

Ecological studies on a tropical limpet *Cellana radiata*

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Abstract

Some aspects of the habitat zones, distribution pattern, and population density with reference to tidal levels of the tropical limpet *Cellana radiata* (BORN) are presented. Observations have also been made on the 'homing' behaviour of the limpet. Unlike the temperate limpets, no migration to different tidal levels during different seasons was observed in *C. radiata*.

Introduction

Although extensive investigations have been carried out on the biology of the temperate limpets (particularly on *Patella vulgata* from the French and British coasts), very little is known about the tropical forms. The distribution of *Patella vulgata* in the intertidal regions has been studied by several workers, e.g. ORTON (1929), Plymouth, England; ESLICK (1940), Port St. Mary, Isle of Man; EVANS (1947a, b, 1953, 1958), Cardigan Bay (Wales), south coast of England, west coast of France; DAS and SESHAPPA (1947), Cullercoats, England; EBLING et al. (1962), Lough Ine, Ireland.

The population density of *Patella vulgata* in relation to the habitat, effects of wave action and different tidal levels has also received the attention of several workers (ORTON, 1929; DAS and SESHAPPA, 1947; JONES, 1948; SOUTHWARD and ORTON, 1954; SOUTHWARD, 1956). Furthermore, attempts have been made to study the 'homing' behaviour of *Patella vulgata* by MORGAN (1894), RUSSELL (1907), ORTON (1929) and JONES (1948).

The genus *Cellana* is distributed along the coasts of India, Ceylon, Island of Luzon, Japan and Australia. In the present study an attempt has been made to compare the distribution and habits of the local tropical limpet *Cellana radiata* with those of limpets from the temperate water.

Material and methods

Collections were made at 5 stations, which were based on the physical nature of the substratum (Fig. 1). The stations at Visakhapatnam, India, are separated from one another by wide stretches of sand and all of them are exposed to direct surf action and insolation. Stations I to III are characterized by the presence of

big boulders, and Stations IV and V by the presence of shingles. The density of the animals at the 5 stations was measured by counting specimens in areas of 1 m². Detailed observations were, however, made at Palm Beach (Station II), as this station offered a wide range of habitats.

The tidal levels and their vertical range at Waltair coast (Visakhapatnam) have been described by RAO

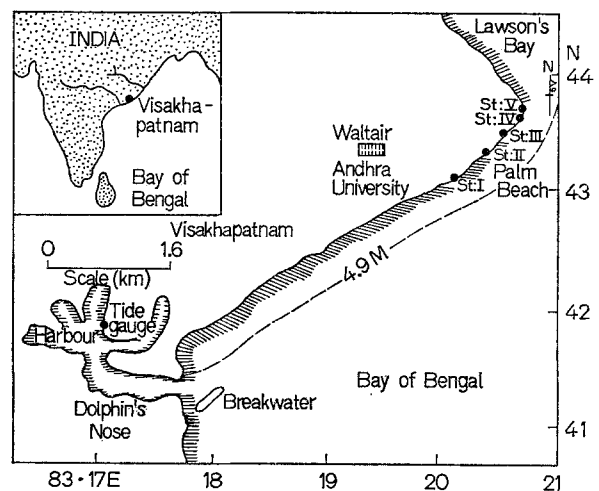


Fig. 1. Coast line of Visakhapatnam, India, showing the locations of Stations I to V

and RAO (1962) and are summarized in Table 1. Collections were made at 4 tidal levels, i.e. Mean High Spring (MHWS), Mean High Water Neap (MHWN), Mean Sea Level (MSL) and Mean Low Water Neap (MLWN), and also at the exposed, semi-exposed and protected surfaces in relation to the wave action.

