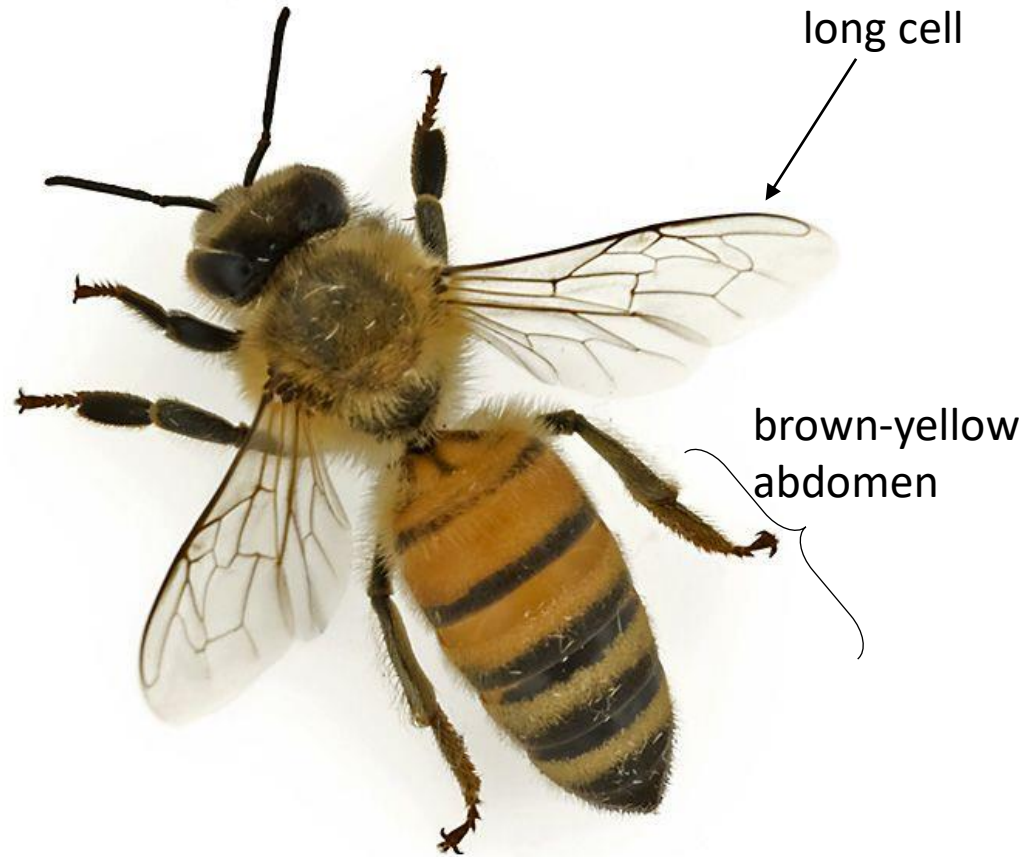


Papilio machaon
(Swallowtail)

Selected insect species: *Apis mellifera* (honey bee)



↔
~13mm



Selected insect species: *Bombus terrestris* (earth bumblebee)



↔
~16mm

- yellow stripe on thorax and 2nd segment of abdomen
- last two segments white

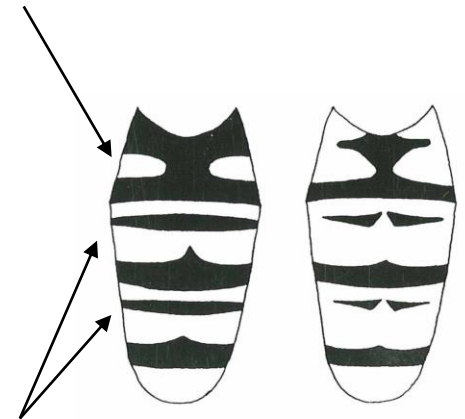
Selected insect species: *Episyrphus balteatus* (marmalade hoverfly)



