ALTERNATE STATES OF POPULATIONS OF *ECHINOMETRA MATHAEI* (DE BLAINVILLE) (ECHINODERMATA: ECHINOIDEA) IN THE GULF OF SUEZ AND THE GULF OF AQABA

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"Individuals of *Echinometra mathaei* from the Gulf of Suez are larger, have more annual rings in the plates of their tests, and more plates between the apical system and the ambitus than individuals from the Gulf of Aqaba. These populations exist in alternate states similar to those of *E. mathaei* at Reunion Island, South Pacific Ocean. The basis for the alternate states of *E. mathaei* on the two sides of the Sinai peninsula may also be the basis for the difference in distribution of echinoid species in the Gulf of Suez and the Gulf of Aqaba. These alternate states may be stable."

Introduction

Lewontin (1969) proposed that there are multiple stable points possible for a community; that is, stable communities with different structures can exist. Sutherland (1974) stated that the identification of multiple stable points depended on attributing some degree of stability to them. His examples of alternate stable-state communities involved the addition or subtraction of an important consumer, which changed the structure of the community.

Contrasting states of the shallow-water algal communities involving the echinoid genus *Strongylocentrotus* have been found off the northern California coast (Lowry and Pearse, 1973), the Aleutian Islands (Estes and Palmisano, 1974; Estes et al., 1978; Simenstad et al., 1978), and the eastern Canadian coast (Breen and Mann, 1976; Chapman, 1981; Mann, 1977). In all of these cases, the basis for the alternate states of the community presumably is in the role of a predator -- the sea otter *Enhydra lutris* in the northeastern Pacific and the lobster *Homarus americanus* off the eastern Canadian coast -- functioning in the role of a keystone species as conceived by Paine (1969). The presumption is that these altered states are stable.

The observations clearly indicate that the populations and individuals of the echinoids in the alternate states of the community are themselves in alternate states. Indeed, this is one of the means of recognizing alternate stable-state communities. The dual purpose of this paper is to describe populations of the echinoid *Echinometra mathaei* (de Blainville) in what seem to be alternate states in the Gulf of Suez and the Gulf of Aqaba and to evaluate the bases for alternate states in echinoderms.

Materials and Methods

E. mathaei were collected in November 1969 and August 1971 from Eil 32'N, 33° 15'E), in February 1970 from Raş el Burqa (29° 13'N, 34° March 1970 from Sharm esh Sheikh (27° 57'N, 34° 44'E) in the Gulf of in January 1970 from El Bilaiyim (28° 32'N, 33° 15'E) in the Gulf of long horizontal diameter was measured, and the color of the test and spines noted. A plate of the test from the ambitus was removed, soaked in ethanol, charred in an alcohol flame, cooled, and then soaked in xylene before the number of major sets of rings were counted (annual rings; see Jensen, 1969).

Results

All *E. mathaei* from the Gulf of Aqaba were pink; all from the Gulf of Suez were black. THe specimens from the Gulf of Aqaba had a smaller horizontal diameter, fewer major sets of rings in the plate from the ambitus, and a smaller number of plates from the apical system to the ambitus (Table 1). The differences between those from Eilat (Gulf of Aqaba) and those from El Bilaiyim (Gulf of Suez) were all significant ($p < .0001$, Student's t-test).

TABLE 1. Characteristics of *Echinometra mathaei* from the Gulf of Suez and the Gulf of Aqaba.

Collection Site	Date (mo/yr)	n	H.D.* (mm)	Number of Annual Rings in Ambital Plate	Number of Plates from the Apical System to Ambitus
Gulf of Aqaba					
Eilat	11/69	5	31 ± 3	8 ± 1	6 ± 1
	8/70	10	37 ± 2	8 ± 1	7 ± 1
Ras el Burqa	2/70	7	48 ± 3	9 ± 1	7 ± 1
Sharm esh Sheikh	3/70	5	27 ± 3	6 ± 1	5 ± 1
Gulf of Suez					
El Bilaiyim	1/70	11	74 ± 3	11 ± 1	11 ± 1

*H.D. = horizontal diameter.

Discussion

The two geographical populations of *E. mathaei* do not meet the strict ... of alternate stable-state communities, which occur in one locality ... times. However, I believe that they can be considered together ... In addition, there are no data substantiating the premise that the different states of the populations in the two gulfs are stable. I see no reason to presume they are not.

The populations of *E. mathaei* in the Gulf of Aqaba and the Gulf of Suez differ in size and other characteristics. The lack of variability in the features of the two populations, as well as the ages suggested by the number of rings in the plates, implies that the two populations are stable. The differences in size and color are identical to those of two populations of *E. mathaei* found on the two sides of Boucan Canot, a small point on Reunion Island in the South Indian Ocean (Lawrence, 1980). Small pink individuals occur on the exposed windward side of the point; large black individuals occur on the protected leeward side.

From comparisons with the observations on other echinoid populations (Table 2), I conclude that there are alternate states of *E. mathaei* populations on the two sides of the Sinai peninsula and the point on Reunion Island, which indicate the existence of alternate states of the communities. Their basis is not known, nor do we know whether these states are stable.