Population studies were made on *Cellana radiata* collected from boulders with even surfaces, as the smaller forms tended to lodge themselves in nooks and crevices of rocks with uneven surface. Large boulders exceeding 1 m in height were selected for the study of the vertical distribution and the different tidal levels

etched on the rock surface during the MLWS period. The quantitative studies on the limpets occupying the 4 tidal levels were carried out by clearing the animals in an area of 0.25 m², taking a uniformly distributed area of the animals. The plants and animals in the immediate vicinity of the limpets were also collected and identified.

protected surfaces, the limpets were sorted into 3 mm-length groups and the percentage frequencies of different size groups at the same tidal zone and rock surface and the same size groups at different tidal zones and rock surfaces were calculated.

Results

Distribution on the shore

The local limpet *Cellana radiata* is found in a variety of locations such as smooth and rough rock surfaces, shingles, rocky platforms, and vertical boulders in the tidal zone. They occur from the most wave-beaten rock surfaces to the most protected surfaces. They are abundant in the wash and splash zones and comparatively rare in the spray zone. They are also present in various kinds of micro-habitats like crevices, cracks, gullies, overhangs and rock pools, but sparse on rocks encrusted with barnacles and weeds. Young *C. radiata* are most abundant on the surfaces directly exposed to wave action and also in shady locations such as crevices, cracks, and overhangs.

Table 1. Vertical intertidal zones of the rocky shore on the Waltair coast, India (After RAO and RAO, 1962)

Zone	Abbreviation used	Height	
		(feet)	(m)
Extreme High Water Springs	EHWS	6.6	1.98
Mean High Water Springs	MHWS	4.9	1.47
Mean High Water Neaps	MHWN	3.5	1.05
Mean Sea Level	MSL	2.8	0.84
Mean Low Water Neaps	MLWN	1.7	0.51
Mean Low Water Springs	MLWS	0.3	0.09

The movements of *Cellana radiata* were studied in the field by observing the limpets during successive low- and high-tide periods. After noting the nature of the substratum (smooth or rough), the limpets and their position on the rock surface were marked with an enamel paint during the low-tide period. They were observed in the successive high- and low-tide periods and the maximum distance which they moved was measured.

A diagrammatic representation of the zonation at Palm Beach is shown in Fig. 2. On large boulders, which jutted out above sea level, *C. radiata* were found to extend vertically from MLWN to MHWS. On the semi-exposed surfaces the limpets are mostly confined to the region between MLWN and MHWS; on surfaces directly exposed to wave action they extend a little above MHWS.

To study the distribution of different sizes at the 4 tidal zones and at the exposed, semi-exposed and

Cellana radiata were absent where the rock surface is heavily scored, and also on shifting pebbles in the shingle zone. They are seldom present below MLWS and above MHWS.

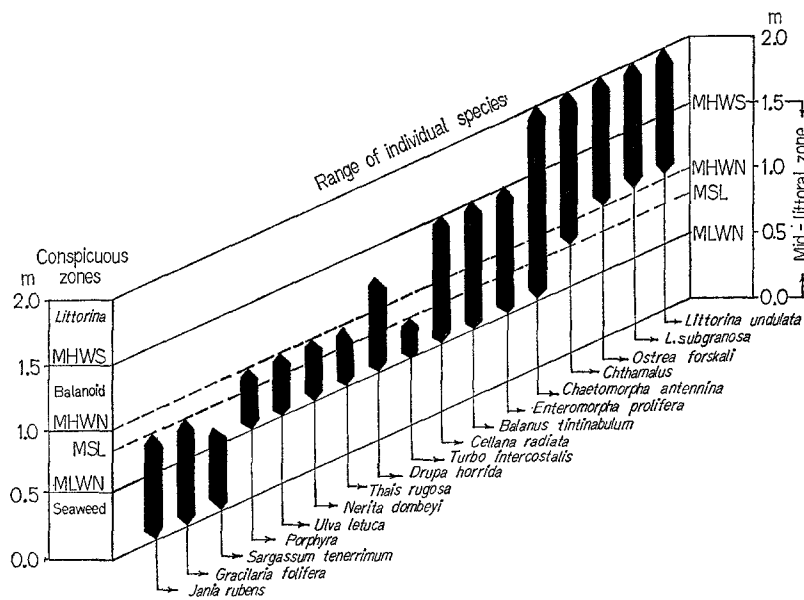


Fig. 2. Diagrammatic representation of zonation at Palm Beach

Population density

The population density of *Cellana radiata* at the 5 stations is given in Table 2. Maximum density occurred at Station II, Palm Beach (65/m²), which is periodically exposed and submerged and also subjected to heavy wave action. Minimum density occurred at

