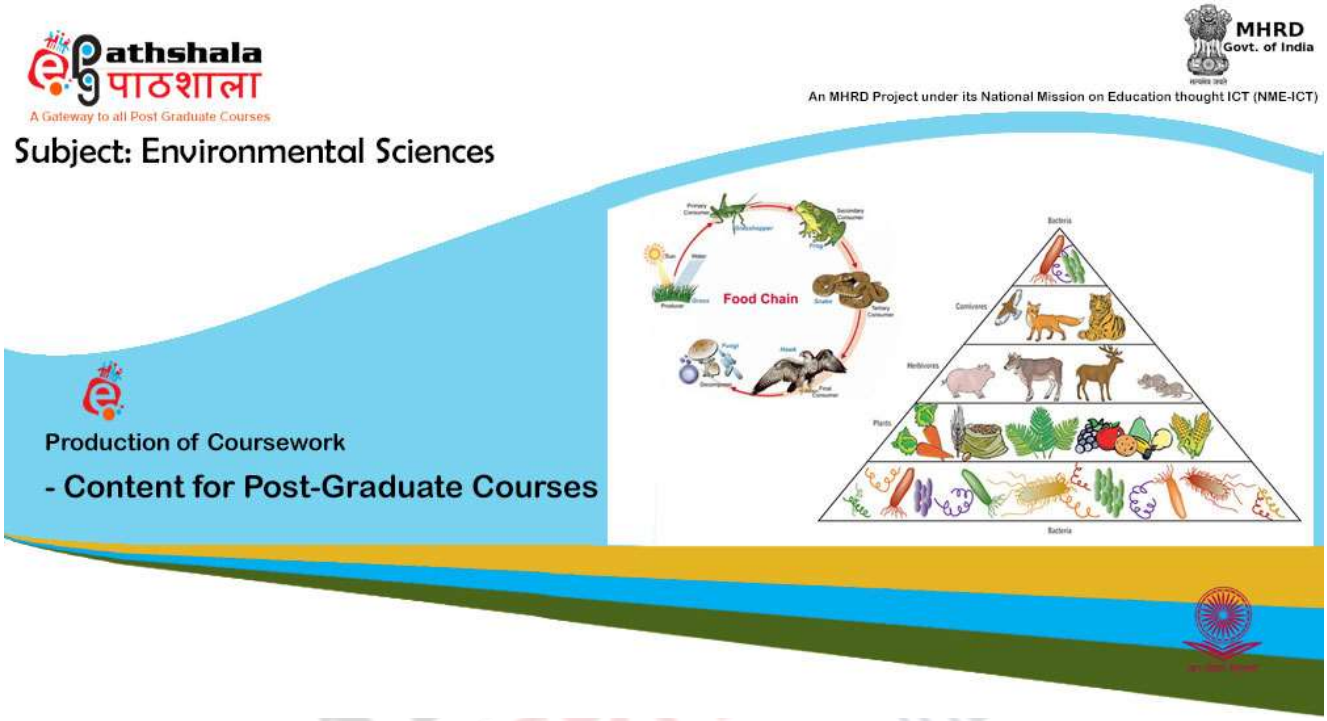

Paper No: 01 Ecosystem Structures & Functions

Module 6: Ecological Pyramids

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Description of Module	
Subject Name	**Environmental Sciences**
Paper Name	Ecosystem Structure & Function
Module Name/Title	6/ **Ecological Pyramids**
Module Id	EVS/ESF-I/6
Pre-requisites	
Objectives	• To understand the concept of ecological pyramids. • To learn about different types of ecological pyramids. • To explain various examples of ecological pyramids in different ecosystems. • To describe the significance of ecological pyramids in the ecosystem.
Keywords	Ecosystem, ecological pyramids, pyramid of number, pyramid of bomass, pyramid of energy, Energy Flow, 10% Energy law.

