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VARIATION IN THE DOMINANCE AND POPULATION STRUCTURE OF INTERTIDAL CORALS AROUND KO PHUKET, THAILAND

by

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VARIATION IN THE DOMINANCE AND POPULATION STRUCTURE OF INTERTIDAL CORALS AROUND KO PHUKET, THAILAND

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ABSTRACT

The community structure of intertidal coral reefs around Ko Phuket, Thailand, has been shown to be governed primarily by exposure to wave action as a result of the reversing monsoon influence. Even at two neighbouring sites, exposed to similar monsoon influences, there are marked differences in the proportions of massive and branching corals inhabiting the reef flat. These differences may reflect various environmental parameters, such as differing sedimentation rates and/or exposure to tin smelter discharges at one of these sites. Furthermore the size-structure of *Goniastrea favulus* at these locations indicates that largest colonies are found where densities of this coral are high (30 per m^2) and where the incidence of fusion between colonies is pronounced.

I. INTRODUCTION

The community structure of intertidal reefs on the south east coast of Ko Phuket, Thailand, has previously been described by Ditlev (1978), Brown & Holley (1982) and Brown & Holley (1984). In the latter study the authors showed that although reefs were not widely separated in space, they differed markedly in their dominance by different coral assemblages. These differences were ascribed to the aspect of the reefs with respect to the prevailing monsoon. More detailed studies have recently shown that even on reefs exposed to the same aspect there may be considereable variability in the population structure of dominant corals. In the present study the density and size structure of the faviid coral *Goniastrea favulus* (Dana, 1846) are considered at a selected number of sites on the Laem Pan Wah peninsula, Ko Phuket. In addition the processes of fission and

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fusion of coral colonies are described for this coral. Fission and fusion have been highlighted by several workers studying reef community composition over time, such as Loya & Slobodkin (1971) working on the recolonisation of a reef flat after a catastrophic low tide; Hughes & Jackson (1980) in their interpretation of the population structure of *Agaricia agaricites* and *Helioseris cucullata* and Highsmith (1982) in his review of fragmentation. Such processes may have a critical influence on interpretation of age and size frequency data as shown in the present study.

II. MATERIALS AND METHODS

(a) The Study Site

Intertidal reef flats which surround the sheltered south east corner of Ko Phuket, Thailand, have been described in several papers (Ditlev, 1978; Brown & Holley, 1982, 1984). Three sites were chosen for investigation in the present study (Fig. 1).

Site A – a reef in close proximity to a tin smelter and exposed directly to the influence of the north eastern monsoon wind (dry monsoon).

Site B – a reef separated by 500 m. from site A and also exposed to the same aspect.

Site C – a neighbouring reef exposed directly to the influence of the south west monsoon (wet monsoon).

Three main transect lines were established across the reef, one at each of the sites. Quantitative estimates of coral cover were made by laying down 30 m. long transects, parallel to the shore at 10 m. intervals across the reef flat. The distance covered on the measuring tape by each coral was noted (after Loya, 1972). Between 8-19 transects were prepared in this way at each site, with surveys being carried out in August 1979 and again in November 1983.

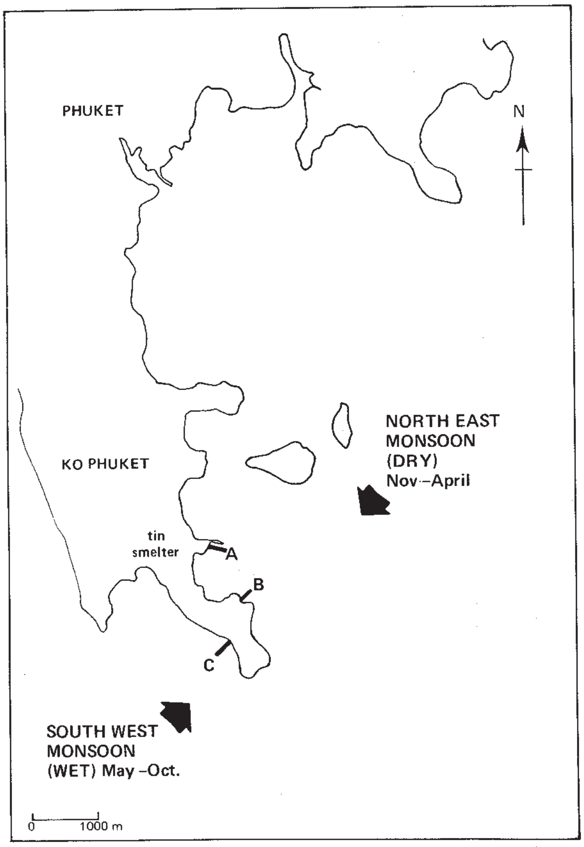

Fig. 1. Map showing the location of sites A (a tin smelter), B and C around the south east coast of Ko Phuket, Thailand.

