General introduction

According to FINLAYSON (1991), the framework for designing a study can be summarized as

Several important phases indicating the procedure to follow. These steps involve notably a series of questions that the manager is confronted with and to which he must try to answer. Each question is important and should be resolved before start any study (USHER, 1991; ROBERTS, 1991). The most immediate are:

1. "What are my objectives?" What is the purpose of the study? What are the data? required?
2. "What should I follow?": Which species? What scale? What can be obtained? by reading existing studies? What is the sample size, etc...
3. "How will I proceed?", "When?", "How often?":
How can the objective be achieved? How to obtain the desired data? What method to use? How many sampling stations? How to choose the areas sampling? How much will it cost (time, money)? What are the sources of bias? How will the results be recorded? How will the results be recorded? This involves deciding on the techniques.
sampling and field surveys.
4. "Are the methods sufficient?" Do we need to measure other variables?
5. "How does the analysis work?" Is the sample size sufficient?
In what form will the data collected periodically be presented? What Statistical methods are facilitated by the use of the computer?
6. "What will the data mean?"
7. "When will the target be achieved?"

Chapter 1: Sampling

1. Sampling:

Sampling is fundamental and results from the impossibility of collecting data on all elements of a population or surface, often for practical, technical, or economic reasons.

Sampling then allows for the study of the whole through statistics. According to Scherrer (1984), it is one of the most neglected aspects of biostatistics, which can also be observed in natural spaces. The part of the population that we are going to examine is called the sample. Defining the sampling methods involves determining the location, number, and size of the samples from the statistical population.

1.1. General Principles:

The variables that can be involved in a description of the structure or functioning of a studied object are very numerous. They can be classified into different categories.

1.1.1. Classification of descriptors

a. Qualitative descriptors:

Qualitative descriptors are categories defined without assigning a measure or even a characteristic that would allow them to be ordered relative to each other.

Examples: The different taxa constituting a community. For each taxon considered, the descriptor is presence or absence.

b. Ordinal or semi-quantitative descriptors:

Ordinal descriptors are defined by the existence of an order relation (smaller or larger; or earlier or later, etc.) without the possibility of measuring a distance between two distinct states.

Examples: The stages of development of a species.

For an organism with continuous growth, a set of age or size classes arbitrarily defined. Stages of succession of a natural community along a spatio-temporal gradient.

Note: Qualitative descriptors can become semi-quantitative if they are classified according to their frequencies (ranking these species by decreasing frequencies).

c. Quantitative descriptors:

Quantitative descriptors are defined as true quantities, for which ratios and differences can be determined.

This definition pertains to a very large number of descriptors used in ecology that measure abundances, rates, percentages, volume, biomass, etc.

d. Complex or synthetic descriptors:

The descriptors mentioned above are simple descriptors, that is to say, characterized, for each observation, by a single number or by the specification of a modality.

Complex descriptors allow for accounting for multiple simple observations within the same sampling plan.

Example: Consider a set of species (each characterized by its relative abundance at a station). We calculate a diversity index (quantitative descriptor), and we establish the law of decline of species abundances ranked from the most abundant to the rarest (semi-quantitative descriptor).

1.1.2. Choice of descriptors

The descriptors used in ecology are extremely diverse. The choice of descriptors depends on the type of descriptive or explanatory model expected at the end of the analysis, that is, the pre-model.

Some examples of descriptors are listed below.

a. Space-time occupancy descriptor:

They can be qualitative, presence or absence of a taxon and indication of the type of habitat occupation (endogean species living in the soil or epiphytic, planktonic, etc.); Semi-quantitative (abundance/dominance scale) or quantitative (biomasses, number of organisms per unit volume or surface area of the biotope).

b. Biometric and demographic descriptors:

They are necessary for the application of dynamic population models.

Example: population demographics.

c. Structural descriptors:

In addition to the spatio-temporal structure and demographic structures, there are structures related to the distribution of biomass among distinct species (distribution of individuals by species, species diversity), trophic structures, etc.

These descriptors can be quantitative, semi-quantitative, or qualitative.

The trophic structure is described by the relative biomasses of producers, consumers, and decomposers. The spatiotemporal structure: Stratification of vegetation, succession of vegetation where each stage prepares the establishment of the next.

d. Systematic descriptors:

The most common of these descriptors are those that account for the dynamics of a biomass, a species, or a chemical element (branch elongation). We find biometric and demographic descriptors if it is a population dynamics model.

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1.1.3. Observation Scale

Ecosystems are structured in space and time. The definition of scale is to consider either a tree stump, a forest, or a region and study their variations over a day, a year, or several years.

From a practical standpoint, the definition of an observation scale involves two distinct elements: the range of the sampled domain and the density of observations within that domain. This actually amounts to defining two scales for each sampling plan: one defining the size of the object being analyzed, the other the scale of variations observed within the object.

1.2. Types of Sampling

1.2.1. Subjective Sampling

It is the simplest and most intuitive form of sampling. The observer judges the locations to be representative of the environmental conditions and chooses as samples the areas that seem particularly homogeneous and representative based on their experience.

The basic principle is to survey the study area and to identify the main plant units. Within each unit thus defined, a survey will be conducted based on criteria of homogeneity and representativeness.

A subjective choice is not random because the records will be all the better established if the researcher has proven experience.

1.2.2. Probabilistic Sampling

a. Simple random sampling methods

Simple random sampling is a method that involves randomly and independently selecting n sampling units from a population of N elements. Thus, each element of the population has the same probability of being part of a sample of n units, and each of the possible samples of size n has the same probability of being constituted.

Note: There are different types of random sampling, simple random, stratified, and cluster sampling.

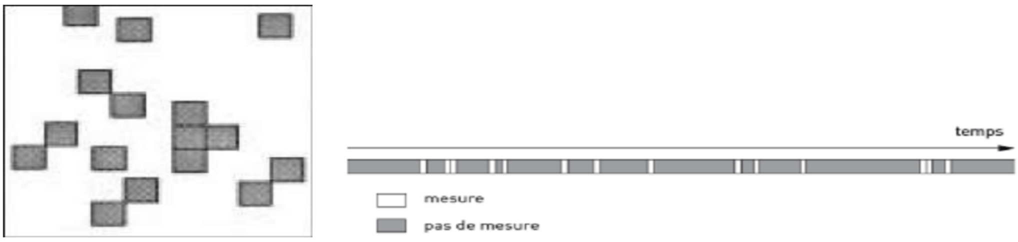

Figure 4. Illustration d'un échantillonnage aléatoire simple dans l'espace (à gauche) et dans le temps (à droite)

Figure 01: Illustration of simple random sampling in space (left) and in time (right).

b. Systematic sampling methods

A sampling is systematic if individuals are selected at regular intervals (for example, a daily measurement every six days). It also involves distributing the samples regularly (e.g., every "x" meters). It is less time-consuming than random sampling. A grid is usually used (often positioned on the aerial photograph of the studied territory). The sampling points are thus easy to locate at each survey.

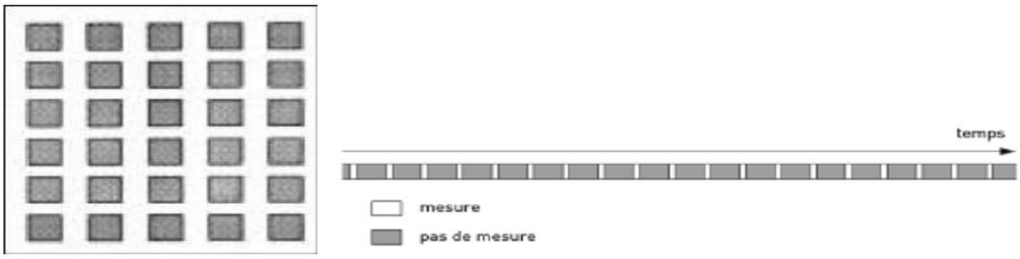

Figure 5. Illustration d'un échantillonnage systématique dans l'espace (à gauche) et dans le temps (à droite)

Figure 02: Illustration of systematic sampling in space (left) and in time (right)

c. Stratified sampling methods

It is particularly used when the area studied is divided into differentiated zones (strata). The strata can correspond to administrative divisions, areas with different topography, etc.

It involves subdividing a heterogeneous population into more homogeneous sub-populations or strata. Stratification is necessary when results are sought at the level of each sub-population. The samples are then distributed within the strata (possibly using random sampling, for example) with a number proportional to the area of each.

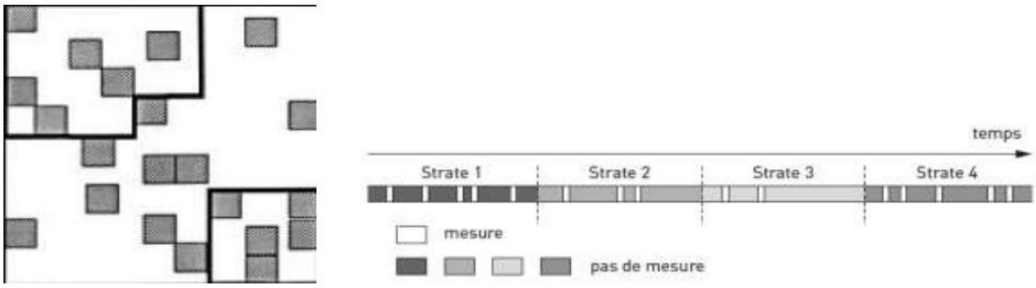

Figure 6. Illustration d'un échantillonnage stratifié dans l'espace (à gauche) et dans le temps (à droite)

Figure 03: Illustration of stratified sampling in space (left) and in time (right)

d. Comprehensive sampling methods

Exhaustive analysis could be likened to an adaptation of systematic sampling. Instead of sampling a small part of the elements with the first point being randomly selected and inferring to the whole, we sample the entirety of the set.

The procedure involves placing plots along a line and studying the structural properties of the vegetation within them. But it should be noted that the pursued goal is not the same. Since the study focuses on the structure, the lines are not necessarily very long and the plots are sufficiently large for us to consider that we are somewhat approaching the population.

e. Mixed sampling methods

It is the most commonly used sampling method in the field.

Fieldwork often involves combining several simple samplings into a more complex sampling, aptly called mixed sampling.

Often, studies begin with stratified sampling, which involves delineating homogeneous areas (stratification) within the study area.

Resulting, for example, in a land use map. Then, within the selected strata, they choose surveys subjectively (subjective sampling) or randomly (random sampling). Once the points are chosen, they can implant a line (Systematic scale) to extract the specific frequencies.

Chapter 2: Vegetation Sampling and Classification Method

1. Method of sampling and classification of vegetation

All the methods aim to save time in understanding the environment. They aim at establishing standard data that can be compared and processed. The best methods are those that provide tangible results in the shortest time possible, with an optimization of the time spent collecting and processing information.

The techniques for sampling vegetation are actually very numerous. They can, however, be differentiated by a wide range of criteria. These include, in particular, the scope, objectives, and spatio-temporal organization.

1.1. Physiognomic Methods

It consists of describing the vertical structure (stratification) and horizontal structure (overlap) to define the vegetation unit (steppe, forest, Sahara, etc.).

Vegetation is distributed on two scales: horizontal and vertical 1.1.1. The Vertical Structure:

Vegetation units, called plant formations based on the predominance of one or several biological types The plant association is stratified, meaning it is composed of plants of different sizes among which several levels or strata can be recognized: thus in a forest one can distinguish:

Stratum I: Mosses, lichens, and fungi.

Stratum II: Herbaceous Plants.

Stratum III: Shrubs.

Stratum IV: Tree-like.

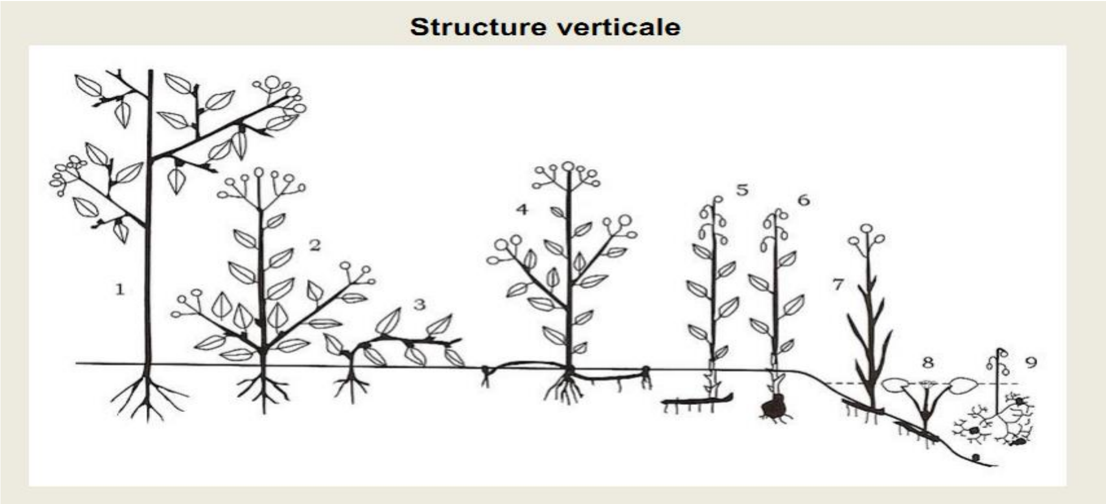

Figure 04: The biological types of Raunkiaer's classification: 1- Phanerophyte, 2/3-Chamaephyte, 4-Hemicyptophyte, 5/6-Geophyte, 7-Halophyte, 8/9-Hydrophyte

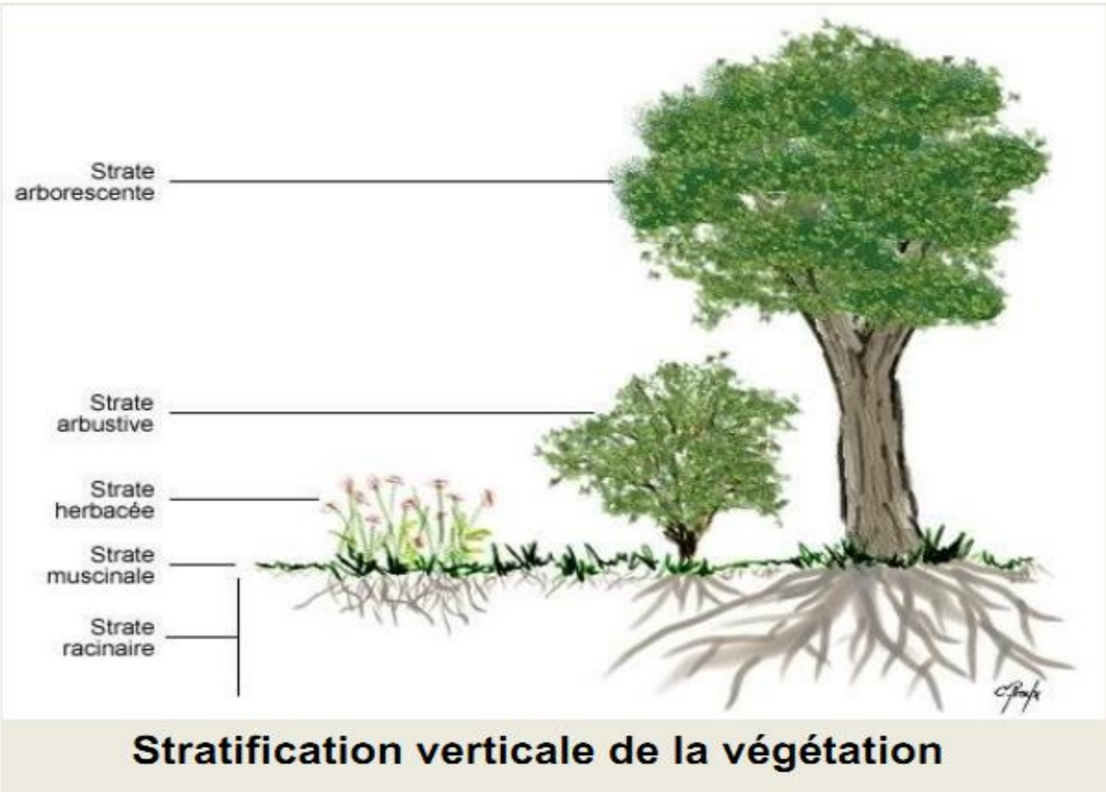

Figure 05: Vertical stratification of vegetation

1.1.2. The horizontal structure:

Plants are not distributed in the same way; some are much more abundant while others are relatively rare. Conventional numerical scales allow for the description of this distribution. it is the Braun-Blanquet abundance-dominance scale.