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Module 6: Ecological Pyramids

Contents

6.1 Introduction

Ecological pyramids are the way to show the structure of ecosystems, the term was first described by Charles Elton in 1920s in the pioneering studies of ecosystem. In his studies, he noted that larger organisms higher in food chains were less abundant than smaller ones in lower trophic levels. Ecological pyramids show the relative amounts of various parameters (such as number of organisms, energy, and biomass) across trophic levels. They can also be called as trophic pyramids or energy pyramids. **A graphical representation of trophic structure and function of an ecosystem, starting with producers at the base and successive trophic levels forming the apex is called as an ecological pyramid.** Three types of ecological pyramids are generally described (Fig. 6.1):

1) Pyramid of Numbers, in which individuals at each successive trophic level are counted per unit area and their numbers are plotted in the form of pyramids.
2) Pyramid of Biomass, in which the total biomass existing at each of the successive trophic levels is measured in terms of dry weight or caloric value, per unit area and plotted.
3) Pyramid of Energy, in which energy flow per unit time at each of the successive trophic levels is measured and plotted. It is also called as pyramids of productivity.

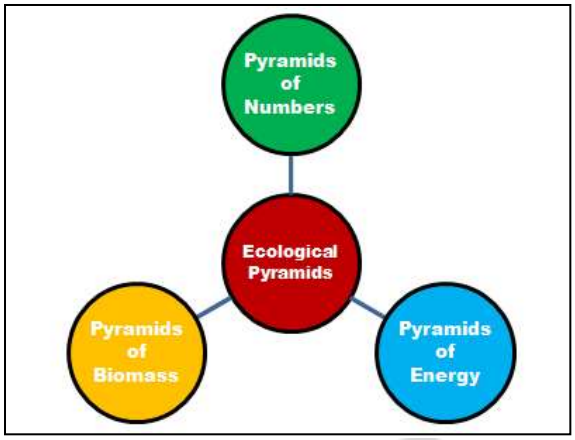

Fig. 6.1: Types of Ecological Pyramids

6.2 Pyramid of Numbers

Pyramid of numbers may be defined as graphical representation of number of individual organisms per unit area at each trophic level arranged stepwise with producers at the base and top carnivores at the top.

The shape of pyramid of numbers may vary from one ecosystem to another ecosystem.

- In grassland and aquatic ecosystems, pyramid of number is upright (Fig. 6.2). The producers in the grassland are the grasses and in aquatic ecosystems are phytoplanktons (algae etc.) which are small in size and large in number per unit area. So the producers form a broad base in the pyramid. The herbivores in the grassland are the insects; carnivores are frogs, birds, etc. and top carnivores are hawk, eagle, foxes etc. which are gradually less and less in number and so the pyramid apex becomes gradually narrower forming an upright and erect pyramid. Similar is the case with herbivores (zooplanktons, etc.), carnivores (small fishes, etc.) and top carnivores (large fishes, crocodile, etc.) in aquatic ecosystems (pond, lake or marine ecosystem) which decreases in number at higher trophic levels, thus forming an upright pyramid of numbers.

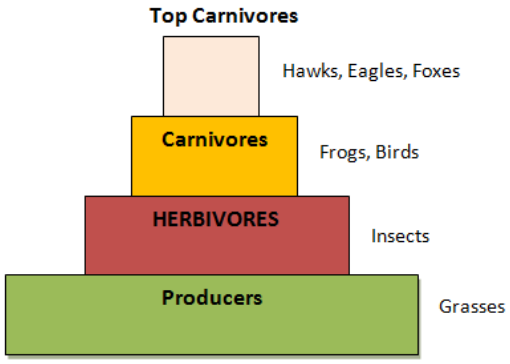

Fig. 6.2: Pyramid of Numbers in Grassland Ecosystem (Upright)

- In a forest ecosystem, large sized trees are the producers, which are less in number and so form a narrow base. The trees support large number of herbivores like insects, birds, frogs, etc. including several species of animals that feed upon leaves, fruits, flowers, bark, etc. of the trees. They are large in number than trees and hence form a middle broad level. The secondary consumers like predatory birds (hawks, eagle, etc.), foxes, snakes, lizards, etc. are less in number than herbivores while top carnivores like lion, tiger, etc. are still smaller in number making the pyramid gradually narrow towards apex. So the pyramid assumes a spindle shape with narrow on both sides and broader in the middle (Fig. 6.3).

