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# Identifying Essential Elements of Good Giraffe Welfare—Can We Use Knowledge of a Species' Fundamental Needs to Develop Welfare-Focussed Husbandry?

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**Abstract:** Measurement of zoo animal welfare states enables improvement to husbandry and management to be evidence-based and implemented according to species' needs. Theoretical welfare concepts are often discussed, and whilst it is helpful to ensure wide consensus across all stakeholders on what welfare comprises, practical application of such evidence-based information is as equally important. All species housed in zoos will have specific needs that must be met by their housing, husbandry, and care to enable them to thrive. Therefore, this paper examined how to identify key animal care needs and an animal's responses to them to form a basis for species-specific welfare assessment approaches. There are examples of familiar-to-the-zoo species that still pose challenges regarding delivery of optimal husbandry and management. As such, the identification and evaluation of core concepts of the biology, behaviour, "needs and wants" of these species is required to support validation and refinement of physical, behavioural, and psychological welfare measures. This article evaluated the use of evidence to build capacity in welfare measurement for a familiar zoo-housed species, the giraffe (*Giraffa camelopardalis*, Linnaeus 1758), by outlining seven key needs and requirements that must be provided in the zoo ("giraffe W-E-L-F-A-R-E" = Warmth, Enrichment, Leaves, Feeding, Alfalfa, Rumination, Exercise). Provision of these inputs, and opportunities for all giraffes in a herd to engage with them, provides the foundation for further welfare assessment to be implemented. Specifically, the validation and measurement of mental states that are more likely to be positive if key behavioural and ecological needs have already been met. This paper advocated for this evidence-based approach to "welfare-focussed husbandry", with distillation of key information that supports species-relevant care, to be developed for other zoo-housed species as support for their welfare assessment protocols. Such welfare-focussed husbandry is layered on top of the basic animal care requirements of the species in the zoo to ensure all individuals have the best opportunity to attain positive welfare states. In this way, and once validated, foundational welfare assessment can be easily completed by busy animal care staff, capacity is built into zoo operations as all stakeholders are aware of exactly what each species needs, and deeper dive welfare assessment (especially concerning animal mental states) can be targeted more effectively. Further evolution of these seven steps for the giraffe is suggested and extrapolation of this approach, to aid identification of key welfare indicators across all zoo-housed species, is encouraged.

**Keywords:** giraffe; zoo animal welfare; applied welfare; husbandry evidence; zoo animal management

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## 1. Introduction

The concept of "animal welfare" conjures many definitions and paradigms, and a universal way to identify and measure welfare is still to be agreed upon. Fundamentally, welfare concerns how an individual is responding to the environment that it is currently in, and the degree of coping that is required [1]. This welfare state comprises of physical, psychological, and behavioural sensations, feelings, and responses [2] that lead to

measurable indicators of an animal's current welfare experience. An animal's perception of its own welfare state includes influences from inputs (resources accessible, care and management regimes, space available) and outputs (emotional constructs, feelings, and behavioural expression), and such ideals are built into the "Five Domains" model of animal welfare [3]. As animal welfare science evolved, consideration of the emotional quotient of positive and negative states, and perception of the animal's current situation as being suitable, gained more traction. Tools for repeated welfare assessment are available [4] and should be implemented to provide a cumulative picture of an individual's experiences over the course of its entire life [5]. Housing, feeding, good physical health, and daily care may not always provide for positive mental states. As a consequence, many zoo organisations moved towards embedding a Five Domains approach into welfare assessment protocols and strategies [5]; considering the inputs that come from the functional domains of nutrition, environment, health and behaviour, and the outputs in the mental domain.

There are, however, important aspects of these functional domains that need to be better understood and correctly provided if captive animals are to successfully experience positive mental states. For some species, where challenges to management are still apparent (and can result in non-sustainable populations or reduced lifespans when compared to mean wild ages), focus on inputs and appropriate nature of care should be a priority. For most zoo-housed species, there is little guidance available on how to accurately, validly, and repeatably measure emotional outputs. Even for species that are closest to humans, and most familiar to us (e.g., primates), we struggle to precisely define how best to infer good mental states, although behavioural outputs and use of keeper experiences of their animals are clearly good ways forward [6,7]. Given the importance of assessing what constitutes species relevant care, and of encouraging the widest possible participation in gathering evidence for husbandry, all stakeholders should be aware of what a species fundamentally needs to thrive and why these inputs are thus essential.

The aim of this paper is to distil down information on the fundamental needs of a species to provide evidence on (i) what must be provided to build a sound foundation for the attainment of positive welfare, (ii) to evidence why fundamental needs must form the basis of how the "correctness" or appropriate nature of care is evaluated against, and (iii) to move away from theoretical review of welfare definitions to encourage practitioners and animal care staff to look at their species (its morphology, anatomy, behavioural ecology, and life history) and base welfare inferences on species' responses to their whole environment and care. The giraffe (*Giraffa camelopardalis*, Linnaeus 1758) is used as the species example for review in this article of evidence that can identify such specific needs and responses to such inputs. This article explains key species-specific needs on top of the basic requirements of all living beings in the zoo (food, water, housing, veterinary care) to evidence what could be termed "welfare-focussed husbandry". Welfare-focussed husbandry is concerned with the provision of animal care protocols that meet the needs and wants of a species, which are based on what the species has evolved to do, what it looks like, how it regulates homeostasis, and what it gains from its behaviour patterns. This article reviews the importance of gathering information on what we know about species' responses to captivity, and why their responses might indicate challenges to attaining good welfare. It outlines the evidence currently available to support welfare-focussed husbandry for the giraffe and considers the wider application of this process of critical review of available information to the advancement of positive in-zoo welfare across species more broadly.

