

## ZOOPLANKTON COMMUNITY STRUCTURE AND PRODUCTION

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Understanding the structure of a community is part of ecosystem analysis. We shall examine here some of the concepts and their applications. These concepts are pertinent not only to zooplankton communities, but others such as phytoplankton, benthos etc., as well.

### Distributions

Once the species composition in sample(s) is known, we look for meaningful interpretation of data. Basic information pertains to distribution patterns. From this, we are able to find out the geographic ranges and temporal variations, if any, of individual species. These are analysed in conjunction with physical parameters such as temperature or salinity and other biological factors controlling distributions such as availability of food, predation etc. These help us to predict abundances of individual species, and in general, the productivity of a region, or during a season etc.

From the distribution patterns, we also know if species have broad (eury) or narrow (steno) ranges with respect to the controlling factors. Further, we will be able to classify species as limnetic, estuarine, neritic, oceanic, etc. A certain species may be associated with a particular water mass and can provide information on the origin and dispersion of the water mass; they are called indicator species. Vertical ranges of species are also important; these provide information on diel migrations and vertical flux of organic matter into deeper waters.

Taxonomic studies on the identity of species are also extremely important. Recent studies show that many species of zooplankton which were thought to have very broad ranges (e.g. circumglobal) may necessarily not be so, but may be species complexes comprising of closely related sibling species (in different areas/oceans).

Seasonal patterns of distributions also might reveal that some species are opportunistic showing rapid rates of increases in populations when conditions become ideal (like in estuaries, upwelling areas). This is opposite to populations which show more stable densities and are called equilibrium populations. Opportunistic species also exhibit catastrophic mortality rates and are typical of fluctuating environments and are designated r - selected, as opposed to K - selected species (for details, see Pianka, 1983).

In order to come to more significant conclusions in analysis of ecosystems we have to look more deeper into the ways in which species interact with the system and between themselves or with other organisms.

The ecological niche:

Niche is a concept that pervades all ecology. Hutchinson (1957) defines it as the total range of conditions under which the individual lives and replaces itself. He further defines fundamental niche as the entire set of optimal conditions under which an organism can live and replace itself. In contrast, the actual set of conditions under which an organism exists, which is usually less than the fundamental niche, is called realized niche.

Species diversity

The number of species tend to vary in different environments/ communities. In zooplankton, there is generally a progressive gradient in diversity from the estuaries to the neritic and open ocean waters (Madhupratap, 1987). There are several theories postulating the reasons for high or low diversities in nature (see Ricklefs, 1973). Perhaps, of greater importance in aquatic systems, are factors such as environmental stability and productivity. More stable environments (like the open ocean, deep sea) tend to have more diverse communities. Diversity is usually higher in tropics compared to higher latitudes. Diversity indices also provide insight to the quality of bitopes (Madhupratap and Onbe, 1986)

Diversity is recognised as the function of two components; one is the number of species (richness) and the other the evenness (equitability). Some of the commonly used indices are:

$$D = \frac{S-1}{\ln N} \quad (\text{Margalef, 1968})$$

where  $\underline{S}$  is the number of species and  $\underline{N}$  the total number of individuals. This is an index for species richness.

$$H' = - \sum_{i=1}^S \frac{P_i}{N} \log_2 P_i \quad (\text{Shannon and Weaver, 1949})$$

where  $\underline{P_i}$  is the proportion of the number of individuals of species  $\underline{i}$  to the total number of individuals. This is an index of information content.

$$E = \frac{H}{(e^{-1}) / (S-1)} \quad (\text{Heip, 1974})$$

This is an index of evenness and the minimum and maximum values lie between 0 and 1.

