〔**Research Note**〕

Welfare assessment of wild animals in zoos

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1. Introduction

Improving welfare of animals is our ethical responsibility as well as a legal obligation in many countries. There are several benefits to improve welfare of animals such as improved production and validity of experimental results in the fields of farm and research animals respectively. In the case of wild animals in zoos, it is likely to improve visitors' understanding of wildlife thereby contributing to its conservation.

However, assessment of animal welfare is not a simple matter. Welfare assessment of wild animals in zoos is especially challenging as the number of species collected in zoos is huge. While 19 to 24 billion farm animals are estimated to exist in the world, the International Union of the Directors of Zoological Gardens (now known as the World Association of Zoos and Aquariums (WAZA)) estimated 1 million vertebrates in about 1,000 zoos in 1990s (Hill and Broom 2009). Furthermore, there are many species whose ecologies in natural habitats are not well understood.

In this note, I will first outline the current available welfare assessment methods developed in the fields of farm and laboratory animals. Then, I will discuss their relevance and applicability to zoo animals.

2. The current available animal welfare assessment methods in farming and laboratory contexts

Animal welfare assessment can be based on two types of measurement: resource (or husbandry)-based and animal-based. The former measures elements of provisions such as housing and environment, environmental enrichment, human-animal relationships, programs of veterinary care, and nutritional programs. The later evaluates elements such as animal's behaviors, body conditions, and disease symptoms. (European Commission, hereafter EC, 2015: 41-42)

2.1 Resource-based approaches

In the early stages of its development, animal welfare assessment focused on resources. It was part of the schemes which assessed quality of animal products. Various quality assurance (QA) schemes were developed in Europe to provide standards of quality of food products (Wood, Holder and Main 1998). The main goal of the QA schemes was to satisfy increasing consumer demands for assurance of food quality and welfare of animals. The aspects of quality emphasized in QA schemes varied internationally and domestically. Animal welfare was strongly

emphasized in the UK schemes. For example, the Royal Society for the Prevention of Cruelty to Animals (1997) developed the Freedom Foods schemes for pigs, which specified welfare standards for pigs. The list of the welfare standards included provisions of food and water, space allowances, veterinary care, and provisions in terms of transportation and slaughter (Wood *et al.* 1998). The elements specified in the list were all resource related.

The Animal Needs Index, ANI 35, developed in Austria was another example of a resource based assessment. It has five components: (1) the possibility of mobility, (2) social contact with members of the same species, (3) condition of the floors on which animals are lying, standing and walking, (4) stable climate including ventilation, light and noise, and (5) the intensity of human care (Bartussek 1999). These are all resource based elements.

2.2 Animal-based approaches

While resource-based assessment methods have advantages such as consistency and objectivity as well as their relative ease and practicality, it can be difficult to correlate the resources and the actual states of the animals measured (Whay, Main, Green et al. 2003). Animal welfare focuses its attention on individual animals, but resource-based approaches may not be able to detect individual welfare status as it is not clearly understood what resources are linked to what welfare issues (Maple and Perdue 2013: 35; Blokhuis, Jones, Geer, et al., 2003: 446). Given these shortcomings, focus of research in animal welfare assessment has shifted to animal-based approaches. For example, Welfare Quality® has been developed in Europe involving 44 institutions in 17 countries. Although it includes resource-based measures as well as animal-based measures, 'one of its central aims is the development of an on-farm welfare assessment system that focuses on animal-based measures' (Knierim and Winckler 2009: 451).

In the following, I will summarize Latham's (2010) discussion of various animal-based measures which evaluate physical, physiological, and behavioral states or responses to stimuli in the context of laboratory animals.

2.2.1 Physical measures

Physical measures include physical appearance and body weight. Routine monitoring of physical appearance can be quick and non-invasive. Body weight can be easily measured if the animal is small such as rats and mice, and it can serve as a criterion for effects of experiments or for euthanasia. However, care is needed as factors other than welfare states such as age, activity levels, and reproductive cycle may affect body weight.

