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An Approach to Assessing Zoo Animal Welfare in a Rarely Studied Species, the Common Cusimanse *Crossarchus obscurus*

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Abstract: Objective welfare assessments play a fundamental role in ensuring that positive welfare is achieved and maintained for animals in captivity. The Animal Welfare Assessment Grid (AWAG), a welfare assessment tool, has been validated for use with a variety of both domestic and exotic species. It combines both resource- and animal-based measures but relies heavily on knowledge of the species to effectively assess welfare. Many zoo species are understudied in the wild due to their cryptic nature or habitat choice; therefore, the published literature needs to be supported with captive behavioural observations and zoo records. Here we adapted previously published AWAG templates to assess the welfare of *Crossarchus obscurus*. A total of 21 factors were identified, and the final template was used to retrospectively score the welfare of two male and two female *C. obscurus* at Marwell Zoo, UK, validating the use of this process for preparing a welfare assessment for a species where the published literature is scarce.

Keywords: cusimanse; *Crossarchus obscurus*; zoo; behaviour; welfare; AWAG; welfare assessment; carnivore; evidence-based; understudied

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1. Introduction

For most UK zoos, maintaining positive animal welfare is not only important from a moral and ethical perspective but from a legislative perspective as well. It also underpins the zoo's ability to fulfil their education and conservation aims, as laid out in the Zoo Licensing Act, 1981. Therefore, there is increasing pressure on animal caregivers to be able to demonstrate that their animals are experiencing positive welfare. There is currently no single definition for 'animal welfare'; however, it is largely agreed within the scientific community that it involves the reflection of physical and psychological health as perceived by the animal itself—the state of the animal and what it then experiences as a result [1–3]. Probably the most well-known welfare concept, the Five Freedoms, developed by the UK Farm Animal Welfare Committee in 1979 [4] to monitor and improve the welfare of livestock, became the key checklist for assessing the welfare of animals, domestic or exotic, across all industries, globally. However, tools used to monitor animal welfare have adapted as more and more has been understood about the factors that feed into an animal's welfare state. The Five Freedoms focuses on resources (such as, food, water, shelter, and veterinary care) with the implication that if these are provided, negative welfare states improve. It is now, however, generally accepted that to understand an animal's welfare state, it is necessary to include animal-based measures (i.e., behaviour and physical/physiological factors) within the assessment. As a result, there is no single method for assessing animal welfare, but a variety, adapted for different species, contexts, and resource levels.

The Animal Welfare Assessment Grid (AWAG) is one such tool, combining both resource- and animal-based measures, i.e., the effects of environment, physical and psychological well-being and procedural and management events, on welfare. Welfare is context specific and is a subjective experience; therefore, although a group of animals may share

an enclosure, receive the same nutrition and live in the same social group, they could experience very different welfare states. The AWAG objectively examines the welfare of the individual animal at key points throughout its life, taking into account the duration as well as the intensity of any suffering and produces both a numeric and visual presentation of the animal's overall quality of life. By using a template to score four parameters (Physical, Psychological, Environmental, Procedural), this system develops a matrix based on data collected as an intrinsic part of husbandry records. Within each parameter various factors are scored to assess the level contributing to welfare and the factors for each parameter can be modified to suit different types of animal husbandry systems and so be relevant for the specific context. Thus, it can identify key events which impact on welfare, and by providing a whole-life assessment of an animal's welfare with a temporal approach, the AWAG allows those caring for animals to plan or intervene with targeted and timely refinements that can improve, or prevent the deterioration of, an animal's quality of life. AWAG templates have already been produced and validated at Marwell Zoo (MZ), UK, with a variety of exotic species, including various primates [5], giraffe *Giraffa camelopardalis*, scimitar horned oryx *Oryx dammah* and cheetah *Acinonyx jubatus* [6], as well as various bird species [5] and Western lowland gorillas *Gorilla gorilla gorilla* [7] at other organisations. This study is the first to use the AWAG for a small, exotic carnivore species, and, where previous studies have either focussed on broad taxonomic groups or species where plentiful information is available, this study shows how the AWAG can be adapted for a species where relatively little published information is available.

1.1. Crossarchus obscurus

Crossarchus obscurus, also known as the common cusimanse (or kusimanse), is a mongoose species native to equatorial western Africa [8–10]. Whilst the species is frequently seen locally [8,9,11], due to its cryptic nature and habitat preference, detailed research of the species in the wild has proved difficult, and with few individuals to study in captivity, this species remains understudied. *C. obscurus* was classified as 'Least Concern' by the International Union for Conservation of Nature (IUCN) in 2015, with an unknown population trend [12]. Current population size is unknown.

Compared to other mongoose species, *C. obscurus* are stocky in appearance, seeming unkempt due to a combination of fine, pale but dense underfur and dark, coarse outer fur (Figure 1). They are opportunistic omnivores and will take advantage of whatever food is available, although their diet consists primarily of invertebrate species and fruits and berries, depending on the season [9,10,13,14]. They will occasionally eat small vertebrates and bird or lizard eggs and have also been reported co-operatively hunting larger species such as rats [9,11,15,16].

Figure 1. *Crossarchus obscurus* or common cusimanse. Marwell Zoo, UK.

C. obscurus is an obligate social carnivore and in the wild has been found living in mixed-sex groups of adults and juveniles, ranging in number from four to 20 individuals [9,10,17]. It has been suggested that the larger groups may be formed of multiple family

groups, which consist of a dominant breeding pair and their offspring from both current and previous litters [9,14]. Although it is yet to be confirmed, it appears that these groups generally remain stable: foraging, moving and resting together [13]. As seen exhibited by other social mongoose species (e.g., slender-tailed meerkat *Suricata suricatta*), *C. obscurus* communicate with one another using vocalisations such as 'peeping' contact calls and 'shrill' alarm calls (observed directed towards humans in the wild [13]), supporting the theory that they live in stable, cooperative groups [13,17]. They also communicate via olfaction, with both males and females using anal and cheek gland secretions to communicate [9,10,17,18]. These scents may be deposited by anal dragging, anal tapping, alternate cheek rubbing, in a 'handstand' position, lifting a hind leg or in addition to kicking the hind legs and urinating [13,17,18]. Scents will be deposited on objects in the environment, the ground, on faeces and on conspecifics and are believed to advertise information on identity, status and possibly ownership [13,17,18]. Similar to the meerkat, *C. obscurus* are a highly complex and cooperative species [17].

As with other members of the *Herpestidae* family, *C. obscurus* are a predominantly diurnal species, active from sunrise to sunset, with this activity punctuated by periods of rest. Research has shown that outside of these hours they are inactive, most likely sleeping, within shelters [13]. Species-typical behaviour is also similar to that of other mongoose species, including group foraging, various forms of locomotion (walking, running and trotting), climbing, resting/sleeping, scent marking, digging, hunting, foraging, stalking prey, sniffing, drinking and predator defence (for example, mobbing or head-darting towards a predator, piloerection, alarm calling and hiding) [9,13,17,19]. Social behaviours include allogrooming (grooming a conspecific, helping to maintain social bonds), mating, aggression, bundling (huddling close to conspecifics to maintain warmth), scent marking and play [9,13,17]. Self-directed and comfort behaviours include scratching, stretching, yawning and autogrooming (grooming itself) [9].

Although *C. obscurus* will climb when foraging, they are more commonly seen active at ground level [9]. During a 2001 study on wild *C. obscurus* in Sierra Leone, Olson [13] found that groups showed a preference for resting overnight in trees and recorded them from a height of 5 m up to 25 m. The only resting places that deviated from this were ~8 m high tree stumps found in more open habitats. The groups changed resting site almost every night, possibly to avoid predation. Other literature has suggested that they also take shelter in underground burrows, either dug themselves or by another species, and hollow logs or fallen trees [9]. There is little information on home range size for this species; however, Olson [13] calculated it to vary from 20 ha to 30 ha based on the three groups that were studied. Olson [13] also found that they will cover ~$^1/_4$–$^1/_3$ of their home range within a day, a minimum distance of 1036–1714 m travelled.

