
Population Density

Invertebrates make up approximately 82-90% of all animal species (Black et al, 2001) and they play a vital role in ecosystems and food webs. Over the past few years, they have begun to play an important role in education within zoos. Their use in these education sessions to help educate the public on conservation efforts and global issues has helped to increase interest and knowledge of worldwide conservation programmes surrounding invertebrate species (Jensen, 2010; Wüst-Ackermann et al. 2018). However, despite their importance in this role, they are often under-represented in research and conservation funding and are excluded from many welfare laws (Broom, 2013; Hovrath et al. 2013). This exclusion from welfare and research means that there is little knowledge of the effect that different husbandry techniques have on invertebrate species such as population density and handling (Hovrath et al. 2013; Moss and Esson, 2010). In this study, the growth rate of *Achatina Fulica* (giant African land snail) was measured over a five-month period to determine whether population density and handling affected their growth rate. No significant difference was seen between high and low population densities and there was also no significant difference seen between different handling frequencies.

Zoos have been a part of our society for hundreds of years; initially in the form of menageries in the Ancient Roman time where their main purpose was for entertainment and as a sign of wealth (Tribe, 2008). Over the past 60 years, the role of a zoo has advanced dramatically with an increase in the greater regulatory regime of laws and legislations, a better understanding of species welfare requirements, and a larger focus on education and conservation of species through breeding in the case of endangered species and exploring ways of attracting the public's attention to visits (Reade and Waran, 1996; Tribe, 2008).

The Zoo Licensing Act introduced in 1981, requires all zoos - defined as any establishment where wild animals are kept for the exhibition to the public – to follow strict guidelines to ensure that all animals (defined in this legislation as any multicellular organism that isn't a fungus or plant) are provided with a suitable environment, allowing them to express natural behaviours. It outlines the correct husbandry, conservation, and welfare measures that are to be met, as well as providing guidelines for the transport and management of species (Zoo Licensing Act, 1981). The Zoo Licensing Act runs alongside the Secretary of State's Standards of Modern Zoo Practice (2012), which provides more comprehensive details into the welfare and safety provisions that must be observed in order to comply with the Zoo Licensing Act. It is also a requirement for all zoos to adhere to the Five Freedoms which are encompassed within the Animal Welfare Act (2006). The Act states that all animals within a zoo have: freedom from hunger and thirst, freedom from discomfort, freedom from pain, disease, or injury, freedom to express natural behaviours, and freedom from fear and distress (Mellor, 2016). The Animal Welfare Act details requirements specifically based on welfare, including the prevention of harm, with the association to the correct treatment of sick or injured animals, and the correct codes of practice for all animals, not just those in zoos.

As a part of these guidelines and laws, all zoos within the UK are required to participate in conservation and education methods as a part of the Zoo Licensing Act (1981), with the aim to engage and excite people about the world around them (DEFRA, 2019). The requirements of

the conservation and education methods are outlined within the Secretary of State's Standard of Modern Zoo Practice. There are no set guidelines about the mode in which the educational aspects need to be delivered, this can be decided by the zoo itself, however, there must be sufficient evidence to prove that the organisation is partaking in educational methods (BIAZA, 2018). The majority of zoos use education as a method of getting people interested in conservation whilst highlighting the importance of global change. There are many forms in which this is achieved, such as talks and events held at the zoo, interpretation using signs, and in some cases, one-to-one interactions with animals (BIAZA, 2018).

Despite the laws and regulations put in place for zoos to follow, invertebrate species which are kept within zoos are excluded from the Animal Welfare Act (2006). This exclusion of invertebrates from welfare laws may create a lack of understanding of the appropriate care of invertebrate species. Over the past 50 years, there has been a lack of research on invertebrate welfare. Out of 1125 articles published about animal welfare between 1966-2007 showed that only 1.36% of these articles are about invertebrates with only seven species studied (Goulart et al. 2009). Further analysis of 744 studies on environmental enrichment in zoos showed that only 0.57% of published research was completed on invertebrates, with these projects including just three species. In comparison with mammalian species made up 92.2% of the articles published (Melfi, 2009). Consideration of species for research is often based upon the complexity of their behaviour, indications of pain and awareness of their surroundings, and the presence of individual identities (Broom, 2013). Due to the misguided assumption that invertebrates do not feel pain and are unaffected by changes within their environment, invertebrates are often overlooked when it comes to research into their welfare, leading them to be excluded from welfare laws (Hovrath et al. 2013).

Within zoos themselves, the representation of invertebrate species has increased over the past few years. Invertebrates are commonly used in education sessions, with many of these sessions including the chance to handle the invertebrates due to their popularity with children (The Zoo, 2019). The popularity of invertebrates has been increasing recently due to institutes such as Association of Zoos and Aquariums (BIAZA) holding events which included the Big Bug Bonanza in August 2019, and National Insect Week in order to highlight the invertebrate world and its importance (BIAZA, 2019). Despite many zoos placing a large focus on charismatic megafaunas such as big cats, elephants, and apes, in many cases, invertebrates make up the majority of their inventory as can be seen below in figure 1.

Invertebrates play an important role within zoos as part of education for visitors through active educational sessions, which involve direct interactions with staff and animals through handling sessions, these have been shown to have a significantly greater effect on the learning and understanding of conservation and welfare within zoos (Carr and Cohen, 2011). Interactive educational sessions that involve handling do not just help provide a better understanding of conservation and welfare, they also play an important role in changing the perception of invertebrates and drawing attention to the important role that they play within ecosystems (Wüst-Ackermann et al. 2018). Invertebrates are commonly used within these educational sessions due to a lack of welfare concerns when being handled (Hovrath et al. 2013).

Despite there being a large number of invertebrates within zoos and the important role they play within education, their lack of representation to the public impacts the conservation efforts made towards different species (Carere et al, 2011). Analysis of the distribution of conservation funding in 2011 from the European Union LIFE-Nature programme, the largest European funder

of conservation, showed that a total of 10% of funding went towards invertebrate conservation. This was the lowest of all taxa funding, with mollusc species receiving 2% of that and arthropods making up the other 8% with all other invertebrate species not included in conservation programmes (Cardoso et al. 2011). Arthropod species that draw the largest funding for conservation than any other invertebrate taxa on average receive 1000 times less funding than a single mammal species (Barua et al, 2012; Cardoso et al. 2011).