The analysis of canopy structure was developed mainly by agronomists in Japan, Australia, and Britain in the late '50's and early '60's, through the work of Saeki, Monsi, Takeda, Donald, Black, Brougham, Watson, Blackman, and others. Horn quotes only one paper from any of these authors, and that at second hand.

A large number of parameters have to be taken into account in interpreting canopy structure, including leaf area, foliage density, leaf angle, daily and annual changes in the sun's path, and also water and gas fluxes. These have been elegantly handled in general computer models predicting productivity (for example, by De Wit), and there is very little that Horn has to say about trees that is not general to vegetation. There is tragedy here, not just in Horn's book but in the failure of most ecologists to make the slightest attempt to follow the literature of agronomy and of forestry. An understanding of complex systems can only come from the study of simple ones; the simplest terrestrial systems are those of cropped grassland and managed forest. Granted, these simple systems are complicated enough, but they have been made susceptible to theoretical analysis and much formal testing. Ecologists must read this literature even if it shatters some of their conceit. For those many readers who will find that Horn's monograph opens a new vision of the nature of vegetation I append a brief bibliography to correct the perspective:

P. Boysen-Jensen, *Biol Med.* **21**, 1–28 (1949); M. Monsi and T. Saeki, *Jap. J. Bot.* **14**, 22–52 (1953); H. Kasanaga and M. Monsi, *Jap. J. Bot.* **14**, 304–24 (1954); D. N. Moss, *Crop Sci.* **4**, 131–35 (1964); C. T. DeWit, *Versl. Landbouwk. Onderz.* **663**, 1–57 (1965); C. M. Donald, *Adv. Agron.* **15**, 1–118 (1963), and many papers in recent issues of *Crop Sci.* and *Agron. J.*

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Reef Research

Regional Variation in Indian Ocean Coral Reefs. Zoological Society of London Symposium No. 28, London, May 1970. D. R. STODDART and MAURICE YONGE, Eds. Published for the Society by Academic Press, New York, 1971. xxxvi, 584 pp., illus., + tables. $28.

This symposium volume provides an up-to-date account of Indian Ocean reefs, from the Red Sea to western Australia, along with some of the more specialized aspects of reef research being carried out in the region. For those with a general interest in reef origins, environments, and biotas it provides most interesting reading. Though specialists concerned with reefs will encounter many things to argue over, they will nonetheless find valuable data and provocative interpretations. The volume constitutes an important source, to be placed within arm's reach alongside Wiens's *Atoll Environment and Ecology* (1962), Maxwell's *Atlas of the Great Barrier Reef* (1968), and the Smithsonian's *Atoll Research Bulletin* (1951 to present).

The volume is most fittingly introduced with a tribute by C. M. Yonge to Thomas F. Goreau, whose untimely death in 1970 grieved all who knew him and his varied and important contributions to our knowledge of reefs.

The first and last papers in the volume are by D. R. Stoddart. The first is a scholarly and instructive overview of the history, environments, and biotas of Indian Ocean reefs and sets the stage for virtually all the papers that follow. The last concerns problems and prospects; it is a critical review of both the accomplishments of the symposium and the direction of future reef work. It would be a good idea for most reef biologists to study these, for, as K. G. McKenzie points out, quite a few papers in this symposium tend to neglect the time component. The papers are appropriately grouped by subject—Geology and Morphology of Reefs, Regional Studies of Reefs, Distribution of Corals, and Other Reef Invertebrate Communities—fish and calcareous algae being somewhat neglected.

Reef research is a classical field, and various aspects of it have developed at different times and have advanced at vastly different rates. Darwin's theory of subsidence, offered to explain certain morphological features of oceanic reefs, generated a series of reef drillings. The first, by the British Royal Society on Funifuti in 1896, proved beyond a doubt that Darwin was for the most part right. However, the most instructive reef drillings were made in the Pacific, at Bikini and Eniwetok in connection with atomic testing shortly after World War II (Emery, Tracey, and Ladd, 1949) and more recently at Mururoa (Lalou, Labeyrie, and Delibrias, 1966). Unfortunately, Indian Ocean reefs have not yet been drilled, so morphological studies of them suffer from a lack of detailed chronologies, especially related to the Pleistocene, for comparison with those of the Pacific. It can be observed from the literature, however, that atoll rim, terrace, and lagoon depths, to approximately 90 meters in the Chagos Archipelago, are comparable to those of many atolls in the Pacific Ocean, and this suggests comparable Pleistocene histories. It would be very instructive to make shallow drillings (to about 50 meters) and subject the materials to radiometric analyses to see if the chronologies of the past 250,000 years or so are also comparable.

The first deep-sea drillings were made in the Indian Ocean by JOIDES (the Joint Oceanographic Institutions for Deep Earth Sampling) early this year. Several, on the Ninetyeast Ridge, and especially on the Laccadive-Chagos Ridge, were at approximately the same depth (1700 to 1800 meters) as the platforms of many present-day atolls and banks in the Indian and Pacific oceans. These drillings encountered Middle Eocene to Middle Paleocene chert. Comparable chert has been taken near the break in slope on Horizon Guyot (Mid-Pacific Mountains). Correlations of age, depth, and morphology between these two widely separated regions, then, suggest comparable histories as regards subsidence rates, at least since the Paleocene, and indicate that both had basins on the order of 3000 meters below sea level by the end of the Cretaceous.

Further deep-sea drillings are to be made by JOIDES this year, in the Indian Ocean, and some of these will be particularly interesting to those concerned with reefs. R. L. Fisher and Elizabeth Bunce (leg 24) plan at least one site on the Mascarene Plateau at a depth of 1600 meters with the hope of penetrating 700 to 900 meters of coralline reef debris. These and related works are currently providing data that will satisfy many of the criticisms leveled by McKenzie of reef work accomplished to date in the Indian Ocean.