2.2.2 Physiological measures

A commonly assessed physiological measure is activities of hypothalamic pituitary adrenal (HPA) axis. When an animal receives an acute stressor, HPA axis, which is a hormonal pathway, produces glucocorticoids (cortisol for most mammals and fish, corticosterone for rats and birds) which appear in the blood, saliva, urine, feces, and hair. One shortcoming of measuring glucocorticoids is that its level increases not only in aversive situations but also in situations of high arousal.

Another physiological measure is responses of sympathetic adrenomedullary (SAM) axis,

which is a neural network. An animal raises heart rate, blood pressure, body temperature, and respiration rate, and dilates pupils through SAM axis when facing a stressor. The SAM axis responses are less commonly used for assessing laboratory animal welfare as it often requires telemetry devices which must be implanted and whose size is relatively large and heavy for most of the research animals such as rats and mice.

2.2.3 Behavioral measures

Behavioral measures include stereotypies, vocalizations, anticipatory behavior, cognitive bias, preference, and motivation.

Stereotypy is a repetitive, often invariant behavior with no clear purpose. It is caused by frustration or central nervous system dysfunction. Bar-biting, somersaulting, and jumping are common stereotypies in laboratory rodents, and pacing, rocking, and digit-sucking are examples of research primates.

Measuring stereotypies has several concerns. First, assessors need to know what behaviors are stereotypies and what are not. Broom and Fraser (2015: 247) list 10 common abnormal behaviors in livestock such as pacing and weaving in horses and bar-biting in pigs. However, such information may not be available for other less familiar animals. Second, prevalence and severity of stereotypies vary among species, but they may also reflect inconsistencies in definition of stereotypy among researchers. In addition, scoring of stereotypic behaviors is often subjective. Researchers may have different durations; some may count bar-biting as stereotypy if it occurs only one second while others may count it with 10 seconds. Furthermore, when comparing animals in a stereotypy-inducing environment, welfare of the animals with stereotypic behaviors is not necessarily worse than those without stereotypy. For some animals in poor environments, a stereotypic behavior itself may become a reward ameliorating welfare according to Mason and Latham (2004). It may be a way of coping with the poor environment for those animals. Therefore, stereotypy should not be taken as a sole measure of welfare assessment.

Vocalizations can be related to negative animal states such as audible vocalizations in rats, but it can be related to positive states such as tickling and mimicking play of rats.

Anticipatory behavior appears when an animal is expecting some reward such as food after receiving a conditioned stimulus as in Pavlovian classical conditioning. The amount of the behavior between the stimulus and the reward is measured in order 'to assess sensitivity (incentive salience) to different types of rewarding stimuli (Van Der Harst *et al.* 2003b, 2005), or to assess (poor) housing-induced sensitiastion of the mesolimbic dopaminergic system (Van Der Harst *et al.* 2003a)' (Latham 2010: 83). However, it seems that there are species differences; thus, it may work for rats but may not for cats, for example.

A cognitive bias test measures an animal's mental state. For example, in Harding, Paul and Mendl (2004), rats are trained to learn one tone is followed by a positive consequence and another tone with a negative consequence. When they are presented with ambiguous tones, rats from a better environment were more likely to respond to an ambiguous tone positively. Cognitive bias has not been demonstrated as a reliable indicator of welfare, however, so a combination of studies is necessary for welfare assessment in order to improve its accuracy

(Broom and Fraser 2015: 54-55).

A preference test can measure an animal preference by allowing an animal to choose one item over another such as cage height, light intensity, or different substrates. One problem of this test is that it can only give us a relative preference. Another problem is that it may be a short term improvement.

A motivation test (or consumer demand tasks in Latham (2010)) is developed to measure the strength of motivation for different resources. For example, an animal has to pay a cost of pushing doors of varying weights in order to obtain a resource. Motivation for some resources may be influenced by some factors such as whether the resource is visible or whether the cost is paid before or after the resource is obtained. This test is simpler to conduct on individually housed animals, but the individual housing may affect its result.

