IMPACT OF CHANGING HABITATS ON LATITUDINAL VARIATIONS IN TROPHIC SYSTEMS OF TELEOSTEAN FISHES

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ABSTRACT

The trophic systems of teleostean fishes studied at Pacific-Ocean sites widely separated by latitude were more complex and involved more species towards the equator. This situation appeared linked to characteristics of the specific habitats involved rather than to more general latitudinal differences. The character of the temperate habitats was set by the dominating macroalgae and as these algae progressed through their normal life-stages the habitats experienced rapid and profound transformations. This condition favoured generalized feeders and simple trophic systems that are able to accommodate changeable and unpredictable food supplies. The character of the tropical habitats, on the other hand, was set by the dominating scleractinian corals, and, because these organisms grow and change so slowly the habitats remained relatively unchanged during the lives of most inhabitants. This condition favoured specialized feeders and complex systems that are able to develop with stable and predictable food supplies.

INTRODUCTION

It has long been recognized that plant and animal communities generally include more species at lower latitudes (e.g. Wallace 1878, Fisher 1960), which is certainly true of teleostean fishes. In this paper I link this condition to trophic relationships, which I consider are the major forces structuring fish communities (Hobson 1974). I compare trophic relationships in communities widely separated by latitude: a temperate community in Northern California (38°N), a warm-temperate community in Southern California (33°N), and a tropical community in Hawaii (19°N).

METHODS

The communities at each location have been characterized over the past 16 years by visual counts and samples from 25 x 4 m transects established in representative habitats. Prey have been identified from gut contents, and organisms potentially available as prey have been identified in samples taken with a variety of nets, corers, suction hoses, and other sampling devices (Hobson 1974, Hobson and Chess 1976).

LATITUDINAL TRENDS IN TROPHIC RELATIONSHIPS

There were more species in habitats at lower latitudes. Thus, I counted 15 species (41 transects) at the temperate site, 30 species (48 transects) at the warm temperate site, and 128 species (22 transects) at the tropical site. These differences can be linked to trophic relationships. Despite the great variety of form and habit among them, the species represented here can be grouped according to how much their feeding morphologies have diverged from that of their generalized ancestors. (Most modern reef fishes are products of a radiation from just a relatively few generalized forms early during the Cenozoic: Gosline 1959, Shaeffer and Rosen 1961, Hobson 1974).

Teleosts with trophic features relatively unchanged from the ancestral form may be highly specialized in other morphological features, but are characterized by large mouths (Fig. 1). These species are adapted to directly approach, and sieze, exposed prey that are small enough to manipulate, yet large enough to grasp, and which typically are moving when captured. Generally their prey lack heavy armour, and such components as strong spines or tough, fibrous tissues, which their unspecialized trophic systems cannot process. Among fishes in this category are most of the piscivores, as well as most species that take motile crustaceans larger than about 2% of the predator's length. Included are most members of the families Muraenidae, Synodontidae, Holocentridae, Scorpaenidae, Hexagrammidae Serranidae, Priacanthidae, Apogonidae, Carangidae, Haemulidae, Sciaenidae, Cirrhitidae, Clinidae, Gobiidae, Bothidae, and Pleuronectidae. Although species in this category were numerous in all regions studied, they constituted decreasing proportions of the fish communities toward the equator. Based on direct counts in established transects, species in this category constituted 87% of those in the temperate habitats (13 of 15; n = 41 transects), 67% of those in the warm-temperate habitats (20 of 30; n = 48 transects), and 21% of those in the tropical habitats (27 of 128; n = 22 transects).

Most species that belong to groups which have diverged from the main teleostean line on the basis of specialized trophic characteristics are distinguished by adaptations that cope with specific types of defences in prey. Three major subcategories are evident: predators on sedentary prey, herbivores, and diurnal planktivores. They are distinguished by such characteristics as strong jaw and pharyngeal teeth adapted to crush heavy armour (Fig. 2), protruding snouts adapted to reach prey hiding in narrow crevices (Fig. 3), small mouths with dentition adapted to pluck prey too small to be taken by the generalized predator's large mouth (Fig. 4), and digestive systems capable of processing noxious tissues (Fig. 5). Species with such characteristics include members of the Chaetodontidae, Pomacanthidae, Kyphosidae, Pomacentridae, Embiotocidae, Labridae, Scaridae, Acanthuridae, Blenniidae, Monacanthidae, Tetraodontidae, and Canthigasteridae. Of these families, all but the Embiotocidae are primarily tropical or subtropical. They include 20% of the species counted in the temperate habitats (3 of 15), 33% of the species counted in the warm temperate habitats (10 of 30), and 79% of the species counted in the tropical habitats (101 of 128). Species in this category account for most of the increased number of species toward the equator, and for most of the greater complexity of trophic interactions at lower latitudes.