1.2. Dynamic Methods

The dynamics of vegetation: it is the study of changes in vegetation over time. It ranges from very short periods (seasonal changes) to much longer ones (history of vegetation): Periodicity concerns changes related to phenological cycles (most often annual): flowering, winter dormancy…. Fluctuation characterizes changes over a relatively short term (a few years), for example in the productivity of a species: some "eclipse" orchids can go several years without blooming.
The analysis of fluctuations is important because they overlap with the succession phenomena being monitored and can obscure their interpretation. It is sometimes useful to compare the monitoring results with climate data to identify fluctuations related to weather conditions…. Successions are directional changes of short to long duration.
It is mainly the phenomena of succession that are the subject of most vegetation monitoring. The history of vegetation, over very long periods, is often studied retrospectively (pollen analysis).

1.3. Phytosociological Methods

Phytosociology is the science of plant communities (association, alliance, order, class, and their sub-units). That is to say, syntaxa This science is organized into a hierarchical system where the association is the basic unit. The system includes units of progressively higher hierarchical ranks: alliances, orders, classes, divisions. The methodological foundation of phytosociology is the vegetation survey.

1.3.1. The synthetic stage

Analytical comparison of surveys using the table technique According to Braun Blanquet: The plant association is a more or less stable and balanced plant grouping with the ambient environment, characterized by a determined floristic composition in which certain exclusive elements, or almost exclusive (characteristic species), reveal a particular and autonomous ecology through their presence.
According to Guinochet, "a plant association is an original combination of species, some of which are said to be characteristic and are particularly linked to it, while others are classified as companions." Analysis of the vegetation:
The first step to take is the quantitative and qualitative study of the floristic composition of a plant community.
- Floral composition: How is it done?

- In the field We conduct a floristic inventory of the phytocenosis using the survey method. - Conducting a survey Three conditions are required for the completion of a survey.

1- Adequate dimensions to contain a sample of representative species of the minimum area community.

2- Uniformity of the habitat, the survey will not extend into two different habitats.

3- Homogeneity of the vegetation: the vegetation must be homogeneous (based on the physiognomic aspect).

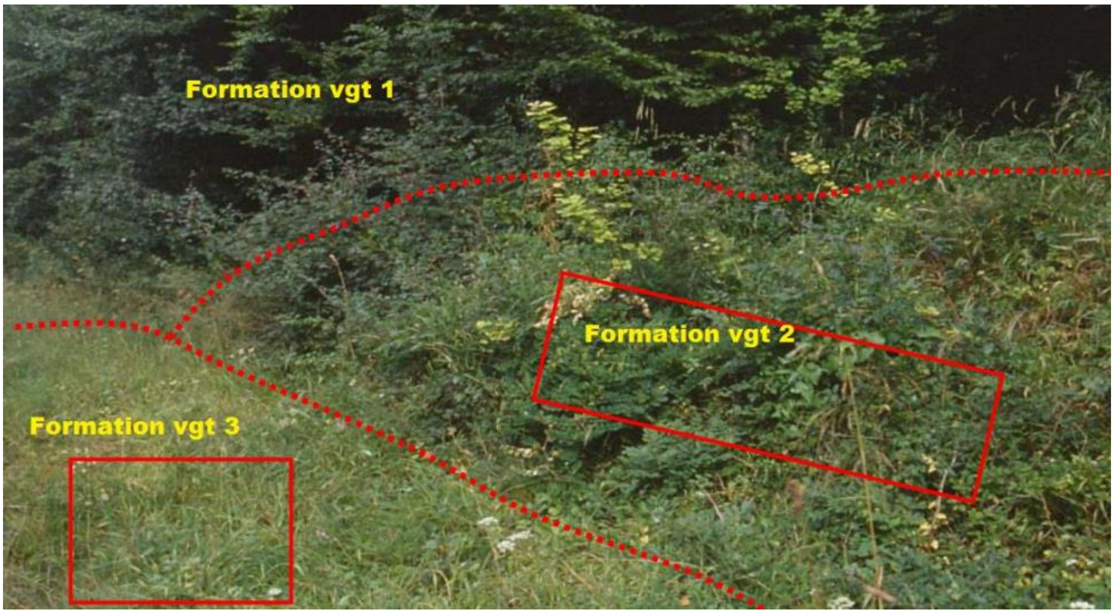

Figure 06: how to differentiate between plant formations

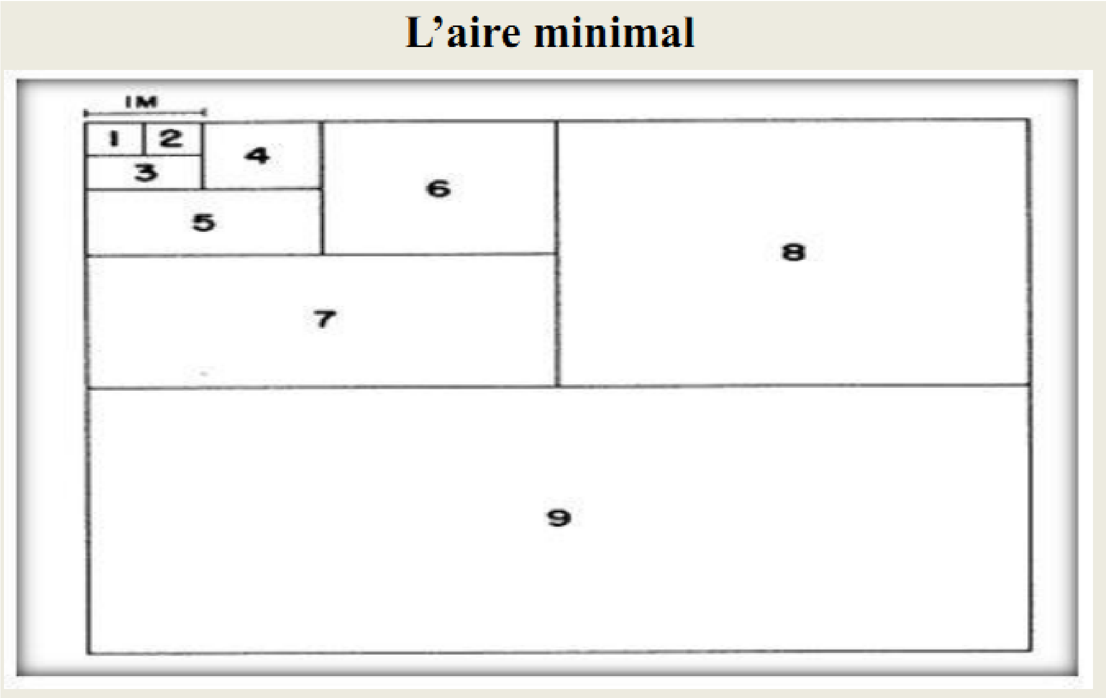

Figure 07: the minimum area method

It is a sufficiently large surface to contain almost all the species present on the association individual (GUINOCHET, 1973).

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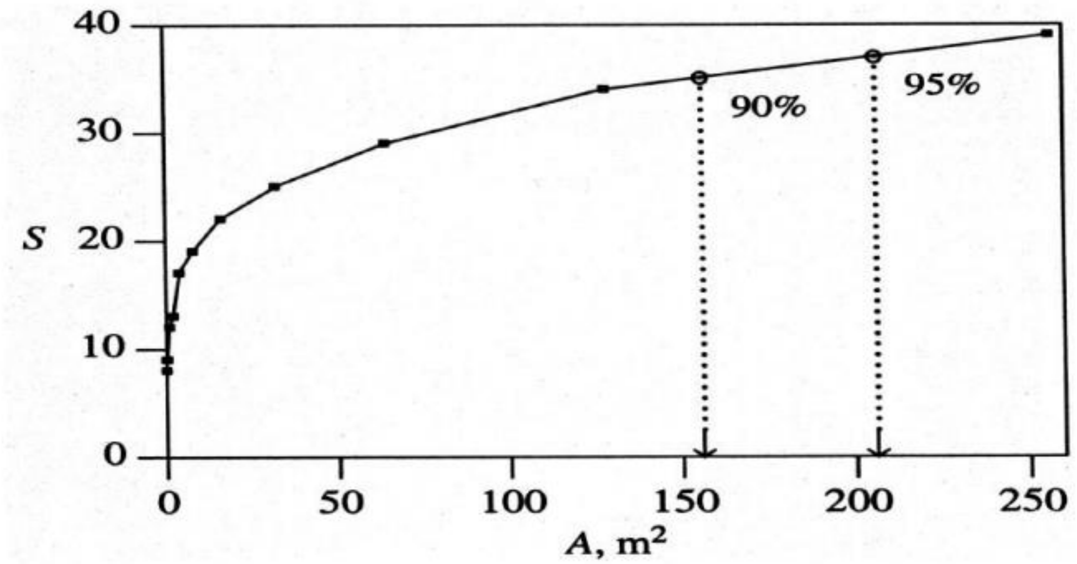
a. The minimum area is defined using the "species-area curve"



Courbe représentant l'accroissement du nombre d'espèces relevé dans un biotope en fonction de la surface

Figure 08: curve representing the increase in the number of species recorded in a biotope as a function of the area

b. Abundance

Express the number of individuals that make up the population of the species present in the survey.

c. Dominance

Represents the coverage of all individuals of a given species

Abundance-Dominance Scale

r: rare or isolated individuals

+: individuals with low abundance, with very low coverage.

1: individuals quite abundant but with low overlap

2: individuals very abundant or covering less than 1/20 of the surface

3: Individuals in any number covering ¼ to ½ of the surface

4: Individuals in any number covering from ½ to ¾ of the surface

5: Individuals in any number covering more than 3/4 of the surface.

d. Dominance abundance scale

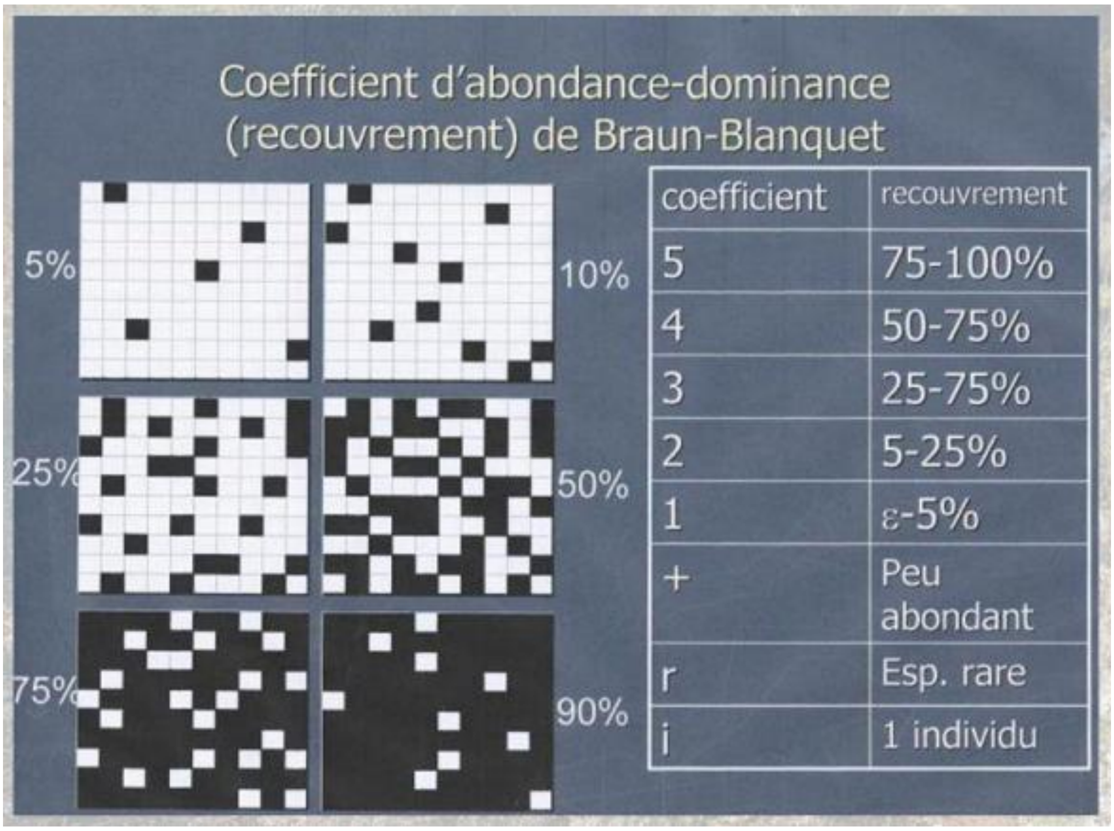


Figure 09: Braun-Blanquet Dominance Abundance Coefficient

e. Sociability

Sociability appreciates the way individuals of the same species are arranged relative to each other within a given population.

Sociability scale:

1: isolated individuals

2: individuals in a tuft

3: individuals in a group

4: individuals in a colony

5: individuals in settlement

f. Composition of a statement

The statements contain 03 categories of information.

-Geographical:

- The station number;
- The statement number;
- The date;
- The geographical coordinates
- Altitude ;
- Slope;
- Exposition.
- Environmental:
- Sun

Context: - Ph

- Climate
- Lithology
- Anthropogenic factors
- Floristic list:
- List of plant species
- Stratification
- Recovery
- Abundance of

Chapter 3: Wildlife Sampling Methods

1. Wildlife Sampling Methods

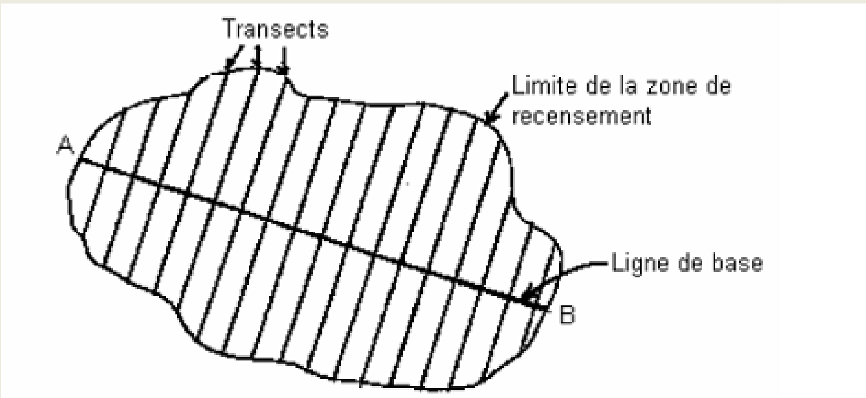
1.1. Mammals

Mammals form a class of warm-blooded vertebrates with skin covered in hair (however, among Mammals, females are equipped with special glands called mammary glands, which secrete milk that serves to nourish their young. This last characteristic, which is absolutely without exception, is the one that gave its name to the class.

1.1.1. Types of Sampling:

a. Transect sampling:

The transect is a straight line along which the animals are counted. To establish the transects, it is necessary to have a census area map. On this map, a baseline is drawn connecting the two furthest ends of the study area. On this baseline, transects are established perpendicularly to it at intervals of 2, 3, or 5 km.



Figures . Disposition de la ligne de base et des transects dans une zone de recensement.

Figure 10: layout of the baseline and transects in a census area

b. Quadrat Sampling:

Less commonly used than the first technique, it involves overlaying a grid of square cells, ranging from 2 to 30 km on each side and numbered, onto the map of the study area, and determining, using a table of random numbers, which squares or quadrats will be subject to a census.

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c. Sampling rate:

The sampling rate (in %) provides an indication of the sampling effort relative to the total area. It is given by the following formula:

$$E = \sum_{i=1}^{n} Si * \times 100 \div Z$$

E: Sampling rate (in %)

If: Sampled area

Z: Surface area of the study zone,

n: number of sampled surfaces.

1.1.2. Sampling Protocol

a. Direct methods

To survey the mammal species present in an environment, it is possible to use three so-called "direct" methods, including

- the capture,
- field observation
- and biochemical analysis.

The first two techniques are applicable to a large number of species, with either of these practices being used depending on the difficulty of identification. Genetic analyses, on the other hand, are more often used in the context of in-depth studies specific to a species, which is why we can say they do not seem suitable for the creation of an atlas (Marchesi & Blant, 2008).

For small-sized organisms that are morphologically quite similar, it is generally advisable to use capture techniques that allow for precise handling and description of each individual.

This particularly applies to rodents, insectivores, and even bats. For micromammals.

Piège INRA — Piège Rat Case — Piège SHERMAN

Figure 11: traps for capturing micromammals

b. Field observations or "contacts"

To discover the roosts or breeding colonies of bats, we surveyed during the day places likely to host bats (GCP, 2010). The most suitable spaces are dark, humid environments that are infrequently visited by humans, such as church attics, abandoned sheds, caves, mines, or the cracks in bridges.

Figure 12: Building (on the left) housing a colony of Lesser Horseshoe Bats (on the right by the arrows)

c. Indirect methods (Analysis of bones and corpses)

Indirect signs of presence can include footprints, bones contained in owl pellets, the carcasses of dead animals, as well as old written accounts or inventories.

These study techniques do not provide details on the abundance of species but allow for inferring the presence or "non-detection" of species in the environment.