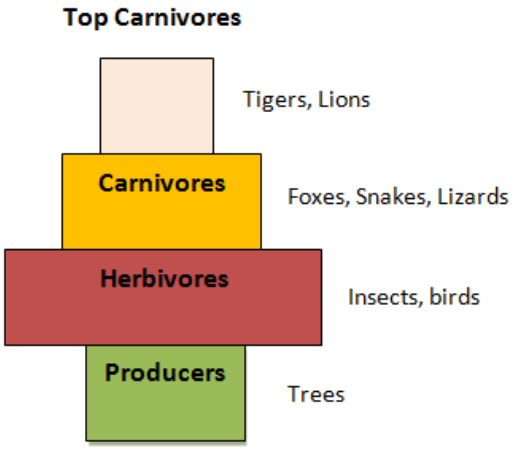

Fig. 6.3: Pyramid of Numbers in Forest Ecosystem (Spindle shaped)

- In a parasitic food chain, for example, the producers like a few big trees offers food to quite a lot of frugivorous birds which are the herbivores and more in number than trees. The birds harbor and sustain a good number of ecto-parasites like lice, bugs, etc., while a greater number of hyperparasites like bugs, fleas, microbes, etc. feed upon them. This when graphically represented form an inverted pyramid (Fig. 6.4).

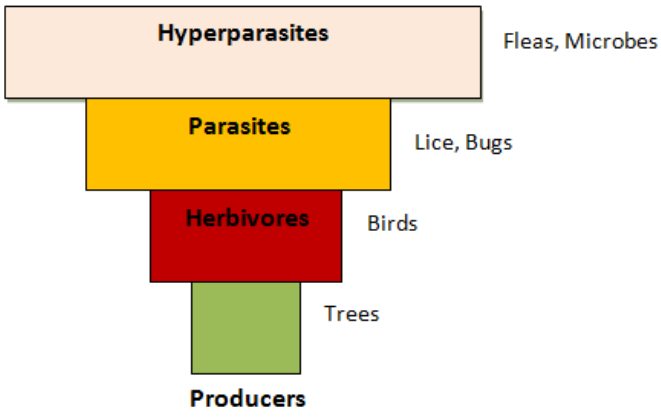

Fig. 6.4: Pyramid of Numbers in a Parasitic Food chain (Inverted)

6.3 Pyramid of Biomass

A pyramid of biomass shows the relationship between biomass and trophic level by quantifying the biomass present at each trophic level at a particular time. It is a graphical representation of biomass (total amount of living organic matter in an ecosystem) present in unit area at a particular time in different tropic levels. The pyramid of biomass may be upright or inverted. For example, in a forest ecosystem, the plants and trees (primary producers) make up a large percentage of the biomass, with gradually lessening of biomass present at herbivores, carnivores and top carnivores level respectively per unit area at a particular time. Therefore, the pyramid of biomass in a forest ecosystem is upright with producers forming the broad base and consumers forming narrow top (Fig. 6.5a).

In contrast, in a pond ecosystem, the pyramid of biomass is inverted (Fig. 6.5b) as the standing crop of phytoplanktons, the major producers, at any given time make up less biomass than the consumers, such as fishes and insects. As with inverted pyramids of numbers, the inverted

biomass pyramid is not due to a lack of productivity from the primary producers, but results from the high turnover rate of the phytoplankton. The phytoplanktons are consumed rapidly by the primary consumers, which minimizes their biomass at any particular point in time. However, since phytoplanktons reproduce quickly, they are able to support the rest of the ecosystem.

One problem with pyramids of biomass is that they can make a trophic level appear to contain more energy than it actually does. For example, all birds have beaks and skeletons, which despite having mass are not typically digested by the next trophic level.

