Is that a testes or an iridescent stripe? A female squid's male-like true colors

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During his time in Daniel Morse's lab at the University of California Santa Barbara, USA, PhD student Daniel DeMartini has seen many Doryteuthis opalescens squid pass through the lab's doors. These squid provide DeMartini with a steady supply of the iridocyte cells that are responsible for the squid's shimmering opal-like markings. Iridocytes are found in many cephalopods, but what makes those of D. opalescens so special is their ability to adapt and produce a rainbow of different colours from the same cell. Most iridocytes are found in patches across the squid's body but DeMartini recalls: 'We started to notice that some squid had bright iridescent rainbow stripes underneath their fins. Sometimes most of the squid in a batch would have them, sometimes none. After a while we started to realise the rainbow stripes were only seen in the females.' So after a few years of observing this, DeMartini decided to investigate this female-only trait further, publishing his results in *The Journal of Experimental Biology*.

Upon the squid's arrival in the lab, DeMartini noted that on average, only half the females displayed colourful stripes, yet all were capable of producing them, as an hour after death all females had these vibrant markings adorning their bodies. When DeMartini examined the underlying tissue under a microscope he found it was full of iridocytes jam packed with layer upon layer of reflectins (the proteins responsible for reflecting the light as colour). The sheer number of iridocytes each packed with a high number of reflectin layers results in stripes that are six times brighter than other patches of iridocytes.

Sandwiched between the two colourful stripes, DeMartini also noticed a large bright white area whose appearance coincided with the emergence of the iridescent streaks. When he delved a little deeper he found the underlying tissue was made up of leucophore cells. Like iridocytes, leucophores contain reflectin proteins, but instead of being arranged into layers, these light-reflecting proteins are packaged into rounded compartments throughout the cell. This alternative arrangement scatters light of all wavelengths, instead of reflecting just a single wavelength as colour, making the skin look white.

While leucophores are widespread in cephalopods, this is the first time switchable leucophores have been identified in D. opalescens squid. What's more, these leucophores are predominantly made up of reflectin subtypes that have only ever been found in adaptive iridocytes before. In iridocytes, these adaptive reflectins contract and change their refractive properties in response to the neurotransmitter acetylcholine, allowing them to fine-tune colour of the reflected light. But are they also adaptive in a leucophores? Sure enough, when DeMartini treated the female squid with acetylcholine the white region became brighter. 'This discovery reveals a fundamental relationship between the switchable leucophores and the tunable colour-producing iridocytes, suggesting they share a mechanism at the molecular level', says DeMartini.

So what is the purpose of these markings in females? In short, DeMartini doesn't know, but he points out that the white stripe looks remarkably similar to the white testes seen in male squid. He speculates that the iridescent stripes might give a 3D perspective to the white strip: 'You could orient the iridocyte's reflection at some specific angle so it'll look brighter from certain positions, instead of white scattering which is always going to be uniformly bright in all directions.' As male squid are notoriously aggressive towards females, DeMartini suspects that these adaptable iridocytes and leucophores could help females mimic males to escape unwanted attention.

More information: DeMartini, D. G., Ghoshal, A., Pandolfi, E., Weaver, A. T., Baum, M. and Morse, D. E. (2013). Dynamic biophotonics: female squid exhibit sexually dimorphic tunable leucophores and iridocytes. J. Exp. Biol. 216, 3733 – 3741 jeb.biologists.org/content/216/19/3733.abstract