

Food chain, Food web and Trophic levels

1-Introduction

The study of food chains helps in understanding some of the important aspects of the ecosystem in particular and environment in general. The main function in the ecosystem is the flow of energy. In ecosystem, all the living organisms (plants and animals) are linked with each other in a systematic way in the form of a chain with respect to their mode of getting food. This includes the manufacturing of food or different feeding habits. For example in a simple grassland ecosystem, the entire stock of green plants (herbs, shrubs and trees) manufacture food by utilizing the radiant energy of the sun through the process of photosynthesis. These are therefore termed as producers or autotrophs. These autotrophs are eaten up by plant eaters which are known as herbivores which, in turn constitute the food of first level carnivores also known as primary carnivores. The primary carnivores are then subsequently eaten up by middle or secondary carnivores and top level or tertiary carnivores.

Here we find that beginning with the producers, onwards to herbivores, first level carnivores, middle level carnivores and top level carnivores, all the organisms are inter-linked in a definite sequence.

2-Definitions and Characteristics of Food Chain

The sequential interlinking of organisms involving the transfer of food energy from the producers, through a series of organisms with repeated eating and being eaten is referred to as the food chain.

All trophic levels in an ecosystem are connected by transfer of food or energy. The transfer of energy or food from one trophic level to the next trophic level is called food chain.

Food chain is always straight and proceeds in a progressive straight line.

The green plants always occupy first level in any given food chain and are commonly termed as the primary producers.

The stored energy in primary producers is then utilized by the plant eaters called as the herbivores which are also known as primary consumers.

Herbivores are subsequently eaten by the flesh eating animals called as the carnivores, also known as the secondary consumers.

The carnivores can be categorized into three categories namely, primary carnivores, secondary carnivores and tertiary carnivores.

Some organisms are termed as omnivores as they eat the producers as well as the carnivores at their lower level in the food chain. The classification of various organisms in a food chain particularly relates to their function in the ecosystem so that any two or more distinct species are likely to occupy the same trophic level.

Characteristics of food chain

1. In a food chain, there is unidirectional flow of energy from sun to producers and subsequently to series of different types of consumers.
2. A food chain involves a nutritive interaction between the living organisms which are the biotic components of an ecosystem. In a food chain, there occurs repeated eating which means that each group eats the other and is subsequently eaten by some other group of organisms.
3. A food chain is always straight and proceeds in a progressive straight line.
4. Usually there occur 4 or 5 trophic levels in the food chain. There cannot be too many links in a single food chain because the animals at the end of the chain would not get enough food (and hence energy) to stay alive.
5. The flow of energy is unidirectional i.e., non-cyclic. However, some energy is lost at every state in the atmosphere. Generally 80-90 % of energy is lost as heat at each transfer in accordance with second law of thermodynamics. Energy decreases as it moves up trophic levels because energy is lost as metabolic heat when the organisms

from one trophic level are consumed by organisms from the next level. The main reason for this loss is the second law of thermodynamics, which states that whenever energy is converted from one form to another, there is a tendency toward disorder (entropy) in the system. In biologic systems, this means a great deal of energy is lost as metabolic heat when the organisms from one trophic level are consumed by the next level.

6. Some organisms occupy different trophic positions in different food chains.

7. A change in the size of one population in a food chain will affect other populations.

This interdependence of the populations within a food chain helps in maintaining the balance of plant and animal populations within a community. For example, when there are too many zebras; there will be insufficient shrubs and grass for all of them to eat. Many zebras will starve and die. Fewer zebras means more time for the shrubs and grass to grow to maturity and multiply. Fewer zebras also mean less food is available for the lions to eat and some lions will starve to death. When there are fewer lions, the population of zebra will increase.

3-Trophic levels

The trophic level of an organism is the position it occupies in a food chain. The word trophic is derived from the Greek τροφή (trophē) referring to food or feeding.

The distinct sequential steps in the straight food chains are referred to as different trophic levels. They are also known as nutritional levels.

The various trophic levels are:

First trophic level: Green plants which are producers stand on the first trophic level. This is known as producer level.

Second trophic level: The plant eaters which are herbivores also called primary consumers belong to second trophic level. This is known as primary consumer level.

Third trophic level: The flesh eaters which are carnivores also called secondary consumers represent the third trophic level. This is known as the secondary consumer level.

It should also be known that the quantum of available energy in a food chain successively gets decreased at each trophic level as a result of waste of energy into unavailable heat. This can be explained on the basis of second law of thermodynamics according to which transformation of energy from one form to the other is inefficient and involves dissipation of unavailable energy. This phenomenon is known as loss of energy at successive levels. This restricts the size of food chain in ecosystem to maximum of 4 to 5 steps.

4-Types of Food Chains

In nature, generally two types of food chains are distinguished namely, grazing food chain and detritus food chain.