The analysis of raptor pellets allows for understanding the dietary habits of raptors, their hunting grounds, and also studying the distribution of small mammal species (Lasnier, 1995).

According to Saint-Giron (1973), since raptors consume numerous small and medium-sized micromammals, their diet reflects the density of organisms present in the environment at a given time (Saint-Giron, 1973; Chaline et al., 1974).

The study of owl pellets is an easily accessible method as long as one has a good identification key (Walravens, 1981) and a magnifying glass (preferably binocular) to facilitate observation. This method is quite popular among naturalists because it involves bone remains, making it a "gentle" technique.

It is not necessary to inflict stress through trapping or to kill individuals to identify them.

Figure 13: Photograph of collected dry castings

A second census technique involves collecting data through carcasses or conducting surveys along roadways.

Like the Red Fox (Vulpes vulpes) or even with anthropophilic organisms that are often in contact with human activities, a disadvantage of this type of protocol is that the discovery of accessible and identifiable corpses is not always possible.

To obtain more data from road collisions, we contacted the highway network services; however.

1.1.3. Attendance Indices

For certain species, it is possible to rely on the study of indirect signs such as feces, tracks and footprints, or even characteristic habitats.

However, although these indirect methods are very useful, they should still be used with caution because the discriminative power of the collected indices fades over time and with changes in environmental conditions (Marchesi et al, 2008).

If it is possible to identify tracks with certainty, such as the European Beaver (Castor fiber), there may still be doubts for certain species, such as the Red Deer (Cervus elaphus) and the Sika Deer (Cervus sika nippon).

The conditions in which these traces are found are important, since traces that are not very visible in hard substrates are sometimes not identifiable.

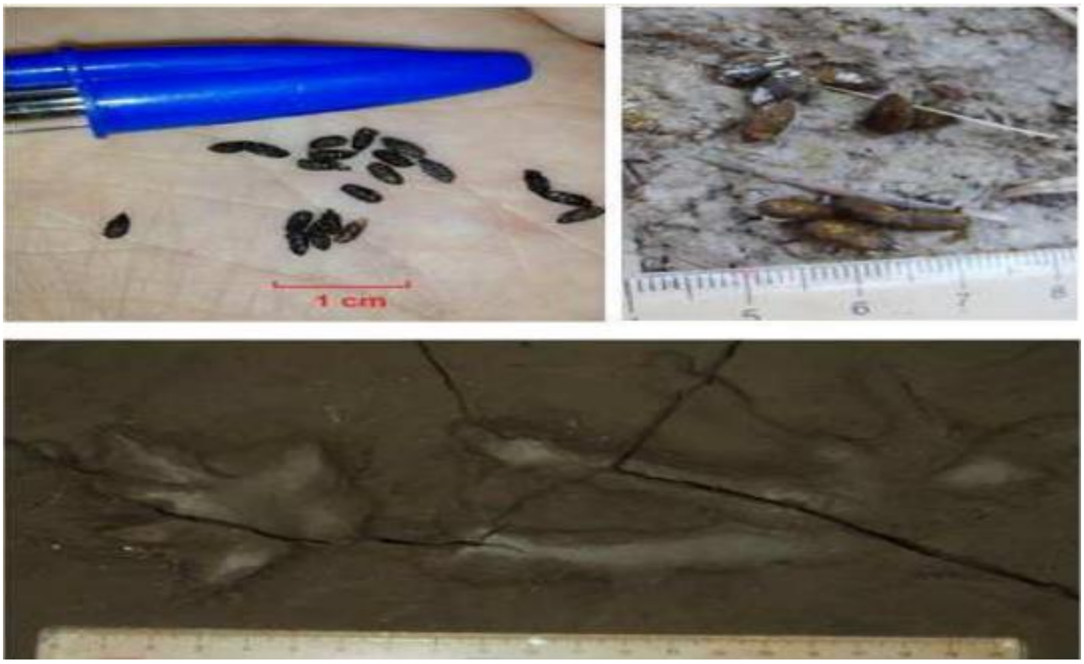


Figure 14: Photographs of European Beaver (Castor fiber) footprints (bottom), guano of the genus Plecotus (Bat) (top left), and droppings of the European Water Vole (top right)

2. The birds

Bird sampling is a method used in ornithology to collect data on avian populations from a representative sample of the total population. This method is essential for studying the demography, spatial distribution, abundance, migratory movements, behaviors, health, and other aspects of bird populations in different habitats and environments.

Here are some elements that contribute to defining bird sampling in detail:

* **Main objective:** The main objective of bird sampling is to collect accurate and representative data on avian populations in order to better understand their biology, ecology, and demographic dynamics. These data are essential for assessing the health status of populations, identifying the threats they face, and developing effective conservation strategies.

* **Data collection methods:** Bird sampling generally involves the use of various data collection methods, such as capturing and marking birds, visual or auditory observations, the use of camera traps, radar data analysis, and other specialized techniques. These methods are selected based on the specific objectives of the study, the characteristics of the target species, and the environmental conditions.

* **Representative sample:** For the results of bird sampling to be reliable and applicable to the entire population, it is crucial that the collected sample is representative. This means that the sampling sites, observation periods, and collection methods must be chosen to cover a sufficiently wide range of conditions and ecological contexts to reflect the diversity of the studied population.

* **Data Utilization:** The data collected from bird sampling can be used for various applications, such as estimating population size, assessing population trends over time, identifying limiting or threatening factors, modeling migration patterns, monitoring population health, and making decisions regarding conservation and habitat management.

* **Ethics and conservation:** Bird sampling must be conducted in accordance with ethical principles, including animal welfare, minimizing stress and risks for captured or observed birds. Moreover, the data collected must be used responsibly to support the conservation of bird populations and their habitats.

Bird sampling is an essential method in ornithology that allows for the collection of valuable data on bird populations to better understand their biology, ecology, and conservation. This rigorous and scientific approach is essential for informing management and conservation decisions aimed at protecting avian diversity and the ecosystems that support them.

2.1. Bird Sampling Methods

2.1.1. Capture and Marking

This method involves the use of nets, traps, or cages to capture birds. Once captured, the birds can be marked with metal or plastic rings, colored tags, electronic chips, or other individual identification devices. Information on species, sex, age, measurements, and other characteristics can also be collected before releasing the birds. This method is widely used to study population demographics, survival rates, migration patterns, social interactions, and other aspects of bird biology.

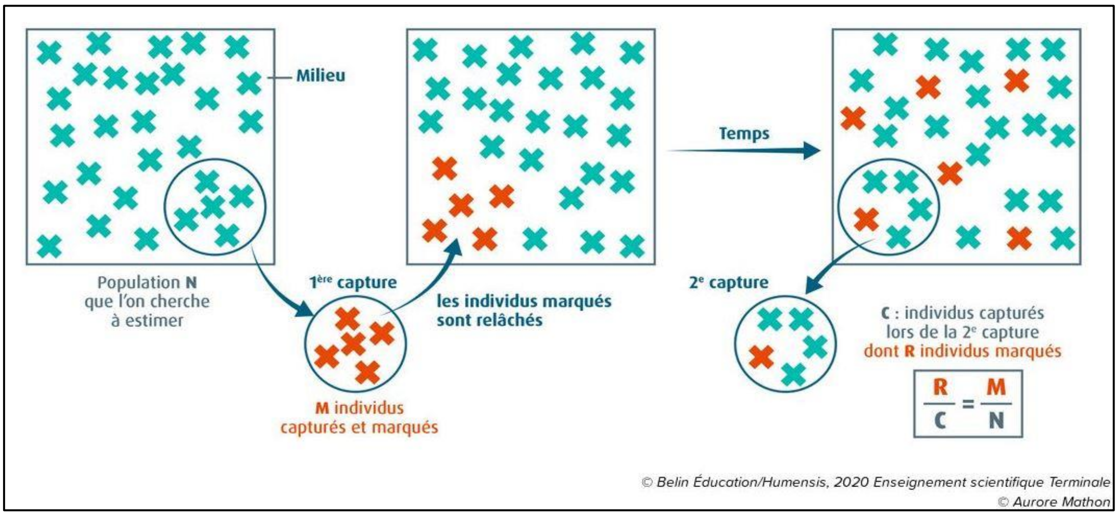


Figure 15: Capture and Marking Sampling Method

2.1.2. Listening Point and Counting Point

Observers record the bird species they hear or see at pre-established listening or counting points, such as forest trails, observation posts, or audio recording stations. This method is particularly useful for estimating species richness, diversity, and abundance of birds in a given area. The collected data can be used to assess population trends, identify biodiversity hotspots, monitor seasonal migrations, and study long-term ecological changes.

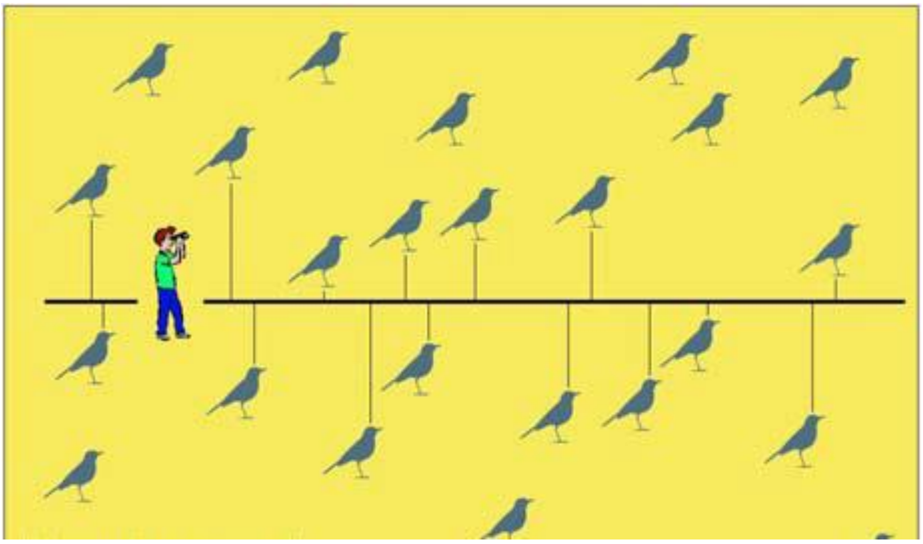


Figure 16: Sampling method by listening point and counting point

2.1.3. Radar Tracking

Radars can be used to monitor the movements of birds over vast territories. Doppler weather radars detect the echoes reflected by birds in flight, allowing for the tracking of nocturnal and diurnal migrations over long distances. This method is particularly useful for studying large-scale bird migrations, seasonal movement patterns, interactions with weather conditions, and the risks of collision with wind turbines and airplanes.

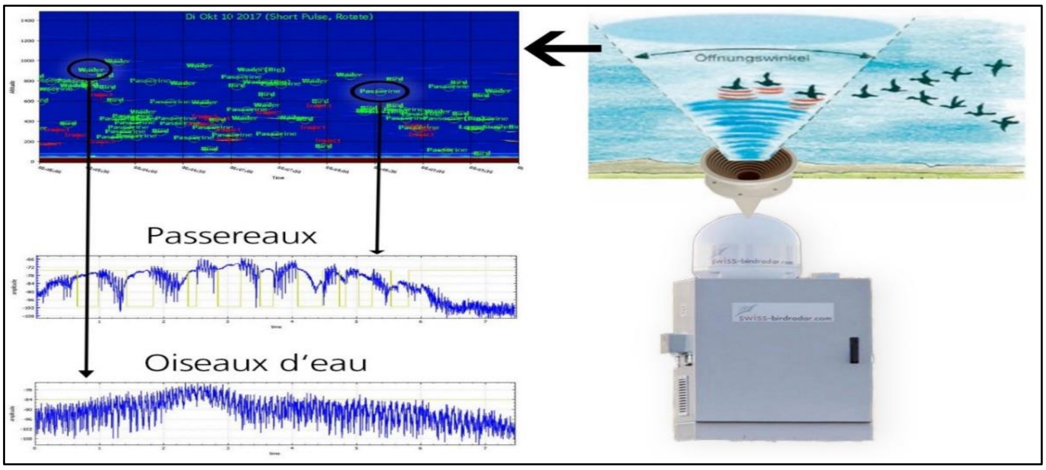


Figure 17: Radar Tracking

2.1.4. Transect Sampling

Researchers walk along predetermined lines or transects through a given habitat and record all bird observations along these lines. This method is used to estimate the density and spatial distribution of bird species, assess seasonal and geographical variations, identify preferred activity areas, and monitor long-term demographic changes. The collected data can be analyzed using statistical models to estimate population size, productivity, survival, and other demographic parameters.

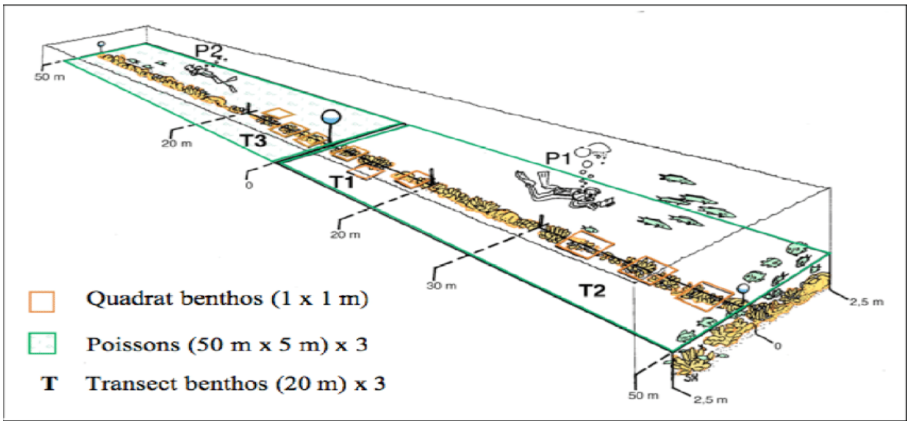


Figure 18: Sampling method by transect sampling

2.1.5. Use of Camera Traps

Automatic camera traps can be used to capture images of birds without disturbing them. These cameras are equipped with motion sensors and automatic triggers that capture photos or videos when birds pass nearby. This method is useful for monitoring discreet, nocturnal, or rare species, and can provide information on behavior patterns, interspecific interactions, the use of nesting and feeding sites, and other aspects of bird biology.

2.2. Choice of Sampling Method

The choice of bird sampling method is a crucial step in the planning of an ornithological study. Several factors must be considered to select the most appropriate method based on the research objectives, targeted species, habitat characteristics, and logistical constraints. Here is a detailed explanation of this process:

Research Objectives: It is essential to clearly define the study objectives before choosing the sampling method. For example, if the objective is to estimate the abundance of bird populations, methods such as point counts or transects may be appropriate. If the objective is to capture and mark individuals to study their demographics or movements, then the capture and marking method will be preferred.

Target species: Different bird species have varying behaviors, habitats, and movement patterns. It is important to select a method that is suitable for the targeted species. For example, some species are more easily detected by their song, while others are better observed visually. Similarly, some species may be easier to capture than others.

Habitat characteristics: The characteristics of the habitat, such as plant structure, topography, availability of food resources, and vegetation density, can influence the choice of sampling method. For example, transects may be more appropriate for open habitats such as prairies, while listening points may be more effective in dense forests.

Logistical constraints: Logistical constraints such as budget, time, access to the field, and equipment availability can limit the choice of sampling methods. It is important to select a method that is feasible under the specific conditions of the study, while ensuring the collection of high-quality data.

Data reliability: It is essential to consider the reliability of the data produced by each sampling method. The methods must be selected in such a way as to minimize sampling biases and produce accurate and representative estimates of the studied population.

2.3. Importance of Bird Sampling

Bird sampling is of paramount importance for several reasons:

Bird population monitoring: Sampling allows for the collection of data on the abundance, distribution, and demographics of bird populations in different habitats and geographical regions. This information is essential for assessing the health status of populations, tracking demographic trends over time, and identifying species at risk or in decline.

Study of bird ecology: Bird sampling provides information on the interactions between birds and their environment, including movement patterns, habitat preferences, reproductive behaviors, dietary habits, and interspecific interactions. These data are crucial for understanding bird ecology and the ecological processes that govern ecosystems.

Environmental health indicators: Birds are often used as indicators of environmental health due to their sensitivity to changes in ecological conditions and their important role in trophic networks. Bird sampling allows for monitoring the effects of anthropogenic disturbances such as habitat loss, pollution, climate change, and emerging diseases on bird populations and ecosystems.

Species and habitat conservation: The data collected through bird sampling are used to inform conservation and management decisions for species and their habitats. This information allows for the identification of ecologically important sites, the design of networks of nature reserves, the implementation of ecological restoration plans, and the monitoring of the effectiveness of conservation measures.

Scientific research: Bird sampling is an essential component of scientific research in ornithology and ecology. The data collected contribute to the production of new knowledge about the biology, evolution, physiology, genetics, and other aspects of bird life. These studies are important for informing conservation policies, guiding natural resource management practices, and addressing fundamental scientific questions about biodiversity and evolution.