C. obscurus appears to be ecologically versatile, primarily inhabiting dense rainforest habitats but also found living in riparian and logged forest, open grassland, fallow, agricultural fields and plantations, up to an altitude of 1500 m above sea level [9,12,13,20]. It has been suggested that this tolerance of varied habitat may be a result of the changing availability of food resources [11]. Temperatures across equatorial western Africa vary from cool nights of 10 °C to hot day temperatures typically around the mid-20s °C but up to low 30s °C with the region receiving a high level of rain annually, <2000 mm over a >5-month rainy season. The rainforest habitats are usually cooler than savannah habitats and are high in humidity [21].

1.2. Crossarchus obscurus in Captivity

The Association of Zoos and Aquariums (AZA) has produced the 'Mongoose, Meerkat and Fossa (*Herpestidae/Eupleridae*) Care Manual' [22], which includes a compilation of expert knowledge on the management of *C. obscurus* in captivity. This manual identifies the environmental parameters for captive *C. obscurus*. Basing their recommendations on what is currently known about the species' wild environment, they suggest a temperature of 20–25 °C, with an indoor area of 22–25 °C. Whilst *C. obscurus* can tolerate cooler temper-

atures, something they would sometimes experience in the wild, the AZA recommend that the temperature should not dip below 13 °C and stipulate that a heated indoor area must be available if these low temperatures are expected. Humidity level is more difficult to specify as there is a lack of information on levels in the *C. obscurus'* wild habitat. Humidity is also likely to fluctuate in the wild depending on environmental factors such as density of vegetation and weather conditions [21]. The AZA do, however, suggest a humidity level of ~55–60% as the minimum. They also recommend the provision of shade and shelter from the elements, sunlight or heat sources for basking and a photoperiod resembling that experienced in the wild habitat (12 h of daylight/12 h of dark) [22].

Enclosure complexity or 'naturalness' should be species-specific, enabling the animals to exhibit an extensive array of behaviours from their natural repertoire with minimal input from animal carers, so that behavioural needs can be met outside of staff working hours, thus providing for the animal's overall lifetime experience [23]. The enclosure complexity should physically reflect *C. obscurus'* wild habitat with extensive vegetative cover at varying heights. Living trees and/or dead branching and logs should be provided to offer the opportunity to climb, forage in various environments and rest at height, as seen in wild *C. obscurus* (the AZA recommends at least 1.22 m above the ground [22]). These will also provide the opportunity for scent marking behaviour. The provision of visual barriers that the animals can use to take themselves out of view of both conspecifics (particularly important for subordinate individuals) and people (both familiar and unfamiliar) are vital for improving welfare. Species that inhabit dense environments, such as *C. obscurus*, have been noted to exhibit a greater negative response to the presence of people than species that would inhabit more open environments [24]. Providing animals with the opportunity in their environment to escape the view of visitors can reduce fear and stress, thus improving welfare [25]. Provision of a variety of substrates is important for enabling digging and foraging, two behaviours that are likely to play a key role in positive welfare for this species. *C. obscurus* also have non-retractable claws whose length can be managed through the provision of digging opportunities rather than requiring veterinary intervention [22]. The provision of resources required to fulfil the species' evolutionary and biological needs will result in positive affects (Figure 2).

Figure 2. Outside habitat for *C. obscurus,* MZ. Environmental features include a stream, a variety of planting, a mesh roof and branching/logs.

For a gregarious species such as *C. obscurus*, being able to maintain good social interactions with conspecifics is key to the individual's welfare state. There are records of

C. obscurus that were housed in isolation experiencing stress, which was noted leading to apathy and self-harm [13,22]. All veterinary procedures requiring general anaesthesia, inevitably resulted in the isolation of an individual from the rest of the group. The period of isolation varies depending on the length of the procedure and the recovery time immediately after the procedure, which itself is affected by the length of the procedure and the physiological health of the individual [26]. As *C. obscurus* are a highly sociable species [17], periods of isolation may have a negative impact on the welfare of the isolated individual and potentially the rest of the group, with the risk that the isolated individual could be rejected on reintroduction. Duration of separation should be kept to a minimum [22]. Captive *C. obscurus,* similar to other members of the *Herpestidae* family, are also prone to developing hypercholesterolaemia [22]. As this condition is not reported in wild individuals, it is hypothesised that it is linked to a captive diet and one dietary trial led to improved blood cholesterol levels [27,28].

Crossarchus obscurus at Marwell Zoo

Two males and two females (a non-breeding sibling group, containing surgically castrated males) are currently housed at MZ, where they arrived in July 2017, aged one year. This group is of a similar size but differs in that it lacks the multigenerational composition seen in wild social groups. Contrary to Goldman's species' description [9], aggression between *C. obscurus* appears fairly common in captivity, possibly as a result of inappropriate social groupings. Behavioural information gathered from MZ's animal records confirmed that it is frequently exhibited by this group where it seems to occur predominantly around food, although it mostly comprises vocalisations and pushing, rather than physical attacks [29].

Relevant behavioural knowledge from MZ's *C. obscurus* was derived from data collected during a behavioural study on the four individuals. This utilised an ethogram developed from a literature search and confirmed that they exhibit a similar activity budget to their wild counterparts, with, on average, 63% of daylight hours spent active (max. 66%, min. 58%), 37% spent resting (max. 42%, min. 34%) and no sleeping behaviour seen. Little difference in behaviour was seen between either the individuals or sexes (males active 61.5%, resting 38.5%; females active 64.5%, resting 35.5%). At 5–6 years of age, with a captive life expectancy, on average, of 8–10 years [14], activity levels would not yet be expected to be affected by age. These observations also indicate a preference for resting at height, particularly when sleeping, as would be expected from what is known of the species' wild behaviour.

Common veterinary procedures historically performed in this group of animals, as identified from medical records, include the administration of medication, manual restraint for minor procedures or the application of topical treatmen, and general anaesthesia for blood samples and skin biopsies. The welfare impact of these procedures was considered to be less if they did not require restraint or general anaesthesia. Whilst the general anaesthesia of small mammals, induced using inhalation medication such as isoflurane, is associated with a negative impact on animal welfare due to the need for pre-operation starvation and the marked breath-holding behaviour that it can cause during induction [30] and the recovery phase, it may have a lower impact on overall welfare compared with manual restraint, depending on the duration of restraint and whether habituation to restraint has occurred. However, in this case, manual restraint occurred infrequently in this group and none of the individuals appeared to experience long-term negative effects when it did occur; therefore, manual restraint was considered to have a lower impact on welfare than general anaesthesia, an example of welfare being dependent on context.

Further clinically relevant information was gathered from the medical records of the animals. This highlighted certain pathological conditions exhibited by all individuals of this group, that appear to occur more frequently in captive *C. obscurus*, in particular, alopecia and poor coat quality (outside of the natural seasonal shedding [9], linked also to behaviour) and skin disease resulting in dry flaky skin and sores. After considerable veterinary

investigation, the underlying cause remains inconclusive, although one individual was identified as having skin allergies that led to more frequent and severe lesions compared to the other three (Figure 3). This condition is now managed using a steroid medication. There are no records of this affecting *C. obscurus* in the wild.

Figure 3. Visual record of a sore on one *C. obscurus* at MZ. Photograph taken while the animal was under general anaesthetic, MZ, 2019.