(b) Colony measurements of *Goniastrea favulus*

Maximum and minimum diameters of between 150-200 colonies of *Goniastrea favulus*, encountered within an 0.5 m. distance either side of the transect lines across the reef, were measured at each site. In this study a colony was defined as a modular unit exhibiting a continuous regular growth form (after Rosen, 1979).

Measurements of colony diameters were also recorded from photographic records of two permanent 10 m. long transects established at each site. Photographs of these transects (which covered areas 0.4 m. on either side of the measuring tape) were taken at low tide in August 1979, November

1983, March 1984 and July 1984 and individual corals were followed throughout this time for features such as fission, fusion, overgrowth and partial mortality. Nailed markers were established on the transect line for spatial reference. Numbers of *Goniastrea favulus* colonies per unit areas of permanent transect at site A (tin smelter) were monitored for spatial pattern of the colonies. The method involved placing eight transparent overlays (each divided into 20 × 25 cm. grids) over transect photographs obtained in 1984 and counting the number of colonies contained within each grid.

In addition, ten 1 m^2 quadrats were placed on the inner reef flat of each site in November 1983 for photographic recording of the position and density of *Goniastrea favulus* colonies in the field.

III. RESULTS

(a) Coral assemblages on the reef flats

Fig. 2 shows the distribution of living coral at each site and the relative proportions of major groups at each site. The dominant groups of corals occupying the reef flats were faviids, *Porites* spp., *Acropora* spp. and *Montipora* spp.

Values of living coral cover over the first eight transects on the inner reef flat were similar (10 %) but the relative proportions of particular coral species making up the total cover differed markedly between sites. These differences are most clearly shown when site A (the tin smelter) is compared with sites B and C. At these latter sites *Acropora* species are conspicuous (between 20-70 % total live cover) on the inner reef flat; at the tin smelter

