Sampling an ecological network

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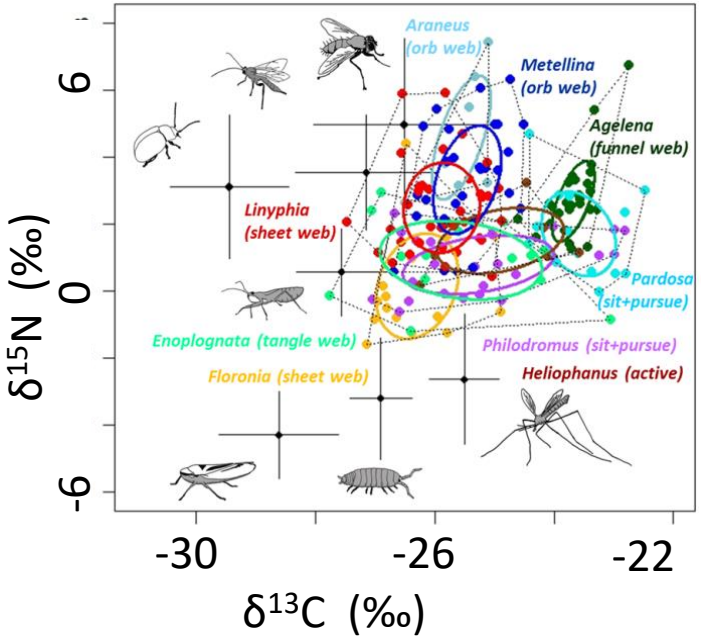
Different types of interactions: important to know which type sampled

trophic interactions: direct enegry 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)

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

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

→ position of organisms in δ 13C–δ15N 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)

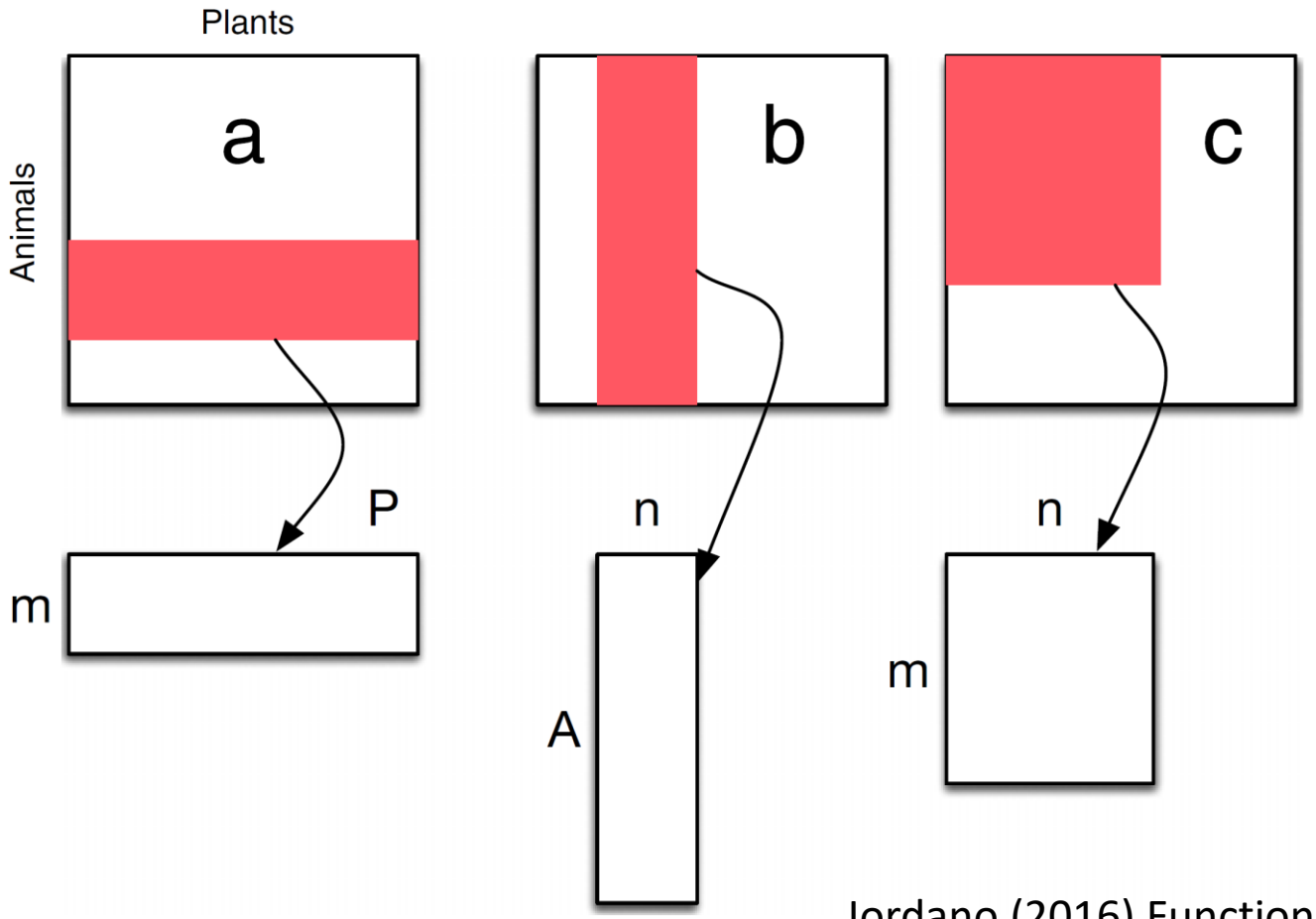
- direct observation in the field, in person or remote (video; pictures)

