change in chloroplast gene frequency within the lifespan of an individual plant. For example, a polymorphic plant that survives herbicide treatment will probably have eliminated susceptible chloroplasts, and will be insensitive to further herbicide treatment. If this process is completed before the plant starts to develop seeds, its progeny will carry only the resistant chloroplast DNA genotype and may therefore be completely resistant to herbicides. Such a phenotypic effect has been found in *Chenopodium album*, in which sublethal treatment with atrazine of plants with intermediate resistance resulted in resistant seeds[9]. This within-plant selection between different chloroplast DNA types will occur whether polymorphism results from rare bipaternal inheritance or stable transmission.

Chloroplast DNA polymorphism therefore provides an additional level of selection that gives plants a powerful mechanism by which they can adapt rapidly to specific environments. This mechanism may in part be responsible for the very rapid evolution of triazine resistance in *S. vulgaris*.

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Are vent shrimps blinded by science?

The exploration of deep-sea hydrothermal vents has depended on the use of manned submersibles, which are invariably equipped with high-intensity floodlights. But the eyes of many deep-sea crustaceans, which are exquisitely adapted for the dim conditions at such depths, can suffer permanent retinal damage as a result[1–3]. We suggest that the use of floodlights has irretrievably damaged the eyes of many of the decapod shrimps (family Bresiliidae) that dominate the fauna at vents on the Mid-Atlantic Ridge[4].

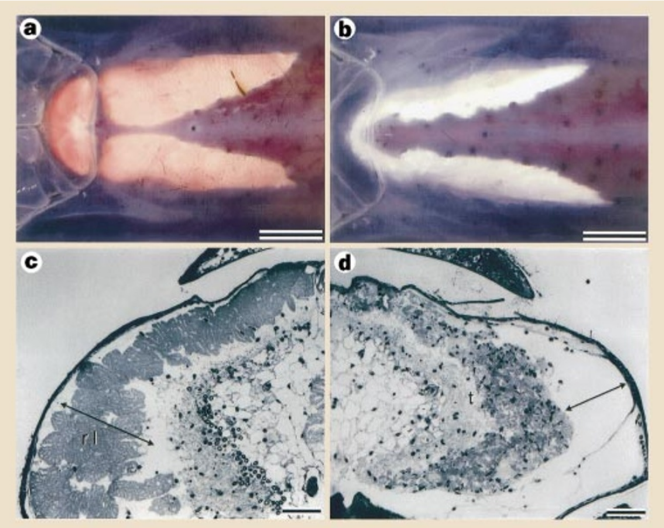

Figure 1 Eyes of deep-sea shrimp. **a, b,** The dorsal surface of live *Rimicaris exoculata* showing variations in the thoracic eye: **a,** the pink-eyed type, possibly coloured by rhodopsin; **b,** the white-eyed type, apparently with only the reflective tapetum. **c, d,** Sections through resin-embedded specimens of *Mirocaris fortunata*. **c,** In pink-eyed specimens there is an extensive rhabdom layer (rl, arrow) extending beneath the carapace from the mid-line to the lateral margin. **d,** In white-eyed specimens there is no rhabdom layer (arrow), although the tapetum (t) remains undamaged. Scale bars: **a,b,** 1 mm; **c,d,** 100 μm.

We collected *Rimicaris exoculata* and *Mirocaris* (*Chorocaris*) *fortunata* shrimps at the Rainbow and Lucky Strike sites, respectively, using the submersible *Nautile* during the AMORES Marvel cruise of RV *Atalante* in August 1997. We captured the animals by using a suction pump in floodlight illumination and brought them to the surface in a blacked-out Perspex chamber, which provided limited protection against surface light exposure.

The thoracic eyes of some individuals were pink, with a smooth outline and regularly dappled appearance (Fig. 1a), whereas others were a matt chalky white, often with dark areas or streaks in the otherwise featureless reflector (Fig.1b). We examined the morphology of pairs of specimens of both *R. exoculata* and *M. fortunata* with pink and white eyes, each pair taken from the same sample. The pink-eyed specimens show the normal extensive rhabdom (photoreceptor) layer[5,6], although there is some evidence (confirmed by electron microscopy) of recent damage to the microvilli (Fig. 1c). The white-eyed specimens of both species show severe breakdown, often with complete loss of the rhabdom layer (Fig. 1d).

The Rainbow site was discovered in 1994 by remote physicochemical sampling without illumination[7]. The submersibles *Alvin* and *Nautile* first visited the active vents in July 1997. We suggest that the retinal damage observed in white-eyed *R. exoculata*, collected just one month later, was caused by the lights used during these surveys. The shrimps swarm over the vent chimneys and are illuminated by any vehicle working at the active region. The Lucky Strike sites have been visited many times, and we believe that the differences in our Lucky Strike specimens of *M. fortunata*, most of which had white eyes, have the same cause.

The eye structures of vent shrimps have varying degrees of abnormality, usually ascribed either to poor fixation or to light damage during collection[5,6,8]. *Alvinocaris*, for example, apparently has no rhabdoms[9], but this may be a consequence of previous encounters with a submersible, rather than being a specific adaptation. The only cases where damage has not been observed are those of juvenile specimens taken by trawling in midwater well above the vents[10]. These shrimps would not have been subject to previous floodlighting.

The rate of onset of retinal pathology is slow enough for the structure of the retina to be relatively unaffected over a period of hours (as can be seen from our illuminated pink-eyed specimens) but rapid enough for dramatic deterioration to occur in the few weeks between the initial visits to the Rainbow site and our capture of the *R. exoculata* specimens. There is at present no means of working at the vents without causing this damage, so every vent population visited will already have been exposed to it.

We have established an associative link but not a causal one. Confirmation of these conclusions will require study of the eyes of shrimp captured at the first visit to any new vent site and, ideally, an *in situ* time series of light-exposed specimens from the same site. Meanwhile, any behavioural observations at previously visited vent sites may relate to shrimp that are already blind.

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