

Fig. 2 *Xenopus romeri*, n. sp., DGM 569. A, ventral view of snout; B, dorsal view of snout; C, right lateral view of skull. Abbreviations as in Fig. 1

ment with regard to the timing of the separation, but available evidence indicates that a date of 120 Myr (early Cretaceous: Neocomian) for the onset of plate separation is consistent with a date of 90 Myr (late Cretaceous: Turonian) for the actual separation of the continents by a water gap. By about 70 Myr ago (late Cretaceous: Maastrichtian) there seems to have been a gap large enough to have prevented east-west migration of marine reef colonies⁴. *Xenopus* tadpoles can tolerate some salinity¹¹, but in view of the aquatic habits of the genus such tolerance would probably not be sufficient to permit migration over an oceanic barrier, even on a large raft of floating vegetation. It thus seems possible that species of *Xenopus* not much more primitive than *X. romeri* (and therefore closely related to extant species) had developed by at least 70 Myr ago, and possibly as far back as 95 Myr ago¹².

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Physical basis and ecological significance of iridescence in blue plants

MANY terrestrial plants of lowland tropical rainforests exhibit a conspicuous blue-green iridescence on their leaves—Richards¹ has observed these plants in Africa, South America, and South-east Asia. We have seen many species of blue plants on the rainforest floor in Malaya, from diverse groups including the ferns, *Selaginella*, and flowering plants. In Malaya the most spectacular and most common iridescent blue plant is *Selaginella willdenovii* (Desv.) Spring, also frequently cultivated in greenhouses. All comments on the iridescent colour refer back to the observation of Stahl² who reported the presence of reflection granules in the epidermal cells of *S. willdenovii*.

Although there has been ample research on iridescent colour in animals, virtually nothing has been done with plants. The iridescent green colour of the cave moss, *Schistostega*, has been explained by the presence of peculiar epidermal cells which act as refractive lenses, focusing light on specially

oriented chloroplasts³. Here, we propose an explanation for the iridescent blue colour in plants (*S. willdenovii* in particular), provide evidence supporting our hypothesis, and speculate on the physiological and ecological significance of this iridescent blue colour in shade-tolerant herbaceous tropical plants.

Stahl's early conclusions about plant iridescence can be refuted by simple observation. First, the existence of granules reflecting blue light cannot be verified by microscopic observation. Secondly, the iridescent colour disappears when the leaves are immersed in water. Therefore, the colour must be an optical effect of the leaf surface and not of the internal structure. The two optical phenomena that can provide a physical basis for this effect are diffraction and thin-film interference, both of which have been invoked to explain the iridescent colouring of many animal cuticles^{4,5}. Diffraction effects can be ruled out in the present case because there is no dispersion; reflected blue colour is constant for white incident light over a wide range of angle of incidence. Furthermore, microscopic examination has revealed no surface features that could function as a grating. Therefore, we suggest that the iridescent blue colour in *S. willdenovii* is caused by a thin-film quarter wavelength interference filter on the upper cell wall of the epidermis. This would account for previous observations; and direct experimental support has been obtained by analysing the reflectance of light from the leaves. The spectral analysis was carried out using a Beckman Acta V spectrophotometer with total fluorescence attachment. An opaque blank was used to project a monochromatic beam of light on to the leaf (at an incident angle of 60°) and to measure its intensity reflected (at the same incident angle) into the photocell. A slit programme and a wavelength interval of 300–700 nm were used for all measurements.