Theoretical considerations of sampling an ecological network

zoo-centric:
one pollinator,
all plants

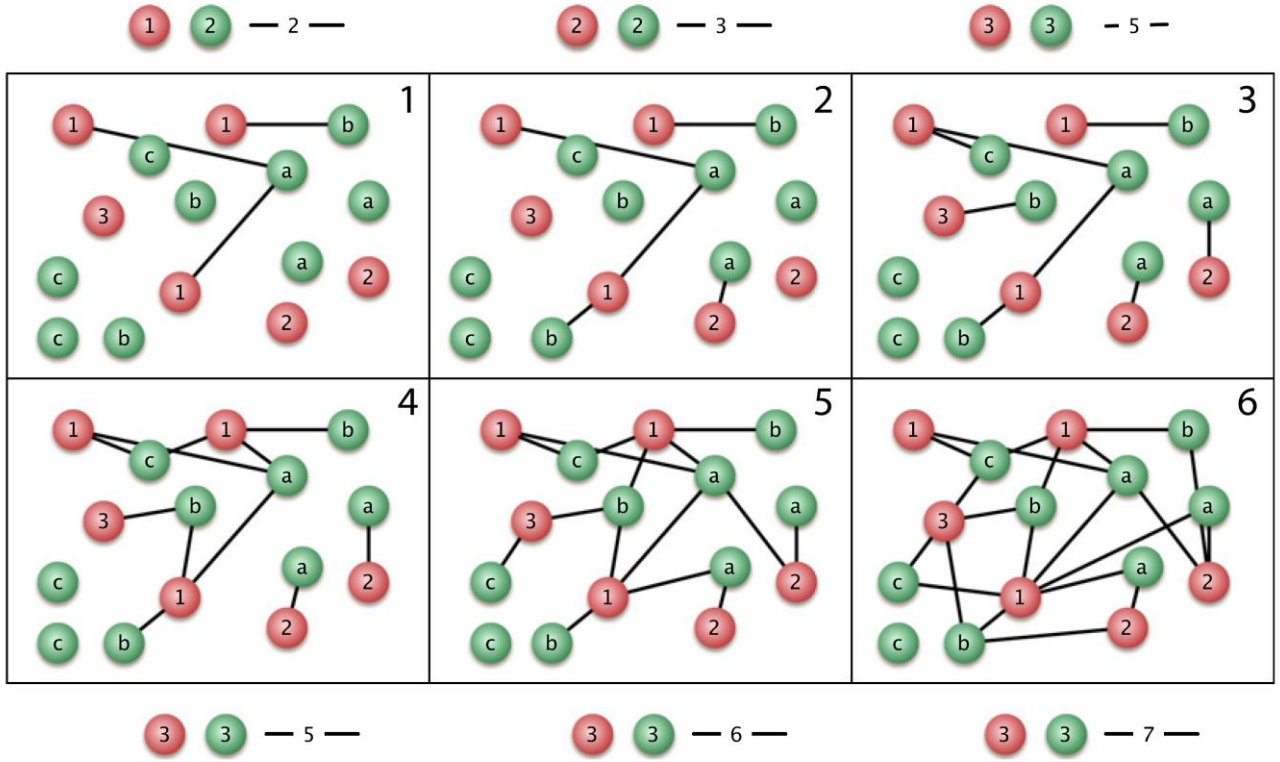
phyto-centric:
all pollinators,
one plant

both:
subset of pollinators,
subset of plants



Jordano (2016) Functional Ecology

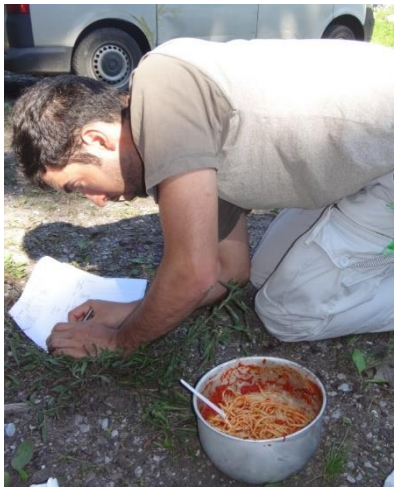
Sampling effort key for number of interactions sampled



- 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., indivduals, species)