Bird sampling is crucial for monitoring, understanding, and protecting bird populations and the ecosystems they are part of.

2.4. Use of Sampling Data

The use of bird sampling data is an essential step that follows the collection of data on avian populations. This part of the presentation explores how data collected from different sampling methods are used for various applications in the fields of ornithology, ecology, and conservation. Here are some subtitles that can be included to explain this part:

Evaluation of abundance and distribution: Bird sampling data are used to estimate the abundance and distribution of species in different habitats and geographical regions. This information is crucial for understanding the spatial distribution of bird populations, identifying areas of ecological importance, and monitoring demographic trends over time.

Identification of demographic trends: By analyzing the data collected from bird samples, researchers can identify demographic trends such as changes in population size, reproduction rates, mortality rates, and migration patterns. This information is used to assess the viability of populations and identify species at risk of decline.

Study of limiting factors: Bird sampling data can be used to study the limiting factors that affect the health and survival of avian populations, such as the availability of food resources, habitat quality, weather conditions, and interspecific interactions. This information is important for identifying potential threats and designing effective conservation measures.

Habitat modeling: Bird sampling data can be used to model the preferred habitats of avian species by identifying the environmental characteristics associated with their presence or absence. These models are useful for predicting the spatial distribution of species, assessing the impact of environmental changes on their habitat, and informing conservation planning.

Evaluation of the effectiveness of conservation measures: Bird sampling data are used to assess the effectiveness of conservation measures implemented to protect bird populations and their habitats. By comparing data before and after the implementation of conservation measures, researchers can assess their impact on the health and dynamics of bird populations.

3. Amphibians and reptiles

3.1. Amphibians

The term amphibian (amphi: double, bios: life) indicates that these animals live both in the aquatic environment (larval life) and in the terrestrial environment (adult life). It is true that most commonly, amphibians transition from an aquatic larval life to a terrestrial adult life following a metamorphosis.

Amphibians constitute a fascinating and diverse group of cold-blooded animals, often associated with both terrestrial and aquatic life. Their classification and diversity offer a captivating insight into evolution and adaptation to different environments.

3.1.1 Classification of amphibians

The classification of amphibians is based on their phylogeny and anatomy. Traditionally, they are divided into three main orders:

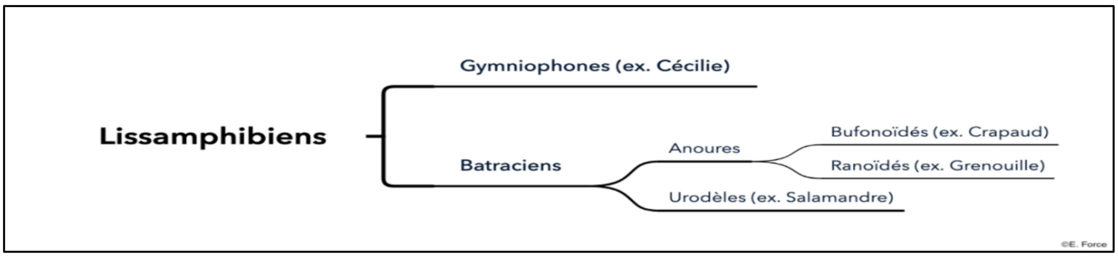


Figure 19: the classification of lissamphibians

a. Anoures (Anura)

Anurans include frogs and toads. They are characterized by the absence of a tail in adulthood and an adaptation to terrestrial life. One of the most well-known families is the Ranidae, which includes species such as the leopard frog (Rana pipiens) and the bullfrog (Lithobates catesbeianus).

Figure 20: Order Anura (species Agalychnis callidryas)

b. Urodeles (Caudata)

Urodeles, also known as salamanders and newts, are distinguished by their persistent tails in adulthood. They generally have an elongated body shape and remarkable regenerative ability. For example, the axolotl (Ambystoma mexicanum) is a fascinating species capable of regenerating lost limbs.

Figure 21: Order Caudata (species Cynops pyrrhogaster)

c. Gymnophiones (Gymnophiona)

Gymnophiones, or caecilians, are the least known of the three orders. They resemble earthworms and primarily live in the moist soils of tropical regions. Their serpentine appearance and underground lifestyle make them mysterious creatures. An interesting study conducted by Gower et al. (2005) revealed unique adaptations in caecilians, particularly their highly specialized skull.

Figure 22: A gymnophione, the caecilian Caecilia tentaculata

3.1.2 Diversity of amphibians

The diversity of amphibians is remarkable, with around 7,000 species distributed worldwide. Their geographical distribution varies according to habitats, ranging from tropical forests to arid deserts. This diversity is the result of adaptation to a wide variety of environmental conditions.

The adaptations of amphibians are numerous and fascinating. For example, some have developed camouflage mechanisms to blend into their environment, while others display bright colors as a warning against predators. Tree frogs, such as species of the genus Hypsiboas, are equipped with suction cups on their fingers to cling to branches.

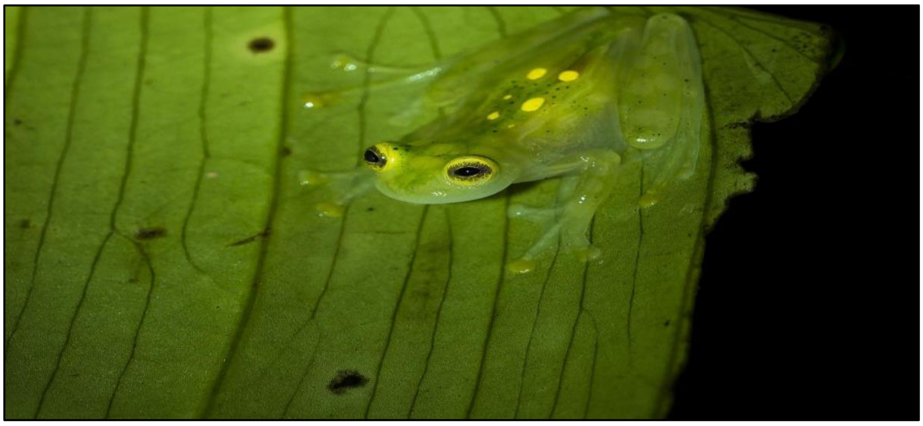


Figure 23 : Hyalinobatrachium sp is a genus of frog, called glass frog due to its translucent skin that reveals its organs. It is a widely used camouflage technique.

Research on amphibians is essential for understanding their diversity and ecology. For example, a study conducted by Houlahan et al. (2000). Revealed an alarming decline in amphibian populations worldwide, highlighting the importance of conserving natural habitats.

The classification and diversity of amphibians offer a fascinating insight into evolution and adaptation. Their study continues to provide crucial information for the preservation of these species and their habitats.

3.1.3. Capture and Identification Techniques

Capture and identification techniques are essential for studying amphibians effectively. They allow researchers to collect precise data on the distribution, abundance, and diversity of populations. Here is a detailed overview of the main methods used:

a. Trapping

Trapping is one of the most commonly used methods for capturing amphibians. The traps can be of different types, such as funnel traps, pitfall traps, and noose traps. These devices are strategically placed in amphibian habitats, such as wetlands, streams, and marshes. Once captured, the amphibians can be tagged, measured, and released or kept for further study.

A study conducted by Smith et al. (2018). Compared the effectiveness of different types of traps for capturing tree frogs in tropical forests, demonstrating the importance of choosing the appropriate type of trap based on the target species and its habitat.

Figure 24: The "Amphicapt" type trap consists of a 15-liter bucket with three lateral funnels (this system ensures the buoyancy of the trap in water bodies).

b. Acoustic sampling

Acoustic sampling is a non-invasive method used to detect and identify amphibians by recording their vocalizations. Amphibians, such as frogs and toads, produce specific calls during the breeding season to attract mates. Audio recordings can be analyzed to identify the species present in a given area.

A study conducted by Davis et al. (2019) used acoustic recordings to monitor amphibian populations in urban areas, highlighting the effectiveness of this technique in assessing the impact of human activities on amphibian populations.

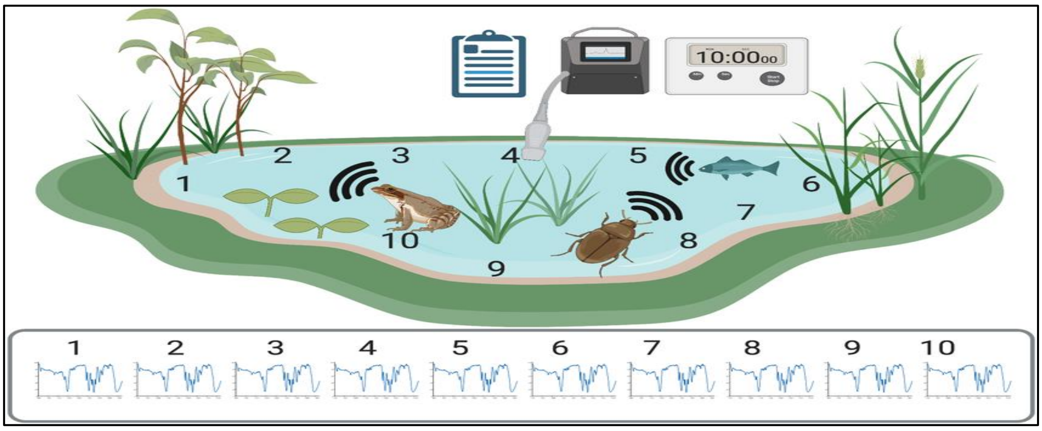


Figure 25: Acoustic sampling plan of the pond. Each sample consists of a 10-minute underwater sound recording from the pond, comprising 10 recordings, each one minute long, taken at different locations around the water body. Environmental parameters and survey metadata are systematically collected to accompany each healthy sample.

c. Visual research

Visual search involves actively looking for amphibians in their natural habitat. Researchers often scour wetlands, marshes, and lakes in search of active amphibians at night. This method requires careful observation and can be limited by visibility and weather conditions.

A study conducted by Tyler et al. (2020) used visual search techniques to study the distribution of salamanders in mountain forests, highlighting the importance of combining it with other capture methods to obtain comprehensive data on species diversity.

d. Identification of species

The identification of amphibian species can be carried out using a combination of morphological characteristics, such as body shape, skin color, size and structure of limbs, as well as more advanced techniques such as genetic analysis.

Taxonomic studies, such as the one conducted by Johnson et al. (2021), have allowed for the description of new amphibian species based on morphological and molecular analyses, thereby enriching our understanding of amphibian diversity.

Capture and identification techniques are crucial for studying amphibians and understanding their ecology and evolution. By combining different methods, researchers can obtain valuable data for the conservation and management of amphibian populations.

Figure 26: Identification and Comparison Sheet for Amphibians

3.1.4. Study of Habitat and Ecology

Understanding the habitat and ecology of amphibians is crucial for their conservation and management. This section will examine in detail the different facets of this study.

3.1.5. Microhabitat Preferences

Amphibians often exhibit specific preferences for microhabitats within their general habitat. These preferences can vary depending on factors such as temperature, humidity, vegetation cover, and prey availability.

Studies conducted by Jones et al. (2017) have shown that red-legged frogs (Rana temporaria) prefer microhabitats with dense vegetation and higher ground cover, thus providing protection against predators and an abundant food source.

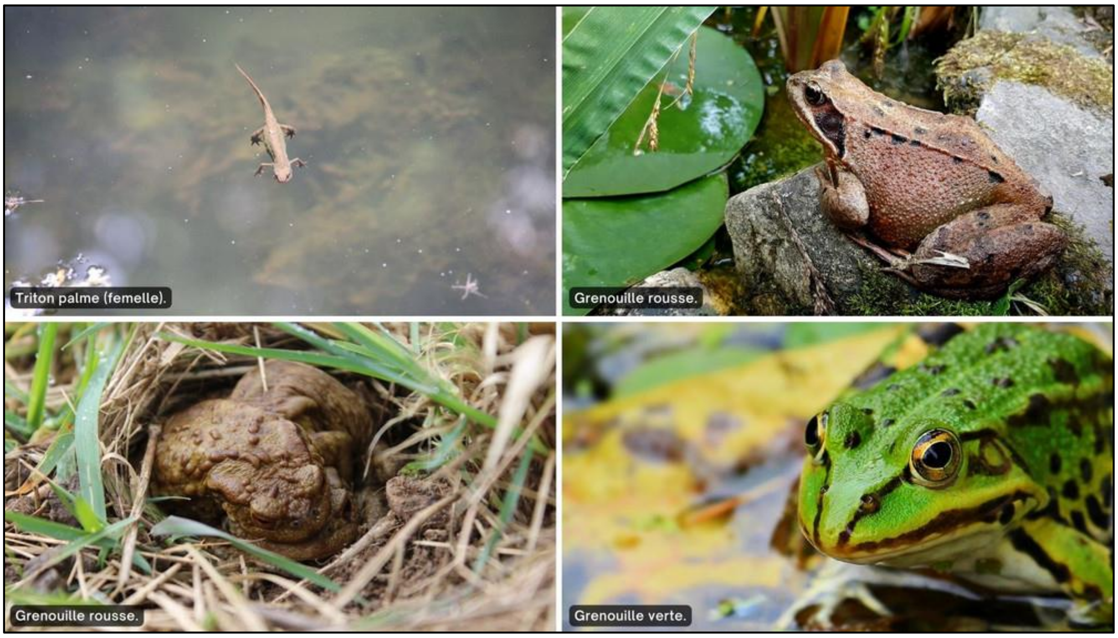


Figure 27: There are 450 ponds recorded in the Chartres Métropole area. This natural habitat is home to amphibians, which carry out all or part of their life cycle there.

3.1.6. Use of Water and Land

Most amphibians depend on aquatic environments for reproduction, but many also spend a significant part of their lives on land. The ability of an amphibian to effectively use these two environments can influence its distribution and survival. For example, terrestrial salamanders, such as species of the genus Plethodon, spend most of their lives in humid forest habitats, where they feed on small invertebrates. In contrast, frogs and toads lay their eggs in water but can migrate to terrestrial habitats once they are adults.

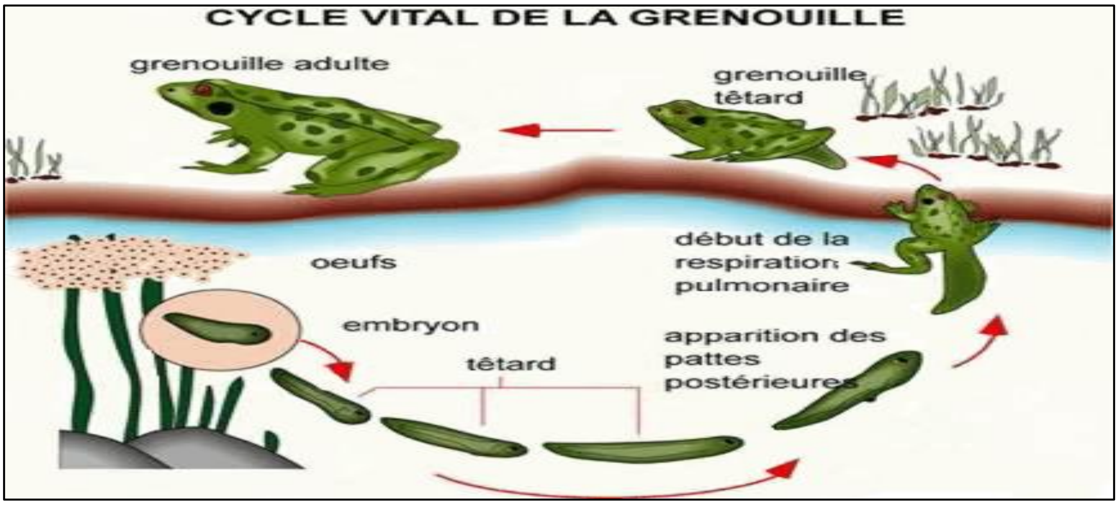


Figure 28: life cycle of the frog

3.1.7. Environmental factors influencing distribution

Many environmental factors influence the distribution of amphibians, including temperature, humidity, water availability, water quality, terrestrial habitat quality, the presence of predators, and prey availability.

Studies have shown that amphibians are sensitive to climate change, with declining populations in regions subjected to prolonged droughts or extreme weather events. Smith et al. (2020). Moreover, habitat degradation due to urbanization and land fragmentation can also have a negative impact on amphibian populations (Brown et al., 2019).

3.1.8. Abundance and distribution of amphibians

The abundance and distribution of amphibians vary considerably depending on their species, habitat, and local environmental conditions. Field surveys, visual surveys, acoustic sampling, and capture techniques are often used to assess the presence and density of amphibian populations in a given area.

For example, a study conducted by Johnson et al. (2022) revealed significant differences in the distribution of frogs between wooded areas and open areas, highlighting the importance of considering habitat characteristics when assessing amphibian distribution.