Abnormal behaviours, such as overgrooming (both auto- and allo-) and barbering, self–mutilation, excessive scratching, repetitive pacing and circling behaviours have been recorded for various mongoose species in captivity [13]. These behaviours can be used as animal-based indicators of potentially compromised welfare [31–33]. Evidence gathered via camera traps during a study in 2019 indicated that barbering, over-grooming and/or excessive scratching were contributing to hair loss, possibly in response to pathological issues. In addition to indicating an attempt to cope with an aversive situation, the hair loss itself can have a negative impact on welfare, affecting communication with both con- and contraspecifics (when threatened piloerection will occur along with an arched back to appear larger [9]) and the animal's ability to thermoregulate and protect the skin from the sun and injuries. No other abnormal behaviours have, to date, been exhibited by this group of individuals.

Since 2017 there have been changes in the group's diet with the replacement of items of a higher fat content (e.g., chicks and mice) with more invertebrates, plus the addition of crayfish/crab and whitebait to determine whether this would impact coat condition, as was found by Totten [27]. The reduction in large single item feeds for invertebrate feeds that stimulate active foraging behaviours also led to reduced aggression among the group at feed times. A higher-than-expected cholesterol level was found during a veterinary exam on one individual in early 2019.

The indoor area of the *C. obscurus* enclosure at MZ is heated by a bar heater and fluctuates in temperature from 13.5 to 30 °C (Figure 4), depending on the season, with heat lamps provided during cooler weather. Data on enclosure usage by this group identified that above the bar heater is the area most used by all individuals (on average, 32% of their time). Behavioural data also showed a positive correlation between use of this area and poor weather. This indicates that temperature is an important environmental factor for these individuals and likely the species, considering the environment it evolved in, and excessive use of this area in addition to an increase in bundling behaviour can indicate a potential compromise to welfare. As a link between sub-optimal humidity and skin and hair issues has been found in rodents [34], it was speculated that low humidity level, along with the behaviour of sitting above the radiator, was a contributor to the skin issues in this group. Humidity levels were therefore increased by changing the substrate from wood shavings to bark mulch that could be dampened regularly.

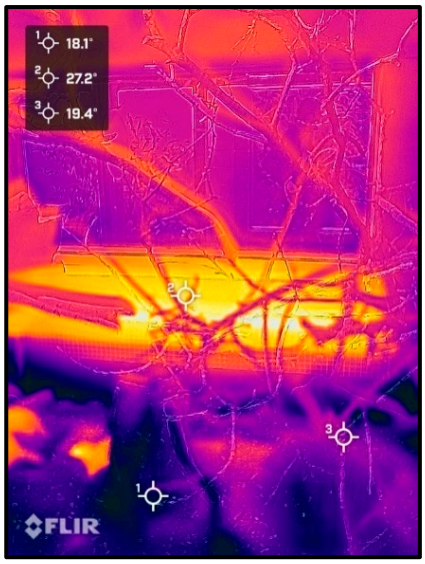

Figure 4. Image from the inside area of the *C. obscurus* enclosure. FLIR thermal image of bar heater reading 27.2 °C (as indicated by the white crosshairs numbered 2) and floor temperature reading 18.1–19.4 °C (as indicated by the white crosshairs numbered 1 and 3).

This *C. obscurus* group typically show little behavioural response to unfamiliar people, as supported by data on their enclosure use where they were found to spend 51% of the observed time in areas of the enclosure that are adjacent to guest viewing windows. It is probable that resources in these areas attract the *C. obscurus*, for example, one area was particularly suitable for digging, one of the most common behaviours observed, and gave the best view of familiar people approaching the enclosure, whilst the other area was on top of a heater. Even so, the presence of unfamiliar people in proximity did not deter them from using these areas. Individual and species-specific responses will lead to variation in behaviour exhibited, as will habituation and previous positive or negative experiences with people.

To assess and monitor the welfare of these individuals, previously published AWAG templates were adapted utilising the limited species-specific knowledge that was available from the literature supplemented with data from zoo records and direct observations to better reflect this species, these individuals and their specific context. As this system relies on knowledge of the species in order to effectively assess welfare, it is more difficult to put together a template for species where there is relatively little information available. Hence, this paper shows one possible approach to creating a template when information is scarce.

2. Parameters of the AWAG

2.1. Physical

Wolfensohn, et al. [35] published the following factors under this parameter: general condition, clinical assessment, activity level/mobility, presence of injury, not eating/drinking. Justice, et al. [5] adapted the template to include 'faecal consistency', as it is a commonly used indicator of gastrointestinal health and diet suitability in zoological institutions, and exclude 'presence of injury', instead including this under 'clinical assessment'. For this study, these animal-based measures were largely kept the same, using relevant species knowledge available from the literature.

The factor 'clinical assessment' was split to allow the scoring of skin condition separately from other clinical signs. 'Body condition score' (BCS), where subjective visual assessments of muscle and fat, typically scored on a 1–5 scale with 3 representing optimum condition, are used to determine whether an animal is a healthy weight, replaced general condition. Change in an animal's BCS can indicate the presence of underlying health conditions and can be used to monitor the progression of the disease and the success of

veterinary intervention [36] and husbandry practices [37]. Extremes in body condition can predispose an individual to disease [38,39]. This measurement is used because although weight is important to monitor, it is not always easy to assess its relevance to health depending on the size and age of an individual. Whilst the coarse fur of this species may impede a consistently reliable result, BCS is non-invasive and quick to carry out, both important factors when considering the practicalities of assessing welfare in a zoo setting [40,41]. BCS is also validated by hands-on physical examination and weighing when the opportunity arises (i.e., during veterinary care). 'Faecal consistency' was retained in this template but as *C. obscurus* is a midden utilising species, faecal consistency was scored for the group.

See Table 1 for the full list of factors and 1–10 criteria for the parameter: Physical.

2.2. Psychological

Psychological factors scored in a previous study by Wolfensohn, et al. [35] comprised the following animal-based measures: stereotypy, self-harming, unusual grooming; response to catching events; hierarchy upset/dispute, aggression/bullying; alopecia score; use of enrichment; and aversion to 'normal' events. These were revised by Justice, et al. [5] for use in a zoo context to consist of: abnormal behaviours; response to catching event; hierarchy upset/dispute, aggression/bullying; use of enrichment; aversion to 'normal' events and training. Although there are some similarities, for this study the factors scored under this parameter were significantly adapted.

'Abnormal behaviour' was retained, and the criteria adapted to include alopecia that may be occurring as a result of barbering, over-grooming and/or excessive scratching. Videos indicated that a proportion of these behaviours were occurring overnight; hence, the criteria for this factor were adapted to allow scoring to be carried out on behaviour seen as well as the extent of hair loss as a proxy for these behaviours occurring out of sight. The 'Rule of Nines', as used by the emergency services to quickly assess the total body surface area of burns victims [42], was adapted for *C. obscurus* (Figure 5), to help zookeepers objectively quantify hair loss. Excessive scent-marking of conspecifics was also considered as a possible cause of hair loss, with areas of 'wet' fur occurring in some of the same locations. This was encapsulated in this factor as a possible result of an abnormal frequency of the behaviour.

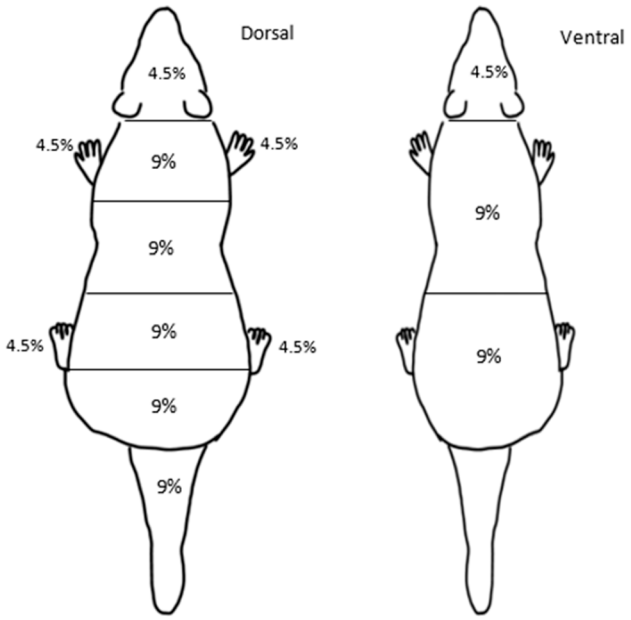

Figure 5. The 'Rule of Nines' schematically depicted for *C. obscurus*. The 'Rule of Nines' can be used to calculate a rough percentage of hair loss to support welfare assessment.