Jordano (2016) Functional Ecology

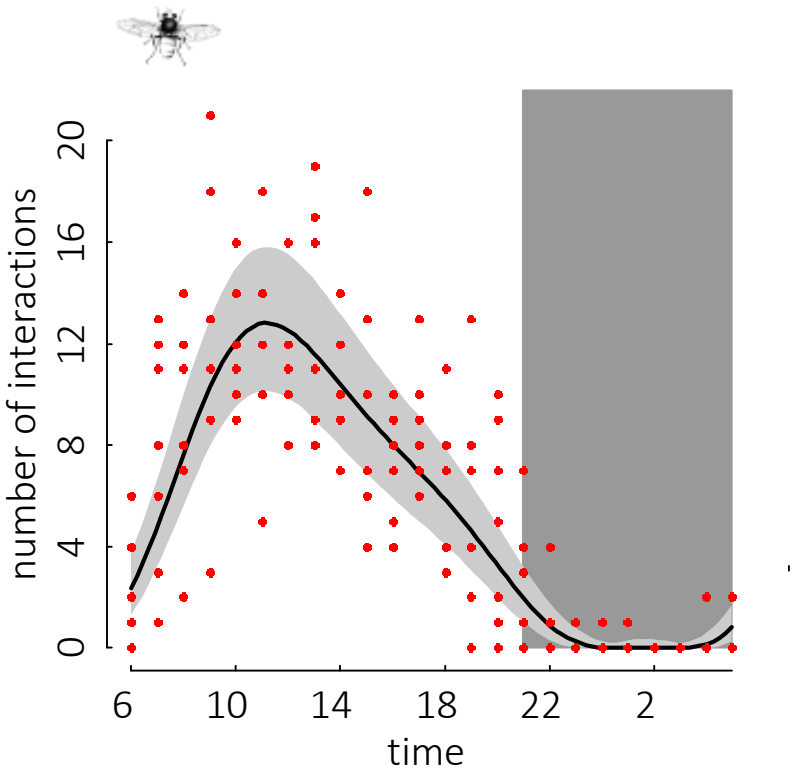
Sampling procedure



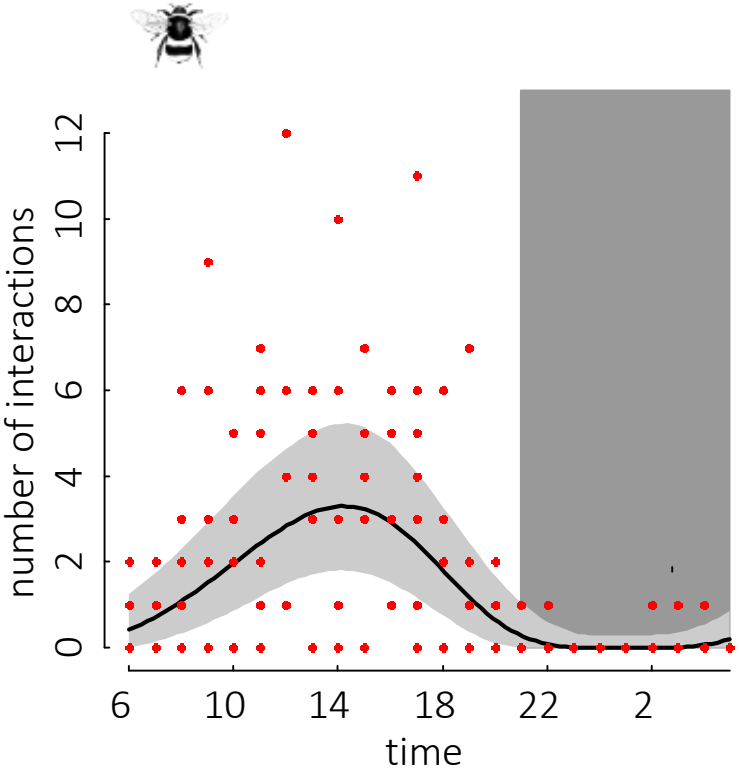
Sampling conditions: influence community sampled

Plant-flower visitor interactions over 24-hour cycles

Diptera (flies)