The study of amphibian habitat and ecology is crucial for understanding their distribution, behavior, and survival. By combining different study methods, researchers can obtain valuable information for the conservation and management of amphibian populations.

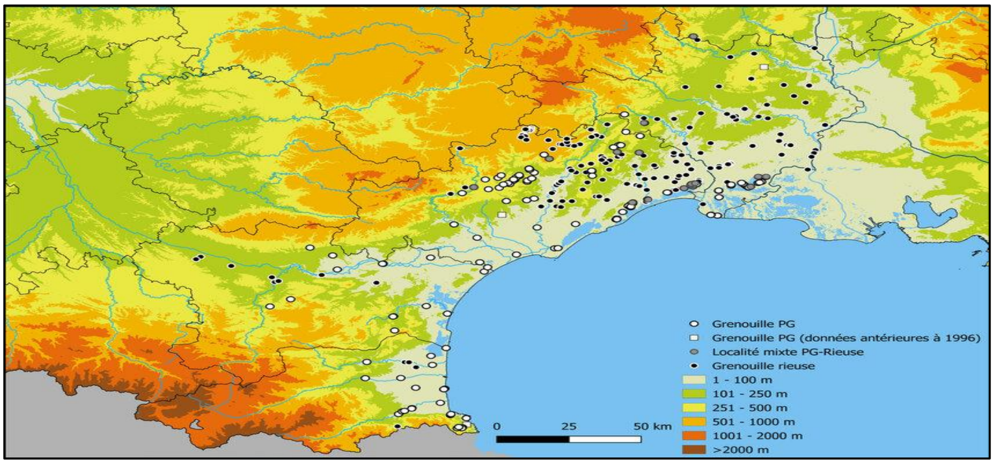


Figure 29: Updated distribution map of P-G system frogs and the Laughing Frog in the study area. The background color of the map indicates the altitude (as shown in the map legend).

3.1.9. Monitoring of Populations and Migrations

Monitoring amphibian populations and migrations is essential for understanding their movements, life cycles, and responses to environmental changes. This section will examine in detail the different methods used in this field.

a. Individual marking

Individual marking of amphibians involves the identification and tracking of individuals using unique markers, such as colored tags, subcutaneous implants, or radio transmitters. These techniques allow researchers to track the movement of individuals in their natural habitat, estimate their survival rates, and understand their social behaviors.

A study conducted by Smith et al. (2019) used radio tags to track the movements of bullfrogs (Lithobates catesbeianus) during the breeding season, revealing complex migration patterns between aquatic and terrestrial habitats.

Figure 30: Common frog wearing a radiogoniometric "tag" transmitter around its waist. The technology is inexpensive and very lightweight, allowing scientists to learn more about small amphibians. Photo by Betsy Roznik.

b. Monitoring of larvae

The monitoring of amphibian larvae is often carried out to assess the survival and growth of young individuals in their natural environment. This method often involves the individual marking of larvae with non-toxic dyes or tags, followed by regular surveys to determine recruitment and mortality rates.

A study conducted by Davis et al. (2021) used fluorescent dyes to mark wood frog tadpoles (Rana sylvatica) and tracked their development and survival in forest ponds, thereby providing valuable information on breeding conditions and potential threats.

c. Population genetics studies

Population genetics studies allow for the evaluation of the genetic structure of amphibian populations, the rates of gene flow between populations, and the levels of genetic diversity. This information is crucial for understanding habitat connectivity, dispersal patterns, and evolutionary responses to environmental changes.

For example, an analysis conducted by Johnson et al. (2023) on spotted salamander populations (Ambystoma maculatum) revealed a complex genetic structure, suggesting patterns of limited migration and implications for the conservation of fragmented habitats.

d. Seasonal migrations

The seasonal migrations of amphibians, particularly between breeding sites and terrestrial habitats, are crucial events in their life cycle. These migrations can be influenced by factors such as temperature, precipitation, and water availability.

A study conducted by Brown et al. (2022) tracked the seasonal migrations of common toads (Bufo bufo) in wet meadows, showing migration patterns synchronized with precipitation and water availability for reproduction.

Monitoring amphibian populations and migrations is essential for understanding their ecology and conservation. By using a combination of marking techniques, genetic studies, and ecological monitoring, researchers can obtain valuable information for habitat management and the protection of threatened species.

Figure 31: During the breeding migration, common toads willingly stay on the roads, where they wait for the migrating females. (© Thomas Mermod).

3.2. Reptiles

Reptiles are a class of vertebrate animals with more or less thick skin covered in scales, comprising nearly 8,000 species divided into 62 families and 4 orders: snakes and lizards (or squamates), crocodilians (crocodiles, caimans, gharials, and alligators that have hardly evolved in the past 65 million years), turtles (chelonians, which have their own section on Anigaïdo), and tuataras, which resemble lizards and are the last representatives of reptiles that were very common over 200 million years ago, now confined to a few islands off the coast of New Zealand.

3.2.1. The most important characteristics of reptiles

Reptiles have developed a range of strategies to survive in their often hostile habitats. Their lifestyle varies depending on the species, but a few general characteristics define them:

a. Regulation of body temperature

Unlike warm-blooded animals, reptiles are cold-blooded, which means they rely on their environment to regulate their body temperature. They warm themselves in the sun to increase their internal temperature and cool down in the shade or in shelters to avoid overheating.

b. Nutrition

Reptiles have a wide variety of diets. Some are carnivorous, feeding primarily on prey such as insects, small mammals, or other reptiles. Others are herbivores, feeding on plants, while some are omnivores and consume both meat and plants.

c. Reproduction

Most reptiles reproduce by laying eggs, although a few species are viviparous, giving birth to live young. The nesting sites vary by species and can include ground nests, tree nests, or even holes in the ground.

d. Habitats

Reptiles inhabit a wide variety of terrestrial and aquatic habitats, including deserts, forests, grasslands, swamps, oceans, and rivers. Their habitat can influence their behavior, morphology, and diet.

e. Behavior

The behavior of reptiles varies considerably from one species to another. Some are solitary, while others are social. Some reptiles are nocturnal, while others are diurnal. Overall, reptiles are remarkably adaptable and have evolved to survive in a wide variety of environments around the world. (reptile biology)

f. life cycle of reptiles

Snakes and lizards are reptiles. Alligators and turtles are also reptiles. All reptiles go through similar stages during their lives. These stages are the egg, the hatching of the newborn, the juvenile, and adulthood. Most newborns and juveniles resemble adults. However, they are much smaller.

Generally, mothers bury their eggs in the sand or soil, and the number of eggs varies greatly from one species to another. Some reptiles lay only one or two eggs at a time, while others can lay more than a hundred. Usually, the parents do not stay with their young. After they hatch, the babies live alone.

3.2.2. Capture and Identification Techniques

The capture and identification of reptiles are crucial for understanding their ecology and distribution. Among the commonly used techniques are trapping, direct field observation, and the analysis of traces left by reptiles, such as footprints and droppings.

Trapping, using appropriate traps, allows for the non-invasive capture of reptiles for further studies. Direct field observation, particularly during the peak activity periods of reptiles, offers an opportunity to identify the species present in a given habitat [03].

Moreover, the analysis of traces such as footprints can provide clues about the presence and distribution of reptiles in an environment [04].
The identification of reptile species relies on specific morphological, behavioral, and ecological criteria [05]. For example, body shape, color, scale structure, and patterns can be key characteristics for distinguishing species [06]. Moreover, observing behavior, modes of movement, and preferred habitats can help identify reptiles in the field.

Figure 33: New tools for identifying reptiles

a. simple inventories

By multiplying the number of follow-ups on a national scale (Presence/absence), it will be possible to better understand the distribution of species but also to identify the habitats and environments important for the conservation of reptiles.

b. temporal monitoring

By increasing the number of temporal follow-ups (presence/absence), it will be possible to establish national trends.

c. habitats and management

This protocol is more substantial (number of transects >10) and its design requires a "case-by-case" consideration. It allows for the comparison of occurrence, detection probability, or relative abundance at a local scale.

d. Combined with sight and plate

It allows for the detection of both heliophilous species and discreet species. This method is therefore suitable for assessing species richness.

Attentive visual surveys will be conducted 2 meters on each side of the transect (only one side for border environments) and at a constant speed (approximately 20 meters/minute) on the "outbound" journey. The plates are lifted on the "return" trip.

e. Plaques alone

The method of plate surveys allows for the detection of a number of species (particularly discreet ones). This approach is suitable for people who are not accustomed to observing reptiles visually.

The observations are collected only visually. Careful visual inspections will be carried out at a constant speed (20 meters/minute) on the "outbound" route. This method is proposed in cases where the installation of plates on a site is not possible/desirable.

f. Line of sight only

❑Each plate is geo-referenced (GPS point). We recommend annotating the plates to inform about the ongoing monitoring.

It is recommended to lift the plate with a gloved hand or with the help of a hook in the presence of venomous species. It is advisable to gently place the plate back if there are animals underneath or, better yet, to scare them away to avoid crushing them.

❑As part of inventories (limited duration), it is important to remove the plates once the monitoring is completed.

g. Capture-Recapture (CR)

The CMR method is often used to estimate the size of reptile populations. It involves capturing individuals, marking them non-invasively (for example, with individual tags or physical marks), and then releasing them back into their environment. After a certain period of time, a new series of captures is carried out, and the number of marked individuals among the newly captured ones is recorded. This technique allows for the extrapolation of the total population size.

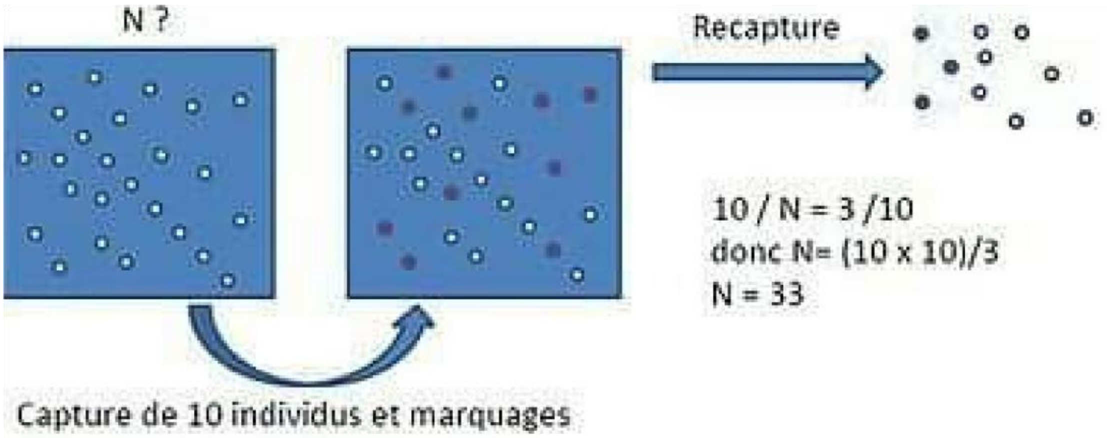


Figure 34: The Capture-Recapture Method (CRM)

h. Capture-Mark-Recapture of Super-Individuals (CMRS)

This method is used when individuals in a population cluster into larger units, such as families, social groups, or aggregates. Rather than marking each individual, "super-individuals" are marked as collective units. Then, during recapture, these super-individuals are found and the presence or absence of their individual members is recorded. This allows for estimating the population size while taking into account the social or spatial structure of the individuals.

These methods are often used in combination with the CMR method to gain a deeper understanding of population dynamics and the movement patterns of reptiles.

i. Double Capture-Mark-Recapture (CMRD)

This method is an extension of the CMR method and is used when individuals can change groups or populations during the study. It involves conducting two cycles of marking and recapture, with a different distinctive marking for each cycle. This allows for distinguishing individuals marked during the first cycle from those marked during the second cycle, and estimating the rates of migration or dispersion between populations.

4. Arthropods (mainly insects)

Figure 35: some species of insects

The collection of insects is essential in entomology: Most species cannot be identified "by eye" in the field. Most studies require numerical results (number of individuals of a species, number of species present, etc.). So, the need to collect and preserve What can we expect from an entomological study?

The entomological study is an In Situ investigative approach aimed at revealing the presence of one or more insect species as well as, potentially, the significance of the populations.

The entomologist or a third party collects insects in the field for identification purposes.

4.1. Relative methods for insect sampling

4.1.1. Filet

The principle of using the scythe net is simple. You just need to "beat" the herbs with the net to capture the insects buried in the vegetation.

Please provide the text you would like me to translate.

Mow the plants from right to left over a small area.

Harvest the insects by making well-measured scything movements.

The movements must be fast and strong enough to surprise and knock the insects into the pocket, but not too much to avoid cutting the plants.

Allows "sight" captures

· Indicates only whether a given species is present or not at a given location

· Does not provide much insight on abundance or diversity (no numerical results)

The captures are not very representative of the actual diversity.

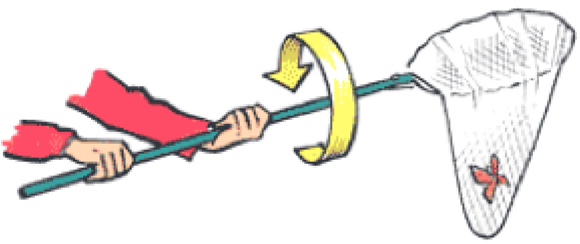


Figure 36: Method for imprisoning a captured insect

4.1.2. Mower Net

Technique consisting of moving forward a certain distance while mowing the grass with the net.

Allows obtaining numerical results (relative abundance)

Ex. number of individuals of a given species captured after 20 net casts over a distance of x meters.

Difficult to standardize the method (the way of mowing varies from person to person, the result varies greatly depending on the density and nature of the vegetation)

4.1.3. Light traps

• Very selective: not all species are attracted to light.

• Some species are more attracted than others.

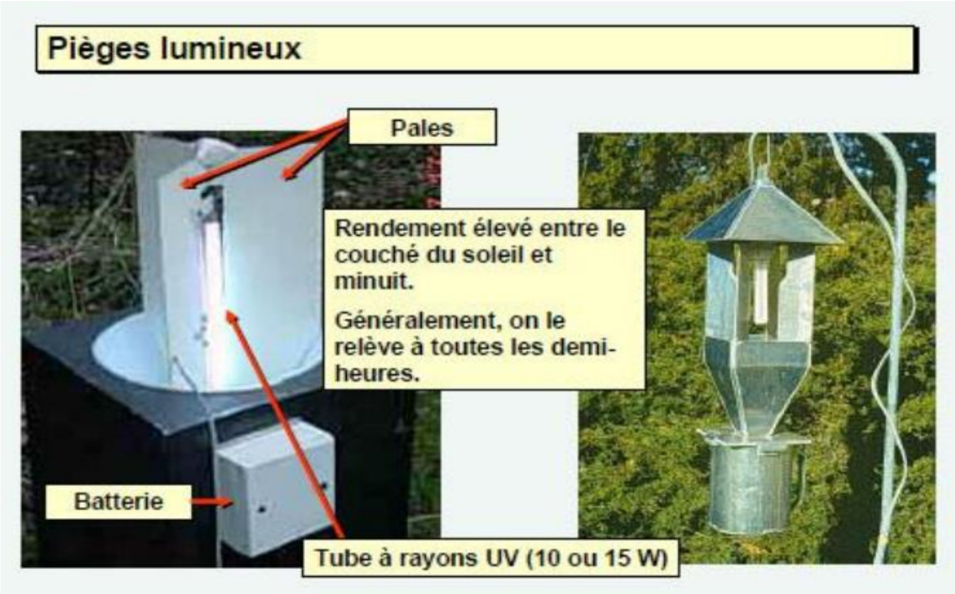
• Some species are more likely than others to be captured (the larger ones or those that fly less well, like beetles).

Some species cover greater distances than others to reach the trap (does not provide information on the sampled territory area).

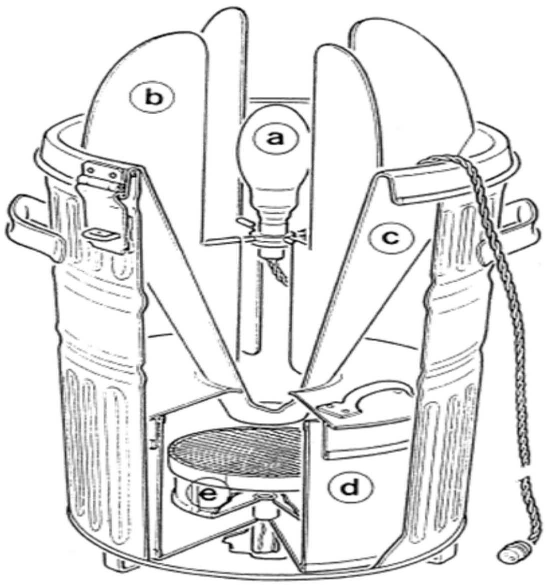
• The range of light varies depending on the environment (less in the forest, for example).

