Zoo Animal Welfare Assessment

Subjects: Veterinary Sciences | Zoology | Biodiversity Conservation

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Zoological institutions, such as zoos and aquariums, have made animal welfare a top priority, as it is not only a moral obligation but also crucial for fulfilling their roles in education and conservation. Thus, there is a need for science-based tools to assess and monitor animal welfare in these settings.

animal-based indicators   animal behaviour   stress   welfare assessment

1. Introduction

Animal welfare has become an absolute priority for zoos and aquaria (from now on, zoos). Ensuring the highest possible standards of animal welfare is not only a moral duty but also a necessary condition if zoos are to realize their educational and conservational functions. Having science-based tools to assess animal welfare is needed to identify welfare problems and to monitor progress when improvement strategies are implemented. However, assessing the welfare of zoo animals is challenging due to, among other reasons, the sheer diversity of species kept in zoos and the lack of knowledge on the general biology and specific needs of many of them.

2. Fundamental Principles of Zoo Animal Welfare Assessment

Methodologies to assess zoo animal welfare must be based on the current understanding of the concept of animal welfare. Historically, animal welfare has been defined using different approaches (see Fraser et al. [1] for a review), which can be grouped into three categories: biological functioning, emotional state, and "naturalness". Each of these approaches has its own merits but none of them captures on its own the different aspects of animal welfare. It has been suggested, therefore, that the assessment of animal welfare must include all three approaches [1]. In fact, it is now widely accepted that animal welfare encompasses not only the physical health of the animals (i.e., the absence of diseases and injuries) but also their behaviour and emotions [2][3]. Behaviour is an essential element of welfare, among other things, because the possibility to engage in highly motivated behaviours contributes to animals experiencing positive emotions ([4], see below). In summary, when assessing zoo animal welfare, it is important to remember that the concept of animal welfare is broader than that of physical health, understood as the absence of diseases and injuries, since animal welfare includes both the physical and the mental state of the animals. Therefore, any assessment methodology must include both aspects.

For many years, the Five Freedoms and provisions [5] have offered a useful framework for the identification of welfare problems in animals. The Five Freedoms were initially developed for farm animals but have also been used

for zoo animals. In recent years, the Five Freedoms have been criticized mainly because they fail to capture the current understanding of the biological processes underlying animal welfare [6] and because they are limited almost exclusively to the absence of negative situations, paying less attention to the importance of the positive aspects of well-being. Over the last few years, several authors have emphasized the so-called "positive welfare", that is, the fact that to reach true animal welfare, it is not enough to guarantee the absence of suffering in animals, but that researchers must also provide them with the necessary conditions for them to experience positive emotions [4].

As an alternative to the Five Freedoms, the so-called Five Domains Model for assessing animal welfare was developed to address these problems. According to this model, the welfare of an animal results from its global emotional state, that is, from the balance between the positive and negative emotions that the animal experiences at a certain moment or over a period of time. This global emotional state constitutes the fifth domain of the model. The model recognizes four other domains, which are the "physical" domains (feeding, environment, health, and behaviour) from which positive and negative emotions are derived, which, when combined, define the fifth domain [7][8].

3. Main Approaches to Zoo Animal Welfare Assessment

There are several approaches to zoo animal welfare assessment, and they can be broadly grouped into five main categories:

- Species-specific protocols;

- Generic protocols and risk assessment methods;

- Assessment of welfare based on time budgets;

- Keepers' ratings;

- Cognitive bias testing.

These approaches are not mutually exclusive, and, for example, some zoos combine keepers' ratings with measurements of other animal-based and environment-based welfare indicators [9].

3.1. Species-Specific Protocols

For a few species of zoo-kept animals, there are species-specific welfare assessment protocols that include a set of indicators and a description of the methodology to measure them. Some of these protocols are based on the Welfare Quality© protocols that were initially developed for farm animals kept under intensive production systems [10]. The Welfare Quality© protocols include four animal welfare principles (feeding, environment, health, and behaviour), which coincide with the four physical domains of the Five Domains Model. In turn, each principle includes several animal welfare criteria and, finally, each criterion is evaluated through one or several indicators.

