Assessing the welfare of captive Lesser Antillean iguanas *(Iguana delicatissima)* using the Zoological Society of London's (ZSL) Welfare Audit

Abstract

Interest in the welfare of zoo-housed reptiles is increasing. However, there is currently a lack of reliable methods for assessing reptile welfare. This project is a validation of the Animal Welfare Audit tool (AWA) developed by the Zoological Society of London (ZSL) and its suitability for welfare assessments of captive reptiles. This tool is used widely within zoos and within a variety of taxa but has not previously been published or appraised in scientific literature. In this project, the AWA was adapted into a species-specific protocol for Lesser Antillean iguanas (*I.delicatissima*) with 4 main principles and 23 welfare criteria. The protocol was applied to two iguanas at Nordens Ark, Sweden. The results allowed for recommendations to improve the welfare of the iguanas at Nordens Ark, primarily relating to environmental conditions and spatial complexity. It is concluded that the AWA is a practical and valid tool for assessing reptile welfare. As with other welfare assessments, the method is limited by the availability of knowledge and literature on a chosen species. For *I.delicatissima*, future research should focus on senses, activity budgets and routine veterinary care to improve the accuracy of welfare assessments for this species.

Keywords: *reptile welfare, welfare assessment, Lesser Antillean iguana*, *Iguana delicatissima, ZSL Animal Welfare Audit*

1. Introduction

Interest in the welfare of captive zoo-housed animals has been increasing in recent years (Moran, 1987, Miller, 2012, Sherwen et al., 2018). Current animal welfare literature focuses on promoting positive emotions through the expression of natural behaviours, rather than simply minimising suffering (Green and Mellor, 2011, Mellor, 2016). This evidence-based management, based on the biological, physiological and behavioural needs of wild animals, is crucial for high standards of animal welfare (Melfi, 2009, Whitham and Wielebnowski, 2013).

It is recommended that welfare assessments are conducted regularly and systematically over time, in order to monitor an animal's health and behaviour and identify potential improvements to enclosure design and the environment (Melfi, 2009, Sherwen et al., 2018). Applied welfare assessment tools such as the Five Domains model and the EU Welfare Quality® protocol are most commonly used in the agriculture industry (Boissy et al., 2007, D'Eath et al., 2009, Blokhuis et al., 2005, Knierim and Winckler, 2009). These methods are increasingly being adapted to zoo-housed species (Mononen et al., 2012, Mellor and Beausoleil, 2015, Clegg et al., 2015, Salas et al., 2018, Sherwen et al., 2018, Skovlund et al., 2021). Several welfare assessment tools have also been developed specifically for wild animals within zoos and conservation breeding programmes (Sherwen et al., 2018, Kagan et al., 2015, Greggor et al., 2018).

There is currently a lack of evidence to conclude that welfare assessments are valid for captive reptiles (Melfi, 2009, Benn et al., 2019). At present, there is only one publication outlining a full welfare assessment of a reptile species (Benn et al., 2019). This is a challenge for reptile welfare, as there are over 12,000 distinct species with different behavioural and physiological requirements in captivity (Pincheira-Donoso et al., 2013, Uetz, 2022). While existing assessment tools may be suitable for reptiles, there are several

limitations. For instance, assessment tools require adaptation using species-specific welfare indicators. The lack of knowledge of reptile welfare may have deterred zoos from attempting welfare assessments, instead relying on tradition and 'folklore husbandry' (Warwick et al., 2013, Mendyk, 2018).

Typically, an assessor observes an animal and its environment within one day and determines a welfare score based on the observations within this short period (typically 1-3 hours, but can be as short as 15 minutes) (Heath et al., 2014, de Jong et al., 2016, Sherwen et al., 2018). This provides a limited view of long-term welfare, as it does not cover the full range of stressors, behaviours and environmental conditions which can occur from day-to-day. As reptiles tend to be behaviourally inexpressive and inactive for long periods of time, a welfare assessment conducted within several hours is unlikely to reflect the full range of potential behaviours. In this case, long-term welfare assessments may be more suitable for reptiles. One such method is the Zoological Society of London's (ZSL) Animal Welfare Audit (hereafter 'AWA'). This is a long-term welfare assessment tool which is widely used by zoos but has not yet been published or appraised in scientific literature.