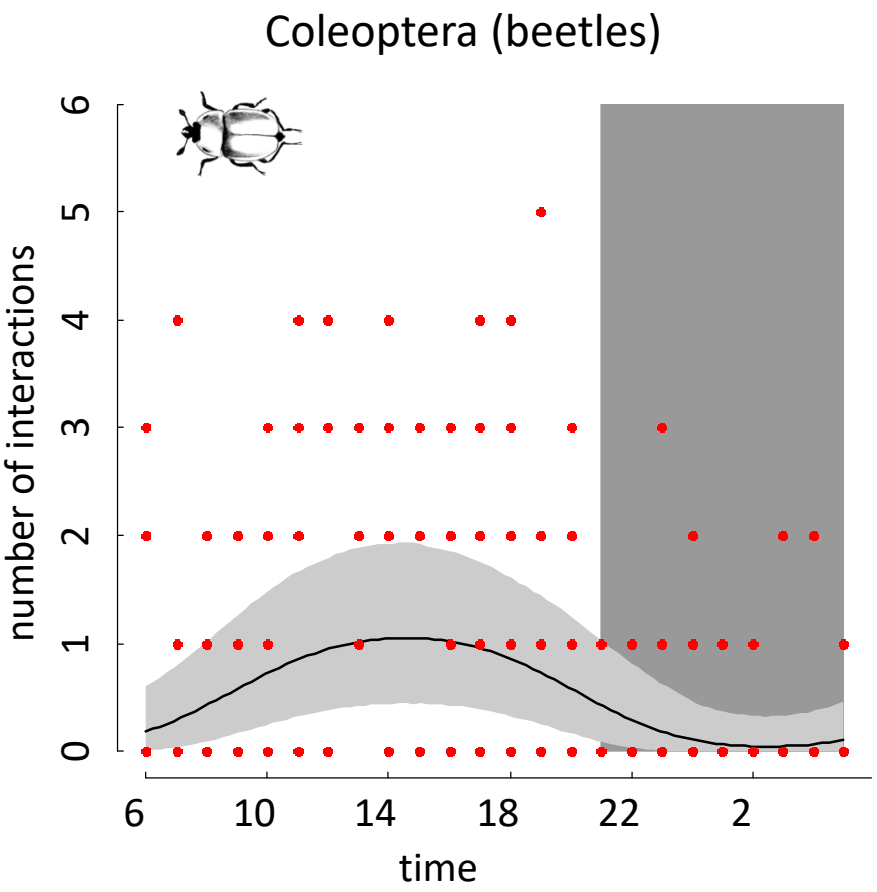


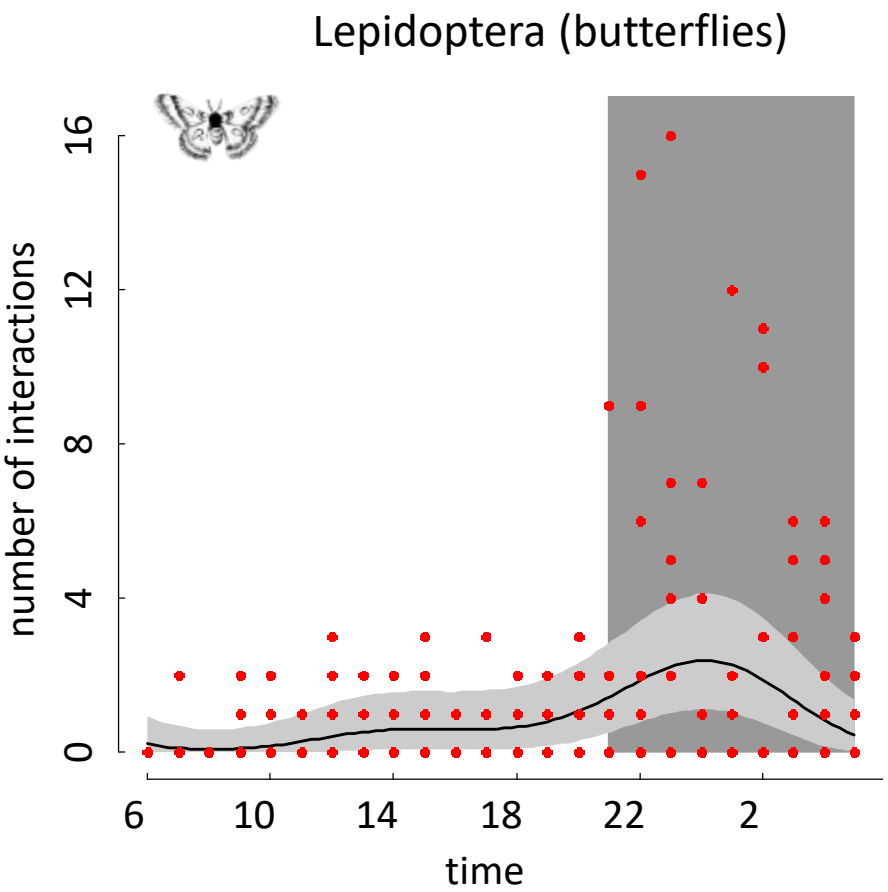
Hymenoptera (bees)



Knop et al. (2017) Insect Conservation and Diversity

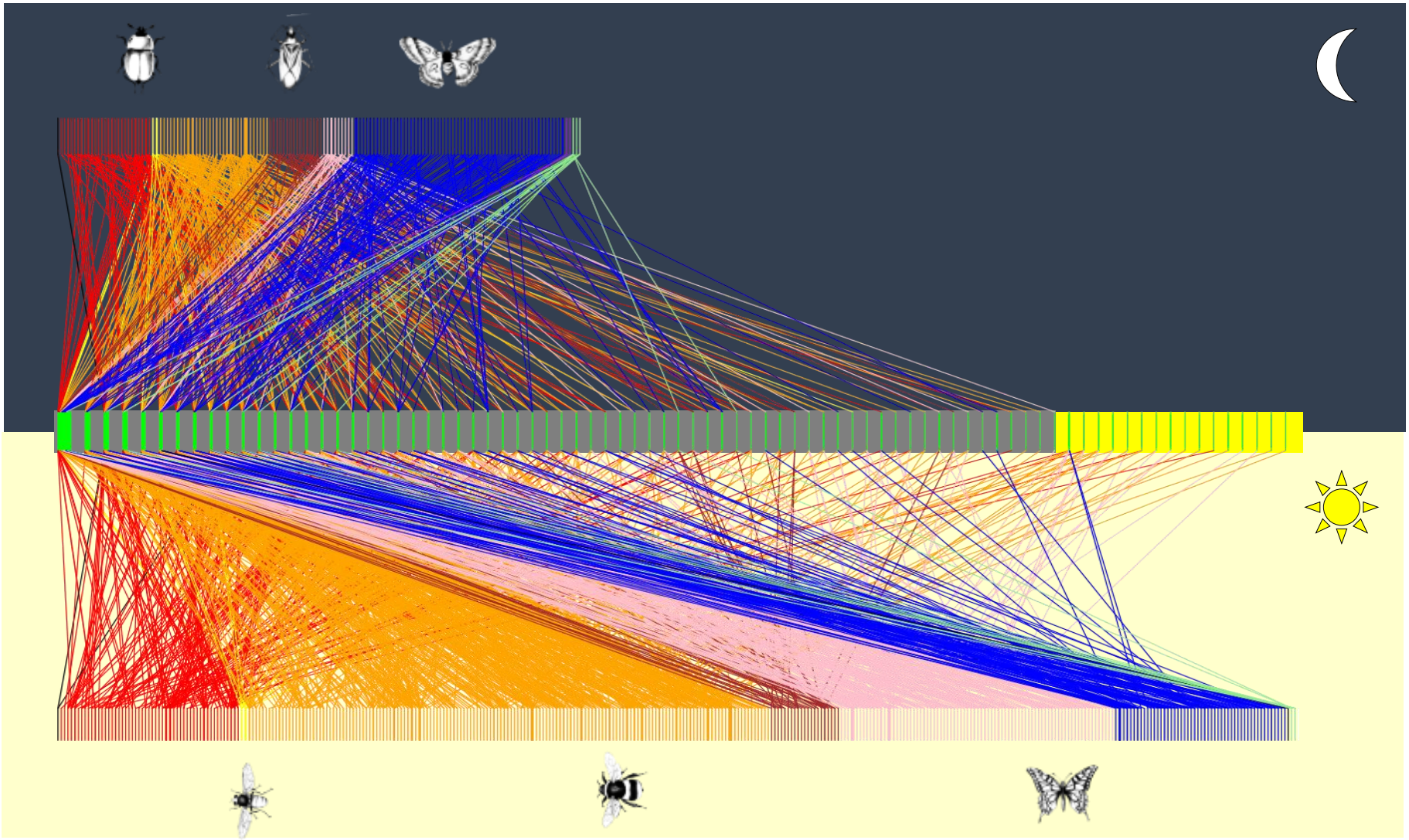
Plant-flower visitor interactions over 24 hour cycles