One of the advantages of the Welfare Quality© protocols is that they combine animal- based indicators (such as behaviour, clinical signs, and body condition, among many others) and resource-based indicators (such as space available to the animals, for example). Traditionally, animal welfare used to be assessed through resource-based indicators, mainly because they are easier to measure and require less time and training. However, resource-based indicators sometimes fail to provide accurate information on the welfare state of animals and animal-based indicators are often preferred [11]. This is because the effect of a given environmental feature on the welfare of animals can vary across individual animals. Additionally, environmental features often interact with each other, and their effect on the animals may be difficult to predict.

Based on the Welfare Quality© assessment protocols, Clegg et al. [12] developed a welfare assessment protocol for bottlenose dolphins (*Tursiops truncatus*) under human care. The protocol included a total of 36 measures (more than half of which were animal-based) that were tested for feasibility and accuracy. Although the protocol has some limitations (including its restricted applicability to very young and very old dolphins), it is a very useful step towards a standardised welfare assessment tool for dolphins under human care, and has led to the development of other welfare assessment protocols for this species [13].

A slightly different approach was followed by Yon et al. [14], who developed a behavioural protocol to assess the welfare of captive African and Asian elephants (*Loxodonta africana* and *Elephas maximus*). The protocol includes three sections: Qualitative Behavioural Assessment (QBA), daytime behaviour questions and nighttime observations. QBA is a methodology that was initially developed for farm animals to assess the valence of an animal's emotional state by measuring its demeanor ([15], see below). The items included in the protocol were tested for feasibility, validity, and reliability. The authors suggested that the protocol could be used together with other elephant welfare assessment tools that focus on health and physical condition.

Species-specific protocols have, at least in theory, several advantages over other welfare assessment methods, as they are meant to cover all aspects of animal welfare, use measures that have the potential of being tested for validity and reliability, and are tailored to the biological needs and peculiarities of each species. However, their main limitation is that very few of them have been developed until now. In fact, for the vast majority of zoo-kept species, there is a lack of validated indicators that can be integrated into a protocol. For example, despite being very charismatic species that have probably attracted more research efforts than many others, the number of fully validated welfare indicators for polar bears (*Ursus maritimus*) and African and Asian elephants is very small.

3.2. Generic Protocols and Risk Assessment Methods

Due to, in part, the lack of species-specific protocols for the vast majority of zoo-kept animals, several authors have proposed generic assessment protocols, i.e., protocols that can be used in any species. One example of these generic protocols is the welfare assessment tool proposed by Brando and Buchanan-Smith [16] as part of their 24/7 welfare framework. The authors adapted and expanded the 12 criteria of the Welfare Quality© assessment protocols, adding two more criteria. The resulting welfare tool is meant to be used by zoo staff to find out if their animals' welfare needs are met.

Sherwen et al. [17] developed a welfare risk assessment protocol that includes a total of 20 indicators (both animal- and resource-based), as well as an scoring methodology, and each indicator was given a value of 0, 1 or 2. This method is meant to identify potential welfare issues and prioritize improvement actions so that zoo personnel can take a proactive approach rather than simply flag welfare problems when they have already appeared.

Generic protocols and risk assessment methods are obviously more flexible than species-specific protocols, as they are designed to be applied to any species. A main limitation, however, is that they can only be successfully applied if the biology and welfare requirements of each species are well-known, which is not always the case. Recently, new proposals have been suggested to, at least partially, overcome some of these limitations [18].

3.3. Assessment of Welfare Based on Time Budgets

Welfare assessments based on time budgets follow the assumption that the proportion of time that an animal spends in positive and negative behavioural states reflects its overall welfare.

This methodology was developed by Watters et al. [19], who provide a list of positive and negative behaviours, and suggest a methodology to obtain the above-mentioned ratio. One of the main advantages of this approach is that it gives an overall score of welfare that allows zoo personnel to follow possible changes in the welfare of their animals. Additionally, although the method requires behavioural observations, it is likely to be less time-consuming than some species-specific protocols, for example.