• Can still give a good idea (quantified) of the abundance of a species (n individuals during a period of time t at a given moment of the
night).

• Allows for the comparison of different strata within the same environment (herbaceous, shrubby, and arboreal, for example).• Allows for comparing population variations during the night or the season.



Trap equipped with a mercury lamp (a)



Simplified light trap. Only allows for manual and selective collection (not really any usable numerical results)

4.1.4. Pit trap

Allows obtaining abundance indices of certain
species living on the ground (however, unreliable for estimating the
population density).

Allows for comparison of different environments.

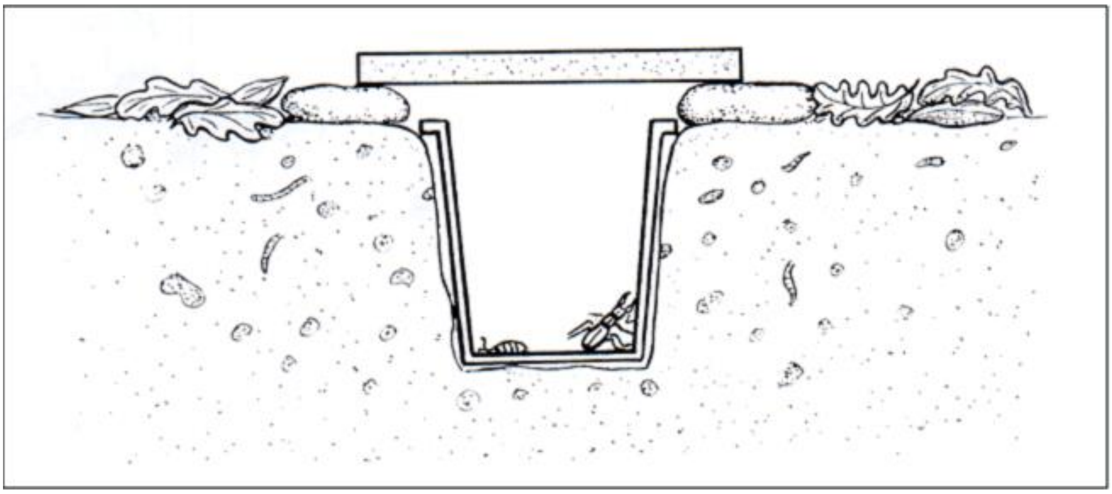
The diameter of the trap has an effect on the size of the catches (in
the Beetles); a larger diameter trap captures
proportionally more large prey than a smaller one.

You can add a preservative liquid to the bottom:

- Alcohol
- Formaldehyde
- Propylene glycol (50-65%)
- Water, salt, and detergent (for short periods only)

Advantage: allows the trap to be left in place for several days and even several weeks.

Disadvantage: the preservation liquid makes the trap selective (attracts some and repels others).



4.1.5. Threshing

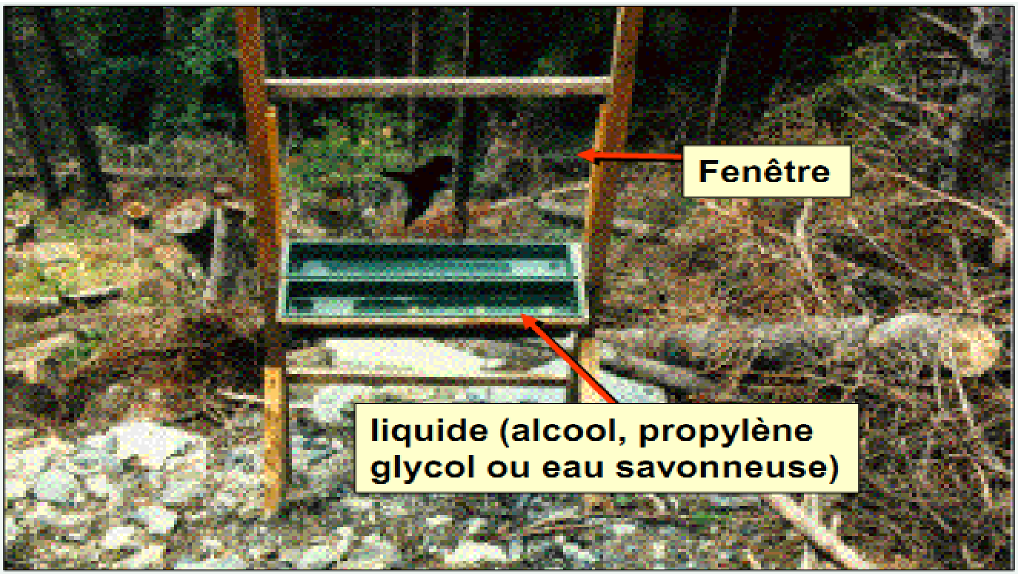
For the collection of arthropods living on the foliage of trees and shrubs.

Effective especially for beetles, larvae of phytophagous insects and phytophagous mites.

Allows associating insect or arthropod species with a host plant.

Does not allow for obtaining truly useful numerical data.

4.1.6. In-flight interception trap (Impact trap)



The flying insects hit the transparent surface and fall into a preservative liquid.

Selective: the species do not all have the same vulnerability to this trap (beetles are more vulnerable).

Very variable yield depending on the weather conditions or the location where the trap is placed.

4.1.7. In-flight interception trap (Malaise trap)

It is based on the tendency of insects to climb when they encounter an obstacle.

Effective especially for Diptera, Hymenoptera, and Lepidoptera.

Piège Ngu Piège H

Variantes du Malaise conçues pour évaluer l'abondance de certains diptères hématophages comme les Tabanidés ou la mouche Tsé-tsé. Ces espèces sont attirées par les formes sombres (notez la couleur sombre des « murs » intérieurs).

Variants of the Malaise trap designed to assess the abundance of certain hematophagous dipterans like tabanids or the tsetse fly. these species are attracted to dark shapes (note the dark color of the "interior walls").

4.1.8. Pheromone trap

Use sexual pheromones to attract specific species.

Very selective. Attract only a very specific species and only one sex (generally males). Disadvantage: high cost

4.1.9. Lindgren Funnel trap

Trap for beetles that bore galleries in trees (mostly Scolytidae).

Made of a series of stacked funnels. Based on the tendency of the insect to fall to the ground when it loses grip while trying to land.

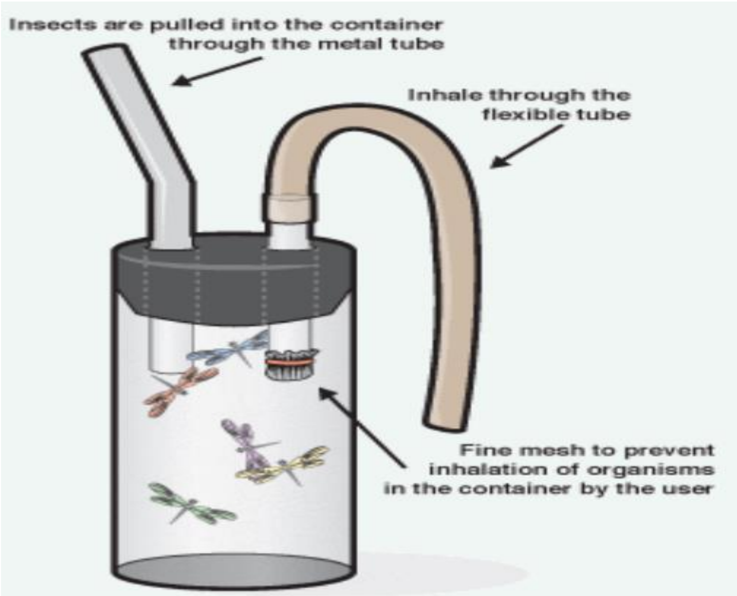
Perhaps lured with pheromones, substances extracted from the host tree (alpha-pinene, for example), alcohol, or turpentine.

The insects are collected in the container at the base which contains a preservative liquid.

4.2. Absolute Methods

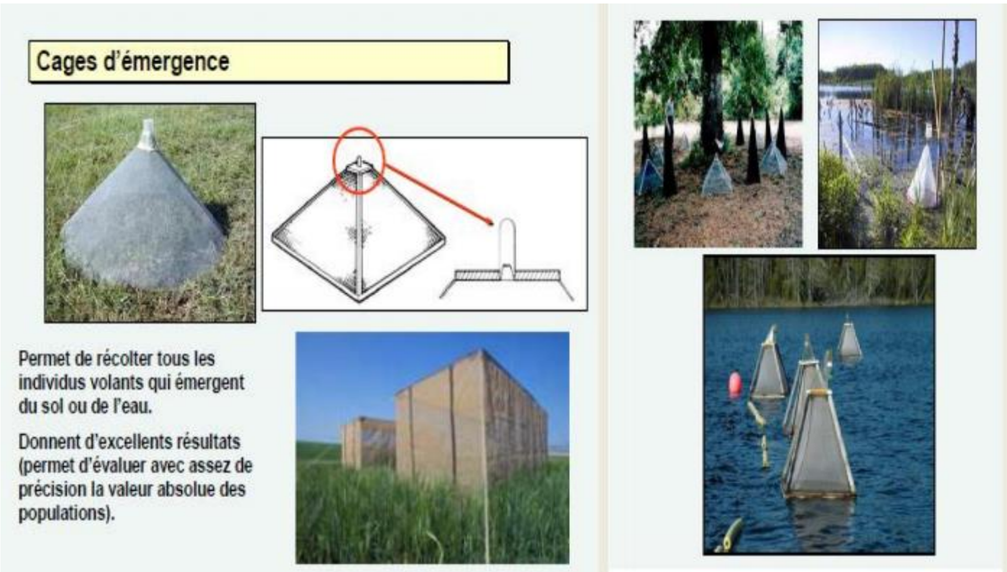
4.2.1. Manual Collection

Often the simplest and fastest method to sample insects that live on the surface of plants (on the leaves, for example).
It is often useful to use a vacuum cleaner to collect small insects.



4.2.2. Emergence cages

Allows harvesting all the emerging flying individuals of the soil or of the water.
Give excellent results (allows for evaluation with enough precision the absolute value of population).



4.2.3. Aspiration (D-Vac)

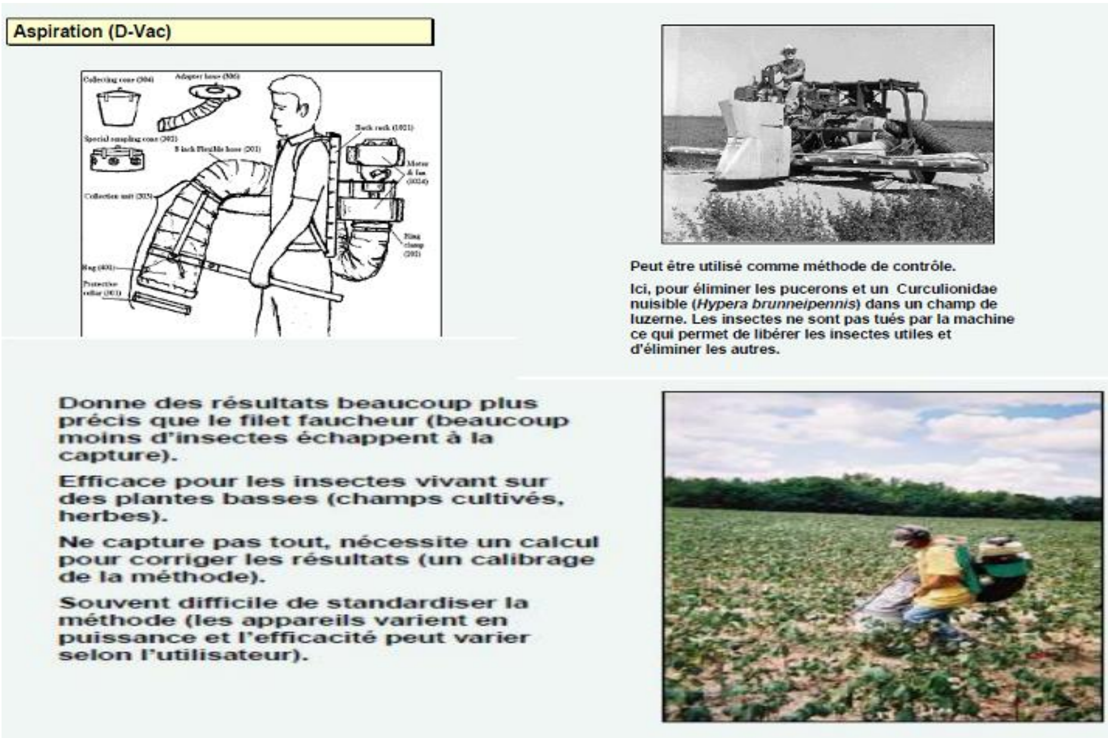
Gives much more results precise that the mower net (a lot fewer insects escape from the captura).

Effective for insects living on low plants (cultivated fields, herbs).

Doesn't capture everything, requires a calculation.

to correct the results (a calibration of the method).

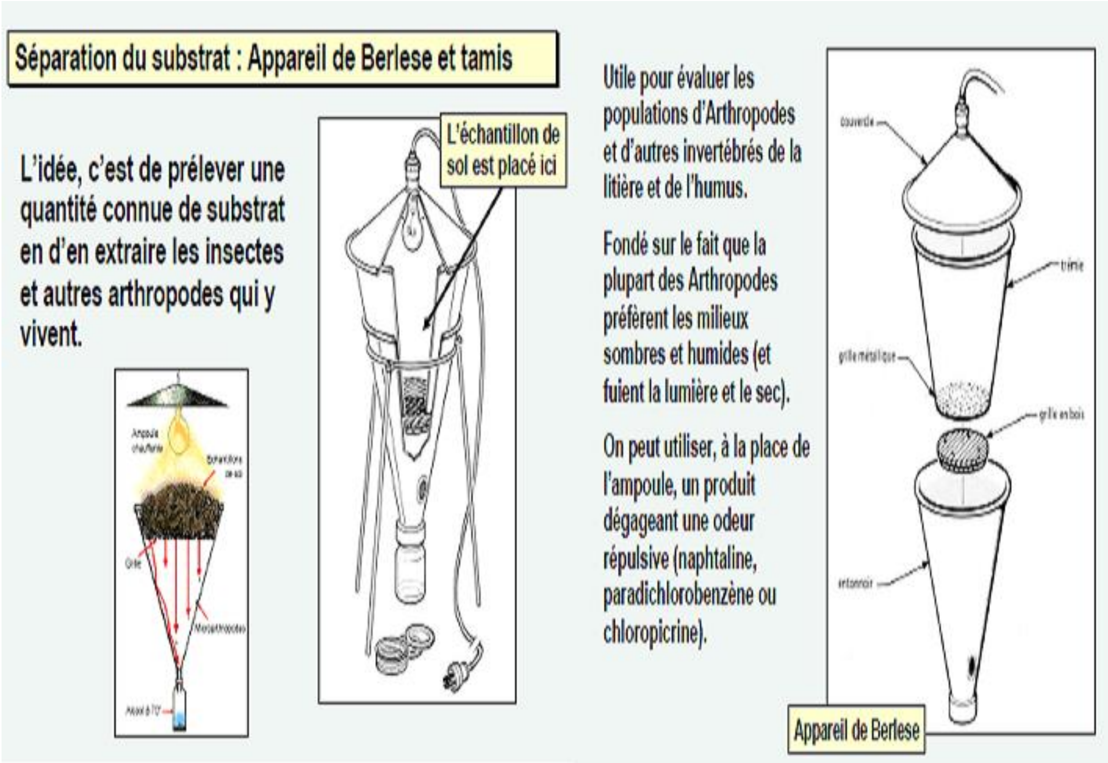
Often difficult to standardize the method (the devices vary in power and efficiency may vary according to the user).



4.2.4. Substrate Separation Berlese Apparatus and Sieve

The idea is to take a known quantity of substrate and extract the insects from it. and other arthropods that live there..

- Useful for assessing populations of Arthropods and other litter and humus invertebrates.
- Based on the fact that most Arthropods prefer dark and humid environments (and flee from light and dryness).
- One can use, instead of the bulb, a product that emits a repulsive odor (naphthalene, paradichlorobenzene, or chloropicrin).



4.3. Kill and preserve the captured insects

a. The hunting flask

Just place a bit of absorbent paper at the bottom of a jar and drop a few drops of ethyl acetate into it. The bottle will be effective for a few hours. For the smaller insects, a small bottle is used in which a strip of paper soaked with a drop of ethyl acetate is placed.

