Zoology 567

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Topic Summary – Cuttlefish Camouflage

Cuttlefish could be considered vulnerable organisms due to their lack of protective exoskeleton however, to mitigate this vulnerability, they have evolved one of the most impressive displays of camouflage. This literature review focuses on cuttlefish camouflage behavior with emphasis on how the environment influences camouflage reactions and the control behind those reactions. Camouflage in cuttlefish is extremely versatile and is driven by the components of either the background environment or the substrate they are trying to match (Hanlon et al., 2009; Panetta 2017). This behavior is utilized in predation and defense against predation with the shared goal of remaining inconspicuous (Allen et al., 2013). Depending on environmental features, cuttlefish will change both their color and their texture to maximize effectiveness (Hanlon et al., 2009; Zylinski et al., 2009; Chiao et al., 2015; Buresch et al., 2015; Panetta et al., 2017; Josef et al., 2017). Therefore, camouflage success is achieved with the collaboration of an advanced visual system, neural control of the skin, and muscular response (Zylinski et al., 2009; Allen et al., 2009, 2013, 2014; Chiao et al., 2015; Gonzalez-Bellido et al., 2018).

The visual system of cuttlefish is the key to their exceptional camouflage ability as all color and textural changes are induced by visual perception alone (Allen et al., 2009; Chiao et al., 2015). Researchers discovered this by exposing cuttlefish to substrates either covered by a pane of glass or in photograph form and recording their textural response (Allen et al., 2009). In both cases, the cuttlefish exhibited a change of texture to match the substrate which suggests that no tactile stimulus is needed and only visual stimulus is required (Allen et al., 2009). Despite being color blind, cuttlefish also display one of three color patterns when visually assessing their environment (Hanlon et al., 2009; Chiao et al., 2015) and demonstrate exceptional self-awareness of which pattern is necessary (Josef et al., 2017). These patterns are a direct reflection of the surrounding environment with uniform occurring in low contrast, homogenous rock environments, mottle in even distributions of light and dark color with moderate contrast environments, and disruptive in high contrast, variously shaped-substrate environments (Hanlon et al., 2009). By recording the success of camouflage in varying amounts of light, researchers found that the amount of light present is vital to effective camouflage, along with substrate contrast, shape, and size (Chiao et al., 2015; Buresch et al., 2015).

The components of cuttlefish skin that allow them to camouflage so effectively include chromatophores and papillae (Allen et al., 2009; Gonzalez-Bellido et al., 2018). Chromatophores are the cells responsible for colour changes while papillae are the muscular components of the skin that extend or retract based on the texture desired (Allen et al., 2009; Gonzalez-Bellido et al., 2018). Papillae extension is initiated in response to a neural signal by extending muscles and is maintained hydrostatically with the pressure created by interstitial fluid in the surrounding tissue (Allen et al., 2013, 2014; Gonzalez-Bellido et al., 2018). Researchers have recently found that papillae retraction is accomplished by retractor muscles and connective tissue, foiling the previous assumption that retraction is elastic (Allen et al., 2014). These discoveries of papillae morphology and neural control were explored via various microscopy methods and both external and internal manipulation of nerves (Allen et al., 2013, 2014; Gonzalez-Bellido et al., 2018).

Although cuttlefish camouflage research has been increasingly explored in the past two decades, there are still many gaps in knowledge. For example, integration of visual stimuli by the brain and resulting neural stimulation of papillae has not been fully mapped, requiring further research to determine how the rapidity of camouflage occurs (Gonzalez-Bellido et al., 2018). Future research could also pursue predator perception as Panetta et al., (2017) and Chiao et al., (2015) highlight how their findings of cuttlefish camouflage could offer insight to predator cognition of prey. Furthermore, as explained by Panetta et al., (2017), research on the visual system of cuttlefish is necessary to completely understand how they are able to perceive texture with such precision while having monocular vision. Ultimately, understanding of cuttlefish camouflage is just skimming the surface and future research can begin to dive deeper into this behavior to truly reveal the secrets to its success.

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