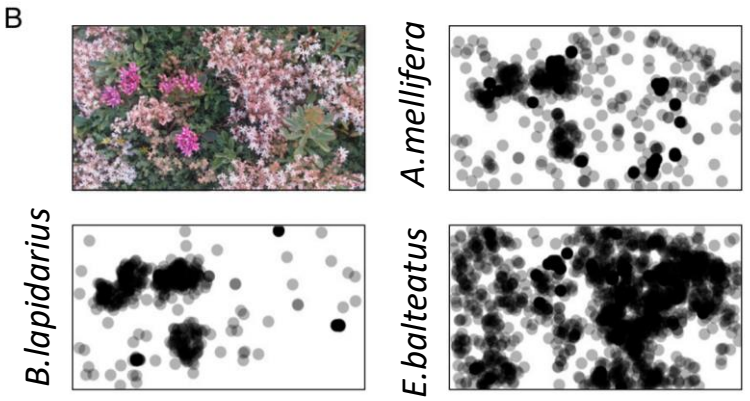
Knop et al. (2017) Insect Conservation and Diversity

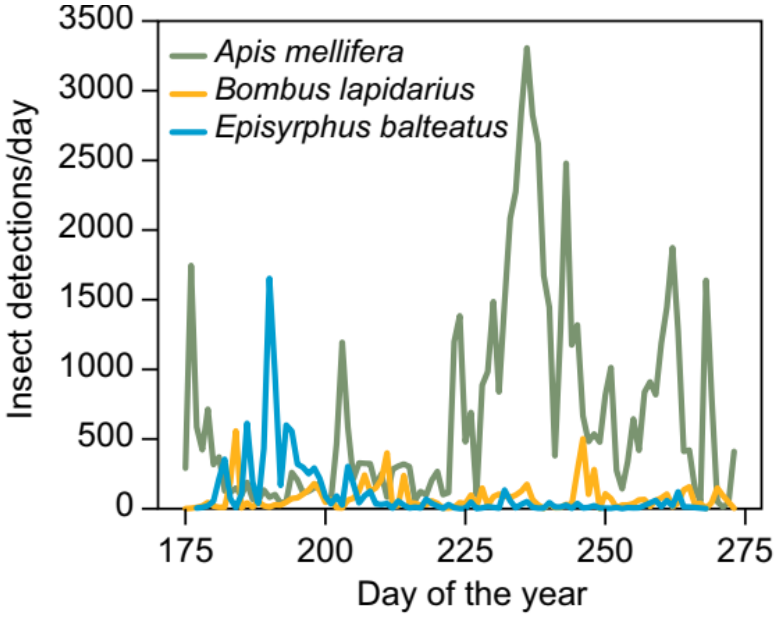
Interdependent nocturnal and diurnal networks