One of the main limitations of time budgets as a basis for welfare assessment is that it is not always easy to decide if a given behaviour is positive or negative. For example, an animal can be inactive because it is resting and content, or because it is bored. Additionally, time spent engaging in a given behaviour may not be enough to assess its welfare relevance. For example, aggressive interactions can have very negative effects on animal welfare even if they are very brief. Finally, time budgets provide information on the behavioural aspects of welfare, but not on the health or physical state of the animals.

Time budgets can be used to work out behavioural diversity, which has been proposed as an indicator of positive welfare. The rationale for using behavioural diversity as an indicator of good welfare is that a high behavioural diversity indicates that the behavioural needs of the animals are being met, as animals can display a wide repertoire of natural behaviours. On the contrary, when animals are unable to show their natural behaviours and engage in repetitive behaviours or become lethargic (which would be indicative of poor welfare), behavioural diversity will decrease [20]. There are several methods to calculate behavioural diversity and the so-called Shannon's diversity index is the method that is most frequently used [21]. The validity of behavioural diversity as an indicator of positive welfare has been criticised based on both methodological problems and because the calculation of the diversity index does not consider the valence of the behaviours, i.e., whether a given behaviour reflects a positive or a negative welfare state [22]. These criticisms should stimulate further research on the validity of behavioural diversity across different taxa.

4. Animal-Based Welfare Indicators for Zoo Animals

In general, welfare indicators are divided into two main categories: environment-based indicators (also known as 'input-based or resource-based indicators') and animal-based indicators (also known as 'output-based indicators') [23]. Among numerous others, the size and layout of the facilities, ambient temperature, and type and quantity of food are considered environment-based indicators. While environment-based indicators are widely used and known for their reliability and feasibility, this research does not cover these indicators. Conversely, the main animal-based indicators for animal welfare are behaviour, body condition, existence of clinical signs, fur or feather appearance, as well as diverse physiological and biochemical parameters.

Behavioural indicators are the most commonly used indicators for evaluating animal welfare [24]. This may be because behavioural observations are considered a non-invasive method of data collection [25], for which advanced technology is usually not required [24] and can be relatively inexpensive to apply [26].

Each individual is inherently unique, leading to diverse experiences and distinct needs. Consequently, these individual differences can significantly influence animal welfare. Specifically, these differences can be best characterized as variations in personality, reflecting stable behavioural differences observed across time and situations [27] (p. 654). Personality traits are influenced by a combination of genetic and environmental factors, resulting in the widely acknowledged notion that individual animals possess distinct personalities that can impact their welfare when kept in captivity [28][29]. Moreover, zoo animals have a wide range of behaviours in their repertoire, and therefore, may respond differently to conditions that could potentially impact their welfare [26]. Consequently, it is not possible to rely on a single behaviour-based indicator to assess an individual's welfare. The most commonly used welfare indicators based on behaviour are those that assess abnormal behaviours and changes in the expression (frequency, duration, or intensity) of normal behaviours [23].

4.1. Indicators Related to Abnormal Behaviours

4.1.1. Abnormal Repetitive Behaviours

Abnormal repetitive behaviours (ARB), also called stereotypies, were initially defined as repetitive, invariant behaviours without an apparent immediate function [30]. An updated definition considers stereotypies to be repetitive behaviours caused by frustration, repeated attempts to adapt to the environment and/or a dysfunction of the central nervous system [31]. This updated definition takes into account that these behaviours may not be as invariant as previously assumed, and that some of them might actually aid animals in adapting to challenging or unsuitable environments [23][31].

In zoo animals, ARB can manifest in various ways, and the frequency of each type may differ depending on the taxonomic group [32]. For example, locomotor repetitive behaviours (such as pacing) are more commonly observed in carnivores, where the animal moves repetitively along the same path. Oral repetitive behaviours (such as licking or biting objects) are more frequently observed in ungulates. Primates tend to show ARB related to repetitive body movement without displacement. Oral and locomotor repetitive behaviours have also been described in birds.

There is still little information on possible abnormal behaviours developed in reptiles, amphibians, and fish [25]. However, in some reptile species [33], individuals have been observed to repetitively interact with transparent barriers (such as glass), and in fish, possible ARB including repetitive swimming patterns have been observed [34].