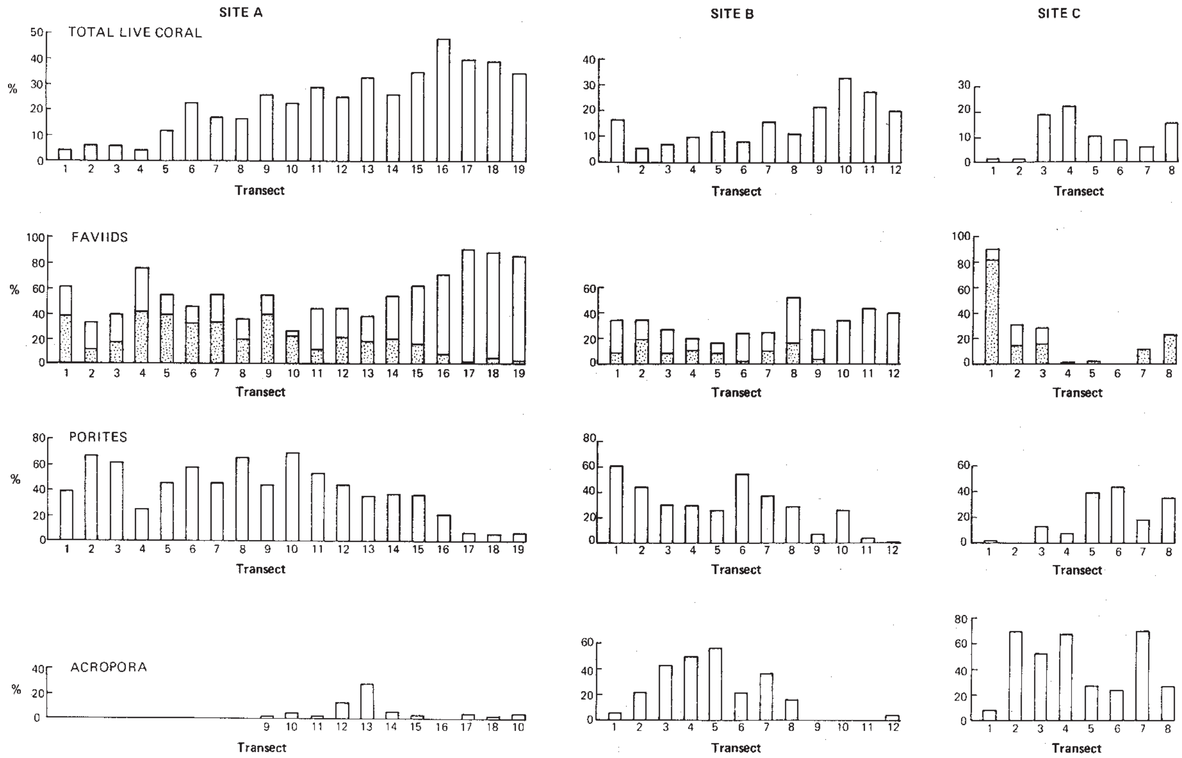

Fig. 2. Histograms showing the distribution of living coral cover across the reef flat at sites A (a tin smelter), B and C. Shaded areas on histograms show the percentage cover of *Goniastrea favulus* as a proportion of the total faviid cover across the reef flat at each site.

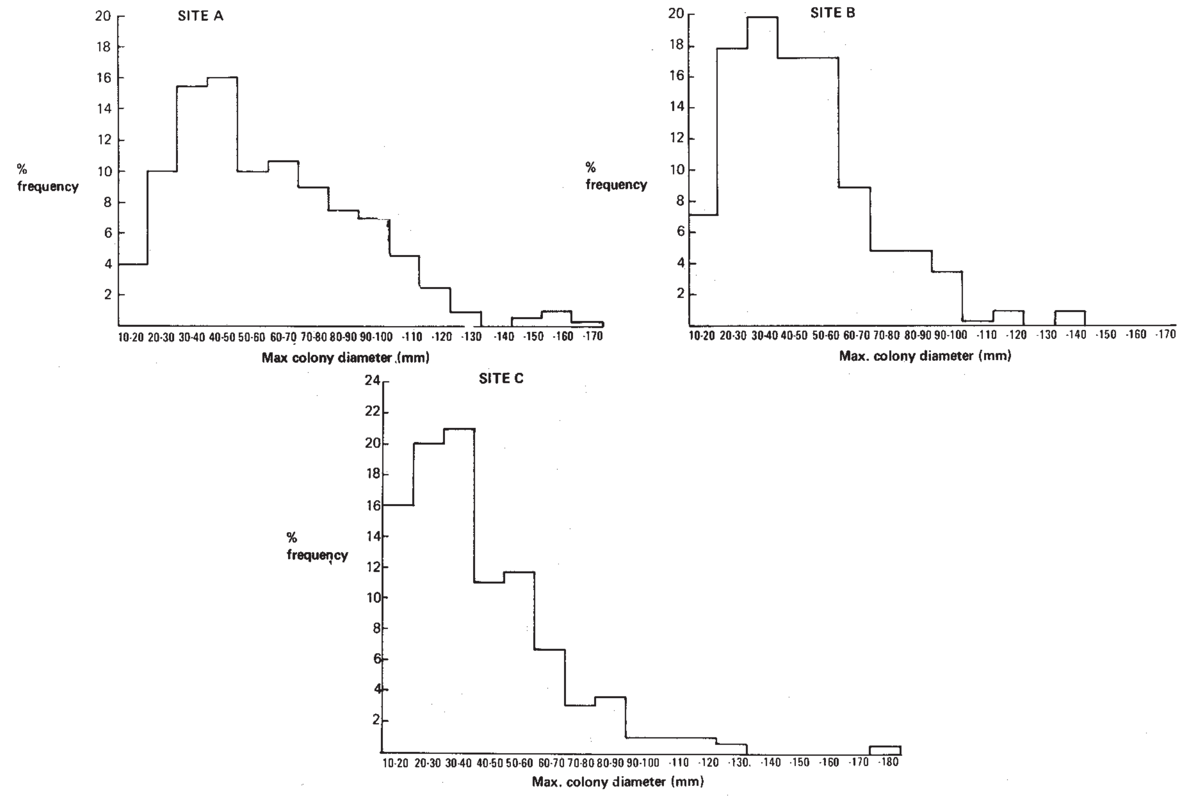

Fig. 3. Plots of size-frequency (measured as maximum colony diameter in mm.) of *Goniastrea favulus* measured at sites A (a tin smelter), B and C.

(site A) *Acropora* species are totally absent from the inner reef flat and account for only a small proportion (25%) of total coral cover on the outer reef flat.

The dominance of faviids at this site, when compared with sites B and C, is strikingly shown in Fig. 2, with over 50% of faviid cover being due to *Goniastrea favulus*.