Table 2. *Cellana radiata*. Population density at the 5 stations

Station	Numbers/m ²	Average/m ²
I	15—75	45
II	20—110	65
III	30—75	50
IV and V	10—50	25

Table 3. *Cellana radiata*. Population density at different habitats at Palm Beach, Waltair, India

Habitat	Density/m ²
Bare rock	20—75
Rocks covered partly by <i>Chaetomorpha</i> , <i>Enteromorpha</i> , <i>Ulva</i> and <i>Porphyra</i>	50—150
Rocks covered partly by <i>Sargassum</i> and <i>Gracilaria</i>	15—50
Rocks covered partly by barnacles (<i>Chthamalus</i> sp.)	20—100
Rock crevices and cracks	30—100
Rock pools	50—150

Table 4. *Cellana radiata*. Population density on the 3 rock surfaces of the 4 tidal zones

Zone	Number of samples examined	Average number of animals/0.25 m ²		
		Protected	Semi-exposed	Exposed
MHWS	14	4	6	8
MHWN	13	8	10	12
MSL	15	10	12	14
MLWN	16	6	8	10

Stations IV and V (25/m²), which are submerged for longer periods and where surf action is less pronounced.

Population densities of *Cellana radiata* in different habitats at Palm Beach are shown in Table 3. Density was high in rock pools, crevices, cracks and also on rocks partly covered by algae such as *Chaetomorpha*, *Enteromorpha*, *Ulva* and *Porphyra*. Density was low on rocks thickly covered by weeds such as *Sargassum* and *Gracilaria*.

Population densities of *Cellana radiata* in the protected, semi-exposed and exposed surfaces at the 4 tidal zones/0.25 m² at Palm Beach is shown in Table 4. The results show that maximum density occurs at MSL, above and below which population numbers decrease. The average numbers of limpets on the exposed surface were more than those on the semi-exposed and protected surfaces of the 4 tidal zones (Table 4).

Shell length distribution

The distribution of 3 mm length groups at the 4 tidal zones, at the exposed, semi-exposed and protected surfaces is shown in Figs. 3 to 6. The smaller size groups occur mainly at higher levels and exposed

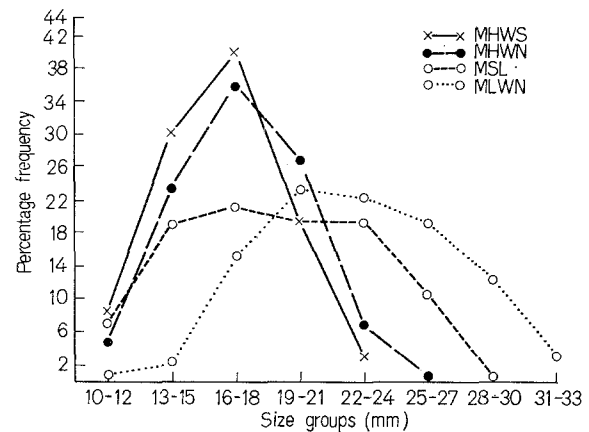


Fig. 3. *Cellana radiata*. Percentage frequency of different size groups in the same tidal zone

surfaces than at lower levels and semi-exposed and protected surfaces. It may be seen from Fig. 3 that, among the different size groups, the greatest percentage of limpets occurring at MHWS, MHWN and MSL were in the 16 to 18 mm size group, and at MLWN in the 19 to 21 mm size group. On the exposed, semi-exposed and protected surfaces, the 13 to 15 mm size group, the 16 to 18 mm size group, and the 19 to 21 mm size group were dominant, respectively (Fig. 4). Among the same size groups at different tidal levels, the 10 to 12 mm size group was maximum at MHWS and MHWN, the 22 to 24 mm size group at MSL, and the 31 to 33 mm size group at MLWN (Fig. 5). Fig. 6 shows the distribution of the same size groups on the 3 rock surfaces. The 10 to 12 mm size group are predominant on the exposed surface, the maximum size groups of 16 to 18 mm and 25 to 27 mm are found on the semi-exposed and protected surfaces, respectively.

