Handout: Sampling an ecological network

PD Dr. Eva Knop, eva.knop@ieu.uzh.ch, www.knoplab.ch

Below I have put together a manual for sampling an ecological network. It includes the following parts:
1) Theoretical considerations when sampling an ecological network
2) Background information for sampling plant-flower visitor interactions in Zürich
3) Instructions for recording species interactions in the field

The idea is that you read the manual carefully and by doing so, you will learn all you need for recording an own network in the field. The goal is, that you collect your own networks, that you enter the data and visualize it with the help of the provided R Markdown document. If you have questions, please do not hesitate and call me: 079 362 27 90; eva.knop@ieu.uzh.ch.

I hope you will enjoy!

1) Theoretical considerations when sampling an ecological network

The theoretical considerations of sampling an ecological network have nicely been summarized in the publication by Jordano (https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2435.12763). Please read this paper carefully, I will not repeat its content here. I only refer to the two basic steps regarding the sampling of interactions mentioned in the paper, which are that one needs to define:

(i) which type of interactions will be sampled

(ii) which type of record documents the existence of an interaction

In the context of network sampling one usually distinguishes between antagonistic interactions and mutualistic interactions. The entire range of possible types of species interactions (such as competitive interactions) is described in general books on Ecology, so I will not repeat them here. Three kind of antagonistic interactions are often studied using an ecological network approach. Those are prey-predator interactions, plant-herbivore interactions, and host-parasitoid interactions. The most frequently studied mutualistic interactions are plant-pollinator interactions, though also many more kinds of mutualistic interactions exist, such as ant-aphid interactions. For example, in ant-aphid interactions the aphids provide honeydew to the ants and in return the ants protect the aphids from predators. There are many more examples, however, the important thing to know is, that there ARE different types of interactions (antagonistic versus mutualistic). The type of interaction has implication for network structure. It is therefore important to know what type of interaction one is interested in and to confine sampling to this type of interaction.
The second point (which type of record we get to document the existence of an interaction) refers to the problem, that one can always either observe/record interactions from the perspective of the interaction partner A or from the perspective of the interaction partner B. For example, in a plant-pollinator system, one can observe interactions in a zoo-centric way by sampling animal activity and documenting all the plants visited by a pollinator A. Alternatively, one can do it in a phyto-centric way, i.e. observe a plant B and document all the visits the plant receives from pollinators. Combining the different perspectives would, of course, provide the most complete picture. However, this is often practically not feasible and most often just one perspective is taken.

2) Background information for sampling plant-flower visitor interactions in Zürich

It is often not easy to directly observe species interactions in the field and this is particularly true for small, rare, or secret animals, or for interactions that occur in the soil, for example. That is, why the interaction is often inferred indirectly by inspecting traits or gut contents of organisms. For example, the analysis of the gut content of a predator can provide information on what the predator has preyed upon, or the analysis of the pollen collected on the body of a pollinator can provide information on which flowers the pollinator has visited. Also when direct observations are possible, they often make assumptions. For example, when a flower visitor is visiting a flower it is often assumed that it is visiting the flower as a pollinator. However, in theory, we only know whether a visiting insect has pollinated as certain flower when we check whether it has deposited pollen grains on the stigma. This is in a community context often not feasible. Despite these challenges, we can try to maximize the likelihood that a certain flower visitor (or interaction partner) is doing what we think it is doing. For example, when observing plant-pollinator interactions, one should only record the actively moving flower visitors (and not also the ones that are resting on the flower), which often corresponds to a mutualistic interaction.

Due to the current situation and the short duration of the course, we can only observe interactions, without catching animals for identification or analyse their pollen load. This is particularly challenging for the identification of insects, as it is estimated that up to 60'000 insect species occur in Switzerland. On the other hand, insects visiting flowers are relatively easy to observe. Thus, in this course you will build your own network of plant-flower visitor interactions, based on observations in the field. For the mentioned reasons, we will restrict our observations to **insects actively visiting flowers**. Furthermore, you will mostly only be able to determine whether it is a fly (Diptera), bee (Hymenoptera), butterfly (Lepidoptera) or beetle (Coleoptera), which are the most abundant insect pollinators (see below). After identifying the order of the insect (or if you do not manage to identify the order you directly classify it into a morphospecies), you will classify them into morphospecies, i.e., you give every insect that looks similar the same label. You do the same for plants that look the same (see example in the datasheet). The number morphospecies usually correlates well with the number of species (https://link.springer.com/article/10.1007%2Fs10531-010-9832-y). Sometimes you might be able to identify them, for example the honeybees or some butterflies are quite easy, see pictures below. Also, some of the plants are well known. There are also several apps available which help to identify plants and insects, so you may install one. In the following I have put together information on the insect orders, which you are very likely to observe. Sometimes I also provide information on the genus or species, though I am fully aware that most of you will simply identify the order or only classify the organisms into morphospecies.