↔
~11 mm

- yellow stripe on thorax and 2nd segment of abdomen
- last two segments white

yellow dots



black stripes in between
the main stripes

Morphospecies



1



2



3



4



5



6

Morphospecies



Vanessa cardui



Eristalis tenax



Apis mellifera



Tricrius fasciatus

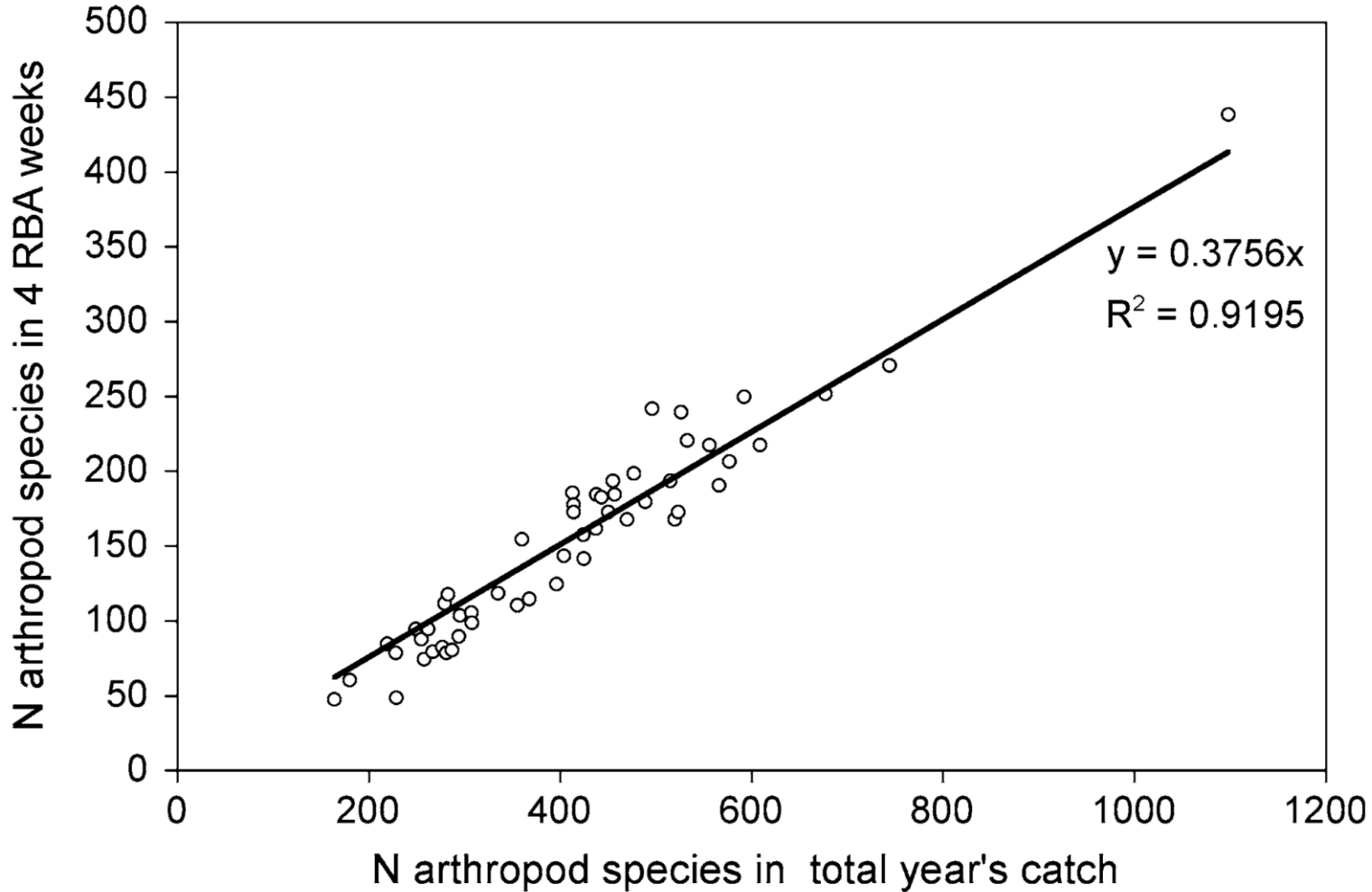


Apis mellifera



Apis mellifera

Morphospecies often correlate relatively well with true species



Selected plant species that are present early in the year:

Conus mas



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- **Shrub up to 5 m tall.** Leaves opposite, broad-lanceolate, up to 8 cm long, with entire margins, usually with 4 pairs of arching lateral veins. **Flowers yellow**, 4-toothed, appearing before the leaves, in 10-25-flowered, spherical umbellate inflorescences, these surrounded by 4 yellow-green bracts. Fruits ("Tierli") hanging, bright red, up to 2 cm long, elongated-ovate, usually only 1-3 per inflorescence.

Selected plant species that are present early in the year:

Primula caudalis



- **5-15 cm high**, without developed stem. Leaves in basal rosette, long obovate, gradually narrowing into an indistinct winged stalk, up to 15 cm long, irregularly finely toothed, glabrous above. Flowers solitary on long, thin stalks, pale yellow, orange-yellow towards the throat, to 3 cm in diameter, with spreading, fringed spikes. Fruit shorter than the calyx.

