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Effects of *Polymorphus* (Acanthocephala) on Colour and Behaviour of *Gammarus lacustris*

IN 1969–70 1,420 adult specimens of the amphipod *Gammarus lacustris* were taken from 2 eutrophic ponds in the northern Zealand; 94.9% were normal in colour (grey to brown) and 5.1% were blue. Dissections showed that all the blue shrimps were infected with the final larval stage (cystacanth) of the acanthocephalan genus *Polymorphus*, whereas the brown shrimps were only 3.9% infected with cystacanths. This difference was statistically highly significant ($\chi^2 = 860.2$, $P < 0.001$).

Two of these parasites were successfully reared to adults in a domestic duck and were identified as *Polymorphus minutus*. Measurements of the proboscis hooks of 12 larvae indicated that these were probably *P. minutus*.

Occurrence of the blue shrimps varied throughout the year; the first few specimens occurred in May and the maximum number was reached in June–July simultaneously with the highest infection. No blue shrimps were found during the winter.

On air drying at room temperature the brown shrimps turned red; the blue specimens turned pale, suggesting a lack of carotenoid pigment. To test this possibility the total carotenoid contents of 13 blue and 28 brown male shrimps were extracted. Because of indications of a fluctuation in the carotenoid content of the ovaries correlated with the reproduction cycle, female shrimps were not studied. Before extraction the parasites were removed from infected shrimps. Spectrophotometric examination of the extracts showed a smaller amount of carotenoids/mg wet weight in the blue shrimps as compared with the brown shrimps ($P = 0.016$ by the binomial test).

Using a dissection needle I punctured the shrimps dorsally under water and the colour of the outflowing haemolymph was estimated by eye. From 625 uninfected brown shrimps the colour distribution was 59.8% blue, 13.1% bluish-green and 27.0% green. From 20 brown shrimps, harbouring cystacanths, the frequency of the blue haemolymph was higher (90%) ($\chi^2 = 7.4$, $0.01 > P > 0.005$). The frequency of the blue haemolymph among 9 brown shrimps infected with the growth stage (acanthella) of the parasite, on the contrary, did not differ significantly from the uninfected shrimps ($\chi^2 = 0.015$, $0.70 > P > 0.50$). All blue shrimps contained blue haemolymph. Their colour was lost when all the haemolymph was removed, indicating that the abnormal colour was due to blue haemolymph seen through an unpigmented cuticle. The brown specimens, on the contrary, did not change colour on removal of the haemolymph, owing to the normal pigmentation of the cuticle masking the colour of the haemolymph.

The red colour of the cystacanth of *P. minutus* has previously been shown to be due to esterified astaxanthin derived from the shrimps[1]. My results show that the larvae of *P. minutus* affect the amount and distribution of the carotenoids of *G. lacustris*.

A colour change of the shore crab *Carcinus maenas*, due to carotenoid intake by the rhizocephalian parasite *Sacculina carcini*, has previously been described[2].

Because of the contrast of their light blue colour to the dark bottom of their ponds, the blue shrimps were easily seen when swimming in the surface water. The preferred occupation site of the shrimps was tested in the laboratory. A total of 18 infected blue and 26 uninfected brown shrimps were placed in an aquarium with a light exposed top and a dark bottom. The bottom was provided with bottom material and *Fontinalis* sp. from the ponds; this resembled the conditions in the natural habitat. The shrimps inhabiting the light exposed area were counted 50 times with intervals of 30 seconds, and after every 10 countings the shrimps were disturbed by stirring. The dark bottom was most frequently inhabited by both the blue and the brown shrimps but in the light exposed top area the blue shrimps were observed 81 times more frequently than the brown ones.

By varying the light and dark areas I have confirmed that blue shrimps show a higher positive phototropism.

Denny[3] found that *G. lacustris* infected with *Polymorphus paradoxus* were found more frequently among shrimps clinging to floating objects than among shrimps caught from the bottom. In this respect *P. paradoxus* resembles *P. minutus* but Denny does not mention any colour changes.

The behaviour of the blue *G. lacustris* increases the chance of the parasites' reaching their final hosts (waterbirds). This was shown by placing a domestic duckling in an aquarium to which were added 11 blue (infected) and 39 brown uninfected shrimps selected from a July sample, giving a distribution of infected shrimps similar (22%) to that found in the sample. After about half of the blue shrimps had been eaten the duckling was removed and the residual shrimps were counted. The result showed that 7 blue and 10 brown shrimps were eaten, that is, the chance of being eaten was 2.5 times greater for the blue than for the brown shrimps ($\chi^2 = 5.5$, $0.025 > P > 0.020$).

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Effects of Alkali Metal Chlorides on Activity in Rats

LITHIUM salts are widely used in the clinical control of manic states[1] and also have effects on animal behaviour, suppressing vertical rearing activity in rats[2] and reducing aggression in several species[3–5]. In contrast, salts of rubidium increase activity and aggression in mice and monkeys[6,7], leading to the suggestion that rubidium might be useful in the clinical