Order Heteroptera (true bugs)

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


Order 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), but consider the ones you find on flowers as pollinators


Order Hymenoptera (bees)
- two pairs of membranous wings
- usually hairy body
- more than 600 wild species in Switzerland, domesticated species: honeybee (see picture)
- pollinators

- bumblebee (genus: Bombus)
- large (up to ~3 cm) and hairy

- honeybee (*Apis mellifera*)
- very abundant
- medium size (~1.5 cm)
- long cell on wing (see picture)

- 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)

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
- PlantSnap

3) Instructions for recording species interactions in the field

3a) Design and approach

The design and approach depends of course on the specific question. Usually, one is interested in not only sample one network but rather in recording several networks and comparing them. In order to be able to compare them one has to standardize the sampling technique. When sampling ecological networks the most important variable to standardize is the sampling effort, which is usually determined by the area on which one records the network (for example a 100 m long transect or a patch of 10 m^2) and the time spent recording the network. As the purpose of this practical is to sample two or three networks without the goal to compare them, we ignore the sampling effort and focus on **sampling as many interactions as possible**. In order to obtain a bit variation between the networks you sample, you best go to different habitats at different occasions. Thus, you may go to a park, sample along street plantings or to a garden (and document it with the variable "habitat", see example below). The reason for doing so is, that within the short time available we are very limited in terms of what we can sample and therefore it is important to collect as much as possible. As activity of insects very much depends on weather conditions, do only sample interactions between **10:00 and 17:00 h**, and only on **sunny days without wind**.

3b) Template

Again, the datasheet needed for recording the interactions varies depending on the question. Please find below a template of what you should record for this course. **Please use identical headers** as the command provided in R Markdown works with the headers and columns shown below.

insect: interaction partner higher level. In our case this is the visiting insect that interacts with the flower. In the example, I have written Bombus.terrestris, Bombus.m1, and morphospecies.12. Bombus.terrestris refers to the species name (i.e., I was able to identify it). In the case of Bombus.m1, I only managed to identify that the insect belonged to the genus Bombus (a bumblebee). In the case of morphospecies m1, I do not even know to which order or genus the insect belonged, and I thus have simply given it the name morphospecies.m12. The two entries of morphospecies.m12 means that I have observed twice an insect that looks like morphospeices.m12, once on Salix.sp and once on Taraxacum.officinalis.

plant: interaction partner lower level. In our case the plant species. Try to find out the species name (you can also use iNaturalist). If you do not manage, simply describe them as I did, for example yellowflower.m1.

interaction: should actually always be 1 (as we have one entry per observation).

observer, date, time, location, habitat, temperature: should be self-explanatory

insect	plant	interaction	observer	date	time	location	habitat	temperature
Bombus.terrestris	Primula.vulgaris	1	Eva	20.03.2023	14:02	Irchel	hedge	18
morphospecies.12	Salix.sp	1	Eva	20.03.2023	14:05	Irchel	hedge	18
morphospecies.12	Taraxacum.officinalis	1	Eva	20.03.2023	14:07	Irchel	hedge	18
Bombus.m1	Yellow.flower.m1	1	Eva	20.03.2023	14:20	Irchel	hedge	18
Apis.mellifera	Gallanthus.nivalis	1	Eva	21.03.2023	11:12	Irchel	meadow	15
Episyrphus.balteatus	Taraxacum.officinalis	1	Eva	21.03.2023	11:30	Irchel	meadow	15

3c) Task

- read manual carefully and produce a template as described above
- go out and observe as many plant- flower visitor interactions as possible on sunny days without wind, between 10:00 and 17:00 h, and in different habitats.
- use the literature/apps for plant and insect identification described above
- run file in R Markdown and produce your own networks
- if you have problems: send me an Email (eva.knop@ieu.uzh.ch) or call me (079 362 27 90)