Repetitive behaviours are probably the abnormal behaviours that cause the most concern in zoos because they are very obvious when present and can cause anxiety to visitors when they observe them [25][35]. They are also some of the most used welfare indicators and are very useful, as they can indicate welfare problems related to frustration, stress, behavioural restrictions [31] and the onset of medical problems [23]. However, the use of ARB as welfare indicators can be confusing because the relationship between an ARB and welfare can sometimes be complex. For example, an ARB that has existed for a long period of time may become 'fixed', and therefore, there is a possibility that an animal currently maintained in an appropriate environment shows an ARB as a result of a previous unsuitable environment [36].

4.1.2. Damaging Behaviours

Self-Injurious Behaviours

Self-injurious behaviours (SIB) have been linked to poor welfare in captivity. In captive birds, particularly psittacines, feather damaging behaviour (FDB) has been reported as a behaviour where birds pluck their own feathers [37], which is considered abnormal and associated with the inability to perform natural behaviours such as foraging and podomanipulation [38][39].

Captive primates have been reported to exhibit hair-plucking behaviour [40], which resembles FDB, as well as other SIB such as self-biting and head-banging [41]. These abnormal behaviours present a significant and immediate threat to an individual's physical health and overall welfare [42].

Regurgitation and Reingestion

Another abnormal behaviour observed in captive primates is the intentional regurgitation and reingestion of previously ingested material [43][44][45], which has also been observed in marine mammals. This behaviour can lead to health problems and is believed to be an adaptive response to boredom, stress, space restriction, lack of control over the environment, dieting, or the inability to develop normal foraging behaviour [46].

4.1.3. Apathy

The abnormal state of inactivity and lack of response to environmental stimuli in animals is referred to as apathy [23]. In humans, this condition is commonly linked to depression [47][48]. Animals may exhibit apathy in monotonous or stressful environments, where they feel they have no control, and when they are experiencing pain [49].

However, it is essential to note that there are individual and species differences when assessing apathy in zoo animals. To distinguish between normal levels of inactivity and apathy-associated inactivity, one must consider the typical activity rhythm of each species, including whether they are nocturnal or diurnal animals [23].

4.2. Indicators Related to Changes in the Expression of Normal Behaviours

A good understanding of the species being assessed (including individual differences) is necessary to identify a normal range of activity or deviations from it. Unfortunately, such knowledge is lacking for many zoo-housed species, as their needs in natural habitats are not always fully understood [26].

When using normal behaviours to assess welfare, researchers should pay attention to changes in their expression, specifically changes in the frequency, intensity, and/or duration of these behaviours [23]. Therefore, it is important to regularly measure the normal behaviour of animals and compare it to detect changes in the expression of these behaviours.

4.2.1. Social Behaviours

Affiliative and Agonistic Behaviours

Social interactions, including both affiliative (or positive) and agonistic (or negative) behaviours, are a normal part of the behaviour repertoire in all species. However, an excess or high intensity of negative behaviours may indicate a welfare problem and can cause injury and stress. Negative emotions such as pain, fear, chronic stress, and frustration can cause or increase aggressive behaviour [23]. Conversely, affiliative behaviours are generally considered rewarding and can have a buffering effect on stress and reduce social tension, improving group cohesion and bonding between individuals. Therefore, affiliative behaviours are often considered indicators of positive welfare [50]. However, an increase in affiliative behaviours does not always indicate good welfare. For example, after a conflict between two or more animals in a group, an increase in affiliative interactions may occur, a phenomenon known as 'behavioural reconciliation' [51].

Maternal Behaviour

Maternal behaviour is another social behaviour that can be affected by stressful situations, pain, or other negative emotions. Negative emotions can lead to abnormal maternal behaviours such as neglect or aggression towards the young, excessive grooming of the young, or frequent movements of them from one place to another [23].