## 2. Identifying and Understanding Animal Wants and Needs

As we move to a more individual animal and species-specific approach to care and management, understanding more about what an animal wants and determining how valuable resources are to them is crucial for providing experiences of good welfare [8]. This allows us to put natural behaviour in context whilst acknowledging that not all needs must be met for an animal to feel pleasurable outputs [9]. There are key characteristics of a species that we have to provide for in captivity if we are to promote opportunities to thrive;

it is these needs and wants that motivate behaviours, and that are likely important for attainment of good welfare [10]. Behavioural performance is clearly important in providing a foundation for our understanding of what is correct care and housing. Behavioural outputs are indices of an animal's perceptions of their external circumstances [3]; therefore, we can judge the suitability of care if we know what behaviour to look for according to a species' biology, resource needs, and responses to the environment (and what is appropriate or relevant about such a behavioural response) [11]. When we consider the evolutionary history of a species, and use this information to decipher and examine its behaviour patterns and the meaning behind them, we can better understand how to promote good welfare because we know what we have to enable in a captive setting and what can happen if specific behaviours cannot be fully realised (Figure 1). We should ask such questions for all species that we care for when attempting to review husbandry and provide best practice approaches to care. By discussing positive elements of an animal's response to specific aspects of their husbandry (e.g., engaged behavioural expression around enrichment of enclosure change) compared to observation of indicators of poorer welfare (lethargy, depressive-like states, boredom when animals have restricted access to different enclosure areas) care givers can create a record of what works for (individuals) of a species and what should be altered or avoided.

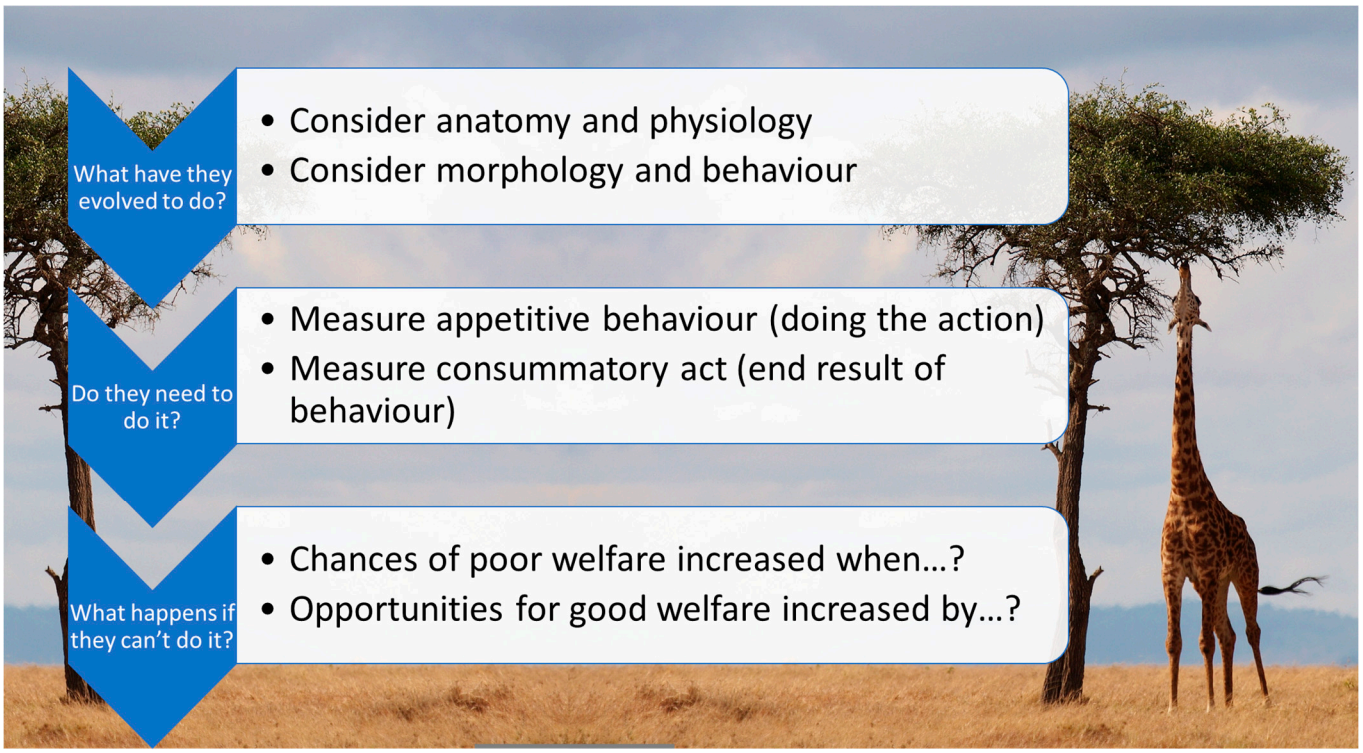


**Figure 1.** A simplified scheme of determining what evidence can be used to underpin welfare positive husbandry and species' responses that are indicative of positive welfare states.

Figure 1 suggests that stakeholders in giraffe care should review key adaptive characteristics (step 1, what have they evolved to do?), assess the underlying motivation for a behaviour and the fitness benefit provided (step 2, do they need to do it?), and consider what behaviours need to be promoted to enhance chances of experiencing positive affective states (step 3, what happens when a behaviour's performance is thwarted?). Questions are posed for stakeholders to consider and answer based on review of scientific evidence and observation of species' responses in captive settings. Knowledge of appetitive actions, those that involve locomotion and exploration and are highly motivated, can give us some insight into behavioural needs [12,13]. And whilst this is not a complete picture of wants, needs, and associated welfare states, such goal-oriented behaviours, therefore, provide

inferences of what animals need to do [14]. Individuals can become frustrated when such behaviour is thwarted [15] and, therefore, may experience a welfare comprise. The end result of an appetitive behaviour, the consummatory phase, is highly species-typical [16], and if the animal can reach consummation, abnormal repetition actions (i.e., being "stuck" in the appetitive phase) are reduced, the goal of the behaviour is reached and animal welfare is improved [17]. Consequently, we can adapt and change captive environments accordingly, based on intrinsic behavioural needs and cognitive processes that underpin appetitive actions such as foraging and movement patterns [18]; this promoted performance of behavioural indicators helps demonstrate an animal's needs and wants have been successfully realised and husbandry and care is advanced.

Species will "tell" us what they need from their captive care if we examine their ecology and evolution [19], and use such information to decipher their responses to care, and infer why they thrive, survive, or seem to struggle [18–21]. The use of such natural history information is documented in the scientific literature to provide empirical information on success (or not) in captive conditions [19–23]. An important extension of such scientific research is to convert these academic findings into practical changes to zoo animal husbandry. Capacity building, regarding people's knowledge and understanding of topics important for zoo operations, is an important way to advance the zoo's aims [24], including a wellbeing aim [25]. This article aims to encourage the review of evidence and the application and dissemination of valid species-specific information to spread the use of evidence more widely across all zoo-housed species. Even for familiar zoo animals, delivering optimal husbandry and ensuring individuals can, on balance, experience more positive to negative welfare states, is not always easy to achieve. Bridging the gap between theory and application and providing wider access to supporting information that can enable animals to attain good welfare is required.

