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ZONATION ON TWO SHORES ON THE WEST COAST OF CEYLON

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INTRODUCTION

MUCH work has been carried out on the zoning of plants and animals on rocky shores in various parts of the world. The more important amongst these have been listed by Southward (1958). A geographical index of papers on rocky shore ecology has been given in tabular form by Doty in Hedgepeth (1957). The shores of Western Europe have received the most attention, but considerable information is also available on the warm temperate shores of the Western Atlantic, the Mediterranean, South Africa, Australia and New Zealand. Tropical shores have been studied in West Africa [Saurie (1954) ; Lawson (1955, 1956, 1966)] ; in Mozambique [Macnae and Kalk (1958)]; in South America [Oliveira (1948, 1950)]; in the West Indies [Stephenson and Stephenson (1950)] ; in Malaya [Enoch and Purchon (1954)] ; and in Ceylon [Arudpragasam and Ranatunga (1966)]. The papers relating to Malaya and Ceylon seem to afford the only available information on zonation on shores of the Indo-Malayan region. Moreover, the paper on Ceylon shores sets down only a few brief notes on the appearance of zones on a sandstone reef. There is a great need, therefore, for studies on Ceylon shores, both from the point of view of describing local conditions and from the point of view of contributing to the body of information on the features of zonation in the tropical Indian Ocean. The present paper is the first of a projected series on the shores of this island.

In the present work it has been considered unnecessary to make any attempt to define the zones in relation to tidal levels. It is true that the use of average tidal levels has become the commonest means of defining the position of an animal on the shores of Europe [Southward (1958)]. However, Stephenson and Stephenson (1949) pointed out that some zones and their boundaries may be completely different one from another, though separated by only a few yards. Moreover, in their comment on Lewis' (1955) observations on the occurrence of universal inter-tidal zones in Great Britain, they emphasised that any system of zonation must be based on organisms and not on tide levels. The case for treating the shore as a biological rather than as a physical entity has been well stated by Lewis (1962, 1964), who concludes that there is no alternative but to use the dominant zone forming organisms to define zones. On the west coast of Ceylon, the precise definition of tidal levels on particular shores is a matter of great difficulty. The tidal range is small, the maximum for the Colombo area being in the region of 0·70 metres. The maximum height of the tide for the same area is about 0·88 metres. Further there is often considerable wave action which is difficult to account for. When it is also considered that tidal levels laboriously defined at one point on the shore may not apply to a corresponding point a short distance away, the whole exercise becomes very limited in value. Therefore, it has been preferred in this study to first recognise the overall patterns of zonation on the shores studied and then to define the limits of zones and sub-zones by reference to convenient zone forming organisms.

The present paper deals with zonation on two shores. In the selection of shores for study a deliberate attempt was made to select two that afforded contrasting conditions especially of substrate, slope and wave exposure. Atapattu (1968) indicated that rocky shores on the west coast of Ceylon may be made up of one of three types of substrate—granitic rock, sandstone or coral. Of the shores described here one is of sandstone and the other of granitic rock.

The Tidal Regime

Though no attempt has been made to define tidal levels, it is nevertheless important to describe the tidal conditions that influence the two shores under consideration. Information about tides on the west coast of Ceylon are available only for the Colombo Harbour. One of the shores studied lies immediately south of the south-west breakwater of the harbour while the other lies some 25 miles to the north. However, the general characteristics of the tides predicted for Colombo seem to be applicable to both shores. Figure 1 is based on predictions for Colombo for the month of June 1968. (Tide Tables, Department of Meteorology, Colombo.) It will be seen that the tides are of the mixed variety, with 2 High Waters and 2 Low Waters during each 24 hour period, the heights of the two sets being different (Figure 1 A & B). The difference in range between the A and B tides is greatest during the springs and least during the neaps. During each tidal cycle the A and the B tides change over. The maximum height and the range of the tides have already been referred to above. A study of predictions over a whole year (1966) shows that during the year, the lower low waters of each day occur between 7 and 11 in the morning from January to September and between 7 and 9 in the night from October through December. Since normally the highest daytime temperatures are attained about 2 in the afternoon, the shores around Colombo are never completely exposed during the hottest part of the day.

The Shore at Duwa

The Shore

The shore lies on the West coast of Ceylon, approximately 25 miles north of Colombo. It is part of a fringe of sandstone which begins immediately north of the mouth of the Kelani River, and terminates just south of the mouth of the Negombo Lagoon. Over much of its extent this strip of sandstone slopes gently seaward from the adjacent sandy beach. Just beyond the site selected for study, the sandstone platform diverges from the sandy beach and runs diagonally out to sea (Fig. 2).