Selected plant species that are present early in the year:

Bellis perennis



- **Height 5-15 cm.** Stem naked, with 1 flower head. Leaves basal rosette, obovate to spatulate, pubescent to glabrescent, attenuated in stalk, genus with obtuse teeth. **Capitula 1-3 cm wide**; yellow tubular flowers and **white** ray-florets, the latter often tinged with **purple**. Involucre 4-6 mm long; bracts obtuse, gen. 13, sometimes briefly acuminate. Receptacle conical, hollow. Achenes ca. 1 mm long, without a clasp

Selected plant species that are present early in the year:

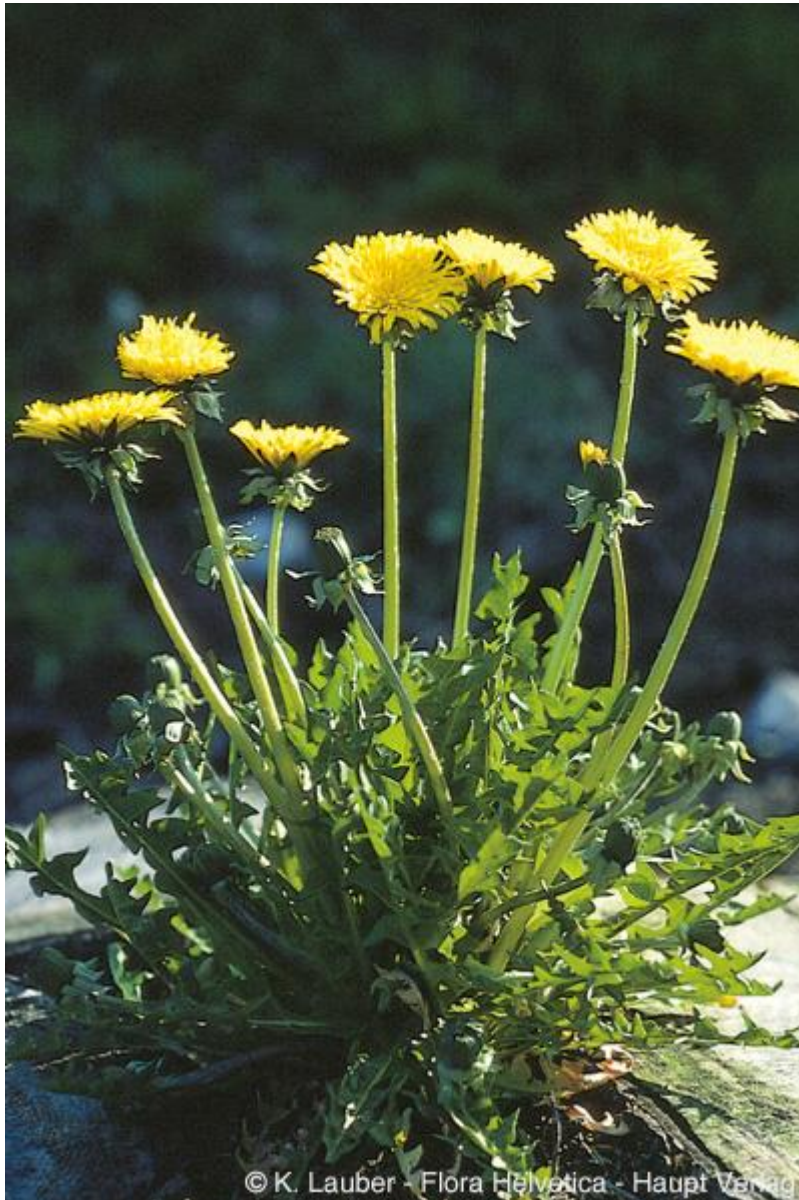
Salix sp.



- **Different species around Irchel**
- **Reaches 9 m in height.** Bark with small diamond-shaped crevices. Young twigs pubescent. Leaves ca. broadly elliptic, 3-10 cm long, 1.5-2.5 times as long as broad, with greater width below or about halfway up; upper surface matt, olive-green, veins reticulate, depressed; lower surface glaucous, ca. tomentose, veins prominent. Flowering precedes leafing. Capsules up to 10 mm long, tightly packed, tomentose.

Selected plant species that are present early in the year:

Taraxacum officinale



- **Height 5-30 cm.** Rosette of hairy-lain leaves at base, gen. without remains of old leaves. Gen. leaves runeate-pennate; divisions 1-2 times as long as wide. Involucral bracts ext. narrowly lanceolate, 2.5-4 mm wide and almost as long as int., spreading or reflexed when flowering, without membranous margin. Achenes light brown. Beak 2-4 times as long as achene.

Instructions for sampling plant-flower visitor networks

- between 10:00 and 17:00, no wind, if possible sunny days
- 3 times for 30 minutes
- all insects actively visiting flowers
- note species name of insect and plant, if you do not know the name, then write down morphospecies including order, family name, or genus. For example:
Bombus.m1 (Genus: Bombus, m1: morphospecies 1)
- create datafile similar to below, use same headers!

plant	insect	date	time	temperature
Primula.vulgaris	Bombus.terrestris	22.03.2022	14:02	18
Salix.sp	Bombus.m1	22.03.2022	14:05	18
Yellow.flower.m1	Bombus.m1	22.03.2022	14:20	18
Gallanthus.nivalis	Apis.mellifera	23.03.2022	11:12	15
Taraxacum.officinale	Episyrphus.balteatus	23.03.2022	11:30	15

- run file in R Markdown, produce own network

questions/help:

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