Following Sutherland (1974), one would postulate a predator whose presence or absence determined the state of the *E. mathaei* populations. Estes et al. (1978) and Simenstad et al. (1978) suggested that size-specific predation by *Enhydra lutris* on large *Strongylocentrotus polyacanthus* resulted in a population of small individuals of low density. Similarly, a population of small individuals of *Echinometra lucunter* on the windward side of Barbados was less dense than a population of large individuals on the leeward side (Lawrence and Kafri, 1979). Luxuriant intertidal algal growth occurs on the windward coast of Barbados, whereas only boring blue-green algae occur in the intertidal where *E. lucunter* was collected on the leeward coast. Higher mortality on the windward side may have been the basis for the difference in the size and density of *E. lucunter* there, but due to wave activity instead of predation (Lawrence and Kafri, 1979).

However, the population of small individuals of *E. mathaei* on the windward side of the point at Reunion Island was denser than the population of large individuals (Lawrence, 1980). The dense population of small individuals at Reunion Island were in burrows in a substratum covered with a dense algal felt; the less dense population of large individuals was not burrowed into the substratum that was devoid of algae. The necessity to burrow probably restricted the size of individuals on the windward side of the point, but not on the protected leeward side.

The disappearance of *Homarus americanus* resulted in *Strongylocentrotus droebachinensis* becoming small and abundant as the kelp was consumed (Breen and Mann, 1976; Mann, 1977) off Newfoundland. In contrast, dense populations of large individuals of *S. polyacanthus* developed associated with the absence [of] *E. lutris* noted by Estes et al. (1978) and Simenstad et al. (1978) in [the] Aleutian Islands. This may be associated with a difference in the amou[nt of] drift algae available for feeding.

As Ebert (1968) pointed out, the density of echinoids is noto[...] food, but biomass is. Lindahl and Runnström (1929) concluded that [...] ence in individual size of the S-type and Z-type of *Psammechi[nus]* [...] due to the populations living in different communities with [...] physical conditions. Ebert (1968) suggested that echinoi[ds ...] size set by local conditions, and that individuals will [...]

...lternate states of echinoid populations.

...cies	Location	Relative Size	Relative Population Density	Environment	Reference
Strongylocentrotus droebachiensis	Newfoundland coast	large	low	predator present; macroscopic algae	Breen and Mann, 1976; Mann, 1977
		small	high	predator absent; no macroscopic algae	
Strongylocentrotus polyacanthus	Aleutian Islands	small	low	predator present; macroscopic algae	Estes et al., 1978; Simenstad et al., 1978
		large	high	predator absent; no macroscopic algae	
Echinometra lucunter	Barbados	small	low	high water energy; macroscopic algae	Lawrence and Kafri, 1979
		large	high	low water energy; no macroscopic algae	
Echinometra mathaei	Reunion Island	small	high	high water energy; macroscopic algae	Lawrence, 1980
		large	low	low water energy; no macroscopic algae	
Echinometra mathaei	Sinai peninsula	large		macroscopic algae	(this paper)
		small		no macroscopic algae	

to the amount of food available. Sufficiently dense populations of echinoids can compete intraspecifically for food and thus affect their growth rates (Ebert, 1977). Paine (1976a) found a difference in the size of *Pisaster ochraceus*, which he related to food availability, and noted (Paine, 1976b) an inverse relationship between individual size and density. Intraspecific competition seems involved in the inverse relationship between individual size and population density of the asteroid *Oreaster reticulatus* (Scheibling, 1980a, 1980b). Menge (1975) described a variation in the size of *Leptasterias hexactis* related to food availability, in this case controlled by interspecific competition with *P. ochraceus*.

Thus, although alternate states of a community can come about by the addition or subtraction of an important consumer, this is not the sole agent. A physical factor that can control the presence or absence of a member of the community can have the same effect. Therefore, the amount of wave action can determine the presence or absence of intertidal algae on tropical shores such as Barbados, but cannot control the presence or absence of the echinoid *E. lucunter*. This may be a similar control of the populations of *E. mathaei* on the twosides of the Sinai peninsula and the point at Boucan Canot at Reunion Island.

The characteristics of the individual echinoid and its population would reflect what Paine (1976b) called a complex interrelationship between size-related metabolic needs, density, and character of food resource. Other factors may be important in particular situations. Because individual biomass can be either density-independent or density-dependent, the particular result of a categorical change in community composition resulting from either biological or physical causes can vary. These categorical changes in the characteristics of the communities are not gradients, which themselves can affect density and individual size of echinoids (for *E. mathaei* and *E. lucunter*, see Abbott et al., 1974; Kelso, 1970; Lawrence, 1978; McPherson, 1969; Russo, 1977).

The differences in the Gulf of Suez and the Gulf of Aqaba that result in these alternate states of *E mathaei* may also be the cause of the difference in distribution of echinoid species that occur between the two gulfs (Clark, 1966).

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