At the study site the sandstone forms a platform standing approximately one metre above the level of the adjacent sandy beach. Both the landward and the sea-

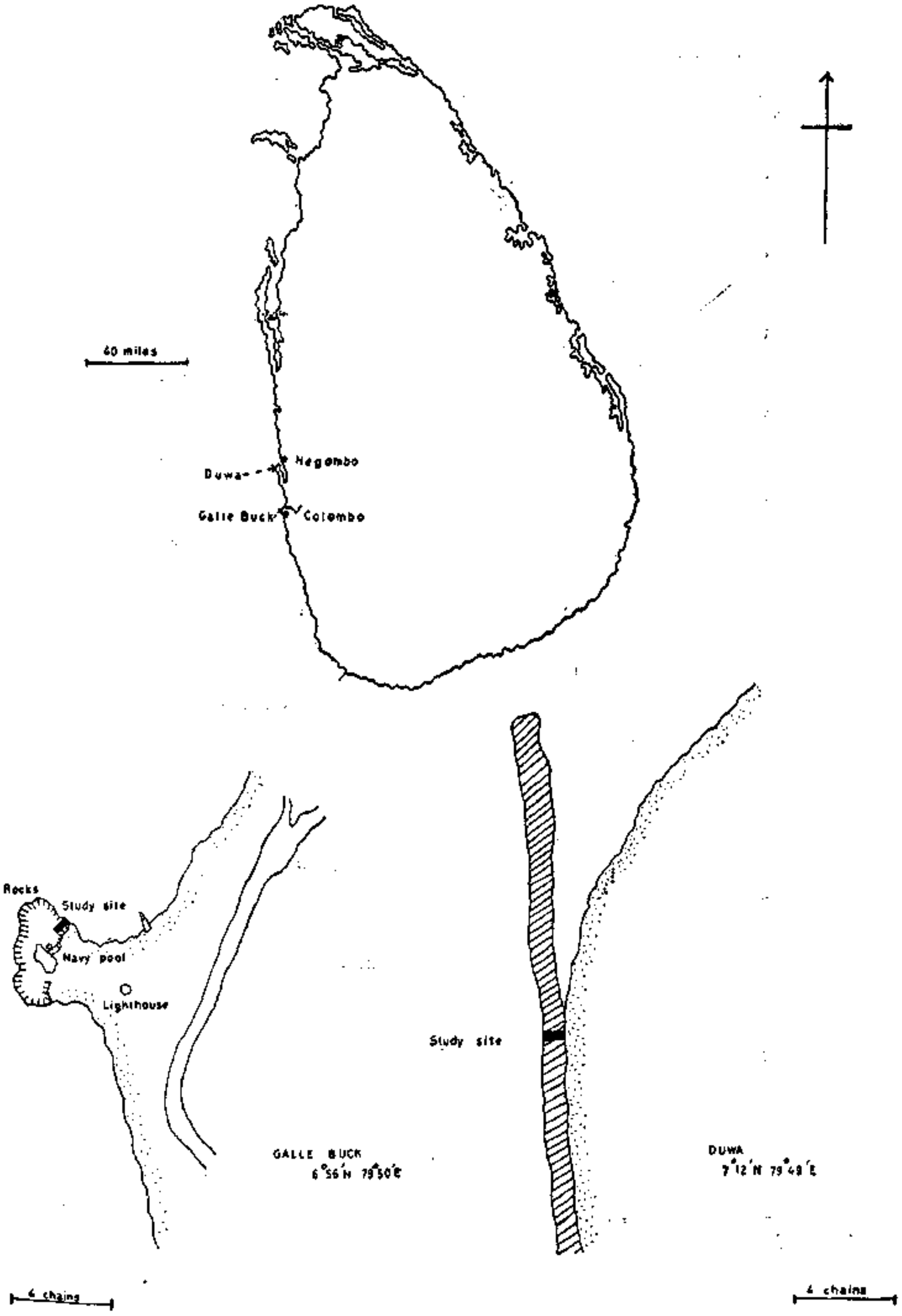

FIG. 1. Maps showing the locations of the two shores on the west coast of Ceylon and the study sites.