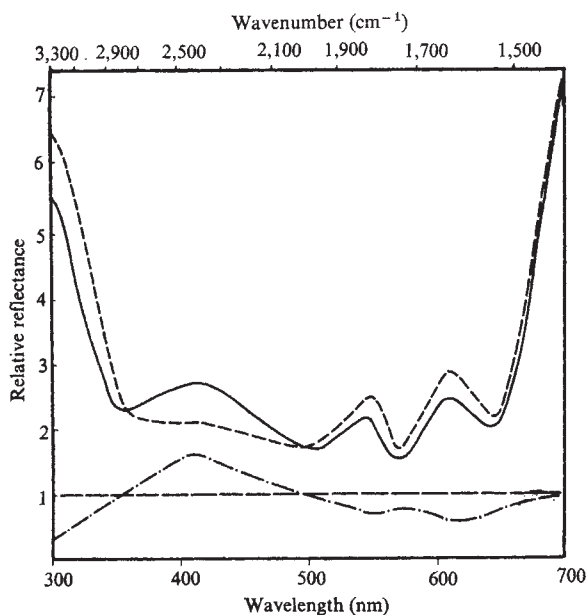


Fig. 1 Reflectance spectra of *S. willdenovii* leaves. Reflectance of the iridescent leaves is indicated by the solid line, of the non-iridescent leaves by the dashed line, and the difference between the two by the dotted line. The horizontal dashed line indicates wavelengths of enhanced reflection or transmission. Reflectance units are relative, and based on response of the spectrophotometer on a scale of percentage transmission.

When iridescent leaves age or are exposed to sunlight for some time they lose their iridescence and develop an ordinary green appearance. Chlorophyll content was found to be the same in both types of leaves (12 mg per g dry weight, by a colorimetric determination). We measured the reflectance of both iridescent and non-iridescent leaves, and plotted a difference spectrum (Fig. 1). The difference spectrum shows maximum enhanced reflectance at 405 nm, a null point at

500 nm, and decreased reflectance at longer wavelengths; the effect was obscured above 660 nm by the strong reflective characteristics of all leaves^{6,7}. This curve corresponds closely with the operation of a quarter wavelength interference filter. Precise analysis of the curve is only possible if the refractive index (n) of the filter is known. We were not able to determine this, but estimate the filter thickness at 135–150 nm (assuming $n = 1.4$ – 1.5). Electron microscopic analysis would verify the existence of such a structural layer on the wall surface. Solubility experiments suggested that cuticular waxes were not acting as the filter; the structural basis may well lie in cellulose orientation at the wall surface.

General field observations suggest the functional significance of iridescence in certain plants. Iridescent blue plants from distantly related groups grow exclusively in extremely shady tropical forest environments. Furthermore, we have observed that leaves of *S. willdenovii* lose their iridescence when they grow in sunlight, even when shade-green leaves of the same plant have the iridescent colour. The light climate on the floor of the rainforest is extremely limiting for plants; the light intensity is low and deficient in wavelengths important for photosynthesis^{10–12}. The ecological importance of an interference filter in these circumstances is that the increased reflection of photosynthetically less active light (400–500 nm) is accompanied by increased penetration in the most photosynthetically active range (600–680 nm); this would have definite adaptive value. Finally, preliminary observations on the leaf anatomy of *S. willdenovii* indicate that the epidermal cells of these plants—egg-shaped with convex outer surface and chloroplasts in a peculiar position distal to the surface—may also function as lenses in a manner similar to that found in the moss *Schistostegia*⁸. Thus the analogy of a camera with coated lens may aid our understanding of the function of the leaf surfaces in these iridescent plants.

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Sex recognition pheromone in tsetse fly *Glossina morsitans*

ATTEMPTS to identify a sex attractant substance in tsetse flies have failed because there seems to be no olfactory agent for sex recognition^{1,2}. Males are apparently sexually activated only by movement of the female, but the adverse effects of naturally occurring low population densities³ on mating frequency is overcome as both sexes encounter one another at relatively high density around host animals¹. Experience in the laboratory confirms that sexual arousal in male tsetse flies, *Glossina morsitans morsitans* (Westwood), is initiated by movement of other individuals. Thus, mature adult males will initiate sexual behaviour in the absence of females and the level of activity is increased if the flies are disturbed. This behaviour ceases, however, as soon as physical contact is made with the target