J. mar. biol. Ass. U.K. (1958) 37, 43–47
Printed in Great Britain

SPECTRAL COMPOSITION OF THE LIGHT OF *PHOLAS DACTYLUS* L.

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(Text-figs. 1–6)

The light of the piddock *Pholas dactylus* L. appears bluish, but its spectral energy composition has not been determined. A spectral energy curve for the light of this species is desirable in order to calculate absolute energy content (radiant flux) and to relate it to pertinent visibility curves. To this end I have determined relative spectral energy approximately by means of a set of nine different spectral filters, covering the visual spectrum and the near ultra-violet and infra-red.

MATERIAL AND METHODS

Specimens of *Pholas dactylus* were obtained from the red sandstone at Exmouth, near low tide level. The animals were anaesthetized with iso-osmotic $MgCl_2$ and the luminous regions removed. These have been described and figured by Panceri and others (literature in Harvey, 1952). I selected the paired triangular organs in the mantle cavity and the siphonal cords for recording. The bits of tissue were washed in running sea water, and pinned out in black dishes.

The light from the pholads was analysed by means of spectral filters mounted in a rotating disc. The luminescent tissue was placed below the disc, the photomultiplier above, so that light passed through the various filters in turn as the disc revolved. Rotation of the disc was slow, about 1 revolution each 3 min. The photomultiplier was connected to a cathode-ray oscilloscope, and the deflexions were photographed on moving paper. Noise level was reduced by placing a 0·05 μF condenser across the input of the oscilloscope. The apparatus is described in more detail elsewhere (Nicol, 1957).

The photomultiplier was an E.M.I. tube, type no. 6685, with a blue-sensitive photocathode, the spectral sensitivity of which had been measured by the National Physical Laboratory. The disc contained the same spectral filters as the disc IV used for *Chaetopterus* (Nicol, 1957, p. 631), namely, in sequence, Ilford red 608, Ilford orange 607, Ilford yellow 606, Ilford yellow-green 605, Ilford blue-green 603 plus Chance neutral ON 31, Ilford blue 602 plus Chance neutral ON 32, Ilford violet 601 plus Chance neutral ON 33, Chance deep purple OV 1, with Ilford green 604 interposed between each.

Curves for the products of sensitivity of the photomultiplier (S_λ) times transmission of a filter (T_λ), plotted against λ, are given in Nicol (1957, fig. 5). In the same paper will be found values for $\eta_x = \int S_\lambda T_\lambda d\lambda$, and mean representative wavelengths (mean λ) for these particular filters (x = filter).

Luminescence was evoked by electrical stimulation. Light is extracellular, and the response is slow, lasting several minutes. Temperatures were 18–19° C.

OBSERVATIONS

A photographic record of the responses obtained with the spectral filters is shown in Fig. 1. Responses obtained with the green filters No. 604 were used as reference levels. Let $D_{604(1)}$ and $D_{604(2)}$ be the measured deflexions of two contiguous green filters 604, and let D_x be the measured deflexion of a spectral filter placed between the two green filters. Then the corrected response is $2D_x/(D_{604(1)} + D_{604(2)}) = R_x$. By this means, changes of light-intensity at the source are compensated for.

First approximate results $R_x/\eta_x = Q_x$ are plotted in Fig. 2. The light is blue-green, with a peak at about 490 mμ. There is no emission below 410 mμ, and emission in the red is small.

To correct these first results for broad spectral transmission of the filters, the following procedure was adopted. Spectral energy levels ($E_{\lambda A}$) were taken from the curve in Fig. 2, and new curves were drawn for $E_{\lambda A} S_\lambda T_\lambda$ against λ (Fig. 4). Ratios were calculated:

$$\rho_1 = \frac{\int E_{\lambda A} S_\lambda T_\lambda \text{ filter } X}{\int E_{\lambda A} S_\lambda T_\lambda \text{ filter } 603}, \quad \rho_2 = \frac{R_x}{R_{603}},$$

and $\rho_2/\rho_1 = \rho_3$.

The values for ρ_3 were then used to correct the first approximate results, thus $Q_x \rho_3$. Values for the latter are plotted against mean λ in Fig. 3, and a new

Fig. 1. Oscillograph record of the light of *Pholas* passed through spectral filters. Filters presented in the following order: 1, red 608; 2, green 604; 3, orange 607; 4, green 604; 5, yellow 606; 6, green 604; 7, yellow-green 605; 8, green 604; 9, blue-green 603 + Chance neutral ON 31; 10, green 604; 11, blue 602 + Chance neutral ON 32; 12, green 604; 13, violet 601 + Chance neutral ON 33; 14, green 604; 15, Chance deep purple OV 1; 16, green 604. Light falling on the photomultiplier causes a downward deflexion of the lower trace. Time scale above $\frac{1}{5}$ sec.

spectral energy curve is drawn for these values. The value of mean λ for each filter, used in Fig. 3, has been estimated from the centre of gravity of the individual curves $E_{\lambda A} S_\lambda T_\lambda$ of Fig. 4.