(b) Size-frequency of *Goniastrea favulus* colonies

Fig. 3 shows size-frequency plots obtained for *Goniastrea favulus* from each site, based on measurements of maximum diameter of colonies in the field. Similar distributions were also obtained for data derived from photographic measurements.

Statistical comparison of log-transformed data (Analysis of variance (ANOVA) and a *posteriori* comparison of means by least significant range (LSR)) from each site indicates that the population structure of *Goniastrea favulus* differs significantly ($p<0.05$) at each site studied with the greatest differences shown between site A and sites B, C. Colonies at site A (the tin smelter) have the greatest mean diameter (56 mm.) while colonies at site C have the smallest mean diameter (40 mm.); site A showing a higher proportion of larger-sized colonies in the population than was recorded at other sites.

Similar comparison of minimum diameters of *Goniastrea favulus* colonies from all sites reveals a significant difference in mean colony size only between site A (tin smelter) and sites B,C ($p<0.05$).

There is no significant differences in the mean colony size of *Goniastrea favulus* from sites B and C when minimum diameters are compared.

(c) Density and dispersion of *Goniastrea favulus* colonies

Table 1 indicates the density of *Goniastrea favulus* colonies as measured in 1 m^2 quadrates on the inner reef flat of each site. Obvious differences exist between the number of colonies recorded at each site with site A showing a very high density of colonies.

Table 1. Mean number (± standard deviation) of *Goniastrea favulus* colonies monitored per m^2 in ten quadrats placed on the inner reef flat of sites A, B and C.

Site	Mean number of colonies per m^2 (± SD)
A (Tin Smelter)	30.5 ± 8.0
B	4.0 ± 4.0
C	2.2 ± 2.6

Log-log plots of spatial variance against mean density for *Goniastrea favulus* colonies at the site A (Fig. 4) show values falling to the left of the line of equality (which represents randomness) indicating a partially aggregated distribution of this species (Lewis & Taylor, 1967). Spatial variance (S^2) is related to mean population density (m.) by a power function and in the present study the spatial pattern of *Goniastrea favulus* is described by $S^2 = 0.32\ m^{1.8}$

Morisita's index of dispersion (Elliott, 1977), for numbers of colonies counted in two quadrat sizes, (0.25 m^2 and 0.4 m^2) gave significant ($p < 0.05$) departures from randomness in both cases, indicating some degree of aggregation by *Goniastrea favulus.*

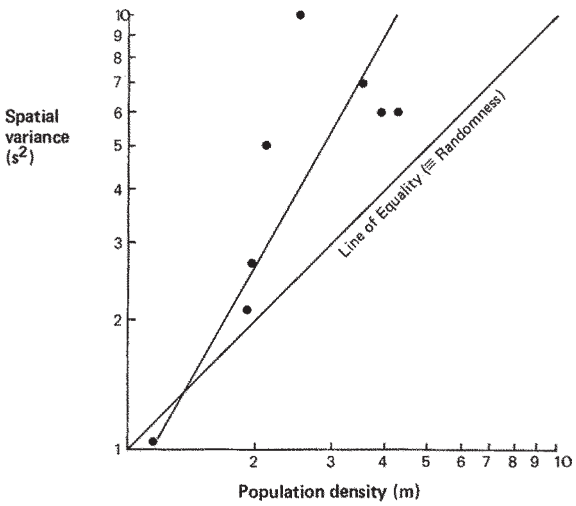

Fig. 4. A log-log plot of spatial variance (S^2) against mean population density (m.) for *Goniastrea favulus* measured at site A (a tin smelter).

(d) Incidence of fission and fusion in *Goniastrea favulus* colonies

Table 2 shows the number of colonies showing fusion and fission on the inner reef flat of site A (the tin smelter) over the period 1979-1983 and 1983-1984. It is clear that the number of colonies involved in fusion is greater than that for colonies displaying fission, during the detailed monitoring period 1983-1984. Fusion also appears to be an

Table 2. Showing number of colonies per unit area (1 × 0.8 m.) of permanent transect which displayed fusion and fission over periods 1979-1983 and 1983-1984 at site A (tin smelter).

