Abstract

Advances in animal welfare science have led to a high number of studies published for farm, laboratory and zoo animals, with a huge breadth of innovative topic areas and methodologies. This paper investigates the different approaches used to undertake welfare research in farm, laboratory and zoo animals due to the variety of constraints that each group brings. We also set recommendations to how groups can support each other in moving forwards to reduce animal suffering and promote a life worth living, a goal that all parties aim to achieve. We propose that researchers develop more collaborations across species, in particular to focus on the applied component of animal welfare and utilizing positive welfare indicators; facilitate knowledge transfer and share good practice worldwide; and accept small *n* based studies that can still be scientifically robust and provide individual-based steps into advances in our knowledge. Ultimately, we need to be progressing animal welfare science to a point beyond legislative needs, and ensure that 'high animal welfare' becomes an additional mission statement for all animal-based industries.

Keywords: farm, five freedoms, captivity, positive welfare indicator, animal behavior

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Introduction

Definitions of animal welfare have advanced following the progression in our scientific knowledge and advances in societal interest and influence. Definitions have ranged from a focus on biological fitness (Barnett & Hemsworth, 1990), the state of an individual in relation to its environment and its ability to cope with changes (Broom, 1991), and the 'mind, body and nature' concept (Duncan & Fraser, 1997), with a more recent emphasis towards animal emotion and affective states (Guesgen & Bench, 2017; Paul & Mendl, 2018). Thanks to advancing definitions, animal welfare science has increased in its scientific rigour and journal outputs, which accentuates the scientific and public interest in the field.

Animal Welfare Science is an applied science, and research in this area generally has the aim of providing captive animals with the best possible life that can be provided. This presumably is the priority of welfare research, whether undertaken with animals on farms, in laboratories, or in zoos. There have traditionally been three different approaches to this goal: by ensuring animals are healthy and live long lives, by promoting positive affective experiences (i.e. keeping animals happy), and by allowing animals to perform positive behaviors they would have been able to do in the wild (Fraser, 2009). All three approaches have varying influences and methodologies within farm, laboratory and zoo welfare research. Farm and laboratory welfare research (henceforth referred to as farm/lab research) has usually had access to large numbers of individual animals, and can thus choose a sample size to ensure statistical robustness (Dell et al., 2002). However, these animals represent just a small number of species. In addition, researchers have generally been able to make substantial experimental manipulations, such as removing confounding variables, setting up control groups and manipulating environments and sometimes animals, again with the aim of achieving a robust experimental design (Johnson and Besselsen, 2002). Zoo researchers, by contrast, have to deal with small numbers of individuals, but of a huge range of different species; furthermore,

manipulation is rarely possible unless it is part of everyday husbandry procedures, and confounding variables can rarely be removed (Hosey et al., 2013).

Because of this, farm/lab and zoo-based welfare research have tended to follow different routes, though there have been some notable areas where zoo welfare has been able to utilize concepts and procedures developed in an agricultural context, such as the assessment of human-animal relationships and the benefits they bring (Ward and Sherwen, 2019). Since both are concerned with essentially the same thing, i.e. the welfare of captive animals, we must consider how the two traditions can be better brought together to provide a convergent approach to this field. The aim of this paper is to investigate the different approaches used to undertake welfare research in agricultural, laboratory and zoo animals due to the variety of constraints that each group brings. We also aim to set recommendations to how groups can support each other in moving forwards to reduce animal suffering and promote a life worth living, a goal that is to be achieved by all parties.

Farm/Lab Animal Welfare Research

Research has been concerned with the welfare implications of transportation on a variety of species including cattle (Teke, 2013), sheep (Parrott et al., 1999; Messori et al., 2015), goats (Alcalde et al., 2017), pigs (von Borell & Schäffer, 2005), rabbits (De la Fuente et al., 2007), chickens (Arikan et al., 2017), and turkeys (Wein et al., 2017). Additionally, the housing and health of animals has been extensively researched, for example perch type and provision for broiler chickens (Bailie et al., 2018), flooring type and housing systems for dairy cattle (Fjeldaas et al., 2011, Grosso et al., 2016), flooring type and presence or absence of bedding/substrate for pigs (Kallio et al., 2018) and indoor versus outdoor housing systems for goats (Grosso et al., 2016). Furthermore, important techniques have been devised, such as

cognitive bias testing in pigs (Carreras et al., 2018), or measuring how hard animals will work for different treatments or housing type (Patterson-Kane et al., 2002). These areas of research all outline various management techniques that can improve the animals' welfare in different situations that have been seen to have a negative impact on the animals involved.

