Reply to Roberts et al.: Reflectivity and pointillist structural color on land and in water

Roberts et al. (1) point out the dominance of water creatures when it comes to multilayer interference in nature, both qualitatively and in terms of quantity. This is perhaps unsurprising when we consider that 70% of the earth is covered by water and that marine life has had a considerably longer time frame than terrestrial plants in which to develop and refine optical innovations. In our comparison of the reflectivity of the *Pollia* fruit to that of structurally colored animals, we focused only on terrestrial species. Although these are most conspicuous to us, Roberts et al. are correct in pointing out the dominance of fish and squid. An accurate revision of our text (2) would state: "The bright blue coloration of this fruit is more intense than that of many previously described biological materials" and "this is the highest reported reflectivity of any land-based biological organism including beetle exoskeleton, bird feathers, and the famously intense blue of *Morpho* butterfly scales."

Interestingly, the primary roles of structural color on land and in water differ. On land, structural color is most frequently used to attract attention, for mate or pollinator attraction, as a warning signal, or, as in the present case, for seed dispersal. The high-broadband reflectivity of fish scales, on the contrary, is a camouflage strategy, reducing the visibility of the fish from below as their bodies merge with the bright surface of the water, thereby protecting them from deeper-water predators. The extraordinarily high reflectivity of fish scales might therefore be interpreted as a consequence of the strong selective pressure to avoid predation—surviving (to reproductive age) is a stronger biological imperative than wide dispersal of offspring that have already been successfully produced.

We do not agree with Roberts et al. (1) that the pointillist effect we describe in the *Pollia condensata* fruit is the same as that described in various animal species. In this case, we believe convergent evolution has resulted in slightly different optical phenomena. Pointillist paintings such as Seurat's "La Parade de Cirque" are defined by the visually discernible individual color spots forming the image. Schultz and Bernard (3), who used this expression in the title of their paper, stated that "these colour patches are too small to be resolved by the unaided eye and spatially fuse to produce an additive colour mixture" (3). In contrast, the different colors produced by the individual epicarp cells of *P. condensata* are clearly visible. To split hairs, we would describe the tiger beetle coloration as "pixelated," like that of a computer screen, whereas the *Pollia* fruit is truly "pointillist," like Seurat's paintings.

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3. Schultz TD, Bernard GD (1989) Pointillistic mixing of interference colours in cryptic tiger beetles. *Nature* 377:72–73.

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