1. Grazing food chain

The common examples of the grazing food chain are those of grassland ecosystem starting from grasses – herbivores – carnivores (i.e. primary, secondary, and tertiary) and aquatic ecosystems starting from phytoplanktons – zooplanktons – small fishes – large fishes.

In grazing food chain for example grassland ecosystem, green plants (producers) constitute the first step. The plant biomass, in turn, is eaten by the herbivores such as insects, rats and mice, grazing cattle, goats, sheep, deer, zebra, giraffe, horses, donkeys etc. and these are subsequently consumed by a variety of carnivores like lion, tiger, panther, cheetah, wolves, snakes etc. The grazing food chains are directly dependent on an influx of solar radiations. Green plants, with the help of solar

radiations, manufacture food by the process of photosynthesis. These are longer food chains and these always end at decomposer level. From energy point of view, these grazing type of food chains are very important.

2. Detritus food chain

The detritus food chains depend upon the dead organic matter either in the form of fallen leaves etc. or dead animal bodies. Hence, these are not directly dependent on solar energy. The starting point, in a detritus food chain, is the dead bodies of animals or fallen leaves etc. which are commonly termed as detritus. This dead organic matter is first eaten by decomposers for example bacteria, fungi and protozoans etc. These decomposing organisms have saprophytic mode of feeding and are designated as primary consumers in this type of chain. These are also termed as detritivores, meaning detritus eating. The detritivores, in turn, are eaten by their predators like insect larvae, nematodes etc. The main function of the detritivores is to release the inorganic elements into the ecosystem by decomposing the dead organic matter. The recycling of inorganic elements in ecosystem helps in keeping them fit.

In comparison to grazing food chains, the detritus food chains are generally shorter.

Common example of detritus food chain is given by Heald (1969) and Odum (1971) after the study of mangrove leaves in the bralisk zone of southern Florida (USA). The starting point of the detritus food chain is the fallen leaves of red mangrove trees (*Rhizophoramangle*) that fall into the warm, shallow waters. The detritus eating animals for example bacteria, fungi, protozoa etc. act upon the dead organic matter of the dead leaves and convert them into simple inorganic substances. The detritivores are subsequently eaten by consumers such as insect larvae, grass shrimp, copepods, crabs, nematodes, bivalve mollusks, amphipodismmysids etc. The last step in the detritus food chain is that detritus consumers are finally eaten by fishes.

A food chain having consumers in it is called predator food chain. The decomposers may be excluded from the food chain because they act at all the trophic levels of a food chain. The producers are also called energy transducers because they change the radiant energy of the sun into chemical energy which is stored in organic compounds.

5-Examples of Food Chains

The food relations are very complex, even in a small community, but may be illustrated by two simplified examples:-

i) Food chain in a pond.

In a pond, rooted or floating plants and floating algae synthesize food materials from dissolved nutrients by the process of photosynthesis. They, therefore, act as the producers. Unicellular algae are eaten by protozoans (amoeba, paramecium) and water fleas. The snails, mosquito larvae and tadpoles take aquatic plants as food. All these herbivore organisms are regarded as primary consumers. These are eaten by Hydra, dragonfly larvae, water insects (giant water bugs, water scorpions, water beetles etc.), and small fish. These carnivore organisms are secondary consumers. They are fed upon by large fishes and frogs. These animals are tertiary consumers. Frogs and fishes are eaten by snakes and birds, which are quaternary consumers. The snakes and birds and also the organisms of other trophic levels, when dead, serve as food for the bacteria and fungi of decay. The latter change the dead organisms into simple inorganic materials for reuse by the producers. This completes the cycle.

ii) Food chain on land.

On land, grass grows by manufacturing food from carbon dioxide of air and water and minerals of soil with the help of chlorophyll and sunlight. Grass, therefore, acts as the producer on land. Grass is eaten by rabbits, the primary consumers. The latter are preyed upon by cats, the secondary consumers. The cats may be taken by wolves, the tertiary consumers, and the tigers may capture the wolves. The tigers represent the quaternary or terminal consumers. They are not eaten by any predators. The tigers as well as the other trophic levels of the chain, on death, are decomposed by bacteria and fungi of decay to simple inorganic materials. The latter are reused by grass.

Some other examples of land food chains:

- a) Grass- grasshopper- frog-snake-peacock
- b) Crop-aphids-ladybird beetles –birds
- c) Crop- rats-owls

6-Length and Ecological principles derived from food chains

Length of food chains

A food chain may end at the:

- i) **Primary consumer** (herbivore) level, for example, plants-elephants
- ii) **Secondary consumer** (primary carnivore) level, for example, plants-rabbit-bear
- iii) **Tertiary consumer** (secondary carnivore) level for example, plants-rabbit-wild cat-tiger
- iv) **Quaternary consumer** (tertiary carnivore) level for example plants-rabbit-cat-wolf-tiger

There is perhaps no living thing that does not serve as a trophic level in some food chain. Some animals may form a link in more than one food chain.