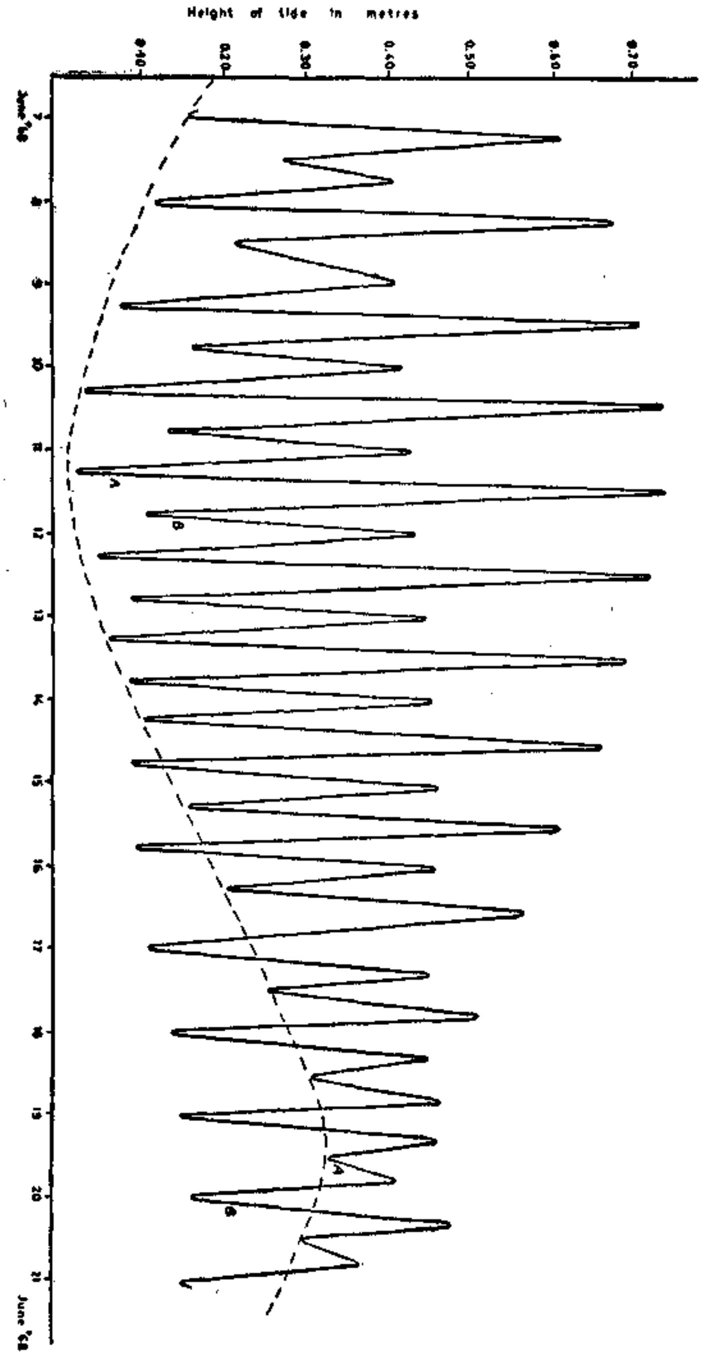

FIG. 2. The spring-neap cycle and diurnal inequalities based on predictions for Colombo. The broken line joins together the low water marks of the A series. Note the change over in the next tidal cycle where the A series becomes the smaller of the two low tides.

ward faces of this platform are practically vertical. The platform itself is 28 metres wide over a measured transect. The surface is more or less flat with a very gentle slope downwards over the seaward half. There are few crevices but there are occasional low depressions. The general surface of the rock is, however, far from smooth. It is made up of large grains of sand firmly bound together, and the surface irregularities so formed are large enough to shelter some of the smaller littorines.

At low water of springs, the entire platform is exposed, but the weed covered lower part of the shore does not dry out completely. When there is little wave action, the water laps against the vertical face and washes gently over the seaward edge. However, waves break with fair regularity on the seaward edge and then the water washes over much of the lower half of the platform. At certain points, the breaking of the waves results in masses of water being thrown up violently while at others the waves break more gently. With the breaking of the waves there is considerable mixing of air and water, and the water washing the lowermost parts of the shore is highly aerated.

The Zones

Two broad regions may first be recognised, the distinction being based on the presence or absence of large weeds. The upper part of the shore appears bare and at low tide dries out completely. The lower part of the shore has a prominent weed cover (dense below and lighter above) and never dries out completely due to intermittent washing by waves. Within these two broad regions, a clear pattern of zonation can be made out. The following account of zones and sub-zones is based on the analysis of two belt transects and of a number of random samples located in the various zones and sub-zones. The studies were carried out during January and February 1968. The nomenclature of the zones is according to the system recommended by Lewis (1964).

The Sublittoral Zone

On the lowermost part of the shore a belt of dense weeds, where *Sargassum* predominates, is exposed at low tide. The upper limit of this belt forms a fairly sharp and easily recognisable boundary between the upper part of the sublittoral below and the eulittoral zone above. Downwards, the belt of dense weeds is continuous with the permanently submerged growths of the sublittoral and there is no obvious dividing line between a true sublittoral and a sublittoral fringe. However, it should be pointed out, that since the sandstone platform is sharply set off from the sublittoral floor, there is a break in continuity of the weed growths.

The dominant weeds in this zone are species of *Sargassum* and *Gracilaria*, the former being the more abundant. Amongst these weeds are also found, species of *Laurencia*, *Padina*, *Ulva*, *Polysiphonia*, *Gelidium*, *Ceramium*, and *Dictyopteris* Amongst the fauna, the sea urchins are the most prominent. Many urchins are seen each in its own burrow. The distribution of the sea urchins and their burrows is clearly limited to the sublittoral zone, especially to regions where, the water is most turbulent and the air water interface is most disturbed. The burrows themselves are free of weeds but the weed growths extend to their rims. In these burrows are also found species of molluscs that occur in the rest of the zone, together with small holothurians, alpheid shrimps, and little fish. Many molluscs are found in this zone. *Anachis terpsichore* Sowerby, is the most numerous. Other species include *Trochus radiatus* Gmelin, *Thais alveolata* Kiener, *Drupa granulata* Duclos, *Cypraea caput-serpentis* Linnaeus, *Cypraea arabica* Linnaeus, Numerous tubes of the serpulid

Pomatoleios crosslandi Pixell are found, especially in the upper parts of the zone. Many small crabs are encountered clinging on to the weeds. These include *Menaethius monoceros* Latreille, and *Hyastenus planasius* Adams and White. Large numbers of amphipods, isopods and polychaete worms are also seen.