Through innovative technology and growing expertise over the years, animal welfare scientists have developed new techniques to assess welfare. Examples include the use of accelerometers to identify gait and locomotor issues linked to health and welfare complaints (Kuźnicka & Gburzyński, 2017; Radeski & Ilieski, 2017), infrared thermography used as a method to remotely monitor dairy cow health and welfare (Stewart et al., 2017), monitoring facial expressions to measure pain (Gottardo et al., 2016; McLennan et al., 2016), ear and tail posture to understand emotion (Reefmann et al., 2009; Proctor & Carder, 2014) and measuring affective states that may underpin how an animal feels i.e. it's mental state (Boissy et al., 2007; Kappel et al., 2017). All of these contribute towards the growing bank of knowledge for farm/lab animal welfare and are applicable across all animal industries. In fact, could be of huge benefit within zoo welfare science due to the remote monitoring involved with some of these technologies. However, more recently some of the welfare research has become more 'theoretical' in form in that it seeks to understand the mechanisms underlying animals' behavioral choices, or else uses complex and time-consuming experimental procedures to diagnose the affective states which might influence the welfare of the animals. For example, Smulders (2017) uncovered the effects that poor environments have on brain structures such as the hippocampus, and an animal's time perception has been suggested as a window into their affective state (Andrews et al., 2018). Although such studies as these further our understanding of the way environments bring about welfare issues, it is often difficult to see how they can be applied in a day-to-day setting across all animal industries, particularly in a zoo.

Zoo Animal Behaviour and Welfare Science

Growing awareness in the 1960s and 70s of the importance of considering animal welfare in zoos led to the recognition of abnormal behaviors in zoo-housed animals, which were attributed to poor enclosure design (enclosures that were too small and too barren), lack of social stimulation, and the proximity of people (Morris, 1964; Meyer-Holzapfel, 1968; Boorer, 1972). Many of the increasing number of empirical zoo-based studies in the 1980s were designed to address this issue. Among them were various interventions intended to stimulate animals and increase both the amount and type of their activities (Markowitz, 1982), now generally referred to as 'environmental enrichment'. Typically, these involved comparing the behaviour of one or more animals before, during and after an intervention, such as introduction of new enclosure furniture or a manipulable object. The rationale and conceptual underpinnings of enrichment have been developed and refined since then, in that it is seen as something that has to be tailored to individual animals according to their species, behavioral ecology and individual needs. Additionally, enrichment requires a firm goal so that its efficacy can be assessed (Mellen and MacPhee, 2001) and consequently environmental enrichment is seen as a powerful and successful tool in improving zoo animal welfare (Young, 2003) that is now utilized daily in most institutions. Here is an example of where zoo researchers can offer expertise in helping environmental enrichment become an implementable task in large scale housing systems and understanding which types of enrichment are successful for similar taxonomic groups.

Another approach to improving welfare in zoo-housed animals concentrated on identifying how different aspects of housing (such as enclosure size and complexity, or group size and composition) and husbandry (such as provision of food or animal capture) affected

behaviour, and hence welfare. Again, this typically involved the study of a group of animals in one enclosure (e.g. Goerke et al., 1987; Ogden et al., 1990), though some studies were achieved across a number of different zoos (e.g. Wilson, 1982; Perkins, 1992). Nevertheless, general principles could be derived through the review of many different studies, each of which was relatively small scale (eg Price & Stoinski, 2007; Fabregas et al., 2012). Recently the breadth and variety of zoo welfare studies have increased, with new approaches such as the study of personality (Tetley & O'Hara, 2012) and human-animal relationships (Hosey, 2008;Patel et al., 2019), as well as the application of assessment techniques such as social network analysis (Rose & Croft 2015) and cognitive bias (Bethell 2015, Clegg 2018).

From early in this history, zoo-based researchers have been encouraged to form collaborations with academic institutions (Moran & Sorensen, 1984; Kleiman, 1985; Fernandez & Timberlake, 2008), which potentially offer access to skills, equipment and funding that may not be otherwise available to the zoo. This has led to valuable research on the influence of zoo environments on welfare, but the additional notion of providing animals with the opportunity to perform the behaviours they would do in the wild has led to a substantial emphasis on enrichment as a way of increasing behavioural diversity or promoting "missing" behaviours. However, although these have massive benefits for the animals involved, the sheer variety and number of species is an impediment to the development of zoo welfare as a predictive science. At least one possible way out of this is the development of comparative assessment (Mason 2010), which seeks patterns of responding to captivity across different species while controlling for phylogeny. Zoo research needs to distinguish between the 'case study' and 'predictive/evaluative' approaches to research that may make zoo-based research more palatable to other fields of welfare science.

