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Cuttlefish in captivity: An investigation into housing and husbandry for improving welfare

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ABSTRACT

The European cuttlefish (*Sepia officinalis*) is often kept in public aquaria, is becoming more common in aquaculture, and is also the most frequently used cephalopod in European research. Since 1st January 2013, all cephalopods (*Mollusca*) have been protected under UK/EU law (A(SP)A 1986, European Directive 2010/63/EU), following Australia, Canada and New Zealand. Presently, unlike other organisms used in research, there is no detailed specific guidance available from UK/EU legislators on best practices for keeping cuttlefish. In captivity, juveniles can easily become damaged by impacting with tank walls when startled. These injuries rarely heal and can have a major impact on growth and survival. Six experiments were performed, using juvenile and adult cuttlefish, in which exhibition of thigmotaxis in different environments, responses to simulated husbandry in different scenarios, and responses to typical and novel forms of enrichment (e.g. photographs of substrates) and refuges was investigated. Refuge use was also investigated, including response to husbandry when different refuges were provided. In addition to thigmotaxis, the frequency of negative behaviours (such as those likely indicating stress or preceding damaging behaviours) was recorded. The results suggest that certain environments, clothing/equipment and refuges/enrichment can significantly reduce the frequency of negative behaviours. It was also found fake seaweed and photographs of substrates placed in tanks may be used by cuttlefish with the benefit of preventing localised pollution. We conclude by providing an evidence-based guide to improving husbandry practices, which could improve the lives of captive cuttlefish.

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1. Introduction

With the exception of public aquaria, the standard conditions in which aquatic organisms are kept in most mediums to large facilities are impoverished. Bare laboratory conditions may aid in the maintenance of good environmental conditions and therefore good animal health (Olsson and Dahlborn, 2002), but impoverished environments can alter behaviour and reduce the ability of captive animals to perform natural behaviours for which they are highly motivated (Dawkins, 1988). This has the potential to reduce health and well-being (Dawkins, 1988, 1998), and also limit the reliability of conclusions drawn from research (Würbel, 2001). There is a substantial body of research which suggests that environmental enrichment is beneficial for captive animals (e.g. Brydges and Braithwaite, 2009), and studies have also shown that increasing the complexity of rearing environment can be beneficial for aquatic species kept in commercial aquaculture (*Salmo salar* Brown et al., 2003; *Gadus morhua*; Salvanes and Braithwaite, 2006) and scientific research (Williams et al., 2009; *Danio rerio* Schroeder et al., 2014) systems. However, many other benefits of enriched environments, such as reducing fear and aggression (Reinhardt, 2004; Kadry and Barreto, 2010); removing stress and negative response to stressors (Fox et al., 2006); and reducing negative stereotypic behaviour (Mason et al., 2007) have only been investigated for terrestrial laboratory animals.

Cephalopods are increasingly reared in commercial aquaculture systems and frequently used in research. Due to growing evidence suggesting that the cognitive abilities of these animals may be comparable to some vertebrates (e.g. Mather and Anderson, 1999; Dickel et al., 2000) these complex invertebrates have the ability to experience physiological (Broom, 2007; Andrews et al., 2013) and psychological suffering (Andrews et al., 2013), considerations of welfare are increasing and legislation is being put in place to provide these animals with the same protection as vertebrates. *Octopus vulgaris* has been protected under the UK Animals Scientific Procedures Act 1986 since 1993, and since the 1st January 2013 *all* other cephalopods have also been given protected status under UK & EU law – A(SP)A 1986 & European Directive 2010/63/EU

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– following Canada in 1991, New Zealand in 1999 and Australia in 2004. In addition to the paucity of studies on the effects of captivity on cephalopod behaviour and physiology (but see Malham et al., 2002), in recent years (2005–2011), a substantial body of research has been published which if carried out now would require a procedural licence because it would likely cause pain or lasting stress (see Smith et al. (2013) for a review on previous research). This indicates a pressing need for further investigations into the welfare of captive cephalopods (e.g. Smith et al., 2013). Although some studies have investigated improving growth conditions in cephalopod aquaculture systems (Sykes et al., 2011; Forsythe et al., 1994; Correia et al., 2005; Boal et al., 1999), and also for captive breeding (Boal et al., 1999; Adamo et al., 2000), the few studies aimed at improving the overall welfare of captive cephalopods have been conducted in zoos and are therefore limited to observations on a very small number of individuals (e.g. Anderson and Wood, 2001). Additionally, suggestions for enrichment for zoo animals may frequently not be suitable for other situations in which cephalopods are commonly kept. Therefore, despite environmental enrichment being a requirement for all protected animals (under annex III of Directive 2010/63/EU), and the "freedom to express normal behaviour" and "freedom from fear and distress" being incorporated into UK/global animal welfare laws (see The Brambell Report, 1965), there are, as yet, no guidelines for best husbandry practices for cephalopods kept for scientific research.

