Fish Predation on Pulmonate Limpets

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(2 Text figures)

FISHES MAY BE IMPORTANT PREDATORS on invertebrates in tropical marine systems (BAKUS, 1969) either because they inadvertently remove invertebrates while browsing on algae (RANDALL, 1974; VINE, 1974; DAY, 1977) or because they focus specifically on invertebrate prey (HIATT & STRASBURG, 1960). In this note I present indirect evidence that loss of 21% of a population of the intertidal pulmonate limpet *Siphonaria normalis* at Enewetak Island, Enewetak Atoll, Marshall Islands resulted from selective removal by fishes during a spring high tide. Mortality was size-specific and altered the size structure of the population.

Siphonariid limpets occupy specific home sites on rocks (COOK, 1969) when they are not grazing on microscopic algae (VOSS, 1959). Home sites of individuals on soft rocks are marked by "scars," depressions whose dimensions are the same as limpet basal dimensions. Because *Siphonaria normalis* are always "at home" at dead low tide (1 homing failure out of 133 grazing excursions) and limpets which do wander stay close to scars and can be readily recognized by visible gaps between shell margins and the rock, the presence of empty scars at low tide coupled with a lack of "extra" limpets on the rock is evidence of mortality.

Such a combination of events occurred in a *Siphonaria normalis* population located on beachrock on the lagoon side of Enewetak Island. During one late afternoon spring tide (1.5 m above 0 datum, October 6, 1975), four of the 19 original residents of a 25 x 25 cm quadrat disappeared. On the next daytime low tide, I found no "extra" limpets and discovered that empty scars were distinctively marked with grooves extending from the adjacent rock down into scars (Figure 1). Within a nearby 50 x 50 cm area, similar marks were associated with the empty scars of 10 of 49 residents, while all of another 50 empty scars on the rock outside of these two areas were marked. Marks were rare on the rock between scars (<10% of the total number found).

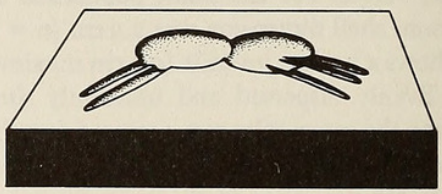

Figure 1

Two adjacent empty limpet scars marked by prominent grooves; each scar is about 8 mm in length

Bits of limpet tissue present in two of the marked scars confirmed that limpet mortality had indeed occurred. Although the rock in the vicinity of two additional animals was also marked, these animals escaped removal. All empty scars and marks were obliterated by algal growth within 2-4 days.

Marks were of an appropriate size and spacing to have been made by the canine teeth of a large wrasse such as *Coris aygula* (J. Randall, personal communication). This species is found at Enewetak in shoal areas, as well as deeper water, and often eats mollusks (J. Randall, pers. comm.). Two other possible predators, the golden plover *Pluvialis dominica* (A. Kohn, pers. comm.) and the muricid gastropod *Thais armigera* (Menge, 1973), can be excluded. Plovers are not likely to dive to reach limpets submerged during spring high tides. Predatory snails were not

seen in the area either before or after limpet loss and in any case would not have left grooves on the rock.

Large limpets were clearly more affected than were smaller individuals. The mean length of empty scars (and therefore of former residents) was significantly greater than the mean length of survivors (Figure 2, t-test, $P < 0.001$). Proportions of scars in the size categories 4-7 mm and 8-12 mm were significantly different from proportions expected if limpets had been removed according to initial abundance (chi-square goodness of fit, $P < 0.05$). One reason for the relatively better survival of small individuals may be inaccessibility: the two survivors mentioned earlier were small (<6 mm) individuals whose homes were located at the bottoms of small pits in the rock. Predation resulted in a small but significant decline in the mean length of limpets within the two quadrats (from 6.7 mm to 6.1 mm, t-test, $0.05 > P > 0.02$).

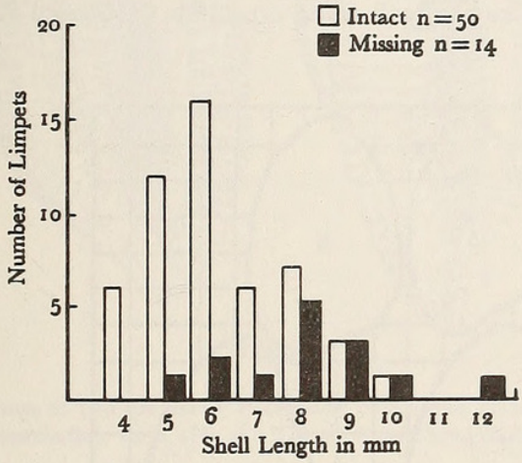

Figure 2

Size comparisons of intact limpets on scars and unoccupied grooved limpet scars following fish predation

Information on how often fish predation affects tropical limpet populations over the long term is lacking. Although such predation is one explanation for the scarcity of large *Siphonaria normalis* at Enewetak (less than 1% larger than 8 mm, MENGE, 1973; less than 1% larger than 8 mm at another study site, Cook, unpublished), alternative explanations are possible. These include size-specific predation by *Thais* (MENGE, 1973) or shorebirds, or both, as well as periodic catastrophic mortality of all limpets followed by recruitment and growth of recruits into small to medium sized limpets.

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