In summary, a thorough assessment of animal welfare should include both resource-based and animal-based measures to supplement shortcomings of each measure.

3. Relevance and applicability of the existing animal welfare assessment methods to zoo animals

When we assess welfare of zoo animals, we should be able to adopt the assessment methods developed in the fields of farm and laboratory animals to some extent. In this section, I will discuss their relevance and applicability to zoo animals.

Before discussing each method, we need to consider issues arising specifically in the zoo animal context. First, there are a huge number of species in zoos. For example, London Zoo in the UK houses a total of 758 species with 16,869 specimens according to the International Zoo Year (2015). It seems unlikely to obtain a full range of information about each species' needs in their natural habitats as well as those in captive environments. Furthermore, even if we have enough information about the species-specific needs, there are individual variations as well. Individual animals in zoos have different experiences; some may come from the wild, a sanctuary or another zoo, and some may be born at zoos. Therefore, individual variation needs to be taken into account.

Given these issues, assessment of welfare of zoo animals should employ a combination of methods appropriate to them. I will discuss their applicability and limitations below.

3.1 Resource-based approaches

Provisions of food and water, space allowances, veterinary care, and provisions in terms of transportation and slaughter are the resource-based measures included in the Freedom Food schemes discussed above. Food and water, space allowances, and veterinary care may vary among species, but once information of these provisions is obtained, measuring these can be done by simple observation or by making inquiries. Transportation and slaughter are less important for zoo animals than for farm animals. Although transportation takes place when animals are moved to another enclosure or another zoo, it does not take place routinely. Whether methods of transportation and euthanasia should be included in an assessment seems to depend on the extent to which the assessment should be extended.

3.2 Animal-based approaches

3.2.1 Physical measures

As in the case of farm and laboratory animals, checking physical appearance can be quick and non-invasive although there might be a subtle indication on the body which may be difficult to detect if, for example, an animal is covered with thick fur. Body weight should not be so difficult to measure if each enclosure is equipped with an appropriate weighing device.

3.2.2 Physiological measures

According to Hill and Broom (2009), Some physiological measures are relatively easy to obtain while others are more difficult.

Glucocorticoids from the HPA axis can be measured non-invasively in feces, urines or hair of various species for assessing short-term responses to stressors. However, it should be combined with other measures as the HPA axis produces glucocorticoids in pleasant situations as well.

Sample collection may not be easy, however. It is especially difficult for 'large, powerful and unpredictable wild animals that have evolved strong "fight and flight" responses in order to cope with perceived threats' (Hill and Broom 2009: 540). Even if they can be obtained, such data may not reflect the normal state of the animal as the process itself is likely to increase the fear responses of the animal. In some cases, training of animals for sample collection was successful while in another case, sample collection was facilitated by exhibit design. Successful sample collection depends on the keepers' support for the study.

Responses of the SAM axis to stressors such as heart rate, blood pressure, body temperature and respiration rate are difficult to obtain safely as the processes of obtaining these data require physical attachment to the animal's body or anesthesia, which are likely to trigger fear responses.

3.2.3 Behavioral measures

Animals have a range of behavioral responses to various stimuli. In order to conduct an assessment in terms of their behaviors, we need to know the full range of the behavioral repertoire for a particular species so that we can distinguish normal behaviors and abnormal behaviors. In the case of zoo animals, such information is scarce for most of the animals. In such cases, information about those of similar species may be used (Hill and Broom 2009: 537). It should be noted, however, that behaviors that do not appear in the wild do not necessarily indicate poor welfare as they may appear as a result of having better living conditions. In addition, individual and population differences should be taken into account. Studies have shown that animals in different populations show different behavioral patterns or traditions. For example, wild orangutans show cultural differences in food-sharing (van Schaik 2003) and foraging (Fox, Sitompul, and van Schaik 1999). Furthermore, it is important to minimize the discrepancy among researchers to what extent a behavior is abnormal so that we can compare data reliably as mention in section 2.