Table 1. Factors scored within the physical parameter.

	Body Condition Score	Food Intake	Activity Levels (Based on Wild Behaviour). Diurnal Species.	Faecal Consistency	Clinical Assessment (Excluding Skin Condition)	Skin Condition
Score						
1	3—Ideal	Eating normally. No signs of increased/decreased hunger. All food is consumed.	Normal balance between activity and resting. Little to no sleeping seen during the day. Activity begins around sunrise and continues throughout day until sunset or drop in temperature, with periods of resting.	Normal	Nothing observed	Skin looks healthy, no dryness or flaking. No wounds.
2	More/less than 3 but not quite 2.5/3.5	Food intake slightly lower than normal for one day OR animal reported hungry	Slight increase/decrease in activity not related to normal daily variation	Loose (below 10% of total) or clumpy (below 30%)	Mild clinical signs that show no impact on the animal's ability to perform normal behaviours. Full recovery expected	Small area/s of dry, flaky skin visible.
3	2.5/3.5—Slightly over/under	Food intake significantly lower than normal for one day OR reported hungry for 2–3 days	Moderate increase/decrease in activity (no obvious cause)-showing full recovery within 8 h	Loose (below 20% of total) or clumpy (below 40%)	Mild clinical signs having a short term impact on the animal's ability to perform normal behaviours. Full recovery expected.	Large area/s of dry, flaky skin visible.
4	More/less than 2.5/3.5 but not quite 2/4	Food intake slightly lower than normal for 2 days (lower than 80%) OR reported hungry for 4–5 days	Moderate increase/decrease in activity (no obvious cause)-showing full recovery within 12 h	Loose (below 30% of total) or clumpy (below 50%)	Mild clinical signs having a longer term impact on the animal's ability to perform normal behaviours. Full recovery expected.	Healing/scabbed sore/s
5	2/4—Over or under	Food intake significantly lower for 2 days (lower than 50%) OR reported hungry for 6–7 days	Significant increase/decrease in activity (no obvious cause)—showing full recovery within 12 h	Loose (below 40% of total) or clumpy (below 60%)	Moderate clinical signs having limited impact on the animal's ability to perform normal behaviours. Full recovery expected	One small open sore
6	More/less than 2/4 but not quite 1.5/4.5	Food intake slightly lower than normal for 3 days (lower than 80%) OR reported hungry for 8–9 days	Significant increase/decrease in activity (no obvious cause)—not showing full recovery to normal or recovery taking over 12 h.	Loose (below 50% of total) or clumpy (below 70%)	Moderate clinical signs having limited impact on the animal's ability to perform normal behaviours. Recovery potential unknown.	One medium OR multiple small open sores OR multiple medium/large wounds scabbed and beginning to heal
7	1.5/4.5—Very over/under	Food intake significantly lower than normal for 3 days (lower than 50%) OR reported hungry for 10–11 days	Inactive but does get up to eat/drink/defecate OR very active throughout the day with not much rest	Loose (below 60% of total) or clumpy (below 80%)	Moderate clinical signs with medium to long term impact on animals ability to perform normal behaviours. Recovery potential unknown.	Multiple medium open sores OR one large open sore OR open wound on face, ear/s, groin or foot/feet
8	More/less than 1.5/4.5 but not quite 1/5	No sign animal has eaten for 1 day OR reported hungry for 12–13 days	Very minimal movement/signs of hyperactivity	All clumpy or all loose	Severe clinical signs but with short term impact and expected recovery OR moderate to severe signs with long term impact on animal's welfare and little chance of recovery.	One large open wound present for >1 week <4 weeks

Table 1. *Cont.*

Score	Body Condition Score	Food Intake	Activity Levels (Based on Wild Behaviour). Diurnal Species.	Faecal Consistency	Clinical Assessment (Excluding Skin Condition)	Skin Condition
9	1/5—Very Thin/Obese	No sign animal has eaten for 2 days or reported hungry for 14–15 days	Completely hyperactive OR inactive	All watery diarrhoea	Severe or chronic clinical signs that are having serious negative impact on the animal's ability to perform normal behaviours	Multiple open wounds, various locations on body for <4 weeks OR one large open wound present for >4 weeks.
10	0—Emaciated/Starving OR 6—Morbidly Obese	No sign animal has eaten for 3 days OR reported hungry for >15 days	Animal causing itself harm through inactivity or hyperactivity OR completely recumbent	Presence of abnormal elements e.g., mucus or blood	Severe clinical signs that are rendering the animal recumbent/unable to carry out any normal behaviour	Multiple open wounds, various locations on body, present for >4 weeks

The presence of humans in and around the animals' enclosure is an inevitable consequence of living in a captive environment. Research across various species has shown that human presence can elicit a variety of responses, although most research to date has focussed on the negative impacts on animal welfare [25,43]. It has also been evidenced that animals are able to distinguish between familiar and unfamiliar people [44]. Therefore, the factor 'response to unfamiliar people' was added to this parameter, with scoring criteria to reflect the range of impacts on welfare and response to familiar people, i.e., zookeepers, encapsulated under the factor 'response to normal events'. The term 'unfamiliar people' was used instead of visitor or guest as this was felt to be more encompassing of the array of people that may have an impact on the animals (for example, contractors or service providers).

The factor 'aversion to normal events' was changed to 'response to normal events' to allow the inclusion of scores that would reflect a positive impact on welfare, in line with contemporary welfare science [45]. The criteria for this factor were adapted to include anticipatory behaviours (as was included by Brouwers and Duchateau [7]), such as increased activity ahead of scheduled feed times, as these can indicate the level of importance an animal attributes to a positive event, with those positive events that occur less frequently potentially resulting in the greater duration or intensity of anticipatory behaviour. Whilst anticipation is associated with dopamine production and thus in limited duration may indicate positive welfare at the moment when it is occurring, the behaviour may be more useful as an indicator that outside of that time, the animal's overall welfare is suffering due to a lack of something or the lack of ability to do something that the animal considers important [46–48]. Affiliative behaviours, including play, grooming and bundling, are positive social interactions, likely resulting in positive emotional states for the individuals involved [49]; therefore, 'hierarchy upset' was changed to 'social interaction', to enable these positive impacts on welfare to be taken into account. As food-related aggression is commonly seen in mongoose species in captivity [22], it was important that this was also captured in this factor's criteria.

'Response to catching event' was replaced with 'response to restricted access to part of the enclosure' as catching occurs infrequently for these individuals. When it is required, it is usually for veterinary care; therefore, it was incorporated in the procedural parameter instead. Restricting the *C. obscurus* group to part of the enclosure occurs more often, for example they would be shut into the house for landscaping of the outside area. This group rarely shows any negative response to being shut out of the house, or being shut in the house for short periods of time. However, they show signs of frustration if shut inside the house for an extended period; therefore, it is important to assess each occurrence individually.