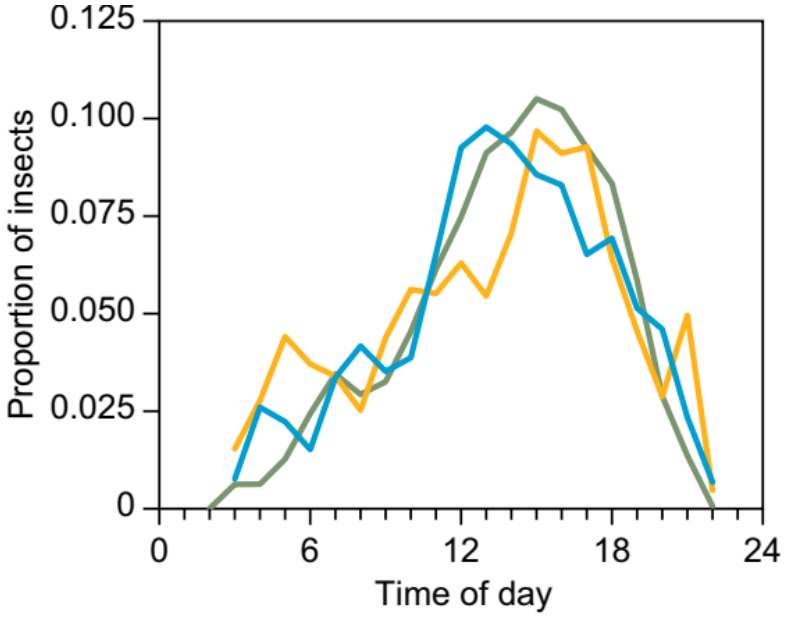


Knop et al. (2017) Nature

Direct observations: Deep learning and computer vision





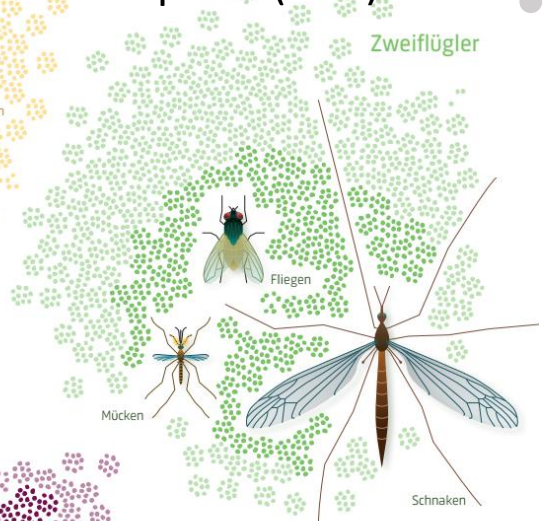


Hoye *et al.* (2021) PNAS

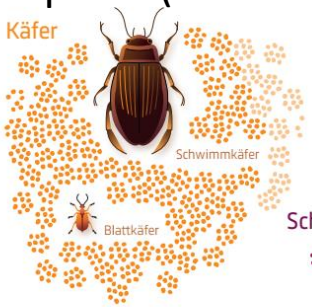
Overview insect flower visitors in Switzerland

Hymenoptera (bees and wasps)

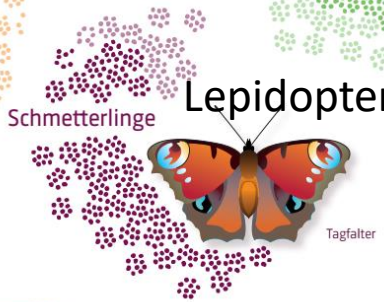
Diptera (flies)

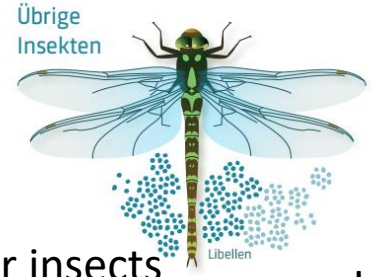


Coleoptera (beetles)



Lepidoptera (butterflies & moths)





other insects

Hemiptera

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

→~up to 60'000 insect species in CH

Widmer *et al.* 2021 Swiss Acadmics Reports

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

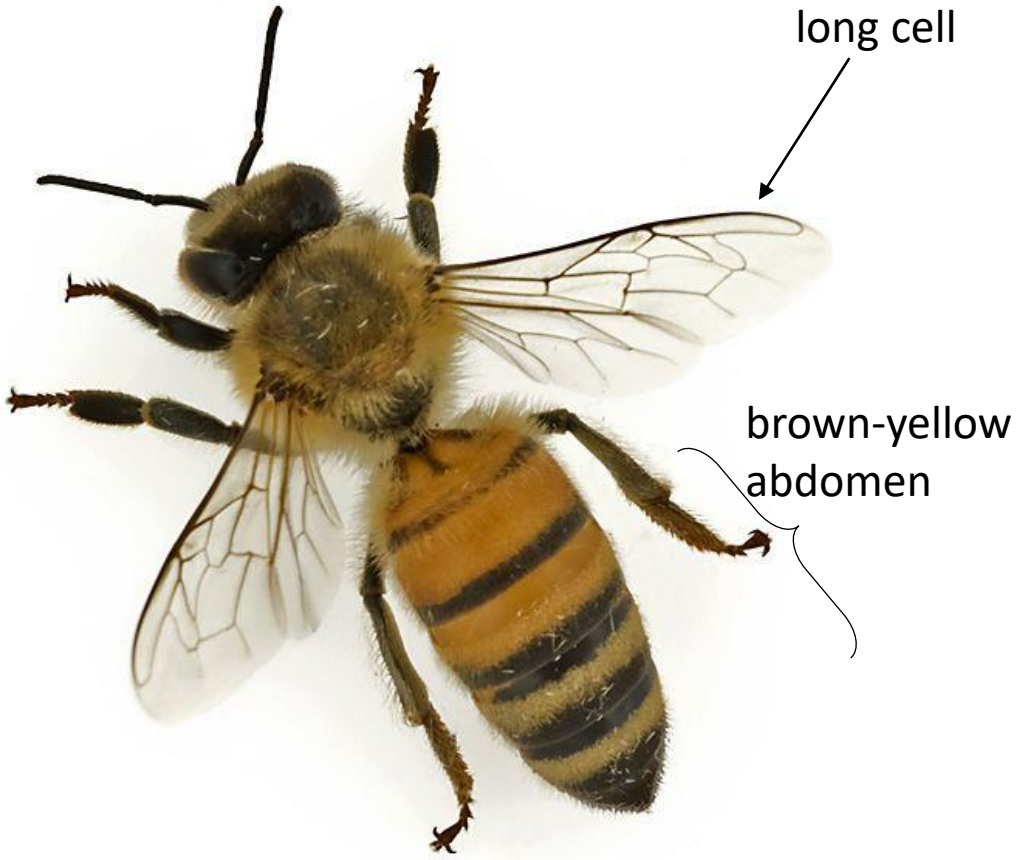
Pierris brassicae
(Large white butterfly)

