Fig. 2.2.3. A. A large deep lake (Lake Tanganyika, Burundi); **B.** A shallow lake with aquatic vegetation, Mozambique. (Photographs by R. Blažek.)

Fig. 2.2.4. A. Beach seining in Lake Turkana, Kenya; **B.** Dip netting in marshes, Mozambique. (Photographs by R. Blažek.)

Fig. 2.2.5. A. Cast net sampling in Lake Turkana, Kenya; **B.** Sampling fish from Uvira fish market, Democratic Republic of the Congo. (Photographs by R. Blažek.)

also lead to the transfer of ectoparasites such as monogeneans between hosts, which may bias subsequent ecological studies.

Rod and line (passive) is a simple angling method that can potentially be used for sampling fish for scientific purposes. Note, however, that use of rod and line tends to be highly selective for particular species (especially predators) and/or sizes of fish, depending on the gear or bait used, and it may take a long time to catch sufficient numbers. On the other hand, the material needed is relatively small and light, making it easy to transport. Efficiency will largely depend on the experience of the user and knowledge of local conditions.

Beach seining (active; Figs 2.2.3, 2.2.4) utilises a large net of uniform mesh size consisting of two 'wings' and a 'purse-like' central section that holds the catch. As its name implies, a beach seine is typically used in shallow waters, the net generally being set in a semicircle around the target area, either by boat or by wading, and dragging the net back to shore. The net is kept open while deployed by floats on its upper line, while weights on the lower line ensure the net stays close to the bottom substrate. A larger area may be fished by attaching long towing lines to each end of the net. Seine nets are most effective for catching near-shore species or fish that concentrate near-shore periodically. Beaches should preferably be free of obstacles (*e.g.*, rocks, tree stumps) or heavy vegetation.

Push net, dip nets, lift nets and cast nets (active; Figs 2.2.3-2.2.5) are all simple tools that can be used by a single person. Push and dip nets, which are made of netting attached to a round or triangular frame fixed on the end of a pole, are used to collect small fishes along the bank or in places with dense vegetation where other methods may be impractical. Fish are generally pursued by the user. Lift nets or cast nets are used to catch small schooling fish in open waters. Lift nets are left on the bottom (or lowered in deep lakes) by the user who retains hold of the net by a line. Bait (or a light at night) can be used to concentrate fish over the lift net, which are then caught by quickly lifting the net out of the water. Cast nets are circular nets with weighted edges that are thrown so that they cover the fish. The net is closed and retrieved by pulling on a retaining line. The use of cast nets is restricted to areas free of obstacles or plants. Experience is needed to cast the net successfully, allowing it to hit the water completely open over the target fish.

Electrofishing (active) works on the principal of galvanotaxis, whereby direct current (DC, sometimes pulsed) electricity flowing between a submerged cathode and anode causes a muscular convulsion in the fish, causing it to swim toward the anode where it can be caught with a dip net. The cathode, a long, braided steel or copper cable, trails behind the operator and the anode is operated by a switch on a long pole, the operator directing the anode toward the target fish or site. At least two people are required for effective electrofishing, one to operate the anode and the other to catch the fish. The electrical current is produced either by a battery-powered backpack or a petrol-powered generator that remains stationary on the bank or is placed in a boat. The effectiveness of electrofishing will be influenced by a range of biological, technical, logistical and environmental factors. The pulse rate and intensity of the electric field produced can strongly influence the size and

nature of catch, whereas conductivity of the water will influence the shape and extent of the electric field, and thus the field's ability to induce galvanotaxis.
Electrofishing is limited to sites with clear water, conductivity of 100-600 µS/cm and a depth of ≤ 1 m. Electrofishing is much less effective in waters with low conductivity (low dissolved salt concentration), whereas a stronger generator will be required in waters with high conductivity. Electrofishing is particularly efficient at sites with obstacles (*e.g.*, vegetation, woody debris, rocks) and in running waters, where other methods may be inefficient or impossible to use. In some cases, electrofishing may harm fish by causing muscle spasms that damage the fish's backbone; a problem more common and severe in longer fish. Used correctly, however, electrofishing causes no permanent harm to the fish, which will recover minutes after being caught. Note that the use of any electrical equipment in and around water is dangerous. For operator safety and for efficient and successful sampling, all equipment should be designed specifically for electrofishing and all personnel adequately trained in its use. Many countries also require that the user is licensed. In some countries, electrofishing is illegal.

Table 2.2. A simplified comparison of passive and active methods of sampling fish

	Method	Advantages	Disadvantages
Passive methods	Gill nets, traps, rod and line	Simple manipulation, cheap, low man power, light, easy to transport	Non-selective for species and size, may damage fish, time-consuming, fish may die in gill nets
Active methods (simple)	Dip nets, scoop nets, hand nets, cast nets	Simple manipulation, cheap, low man power, easy to transport, can target specific species/ sizes	Practice needed, less efficient, time consuming
Active methods (technical)	Beach seine, electrofishing	Mobile, faster, can target specific species/ sizes, greater numbers caught	Expensive, practice and/or training needed, transport difficult, higher man power

For more information about fish sampling methods see Bohlin *et al.* (1989), Murphy & Willis (1996), Lapointe & Corkum (2006) and Pierce *et al.* (1990).

Fish sampling strategy for parasite community studies

In comparison with fish population or community studies, different criteria apply when sampling fish for parasitological surveys. Instead of obtaining a general description of fish assemblage structure (*e.g.*, species richness, density, population structure) for the sample site, the operator aims to obtain a representative sample (number) of specific target species and size categories. Sampling area and timing of sampling should be adapted and aimed specifically at where and when the target fish are most likely to occur.

For ectoparasites found on the skin and/or fins, sampling methods should involve minimal handling of the fish as contact could damage or remove the parasites. Appropriate methods include electrofishing, angling, pot traps or small beach seine nets. For endoparasites and gill parasites, more robust sampling methods (*e.g.*, large seine nets) can be used as they are unlikely to affect parasite numbers. It may even be possible to obtain fresh fish from local fishermen or markets.

Fish transport and treatment

Whatever the method used to sample the fish, they should always be handled carefully prior to dissection to prevent loss or transfer of parasites. The fish should be maintained and transported in water taken from the sampling site and only wet hands or dip nets used for manipulating the fish. During transport and storage, oxygen levels should be maintained with an aerator or oxygen cylinder. Fish should be transported to the laboratory as soon as possible and kept alive until examination. Parasitological examination should be carried out no more than three days after capture; any later and parasites may die or reproduce, biasing infection parameters (Kvach *et al.* 2016). During storage, the fish should not be fed and the density kept relatively low to prevent host mortality and transfer of parasites. The tank should be placed in shade to maintain a stable temperature. In the case of untimely mortality, complete freezing should be avoided if possible as it can affect morphological and ultrastructural observations (for transportation or temporary storage, fish may be kept for a short while in crushed ice).

Fish should always be handled with full regard to the animal's welfare (in line with local regulations) and euthanised using the most 'humane' methods available.

References

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