The Eulittoral Zone

The upper limit of the dense weed growths of the sublittoral marks the lower boundary of this zone. The definition of the upper boundary of the zone however, presents certain difficulties. Barnacles are very scarce on this shore and cannot serve as indicators on their own. The distribution of the littorine species is not very helpful either. Of the three species present one, *Nodilittorina granularis* Gray, is widespread, extending from the lower eulittoral into the littoral fringe. The other two species, *N. pyramidalis* Quoy & Gaimard and *Littorina undulata* Gray, are predominantly littoral fringe forms, but a few extend down into the upper eulittoral. By careful analysis, however, it is possible to recognise a transitional area, where barnacles disappear, and *L. undulata* and *N. granularis* become commoner. This region seems to coincide with the upper limit of the dense oysters, *Crassostrea cucullata* Born. For practical purposes therefore, it seems convenient to use the upper limit of dense oysters as the upper boundary of the eulittoral.

Three sub-zones may be clearly distinguished within the eulittoral. These are: lowermost a sub-zone of patchy weed growths, followed in order upwards by a sub-zone of limpets and barnacles and a sub-zone of oysters.

Sub-zone of patchy weed growths: This is a very clearly defined sub-zone. Its lower boundary coincides with the lower boundary of the zone itself. Its upper boundary is marked by the last of the large algae. Since the transition from the weed patches to bare rock is fairly sharp, the upper limit is easily fixed. The general appearance of the sub-zone is quite different from that of the zone below, since here the weeds grow in discrete patches and so do not form a complete cover. Many of the weeds that occur below, grow here too, but in different proportions. Here the dominant weeds are species of *Gracilaria* and *Laurencia*. *Sargassum* also occurs here but in much smaller quantity. Patches of *Ulva*, *Padina* and *Chaetomorpha* are also seen. The littorine *Nodilittorina granularis* begins to appear about the middle of this sub-zone. A number of tubes of *Pomatoleios crosslandi* occur amongst and between the weed patches. Some of the molluscs found lower down occur here too, while *Anachis terpsichore* seems to be more numerous here. A few barnacles *Balanus amphitrite* Darwin and a few limpets *Cellana radiata* Born, appear in the upper parts of this zone.

Sub-zone of limpets and barnacles: This sub-zone is limited by the last of the weed patches below and by the lower limit of the dense oyster belt above. This is also the lowermost part of the shore that dries out completely at low tide, since waves do not normally wash into it. This is the main barnacle region of this shore, but even here barnacles are scarce and distributed in patches. *N. granularis* occurs throughout this region and is especially abundant in its lower parts. This is also the main centre of the limpets, *Cellana radiata*.

Sub-zone of oysters: This sub-zone is relatively narrow. Its limits are defined by the upper and lower limits of the dense bed of oysters. In addition to *Crassostrea cucullata*, a few barnacles *Balanus amphitrite* are also found and *N. granularis* is still quite numerous, though less so than in the preceding sub-zone. In the upper parts of this sub-zone isolated individuals of *N. pyramidalis* and *L. undulata* may be encountered. A few isolated oysters may be seen above and below the limits of the sub-zone.

The Littoral Fringe

The location of the dividing line between this zone and the eulittoral has already been discussed. The shoreward edge of the sandstone platform is sharply set off from the adjacent sandy beach and forms a natural upper limit. There is no apparent intergradation between the sandstone and the sand. The fauna is made up of three littorine species—*N. granularis*, *N. pyramidalis* and *L. undulata*. *N. granularis* is found throughout the zone and is the most numerous. Its numbers fall off as one proceeds up the zone. Of the other two species *L. undulata* is uniformly distributed over the whole zone while *N. pyramidalis* tends to be more numerous in its lower parts.

THE SHORE AT GALLE BUCK

The Shore

This shore lies immediately south of the south-west breakwater of Colombo Harbour. It consists of a group of granitic rocks lying seaward off the lighthouse and separated from the latter by a strip of sandy beach. The site selected for study lies on the north-eastern flank of the so-called Navy Pool (see Figure 1). The rocks here face northeast. The line of rocks extends seawards in a north-westerly direction and then curve southwards, facing the income waves. From the water level the rocks slope upwards to a maximum height of about 5 metres (see profile diagram, Figure 4). The surface of the rocks is mostly smooth, but there are also numerous crevices and depressions. Most of the north-eastern rock face is not subject to any considerable wave action. Waves break on the western face of the group of rocks and water washes shorewards along the edge of the north-eastern face. Therefore, at the study site, wave action is very limited and consists mostly of a gentle rise and fall in the level of the water. However, the effect of this rise and fall is more marked seawards than shorewards.

The following account of zonation is based on the analysis of 2 belt transects and a number of random samples located in the various zones and sub-zones. The studies were carried out during January and February 1968.