Inachis io
(Peacock)

Papilio machaon
(Swallowtail)

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

~13mm



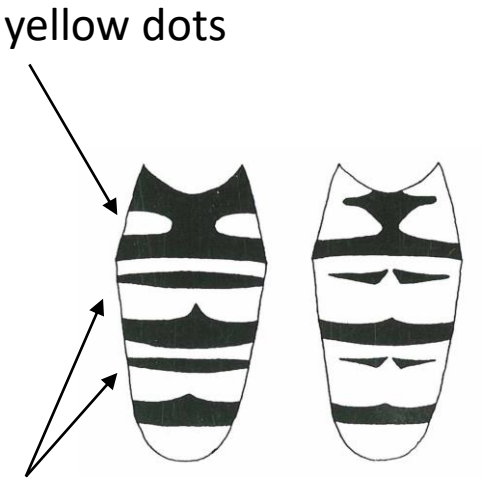
Selected insect species: *Bombus terrestris* (earth bumblebee)

~16mm

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

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

~11 mm



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

Morphospecies

1

2

3

4

5

6

Morphospecies

Vanessa cardui

Eristalis tenax

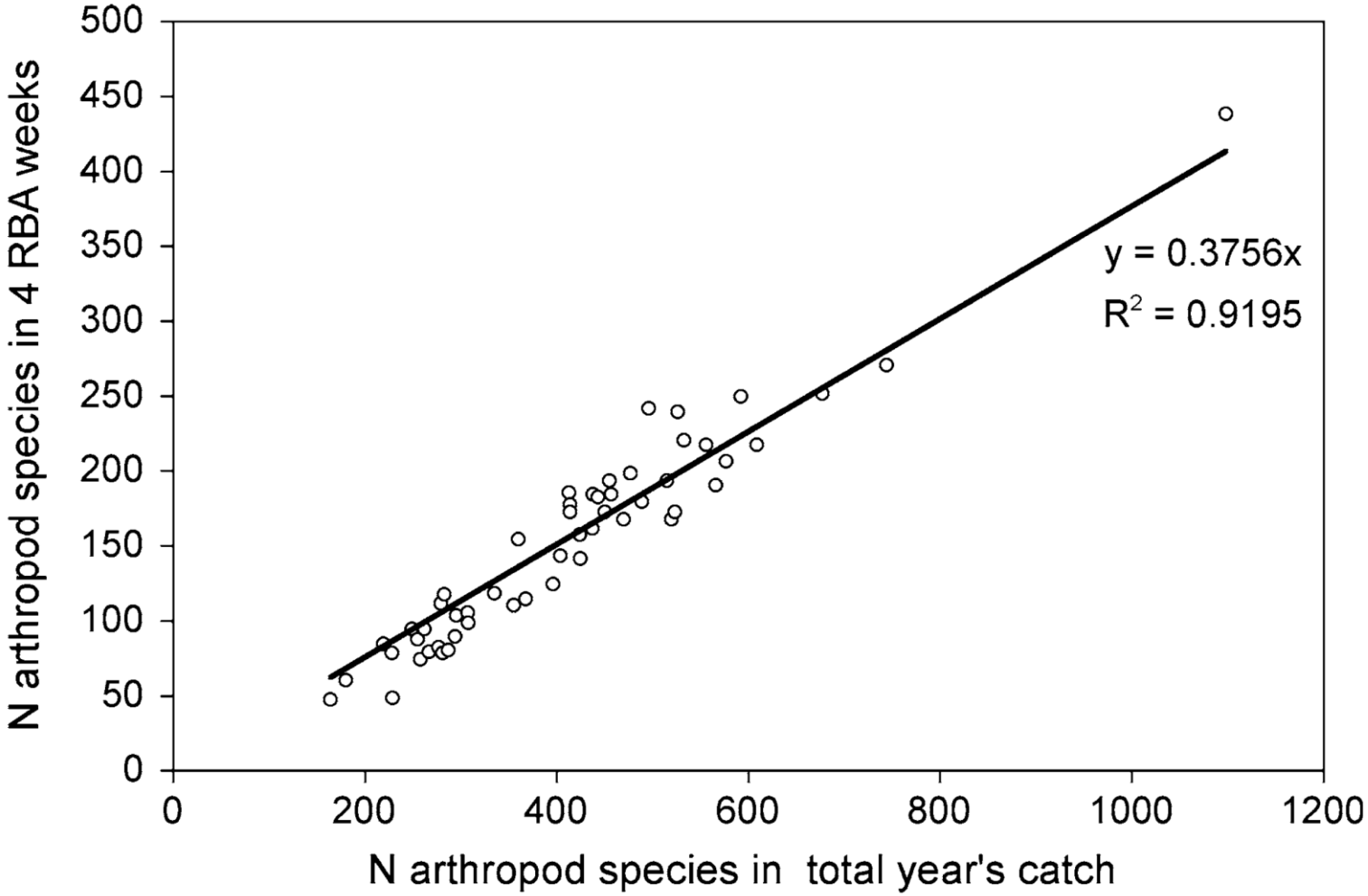
Apis mellifera

Tricius fasciatus

Apis mellifera

Apis mellifera

Morphospecies often correlate relatively well with true species



Obrist and Duelli (2010) Biodiversity and Conservation

Keys for identifying insects and plants

Books

- Pareys Buch der Insekten: Über 2000 Insekten Europas. 2004. Michael Chinery. Kosmos Naturführer

- Flora Helvetica. 2018. Konrad Lauber et al. Haupt Verlag.