Unit Area of Permanent Transect	Period of observation			
	1979-1983		1983-1984	
	Fission	Fusion	Fission	Fusion
1	-	3	1	2
2	1	5	1	5
3	-	4	-	3
4	-	2	-	2
5	1	3	2	6

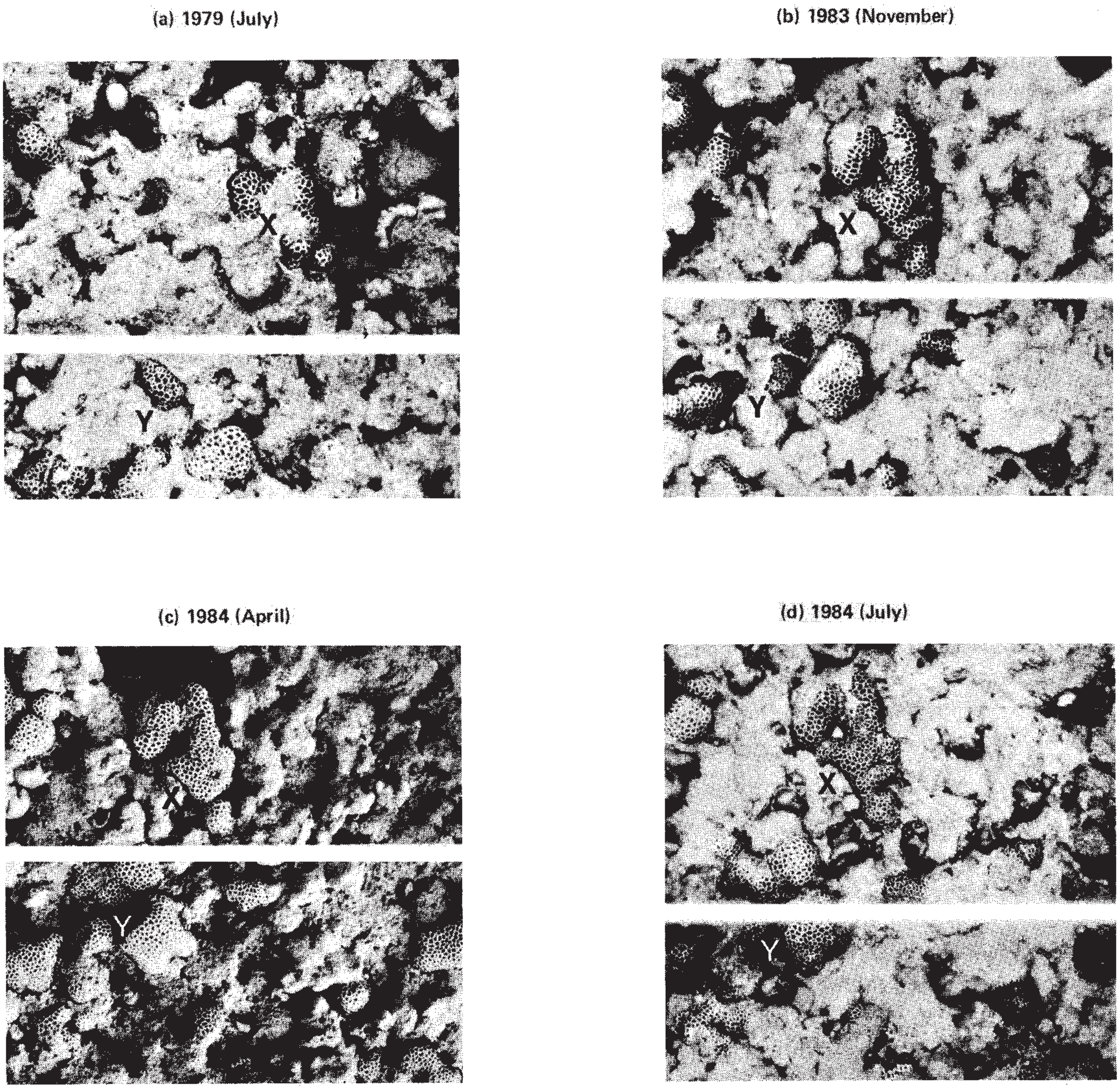

Fig. 5. Time-sequence photographs of portion of permanent transect at site A (a tin smelter) showing fusion of colony fragments reunited after partial mortality at X, and fusion of recently reunited juveniles at Y. Photographs taken in August 1979, October 1983, April 1984 and July 1984.

important process in the period 1979-1983 but the time interval between monitoring (4 y) makes accurate interpretation of the relative importance of fusion v fission impossible. Fig. 5 indicates fusion resulting from a) possible previous partial mortality of a colony which has subsequently recovered and where lateral growth has reunited separated parts of the colony, and b) from individual recruits, presumably of the same genotype, which settled in close proximity to one another. Overgrowth of one colony by another was also noted in the present study.