The term 'enrichment' in everyday animal care seems to have become synonymous with the provision of resources, e.g., novel objects, which are aimed at reducing indicators of poor welfare, such as abnormal behaviour, or to stimulate positive, but mostly short-term, changes in behaviour, instead of focussing on enabling and encouraging species-specific behavioural repertoires. As a non-invasive, accessible and thus practical tool, assessing behaviour is the most used method for evaluating animal welfare [41,50]. Both the specific behaviours exhibited, and overall behavioural diversity can be used as animal-based indicators of welfare. Behavioural diversity is classically compared to the species-typical wild behaviours. Several studies have found when the amount of abnormal or stereotypical behaviour displayed is high, behavioural diversity is generally low and vice versa (see Miller, et al. [51] for examples) and although stereotypes may develop as a coping mechanism that helps to improve welfare, their presence can indicate a suboptimal situation that the animal is attempting to cope with [33]. Although information on wild behaviour and behavioural diversity is limited for this and numerous other captive species, what is known can provide a benchmark that captive animal behaviour can be compared to. For these reasons, the factor 'use of enrichment' was adapted and renamed 'species-typical behaviours' for this template. Finally, 'training' was removed from the template as the group do not receive any training at present.

See Table 2 for the full list of factors and 1–10 criteria for the parameter: Psychological.

Table 2. Factors scored within the psychological parameter.

	Abnormal Behaviour (Overgrooming, Barbering, Increased Scratching—For Hair Loss (Use 'Rule Of Nines')	Response to Presence of Unfamiliar People (e.g., Guests, Contractors, Keepers from Other Sections)	Response to Normal Events	Response to Restricted Access to Part of the Enclosure	Social Interaction (with Conspecifics)	Species-Typical Behaviours—Either Observed Occurring or Evidence of
Score						
1	No hair loss, coat is in healthy condition, looking bright and glossy. No abnormal behaviour or frequency of behaviour observed.	Actively seeks out familiar and unfamiliar people. Appears to prefer parts of enclosure close to people.	Actively seeks out keeper during normal events, exhibiting positive behaviours.	No restricted access to part of the enclosure	Animals are interacting with one another positively. Exhibiting affiliative behaviours e.g., bundling, frequently	Animal is observed performing all expected natural, primarily positive, behaviours (e.g., group foraging, exploration, scent marking, walking, running, trotting, climbing, resting, sleeping, bundling, digging, hunting, foraging with nose, foraging in vegetation, egg smashing, stalking, sun bathing, sniffing, drinking, aggression, allogrooming, mating, scratching, stretching, play, predator defence and hiding) at expected rate with no abnormal behaviours.
2	No hair loss but coat is looking dull, greasy or wet AND/OR limited time spent, low frequency, distractable	Completely habituated to presence of unfamiliar people, no concern shown. No preference for particular parts of enclosure noticeable.	Well habituated to keeper interactions/daily events, no response	Animal comes in easily with call and no further intervention required. Animal remains calm until released.	Animals are interacting with one another positively. Exhibiting affiliative behaviours e.g., bundling, occasionally	Animal is observed performing most natural behaviours as expected in captivity (may not include, for example, mating, egg smashing or predator defence) at expected rate with no abnormal behaviours.
3	Hair is thinning in patches but there are no bald areas AND/OR limited time spent, low frequency, distractable	Preference to avoid areas close to viewing areas but does use rest of enclosure. No signs of stress observed.	Anticipatory behaviour begins on seeing keeper heading to enclosure but stops immediately on keeper arrival. Well habituated to keeper interactions/daily events.	Animal well trained and/or habituated and comes in easily but intervention/enticement is required. Animal remains calm until released.	Animal interacts with conspecifics without affiliative behaviours or fear/stress/aggression (exhibited/received)	Animal is observed performing a wide variety of positive natural behaviours including: foraging, stalking/hunting, digging, locomotion, social, self-maintenance, climbing, resting, at expected rate with no abnormal behaviours.
4	1–5% hair loss AND/OR moderate time spent, medium frequency, distractable	Spends most of the day away from viewing areas or hiding out of sight, utilises enclosure when zoo is closed. No signs of stress observed	Well habituated to most keeper interactions/daily events but mild stress seen for single specific interaction.	Animal shows some reluctance to come in and mild signs of stress. Takes between 5–15 minutes to get the animal inside/attempt abandoned. OR animal is showing signs of stress as a result of attempts to shut conspecific in. AND/OR mild signs of stress when shut in.	Animal has opportunity to interact with conspecific but choses not to. No fear/stress/aggression (exhibited/received) noted.	Animal is observed only performing fundamental behaviours such as feeding, resting, drinking, urinating, defecating but no negative or abnormal behaviours.
5	>5–15% hair loss AND/OR moderate time spent, higher frequency, no damage done and distractable OR 2–4 and not distractable	Preference to avoid viewing areas/hide out of sight but does use rest of enclosure for some of the day. Shows mild signs of stress when unfamiliar people around but recovers when they leave area.	Shows some mild signs of stress during normal daily interactions but recovers as soon as interaction is over AND/OR short-term anticipatory behaviour in lead up to keeper arrival for a single routine event.	Animal very reluctant to come in and shows moderate signs of stress. Single attempt required but takes over 15 minutes/abandoned after 15 mins.	Animal shows mild fear/stress/aggression (exhibited/received) in interactions with conspecifics which is temporary e.g., around food. Majority of interactions are normal.	Animal is observed performing a wide variety of positive natural behaviours including: foraging, stalking/hunting, digging, locomotion, social, self-maintenance, climbing, resting, at expected rate with some negative or abnormal behaviours.

Table 2. *Cont.*

Score	Abnormal Behaviour (Overgrooming, Barbering, Increased Scratching—For Hair Loss (Use 'Rule Of Nines')	Response to Presence of Unfamiliar People (e.g., Guests, Contractors, Keepers from Other Sections)	Response to Normal Events	Response to Restricted Access to Part of the Enclosure	Social Interaction (with Conspecifics)	Species-Typical Behaviours—Either Observed Occurring or Evidence of
6	>15–25% hair loss AND/OR significant time spent, higher frequency, not distractable	Spends most of the day away from viewing areas/hide out of sight and show mild signs of stress when unfamiliar people are around but recovers when they leave area.	Shows some moderate signs of stress during normal daily interactions AND/OR short-term anticipatory behaviour in lead up to keeper arrival for all routine events.	Animal very reluctant to come in and shows moderate signs of stress. Multiple attempts required/abandoned after multiple attempts. AND/OR moderate signs of stress when shut in.	Animal shows moderate fear/stress/aggression (exhibited/received) in interactions with conspecifics that is temporary.	Animal is observed primarily performing fundamental behaviours such as feeding, resting, drinking as well as a few positive behaviours (e.g., digging, climbing or self-maintenance) with an increase of negative or abnormal behaviour.
7	>25–35% hair loss AND/OR significant time spent, higher frequency, not distractable	Avoid viewing areas/hide out of sight and show moderate signs of stress when unfamiliar people around but recovers when they leave area.	Shows significant stress behaviour during normal daily interactions AND/OR considerable time spent in anticipatory behaviour in lead up to keeper arrival for a single routine event.	Animal very reluctant to come in and showing severe signs of stress/fear. Significant time (over half an hour) and/or multiple attempts to get in/abandoned.	Animals shows moderate fear/stress/aggression (exhibited/received) in interactions with conspecifics OR no opportunity to interact with conspecific (gregarious species)	Animal is observed performing fundamental behaviours such as feeding, resting, drinking but spending some time on negative or abnormal behaviours.
8	>35–45% AND/OR majority of time spent, high frequency, not distractable.	Significant signs of stress when unfamiliar people are around but recover within an hour when they leave area.	Shows significant stress/fear behaviour during normal daily interactions AND/OR considerable time spent in anticipatory behaviour in lead up to keeper arrival for all routine events.	Animal very reluctant to come in and showing severe signs of stress/fear. Significant time spent (over 1 hour). AND/OR showing severe signs of stress when shut in.	Animal shows severe fear/stress/aggression (exhibited/received) in most interactions with conspecifics.	Animal is observed performing fundamental behaviours such as feeding, resting, drinking but spending greater proportion of time exhibiting negative or abnormal behaviours.
9	>45–55% AND/OR majority of time spent, very high frequency, not distractable.	Significant signs of stress when unfamiliar people are present. Takes up to 8 h to recover when they leave area.	Animal is stressed and aggressive during normal daily routine events	Animal extremely difficult to get in and showing aggressive behaviour in response to attempts	Animal shows fear/stress/aggression (exhibited/received) in all interactions with conspecifics.	Animal is observed performing fundamental behaviours such as feeding, resting, drinking but spending most of their time exhibiting negative or abnormal behaviours.
10	>55% hair loss AND/OR majority of time spent, very high frequency, not distractable.	Significant signs of stress AND/OR aggression/self harm in response to presence of unfamiliar people.	Animal is self-harming as a result of a normal or routine event.	Animal harming itself and/or conspecifics as a result of being shut in or attempts at shutting in.	Animal is aggressive and either self harming or harming conspecific.	Complete lack of natural behaviour observed, overwhelming abnormal or negative behaviour exhibited (e.g., aggression, hiding, pacing, self-directed or escape behaviours)