## 3. Fundamental Evidence to Help Advance Good Giraffe Welfare in the Zoo

The giraffe is a familiar zoo-housed species, having been kept consistently in scientific zoos since the 1830s [26]. Despite this long familiarity, many aspects of giraffe care are still challenging [27,28]. Beneficial developments to captive husbandry have occurred since the first instances of "peracute mortality" (unexplained sudden death caused by lack of correct diet, inadequate housing, and chronic physiological stress) were described in the 1960s and 1970s [29,30], these most charismatic of zoo ungulates still causes us a challenge when providing a correct diet and species-appropriate husbandry. Positive change to how we keep giraffes include a wider understanding of the negative impacts of feeding grass hay, the need for legume hay (alfalfa or lucerne) as the most suitable forage ration currently available, and improvements to foot care /health that result in fewer anaesthesia interventions [31–34]. Most encouraging (in terms of direct promotion of positive welfare) is that, in a majority of accredited or membership zoos, browse (i.e., cut tree branches) is now considered essential to routine daily care and not simply a giraffe enrichment item [27,35]. However, abnormal repetitive behaviours (e.g., stereotypic licking and chewing, pacing and head circling) are still common in zoo-housed giraffe [36–38]. The build up to, and symptoms of, chronic loss of condition leading to an energy deficit and sudden physiological and physical collapse are documented [31,34,39] and warning signs should be heeded if such incidences are to be averted [40]. What is evident, from even casual observation of zoo-housed giraffes, is that individual animals respond very differently to the care provided and, therefore, zookeepers' knowledge of their animals is key to promoting good welfare for all within a herd.

Therefore, to catalyse the development of a rapid and easy-to-apply method of reviewing giraffe welfare, which can be used quickly by zoo professionals to judge the current state of their animals, this articles examines a checklist that focuses on the mnemonic "W-E-L-F-A-R-E". This concept was first introduced in Hickey et al. [26] as a case study on determining what zoo ungulates should be provided with and is here expanded further to illustrate the application of such a stepwise guide to care and welfare. This seven-step

checklist provides the evidence for a "deeper dive" welfare audit if needed, as well as a foundation for further giraffe care training and identification of key factors most likely to cause suffering in captive giraffe. Working towards valid and repeatable assessment of the mental domain is important yet challenging. But this challenge could be simplified by first defining core ecological components and animal needs required to promote good care, good health, and species-typical behaviour, which form the basis of sound inference of positive mental states. These core components and needs are explained in Section 3.1 to illustrate where evidence is vital to support identification of good care, which leads to welfare-focussed husbandry overall.

### *3.1. Giraffe W-E-L-F-A-R-E*

Giraffe W-E-L-F-A-R-E aims to be a checklist of fundamental concepts that are quick and easy for zoo professionals to remember and look for in their adult animals (and in their animal's husbandry regimes). This seven-step list is evidenced from research into giraffe needs, giraffe biology and ecology, and review of past challenges that demonstrated limitations to giraffe care and management (Figure 2). Alongside of following current, and any updates to, guidelines on housing and social group construction [31] and on nutrition and diet formulation [27,34] keepers, these seven-steps aim to provide identifiers of animal responses to their care that could form the basis of a validated and cross-institutional welfare assessment toolkit bespoke for the giraffe. Figure 2 describes giraffe W-E-L-F-A-R-E against seven key steps that consider the need for warm environmental temperatures, species-appropriate enrichment, access to leaves for browsing, feeding of a specific browser concentrate pellet, use of a legume hay such as alfalfa/lucerne, and maximal opportunities for rumination and physical activity. Example positive indicators of welfare (browse provision and browsing, ad lib forage access, an enriching environment and social group, and opportunities for rumination and rest) are provided in the top images and negative indicators of welfare (poor body condition and abnormal foot growth, pacing and abnormal repetitive actions, and a thin, rectangular neck shape) in the lower images.

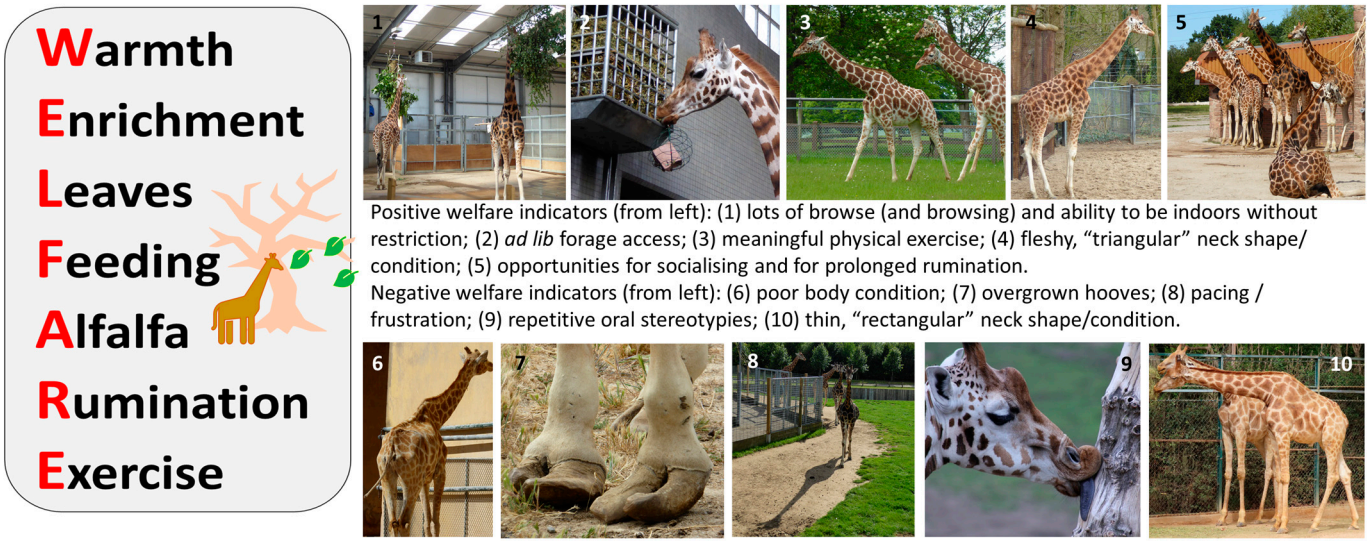


**Figure 2.** Identifying positive and negative responses of giraffes to their care by using a welfare-focussed husbandry approach that centres around warm environmental temperatures, species-appropriate enrichment, access to leaves for browsing, feeding of a specific browser concentrate pellet, use of a legume hay such as alfalfa/lucerne, and maximal opportunities for rumination and physical activity.