You can also kill insects by placing them in the freezer for a few days.

b. Freezing

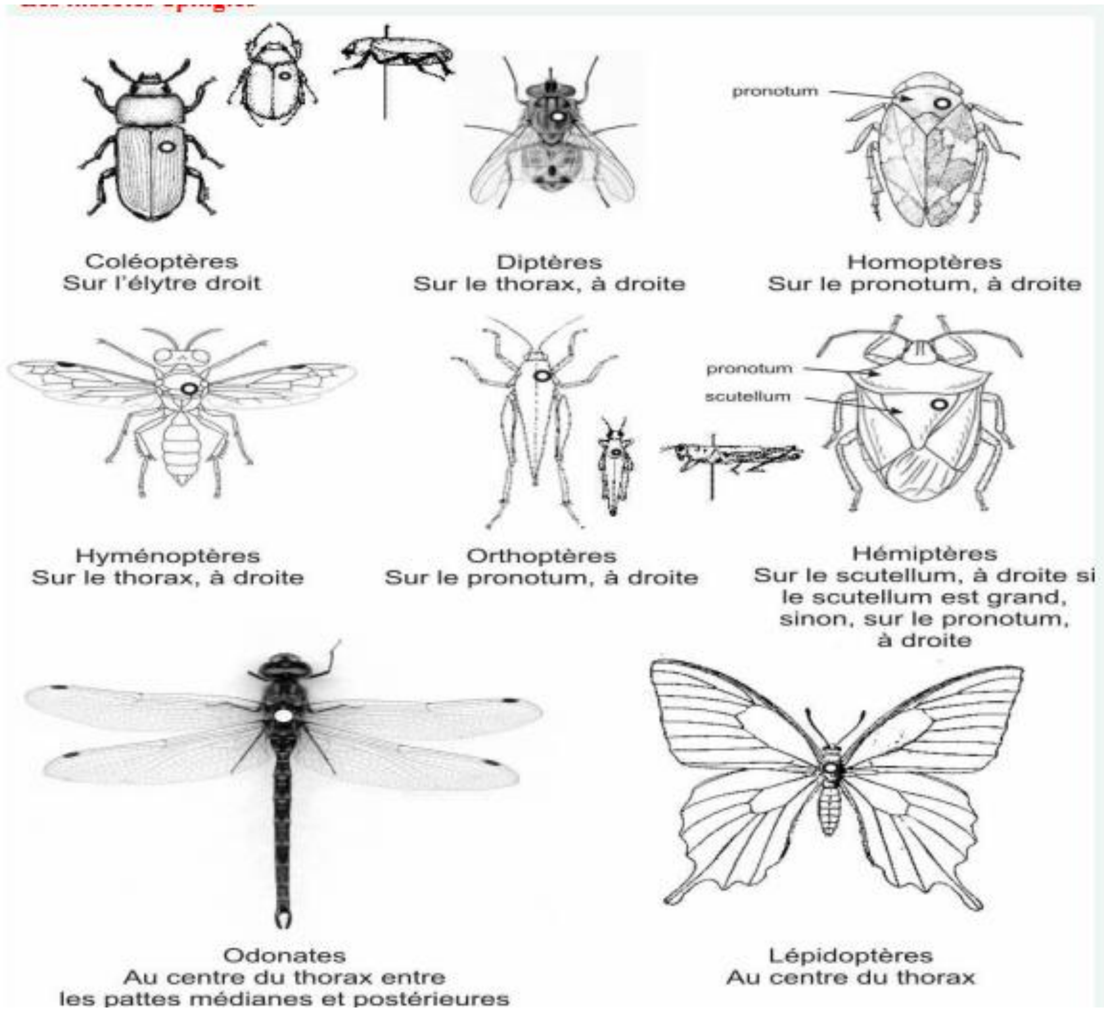
You can also kill insects by placing them in the freezer for a few days.

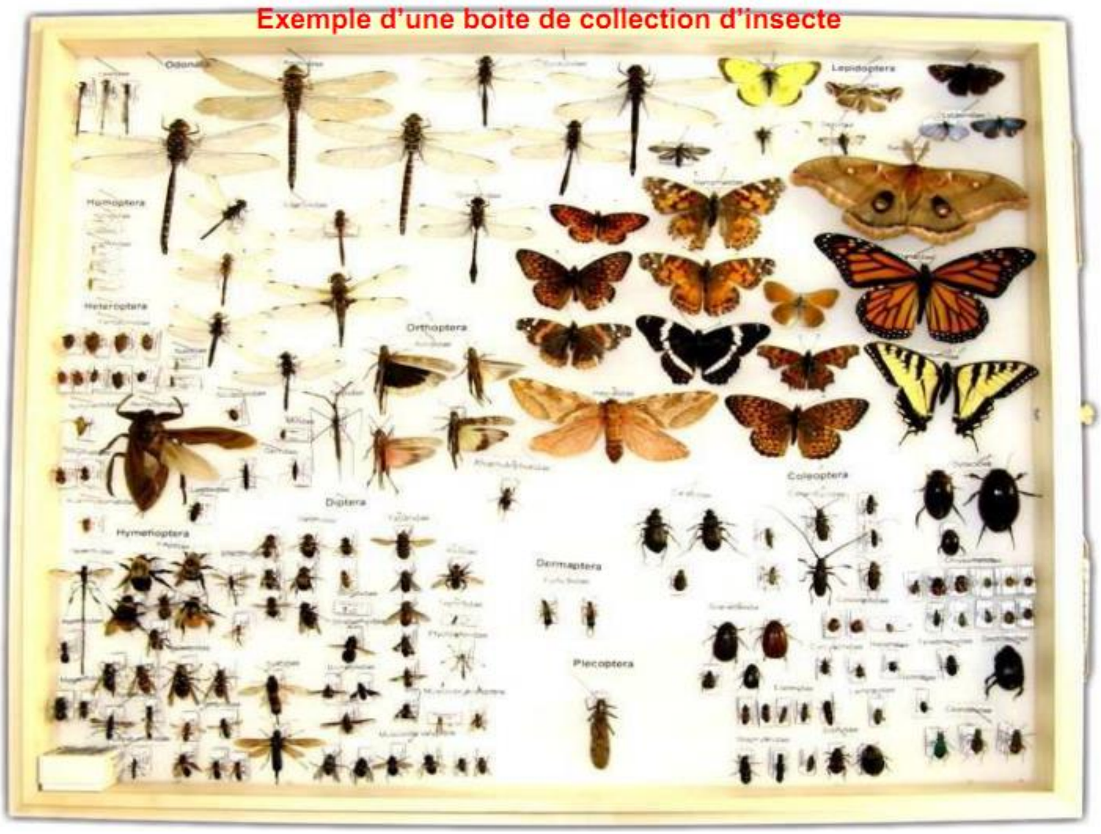
c. In alcohol

The smallest insects that cannot be mounted or those with soft bodies like larvae or spiders can be directly placed in a vial containing 70% alcohol. Specialists usually use ethanol, but rubbing alcohol sold in pharmacies (isopropyl alcohol) can also be used. Each capture must be identified by a paper bearing a number corresponding to a note in the observation notebook, paper placed in the bottle.

Once the insect is killed, we place it on the plate of polystyrene. It is very important to pin the insect correctly.

This place varies according to the orders of insects of so that the head of the pin does not exceed the level from the body of the insect by a distance of 10 to 15 mm, then we carefully spread the different parts of the body (wings, antennae, and legs).





5. Aquatic fauna (Fish)

To best manage fish resources in an environment, it is essential to identify the species that live there and to know their abundance, distribution, biology, and ecology.

5.1. The methods of studying fish

5.1.1. Passive Techniques

We categorize all sorts of fixed traps in this category that take advantage of the fish's movements to capture them.

a. all types of dam fisheries

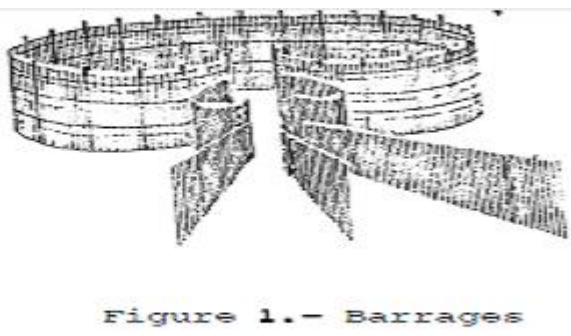


Figure 36: Dam

b. The traps and the pots

Engines are generally very selective and rarely used for population studies.

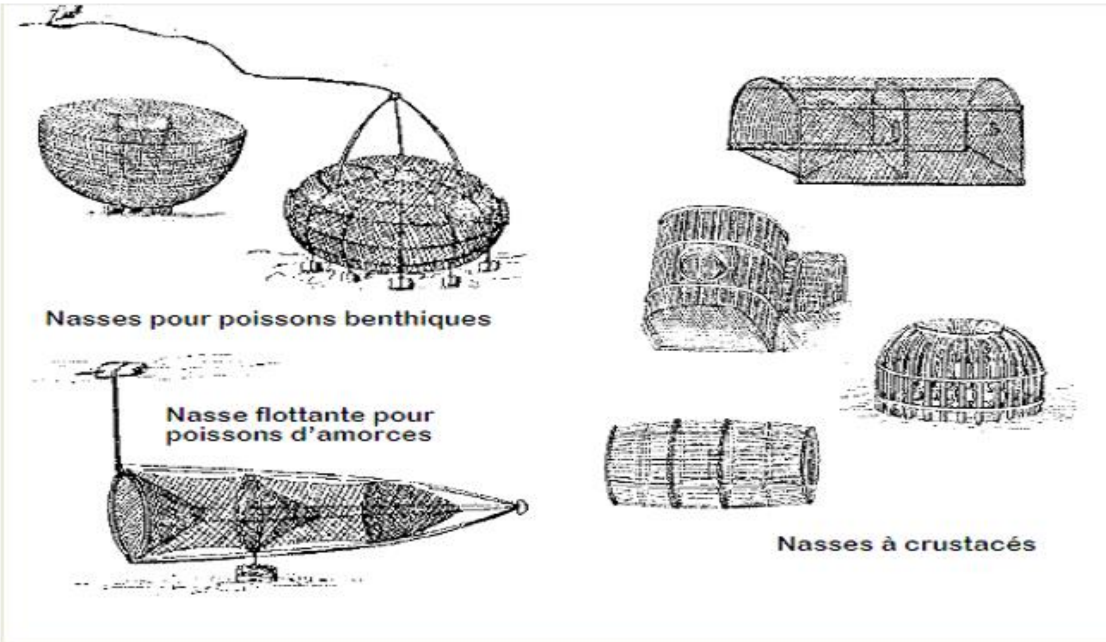


Figure 37: Types of traps

c. The lines and the longlines

Also very selective. However, it can be noted that the examination of the catches obtained by unbaited palangres (known as Malian lines) shows, through the diversity of species and sizes captured, that this gear can be a good sampler of the demersal community.

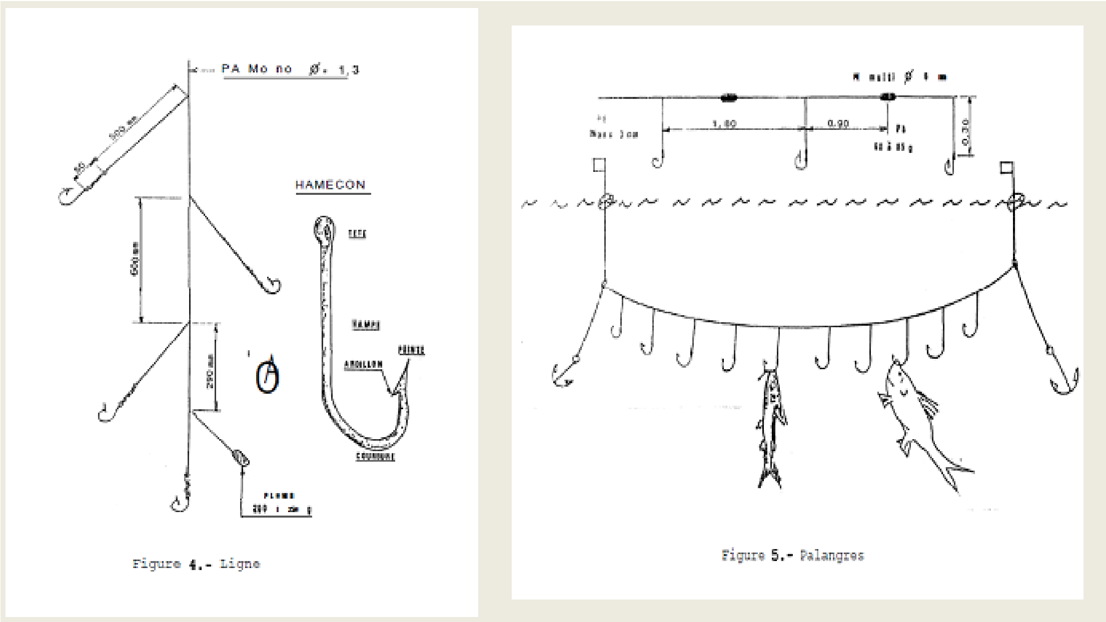


Figure 38: The lines and the longlines

d. The gillnets

are the most commonly used for population studies. Generally, different mesh sizes and several types of nets are combined to maximize the range of species captured.

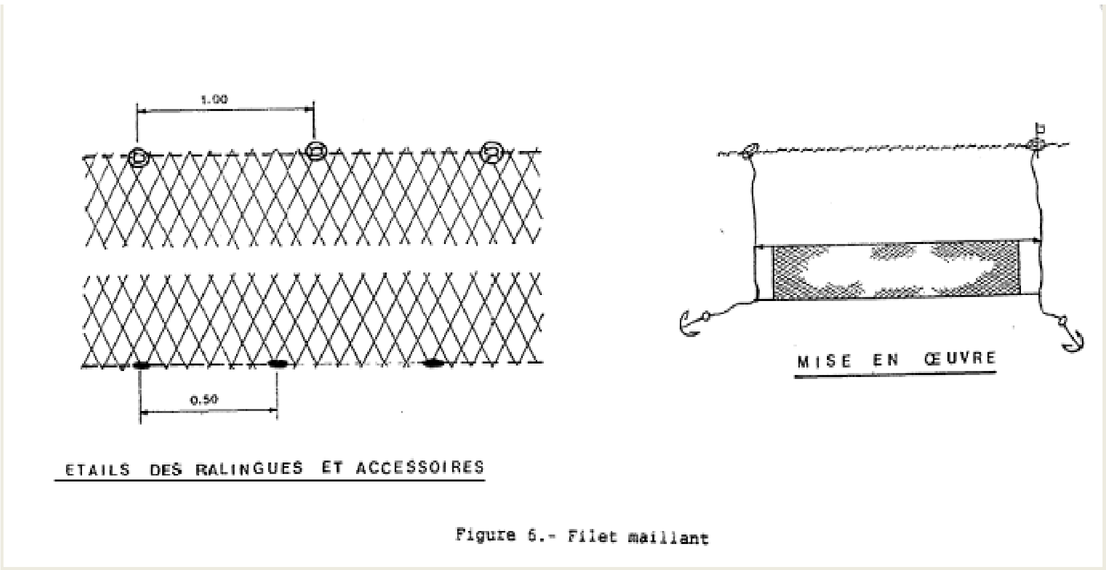


Figure 39: The gillnets

5.1.2. Active techniques

a. The covering machines

Generally of limited size, their prototype is the hawk. Of small to medium size, this device is used in shallow marine or continental waters.

Avoidance (the fish detects the device and avoids it) The sampled surface unit is small.

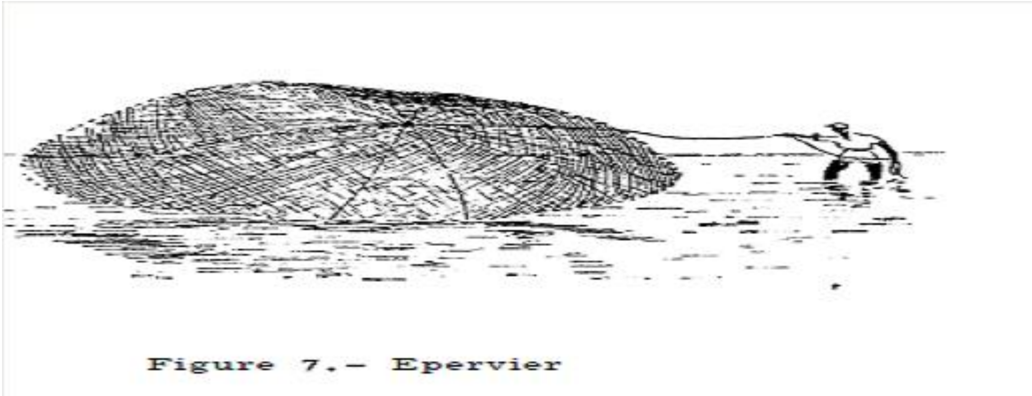


Figure 40: sparrowhawk

b. Towed vehicles

It concerns the various types of pelagic and demersal trawls for fish. For population studies, small-mesh trawls are generally used (sometimes shrimp trawls).