The Zones

The broad picture of the zones presented by this shore is quite different from that seen at Duwa. Even at a distance, it is possible to make out a broad belt of oysters with a clear white band of barnacles above that belt. On closer examination the usual three zones can be defined and the eulittoral can be divided into three sub-zones. However this sub-zonation is not identical with that described for Duwa.

The Sublittoral Zone

Weeds extend upwards from the waterline at low tide of springs to the lower limit of the dense oyster belt. Part of this weed belt is sublittoral and part is eulittoral. The dividing line between these is by no means distinct. The eulittoral weeds tend to be patchy and low growing but the patches tend to run together. The sublittoral weeds cover the rock more completely. There is some variation in composition apparently related to position in relation to wave action. At the north-western edge of the line of rocks the most dominant sublittoral weed is *Padina* sp. At the north-

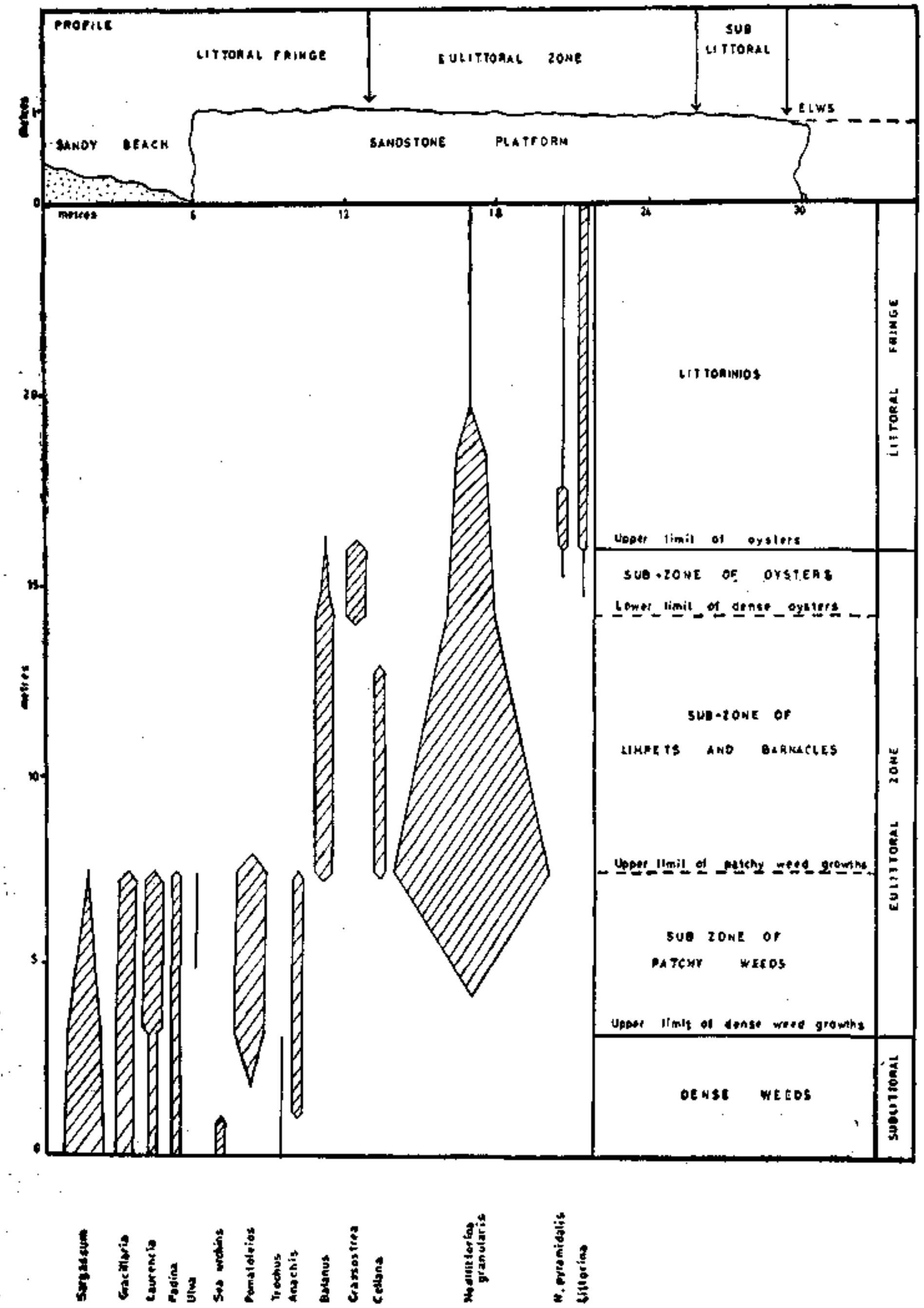

FIG. 3. Zonation of the more common plants and animals on the shore at Duwa. The upper part of the diagram shows a profile of the study site.

eastern edge the dominant weed is *Gracilaria*. Other sublittoral weeds are species of *Jania, Turbinaria* and *Sargassum*. The fauna includes large numbers of *Anachis terpsichore*, and isolated specimens of *Trochus radiatus, Gibbula stolickzana* Nevill, *Euchelus asper* Gmelin, and *Thais alveolata* Kiener. Also seen are young mytilids, some small crabs, numerous amphipods, isopods, and polychaetes. Serpulids are not prominent and the sea urchins and their burrows, so characteristic of the sublittoral at Duwa, are completely absent.