This project was designed to validate the ZSL AWA tool and appraise its suitability for assessing reptile welfare. The reptile species chosen for the project is the Lesser Antillean iguana (*Iguana delicatissima). I. delicatissima* is a large iguana species distributed throughout the northern Lesser Antilles in primarily arboreal habitats (Day et al., 2000). The IUCN Red List defines *I.delicatissima* as 'Critically Endangered', and it faces extinction in the wild due to hybridisation with the common green iguana (*Iguana iguana*) (van den Burg, 2018, Knapp et al., 2014, Goetz et al., 2023). Therefore, it is increasingly important to monitor and improve the welfare of captive populations for conservation breeding programmes. The project was conducted in two stages: first; the AWA was adapted into a species-specific protocol for *I.delicatissima;* and second; the adapted protocol was applied to two iguanas in Nordens Ark zoo, Sweden.

Aims:

1. To assess the welfare of two Lesser Antillean iguanas (*I. delicatissima)* at Nordens Ark
2. To validate and appraise the ZSL Animal Welfare Audit tool

2. Methods

2.1. Subjects

The two iguanas assessed in this project were transferred from Jersey Zoo to Nordens Ark in May 2023. They are a male and female born in the same clutch in June 2016. During the project, the iguanas were housed in an off-show enclosure. The iguanas are due to move to a newly built public enclosure in November 2023. This species was chosen for a welfare assessment as the zoo wanted to incorporate welfare targets into the design and construction of the new enclosure.

2.2. Development of a species-specific protocol

The AWA considers four key welfare principles (Health & Physiology, Environment, Behaviour and Stressors) and 23 criteria (13 animal-based, 10 resource-based) (Table 1).

Table 1: The four welfare principles used in the AWA and the criteria related to each principle

Principle	**Criteria**
Health & Physiology	Physical condition; Injury; Illness; Nutrition; Other
Environment	Temperature range; Water source and humidity; Light; Surfaces & substrates; Cover and privacy; Spatial complexity
Behaviour	Social; Foraging & feeding; Species-specific; Locomotion & activity
Stressors	Husbandry and management; Visitors & events; Transport; Veterinary; Sensory; Competition; Repetitive behaviours

A literature search was conducted to choose appropriate species-specific indicators for each welfare criterion (i.e. physiological, environmental, and behavioural requirements, physical signs that an animal is thriving or struggling to cope). Where species-specific information was not available, literature referring to West Indian iguanas was used. West Indian iguanas refers to *I. delicatissima* and ten species from the genus *Cyclura* (rock iguanas) (Lemm et al., 2010). Most information used to develop the protocol was adapted from Best Practice Guidelines and Husbandry manuals for captive iguanids (Lemm et al., 2010, Goetz et al., 2023).

2.3. Data collection

The AWA was designed to be conducted by a keeper who regularly works with an animal and is familiar with their routines, behaviour and husbandry. For this project, the assessor was not familiar with the animals as they had only been housed at the zoo for a short period of time. Therefore, a period of data collection (behavioural observations and recordings of environmental data) was required. First, an ethogram was designed to include all behaviours typically observed in captive iguanas (Table 2). This was done by observing the iguanas and using information from husbandry manuals (Goetz et al., 2023, Lemm et al., 2010) Each behaviour relates to one or several welfare criteria from the AWA.

Table 2: Ethogram for *I.delicatissima*, and the relevance of each behaviour to the welfare criteria in the AWA

Behaviour	Class	Description	Welfare Context
Basking	State	Basking under heat lamp	Temperature range, Light, Locomotion & Activity
Climb	Event	Climbing enclosure	Locomotion & Activity
Climb tree	Event	Climbing tree logs or branches	Locomotion & Activity
Eating	Event	Eating from food tray or attempting to eat plants or part of enclosure	Nutrition, Foraging & Feeding
Head bob	Event	Up-down head-bobbing	Social, Species specific, Repetitive behaviours
Head shake	Event	Up-down head-bobbing accompanied by shaking of the head and dewlap	Social, Species specific, Repetitive behaviours
Leap	Event	Leaping from a structure or from the ground onto a structure	Locomotion & Activity
Out of sight	State	Animal is hidden behind structure or inside nest box	Cover & Privacy
Nest Box	State	Within nest box	Cover & Privacy, Surfaces and substrates
Resting (Enclosure)	State	Standing vertically on the bars of the enclosure	Locomotion & Activity
Resting (Floor)	State	Standing still or lying down on the floor	Locomotion & Activity
Resting (Log)	State	Standing still or lying down on a log	Locomotion & Activity
Resting (Window)	State	Standing still or lying down on platform at window	Locomotion & Activity, Light
Scraping	Event	Scraping / scratching claws against tree or walls of enclosure	Repetitive behaviours
Social	State	Mating or attempted mating, rapid head shaking while approaching conspecific, head bobbing	Social, Species specific, Competition
Tail whip	Event	Whipping tail (towards keeper or conspecific) (aggression)	Social, Husbandry & Management
Tongue	Event	Flicking or extending tongue to taste the air or structures within enclosure, or to lick water droplets from surfaces	Water source & humidity, Species specific
Other	Event	Other behaviour not in list - abnormal behaviour or notable interaction with environment	Repetitive behaviours, Sensory, Locomotion & activity