Research logistics

The scientific benefits of researching farm/lab animal welfare are linked to the large datasets available due to the sheer numbers of animals involved within these industries. In 2016, data suggest that in the UK alone there were in excess of 33.9 million sheep, 10 million cattle, 4.8 million pigs and 161 million chickens (FAOSTAT, 2016). In 2016 in the USA, there were 16,400,000 lab rodents (mice and rats) and 183,237 guinea pigs (Coleman & Heagerty, 2019). Animal behaviour and welfare research dedicated to these animals therefore creates a large impact value for potential funding bodies and opens various external funding grants.

In zoos, these numbers are just not possible and there have been concerns about the design of zoo studies regarding the issues of small sample sizes and ecological validity with single animal or single enclosure studies. Concerns are raised with the fear that these might undermine the scientific value of zoo research and discourage academic researchers from becoming involved (Hosey, 1997; Stoinski et al., 1998; Swaisgood & Shepherdson, 2005). Small *n* studies, however, can be statistically robust (Bishop et al., 2013), and ecological validity is not an issue if the answer we seek in our research is about those particular animals in that particular enclosure (Saudargas & Drummer, 1996; Kuhar, 2006). Since this is often the case with zoo research, there has been a call to continue with small-scale subject research (Whitham and Wielebnowski, 2013). As we move to more individualized methods of measuring welfare such as qualitative behaviour assessment (Wemelsfelder & Lawrence, 2001; Wemelsfelder et al., 2000; 2001).We hope to understand the impact that certain individual traits (Carlstead et al., 1999) or keeper-animal interactions (Ward & Melfi, 2015, Carlstead et al., 2018) may have on welfare. We suggest that these small-scale studies play an important role in understanding how stressors impact on individuals rather than at a group/herd level. It could be that farm/lab research increase their uptake of these studies.

Nevertheless, because of its reliance on low numbers of individuals and difficulty in setting up controlled experiments, zoo welfare science suffers from the lack of recognition as a serious science, as evidenced by the lower impact factors of zoo journals and the paucity of grant funding for zoo research. For example on the 21st May 2018, the Biotechnology and Biological Sciences Research Council (BBSRC) in the UK, had a total of 2794 awards totaling £1,437,323,899 none of these dedicated to zoo research (BBSRC 2018). Additionally, the poor uptake of zoo-based talks by welfare conference organizers; for example the 2018 Association for the Study of Animal Behaviour (ASAB) 'Behavioural Biology in Animal Welfare Science' meeting held in London, UK included only two from 25 oral presentations on zoo-housed species, and a high proportion of the non-zoo talks did not allow application of the research to other animal industries or domains. Similarly, the 2018 Universities Federation for Animal Welfare (UFAW) conference 'Animal Welfare across Borders' conference held in Hong Kong featured 22 oral presentations (excluding plenary talks), none of which had a focus on zoo animal welfare. We feel that zoo welfare researchers need to develop and adopt more predictive methods, and also utilize more of the applied research ideas coming from farm/lab research; but also that the farm/lab-dominated animal welfare conferences and journals need to be more accepting of the value of smaller scale zoo research.

An additional aspect where zoos are at the forefront involves multi-institutional studies. Where farm/lab studies concentrate on numerous animals housed at one location, zoo researchers include multiple institutions to investigate a problem that may be similar across multiple institutes, to increase the number of individuals utilized and also to increase the impact of the research. Of course there are additional variables to be considered here but again, appropriate statistical techniques can be applied to ensure that this is adjusted for within the results; or depending on the aim of the research, this can become an independent

variable that we might want to consider. For example Shepherdson et al. (2004) investigated fecal corticoids in two species across a number of zoos (Polar bears *Ursus maritimus:* 18 zoos; Clouded leopard *Neofelis nebulosa:* 4 zoos). Ward & Melfi (2013) investigated the impact of positive reinforcement training on human-animal interactions for three species at five different zoos and Greco et al. (2016) collected data from 67 North American zoos that house elephants, to characterize and understand the variations in elephant management strategies. As more data become available on behaviors of different species in zoos, opportunities arise for meta-analytic studies that look at patterns of responding across different taxa (Mason, 2010). Such studies have been achieved on the phylogenetic distribution of stereotypies in carnivorous mammals, thus enabling the formulation of predictive hypotheses about the causes of this behaviour and the species most at risk (Clubb and Mason, 2007). Similar analyses have now been attempted with other behaviors and other taxonomic groups (Hanzlíková et al., 2014; Pomerantz et al., 2013). Studies like these offer a promising new direction for zoo welfare research (Whitham and Wielebnowski, 2013), but note that they depend on the data contained in small-scale studies.