**W**armth: Research identified that giraffe become physiologically and behaviourally stressed when they experience colder external temperatures [41]; therefore, a sound foundation to good giraffe health is to ensure they do not lose excess heat in cold weather. Giraffes

evolved for evaporation of heat away from the body and have physiological mechanisms specific for life in a hot environment [42]. This is an essential concept for zoo professionals to remember because in cold conditions, giraffes will still be losing heat as their ability to retain body heat is poor. In temperate climes, giraffes can die when exposed to temperatures of 6 °C and lower for prolonged periods of time when no supplementary heating is provided [43]. A combination of low external temperatures and poor diet predispose giraffes to a chronic loss of energy that reaches a tipping point from which it is unable to recover [39]. This energy deficit is now termed "serous fat atrophy" and was previously known as peracute mortality. The change in terminology refers to the chronic progression of the condition [34], even though death may be acute, the causal factors (notably malnutrition and a lack of coping with environmental conditions) were experienced for several months prior [43,44].

**E**nrichment: Giraffe benefit from different forms of environmental enrichment that increase their interest in their immediate surroundings [26]. A social group that provides multiple opportunities to be with preferred associates as well as spending time alone is an important way to promote good welfare [45]. For example, incidences of dominance and aggression increase during forced social encounters in small herds [41], as giraffe have limited choice of associate and, therefore, cannot benefit from social enrichment. Devices to prolong foraging [46] are useful in reducing oral stereotypies. Enrichment is always useful, alongside of daily browse, to occupy giraffes and provide opportunities for foraging and food manipulation when animals are housed indoors due to inclement weather [47]. Giraffe display vigilance behaviour when feeding and socialising [48] and their extreme height allows them to see over wide distances to gather information about their local environment [49]; consequently, a view out across the animal's paddock that enables all giraffe to view the ongoing activity of the zoo is a form of enrichment, providing this experience is managed according to zoo operational needs, or during building and construction work [50,51]. As noted in other zoo-housed species [52], choice and control over use of indoor and outside enclosures (being mindful of environmental temperature), and the ability to choose to be on show (to public) or not must also be considered as enriching options for giraffes. Animal care staff can access resources, such as the Shape of Enrichment [53] or various zoo ungulate specialist groups [54] to discuss the design and implementation of enrichment that has biological relevance and meaningful value to their giraffe. Measures of the time that animals spend engaging with enrichment, and socialising with conspecifics, as well as individual responses to their immediate environment, should be undertaken regularly to ensure that animals are comfortable, display positive behavioural diversity and regularly utilise enrichment for the purposes it was designed and implemented for.

**L**eaves: Giraffe evolved to collect, process, and digest leaves from trees and shrubs [35,55] and, therefore, all zoo-housed giraffe should receive daily provision of browse taken from a range of appropriate tree species, e.g., those identified as suitable by Browse Poster (https://www.browseposter.co.uk/ accessed on 19 July 2023) or similar. Although providing a large enough quantity of browse to meet a meaningful proportion of daily dry matter intake is very challenging to impossible [56], any zoo that houses giraffe must maximise the amount of browse provided at all times of the year. Browse provided at 25% of total daily ration intake is provided as a benchmark for good health [30] and zoos should try to meet this demand where possible, as high volumes of browse can be provided at certain times of the year [56]. Browse can be provided in an ensilaged form or as "tree hay"—cut twigs of deciduous trees and shrubs in full leaf [57]—for feeding at times of the year when freshly cut browse may not be readily available. An increase in browse on an individual animal basis should occur when needed by that giraffe (i.e., any propensity towards abnormal behaviour patterns or unusual change to body condition that is suggestive of an underlying digestive issue).

**F**eeding: Feeding a concentrate ration of a suitable browser pellet is an essential, if artificial, component of captive giraffe nutrition [31,58]. That is, it is impossible in many facilities to provide enough browse and forage for giraffe to maintain their basal energetic

need [56]. Concentrate rations should be fed in weighed amounts for each individual animal in the herd, at several times per day [31,58], to reduce a large amount of pellet suddenly entering the rumen and disrupting microbe populations, thus impacting fermentation and assimilation of energy. Wild giraffes can spend up 53% of daylight hours searching for food [58], but will also forage nocturnally [55,59]; multiple feedings of (a weighed amount) of pellet available throughout a full 24 h period would appear to best align with natural foraging activity and promote welfare. Keepers should follow evidence-based practice, e.g., EAZA [31] when determining the amount of pelleted feed needed for their animals. The amount of silica in concentrate pellet can cause abnormal wear of a giraffe's teeth [60], impacting on rumination and processing of food. An appropriate amount of pellet per animal (based on physiological state, development, and life stage) is, therefore, essential and this is further explained in the EAZA guidelines for giraffe [31].

**A**lfalfa: Grass hay is not an appropriate forage for giraffes, causing excess tooth wear and stratification of rumen contents that blocks the passage of food through the chambers of the stomach, thereby reducing energy uptake [43,61]. Alfalfa (lucerne) is the most suitable currently available forage ration for giraffe that is less likely to wear teeth or cause rumen blockage. The forage proportion should be 50% of a captive giraffe's daily dry matter intake [31], and this must be supplemented with browse each day.

**R**umination: A positive welfare indicator for giraffes, as it is in other ruminant herbivores [62], rumination should be promoted by captive diets during the day and overnight. This is especially important overnight, as it has been documented as a wild giraffe's dominant nocturnal activity [63]. Giraffe have a small rumen for their body size and the muscles of the rumen are comparatively weak [64]. Therefore, the giraffe relies on food selection and rumination to maximise nutrient and energy gain. Feeding an unmeasured amount of pellet, limiting browse, and feeding unpalatable forage reduces rumination rates, which negatively impacts on physical and psychological health. Reduced opportunities to browse and consume forage reduces material available for rumination and predisposes a giraffe to perform abnormal repetitive behaviours [65]. As rumination and resting occur together [62], opportunities for meaningful, regenerative rest can also be identified and measured by animal care staff when documenting captive giraffe welfare.