The ethogram was configured using the phone application Behayve (Fulton, 2023). Practice ethograms were conducted from 5th June – 7th June 2023, and data collection began on 8th June 2023 using the continuous focal sampling function on Behayve. In total, 58 hours of behaviour were observed on 21 days from 8th June 2023 – 7th July 2023. Observations were made between 0800 and 1600 and alternated daily between morning and afternoon sessions of 2-3 hours. During this time, recordings were taken regularly of environmental

conditions (enclosure humidity, ambient temperature and basking temperatures) and of enclosure design.

Frequency of behavioural events per hour and mean duration of behavioural states were calculated. These values were provided to Nordens Ark as a control as they intend to repeat the project once the iguanas have moved to the new enclosure. These values were not required within the AWA as the welfare scores are based on observations rather than analysis, so they are not included within this report.

2.4. Application of protocol

The welfare assessment was applied with four principles and 23 welfare criteria. No criteria were excluded from the original AWA template. An individual assessment was completed for each iguana. Most criteria were scored using a combination of behavioural observations (Table 2), visual checks of the animals' body condition and visual assessment of environmental design and conditions. A scoring system of 0-3 was used, where 0 means that conditions are never optimal, and 3 means that conditions are perfect and cannot be improved. A score of 0 or 1 required a mitigation, and it was also possible to apply mitigations to a 2-score. The scores were averaged and converted into a percentage for each principle and an overall percentage. It took approximately 3-4 hours to complete each assessment after the required information was collected.

3. Results

3.1. Summary

The female iguana had an overall welfare score of 68% (Table 3). The male iguana had an overall welfare score of 65% (Table 4).

Table 3: Summary of welfare scores for the female Lesser Antillean iguana at Nordens Ark

Criteria	Score
Health & Physiology	80%
Environment	44%
Behaviour	67%
Stressors	81%
OVERALL:	**68%**

Table 4: Summary of welfare scores for the male Lesser Antillean iguana at Nordens Ark

Criteria	Score
Health & Physiology	73%
Environment	44%
Behaviour	67%
Stressors	76%
OVERALL:	**65%**

The completed welfare assessments with full comments and recommendations were submitted to Nordens Ark. Below is a summary of the main welfare targets identified for each principle and recommended improvements.

3.2. Health & Physiology

Both iguanas scored 3 for 'Illness' and 'Other (Parasitic illness)', meaning the animal was consistently in peak health and no intervention was required to treat illnesses. The female iguana scored 3 for 'Injury' as there was no evidence of regular or recurring injuries and normal behaviour was permitted. The male iguana scored 2 for 'Injury' but would have scored 3 if he had not been occasionally observed falling from the basking platforms. It was recommended that a large leafy plant was placed under the platforms to break his fall and prevent future injury. Both iguanas scored 2 for 'Physical condition' as they were in good, robust body condition with no clinical signs of lameness, obesity or emaciation. Both iguanas scored 1 for 'Nutrition' and this required a mitigation. The diet sheet designed by Nordens Ark met recommendations for this species (a variety of leafy greens supplemented with grated carrot 1x a week, fruit 2x a week and seeds 1x a week) (Goetz et al., 2023). However, actual feeding rarely reflected the planned diet. It was recommended that the head keeper ensures that all keepers follow the correct feeding schedule.

3.3. Environment

Environmental criteria were scored the same for each iguana as they are housed in the same enclosure. 'Surfaces and Substrates' and 'Light' both scored 2 as conditions were close to optimal. All other environmental criteria scored 1, as optimal conditions were rarely available. Several major mitigations were required to improve welfare. In regards to 'Temperature range', the ambient temperature of the enclosure (average 33.4°C) almost always exceeded the recommended range of 23.9 - 29.4 °C, and regularly exceeded 32.2 °C which is considered the maximum for normal physiological functioning of *I.delicatissima* (Goetz et al., 2023, Lemm et al., 2010). It was recommended that a maintenance team investigates and improves the enclosure's ventilation.