Combined Appreciation for Animal Behaviour and Welfare Science

Farm/lab and zoo researchers have had somewhat different approaches to animal welfare, largely because of constraints or opportunities in the resources available to them. However, for both groups, the overall goal is the same, i.e. to reduce suffering and promote a positive life worth living of the animals in our care. It is therefore imperative that animal welfare scientists worldwide collaborate on projects that can work towards this goal no matter the species in question, for example by using funds, technology and methods in support of a bigger animal welfare research community. Networks, such as the Animal Welfare Research

Network (AWRN, 2019) in the UK or the Global Animal Network as part of World Animal Protection (World Animal Protection, 2019) are important for knowledge transfer and enable expertise across a wide range of species to be circulated amongst members. However, welfare researchers need to engage with this process and attend conferences and events that may be slightly outside of their normal expertise to enable this sharing of good practice to develop further. We would also encourage conference organizers to include more diversity in topics when selecting oral presentations.

The understanding that animal welfare is a property of individual animals is making small *n* studies more appropriate and more acceptable, and there is no reason why such studies should not be scientifically robust and provide important information that advances the field. With details on individual animal needs, gathered from research there is the potential to move towards 'animal-based' rather than the 'resource-based' measures of welfare that are commonly used in farm/lab situations. Within the zoo industry, there is a trend towards evidence-based practice (Ward et al., 2018), which suggests that scientific knowledge gathered directly from research is improving the way zoo animals are managed; unfortunately, this is not always the case for farm/lab animals. However, we feel that many researchers might be discouraged from following this path because of perceived difficulties in obtaining funding and publishing in high quality journals. To this end, we would encourage journal editors, conference organizers and funding bodies to be more accepting of this trend and authors to not draw too many population-based trends from the data presented.

There are already beneficial welfare collaborations on varying projects; however, there is always more that can be done to encourage this. Moving forwards, as a scientific field, a focus towards positive welfare indicators in farm/lab and zoo animals is key. As discussed above, research has previously focused on ensuring we meet the needs of the animals and covering the minimum standards, but now is the time to emphasize more on what makes the

239 animals happy and how we measure it. We would encourage more researchers to embrace
240 these directions. Examples include measuring vocalizations when tickling rats (LaFollette et
241 al., 2018), occurrence of play and affiliative behaviors (Boissy et al., 2007) and measuring
242 anticipation as a means of understanding what an animal wants (Clegg et al., 2018) for all
243 farm/lab and zoo species.

244 Ideally, we need to be progressing animal welfare beyond legislative needs and developing an
245 increased standard to not only ensure sustainable productivity (whether for farming or captive
246 breeding) but also to ensure our animals have the best lives in captivity that we can provide
247 for them. Modern zoos, for example, list conservation, education, research and visitor
248 enjoyment as their aims, and we would encourage the zoo community to add 'high animal
249 welfare standards' to this list. It is also important to not only share new and innovative
250 techniques amongst our peers but to share good practice amongst less economically
251 developed countries. We need to ask ourselves, what do we really know about the farm and
252 zoo animal welfare needs around the globe and is there something that as experienced
253 researchers and practitioners, we can do to support them. Working more closely together,
254 there is much that the agricultural and zoo communities can do to advance animal welfare
255 theory and practice.

256

257 **Conclusion**

258 Assessing the welfare of captive animals using our perception of it is one thing, but quite
259 another to use the animals' perceptions of their welfare. Good progress has been made in
260 doing this across the three animal groups discussed in this paper, but much of it relies upon
261 experimental techniques that are difficult or costly to carry out and therefore rely on funding
262 that is not always allocated evenly across the groups. Animal welfare science would benefit if

more guidance could be given by those doing this research as to how their findings could be implemented practically. There has been some movement towards doing this, for example in the case of judgment bias. At the same time, zoo researchers need to move more towards devising ways of overcoming the difficulties of controlling variables and examples such as multi-zoo research are an obvious way of doing this with recent studies increasingly using this technique. Through changes like these we should hopefully move towards zoo welfare science being more recognized like farm/lab research in its status and approach, while providing the best welfare it can for all animals whatever the species or setting.

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