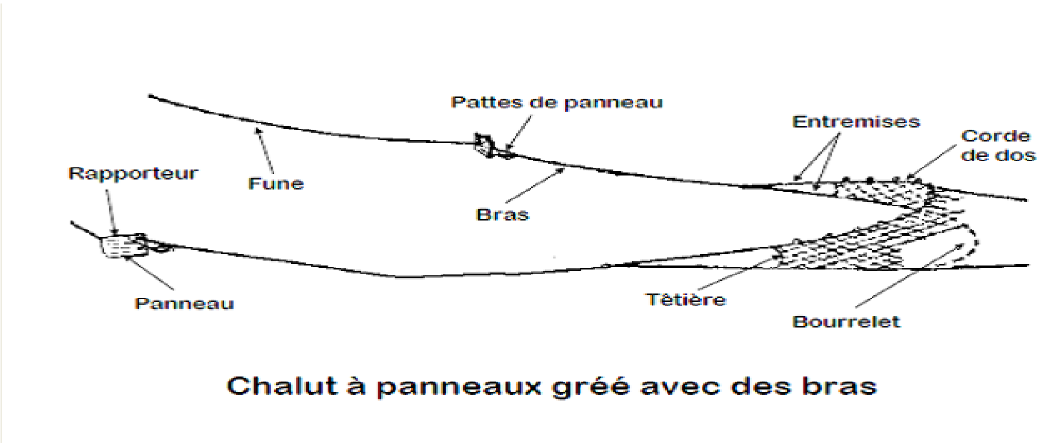


Figure 41: Panel trawl rigged with arms

c. The encircling vehicles

Various small seines (pocket, stick, border net) are frequently used for the study of populations of small species or juvenile forms.

The large seines: round (sliding) seines and beach (or shore) seines are used for the study of populations in generally vast and not too deep environments (1 to 20 m).

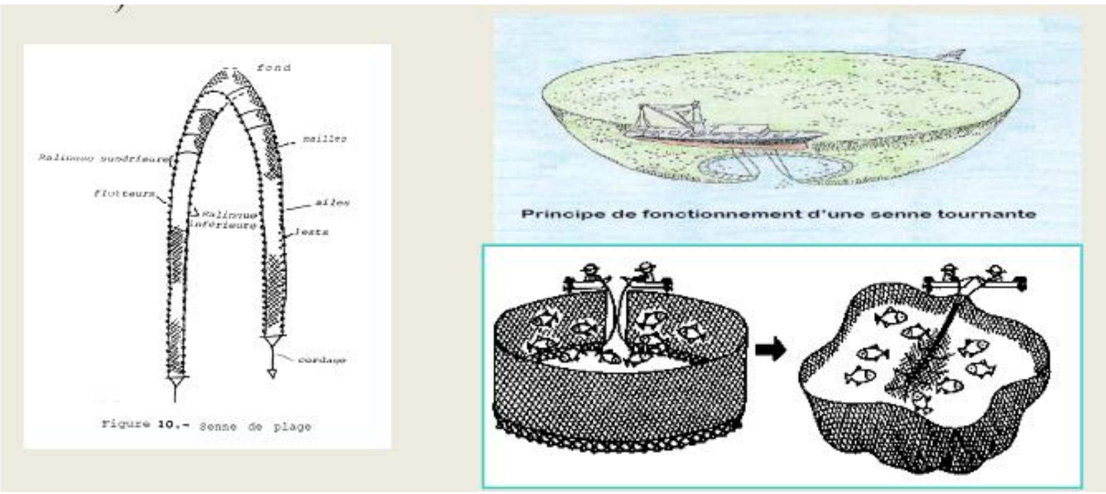


Figure 42: Sennes

d. Electrified vehicles

Unlike previous methods, "electrofishing" is only used in freshwater (or very slightly brackish) environments. Electric fishing is a highly effective sampling method particularly suited to certain specific environments (small rivers, streams, ponds, edges, rapids) that are inaccessible to other collection techniques. It allows the capture of a large number of species, particularly small species that are generally difficult or impossible to catch with other methods.

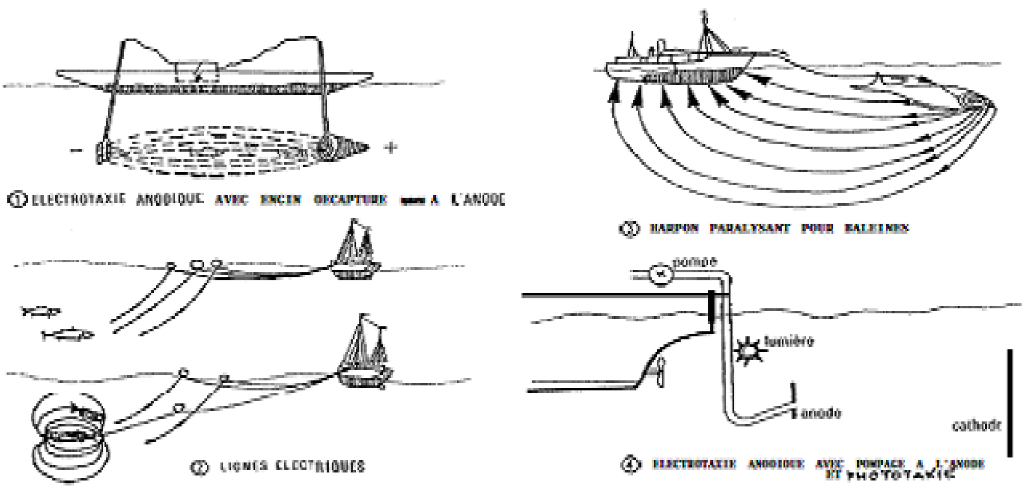


Figure 11.- engins électrifiés

Figure 43: Electrified vehicles

5.1.3. Direct Observation Techniques

a. Observation in diving

It is practiced in oceanic environments where turbidity is low and capture methods are not applicable (lagoons, coral reefs, seagrass beds). Although it has some advantages, particularly the complete preservation of the environment and its fauna,

b. Direct observation of migratory species

It is practiced in rivers at the level of dams where real fish observation chambers are sometimes created (sometimes enhanced or supplemented by automated counting systems, video recordings...).

c. Aerial observations

It can provide valuable elements (behavior, distribution, composition of schools...) for the study of the populations of large oceanic pelagics.

d. Acoustic methods

Their principle is as follows: a device fixed on a boat or a canoe emits a sound that reaches the fish and is reflected.

Towards the water surface where the return signal is recorded. The intensity of this response provides information about the quantity of fish present in the environment.

5.1.4. Various (or complementary) methods

• Monitoring of professional fisheries.

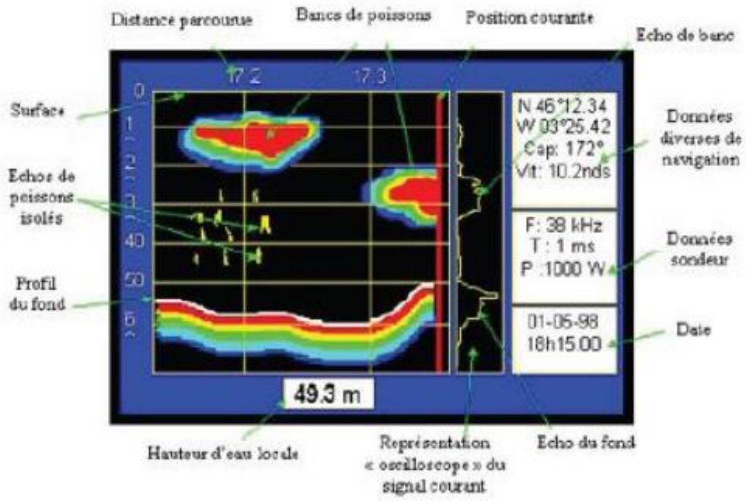
• Ecologists generally tend to overlook this source of information, which is quite interesting. Although rarely sufficient (issues with unprospected areas, seasonality of fishing activities, the existence of target species (which can change), species mixtures, etc.).

• Fishery data provide additional information through the observation of landings or, better yet, participation in fishing campaigns. Very often, only the statistical series from fishery biologists will allow the ecologist to place their study within the medium or long-term dynamics of the ecosystem they are studying.

These data will particularly allow for the perception and sometimes the understanding of phenomena such as the replacement of dominant species (ecological successions), or the effects of environmental upheavals (climatic or otherwise) on aquatic populations, which a necessarily time-limited experimental fishing campaign cannot achieve.

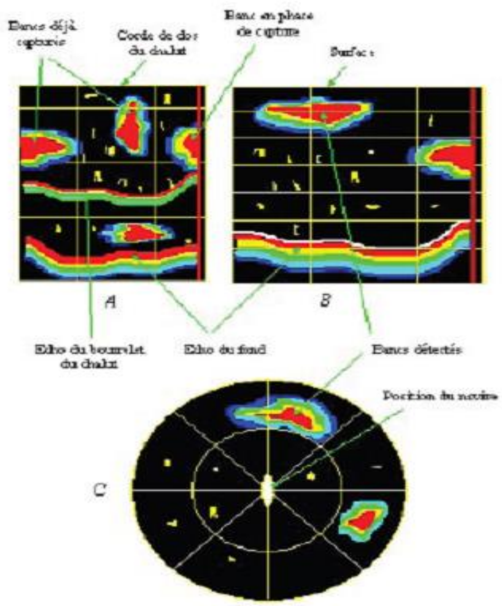
Figure 44: boat for monitoring professional fisheries

EQUIPEMENTS D'AIDE A LA PÊCHE: LE SONDEUR



Exemple type de visualisation d'un sondeur monofaisceau bathymétrique ou de pêche. Les lignes verticales correspondant à des émissions successives du signal permettent de constituer une coupe verticale de la tranche d'eau parcourue par le navire. Le sondeur étant souvent couplé aux autres systèmes de navigation du bord, les données correspondantes peuvent ainsi être présentées à l'utilisateur, ainsi que les paramètres de réglage du sondeur.

EQUIPEMENTS D'AIDE A LA PÊCHE: LE SONAR



Visualisations associées aux différents systèmes sonar utilisés en pêche. (A) Netsonde: on visualise la tranche d'eau située sous la corde de dos du chalut, faisant apparaître les captures entrant dans la poche, dont l'ouverture est délimitée par l'écho du bourrelet inférieur. (B) Sondeur: cette représentation, la plus courante, permet de faire apparaître les cibles passant à la verticale du navire. (C) Sonar panoramique: les cibles sont détectées et présentées dans un plan horizontal, de manière analogue à un radar de surveillance aérienne.

Figure 45: fishing aid equipment

Chapter 4: Collection and Analysis of Faunal and Floral Data

1. Collection and analysis of faunistic and floristic data

1.1. Presentation of the data

Whatever type of evaluation is conducted, it is essential to choose the methods of data collection and analysis carefully and to apply them correctly.

Main points

1- The methods of data collection and analysis must be chosen based on the evaluation in question, its key evaluation questions, and the available resources.

2- The methods of data collection and analysis must be selected to ensure the complementarity between the strengths and weaknesses of each.

1.2. Data Preparation

After data collection comes data preparation. Data preparation, sometimes called "Preprocessing," is the stage during which raw data is cleaned and structured in preparation for the next stage of data processing. During this preparation phase, the raw data is carefully checked to detect any potential errors.

The objective is to eliminate poor-quality data (redundant, incomplete, or incorrect) and to start creating high-quality data that can ensure the quality of your work environment. Example:

Data on the fauna and flora of a region or site, that is, it all depends on the spatial and temporal scale (Diversity, richness, distribution of fauna and flora).

1.3. Data Importation

The clean data is then imported into its destination location (for example: a folder containing an Excel file or converted to a format supported by that destination). The import of data is the first step during which raw data begins to transform into usable information.

1.4. Data Processing

Data processing is carried out as soon as it is collected, with the aim of translating it into usable information: Data processing is generally carried out by a data scientist, biostatistician, etc. (or a team). It is important that it is done correctly in order not to negatively impact the final product or the data output.

Data processing begins with clean raw data:

Convert the data into a more readable form (charts, text documents, etc.) by giving them the necessary format and context so that they can be interpreted by the concerned party.

Example:

Data on the fauna and flora of a region or site, that is, it all depends on the spatial and temporal scale (Diversity, richness, distribution of fauna and flora).

The objectives of this study are to inventory (species richness) the fauna or flora with the abundances and density that exist in a well-defined site. Of course, all communities (fauna and flora) have attributes or characteristics that differ from those of the components that make up the community and that only make sense in relation to the collective assembly or the community.

These attributes are:

- Number of species (Richness)
- Abundance of species and density
- **Abundance:** The abundance of species is generally based on the number of individuals per species, or on variables such as the percentage of coverage or the biomass of the species.
- **Species density:** the number of individuals of a species collected in a particular total area. For quadrat samples or other methods

Sampling of a fixed area, the density of species is expressed in units

Species per specified area. Example: 10 ind/m2, 100/quadra of 10 m2...etc.

- Estimation of specific richness:

a- Shannon Index

$$H' = -\sum_{i=1}^{S} P_i \log p_i$$

pi = proportional abundance or percentage of species importance, is calculated as follows:

pi = ni/N ;

S = total number of species;

ni = number of individuals of a species in the sample;

N = total number of individuals of all species in the sample.

Thus, the value of H' depends on the number of species present, their relative proportions, the sample size (N), and the logarithm base. The choice of the logarithm base is arbitrary (Valiela, 1995) but, when comparing indices, the base used must be mentioned and be the same.

The marked dominance of a species reveals low diversity, whereas the co-dominance of several species reveals high diversity. Since the equation is a biased estimator (Valiela, 1995).

This index allows for the quantification of the heterogeneity of biodiversity in a study environment and thus to observe changes over time. This index always varies from 0 to ln S (or log S or log2 S, depending on the choice of the logarithm base).

- Fairness Index

It is the ratio of the observed diversity to a completely equal frequency distribution of species (scale of 0-1), which can be quantified separately using the Shannon-Wiener index as:

J' = H'/H'max

where **H'** is the observed species diversity and **H'max** is the logarithm of the total number of species **(S)** in the sample (Gray et al., 1992).

For example, two species each with 50 individuals would represent complete evenness or equality with a value of 1.

Two species, the first represented by one individual, and the second by 99, would only achieve a result of 0.08.

1.5. Statistical treatments and multivariate methods for the identification of species groupings:

a. History:

The theoretical foundations of these methods are old and are mainly derived from American "psychometricians": Spearman (1904) and Thurstone (1931, 1947) for Factor Analysis, Hotteling (1935) for Principal Component Analysis and Canonical Analysis, Hirschfeld (1935) and Guttman (1941, 1959) for Correspondence Analysis. Practically, their use only became widespread with the dissemination of computing resources in the 1960s.

Under the name "Multivariate Analysis," they pursue objectives that are significantly different from those that will appear in France. An individual or statistical unit is often considered there only for the information it provides on the understanding of the relationships between variables within a statistical sample, whose distribution is most often subject to normality assumptions.

In France, the term "Data Analysis" encompasses techniques aimed at the statistical description of large tables (n rows, where n varies from a few dozen to a few thousand, p columns, where p varies from a few units to a few dozen).

These methods are characterized by intensive computer use, their exploratory objective, and an almost systematic absence of probabilistic hypotheses in favor of properties and results of Euclidean geometry. They emphasize graphical representations, particularly those of individuals, which are considered on the same level as variables.

Since the late 1970s, numerous works have made it possible to bring together or reconcile the two viewpoints by introducing, in appropriate multidimensional spaces, probabilistic tools and the notion of a model, commonly used in inferential statistics. The techniques have thus been enriched with notions such as estimation, convergence, result stability, the choice of criteria... The essential objective of these methods is to aid in the understanding of often considerable volumes of data. Dimensionality reduction, optimal graphical representation, search for latent factors or variables... are equivalent formulations.

b. Methods

Multidimensional exploratory statistical methods are classified according to their objective (dimensionality reduction or classification) and the type of data to be analyzed (quantitative and/or qualitative):

*** Description and dimensionality reduction (factorial methods):**

1. Principal Component Analysis (p quantitative variables).
2. Discriminant Factor Analysis (p quantitative variables, 1 qualitative variable).
3. Simple Correspondence Analysis (2 qualitative variables) and Multiple Correspondence Analysis (p qualitative variables).
4. Canonical Analysis (p and q quantitative variables).
5. Multi-dimensional Scaling (M.D.S.) or multidimensional positioning or factor analysis of a distance matrix. All the previous methods are based on classical tools of Euclidean geometry that are developed in the reminders and supplements of linear algebra.
6. Non-negative Matrix Factorization or NMF.

*** Classification methods:**

1. Hierarchical ascending classification,
2. Dynamic Reallocation Algorithms,
3. Kohonen maps (neural networks)

2. Output and interpretation of data

During the output/interpretation stage, the data becomes usable by everyone, including those who do not have specialist skills. They are converted, become readable, and are generally presented in the form of graphs...etc.