Kate Ukrainetz 30069549
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Topic Summary

Cuttlefish are intelligent invertebrates who possess the ability instantaneously alter the pattern and texture of their skin, referred to as dynamic colouration (Hanlon et al., 2020). Depending on the situation, cuttlefish will employ camouflage behavior to match the substrate, or mimicry behavior by adopting the appearance of another organism. These behaviors enhance success in hunting, predator avoidance, reproduction and overall contribute to increasing their fitness as they navigate their environment.

To effectively study cuttlefish behavior, there must be minimal disturbance to their natural environment. As such, observational research dives or submerging a bait bag with a hidden camera inside (Van Elden et al., 2020) are used. Observational study techniques extend to the lab where researchers carefully manipulate the environment to elicit certain behavioral responses.

To elicit camouflage responses in a laboratory setting, researchers presented cuttlefish with different artificial backgrounds, substrates and objects which simulated their natural environment (Buresch et al., 2011; Zylinski et al., 2009). Zylinski et al. (2009) found that cuttlefish presented with checkerboard patterns of differing contrast levels were able to camouflage to each pattern. Buresch et al. (2011) found that cuttlefish presented with artificial objects and substrates were able to elicit the exact pattern needed to camouflage. This suggests that camouflage behavior is extremely adaptable and thus is essential for cuttlefish survival.

Research has shown that despite their colourful displays, cuttlefish are actually colour-blind (Messenger, 2001). Messenger (2001) found that albeit their colour-blindness, cuttlefish rely entirely on their vision as their primary sensory modality. Deravi (2021) added that extraocular photoreceptor organs help to perceive incoming light and differing levels of contrast. This suggests that the absence of colour-vision yields an enhanced ability to detect contrast and light levels (Deravi, 2021).

Whether cuttlefish will employ camouflage or mimicry behavior is first determined by visual cues, with colour production being attributed to sophisticated neuronal and hormonal pathways (Morris et al., 2014; Messenger, 2001). Researchers were interested in understanding the pathways and brain function required to produce these behaviors. Morris et al. (2014) identified cuttlefish chromatophores as neuromuscular organs; functioning via neuronal signals sent to activate radial muscles which pull open pigment sacs within the chromatophores. Messenger (2001) found that acetylcholine signalling cascades originate from the cuttlefish's eyes and central nervous system and work in conjunction with the neuronal signals to produce different colours and patterns. The findings from both studies suggest these hormonal and neuronal mechanisms are highly derived and therefore contribute to successful colour production for every activity, encounter or situation.

Evolutionary studies on cuttlefish mimicry and dynamic colouration behavior for reproduction reveal conflicting conclusions regarding which male traits influence female choice. Early observational studies of wild cuttlefish from Norman et al. (1999) and Boal (1997) were interested in mimicry behavior during reproduction. Norman et al. (1999) observed that female impersonation, a form of mimicry by small male cuttlefish was performed to intercept a larger male mating with a female and found that both male size and colorful display were irrelevant in influencing female choice. Boal (1997) observed females mating with males who had the lengthiest mating history and found similarly, that colourful displays were unimportant to females. Recent research by Hanlon et al. (2020) and Okamoto et al. (2017) sought to determine the efficacity of larger male's conspicuous courtship displays. Hanlon et al. (2020) observed males displaying the colourful "Flamboyant Display" and found that these males successfully mated with a female. Okamoto et al. (2017) observed male's aggressive arm-flapping display and found that it was an indicator of good fitness to females, resulting in a mating. These conflicting results suggest that there is no single marker of male fitness influencing female choice. In all cases, male's utilized mimicry or dynamic colouration behavior to secure a mate, ensuring the contribution of his own genes to the successive generation, thereby increasing his fitness.

Although cuttlefish dynamic colouration behavior has been extensively researched over the past thirty years, many questions remain regarding the genetic basis of these behaviours. Future research could address whether the internal mechanism responsible for every camouflage pattern is found within the cuttlefish genome or if some patterns are learned. Additionally, Boal (1997) addressed a gap in knowledge regarding a male's mating history being communicated to females.

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