The Eulittoral Zone

The lower limit of this zone is not very distinct, since the transition from the dense algal cover of the sublittoral weeds to the rather more patchy distribution of the eulittoral weed zone is gradual. The upper limit, on the other hand, is quite well defined by the barnacles. Barnacles of the species *Balanus amphitrite* are plentiful and a clear line may be recognised below which these animals are abundant and above which they are very scarce or absent. This line would mark the upper limit of the eulittoral.

Three sub-zones are recognisable. These are: lowermost, a sub-zone of patchy weed growths, followed in order upwards, by a sub-zone of oysters limpets and barnacles and by a sub-zone of barnacles.

Sub-zone of patchy weed growths: The lower limit of this sub-zone is indistinct. Its upper limit is formed by the lower limit of the dense oyster belt. Though the weeds do not form a complete cover, they are yet, fairly densely packed, with little intervening bare rock. *Gracilaria* sp. is the most dominant weed. Small quantities of *Jania* sp., *Turbinaria* sp., and *Sargassum* sp. also occur. The fauna includes species that are found in the sublittoral, but these are less numerous here. In addition, the limpet *Cellana radiata* and the fissurellid *Clypidina notata* (Linnaeus), begin to appear here, the latter being the more abundant. At the upper edge of this sub-zone a few barnacles, *Balanus amphitrite* appear. A few isolated oysters may also be seen.

Sub-zone of oysters barnacles and limpets: This region stands out clearly and is defined by the upper and lower edges of the dense band of oysters. Large weeds are not seen here. The oysters belong to the species *Crassostrea cucullata*. *Balanus amphitrite* is found in large numbers throughout this region. Two species of mollusc found below are found here too—*Clypidina notata* and *Cellana radiata*. The former occurs mostly in the lower half while the latter is found throughout the sub-zone, with maximum density about the middle of the sub-zone. *N. granularis* begins to appear at about the middle of this region. Numbers are much less than on the shore at Duwa.

Sub-zone of barnacles: The lower limit of this sub-zone is formed by the upper border of the dense belt of oysters. Its upper limit is defined by the level beyond which *Balanus amphitrite* is no longer found in quantity. Apart from the barnacles, the only other animal found here is *N. granularis*, which reaches maximum density at about the middle of this sub-zone.

The Littoral Fringe

The lower limit is defined by the last of the barnacles in quantity. The upper limit may be placed at the level at which rock surface blackened by myxophyceae is replaced by bare rock which is grey in colour. This region is populated only by