**E**xercise: Giraffes prefer to move between foraging locations, showing selectivity in browsing behaviour and seasonality in travel time in the wild when browsing [63,66,67]. Captive animals should be provided with opportunities to move between foraging resources (e.g., browse poles or forage racks) that enhance physical and psychological health (i.e., giraffes are kept interested in their environment and the likelihood of stereotypic or abnormal behavioural coping mechanisms are reduced), and this physical exercise (coupled with an appropriate diet) enhances regular and equal hoof wear [68,69] and normal hoof growth [32]. It is important to monitor nocturnal [36] and winter [70] activity as abnormal behaviours may predominate when each giraffe's available space is restricted due to reduced outside access. Abnormal pacing is noted as a very common stereotypic activity performed by captive giraffes [47] and, as such, space to roam around different structural features (e.g., browse poles and enrichment devices) within a captive enclosure would reduce frustrated pacing behaviour.

### *3.2. Examples of W-E-L-F-A-R-E Checks That Giraffe Care Staff Could Conduct*

For each individual animal, and the herd overall, animal care staff can use the following indicators to make sure that the principles of W-E-L-F-A-R-E are embedded into giraffe husbandry and management protocols (Table 1). These pointers are provided as suggestions to help develop specific welfare assessment protocols for facilities that house this species. Table 1 aims to provide a foundation for the extension of W-E-L-F-A-R-E to other species too, by explaining and illustrating how such a checklist could be applied to the giraffe.

**Table 1.** Examples of checks that zoo animal care staff can make of each giraffe to see if fundamental needs are provided to support further welfare assessment and inferences of welfare state.

| Attribute | Check |
| --- | --- |
| W (warmth) | Is the external temperature appropriate for outside access, i.e., consider dangers of temperatures below 6 °C [43]?<br>Can all animals access heated areas when indoors without competition?<br>Is the indoor temperature warm enough, i.e., always +18 °C [31], to reduce the chance of a physiological energy deficit? |
| E (enrichment) | Are giraffes interested and engaged in their environment?<br>Are all giraffes able to exert some form of autonomy (self-control) over what they do, where they go and when they do it? |
| L (leaves) | Is browse management as optimal as practically and logistically possible?<br>Are giraffes provided with browse during daylight and nocturnal time periods?<br>Is the browse readily available to, and accepted by, all animals in a herd? |
| F (feeding) | Are low-sugar, low-starch browse-specific concentrate pellets being used?<br>As body condition and hoof growth can be impacted by amount of pellet fed, are estimations or actual mass of each giraffe is recorded, and pelleted ration provided accordingly (considering physiological state, growth, and development)?<br>What is the condition of each adult giraffe neck? A giraffe's neck should be triangular (thick at the bottom, see Figure 2) and not a thin rectangle all the way from head to base—this is an easy spot for keepers to check on individuals that are likely to be losing fat and in danger of developing an energy deficit. |
| A (alfalfa) | Is a quality, palatable legume forage, which is always accessible to all animals, being fed?<br>Is forage intake observed and recorded to ensure that animals are consuming their forage readily?<br>Remember to check, remind, and check again that all animal care staff never feed giraffes grass hay. |
| R (rumination) | It is easy to observe a ruminating giraffe as it will stand in a characteristic position with neck held forward and the bolus of food can be observed travelling up and down the animal's neck.<br>Do animal care staff see rumination, in all animals mature enough to ruminate, regularly?<br>Can rumination be observed and recorded each day for a meaningful amount of time, i.e., for at least 30% of daily time activity patterns [63]?<br>Do animal care staff make the best possible efforts to ensure that all giraffes regularly ruminate each day? |
| E (exercise) | Are the movement patterns and enclosure usage of each giraffe monitored for signs of frustration and pacing?<br>Is body condition and hoof condition of each giraffe assessed and monitored for signs of over-conditioning and overgrown hooves (from lack of exercise and too much pelleted feed)?<br>Are the normal movement patterns and choices (with and without conspecifics) monitored for each individual to flag any sudden and unfamiliar changes in activity? |

Zoos can use the application of this evidence for welfare-focussed husbandry to further engage with their visitors and explain specific aspects of animal care. For example, Figure 3 illustrates visitor interpretation at the giraffe enclosure of a large European zoo informing visitors that the animals will not be in their outside paddock if the external temperature is below 10 °C. Therefore, by using evidence to inform care, and by continuing to collect data on their giraffes' responses to such care, zoos can be more confident in how they explain, describe, and justify husbandry practices to their visitors because they will be using methods and approaches that are in the best interest of the animals.

**Figure 3.** An example of zoo signage explaining species-specific aspects of care implemented to uphold good health and wellbeing. In this case, giraffes will be housed indoors at low temperatures.

## 4. Discussion

This paper examined why our understanding of a species' ecology and evolutionary history is fundamental to evaluation of correct husbandry and care in the zoo. Observing our zoo-housed species and documenting their responses to such care can allow for welfare inferences to be made. As we move forwards with the development of best practice guidelines [71] that showcase exactly what husbandry must be for any given species, we can use our knowledge of species' responses to such a "gold standard" approach to ensure it remains current, relevant, and suitable for the species to which it is intended. By using the giraffe as a worked example, a species that is familiar in the zoo but one that still poses population management, animal care and attainment of good welfare challenges to us, this paper identified a potential way of observing behaviour, physical signs, and behavioural expression (as inferences of the mental domain of welfare) that could be used to form a validated and cross-institutional tool for giraffe welfare assessment. The seven-step W-E-L-F-A-R-E concept of identifying fundamental aspects of care for captive giraffes (things that must be met to enable animals a strong foundation for the eventual attainment of positive physical, behavioural, and psychological welfare states) can be applied across all species. This paper hopes to encourage further development of this concept by inspiring other interested parties that have the relevant expertise to objectively discuss and document what W-E-L-F-A-R-E means and looks like for each and every zoo-housed species across all taxonomic groups.

Practitioners such as animal care staff, population managers, veterinary surgeons and curators, together with research and animal welfare scientists, field ecologists and other species' experts can come together to identify a species' fundamental needs, to describe and observe a species' responses to in-zoo care, and to then design and implement a way of measuring these responses in a robust and repeatable manner. Such an undertaking would feed into One Plan Approach initiatives [72] that see collaboration from all stakeholders for a given taxonomic group providing evidence for and development of how that species should be managed into the future [73]. This would truly build relationships between those invested in wild populations and those working for the welfare and conservation of populations under human care.