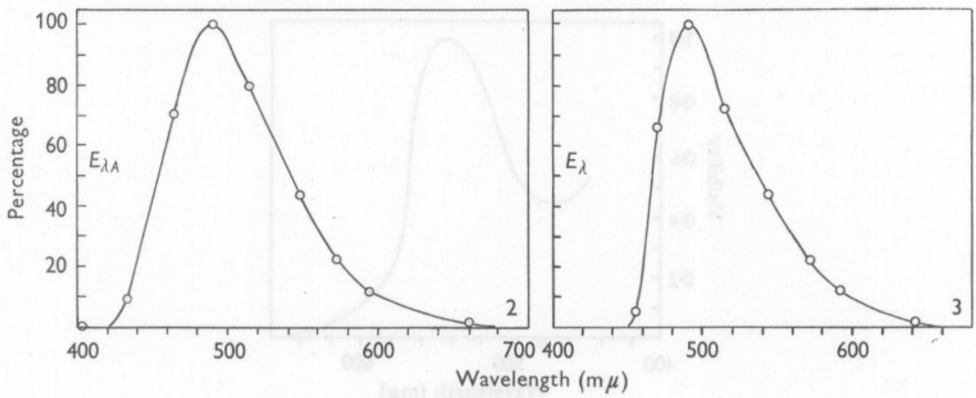

Fig. 2 Fig. 3

Figs. 2, 3. Spectral composition of the light of *Pholas dactylus*. Relative emission plotted against mean λ of the filters. Fig. 2, first approximate results. Fig. 3, corrected results (see text for details).

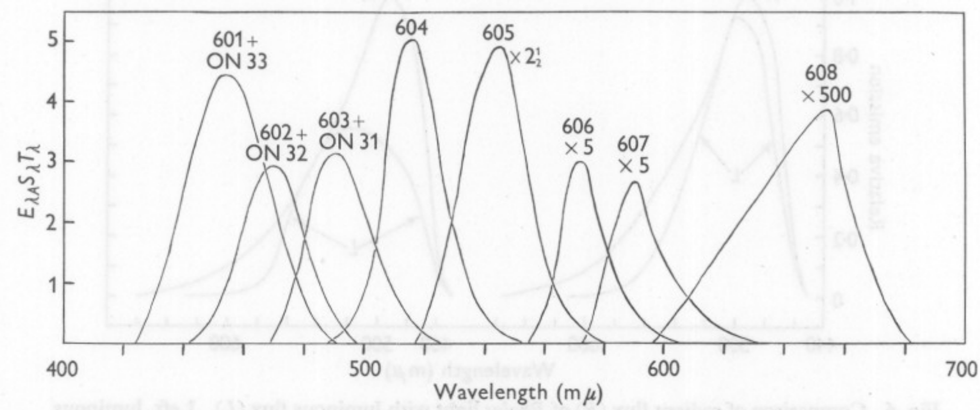

Fig 4. Plots of $E_{\lambda A} S_\lambda T_\lambda$ against λ. ($E_{\lambda A}$ = relative spectral emission (from Fig. 2); S_λ = relative spectral sensitivity of photomultiplier; T_λ = transmission of filter(s).)

COMMENT

The light of *Pholas* is blue-green. Spectral emission extends from about 440 to 670 mμ, with a maximum at about 490 mμ. The action spectrum of *Pholas* has been determined (Hecht, 1928), and it is reproduced in Fig. 5. This has a maximum at about 545 mμ, with evidence for another rise in the violet. Visibility and luminescence spectra, therefore, are quite dissimilar in shape, although all energy is emitted in a spectral range to which *Pholas* is sensitive. 'Luminous flux' for *Pholas* vision and human scotopic vision have been calculated, and curves for these values plotted against λ are shown in Fig. 6. 'Luminous efficiencies' (total luminous flux ÷ total radiant flux) are

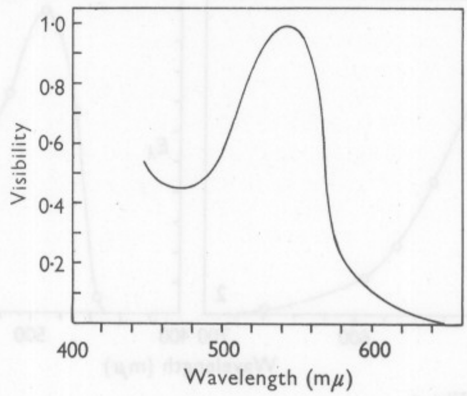

Fig. 5. Action spectrum of the light of *Pholas dactylus*. From Hecht, 1928.

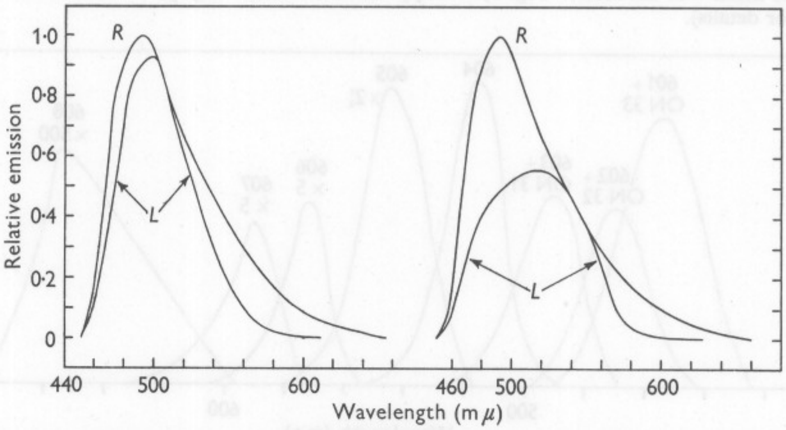

Fig. 6. Comparison of radiant flux (*R*) of *Pholas* light with luminous flux (*L*). Left, luminous flux based on human scotopic vision. Right, luminous flux based on Hecht's visibility curve for *Pholas*.

61% for *Pholas* visibility, and 76% for human scotopic vision. The use to which *Pholas* puts its light is unknown. Absolute threshold for photo-sensitivity and the intensity of *Pholas* luminescence have not yet been determined, so it is uncertain whether *Pholas* can detect or respond to its own light.

SUMMARY

A spectral emission curve for the light of *Pholas dactylus* has been determined by means of spectral filters and photomultiplier cell. Emission extends from about 440 to 670 mμ, with a maximum at about 490 mμ. The emission curve is compared with the action spectrum determined by Hecht.

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