A NEW HYPOTHESIS TO ACCOUNT FOR THE OPPOSITE TROPHIC-BIOMASS STRUCTURE ON LAND AND IN WATER

WHILE discussing the Y-shaped energy flow model, Odum[1] states that the marine community holds a relatively large standing crop of animals compared to that of plants (phyto-plankton). The situation is reversed in terrestrial communities which maintain a larger biomass of the plants. Phillipson[2] while comparing the biomass pyramids of trophic level for terrestrial and some aquatic ecosystems,[3] showed the same phenomenon by drawing an upright pyramid for land and an inverted pyramid for aquatic situations. One of the factors causing this inverse relation between the two habitats may be the difference in the energy flow pathway. For example, in marine community the grazing pathway is more efficient while in the forest community the detritus pathway is predominant.[1] But as Odum[1] further contends, this difference may not necessarily be inherent in aquatic and terrestrial ecosystems. In grasslands, for example, the grazing pathway is very conspicuous and in certain cases as much as 88% of the produce is removed for livestock consumption within a short period,[4] and yet the trophic-biomass pyramid is not inverted. It is obvious, therefore, that an explanation for this paradox has to be found in altogether different quarters.

The most significant difference in the aquatic and terrestrial ecosystems is that the variations in the oxygen concentration of the gaseous medium on the land are much less and being in abundance it ordinarily never becomes a limiting factor for respiration[5] of terrestrial communities. The much limited oxygen concentration of the aquatic environment, on the other hand, exhibits greater fluctuation both seasonally[6,7] and diurnally.[8,9] The limited supply of oxygen in water is causal to many physiological adaptations of the biota. The various animals, therefore, have been labelled as oxygen regulators or oxygen conformers.[10]

One of the major sources of energy dissipation is respiration. A survey of the literature[10-15] indicates that the rate of respiration or energy dissipation is lower in the case of aquatic animals than in the terrestrial ones (Table I). Further, in the latter case the respiration may increase manifold during period of activity. For example, in man, rate of energy dissipation through respiration may go up 15–20 times than the resting value; and in insects, flight may cause 50–200 times increase.

TABLE I

Rate of respiration of some aquatic and terrestrial animals at rest

Aquatic		Terrestrial	
Animals	Range of O_2 consumption (mg./g. wt /hr.)	Animals	Range of O_2 consumption (mg./g. wt./hr.)
Fishes ..	0·005–0·349	Mammals	0·124–13·70
Insects ..	0·1[illegible]2–0·381	Birds	1·50 –10·70
Crustaceans	0·05 –0·11	Insects	0·63 – 1·70
Molluscs ..	0·002–0·186	Arthropods	0·27 –7·40
Worms ..	0·008–0·031		

However, the active metabolism of fish may increase only 4 times the rest metabolism.[12,16,17] Thus both in rest and activity the energy loss of aquatic animals is smaller. Moreover, considerably greater species diversity of terrestrial ecosystem[18] leads to more efficient loss of energy. Now, Patten[19] has shown "if more information is accumulated than used, the excess is converted to biomass". Hence, the inverted trophic-biomass pyramid in marine ecosystems is primarily due to slower energy dissipation of animals *via* respiration as compared to terrestrial ecosystems. This leads to greater build-up of consumer biomass in the former system. Indeed the conservation of biomass at the consumer levels is possible on account of rapid turnover of the producer system and hence the trophic-biomass structures of the aquatic and terrestrial ecosystems have evolved primarily, on the basis of oxygen tension of the two media.

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May 14, 1968.

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