Considering the density and abundance of *Goniastrea favulus* colonies at site A (tin smelter) it is quite probable that fusion plays an important role in structuring the size distribution of colonies observed on this reef flat.

IV. DISCUSSION

It is well known that particular environmental factors, such as wave energy, may be critical in determining the nature of coral assemblages dominating a reef (Rosen, 1975; Chappell, 1980). In the present study reef assemblage differences observed between sites A/B and site C have already been attributed to natural environmental factors (Brown & Holley, 1984). Sites A and B, however, are comparable in their exposure to wave energy, being exposed to the effects of the dry, north east monsoon and being separated from each other by a distance of only 500 m.-yet the composition of corals occupying reef flats at A and B is markedly different. The relatively high diversity index of site A recorded in earlier studies (Brown & Holley, 1982) can be explained by a high diversity of faviid corals. The limited occurrence of *Acropora* spp. at this site may be accounted for by a reduced tolerance of these species to environmental stresses when compared with massive corals. Such generalisations have already been suggested in the literature by Dahl & Lamberts (1978) and current studies on growth rate at sites around site A (the tin smelter) indicate that *Acropora* spp. are more susceptible than massive species to the effects of discharges (Brown *et al.*, in prep.). Alternatively, differences in community structure of sites A and B may be related to sedimentation rates on these reefs. Weekly measurements of this parameter over the year indicate a significantly higher ($p<0.05$) rate of sedimentation at site A than site B (Brown *et al.*, in prep.). Since it is generally recognised that massive corals are more tolerant of sedimentation effects than branching species (Rogers, 1979; Dollar & Grigg, 1981; Brown & Howard, in press) such tolerances may be reflected in community structure at sites A and B.

Significant differences in the population structure of *Goniastrea favulus* at site A, when compared with other sites, may be partly explained in terms of altered community structure at site A. The distribution of *Goniastrea favulus* on other reef flats has previously been described as partially aggregated by Babcock (1983). Investigation of the reproductive biology of this species shows that it produces negatively buoyant eggs which quickly sink to the substrate on release (Kojis & Quinn, 1981; Babcock, 1983). Babcock, however, maintains that the distribution of *Goniastrea favulus* is not as clumped as might be expected from this reproductive strategy. He believes that larval and settlement behaviour are equally important in determining adult spatial patterns, and in *Goniastrea aspera* (where densities of over 40 colonies per square metre on reefs flats of the Great Barrier Reef have been recorded) lack of larval dispersal, gregarious settlement, substrate preference, or a combination of all these factors have been cited as reasons for the highly clumped distribution of this species. Certainly aggregated settlement by marine larvae is well documented (Scheltema, 1974) and at site A, where the density of colonies is high, it is quite likely that progeny may settle in close proximity to parents. Laboratory experiments have shown that self-fertilisation of eggs is quite possible in *Goniastrea favulus* (which is a simultaneous hermaphrodite) and that normal larval development and settlement will ensue from such eggs (Kojis & Quinn, 1981). If colonies of similar genetic makeup are in close contact as a result of high density, then fusion of individuals is quite possible (Hildemann *et al.*, 1975, 1977). Such a phenomenon may contribute to a higher proportion of larger colonies at site A than recorded at other locations. Fusion may also result from partial mortality of colonies whose separated parts subsequently reunite, and this process has already been described by Hughes & Jackson (1980). Should larger colonies of *Goniastrea favulus* result from fusion of adults and progeny at site A, then the scope for reunited growth of large colonies affected by partial mortality, may be considerable.

The relative importance of partial mortality, fusion and fission in affecting the population structure of *Goniastrea favulus* at sites around the Laem Pan Wah peninsula at Ko Phuket remains to be fully evaluated by the continuation of regular photographic monitoring over the next three years. Future work on reproductive biology, larval development and settlement of *Goniastrea favulus* at these sites may clarify whether observed coral distributions on reefs around Ko Phuket are caused by reefs being primarily self-seeded as suggested by Done (1982), or whether coral recruitment occurs by long distance larval dispersal (Harrison, *et al.*, 1984).

V. CONCLUSIONS

The present study highlights differences in community structure of neighbouring intertidal reefs with a reef influenced by tin smelter discharge showing a reduced coverage of branching corals when compared to adjacent reefs. Colonies of the dominant faviid on inner reef flats *Goniastrea favulus* are significantly larger at the tin smelter than elsewhere, probably as a result of higher densities and increased evidence of fusion recorded at this site.

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