Applied Animal Behaviour Science xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

Colour polymorphic Gouldian finches avoid complex backgrounds but prefer simple camouflage colours over white backgrounds

Katarina Perkovic[a,b], Claudia Mettke-Hofmann[b,*]

[a] Faculty of Science, Department of Biology, University of Zagreb, Rooseveltov trg 6, 10000, Zagreb, Croatia
[b] School of Natural Sciences & Psychology, Liverpool John Moores University, James Parsons Building, Byrom Street, Liverpool, L3 3AF, United Kingdom

ARTICLE INFO

Keywords:
Background matching
Camouflage
Welfare
Bird
2D

ABSTRACT

Many animals blend in well with their environment known as camouflage which is a successful predator avoidance strategy. However, captive environments often do not allow for camouflage and may result in stress and reduced welfare. We investigated whether colour polymorphic Gouldian finches use background matching or complex backgrounds as a camouflage strategy. Birds were tested in unfamiliar cages with half of the cage with one background and the other half with another background. The time spent in front of each background was measured. The first experiment compared a simple green background versus a complex patterned background consisting of red, green and black shapes, whereas the second experiment compared a simple green background against a white background which is often used in cages. Backgrounds were swapped after 10 days to control for site preferences (phase 1 and 2). In both experiments all birds clearly preferred the simple green background. Diverting habituation processes were observed in the second experiment with black-headed birds visiting the white background more during phase 1 than phase 2, whereas the opposite was the case for the red-headed birds. In the first experiment, preference for open habitats may have interfered with optimal background matching. The second experiment showed that white backgrounds are aversive for the birds. Different habituation speeds are consistent with differences in exploration and risk-taking between the head colour morphs. The results show that 2D background colours are a simple but effective enrichment to increase welfare in birds.

1. Introduction

Animal welfare is a major concern when keeping animals in captivity. Environmental enrichment plays an important part to improve welfare and promote natural behaviour (Matheson et al., 2008; Newberry, 1995; Robbins and Margulis, 2016). In birds, specifically song birds, enrichment often comprises foraging substrates, water baths, natural branches and area of cover (Bateson and Feenders, 2010). Most of these enrichments aim to increase natural behaviours and reduce stereotypical behaviours. However, another important aspect of welfare is how safe an animal feels in its environment. While many bird species are extremely colourful, their plumage is well adapted to their natural environment and birds often 'hide in plain sight' by using colours and patterns that match their environment making them difficult to detect for potential predators (Kjernsmo and Merilaita, 2012). This kind of behaviour is an adaptation to natural environments (Endler, 1978), and based on the assumptions that natural behaviour improves welfare of captive animals (Bateson and Feenders, 2010; Engebretson, 2006; Matheson et al., 2008), providing the animal with a background that supports camouflage might play an important role as a form of enrichment and to reduce stress.

Blending in with the environment is known as background matching or crypsis, and occurs throughout the animal kingdom (Endler, 1978). A colour pattern is considered cryptic if it approximates those of the background in size distribution, colour frequencies, brightness or contrast and geometry (if the prey is normally seen only in a particular orientation) and resembles a random sample of the background (Endler, 1978). Background matching has been shown to be a predator avoidance strategy (Johnsson and Kjällman-Eriksson, 2008; Morgans and Ord, 2013). The importance of background matching in captivity has been investigated in European cuttlefish (*Sepia officinalis*). Juveniles often injure themselves when startled and Tonkins et al. (2015) investigated the effect of background on thigmotaxis and stress behaviour. They tested plain, bare plastic tanks against four types of enriched tanks (gravel, sand, synthetic seaweed, and photographs of gravel). When simulating cleaning routines, cuttlefish displayed more thigmotaxis and stress behaviours in bare tanks than in enriched tanks. Interestingly, cuttlefish preferred photographs of gravel over actual

* Corresponding author.
E-mail address: C.C.Mettke-Hofmann@ljmu.ac.uk (C. Mettke-Hofmann).

https://doi.org/10.1016/j.applanim.2018.05.029
Received 23 February 2018; Received in revised form 22 May 2018; Accepted 27 May 2018

Please cite this article as: Perkovic, K., Applied Animal Behaviour Science (2018), https://doi.org/10.1016/j.applanim.2018.05.029

gravel possibly due to gravel being too fine for cuttlefish to hide or burry in (Tonkins et al., 2015). The study suggested that 2D backgrounds can be used as a substitute for actual substrate as they do reduce negative behaviours, and as such improve welfare of captive animals. Similarly, the African Clawed Frog (*Xenopus laevis*) which is known to use cryptic colouration as a defence mechanism preferred natural and ecologically relevant black background over non-relevant white background (Holmes et al., 2016). Moreover, corticosterone release, occurrence of atypical behaviour and weight loss was higher in frogs with white backgrounds. The study concluded that tank background colour is an important aspect of welfare in captive African Clawed Frogs (Holmes et al., 2016).

The hypothesis that background matching reduces the risk of detection by visual predators has recently been challenged by an alternative hypothesis. Merilaita (2003) suggested that information processing in predators is reduced in complex habitats resulting in lower detection of prey irrespective of their camouflage with the respective environment. Support for this hypothesis comes from least killifish (*Heterandria formosa*) who preferred complex backgrounds over matching ones in some contexts including predation (Kjernsmo and Merilaita, 2012), blue tits (*Cyanistes caeruleus*) who indeed needed longer to find artificial prey on a complex background (Dimitrova and Merilaita, 2010) and a similar study comparing detectability of artificial prey by birds and humans (Xiao and Cuthill, 2016).