Communities can differ in diversity in several ways. More diverse communities may have (1) greater range of resources (2) component species may be of smaller niche breadths etc. The total species diversity in an area can be divided into spatial, temporal and trophic components. The first two arise from differences in utilisation of resources in different ways (e.g. in an estuary, the high saline zooplankton community and low saline community may use the resources of lower and upper reaches respectively; temporal variations occur from seasonality of river discharge). Trophic separation of component species arises from differences in the ways of resource utilisation (herbivores, omnivores, carnivores, etc.). Carnivorous zooplankton generally occur in lesser abundances compared to other groups (Madhupratap and Haridas, 1986).

#### Species succession:

A change in community composition in time, both by changes in the relative importance of component populations and by extinction of old species and invasion of new ones, is termed a succession (Pianka, 1983). For example, during rainy season, only a low salinity tolerant zooplankton community, occurs in an estuary. Later, when rains stop, high saline forms appear at the lower reaches and along with salinity recovery, invade the middle and upper reaches. Thus, succession of communities occur. Such successions occur in the marine environment also generally after a physical event which disturbs the equilibrium (e.g. upwelling)

#### Species associations

One important aspect in community analysis is to find out the extent to which species share resources. Do they coexist or compete? Competitive exclusion principle (Gause, 1934; Hardin, 1960) states that complete competitors cannot co-exist. However, there are several criticisms to this (e.g. paradox in plankton, Hutchinson, 1961).

There are several methods to assess the degree of associations. Percent similarity index (Whittaker, 1952) is commonly used to determine the affinity between samples.

$$P = \frac{\sum_{i=1}^S \min(P_{a,i}, P_{b,i})}{S}$$

where  $P_{a,i}$  and  $P_{b,i}$  are percent abundances of species  $i$  in samples A and B and  $S$  is the total number of species to be compared.

Grouping using correlation matrix or cluster analysis using similarity indices (e.g. Bray-Curtis index) and illustrated in dendrograms are very useful. (see Fager and MacGowan, 1963; Field et al., 1982). Many studies indicate that the concept of a guild (Root, 1967), where a group of species uses the same environmental resources in a similar way, may be valid for zooplankton.

## Production

Unlike primary production, there are no direct and simple methods for determining rate of production in zooplankton. While biomass (standing stock) gives us some idea about the productivity of an area, in order to translate this to the rate of production, we have to have estimates of generation time, rate of recruitment, mortality, etc. This is further complicated by the fact life history patterns and feeding habits of component species may differ

Production ecologists usually concentrate on a or few species and identify cohorts from field collections or through laboratory culture. Among various theories in marine copepod development, one is that of isochronal development which is characterised by equal duration of each intermolt phase of the life cycle. This might generally apply to neritic forms as opposite to development rule for oceanic copepods for which naupliar instars are of shorter duration than copepodite instars.

Behrdelek's function is commonly used:

$$D = a (T - \alpha)^{-b}$$

where  $D$  is development time (days),  $T$  is temperature ( $^{\circ}C$ ),  $a$  is a constant,  $b$  is a common constant for animal groups adapted to a certain temperature range and  $\alpha$  is a constant called biological zero.

The most common methods for estimation of production are field oriented population dynamic method and laboratory oriented budgetary method. Readers are referred to Omori and Ikeda (1984) for further details.

## Island ecology

Zooplankton in waters surrounding islands typically represent an open ocean community. For example, a study by Moore and Sander (1976) from some of the Caribbean islands showed that most of the zooplankton are tropical/subtropical species having wide distributions. Copepods comprised 76 to 84% of zooplankton counts.

A general increase in zooplankton from offshore to near the islands called

Island mass effect has been observed by many workers.

There may be, however, species endemic to islands. Bowman and Gonzalez (1961) described 4 new species of Pseudocyclops from Puerto Rico. More recent studies from many of the coral reefs and lagoons show that net tows, especially during day time, do not give an accurate picture of zooplankton abundance. This is because a large number of zooplankton are concentrated near the bottom or on coral/sand substrates during day time. They emerge into the water column during night and special gears such as traps are used to study their behaviour and abundance. It is well established that zooplankton form an important source for coral nutrition.

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