### 4.1. Evaluating the Evidence behind Giraffe W-E-L-F-A-R-E

A logical next step would be for animal care staff to validate this approach in practice as part of a giraffe-specific welfare assessment toolkit, so that any welfare limitation can be identified, rectified, and improved, and that baseline, essential husbandry routines are scrutinised for continued relevance to this species. The evidence-based approach to giraffe husbandry provides for species-appropriate inputs that should, ultimately, result in welfare positive outputs when provided consistently to all zoo-housed animals. To advance giraffe welfare states, zoos need to ensure that animal care staff are fully engaged with welfare assessment protocols and know what potential indicators of welfare are for each species being cared for. Reaching a gold standard of the assessment of emotional welfare is commendable but there are many aspects of animal care in zoos that can be improved to provide marked improvements to physical and behavioural welfare states. With such improvements to inputs, environments can be created that are conducive to animals experiencing good mental states. As in the case here for captive giraffe, which involved providing more browse, using an appropriate forage ration that is both palatable and always accessible, to facilitate rates of rumination that are akin to those performed by wild animals—e.g., around 30% of an overall 24 h time activity budget [63]. Enhanced opportunities to ruminate, driven by evidence-based and species-appropriate captive care will lead to enhanced emotional welfare outputs. Likewise, increasing the ratio of hay to concentrate pellet ingested has multiple behavioural and physiological benefits [74], and these can be indicative of improved emotional states (e.g., more contented and comfortable animals that are more relaxed within their current environment). Finally, wild giraffe preferentially select for a high-quality diet at the expense of intake volume [75], and forage quality and palatability is a crucial aspect of zoo feeding regimes [27]. Therefore, if zoo giraffe are forced to consume a poorer quality or inappropriate forage ration in the zoo, this mismatch between evolution and in-zoo care means one aspect of experiencing positive mental outputs will be removed because animals in poor physical health are less likely to be good mental health too.

Examples of how this seven-step W-E-L-F-A-R-E checklist could form the basis for a validated systematic and repeatable assessment of giraffe emotional states are provided in Table 2. Changes in underlying physiological state, e.g., reproduction [48,76,77] and senescence [78], will influence giraffe activity and, therefore, behavioural expression and body language; as such individual animal physiology and development, plus season, need to be considered when making positive inferences of mental states in the zoo. Suggestions for what mental welfare outputs may present as are also given to encourage others to consider the feasibility of their measurement. Research into the expression of the fifth domain, and perhaps validation of behavioural responses against physiological ones is encouraged where feasible, practicable, and can be carried out non-invasively but reliably.

**Table 2.** WELFARE attributes, physical indicators of good care, and suggested emotional outputs that may form the basis for inferences of the fifth (mental) domain in captive giraffe.

| Attribute | Physical and Behavioural Indicators | Emotional/Psychological Behavioural Expression |
|---|---|---|
| W (warmth) | Giraffe maintain good body condition, with fleshy necks akin to those observed in the wild. Reduced or absent performance of abnormal repetitive behaviours. Enhanced longevity according to documented maximal wild lifespan, e.g., [79]. | Content and comfortable behavioural expression; promotion of rumination, lack of negative behavioural activities (e.g., frustrated pacing, oral stereotypy) that suggest discomfort. |

**Table 2.** *Cont.*

| Attribute | Physical and Behavioural Indicators | Emotional/Psychological Behavioural Expression |
|---|---|---|
| E (enrichment) | Increased time spent foraging, socialising, or exploring an enclosure. Reduced time spent on abnormal behaviours or sedentary and inactive. Promotion of good health of coat, body, and hooves. Specific partner preference noted for each giraffe. | Engaged, interested and curious about the environment. Keen to use enrichment and interact with other animals in an affiliative and positive manner. Giraffe engaged and stimulated by, but comfortable and calm when using, the enrichment. |
| L (leaves) | Increased intake of leaves that results in reduced or eliminated abnormal repetitive behaviour, enhances time spent on rumination and improved physical health both during the day and at night. | Giraffe are satiated and feel increased degrees of comfort, will appear less frustrated and agitated due to plentiful opportunities for browsing. |
| F (feeding) | Giraffe physical body condition is good, animals consume specific amount of concentrate according to physiological needs. | As above. Giraffe express positive body language (e.g., interest in the environment, engagement with other animals, and are stimulated by their surroundings) and internal gastrointestinal health is good. |
| A (alfalfa) | Increased time spent consuming forage, enhanced opportunities for rumination, reduced to absent abnormal repetitive behaviour. | As above. Contented and calm behavioural expression caused by processing and chewing of structural fibre. |
| R (rumination) | All giraffe (where relevant to age and development) chew the cud in the manner typical for this species [65]. Rumination is a major part of daily time budgets. Use of trail cameras or other such night vision technology to measure nocturnal rumination and rest for assessment of normality of activity patterns by giraffe age [80]. | Increased rumination time provides opportunities for baseline brain activity, which is linked to mood and emotion in other ruminants [62]. Giraffe are contented overnight and during the day and can choose where to ruminate and who with. Positive social affiliations (e.g., choosing to be in proximity) is noted during rumination and resting. |
| E (exercise) | Exploration, walking as a herd or as an individual animal; socialising and moving between different browsing opportunities in an enclosure. Use of all ecologically relevant enclosure space. Sitting, standing, and resting are apparent but not functionless. | Engaged and interested in surroundings. Little to no aimless wandering or repetitive frustrated pacing. Curious, excited, and outgoing behavioural expression, as a herd or individually. Reduced time spent on apathetic or lethargic standing or sitting, suggestive of a lack of interest with the current environment. |

Similarly, validation of behavioural expression is required across zoos to identify known indicators of positive emotional states. For example, body position, head and neck position, stance and gaze, ear position and visual changes in response and reaction to stimuli can all indicate specific aspects of behavioural expression related to an underlying emotion or mood [81,82]. In the case of the giraffe, contentment and comfortable behavioural expression during rumination can manifest as the position and stance of the animal, the engagement with chewing and the choice of social partner (and how animals respond to each other whilst ruminating). Examples of giraffe activity and behavioural expression that could be measured to support appropriate husbandry and care are provided in Table 3. Descriptions of each behaviour's causation and wider meaning are provided.

