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Natural-born con artists and counterfeiters

Who is being deceived here?

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Deception is ubiquitous in plant and animal kingdoms and is widely thought to provide selective advantages to the individual and evolutionary success to the species. Mimicry, a form of deception whereby an individual imitates their model to advantage by closely resembling their behavior or appearance, is particularly well documented and represented by the peripheral eyespots seen on the wings of many butterfly species. The significance of butterfly eyespots has been convincingly demonstrated to serve as an anti-predatory function either by imitation of a predator's own dangerous enemies (intimidation hypothesis) or by deflecting predator strikes toward less-vital parts of the body (deflection hypothesis). A convincing and compelling explanation in butterflies, the functional role of eyespots as anti-predatory devices has become a widely held and firmly entrenched belief that has been freely adopted into other systems. Here we comment on a recent paper that demonstrates a vastly different role for eyespots, that of intra-specific male-male competition, and make the point that even long-held beliefs need to be tested and challenged under different contexts if we are not to be deceived ourselves.

"Never have so many been manipulated so much by so few."
"*Brave New World Revisited*," by Aldous L. Huxley (1894–1963).

In many biological systems, including human societies, individuals adopt deceptive tactics to change the perception and behavior of others. Perpetrators may deceive by purposely attempting to convince others to believe false information (i.e., the Pinocchio effect in humans),[1] or by misleading them through the deliberate omission or concealment of key information that could jeopardize their interests. The range of traits, behaviors and circumstances involved in the deceit may be very diverse across species, but the ultimate goal is to gain some kind of benefit or to avoid loss, hence leading to an increase in evolutionary fitness. Because of the potential benefits of misleading signals, the art of deception is commonly practiced by many species and, paradoxically, essential for the proper workings of interactions among individuals and groups (e.g., some lies are altruistic and pro-social, making for smoother communication in humans).[2] Interestingly, the deceit only works when embedded within signaling systems with a certain degree of reliability—where signals are reliable often enough because, on average, they convey information that are honest, thus making the response beneficial to receivers (for a review of the topic see Searcy and Nowicki).[3] And indeed, deceptive signaling can be identified only if we first know what constitutes a reliably honest communication within our specific study system. Although arguably one of the most intriguing evolutionary questions, our own interest here does not revolve around the actual issue of reliability and deceit of signaling systems. Instead, we ask a question about the reliability of the context we adopt to interpret the issue and what happens when the function of animal signals is inferred from a look-alike true assumption.

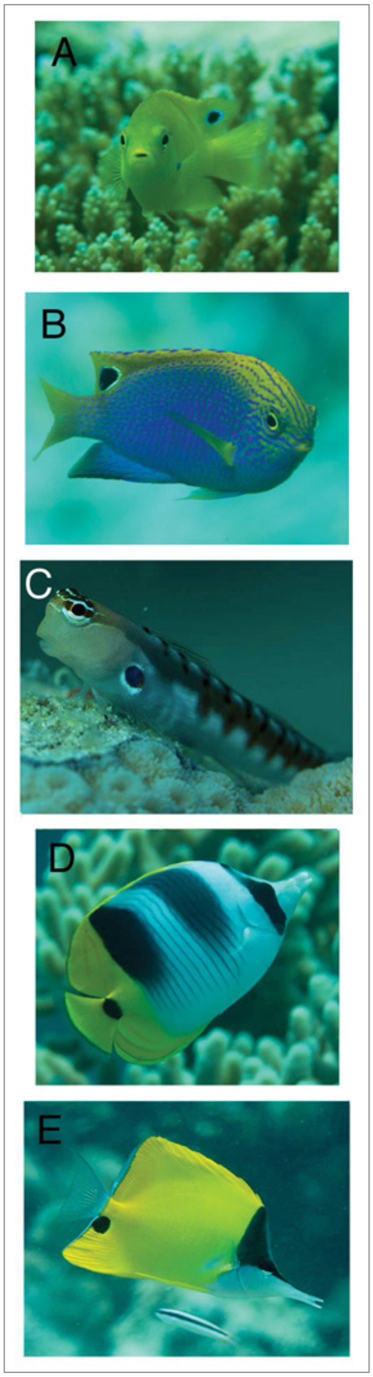

Figure 1. Among coral reef fishes, eyespots are particularly common in damselfishes (**A and B**), blennies (**C**) and butterfly fishes (**D and E**). Photos courtesy of N. Thake.