Stereotypies are common abnormal behaviors of zoo animals. For example, 'pacing is the most prevalent stereotypy among carnivores (97% of reported stereotypies)' according to

Clubb and Mason (2003). They found that natural home-rage size predicted pacing and infant mortality of carnivores in captivity. Stereotypies can be measured by observation but may be time-consuming as some animals continue to do so for a long period of time. Video recording may be a practical option in such cases.

Vocalizations and anticipatory behavior are also observable. On the other hands, cognitive bias, preference and motivation tests are not so simple, but they can be used to measure specific responses of animals to specific stimuli.

4. A case of Andean bears

In this section, I will discuss application of assessment measures to Andean bears. I will first illustrate the ecology and behaviors of Andean bears in the wild. Then I will apply some of the assessment measures discussed above to Andean bears in captivity.

4.1 The ecology and behaviors of Andean bears[1)]

Andean bears, also known as spectacled bears, live in Andes Mountains. They are endangered species whose ecology is not well understood. They are adaptable and opportunistic, so their diet and behavior depend on their local habitat. They are taxonomically carnivores, but in reality, they predominantly eat vegetables. They eat juicy stems of trees by ripping them open using their claws. They climb trees to eat plants and tree fruits. They also dig in the earth in search of beetles, worms and insects as a source of protein and occasionally feed on small mammals.

Andean bears are diurnal and crepuscular. They are arboreal, rock climbers, and good swimmers. They build platform structures high up in trees for resting or eating during the day, but they don't sleep on the trees overnight.

Andean bears are solitary animals, rarely coming into contact with other bears. However, they seem to leave messages on trees potentially for mating purposes by rubbing their backs against tree trunks, leaving scratch marks with their claws, and perhaps urinating or leaving a hormonal secretion around the scratched area. Having olfaction as their principal sense, other bears can detect these signals from far away.

The mean annual home rage of male Andean bears is 59 km^2 and that of female bears is 15 km^2 (Castellanos 2011).

4.2 Assessment measures of welfare of Andean bears in zoos

In order to assess welfare states of Andean bears in zoos, we can combine various measures in resource and animal based approaches.

First, it is essential to assess whether appropriate resources are provided. In terms of the diet, they should be provided with a variety of foods such as trees, plants, and fruits, beetles, worms and insects as well as water. For climbing and platforms, trees, rocks, and branches may be necessary. A pool for swimming may further improve welfare of the bear. These are all resource-based measures and can be measured non-invasively.

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1) The information about Andean bears in this section is mainly from Andean Bear Foundation (undated).

Among animal-based measures, stereotypic behaviors, especially pacing, can be measured by observation, and cortisol level might be taken from feces. Cognitive bias tests may be added to detect chronic stress. For example, an Andean bear is trained to learn that a white box has some food treat while a black box produces some noisy sound which the bear does no like. Then the bear is presented with boxes of ambiguous colors such as grey, the prediction would be that he would not open the grey box if his mental state is pessimistic, but he may open it if optimistic. There are potential problems in this scenario, however. One is that Andean bears have very keen sense of smell, so the bear may be able to detect the food reward by its smell. If so, he may open the box with the reward regardless of the color. Another problem would be that Andean bears may be color blind. If so, the boxes should be distinguished by some other way, for example, size or shape.

Preference and motivation tests may be useful to find out what they want and how strongly they want. Vocalization may not be a useful measure unless the roles of the voices are well understood. SAM axis responses may be difficult to measure as stated in section 3.

5. Conclusion

In this note, I discussed applicability and limitations of welfare assessment measures to zoo animals and considered application of some measures to Andean bears as a case study. It is clear that more research is needed in order to assess the welfare of zoo animals appropriately. In order to evaluate the welfare states of zoo animals, we need to know more about behaviors of the animals in the wild as well as in the captive environments. We also need to evaluate whether the methods of assessment is actually appropriate. That is whether it is measuring what we are trying to measure. It also seems necessary to develop an assessment protocol which is applicable within the financial and resource restrictions that many zoos have.

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