CHEATUM, E. P., M. LONGNECKER, & A. METLER. 1942. Limnological Observations on an East Texas Lake. Transactions American Microscopical Society, 61:336-48.
DAMANN, KENNETH E., 1951. Missouri River Basin Plankton Survey. Federal Security Agency, Public Health Service, Cincinnati, 100 pp.
EDDY, SAMUEL. 1934. A Study of Fresh-Water Plankton Communities. Illinois Biological Monographs. Volume 12, Number 4, 93 pp.
EDDY, SAMUEL & A. C. HODSON. 1952. Taxonomic Keys to the Common Animals of the North Central States, Exclusive of the Parasitic Worms, Insects and Birds, Burgess, Minneapolis. 123 pp.
ELTON, CHARLES. 1929. The Occurrence of *Eurytemora lacinulata* and *Liaptomus gracilis*. Journal of Ecology, 17:383-91.
GROVER, W. W. & R. E. COKER. 1940. A Study of the Depth Distribution of Certain Net Plankters in Mountain Lake. Virginia Ecology 21:199-205.
HARRIS, B. B. & J. K. G. SILVEY. 1940. Limnological Investigations on Texas Reservoir Lakes. Ecological Monographs 10:112-43.
KUDO, RICHARD R. 1950. *Protozoology*. Charles C. Thomas, Springfield, 778 pp.
LACKEY, J. B. 1938. Factors Affecting the Seasonal Distribution of Protozoa. Ecological Monographs 8:501-27.
PATTERSON, MARCILE. 1941. A Study of Fluctuations in Plankton Population in White Rock Lake in Winter and Spring. Masters Thesis, Southern Methodist University, 42 pp.
PEARSALL, W. H. 1923. A Theory of Diatom Periodicity. Journal of Ecology 11:165-83.
PENNAK, ROBERT W. 1953. *Fresh Water Invertebrates of the United States*. Ronald, New York, 769 pp.
————. 1946. The Dynamics of Fresh Water Plankton Populations. Ecological Monographs 16:340-55.
PRESCOTT, G. W. 1951. *Algae of the Western Great Lakes Area*. Exclusive of Desmids and Diatoms, Cranbrook Institute of Science 30:946 pp.
RILEY, GORDON A. 1940. Limnological Studies in Connecticut, Part III. The Plankton of Lindsey Pond. Ecological Monographs 10:279-306.
ROGICK, MARY D. 1938. Studies on Fresh Water Bryozoa. Transactions American Microscopical Society, 57:178-99.
TEXAS ALMANAC, 1952-53. 672 pp.
TRANSEAU, EDGAR N. 1916. The Periodicity of Fresh-Water Algae. American Journal of Botany 3:121-33.
TRESSLER, WILLIS L. & LAVERNE G. WAGNER. 1940. A Limnological Study of Chautauqua Lake. II. Seasonal Variation. Transactions of the American Microscopical Society, 49:1-30.
WARD, H. B. & G. C. WHIPPLE. 1918. *Fresh-Water Biology*. Wiley, New York. 1111 pp.
WELCH, PAUL S. 1935. *Limnology*. McGraw-Hill, New York, 538 pp.
————. 1948. *Limnological Methods*. Blakiston, Philadelphia, 381 pp.

Distribution of the Barnacle Chthamalus dalli Pilsbry at Cabrillo Point, Monterey Bay, California

William B. Stallcup

In this work, I tried to learn the vertical distribution of *Chthamalus dalli* in the Monterey Bay intertidal zone, and its distribution in such areas as receive, or are protected from, wave impact.

Literature regarding the intertidal distribution of *C. dalli* is scant. Fox (1947) in his unpublished study of sessile barnacles in the Monterey region has given something of the ecology of this species; and Michener (1939) in similar work on the barnacles of the Moss Beach region has stated briefly the distribution of a related species, *Chthamalus fissus* Darwin.

The present data were gathered during July of 1948, chiefly in the rocky intertidal region provided by Cabrillo Point, Monterey Bay. I made many observations and area-counts at many stations around the Point. Counts were made in the following manner: each area was divided into units of dimensions adapted to that area, the barnacles in several units counted, and an average computed for the area. The data have been combined in Tables I, II, and III. In the following discussion I have tried to interpret these and other observations.

Vertical Distribution

Many biologists have observed in the intertidal region that strict biotic zonation is hardly possible, for animals supposedly typical of one zone, are often found in others. Loose statement of biotic zonation (the zones characterized by certain animals and plants), is, however, often useful.