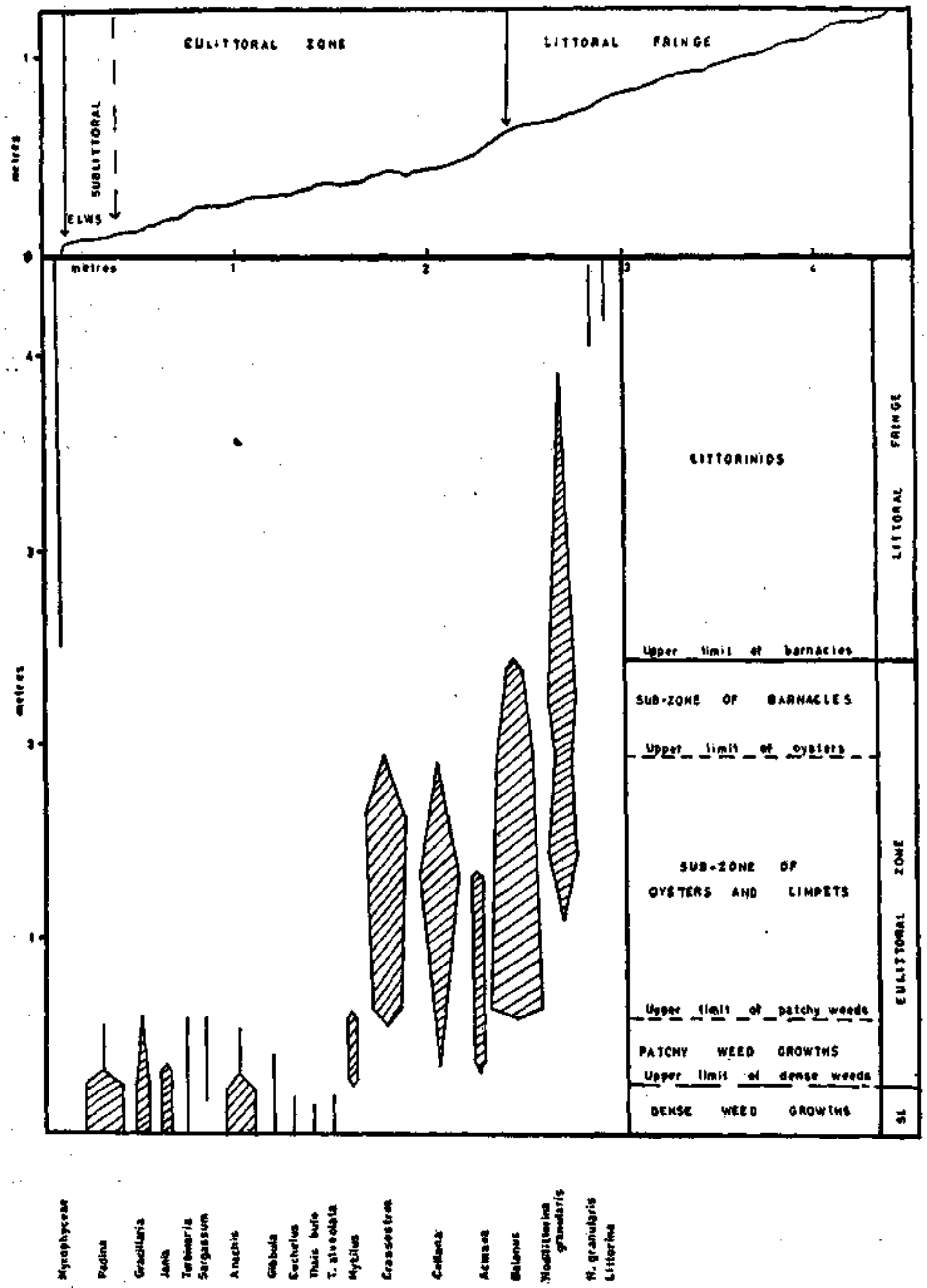

FIG. 4. Zonation of the more common plants and animals on the shore at Galle Buck. The upper part of the diagram shows a profile of the study site. (For N. granularis read N. pyramidalis).

three littorine species but these too are scarce. *N. granularis* extends into this zone but its numbers decline sharply as one moves upwards. *N. pyramidalis* appears as *N. granularis* tails off. *L. undulata* is found in the upper parts of the zone. Over the whole zone and on the lower shore too, littorines are not very numerous, especially in relation to the large numbers of littorines seen on the shore at Duwa.

Comparison of the Two Shores

As indicated earlier, two shores with contrasting physical features were selected for this study. Having described the patterns seen on each of these shores, it is useful, now, to make comparisons and to try to relate similarities and differences to conditions obtaining on each.

Physical Features

The major differences between the shores are related to the nature of the substratum, the slope, wave action and degree of drying at low tide. At Duwa the rock platform is of sandstone while at Galle Buck the rock is granitic. The texture of the surface is of some importance. The sandstone surface is never smooth and this must influence the settlement and growth of permanently attached animals. On the other hand, the presence of innumerable surface irregularities may help in the retention of moisture and may help to shelter small animals like littorines. The granitic surface at Galle Buck is smoother and more regular. Such a surface would be more suitable for permanently attached forms like barnacles and oysters. Even on the granitic surface there are various depressions, grooves, crevices and overhangs but the general character of these is different from the surface irregularities of sandstone.

With regard to slope, it has been pointed out that at Duwa the rock platform is practically horizontal, while at Galle Buck the rocks have a pronounced slope. There are certain obvious effects of this difference in slope. For instance, on the sloping shore, zones must necessarily be relatively narrower, unless there is heavy spray and water drains off more rapidly. Moreover, the slope of the seaward edge influences the breaking of the waves. At Duwa, where the seaward face is almost vertical the waves tend to break violently and since the platform itself is almost horizontal the area washed by the waves is large. At Galle Buck the study site is not subjected to direct wave action, the extent washed by wave action is very limited because of the slope and there is little spray. As a result of the combination of slope, wave action and spray, the degree to which the two shores dry out are different. At Duwa, much of the lower shore remains moist at low tide, while at Galle Buck the moist area is less extensive.

Flora and Fauna

There is little difference in species composition between the two shores. The main differences have to do with the different degrees to which important species dominate the various zones. *Sargassum* species which dominates the sublittoral at Duwa is very little in evidence at Galle Buck. This might, in part, be related to the differences in wave exposure. Lawson (1966), discussing West African shores, indicates that *Sargassum* becomes prominent on moderately wave exposed shores, but is absent from very wave exposed rocks.

Major differences with regard to fauna relate to the density and distribution of littorines, barnacles, serpulids and to the occurrence of sea urchins. Littorines, especially *N. granularis*, are abundant at Duwa. It would seem that the sandstone surface is favoured by these animals. At the study site at Galle Buck numbers are much smaller especially in the littoral fringe. This region is bare, mostly smooth, and often exposed to hot sun. Perhaps such conditions are not suitable for these animals. Where there is more shelter, as for instance in grooves and crevices and under overhangs small concentrations of littorines are seen at Galle Buck in areas adjacent to the study site. On both shores, *N. granularis* has a wide distribution. At Galle Buck *N. pyramidalis* and *L. undulata* do not enter the eulittoral as they do at Duwa. Unlike littorines the barnacles seem to thrive much better at Galle Buck and as has been pointed out above, this may very well be due to the smoother surface available for settlement here. The difference in density between the two shores is very marked and it influences the sub-zonation pattern. The absence of sea urchins from Galle Buck is another striking difference between the two shores. Two factors may be partly responsible. Firstly, the granitic surface at Galle Buck is not suitable for the characteristic burrowing operations. Secondly, since wave action at the Galle Buck site is very limited the water does not attain the high degree of aeration that it presumably attains at Duwa. Sabellariid tubes are often seen at Duwa. Though these have not been included in the description of zonation given above, a band of sabellariid tubes may replace the oyster belt in places. Moreover, these tubes are prominent on the parts of the sandstone platform that extends obliquely into the sea (see Figure 1). At Galle Buck sabellariid tubes are not seen.

