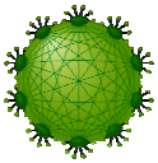

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Comparative fish dissection

Relationship between diet and selected features of digestive tract anatomy

Aim

In this practical dissection students relate the digestive tract morphology to the diet of different fish species.

Introduction

Animals have numerous adaptations to different kinds of food and ways of feeding. Invertebrates' mouthparts and vertebrates' teeth are the easiest features to observe and compare, dependent on type of food and way of feeding. Further parts of digestive system's morphology and physiology are also adapted in many ways. This protocol presents these topics using different fish as an example.

Pre-knowledge

Understanding of the term adaptation.

Knowledge of general vertebrate digestive tract anatomy.

Knowledge of different types of animal food – their chemical composition and nutritional value.

Equipment and materials

Required by each group of students

A fresh, whole fish. These should be chosen to represent typical carnivorous and herbivorous species. Table 3 lists easy-to-obtain species, which we recommend for this protocol.

Dissection equipment (required for each group):

Plastic tray (deep enough for water to cover the dissected fish), scissors, pins, paper towels, forceps, Petri dish (additionally: scalpel, dissecting needles), disposable gloves, laboratory coats, ruler, a piece of string, pencil or pen, worksheet.

Access to zoology reference books and/or the internet (see Publications and Web sites).

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Figures 1 and 2. Pike (Esox lucius) – carnivore and carp (Cyprinus sp.) – herbivore.

Questions

Students, with the teacher's help, formulate scientific questions and scientific hypothesis, relating to the diet and morphology of different fish species, which can be tested by dissection and observation.

Hypotheses

Procedure

Work in teams of 2-3. Each team dissects one fish. Collectively, the class should prepare several herbivorous and several carnivorous fish, as many fish as are teams.

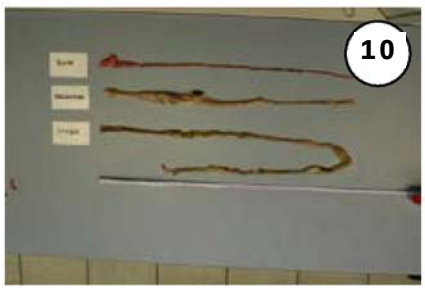
Observation of external features (fig. 2, above)

Place the fish on a plastic tray. Use appropriate references to determine the species' taxonomic group.

Identify the external anatomy. Measure and describe the body length, body shape and the spread of the jaws (gape).

Observations of teeth (fig. 3 and 4)

The teeth of carnivorous fish are located mainly on the jaws (upper and lower – fig. 3), but they can be also present on other pharynx bones and on the tongue. In some families of Cypriniformes some teeth are located deep in the throat, on the bottom part of the last, fifth brachial arch. They are especially well-developed in cyprinid fish (for example, grass carp and silver carp) and are called pharyngeal teeth (fig. 4).



Investigate how the teeth of your fish are placed and what they look like.

Extraction of teeth from carnivorous fish (fig. 3)

WARNING! It should be done very carefully, to avoid injury. Open the fish's mouth and cut out a small fragment of upper or lower jaw with scissors. Rinse with warm water, remove as much of soft tissue as possible, dry with paper towels and place on the labelled Petri dish.

Extraction of teeth from herbivorous fish (fig. 4)

It is difficult because pharyngeal teeth of these fish are located very deep in the pharynx. Insert gently your finger into pharynx and feel teeth on the branchial arches. Teeth can be extracted by breaking the apropriate branchial arch and sliding it out through the mouth. Alternatively, open the operculum (gill cover), insert your fingers into the gill cavity and break out the last gill arch. Rinse with warm water, remove as much of soft tissue as possible, dry with paper towels and place on the signed Petri dish.

Observations of the digestive organs

Hold the fish with its underside uppermost and use scissors to make a short cross cut just in front of the anus (fig. 5).

Slide the scissors blades in (blunt end forward) and pointing the scissors upwards, cut along the centreline of abdomen. Cut carefully to avoid damaging the internal organs. Stop cutting as close to mouth opening as possible (fig. 6).

Place the fish on its right side, pinning it down at both ends if necessary, and cut out a section from the side. To do this, start with cross cut from the anus towards dorsal side (fig. 7).

Before crossing lateral line turn the scissors towards head end and cut the body along the lateral line right up to the rear end of operculum. In this way you can cut out a rectangular muscle flap, revealing the internal organs below. Remove the muscle flap and immerse the fish in water (fig. 8).

Observe the internal organs and find the digestive tract (remove the thin membrane of the peritoneum, if necessary). The digestive tract starts with the oral cavity, turning into pharynx. The pharynx extends into the oesophagus. Next are the stomach and intestine. The intestine ends with the anus. Along the lateral line, in the frontal part of the body, is located a big, brown liver, equipped with a gallbladder (fig. 8).

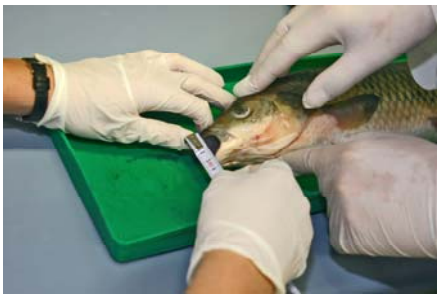


Figure 11. Measuring jaw spread

Cut out the whole digestive tract – make one cut at the oesophagus, as close to the pharynx, as possible, another at the final part of the intestine, close to the anus (fig. 9).

Clean any fatty tissue from the extracted digestive tract if necessary (take care to not break the intestine), rinse with running water, place in a separate container and pour over a shallow layer of water. The digestive tract should be spread so its parts do not touch each other. Measure the total length of the digestive tract and the stomach size (length and width) using a piece of string and a ruler (fig. 10).