Play Behaviour

Play, whether it happens with one's self or socially, is an enjoyable activity that usually only takes place when other needs are fulfilled. In fact, the existence of play behaviour might suggest that the animal is not deprived of significant sources of pleasure and that other biological needs are satisfied. Therefore, play behaviour is generally viewed as a positive indicator of animal welfare, particularly in mammals and birds [50]. However, caution should be exercised when using play behaviour as a positive indicator, as social play in some species can sometimes lead to aggression. Furthermore, there are cases where it was observed that the occurrence of play behaviour can increase following a period of stress or deprivation of opportunities to play [23].

4.2.2. Maintenance Behaviours

Food Intake

If management practices are not improved, food in zoos is typically presented in a simple and direct way, such as in a feeding bowl or at a single distribution point. As a result, foraging and consummatory behaviours, such as chewing, take significantly less time than they would in the wild, particularly if food availability is limited. This can lead to animals having unsatisfied motivations to perform these natural feeding activities [52].

However, a reduction in food intake may also result from an intense stress response, which can be influenced by factors such as the type and intensity of the stressor. It should be noted, though, that stress can occasionally increase feed intake, potentially leading to obesity and other health problems [23].

Rumination

Rumination is a specific feeding function, essential for optimal digestion in ruminants. The duration of rumination is affected by the type of diet, and insufficient fibre intake leads to a decrease in rumination time, which can result in gastrointestinal problems [52]. Furthermore, stress can decrease rumination time [53], and inadequate opportunities for rumination may lead to the development of oral repetitive behaviours [54].

Sleep Behaviour

Sleep behaviour or sleeping is defined as a motionless state in which an animal is not alert and has both eyes closed if anatomically possible. Stress can interrupt sleep patterns, reducing the duration and quality of sleep [55]. For this reason, sleep behaviour can be an important welfare indicator, although not easily observable at night without the use of technology (e.g., infrared cameras).

4.2.3. Behaviours Related with Exploration and Interaction with the Environment

Anticipatory Behaviour

Anticipatory behaviour is a set of behaviours expressed by animals before acquiring a positive outcome or resource [56]. Some examples of the anticipated positives outcomes are opportunities for reproduction, positive social interactions, or food, as well as behavioural opportunities to obtain primary reinforcements (e.g., positive reinforcement training or environmental enrichment). Anticipatory behaviours occur in an area close to where the positive event takes place, their intensity or frequency increases as the time of a predictable positive outcome approaches, and stops being expressed when the motivation is consummated [57]. Anticipatory behaviours themselves are not indicators of positive or negative welfare, but rather the intensity with which they are expressed is related to animal welfare. For instance, the intensity of anticipatory behaviour tends to decrease when animals have more opportunities to obtain rewards, and conversely, increases when opportunities are scarce.

Use of Enclosure

Studying how animals use the enclosure in which they live can help quantify the effects of environmental enrichment, modifications or improvements in facilities, and changes in social groups [58]. It can also help detect each individual's preferred areas and locate where the most valuable resources for the animals are. This can allow zoos to make informed, evidence-based management decisions and redesign areas avoided or underutilized by animals to maximize the enclosure's potential.

4.2.4. Other Behaviours

Displacement Behaviours

Displacement behaviours are behaviours that appear irrelevant and inappropriate in the context in which they appear [59]. Some self-directed behaviours (actions directed at an animal's own body) are considered displacement behaviours resulting from frustration and/or a situation of internal conflict in an animal. They are often linked to negative excitement and even used as indicators of stress or welfare problems in primates [60]. However, several studies indicate that not all displacement behaviours have the same function, and some of them, such as self-scratching, can also increase with positive excitement [61]. For this reason, and because these may be normal behaviours that are unrelated to the animal's emotional state, it is necessary to have long-term records of the frequency of displacement behaviours if they are to be used as indicators of welfare [23].

Vocalisations

Animal vocalizations are sounds that animals actively produce and can reflect their emotional states. The type of vocalization may differ among individuals based on their personality and among species. For instance, in highly emotional circumstances, such as when confronted with predators, some animals may produce alarm calls frequently, while others may produce them less often or remain silent [62]. Nevertheless, combining vocalizations with other indicators of emotions can provide a tool for monitoring both positive and negative emotions, which in turn can be used to assess animal welfare [63].

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