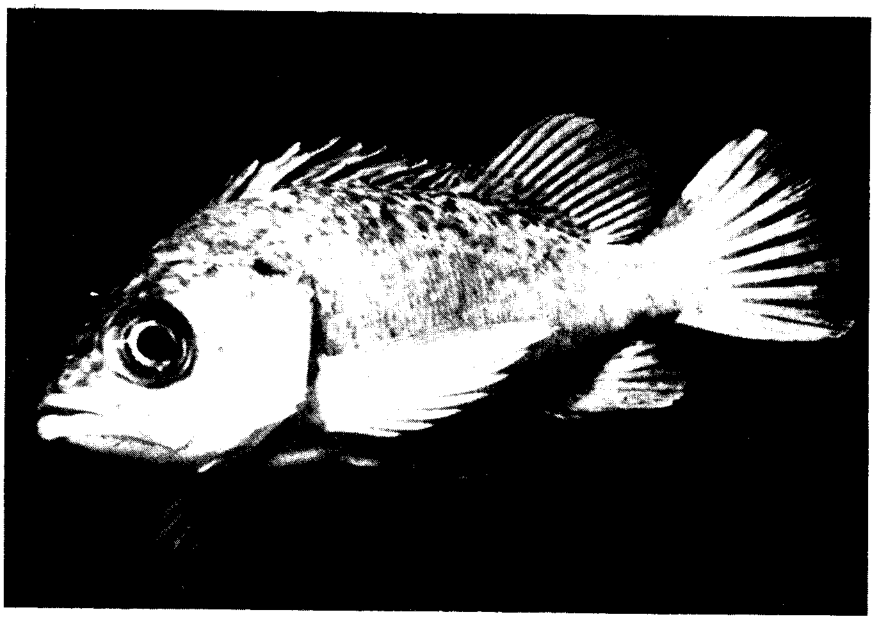

Figure 1. The Kelp rockfish, Sebastes atrovirens, of the family Scorpaenidae in Southern California, has the large mouth of a generalized predator.

Figure 2. The porcupine fish, Diodon holacanthus, of the family Diodontidae in Hawaii, has heavy beak-like jaws suited to crush shelled organisms.

Figure 3. The long-nosed butterflyfish Forcipiger flavissimus, of the family Chaetodontidae in Hawaii, has an elongated snout suited to probe reef crevices for sheltered prey.

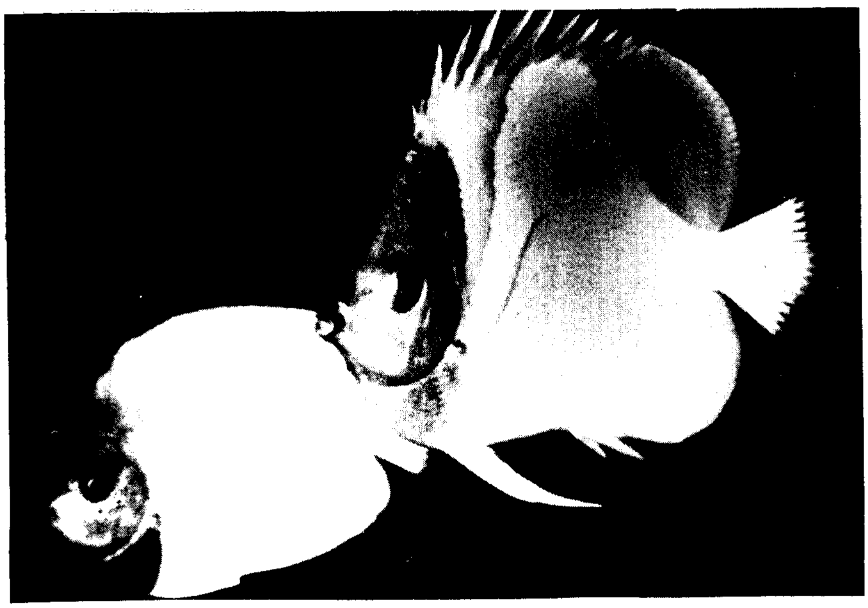

Figure 4. The pyramid butterflyfish Hemitaurichthys polylepis, of the family Chaetodontidae, has a small mouth and dentition suited to take the tiny zooplankters that are its major prey.

Figure 5. The bluechin parrotfish Scarus ghobban, of the family Scaridae in the Gulf of California. The beak-like dentition of this fish is suited to scrape algae from rock surfaces, and its digestive system is specialized to digest this material.

Figure 6. This and other habitats dominated by macroalgae in Southern California (33°N) experienced frequent and profound transformations during 13 years of study (1972-1985). The fish are Chromis punctipinnis, a diurnal planktivore.

Figure 7. This and other habitats dominated by scleractinian corals in Hawaii (19°N) remained virtually unchanged during 15 years of study (1969-1984).

DISCUSSION

There are probably multiple and complex reasons why communities tend to be more diverse at lower latitudes (see Pianka 1966, and MacArthur 1969, for reviews of hypotheses). It is widely recognized that tropical communities include more specialized species (e.g. Cowell 1973), but some investigators (e.g. Sale 1976) doubt that increased specialization is the basis for tropical diversity. In the communities examined here, however, it was clear that the increased number of species at lower latitudes involved mostly specialized feeders. But in these cases the condition seemed to relate to characteristics of the specific habitats involved, rather than to more general latitudinal characteristics.

The pattern of trophic relationships defined in this paper appeared strongly influenced by the normal life-history stages of the predominating biological features of the respective habitats. The temperate and warm-temperate sites are dominated by benthic macroalgae (Fig. 6), and experience profound transformations associated with the rapidly progressing life-stages of these plants. The effect is more pronounced in the temperate habitats because the major alga there, *Nereocystis leutkeana*, is an annual, whereas the major alga in the warm temperate habitats, *Macrocystis pyrifera*, is a perennial. On the other hand, the tropical sites are dominated by scleractinian corals (Fig. 7), and experience comparatively little change because these organisms grow so slowly. It may be because conditions in the coral-dominated habitats at lower latitudes remain comparatively unchanged during the lives of so many inhabitants that the fish communities there include more species with specialized trophic features, and more complex trophic systems. Probably such community characteristics are limited in the algae-dominated habitats at higher latitudes by the frequent and profound changes that prevail there. Favoured instead should be more generalized trophic features, and simpler trophic systems, that can accommodate changeable and unpredictable food supplies.

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