Colorful Deception: The Case of Mimicry and Functional Similarity

Across the animal and plant kingdoms, mimicry has evolved in response to common selective pressures that favor individuals that can conceal their identity and avoid recognition by (more or less) closely resembling their model.[4] For many mimicry systems, body shape, size, color and patterns are the primary signaling mechanisms used to deceive receivers,[5] and the conspicuous eyespots at the end of animals' backs, heads, tails and wings are certainly among the most intriguing forms of these deceptive adaptations. Because eyespots are most commonly found in Lepidoptera, their role has been primarily discussed and examined in this group[6] and several studies over the last few years have supported the two main long-standing hypotheses invoked to explain their occurrence: (1) intimidation—eyespots frighten predators by mimicking the eyes of the predators' own dangerous enemies; (2) deflection—eyespots deflect the attacks of predators to non-vital regions of the body (for a comprehensive review see Kodandaramaiah).[7] Although the eye-mimicry hypothesis has been the most cited explanation for the intimidating nature of eyespots, experimental support for it has become available only recently.[8]

Aside from butterflies and moths, eyespots are a common feature in many other insect groups, birds, reptiles and several fish species (**Fig. 1**). Because of their widespread occurrence and similarity in shapes and forms across species, it has been tempting to assume that they evolved to perform similar adaptive functions, particularly in the context of protection against predators. And indeed, both the intimidation and deflection hypotheses have been proposed to explain the occurrence of eyespots in fish for instance,[9-11] although empirical evidence in support of either idea has been noticeably missing. Interestingly, quite a different story has emerged from more recent studies that have gone far enough to test experimentally the function of fish eyespots in nature.[12,13]

Fishy Eyespots

Eyespots have been observed to occur on the tails and dorsal fins of juveniles in a number of coral reef fish species.[14] Located posteriorly, they have long been assumed to misdirect a predator's attack away from vital parts of the body such as the head, by mimicking the real eyes but being located in a less vital region of the body, such as the dorsal fin.[10] Eyespots in coral reef fishes have also been expected to deflect a predator's attention away by confusing a predator about its actual distance from a potential prey—assuming that a larger eyespot relative to the real eye would induce a predator to initiate an attack from a greater distance than it normally would.[11] Remarkably, the assumption that eyespots in these species have such anti-predator function and larger eyespots relative to the size of real eyes better serve as a decoy, thereby increasing juvenile survivorship in the wild, remained untested until recently.[12] Using a mark-recapture experiment, Gagliano[12] demonstrated that eyespots of the Ambon damselfish (*Pomacentrus amboinensis*) may not confer the long-assumed protection from predators and suggested that these markings may serve other purposes. In our recent paper, we investigated this alternative of a non-predatory function of eyespots in this species and showed that these markings have a deceptive function in the context of intrasexual (male-male) competition.[13] Specifically, we examined the possible functional role of the dorsal eyespots in *P. amboinensis* by exploring differences in body shape among age and gender groups, based on the fact that: (1) all juveniles are females and all have an eyespot, and (2) most individuals lose their eyespots on maturation, yet a few retain them into adulthood. We demonstrated that the eyespot retention is gender-specific, where eye-spotted adults are always sexually mature males, and these eye-spotted males more closely resemble the size and body shape of immature females than that of the males they actually are (i.e., mimicry). Moreover, age data of *P. amboinensis* with and without eyespots indicated that the functional significance of these markings switches within a lifetime from serving as an honest signal of the sexual immaturity of juveniles to reduce aggression by mature males to a deceptive signal of age and non-breeding status. What our study really highlights, however, is a much more perilous trap. Obviously, evidence shown in one system may not necessarily be a panacea for all systems. Something said often enough does not make it so; our study reminds us that hypotheses should be tested and evaluated within their specific context if we are to avoid the risk of developing our science on widely accepted, but not always correct premises. Otherwise, we might wonder who is really being deceived here.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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