Fill in the tables below based upon your results. Data from the whole class should be used to complete summary tables 1 and 2, with separate tables for carnivorous and herbivorous species.

Table 1

Carnivores

Team	Body shape description	Body length (mm)	Jaw spread (mm) – see Fig. 11

Herbivores

Team	Body shape description	Body length (mm)	Jaw spread (mm) – see Fig. 11

Table 2

Carnivores

Team	Teeth morphology (location, shape, size, number)	Stomach size length (mm) width (mm)	Digestive tract length (mm)

Herbivores

Team	Teeth morphology (location, shape, size, number)	Stomach size length (mm) width (mm)	Digestive tract length (mm)

Formulate conclusions from your findings and literature search. Do they agree with your initial hypotheses?

For the teacher

Before the dissection starts, a short introduction from the teacher is required. Students are, with help from the teachers, to formulate scientific questions and scientific hypothesis, relating to the diet and morphology of different fish species, which can be tested by dissection and observation.

Table 3. Selected species of fish available on the market. (Availability of species can differ between different countries.)

Fish	Diet	Optimal body lenght	Remarks
Silver carp *(Hypophthalmichthys molitrix)*	herbivore	min. 35 cm	Recommended as a herbivore with exceptionally long digestive tract.
Grass carp (white amur) *(Ctenopharyngodon idella)*	herbivore	min. 40 cm	Fish often have internal organs padded with fat and its scales are quite large, which can make dissecting difficult.
Wels catfish *(Silurus glanis)*	carnivore	min. 45 cm	Several species of catfish are sold for eating, usually smaller than Wels catfish. We recommend catfish because they have little fat tissue and do not have scales, which makes dissection easier.
Pike *(Esox lucius)*	carnivore	min. 40 cm	Recommended.
Rainbow trout *(Oncorhynchus mykiss)*	carnivore	min. 30 cm	Easy to obtain.

Safety guidelines

Students must wear protective gloves when dissecting the fish. We also recommend wearing laboratory coats. Be extremely careful when extracting sharp teeth from carnivorous fish. Be careful with sharp instruments, like scalpels and scissors. After completing the practical work, students should wash their hands with warm water and soap.

Ethical concerns

There can be different rules in different countries about fish-dissections in schools. Before starting the dissection you must check with your authorities about what rules applies in your country.

Preparation and timing

Time to complete the protocol will take about 90 minutes. We recommend to use fish as fresh as possible. Students should be divided into teams of two or more, each team working on one fish.

Troubleshooting

Fish should come from a good, trusted source. If they were stored too long or in a wrong way, their internal organs can be damaged. The following features are useful indicators of fresh fish:

Gills should be dark or red, not pale

Eyes should be shiny and raised, not matt and sunken

Scales should cling tightly to the skin

Fresh fish meat is springy and resilient (it bends under pressure, but goes back quickly)

Slime shouldn't be sticky

It may be difficult to identify some of the internal organs – they do look different in different species. Another problem might be overabundant fat tissue which can obscure the internal organs – it should be removed carefully. (If you wish to remain on speaking terms with your colleagues, ensure that you ventilate the classroom thoughly!)

Suppliers

Most items can be obtained from normal school laboratory suppliers, from a fishmonger or from the fish counter of a good supermarket.

Waste and recycling of materials

All fish remains should be wrapped in old newspaper or paper towels and disposed of as organic waste. The remains can also be composted. Wash trays and tools with warm water and detergent and dry. Throw away disposable gloves.

Storage of materials

Before lessons, the fish should be stored as short time as possible. The fish should be stored in the fridge, covered with cling film, if you can use it very soon. Otherwise it should be frozen immediately.

Specimen results

Fish body shape depends on its environment and life. Fast-swimming carnivorous fish usually have more elongated bodies than slowly-moving herbivores.

The jaw spread (gape) is typically greater in carnivores than in herbivores, because of the food type and way of feeding.

Carnivorous fish teeth are adapted for holding and killing their prey. There are a lot of teeth and they are located on the upper and lower jaws, sometimes also on other oral cavity bones such as the palate and vomer (the thin bone separating the nasal cavities), on the tongue and on some parts of gill arches. They are sharp and usually point into the mouth. Pharyngeal teeth of fish from some Cypryniform families (most developed in cyprinids) are a very different kind of adaptation. They are located deep, on the last branchial arch and their surface forms a grater, suitable for grinding of hard plant tissue. Strong muscles move the branchial arch with the teeth, grinding the food as it passes trough.

The stomach is well-developed in carnivorous species (as a round or a loop-like enlargement of the digestive tract), and poorly-developed in herbivores. The carnivorous stomach digests proteins, which are abundant in animal food, but less so in plants.

Variation in the length of the digestive tract of fish feeding on different diets is also very notable. Carnivores have much shorter digestive tract then herbivores. This is due to the diet – animal food is easier to digest than plant food which contains cellulose.

Publications

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3. Czubaj A. (red.) - Biologia. Część 1, tom 2. Kształcenie w zakresie rozszerzonym. WSiP, Warszawa 2003.

4. Kubik J., S.M. Klimaszewski – Podręcznik zootomii. PWN, Warszawa 1969.

5. Matwiejew B. (red.) - Zoologia tom 2. Strunowce. PWRiL, Warszawa 1972.

There are many different fish-books published.

Web sites

www.pond-doctor.co.uk/longdigestion.html

www.aquamania.co.uk/feeding-andnutrition-ofherbivourous-fish.asp

www.fishbase.com

Acknowledgement

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