In my area, *C. dalli* was most commonly attached to the rocky substratum, but a few individuals were found attached to mussel shells, iron pipes, and to other barnacles. *Chthamalus dalli* was found in a zone, the lower limit of which was defined by beds of *Mytilus californianus* and by dense growths of algae; while the upper limit was defined by the degree of exposure to desiccation. This vertical distribution extended upward, somewhat, in areas where wave-splash reached greater heights, and in crevice-areas which remained rather damp. This is also the zone in which *Balanus glandula* Darwin occurs. As shown in Table I, however, there are greater concentrations of *C. dalli* in the lower part of the zone, while the greater concentrations of *B. glandula* lie slightly higher. *Balanus glandula* often occurs in large, uninterrupted colonies, but very few such colonies of *C. dalli* occur. Such few colonies occurred on rocks well below the normal *B. glandula* belt, i.e, between +1-ft. and +3-ft. tide level. Here the organisms are submerged for all but four or five hours of the day.

The fact that *C. dalli* can live in lower regions perhaps indicates that it can endure longer periods of submergence than can *B. glandula.* It should be stated here that where, for some reason, *B. glandula* did extend its range to lower regions, its presence seemed greatly to reduce the incidence of *C. dalli.* Some explanation for this fact was sought, but none found. In situations such as the one just described, the individuals of *C. dalli* were attached in the spaces between the *B. glandula,* and to their compartments; and in one instance, a small *C. dalli* was attached to the scutum of a *B. glandula.*

TABLE I

Intertidal Level	Wave Impact		Wave Wash and Splash	
	Chthamalus	*Balanus*	*Chthamalus*	*Balanus*
	Algae covered; few barnacles.		Few scattered barnacles.	
0 - 1	840	500	1920	1500
2 - 3	900	1220	600	1430
3 - 4	300	1840	340	2170
4 - 5	320	940	200	1250

Vertical distribution of *Chthamalus dalli.* Numbers indicate barnacles per square foot. Data on *Balanus glandula* are included for comparison. (Datum in all Tables is mean-low-tide.)

TABLE II

Intertidal Level	Vertical Surface	Flat Surface
0 - +1	few	few
1 - 2	1920	4800
2 - 3	600	960
3 - 4	340	600
4 - 5	200	650

Differences in concentration of *Chthamalus dalli* due to inclination of surface in areas well splashed and washed. Data indicate barnacles per square foot.

TABLE III

Intertidal Level	Splashed	Protected
2 - 3	960	520
3 - 4	600	140

Differences in concentrations of *Chthamalus dalli* on flat surfaces, one type being well protected, the other, well splashed. Data indicate barnacles per square foot.

Distribution as regards Wave Action

In this respect, *C. dalli* occupies three general types of areas which may thus be listed: (a) those which receive wave impact; (b) those which, while protected from impact, receive a great deal of wave splash or wash; and (c) those which are protected from both wave impact and wave splash (although these last areas may remain damp and may receive their normal amounts of submergence.) It was noticed immediately in my study that the greatest concentrations of *C. dalli* did not occur in wave-impact areas (Table I). This paucity of individuals may be due to the difficulties encountered by the larvae at the time of attachment. The greatest concentrations of this barnacle are found in areas which receive a great deal of wave wash and splash.

Here, the rate of water run-off seems to play an important role. One needs only to compare a sharply-inclined surface with one of a gentle or relatively flat slope to see the effects brought about by the speed with which the water runs off the surface (Table II). It may be that the fact that the compartments of those barnacles on a flat surface can retain more water than those of barnacles on an inclined surface, is here important. Greater concentrations of barnacles are found where the water run-off is slower, or in those channels of flat-surfaced rocks in which collects and drains off the water of the area. Here the barnacles are able to feed over longer periods of time. It is interesting to watch the activity of these creatures; they extend and retract their appendages rapidly as the water flows over them, and then close the opercular valves as the water flow ceases.

No large concentrations of *C. dalli* were found in areas well protected from wave wash and splash—even though these areas remained quite damp, underwent normal submergence, and were not in other ways different from areas in which *C. dalli* was found in abundance. (Table III). In several areas where large, flat rocks had parts protected from and parts exposed to wave splash, I found greater concentrations of *C. dalli* in the splashed portion.

Conclusions

Our data show the greatest concentrations of *C. dalli* between +1-ft. and +3-ft. tide levels, where the average time out of water is only three to four hours per day. The fact, also, that here and in higher intertidal zones which are well washed and splashed the barnacles are more numerous, indicates that submergence is an important factor in the distribution of this species. Other factors (amount of insolation, predation) undoubtedly also influence the distribution of this barnacle; but little or no work regarding these factors has been recorded.

BIBLIOGRAPHY

FOX, W. 1947. Distribution of the common sessile barnacles in the Monterey region. Research Report (unpubl.), in library, Hopkins Marine Station, Stanford University.

MICHENER, C. D. 1939. Barnacles of the Moss Beach region. Research Report (unpubl.), in library, Hopkins Marine Station, Stanford University.