Food chains may be longer or shorter than those discussed, but usually there are only 4 or 5 successive trophic levels.

Ecological principals derived from food chains

Five important ecological principles emerge from the study of food chains:

- i) To be complete and self-containing, a food chain must always begin with photosynthesis and end with decay. A food chain must get energy from outside to keep going.
- ii) The shorter a food chain, the more efficient it is. The more steps it has, the greater wastage of energy.
- iii) The size of any population is ultimately determined by the number of trophic levels in the food chain. With the decrease in useful energy at each step, very little energy is available for a population of quaternary consumers. The size of a population of quaternary consumers is less than that of tertiary consumers, a population of tertiary consumers is smaller than that of secondary consumers, and so on.
- iv) In any food chain, the successive members are larger in size though fewer in number.
- v) An organism cannot always be assigned to just one trophic level. The insectivorous plants, such as venus's flytrap and pitcher plant, are producers as well as consumers. Jackals are both carnivores and scavengers. A snake may feed on rats (herbivores) or frogs (carnivores). Frog is herbivorous in the larval stage and carnivorous in the adult stage.

Many mammals, such as fox, bear and man, are omnivorous and belong to many trophic levels.

7-Food Web

In nature, food chains do not operate in isolation. These, in fact, are interconnected forming a sort of interlocking pattern.

Definition

Food web is a network of food chains which become inter-connected at various trophic levels so as to form a number of feeding connections amongst different organisms of a biotic community.

Unlike food chains, food webs are never straight. Interlocking pattern in a food web is supported by the fact that a single living organism may participate at different trophic levels in different food chains. For instance, in grassland ecosystem, the grass may be eaten by the grazing cattle. In the absence of grazing cattle in the biotic community, grass may be eaten by a rabbit or in the absence of both, rat or mouse may consume the grass. Similarly, rat or mouse may be eaten by predatory birds or snakes. Snakes may also be eaten by predatory birds. To sum up, alternatives are available in nature which results in a sort of interlocking pattern or the food web. Thus, in food webs any given species may operate simultaneously at more than one trophic level.

Characteristics of Food Web

1. Unlike food chains, food webs are never straight
2. Food web is formed by interlinking of food chains.
3. A food web provides alternative pathways of food availability.
4. In food web, greater are the alternative pathways more stable is the ecosystem.
5. Food webs also help in checking the over- populations of highly fecundive species of organisms.
6. Food webs also help in ecosystem development.
7. There can be 3 types of food chains in a food web:
 - * Predator chains that begin with plants and proceed from small to large animals
 - * Parasitic chains which proceed from large to small organisms.
 - * Saprophytic chains that proceed from dead animals to microorganisms.

Significance of Food Web

Food webs provide stability to the ecosystem. Most animals are polyphagous, that is, feed on more than one kind of organisms. If the population of a species decreases to an endangered level, its predators shift to another prey and the endangered species may get a chance to recover its population. Even a loss of a particular type of organisms would not produce large fluctuations in the populations of other organisms which uses it as food because they would have alternative food organisms.

Conclusion

In this program, we have learned about Food Chains, its various types with examples, Trophic levels and Food web. All these functions make the biosphere complex and dynamic.

GLOSSARY

Autotroph: an organism that makes its own food

Carnivore: animals that eat meat

Decomposer: an organism that breaks down organic matter

Detrivore: an organism that feeds on detritus, dead and decomposing animals

Food chain: the sequence of who eats whom in a biological community to obtain nutrition

Food web: a network of many food chains in an ecosystem

Heterotroph: a living thing that eats other living things to survive

Omnivore: animals that eat both animals and plants

Predator: an animal that hunts and kills other animals for food

FAQs

1) What is a food chain?

Ans: A food chain is the linear (not branched) sequence in which a living organism serves as food for another, starting with the producers and going up to the decomposers.

2) How is energy transferred along a food chain?

Ans: The energy flow along a food chain is always unidirectional, from the producers to the decomposers.

3) What are primary consumers?

Ans: Primary consumers are living organisms that eat autotrophic organisms; or rather, they eat the producers. Primary consumers always belong to the second trophic level of a chain.

4) What is the difference between the food chain and food web?

Ans: The food chain is a theoretical model to study the energy flow in ecosystems. In reality, in an ecosystem, organisms are part of several interconnected food chains, forming a food web. The food web is a more realistic representation of the nature in which food chains interconnect to form a web.

5) What are the three main types of trophic pyramids studied in ecology?

Ans: The three types of trophic pyramids studied in ecology are the numeric pyramid, the biomass pyramid and the energy pyramid.

6) What do biomass pyramids represent?

Ans: Biomass pyramids represent the sum of the masses of the individuals that participate in each trophic level of a food chain.

7) What do energy pyramids represent?

Ans: Energy pyramids represent the amount of available energy on each trophic level of the food chain.