This article described key components of giraffe care that should be provided for physical and behavioural welfare to be good, based on evidenced from scientific research on captive animals with evidence from the ecology of the species itself. Once the outputs described in this article are validated from observation and measurement on giraffe across institutions, attention can turn to the development of valid and repeatable ways of assessing the fifth domain that is applicable across zoos holding this species. Methods such as qualitative behavioural assessment (QBA) that aims to infer animal emotional states via the description of behavioural expression, e.g., body language [82], may be useful in deciphering giraffe [83] and other zoo-housed species [84] mental states under specific

management conditions. Further work is required to apply QBA approaches more widely, across more individuals of a species using a specific list of descriptors of behavioural expression, in the same manner used for domestic and agricultural species [85]. In the case of the worked example included in this article, it is possible to provide captive giraffe with what they need. The numerous and extensive outputs from the zoo science communities identified key husbandry needs for giraffe, firmly grounded in how these needs are centred on the species' anatomy, physiology, morphology, ecology, evolution, and behaviour. By distilling down this vast research output into the seven-step W-E-L-F-A-R-E approach, a strong foundation for eventual execution of excellent giraffe care and attainment of positive emotional welfare states was provided. These fundamental inputs can be mapped against the fifth domain (Table 2) and form a basis for quantifying mental states, when required, for each zoo's individual welfare assessment strategy. Extending W-E-L-F-A-R-E to encompass other aspects of giraffe husbandry, e.g., "W-E-L-F-A-R-E Plus" could become a next step in the refinement of key husbandry needs for good welfare of individuals within a breeding group, and focus on care and correct development of calves and young giraffe. Such developments may help, for example, decipher and unravel specific challenges around giraffe reproduction such as deficiencies in mother–calf bonding [86] by providing more insight into individual giraffe responses to the zoo overall.

**Table 3.** Examples of giraffe behaviour that can indicate good husbandry and care.

| Behaviour/Behavioural Expression | Link to Example |
| --- | --- |
| *Enrichment to increase foraging time*<br>- Ad lib forage feeder that is enriching because of the time taken by giraffe when consuming forage.<br>- Social element of foraging is promoted. Animals can feed with different individuals for different amounts of time from different areas of the device.<br>- The giraffe has to work for the forage and therefore can ingest forage gradually but regularly, benefitting rumen health. | https://doi.org/10.6084/m9.figshare.23676705.v1 |
| *Rumination posture*<br>- Giraffe is standing is a classic rumination pose with the head held forward and neck around 45°.<br>- Rhythmic movements of the jaws indicate processing of previously ingested, and now regurgitated forage.<br>- A bolus of forage moves up and down the neck for chewing, microbial fermentation, re-chewing, and so on.<br>- Time spent in this posture, performing this action should be measured to assess how diet, social structure, and husbandry impact on this important behavioural need. | https://doi.org/10.6084/m9.figshare.23676762.v1 |
| *Contented giraffe, socialising, and ruminating*<br>- Giraffe ruminating in a social group, in close contact. Characteristic rumination poster, as described above, is evident.<br>- Giraffe have the space (within the enclosure) and number (of animals in the herd) to choose when, with whom and where to ruminate.<br>- Choice and control are key elements of good animal welfare.<br>- The preferred partner of individual giraffe, when ruminating, and how they animals spend together (and where) can be observed and evaluated to see how a herd dynamic and enclosure space impact on the performance of welfare positive behaviours. | https://doi.org/10.6084/m9.figshare.23676927.v2 |

**Table 3.** *Cont.*

| Behaviour/Behavioural Expression | Link to Example |
| --- | --- |
| *Social interaction drive by oestrous*<br>- Change in social interactions caused by underlying physiology and hormonal profiles.<br>- Necking and duelling behaviour may be apparent at specific times and can indicate changes in reproductive status.<br>- Performance of such behaviour can provide insight into physiology, moods, and emotions, and may be used to examine and explore animal responses to husbandry and care. | https://doi.org/10.6084/m9.figshare.23676942.v1 |

Revisiting the questions in Figure 1, we can identify why specific aspects of giraffe evolution inform our knowledge of behaviour, which should be promoted by husbandry and care routines, and provide understanding of welfare challenges when husbandry and ecology misalign (Figure 4). By evaluating each section of Figure 4, we can see that the gastrointestinal anatomy and physiology of the giraffe as a ruminant, its height and shape for losing heat are key clues to what they evolved to do and how they evolved to live. Key measures of appetitive behaviours include time spent on searching for food, across a 24 h cycle, as well as time spent on ingestion of leaves, and the proportion of time spent on rumination. Satiated giraffe can be determined by surveys of different animals under different management regimes to understand animal comfort and behavioural expression (e.g., positive aspects of behavioural expression such as calm, relaxed, and restful could link to prolonged opportunities for rumination). Animal comfort measures used in agricultural settings [87–90] could have a place in supporting the development of comfort indices of captive wild ruminant species. Finally, identification of increased chances of poor welfare because of restricted performance of appetitive behaviours but positive welfare promoted when giraffe have a wider degree of choice and control over what they can do, how, when, and with whom.