Background matching camouflages an organism to only a specific microhabitat. However, animals often use different microhabitats to which they will be matched to different degrees. Organisms can respond in two ways to this challenge: they will either closely match one of the microhabitats or find some form of compromise by loosely matching both or more microhabitats (Sherratt et al., 2006). Several experiments have been conducted to investigate which of the two responses is more protective. In an experiment conducted by Dimitrova and Merilaita (2009), blue tits predated on cryptic artificial prey items with different patterns (small, intermediate, large) set against two different backgrounds (small and large patterned). Intermediate patterned prey had a slightly higher chance of survival than matching patterns. Sherratt et al., (2006) used virtual prey searched for by human predators and allowed the prey to evolve (any undetected prey would automatically replicate) under alternating light-dark backgrounds. Prey rapidly evolved to match one or the other background. Sherratt et al., (2006) suggested that very dissimilar backgrounds favour specialisation (as found in their simulation), whereas more similar backgrounds may favour intermediate morphs (as in the blue tit experiment). This is especially important for species inhabiting two or more habitats and species with variable activity patterns.

Interestingly, species occurring in several habitats often show colour polymorphism (Galeotti et al., 2003). Colour polymorphism is the coexistence in one interbreeding population of two or more sharply distinct and genetically determined forms, the least abundant of which is present in numbers too great to be due to solely recurrent mutation and is a widespread phenomenon across the animal kingdom (Galeotti et al., 2003). Colour polymorphism has been linked to different background-matching abilities (Sowersby et al., 2015) and has been shown to reduce predation (Karpestam et al., 2016). For example, the red devil (*Amphilophus labiatus*) is a polymorphic cichlid fish occurring in two morphs - gold and dark (Sowersby et al., 2015). While the dark morph is much more abundant in nature, the gold morph is genetically and behaviourally dominant and shows higher growth rate. However, the black morph was better able to match different backgrounds than the gold morph (Sowersby et al., 2015) which may reduce risk of predation, and might explain why certain colour morphs might be less abundant in nature despite having some apparent advantages.

In this study we tested background preferences in the colour polymorphic Gouldian Finch (*Erythrura gouldiae*) which is an endemic songbird to Australia and categorised as near-threatened by BirdLife International (2016) and as endangered by the Australian Government (EPBC, 2018) with an estimated population size of less than 2500 individuals. Despite its rarity in the wild it is one of the most abundant birds kept by breeders and private keepers (Nicolai and Steinbacher, 2001) due to its incredibly colourful plumage with a green back, purple breast, yellow underparts and different head colours in both sexes. Much like the red devil, the Gouldian finch has a genetically dominant red-headed morph and recessive black-headed morph which is more abundant than the red-headed morph (70% vs 30%) and a very rare yellow-headed morph (< 1%; Brush and Seifried, 1968). While red-headed birds are more aggressive and dominate black-headed birds (Pryke, 2007; Pryke and Griffith, 2006), the latter are more explorative and take greater risk in dangerous situations (Williams et al., 2012). The aims of this study were to test whether Gouldian finches a) use background-matching as a form of camouflage and whether b) red-headed and black-headed morphs have different preferences. We specifically tested for complex background matching as this reduces predation irrespective of the degree of camouflage (Dimitrova and Merilaita, 2014) but also tested for background matching in general. We also considered whether the two head colours responded differently to the backgrounds over the course of the experiment (habituation). This latter was included as red-headed birds are more cautious in unfamiliar situations than black-headed birds (Mettke-Hofmann, 2012; Williams et al., 2012) which may affect engagement with different complexity (experiment 1).

2. Materials and methods

2.1. Study species

The Gouldian Finch is a colourful song bird of the family Estrildidae found in northern Australia, ranging from the northern region of the Northern Territory to the Kimberley region of Western Australia with a few records from Cape York Peninsula and north-west Queensland (BirdLife International, 2016). It inhabits open tropical savannah woodland and feeds on annual grasses such as *Sorghum* sp. during the dry season and perennial grasses during the wet season (Weier et al., 2017). All birds in captivity outside of Australia derive from wild stocks imported before the import ban in 1960 (Franklin et al., 1999).

For this study 24 captive bred birds purchased from different breeders were used. We had equal numbers of black-headed and red-headed birds in both sexes (six black-headed and six red-headed birds, each) with ages ranging from two to five years. Birds were kept in mixed sex and age groups of six birds in holding cages (1 m x 1.2 m x 0.8 m; H x L x W). All birds were familiar with each other due to mixing birds in other experiments when testing for personality (King et al., 2015; Mettke-Hofmann, 2012; Williams et al., 2012). Holding cages contained natural twigs, perches, food (Blattner Amadine Zucht Spezial, Blattner Astrilden Spezial, bird grit from Blattner Heimtierfutter, Ermengerst, Germany and eggshells) and water ad lib (incl. water bath). Cage walls and ceiling were all wire mesh but adjacent cages were separated by white wooden dividers and the rear of the cage faced a white wall. Cages were arranged along the side of the walls allowing the birds to see each other.

For the experiment groups of four newly assembled individuals were moved into experimental cages (1 m x 1.2 m x 0.7 m) for two weeks. Cages were arranged in the middle of the experimental room in two rows with the rear side of the cages in the two rows facing each other. Experimental cages consisted of two perches; one left and one right of the cage and two feeders (with the same food as in the holding cages) in the middle of the front of the cage (see Fig. 1) and drinkers next to them. Three walls were made of wood, whereas the front and ceiling were wire mesh. Overall, four experimental cages were available for parallel testing of 16 birds. This resulted in two sets of testing, the first set with four groups and the second set with two groups which followed directly after the first set was finished. The arrangement allowed having groups back-to-back to the opposite cage rather than one group without