A comparison of Figs. 3 to 6 shows that the smaller sizes of *Cellana radiata* predominate at higher levels on the exposed surface, and the larger sizes at the lower levels on the protected surface.

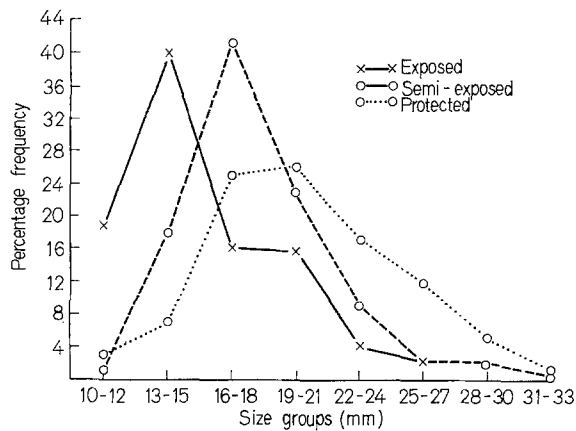


Fig. 4. *Cellana radiata*. Percentage frequency of different size groups in the same habitat

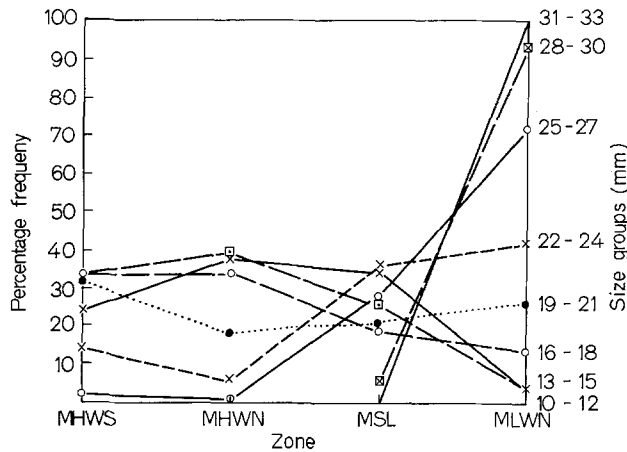


Fig. 5. *Cellana radiata*. Percentage frequency of same size group in different tidal zones

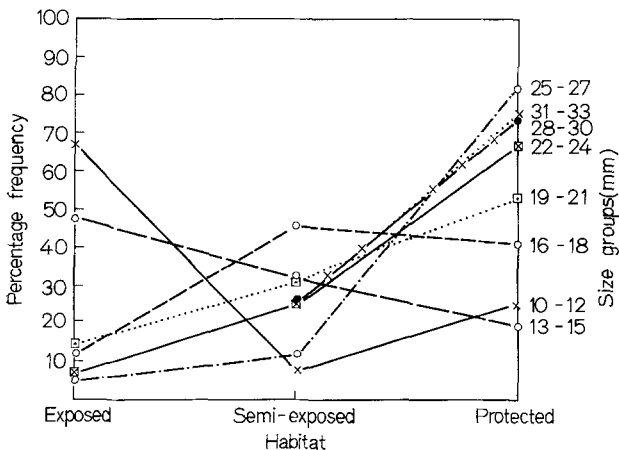


Fig. 6. *Cellana radiata*. Percentage frequency of same size group at the three different habitats

Movements

The animals firmly adhere to the substratum when exposed to air and begin to move only when inundated by the incoming tide. Results of observations of movements of *Cellana radiata* living at the high and low water zones of the smooth and rough rock surfaces are given in Table 5. This shows that the maximum distance moved by limpets living at higher levels is less than those living at lower levels. The distance moved was also found to be more on a smooth surface than on a rough surface. The restricted movement of the limpets at higher levels may be due to the shorter period of submergence in comparison with limpets inhabiting the lower levels. Most of the limpets on the