Zonation and Sub-zonation

On both shores the three main zones are recognisable, but there are important differences in the sub-zonation of the eulittoral. Moreover, the indicator organisms used in the definition of zone and sub-zone limits are often different. The difference in sub-zonation results from the paucity of barnacles and oysters on one shore and the abundance of these organisms on the other. Thus while at Duwa there is no clear belt where barnacles are dominant and there is only a narrow belt of oysters, at Galle Buck a prominent band of oysters extends upwards from the weeds and this band is topped by a clear belt of barnacles. On both shores the lowermost part of the eulittoral is occupied by a sub-zone of weeds. However, at Duwa this sub-zone has a very characteristic appearance and has clearly discernible limits. It is also relatively broad. The condition of this weed zone at Duwa reflects clearly the effects of the regular washing of the waves over the almost horizontal platform. At, Galle Buck, the lower limit of this sub-zone is difficult to define and the weed belt itself is narrower and more compact—a condition that may be related to the rather limited wave action and the slope of the rocks.

Some attention has to be given to the implications of using different indicator organisms to define zone limits on different shores. Referring to a postulated drop in the barnacle line between two shores, Lewis (1966) says, '. . . . these two levels are equal in terms of the survival of the animals, and the difference between them is a more accurate indication of the changed conditions than any but the most detailed and imaginative series of physical investigations could provide.' As long as a single species is used as an indicator for a particular level, this principle will apply and no problems arise. With different species being employed, it is obvious that the same balance of factors will not be indicated. Considering, for instance, the upper limit of the eulittoral on both the shores described, the upper limit of the oysters is used in one case and the upper limit of the barnacles in the other. Yet, if indications are correct the absence of barnacles at Duwa may be due to one overriding factor—the unsuitable substratum. Strictly speaking, therefore, the upper limit of oysters at

Duwa would correspond to the upper limit of the same species at Galle Buck and would represent broadly similar combination of factors. The upper limit of the eulittoral should then lie above the oysters. However, at Duwa, it is not possible to find any indicator by means of which this limit may be fixed and for practical purposes, the whole of the littorine zone above the oysters is considered the littoral fringe.

It becomes necessary therefore, to be able to group shores into a number of categories, as has been done for British shores by Lewis (1966). With such a grouping accomplished, indicators and zonation would be directly comparable on shores belonging to one group, while comparisons between members of separate groups would need to take into account considerations such as have been noted above. Provisionally, the shore at Duwa would fall into one group which may be designated ' littorine dominated ' and that at Galle Buck would be placed in a group designated ' barnacle and oyster dominated '.

The differences in sub-zonation would also follow such a grouping of shores, since they seem to be related to differences in dominant forms. Thus at Duwa, the limitation of oysters to a narrow belt opens up an area between the oysters and the weed line. This area populated by limpets, littorines and barnacles forms a separate sub-zone. At Galle Buck, the bed of oysters extends down to the weed line and masks the limpets. Similarly, the abundant barnacles at Galle Buck establish an additional sub-zone above the oysters.

Conclusion

The present study has demonstrated the feasibility of defining zones on Ceylon shores with reference to indicator organisms alone. It has also pinpointed some of the difficulties likely to be encountered in applying such a procedure. It is obvious that there is a great need for the further study of Ceylon shores with a view to documenting the variations around the island classifying the shores into broad types. Further, the descriptions given above apply to the part of the year when the shores in question are unaffected by the monsoon. During the monsoon period conditions, especially of wave action change. It is very likely that there would be important changes in the pattern of zonation, with upliftment of the zones. However, it is not easy to study these shores during the monsoon and this has not been done so far.

For the present, no attempt is made to compare the patterns seen on these two shores with those described on other tropical shores. It would be more profitable if such a discussion were to follow a rather wider study of conditions on Ceylon shores.

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Summary

1. The patterns of zonation on two shores on the west coast of Ceylon, showing contrasting physical characteristics, have been described. Indicator organisms, rather than tidal levels, have been used in the definition of zone and sub-zone boundaries.

2. The sandstone shore at Duwa is zoned into sub-littoral, eulittoral and littoral fringe zones. The eulittoral is sub-divided into three sub-zones—a lower belt of weed patches, a middle belt of limpets and littorines, and an upper belt of oysters.

3. The shore at Galle Buck shows the same three zones. The eulittoral there is sub-divided into a lower weed belt, a middle belt of oysters, and an upper belt of barnacles.

4. The two shores are compared and the use of biological indicators is discussed.

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