Behaviour can be a useful non-invasive indicator of welfare (Dawkins, 2003) and the ability of cuttlefish to produce complex signal and camouflage to their environment through the use of rapid skin colour/pattern changes and posturing provides great potential for improving welfare. In cuttlefish, anti-predatory signals are well documented (Hanlon and Messenger, 1996) and these displays, and other behaviours such as thigmotaxis (indicative of stress, Schnörr et al., 2012) and jetting and inking (flight responses, Gilly and Lucero, 1992; Lucero et al., 1994; Hanlon and Messenger, 1996; Oestmann et al., 1997), may allow us to decipher how a situation or stimulus is interpreted and aid in our ability to reduce stress and reduce the likelihood of lasting injury (which can occur after impact with tank walls when fleeing perceived threats, Boletzky and Overath, 1991; Oestmann et al., 1997).

Having been used fairly widely in research in Europe (Smith et al., 2013), *Sepia officinalis* (Linnaeus 1758), the common European cuttlefish, is a relatively well-understood cephalopod. Like all cephalopods they are thought to be semelparous with two reproductive phenotypes: depending on foraging success during their first year, individuals may breed either in their first or second year of life (Le Goff and Daguzan, 1991), although, if prevented from breeding, adults may live up to 4 years in captivity (Cooke, personal observation). Juveniles are epibenthic, burying in, or sitting on, the substrate and will only move when threatened or to pursue prey (Hanlon and Messenger, 1988). It has been suggested that cuttlefish strongly prefer a substrate (Boal, 2011; Forsythe et al., 1994) but due to the potential for increased cleaning time or localised environmental pollution, evidence as to the benefits of certain types of enrichment may be necessary before institutions change husbandry practices. Interestingly, it has been shown recently (Schroeder et al., 2014) that the zebra fish (*Danio rerio*) will accept images of a substrate, which removes some costs associated with enrichment of environments for aquatic organisms. It has been proposed (John Rundle, personal communication, MBA, Plymouth) that dark figures leaning over tanks may be interpreted as predators by captive cuttlefish, and that the use of lighter clothing during husbandry has the potential to reduce frequency of negative behaviours.

To our knowledge this is the first study to investigate how different environments (i.e. impoverished, enriched) of captive cuttlefish affect responses to typical stimuli encountered in captivity, such as housing environment, care staff and husbandry activities.

2. Materials and methods

2.1. Experimental animals, rearing and housing

Eggs were obtained from The Marine Biological Association (Plymouth, UK) and hatched in Bangor University School of Biological Sciences marine aquaria facilities, where all experiments were carried out. From hatching they were fed *Mysid* spp., then maintained on a mixed diet of common shore crabs (*Carcinus maenas*) and frozen sand eels (*Gymnammodytes* spp. or *Ammodytes* spp.). Small prey items (*Mysid* spp.) were emptied into tanks using small containers and larger items (*C. maenas*, *Gymnammodytes* spp. or *Ammodytes* spp.) were presented individually by hand. After feeding, remains of crabs were removed from tanks by hand. Juveniles were between 6 and 10 months old during the experimental period (February–May 2014), and had yet to show full adult behaviours or patterns (i.e. courtship behaviours or Intense Zebra Patterning), it was therefore not possible to sex them at this stage. During each experiment, individuals were housed in individual grey plastic tanks (with a mixed substrate of sand and gravel) between trials. Adults were between 20 and 24 months old but had not mated prior to being used in these experiments.

2.1.1. Experimental tanks and facilities

With the exception of the glass tank (*L* 0.7 m × *W* 0.4 m × 0.76 h, volume = 21.56 l) used in experiment 1, all experimental tanks were part of a 75k l recirculating system with an average water temperature of 13.0 °C. All of the smaller grey tanks used for juvenile experiments measured *L* 0.57 m × *W* 0.37 m × *H* 0.11 m (giving a water volume 21.65 l) and were positioned on benches above waist height. Where glass and grey plastic tanks were used in the same set of experiments, glass tanks were filled to a level to keep total water volume the same as the grey tanks. In-flow to tanks was always turned off for 5–10 mins before each experiment. Negative behaviours were recorded following Hanlon and Messenger (1988, 1996), with additional observations defined by us (Table 1). As response to husbandry (and being kept in captivity generally) was the focus of this study, no attempt was made to hide the observer.

2.2. Experiment 1: substrate preference

In this experiment, 12 juvenile cuttlefish were used to compare time spent displaying thigmotaxis (defined as touching the side of the tank with any part of the mantle fin, but facing inwards towards the centre of the tank) in different tank environments. In total, six tank types were set up: two with no substrate (bare glass tank with a white polystyrene base, and a bare grey plastic tank); and four enriched grey plastic tanks with four alternative types of substrate/enrichment (sand, gravel, synthetic seaweed, laminated photograph of gravel). Gravel was chosen as the artificial substrate because, in contrast to sand in which they bury, a photograph of gravel still provides a background against which camouflage may be achieved by alteration of appearance rather than physical interaction. After release into the centre of an experimental tank, a 1 min acclimatisation period was allowed before behaviour observations of the cuttlefish began. Observations lasted 5 min. Each of the 12 cuttlefish experienced each of the six tank types (bare glass, bare plastic, sand, gravel, photograph of gravel, synthetic seaweed).

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