Table 5. *Cellana radiata*. Range of movement on the rough and smooth rock surfaces of the high and low water zones

Level	Number of animals observed	Maximum distance moved (cm)	
		Rough surface	Smooth surface
High level (MHWS)	10	2	5
Low level (MLWN)	10	8	15

rough rock surface returned to their scars or 'homes' which can be recognised as depressions on the rock surface. Many limpets on the smooth surface did not return to their scars.

Discussion

The present investigation attempts to compare the distribution and habits of a local tropical limpet *Cellana radiata* with the temperate form *Patella vulgata* which is widely distributed on the coasts of France and the British Isles. *C. radiata* is restricted to the warm waters of the Indo-Pacific region, and is common on the east and west coasts of India.

A comparison of the habitat zones of the two forms shows that both forms prefer clean rock surfaces without much overgrowth by weeds or encrusted animals, and also surfaces which are not heavily scored. They also avoid shifting pebbles and boulders and prefer stable locations. The limpets are found on both smooth and rough surfaces and also in crevices, cracks, gullies, overhangs and rock pools. They inhabit all types of exposed, semi-exposed and sheltered locations (ORTON, 1929; EVANS, 1947 a).

DAS and SESHAPPA (1947) found *Patella vulgata* extending from Low Water Spring (LWS) to High Water Spring (HWS) at Cullercoats, with a vertical

distribution of about 4 m, while at Cardigan Bay, EVANS (1947a) reports a vertical range of more than 5 m for the same species from Extreme Low Water Spring (ELWS) to Extreme High Water Spring (EHWS). In comparison with *P. vulgata*, the vertical range of *Cellana radiata* is very much more restricted, as the vertical tidal range of the Waltair (India) coast is only about 1 m. *C. radiata* are seldom present above EHWS and below MLWS, indicating that the animals require some amount of exposure. The differences observed in the numbers of *C. radiata* at different tidal levels may be due to the differences in the periods of exposure and submergence at these levels. EVANS (1947a) observed that *P. vulgata* was largely restricted to the area between the tide marks and, according to this author, the necessity for some amount of exposure to air is the prime factor deciding their distribution.

Studies on the population density of *Cellana radiata* have shown that they occur in maximum numbers on the exposed surface in the MSL zone with a decrease in numbers above and below this zone. The predominance of smaller sized limpets on the exposed surface may account for their larger numbers as compared with the fewer but large sized individuals on the protected surface. SOUTHWARD (1953) and SOUTHWARD and ORTON (1954) also observed an increase in numbers of *Patella vulgata* on surfaces exposed to wave action. They, however, pointed out that population density is quite inseparable from the size of the individuals.

The homing behaviour of *Cellana radiata* is similar to that described for *Patella vulgata* from the British coasts (HAWKSHAW, 1879; MORGAN, 1894; DAVIS, 1895; RUSSELL, 1907; ORTON, 1914, 1929; JONES, 1948). The limpets move only when the rock surface is inundated by the tides. A return to the scar or original 'home' was observed in the case of limpets on rough surfaces; those on smooth surfaces displayed no such 'homing' behaviour.

There is no evidence of any seasonal migration of *Cellana radiata* to lower levels in spring and summer and to higher levels in winter and autumn as observed in *Patella vulgata* by LEWIS (1954). The seasonal variation in temperature on the Waltair coast is only 4° to 5°C. Therefore, the absence of seasonal migrations in *C. radiata* may be due to the absence of marked seasonal fluctuations in temperature in the ambient conditions of a tropical location such as Waltair. In *Fissurella barbadensis*, which is also similarly located, WARD (1967) observed no seasonal migration.

Summary

1. The distribution of *Cellana radiata* (BORN) at 5 stations along the coast of Visakhapatnam, India, is described.

2. *C. radiata* are present in all kinds of locations, extending, vertically, from MLWN to MHWS.