Apps

- iNaturalist
  CALIFORNIA ACADEMY OF SCIENCES NATIONAL GEOGRAPHIC

- PlantSnap
  Where Nature and Technology Live in Harmony

Selected plant species that are present early in the year:

Conus mas

- **Shrub** up to 5 m tall. Leaves opposite, broad-lanceolate.
- **Flowers** yellow, 4-toothed, appearing before the leaves, in 10-25-flowered, spherical umbellate inflorescences, these surrounded by 4 yellow-green bracts.

Selected plant species that are present early in the year:

Primula vulgaris

- **5-15 cm high**,
- Leaves in basal **rosette**, 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

Selected plant species that are present early in the year:

Bellis perennis

- **Height 5-15 cm**, with 1 flower head.
- Leaves basal rosette with obtuse teeth.
- **Capitula 1-3 cm wide**; yellow tubular flowers and **white** ray-florets, the latter often tinged with **purple**.

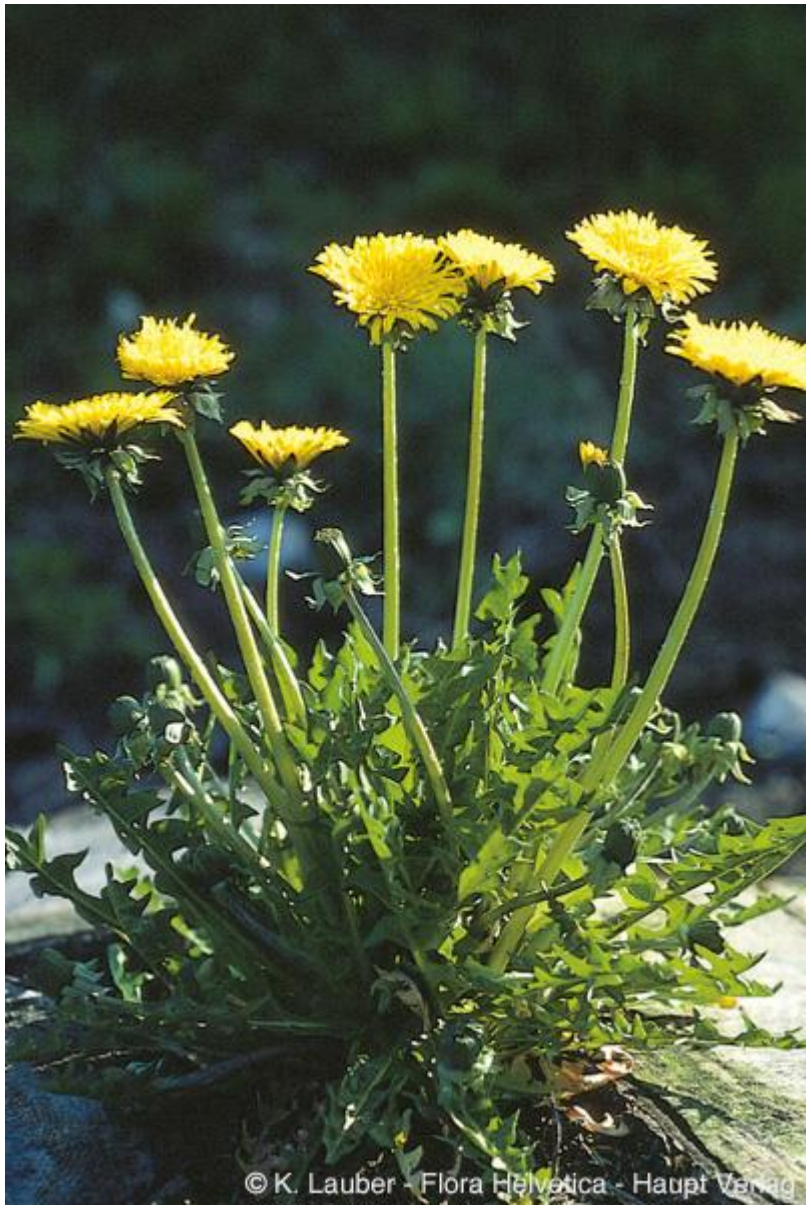
Selected plant species that are present early in the year:

Salix sp.

- **Different species around Irchel**
- **Reaches 9 m in height**. Bark with small diamond-shaped crevices.
- **Leaves** ca. broadly elliptic, 3-10 cm long, 1.5-2.5 times as long as broad, upper surface matt, olive-greenYellow anthers, flowering precedes leafing.

Selected plant species that are present early in the year:

Taraxacum officinale



- **Height 5-30 cm.**
- **Rosette** of hairy-lain leaves at base, divisions 1-2 times as long as wide.
- **Yellow flowers**. Involucral bracts ext. narrowly lanceolate, 2.5-4 mm wide and almost as long as int., spreading or reflexed when flowering

Selected plant species that are present early in the year:

Hepatica nobilis

- **5-15 cm high**.
- Basal leaves **cordate-3-lobed**, often purple underneath, overwintering.
- **Flowers** blue-purple, , with 5-10 petals.

Instructions for sampling plant-flower visitor networks

- between 10:00 and 17:00, no wind, if possible sunny days (standardized abiotic conditions)
- 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.officinalis	Episyrphus.balteatus	23.03.2022	11:30	15

- run file in R Markdown, produce own network

questions/help:
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