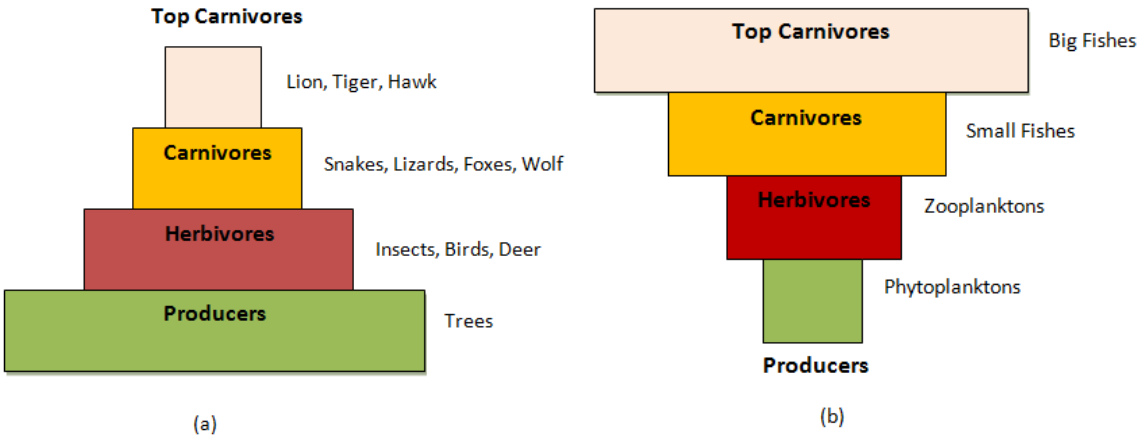

Fig. 6.5 a) Pyramid of Biomass in a Forest Ecosystem (Upright) b) Pyramid of Biomass in a Pond Ecosystem (Inverted)

6.4 Pyramid of Energy

The pyramid of energy is by far the most practical of all the three ecological pyramids as it depicts the actual functional relationships between trophic levels. It represents the amount of energy present at each trophic level. Likewise it starts with the producers and ends with consumers at higher trophic levels. It is also called as pyramid of productivity. Since the productivity or energy flow is expressed per unit time basis, the pyramid is always and for all the ecosystems is an upright position.

For ecosystem to be self sustaining, lower trophic levels should have more amount of energy than the higher trophic levels. This helps the organisms at lower levels to maintain a stable population, but also to transfer energy up the pyramid.

As per the second law of thermodynamics, energy flow declines from producer level to successive trophic levels. When energy is transferred to next trophic levels, only about 10% of it is utilized to assemble body mass and become stored energy. Remaining 90% is lost in metabolic activities. For instance, if the producers make up 100 Kcal energy, only 10 Kcal is passed on to herbivores, then about 1 Kcal of herbivores is transferred to carnivores and then only 0.1 Kcal energy passes on to top carnivores level. This decline in energy at subsequent level is referred to as Lindeman's data or 10% law. Therefore, pyramid of energy is always upright as shown in Fig. 6.6.

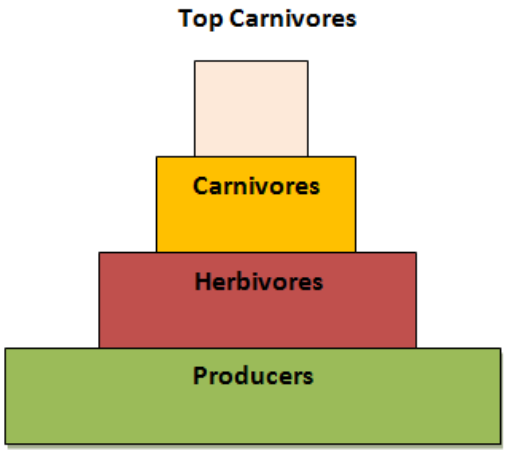

Fig. 6.6: Pyramid of Energy

The advantages of pyramid of energy are as follows:

- It takes account of the rate of production over a period of time.
- The shape of the pyramid of energy is not affected by size or rate of metabolism of organisms, while the other two pyramids (number and biomass) are affected by them. Animals may have larger biomass per unit area than plants, but their production per unit time per unit area would be smaller than the plants.
- The energy content of two species bearing same mass or weight may be different; in such case biomass may be a misleading factor whereas energy is truly comparable.

- In energy pyramids, the relative energy flow within an ecosystem can be compared and so also different ecosystem can be compared using energy pyramids.

However, there are some disadvantages of pyramid of energy. Firstly, the rate of biomass production of an organism is required, which involves measuring growth and reproduction through time. Further, one organism can exist at two or more trophic level. So there is a difficulty while assigning the organisms to a specific trophic level. Also problem exists for assigning the decomposers or detritivores to a particular trophic level.

In the nutshell, pyramids of energy are the most consistent and representative models of ecosystem structure in the study of energy flow through the ecosystem.

Summary

- Pyramids of numbers can be either upright, inverted or spindle shaped, depending on the ecosystem.
- Pyramids of biomass measure the amount of energy converted into living tissue at the different trophic levels.
- Pyramids of energy are always upright since energy decreases at each trophic level.
- All types of ecological pyramids are useful for characterizing ecosystem structure; however, in the study of energy flow through the ecosystem, pyramids of energy are the most consistent and representative models of ecosystem structure.