2.3. Environmental

Wolfensohn, et al. [35] used housing, group size, provision of 3D enrichment, provision of manipulable enrichment and contingent events, under the environmental parameter. These were refined by Justice, et al. [5] for the zoological environment where 'furnishing/enclosure design' replaced 'housing', enrichment was moved to the psychological parameter and 'nutrition' and 'access' (to enclosure) were added. The factors under this parameter were further adapted for this template.

The factors included in this parameter are predominantly resource-based, assessing what has been provided/is available to the animals and thus what the animals could be experiencing as a result. Nevertheless, this does not consider whether the animals are utilising these resources oor the resulting affects. 'Enclosure' and 'enclosure complexity' are scored separately under this factor to account for the suitability of the enclosure parameters to provide physical comfort and fulfil biological functions, and complexity to provide for the species' behavioural needs that may not be captured under the factor 'species-typical behaviour' when not observed. The factors 'group size/structure' and 'contingent events' were retained, whist the impact of reduced 'access' was incorporated into the psychological parameter, under the factor 'response to restricted access to part of the enclosure', to change it from a resource- to an animal-based indicator. As it is not possible to regularly test cholesterol level without an invasive veterinary procedure, this measure was not included in the AWAG, so the only changes made to the criteria for 'nutrition' were to include the presence of a variety of tastes, textures and smells that increase the pleasurable experience of eating, leading to positive welfare [52].

See Table 3 for the full list of factors and 1–10 criteria for the parameter: Environmental.

2.4. Procedural

In Wolfensohn, et al. [35], restraint, sedation, effect of intervention and change in daily routine were included in the procedural parameter. Justice, et al. [5] adapted 'effect of intervention' to focus on veterinary procedures specifically, and two factors were added for birds: 'time bird restrained before/during procedure' and 'visitor score'. Although they may not occur frequently, veterinary procedures are likely to be some of the most stressful events a zoo animal will experience during its lifetime; therefore, it is vital that the negative impact on welfare caused by veterinary procedures is considered.

'Isolation' was included as a separate factor in this study due to the greater welfare impact it could have on this highly social species. 'Vet procedure' and the 'impact of vet procedure' were both included to cover the effect of the procedure itself on welfare as well as the effect on welfare in the lead up to and following the procedure, including manual restraint and changes in husbandry. The factor 'changes in daily routine' was removed as a factor as it was felt that changes to food intake and enclosure would be captured elsewhere in the template. 'Visitor score' was included under the psychological parameter instead and the focus was placed on the animals' response to unfamiliar people rather than assuming increasing group size and noise level has a negative impact on the welfare of these individuals [5].

See Table 4 for the full list of factors and 1–10 criteria for the parameter: Procedural.

Table 3. Factors scored within the environmental parameter.

	Enclosure (Species Specific, e.g., Size, Lighting, Shelter, Ventilation, Temperature, Drainage, Noise Levels, Substrate etc.)	Enclosure Complexity (Species Specific, e.g., Planting, Water Bodies, Food, Shelter, Choice, Hiding Places, Furniture, Sunlight/Heat Lamp) Plus Opportunities Provided by Keepers	Group Size/Structure (Based on Wild Size and Composition)	Contingent Events (e.g., Animal Movement, Enclosure Changes, Building Works, Visitor Event)	Nutrition
Score					
1	Enclosure mirrors the species' wild habitat preference (tropical rainforest, transitional forest, logged forest, agricultural land), size (20–30 ha) with access to temperature >22 degrees C, >60% humidity, 12/12 photoperiod, shelter from inclement weather and sun, guest viewing less than 360 degrees, off show area, ventilation, UVB, low noise level, adequate drainage and substrate.	Enclosure complexity is reflective of the wild environment, including waterbody/ies, suitable substrates for foraging and digging burrows, dense vegetation plus some open areas, climbing opportunities, ability to sleep at height as a group in a variety of locations, and be able to rest as a group elsewhere, variety of weather conditions. All natural behaviours can be expressed.	Group size is reflective of natural wild group size (4–20 individuals) and suitable group structure (dominant breeding pair and young from current or previous litters, both adult males and females, groups appear fairly stable). Stocking density is appropriate for the enclosure.	None	Diet available is optimally suited to the species-specific needs (nutritional, physiological and behavioural (natural acquisition and manipulation)) and the individual. Diet includes a variety of tastes, textures and smells.
2	Enclosure is smaller than wild territory but mirrors other elements	All natural behaviours can be expressed with little reliance on keepers	Group size and structure is similar to wild. No stress observed and natural behaviours seen from all of the group.	External works/visitor event with minimal disturbance	Diet provided is suited to the species-specific needs (nutritional, physiological and behavioural (natural acquisition and manipulation)) and the individual but regularly lacks variety.
3	Enclosure is smaller than wild territory and lacks one other element.	All natural behaviours can be expressed with considerable reliance on keepers	Group size and structure are dissimilar to the wild but no stress observed and natural behaviours seen from all of the group. Stress behaviours NOT seen when separated.	Enclosure move to familiar enclosure with no other events taking place	Diet provided has a slightly reduced suitability to species and/or individual needs AND/OR lacks variety.
4	Enclosure is smaller than wild territory and lacks 2 other elements.	Most natural behaviour can be expressed with minimal reliance on keepers	Group size and structure are not like wild but no stress observed and natural behaviours seen from all of the group. Some stress behaviours seen when separated.	External works/visitor event with some disturbance including visitor event outside of usual opening times but during daylight.	Diet provided has reduced suitability to the individual needs
5	Enclosure is smaller than wild territory and lacks 3 other elements.	Most natural behaviours can be expressed with considerable reliance on keepers	Group size is reflective of natural wild group size and suitable group structure. Stocking density is slightly high for the enclosure (e.g., presence of young)	Enclosure move to a completely new enclosure OR significant change to the existing furniture of the enclosure.	Diet provided has reduced suitability to the species needs

