

Strength varies significantly from shore to shore, and with the level on the shore from which the animals were collected. These differences become highly significant when allowance is made for variation in the sizes of the animals, which was effected using the model II (also termed reduced major axis or geometric mean) regression coefficients between  $\ln(\text{strength})$  and  $\ln(\text{shell size})$ . Strength increases down the shore in both species. There is a very significant rank correlation between corrected strength of the shells and the exposure index of the shore in both species, but this does not fully account for shore-to-shore variation. Furthermore the sign of the correlation differs between the species; the corrected strength decreases with exposure in *L. mariae* but increases in *L. obtusata*.

The logarithm of shell strength is more closely correlated with  $\ln(\text{shell mass})$  than with  $\ln(\text{shell strength})$  in both species. However path analysis of the relationships between the natural logarithms of the measured variables indicates that a better predictor of  $\ln(\text{shell strength})$  is a parameter which is heavily positively loaded on  $\ln(\text{shell mass})$  and strongly offset by a negative loading on  $\ln(\text{shell size})$ . Such a combination of  $\ln(\text{size})$  and  $\ln(\text{shell mass})$  with loadings of 2.3 and -1.3 times the respective model II regression coefficients accounts for 83 % of the variation in *L. mariae* compared with 62 % using  $\ln(\text{size})$  alone, and the remaining variation does not contain any significant dependence on the shore or on the zone and shows only a residual sexual dimorphism. Similar treatment accounts for 77 % of the variation in the strength of *L. obtusata* compared with under 50 % using  $\ln(\text{size})$  alone. The variation between shores and that between zones are reduced by more than 90 % (although they remain significant in this species), and the other identified sources of variation in this species, maturity and parasitism are similarly largely explained.

Thus most of the observed variation in strength from shore to shore and with tidal zone may be explained by the two measures, maximum shell size and shell mass used with appropriate loadings.

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## Shape, size and enzymes : the problem of *Littorina neglecta*

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Among the rough periwinkles on European shores there occur small, barnacle-dwelling individuals. In many instances these may be simply juveniles of the three large species. However there are sexually mature individuals as well, and Reid (1993) has suggested that *Littorina saxatilis*, *L. arcana* and *L. nigrolineata* are all capable of producing forms which may mature at a small size. In view of this, Reid concluded that the evidence was consistent with *L. neglecta* being a barnacle-dwelling ecotype of *L. saxatilis*. In earlier work, Johannesson & Johannesson (1990) examined material from Wales, the Isle of Man, Iceland and Sweden, and concluded that *L. neglecta* was an ecotype of *L. saxatilis*, and that there was gene flow between the populations on any one shore.

In the present work we do not address the question of gene flow, nor do we seek to examine material from a range of sites. We concentrate on one site, the densely barnacle populated platform at 'Peak Steel', on the Yorkshire coast at Ravenscar (Grid Reference NZ/979026). On this shore, small and large individuals of *L. saxatilis* and *L. arcana* occur with large animals living on the boulders and cliff habitats and small ones in the barnacles. We have not found any reproductively active small *L. arcana* in the barnacles, judging by the absence of females with turgid, opalescent pallial oviducts in this habitat and size category. We have found what appear to be reproductively active *L. saxatilis* at shell sizes of < 5 mm. These animals are judged to be *L. saxatilis* on the basis of similarity of shell to nearby boulder populations where the animals are of the larger, 'usual' size, and also on the basis of metabolic studies. We have investigated the activity of the enzymes Aat and Alat in these animals, and find that *L. saxatilis* fall into two metabolic types : high shore animals with higher thermal tolerance of the enzymes, and low shore animals with lower thermal tolerance identical to that of the barnacle-dwelling form. The relative activity levels of the two enzymes is shown to be the same between barnacle-dwelling (small) *L. saxatilis* and low shore (boulder) *L. saxatilis* (ANCOVA,  $P = 0.9458$ ). Distinct from these is another small, barnacle-dwelling brooding periwinkle. This is distinguished by having a slightly more 'patulous' shell with a thinner posterior lip. In a sample of 10 breeding females, the mean size of six shells (*L. saxatilis*) was 3.376 mm (range 2.627 - 3.983 mm), and of the remaining four was 2.687 mm (range 2.505 - 2.972 mm). We suggest that this smaller and differently shaped form represents *L. neglecta*. As well as being distinct in terms of shape, it is metabolically distinct : the enzyme thermal tolerance is lower than that of low shore or small barnacle-dwelling *L. saxatilis*, and the relative enzyme activity levels is different (ANCOVA,  $P = 0.0015$ , for the difference between small *L. saxatilis* and *L. neglecta*).

We conclude that either *L. saxatilis* produces two distinctly different barnacle-dwelling ecotypes on this shore, differing both in shape and in metabolic characteristics, or that *L. neglecta* does exist as a separate and distinct species. The differences between the two forms would strongly suggest the latter to be the case, clearly more work is needed on this system as the potential for understanding evolutionary processes is considerable.

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## Comparison of imposex response in three prosobranch species

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Two methods have been used to analyse imposex phenomenon in gastropods. One uses narcotization and the other does not. In order to compare calculated indices (RPSI = Relative Penis Size Index and VDSI = Vas Deferens Sequence Index) obtained with the two methods, samples were analysed using the two methods. Narcotization leads to an underestimation of RPSI in relation to the method non using narcotization. Furthermore narcotiza-