Whereas deep drilling is an expensive operation, requiring elaborate equipment, specialists, and techniques to handle the quantities and diversity of materials and data acquired, scuba is an inexpensive tool. It has been used widely in reef studies about the world for the past 15 years or so, yielding information on submarine terraces, which for the most part represent Pleistocene stillstands of sea level. Unfortunately scuba divers studying reef zonation in the Indian Ocean apparently have not looked into this aspect of the overall problem.

Stoddard has carefully laid out the distribution of sea-level and elevated reefs on the one hand and rainfall on the other. If one overlays the two maps it will be observed that areas of elevated reefs in good part correlate with low rainfall. G. E. Hutchinson (1950), in *The Biochemistry of Vertebrate Excretion*, noted a comparable correlation with respect to guano deposits, especially on small elevated islands in the equatorial Pacific, explaining the distribution of the deposits on the basis of rainfall patterns (differential rates of subaerial erosion). One wonders if the same explanation might not apply in the Indian Ocean.

Studies of the physiology and energetics of corals, for the most part begun under the leadership of C. M. Yonge (the Great Barrier Reef Expedition, 1928–1929), have not been carried out in the Indian Ocean.

The "mare incognitum" of Wells (1957), ranging from the sea surface down the seaward slope to around 17 meters, has become much better known in recent years. Quantitative investigations of coral communities, begun by Mayor in 1924, have made significant strides over the past few decades. Though Stoddart (1969) views prior quantitative work as contributing little to our knowledge of reef communities beyond that obtained from qualitative studies, the quantitative data such studies do contain actually afford a better understanding of the structure of these communities. However, the focus of nearly all quantitative and qualitative coral reef studies, to date, has been on the zonation patterns of the corals themselves.

It is somewhat disappointing therefore that, instead of seeking details of the organization of reef communities, the studies presented in this volume have sought primarily to redemonstrate coral reef zonation. Ecological aspects of zonation receive short shrift in most studies, and the element of time is completely ignored. However, the use in other studies of general features of reefs and their biotas, which are believed to result from various environmental factors, is a helpful means of presenting zonation. Sampling schemes continue to lack both the desired mechanical randomization and necessary extent for statistical treatment and generalization. The use of sociological associations as a means of determining community structure is encouraging, but perhaps more meaningful would be groupings based on such procedures as recurrent-group or principal-component analyses.

Particularly noteworthy among the papers presented are the attempts to quantitatively determine appropriate-sized sampling units, efforts to ascertain the lateral extent of zonation patterns along a reef, and comparisons of the structural and environmental features of Indian Ocean reefs and the accompanying patterns of their flora and fauna with those of reefs in other seas. Inadequate presentation of data will be disconcerting to the reader, as will the lack of comparison of results with those of earlier quantitative studies.

Biological interactions have long been observed on reefs, but that corals were eaten to a significant degree only became apparent some ten years ago when it was observed that large aggregations of a starfish, *Acanthaster planci*, were devouring some 80 to 90 percent of the stony corals on certain islands of the Great Barrier Reef. This came as a surprise because only a few animals (including *Acanthaster*) were previously known to eat corals, concentrations of *Acanthaster* obviously overwhelming the carrying capacity of a reef had not been reported in the literature, and such biological imbalance was contrary to general ecological theory as regards the tropics. Tropical communities, by virtue of their diversity and the relative constancy of their environment, are considered to be relatively stable. Though reef communities were known to be dynamic, undergoing periods of growth and death, it had been thought that this was a successional response to physical rather than to biological perturbations.

The *Acanthaster* phenomenon, however, did not become of general ecological interest until a comparable outbreak was observed more recently on Guam. The overall problem was then widely publicized and a burst of scientific papers on the matter followed. In light of the apparent problem, information on an area as important as the Indian Ocean has been eagerly looked forward to. The one paper on *Acanthaster* appearing in this symposium provides new data, but falls a little short of the mark in interpretation. This is apparently because the authors, though they include data collected in the summer of 1970, were not aware of literature appearing early that year.

Not being up to date with respect to the literature is not a general shortcoming in this volume. All but two papers include 1970 citations, and about a quarter cite papers published elsewhere in 1971.

This volume is a timely and important contribution in this period of increasing awareness of environmental problems. The multiplicity of papers it contains indeed presents an excellent overview of regional variation in Indian Ocean coral reefs.

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Small Island Ecosystem

Marion and Prince Edward Islands. Report on the South African Biological and Geological Expedition, 1965–1966. E. M. van Zinderen Bakker, Sr., J. M. Winterbottom, and R. A. Dyer, Eds. Balkema, Cape Town, 1971. xii, 428 pp. + plates + maps. 22.50 rands.

Marion and Prince Edward islands are situated in the "Roaring Forties," just outside the Antarctic Convergence, near 47°S and 38°E, south and somewhat east of the Cape of Good Hope. They are within sight of each other on the infrequent clear days. As a result of the South African Biological and Geological Expedition and this report of its work these two bleak oceanic volcanoes, once very little known, are now among the better-understood small island ecosystems in the world.

Constantly wet, the rough volcanic surfaces of the islands are largely covered by bogs and mires. The volcanic activity ceased relatively recently, and the surface geomorphology is of rough lava flows, somewhat faulted and at higher elevations locally modified by late Pleistocene glaciation. As with all subantarctic islands, the biota is extremely limited. The vascular flora totals 36 species, of which 13 are aliens. Other groups both of plants and of animals are comparably restricted.