They are absent on shifting pebbles and on rocks which are heavily scored.

3. Maximum population density of the limpets occurred at Palm Beach (Station II). This beach is periodically exposed and submerged, and the wave action is pronounced. Population density is minimum on shingles (Stations IV and V), which are submerged for longer periods and where wave action is less marked.

4. Population density of *C. radiata* is maximum on rocks partly covered by algae and in micro-habitats such as rock pools, cracks and crevices.

5. The maximum number of limpets occupy the MSL on the exposed surface; the individuals occupying the exposed surface are of notably smaller size.

6. *C. radiata* firmly adhere to the substratum when exposed to the air and move about only when they are submerged. Return to the scar or 'home' was observed only in limpets living on rough rock surfaces.

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Literature cited

- DAS, S. M. and H. SESHAPPA: A contribution to the biology of *Patella*. On population distribution and sex proportions in *Patella vulgata*. Proc. zool. Soc. Lond. **117**, 653—662 (1947).
- DAVIS, J. R. A.: The habits of limpets. Nature, Lond. **51**, 511—512 (1895).
- EBLING, F. J., J. F. SLOANE and H. M. DAVIES: The ecology of Lough Ine. XII. The distribution and characteristics of *Patella* species. J. Anim. Ecol. **31**, 457—470 (1962).
- ESLICK, A.: An ecological survey of *Patella* at Port St. Mary, Isle of Man. Proc. Linn. Soc. Lond. **152**, 45—58 (1940).
- EVANS, R. G.: Studies on the biology of British limpets. The genus *Patella* in Cardigan Bay. Proc. zool. Soc. Lond. **117**, 411—423 (1947a).
- The intertidal ecology of selected localities of Plymouth neighbourhood. J. mar. biol. Ass. U. K. **27**, 173—218 (1947b).
- Studies on the biology of British limpets. *Patella* on south coast of England. Proc. zool. Soc. Lond. **123**, 357—376 (1953).
- The genus *Patella* on west coast of France. J. Conch., Paris **98**, 126—151 (1958).
- HAWKSHAW, J. C.: On the action of limpets (*Patella*) in sinking pits in and abrading the surface of the chalk at Dover. J. Linn. Soc. (Zool.) **14**, 406—411 (1879).
- JONES, N. S.: Observations and experiments on biology of *P. vulgata* at Port St. Mary, Isle of Man. Proc. Trans. Lpool. biol. Soc. **56**, 60—77 (1948).
- LEWIS, J. R.: Observations on high level population of limpets. J. Anim. Ecol. **23**, 85—100 (1954).
- MORGAN, C. L.: The homing of limpets. Nature. Lond. **41**, p. 127 (1894).
- ORTON, J. H.: Note on the feeding habits of *Patella*. J. mar. biol. Ass. U. K. **10**, 257 (1914).
- Observations on *Patella vulgata*. III. Habitat and habits. J. mar. biol. Ass. U. K. **16**, 277—288 (1929).

- RAO, T. S. S. and S. V. V. RAO: Some aspects of intertidal ecology of Waltair coast. *J. zool. Soc. India* **14**, 112—136 (1962).
- RUSSEL, E. S.: Environmental studies on the limpet. *Proc. zool. Soc. Lond.* 856—870 (1907).
- SOUTHWARD, A. J.: The ecology of some rocky shores in the south of Isle of Man. *Proc. Trans. Lpool. biol. Soc.* **59**, 1—50 (1953).
- The population balance between limpets and sea weeds on wave beaten rocky shores. *Rep. mar. biol. Stn Port. Erin* **68**, 20—29 (1956).
- SOUTHWARD, A. J. and J. H. ORTON: The effects of wave action on the distribution and numbers of commoner plants and animals living on the Plymouth back waters. *J. mar. biol. Ass. U. K.* **33**, 1—19 (1954).
- WARD, J.: Distribution and growth of the keyhole limpet *Fissurella barbadensis* GMELIN. *Bull. mar. Sci.* **17**, 299—318 (1967).

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