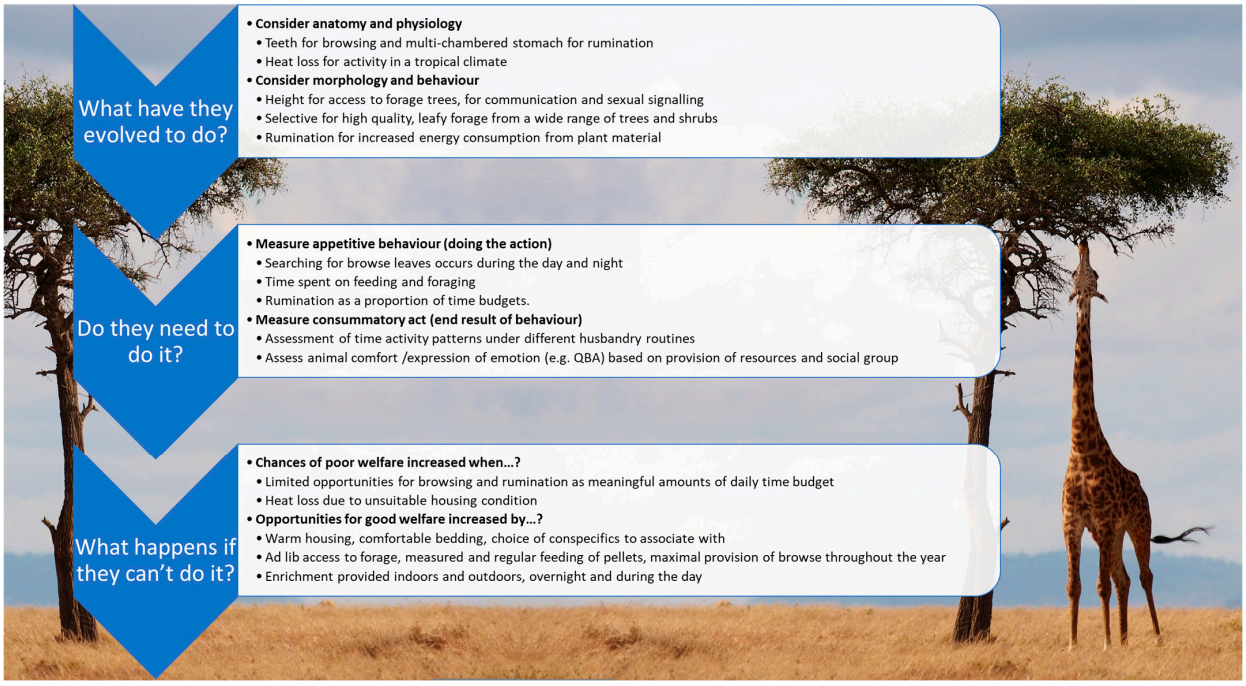


**Figure 4.** Answering each evolutionary and behavioural question in turn, related to how giraffe have evolved, what their behaviour tells us, and how we know what to provide to enable good welfare can support positive welfare outputs in captive animals.

### 4.2. Evaluating the Evidence for Welfare-Focussed Husbandry

It is imperative that review and re-evaluation of husbandry and management continue to be at the forefront of how we provide for good welfare. Individuals of a captive species are not going to be able to reach positive emotional states if they are kept in a manner that is not appropriate for their ecological and behavioural needs or adaptations. Consequently, zoos need to take stock of their collection plans, and consider how well they can cater for species' needs. Scientific evidence has been used many times to show that some species thrive and others struggle in captivity [91]; therefore, by revisiting fundamental aspects of biology and ecology and considering how these evolutionary characteristics determine suitability of captive care, zoos can objectively and rationally review their chances of providing meaningful opportunities for a specific species to attain positive physical and behavioural welfare, and then consider if it is ever possible to meet positive psychological welfare.

The importance performing species-appropriate behaviour in the zoo is something that still needs to be at the forefront of welfare assessment and interpretation. Direct comparison of wild behavioural traits with those of captive-housed individuals is not always relevant for a complete and reliable welfare assessment [92], but our understanding of zoo welfare challenges is better when we consider evolutionary aspects of anatomy, physiology, and behaviour. Any change in time–activity budgets in zoo-housed species can be more fully evaluated if we know what a species has evolved to spend its time doing and what behaviours are going to be the responses to specific stimuli. For example, previous arguments stated that any increased time spent on grazing by captive giraffe may be of little concern [92]; however, we now know that grass consumption by giraffe wears down teeth [93], causes rumen blockage [34], and exposes animals to dangerous parasitic infections [94,95]. Consequently, even seemingly benign changes in overall time–activity budgets (i.e., elevated grazing in place of browsing) in captivity needs evaluation against wild evidence, any available literature, and records that document the potential pathological outcomes of this altered behaviour pattern. Similarly, the accuracy and currency of published information also needs to be checked and reviewed prior to its application; an example of an older published work that states zoo-housed giraffe thrive on a grass hay ration [96] is now incorrect and inappropriate. But this same paper also stated that zoo-housed giraffe will resort to grazing when leaves are not available [96] and this is still a useful piece of information, as it demonstrates the giraffe's underlying motivation to browse and, therefore, why this behaviour must be promoted in the zoo. Discussion, dialogue, capacity building, and continued collaboration are required (involving all stakeholders of all zoo-housed species) to identify what is quality evidence, to flag when our knowledge changes and why, and to then implement the most appropriate evidence in the most efficient way into zoo animal care. Excellent in-zoo care is essential to species survival and positive outcomes for ex situ conservation aims. Embedding welfare into conservation is key and has become a more common expectation of such activities and initiatives [97]. Understanding the needs of animals, based on observation of what they want and find rewarding [98], alongside of implementation of husbandry and housing that is sympathetic to species-specific adaptations and behavioural traits, can provide a balance between use of ecological inform and animal-informed choices on how to improve welfare. Therefore, as zoos continue to work towards identification and application of key species-specific husbandry needs, the role of the species to the zoo's aims and objectives is enhanced, in part because the animals will be experiencing enhanced welfare states [25].

## 5. Conclusions

This paper aimed to bridge the gap between the theoretical constitution of animal welfare and the practicalities of providing species-appropriate care that can enable zoo animals to attain positive welfare states. It introduced the importance of species-specific evidence, and an understanding of what this evidence means, to the development of welfare-focussed husbandry. Welfare-focussed husbandry can become the norm for all

species in all zoos, as all stakeholders are aware of what responses to identify that suggest care is appropriate and relevant. Therefore, changes to husbandry and management, composition of social groups, access to enclosures, etc., is all based on a mixture of evidence of animal biology as well as on individual animal responses and outputs. This paper explained how to create welfare-focussed husbandry with the giraffe as a worked example, and it identified how such applicable, species-specific husbandry can be explained to zoo visitors. Using our knowledge of core giraffe needs and wants, based on evolutionary ecology, anatomy and physiology, and behaviour, keepers can identity what is required by this species and strive to provide these as the core of giraffe husbandry. Further measures of positive emotional outputs, suggestive of good psychological welfare, can then be assessed. This paper encouraged zoo professionals to collaborate with welfare scientists, and to importantly include keeper knowledge and experiences, in the production and implementation of easy-to-understand, easy-to-use protocols to assess the suitability of animal care, housing, and management. This stepwise approach, of considering the fundamentals of what a species needs, what it wants to do, and how it must be cared for, in a simplified and easy-to-disseminate manner, should be considered across all zoo-housed species and not just for charismatic megafauna like the giraffe. Without universal implementation of a husbandry and management approach relevant to a species' ecological wants and needs, zoos will struggle to move forward with delivering opportunities for species to experience positive emotional welfare outputs.

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