Table 3. *Cont.*

	Enclosure (Species Specific, e.g., Size, Lighting, Shelter, Ventilation, Temperature, Drainage, Noise Levels, Substrate etc.)	**Enclosure Complexity (Species Specific, e.g., Planting, Water Bodies, Food, Shelter, Choice, Hiding Places, Furniture, Sunlight/Heat Lamp) Plus Opportunities Provided by Keepers**	**Group Size/Structure (Based on Wild Size and Composition)**	**Contingent Events (e.g., Animal Movement, Enclosure Changes, Building Works, Visitor Event)**	**Nutrition**
Score					
6	Enclosure is smaller than wild territory and lacks 4–5 other elements.	Some natural behaviours can be expressed with considerable reliance on keepers	Group size and structure is similar to wild but environmental pressures cause stress/aggressive behaviours	External works/visitor event taking place with definite disturbance, including visitor event taking place after sunset.	Diet provided lacks behavioural requirements for the species and individual.
7	Enclosure is smaller than wild territory and lacks 6–7 other elements.	Enclosure complexity and keeper intervention are minimal, preventing the expression of numerous natural behaviours.	Group size and structure not completely like wild. Moderate stress behaviours observed either when together OR separated.	Introduction of new unfamiliar animal to group.	Diet provided lacks physiological requirements for the species and individual
8	Enclosure is smaller than wild territory and lacks 8–9 other elements.	Enclosure complexity and keeper intervention are minimal, preventing the expression of most natural behaviours	Group size and structure not completely like wild. Significant stress behaviours observed either when together OR separated.	Prolonged external works with definite disruption.	Diet provided lacks nutritional requirements for the species and individual
9	Enclosure is smaller than wild territory and lacks 10–11 other elements.	Enclosure complexity and keeper intervention is very limited, preventing the expression of almost all natural behaviours.	Group structure very different to wild group and inappropriate for species (e.g., solitary) and/or high degree of overstocking.	New enclosure and new animals introduced at the same time.	Diet provided lacks 2 requirements for the species and individual.
10	Enclosure is smaller than wild territory and lacks 12+ other elements	The options are not available in the enclosure nor provided additionally for the animal to express natural behaviours	Group structure very different to wild group and dangerous for species OR harmful degree of overstocking.	Multiple events happening at the same time (e.g., new enclosure, new group and external works)	Diet provided lacks all requirements for the species and the individual.

Table 4. Factors scored within the procedural parameter.

	Isolation (From Conspecifics)	Vet Procedures (e.g., Daily Medication, Routine Vaccinations, Sedation, Anaesthesia)	Impact of Vet Procedures and/or Catch up for Other Purpose (e.g., Stress/Fear)	Sedation/Anaesthesia
Score				
1	Not isolated	No vet procedure occurred	No vet procedure/catch up occurred	No sedation/anaesthesia
2	Isolated for less than 2 h	Minor procedure performed with minimal effect on animal (e.g., delivery of oral medication in food).	Procedure can be performed easily with no stress or aggressive behaviour (e.g., delivery of oral medication in food).	Mild sedation (e.g., sedated not asleep/recumbent). Calm induction and recovery. Rapid return to normal feeding and behaviour
3	Isolated for less than 6 h	Minor procedure, short term low impact effecting animal (e.g., parasite spot-on treatment)	Animal does not show anticipatory stress/fear behaviour before the procedure (e.g., triggered by arrival of vet or change in husbandry) but some mild stress/fear shown afterwards. Recovery from stress takes less than 8 h	Deeper sedation (e.g., asleep) with calm induction and recovery. Rapid return to normal feeding and behaviour.
4	Isolated for less than 12 h	Minor procedure, medium term low impact effecting animal (e.g., nail clipping).	Animal does not show anticipatory stress/fear behaviour before the procedure but mild stress/fear shown afterwards. Recovery from stress takes less than 12 h	Sedation with stressful induction and/or recovery but rapid return to normal feeding and behaviour after procedure
5	Isolated for >12 <24 h	Moderate procedure with short or medium term moderate impact effecting animal.	Animal shows mild anticipatory stress/fear behaviour before and stress/fear after procedure but recovers from stress within 4 h.	Sedation with stressful induction and/or recovery and/or effects on normal feeding and behaviour for a few hours after procedure.
6	Isolated for >24 <48 h	Moderate procedure with longer term moderate impact effecting animal.	Animal shows moderate anticipatory stress/fear behaviour before and moderate stress/fear behaviour after procedure but recovers from stress within 8 h.	Sedation with stressful induction and/or recovery and/or up to 12 h for normal feeding and behaviour to return after procedure.
7	Isolated for more than 2 days	Moderate procedure with longer term serious impact effecting animal.	Animal shows moderate anticipatory stress/fear behaviour before and severe stress/fear behaviour after procedure but recovers from stress within 12 h	Sedation with stressful induction and/or recovery and/or over 12 h for normal feeding and behaviour to return after procedure.
8	Isolated for more than 1 week	Severe procedure with short or medium term moderate impact effecting animal	Animal shows severe anticipatory stress/fear behaviour before and severe stress/fear behaviour after procedure and takes up to 24 h to recover.	Sedation with stressful induction and/or recovery and/or over 24 h for normal feeding and behaviour to return after procedure.
9	Isolated for more than 2 weeks	Extensive procedure with significant impact on animal and short term pain despite appropriate treatment and analgesia (e.g., tail amputation)	Animal shows severe anticipatory stress/fear behaviour before and aggressive behaviour after procedure.	Sedation with highly stressful induction and moderate to long term effects on normal feeding and behaviour after the procedure
10	Isolated for more than 1 month.	Extensive procedure with significant impact on animal and long term pain despite appropriate treatment and analgesia (e.g., tail amputation)	Animal shows severe anticipatory stress/fear behaviour before and aggressive behaviour after procedure. Animal continues to be aggressive to keepers more than 24 h after the procedure	Sedation with highly stressful induction and prolonged effects on normal feeding and behaviour after the procedure

3. Application of the Template to Real Data

The final template derived from the information above consisted of 21 animal- and resource-based welfare indicators, each scored 1–10, with 1 being best possible welfare state and 10 being the worst, based on incrementally defined criteria (Tables 1–4). To calculate a welfare score, the individual factor scores for each parameter were averaged, resulting in four separate scores that were plotted on a two-dimensional grid then linked to form a minimum convex polygon (Figure 6). The resulting area of the polygon provided the cumulative welfare assessment score (CWAS) for that period.

Figure 6. Visual depiction of welfare scores for one individual on two separate days. Reduction in the area of the polygon (from CWAS 9.39 on 16 March 2018 to 8.16 on 9 March 2022) indicates the potential improvement to welfare resulting primarily from a change in habitat.

In order to validate this approach, the adapted template was used to retrospectively assess welfare using the animal care team's daily animal records, which are based on their direct observations of the animals at least twice daily (see Justice, et al. [5] for further details of methods). All assessments were undertaken by MZ's experienced Animal Behaviourist in conjunction with the veterinary team, to maintain consistency of scoring. The data were analysed using dedicated cloud-based software (AWAG, Reuben Digital).

The impact of management decisions on welfare was assessed using the template to score welfare for one individual on a single day in 16 March 2018 to compare with a score for the same individual when living in a different habitat in 9 March 2022 (Figure 6). The primary difference in score between these two periods related to the environmental parameter, reflecting the improvement in suitability of the enclosure for the species (e.g., improved substrate, ventilation, humidity and temperature) and its complexity (e.g., presence of a waterbody, greater climbing/height opportunities).

The template was also used to retrospectively assess the welfare of all four individual *C. obscurus* for the period 9 March 2022 to 24 March 2022. Over this period, the CWAS across the group varied between 6 and 9 (the increase in score indicating reduced welfare), from a total possible score of 200 (Figure 7). The peaks and troughs in scores can be linked to specific incidences noted in the zoo records, as has been highlighted in Figure 7, providing evidence that this tool is sensitive enough to pick up these nuances in welfare state even where changes in score remain small. It also supports the addition of a separate factor for 'skin condition' in addition to 'clinical assessment'. As shown, the main welfare determinants over this period were skin condition, abnormal behaviour and social interaction, all examples where welfare is context dependent.

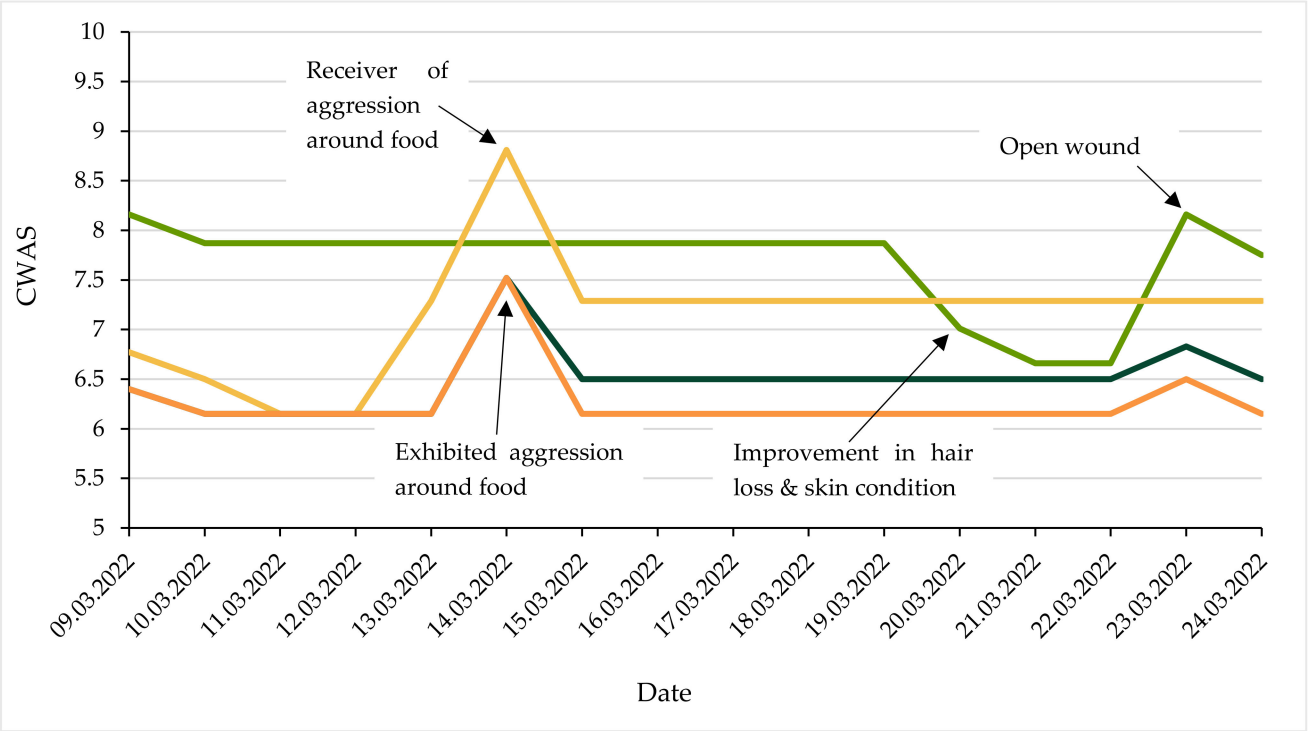

Figure 7. Cumulative welfare assessment scores (CWAS) for the four *C. obscurus* for the dates 9 March to 24 March 2022. Changes in CWAS indicate a likely reduction or improvement in welfare and have been highlighted alongside specific incidences that occurred on the day. Please note, the y-axis was adjusted from a minimum of 0 and maximum of 200 to emphasise the changes in CWAS which highlight discrete events that impact welfare.

4. Discussion

The aim of this study was to demonstrate how a welfare assessment can be created for a species with scarce published information available. Using the specifically designed AWAG template to retrospectively score daily animal records, this approach has been validated. In addition, it has highlighted the benefits of using behavioural observations and zoo records to provide context-dependent information to support the information gathered from the literature.

Reviewing the available literature is a key step in the process of designing a welfare assessment and will save the researcher both time and resources by removing the need to gather this information first-hand. However, when dealing with cryptic species, as many zoo-housed animals are, one of the limitations faced is the lack of published literature, resulting in welfare assessments based, sometimes, on only one or two wild observations. When sources are limited, the information presented must be considered in the original context and the relevance to captivity not exaggerated. For the purpose of welfare assessments, in some cases it may be better to avoid comparison to the wild environment and instead focus on how the captive environment provides for the needs of the species, placing more emphasis on animal-based factors. Some behaviours relevant to welfare may not have been observed in the wild, for example no evidence could be found of wild *C. obscurus* sunbathing, a behaviour commonly seen in other mongoose species [17], yet it is a behaviour seen exhibited by captive *C. obscurus* [27,29] and provision of access to sunlight is recommended in the AZA guidelines [22]. As evidenced here, direct observations of captive individuals can be used to support information gathered from the literature. They provide the opportunity to site individual health and behaviour within context, which is vital for an accurate understanding of that individual animal's welfare. However, care should be taken not to extrapolate generalisations from observations based on small sample sizes.

A limitation of this template in its current form is the inclusion of multiple resource-based indicators to assess welfare. Whilst utilising both resource- and animal-based indicators can provide a greater holistic understanding of welfare, good husbandry and care, or 'inputs', do not necessarily result in good welfare. Although resource-based factors can be used as a proxy for what the animal might be experiencing, only by assessing animal-based factors is it possible to ascertain the animal's likely mental state in response to the provided resources. The list of validated welfare measures is long; therefore, to produce a practical assessment, welfare measures need to be chosen depending on the context. Resource-based factors are often quantifiable, non-invasive, quick to assess and easily replicated, and having been used and validated with various species in different contexts they remain popular. Animal-based factors are still being developed for welfare assessment and there is currently a lack of information on affective states in many zoo-housed species. At present, this multi-faceted approach is valuable in the absence of being able to obtain all the evidence from animal-based factors.

Management decisions in captive environments should be based on scientifically validated evidence, preferably collected over time. For this study, only 16 days of CWAS were assessed to validate the methods; however, continuous monitoring over time is more likely to accurately reflect the impact of life stage or seasonal change on welfare compared with point-in-time audits [23]. One of the key advantages to using the AWAG is that welfare can be rapidly and easily scored, recorded and reviewed at regular frequencies, enabling continuous assessment over the animal's lifetime. This permits prompt identification of changes to specific contexts where welfare may be compromised, allowing the necessary adjustments to be made and their impact to be monitored.

Whilst this template has been successfully validated with *C. obscurus* at MZ, it is important to highlight that much of the data presented have been gathered from a small sample of individuals of the same age, and care should be taken if extrapolating this information to other individuals of a different age. Several suggested changes also resulted from the trial. For this species there was no clear link between 'faecal consistency' and welfare, so further evaluation of this factor as an indicator of welfare may be necessary. Similarly, the previously discussed limitations relating to the use of the wild environment as a benchmark suggest the factor definition for environmental complexity should be re-evaluated. The factor definitions for 'nutrition' could also be adapted to incorporate a time component as food items that may improve welfare short-term (consider the dopamine hit from eating sugary foods) but lead to decreased welfare in the long-term need to be accounted for. Finally, future score definitions could place more focus on animal-based factors, for example, preference testing, cognitive bias and Qualitative Behaviour Assessment.

5. Conclusions

Species-specific knowledge is a crucial part of developing the AWAG template's relevance for use with zoo species. This study demonstrated the development of the AWAG for an understudied species, *C. obscurus,* for which there is little published literature, using behavioural observations and zoo records to place that information within the specific environmental, social and individual context. Limitations of the methods, such as utilising resource-based factors, have been addressed, and future changes to this specific template have been highlighted. However, retrospectively scoring the welfare of the *C. obscurus* group at MZ validated the use of this tool for identifying factors that may have impacted animal welfare (in this instance, aggression, possibly the result of unnatural social dynamics; alopecia and skin lesions; and the environment). Consequently, using this methodology the AWAG demonstrated how the environmental changes likely improved animal welfare based on the features and complexity of the wild environment in which the species evolved (e.g., improved substrate, ventilation, humidity and temperature, presence of a waterbody and greater climbing/height opportunities). The AWAG is a flexible continuous welfare monitoring tool using scoring templates that can, and should, be regularly reviewed and

updated with the latest knowledge as it becomes available, supporting the development of evidence-based management practices that promote the welfare of captive wild animals.

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