For 'Water source and humidity', enclosure humidity (average 52%) was consistently lower than the range of 60-70% which is recommended for West Indian iguanas (Lemm et al., 2010). It was recommended that the enclosure is misted with water twice instead of once per day. 'Cover and privacy' scored 1 as the iguanas were almost always visible to the other iguana. As *I.delicatissima* is a solitary species except during the mating season, visibility of conspecifics can lead to constant low-level stress in captivity (Goetz et al., 2023). It was recommended that dense, heat-tolerant plants are provided as visual barriers throughout the enclosure, such as *Ficus, Hibiscus*, and *Pseudoacaci*. Additionally, a wood shelter or PVC tube should be provided for each iguana to give them the choice to be completely hidden. For 'Spatial Complexity', the enclosure did not meet the minimum recommended height requirement of 300cm (Lemm et al., 2010, Goetz et al., 2023). It was recommended that the enclosure should be at least 60cm taller to facilitate natural climbing behaviour.

3.4. Behaviour

Both iguanas scored 2 for all criteria within the Behaviour principle as the iguanas almost always had the choice to perform a full range of normal behaviours. For 'Species-specific' behaviour, both iguanas showed characteristic signs of quiescence, including unhurried locomotion, relaxed backwards-facing limbs while basking, calmly flicking tongue to taste the air and surfaces, and closed eyes while basking and resting (Warwick et al., 2013). For 'Locomotion and Activity', both individuals were mostly arboreal and were often inactive for long periods of time, which is typical for this species in the wild (Goetz et al., 2023, Lemm et al., 2010). For 'Foraging and Feeding', one minor recommendation was made that browse trees or shrubs should be provided so that the iguanas have the choice to forage directly from the plant as they would do naturally in the wild (Goetz et al., 2023).

3.5. Stressors

Both iguanas scored 3 for ‘Visitors and events’, ‘Transport’, ‘Sensory’, and ‘Competition’, meaning that they always have the choice to avoid these stressors. Both iguanas scored 2 for ‘Veterinary’, and one minor recommendation was made that body measurements should be taken and recorded monthly to regularly assess body condition and food intake (Lemm et al., 2010, Goetz et al., 2023). The female iguana scored 2 for ‘Repetitive behaviours’ as she demonstrated non-functional behaviours only for short periods (hyperactivity and repetitive climbing). The male scored 1 for ‘Repetitive behaviours’ as this occurred for long periods and could cause injury if it continues. For instance, he was observed repetitively trying to climb on the basking lamps. It was recommended that the lamps should be raised higher to prevent burns.

Both iguanas scored 1 for ‘Husbandry and management’ as there were times when the animals could not avoid this stressor and negative behaviours were occasionally observed in response to husbandry routines. The female iguana was typically relaxed while keepers were in the enclosure but occasionally appeared alert and nervous. It was recommended that she is given the choice to hide (e.g. in a PVC tube, box or behind plants) during husbandry routines (Lemm et al., 2010). The male iguana was usually unreactive during routines but occasionally demonstrated aggressive tail-whipping behaviour. In their previous zoo, both iguanas were conditioned to enter a relaxed state during husbandry routines and health checks but several of the keepers at Nordens Ark were unaware of this training. It was recommended that all keepers are trained in the conditioning routine from the iguanas’ previous zoo to enable them to better cope with this stressor. This is supported by Hellmuth et al. (2012), who recommend operant conditioning and desensitisation to reduce stress of captive reptiles, particularly during veterinary care.

4. Discussion

4.1. Welfare recommendations for *I.delicatissima*

This project presents a number of recommendations for improving the welfare of the two Lesser Antillean iguanas at Nordens Ark. The welfare of the two iguanas was good overall. Most recommendations were made with relation to enclosure design or environmental conditions, which is a common concern with zoo-housed reptiles. Mendyk (2018) suggested that reptile enclosure design more often relies on ‘folklore husbandry’ and traditional management than evidence (Mendyk, 2018). Preference experiments suggest that captive reptiles prefer larger and more naturalistic environments, which supports the recommendations made in this present study (Warwick and Steedman, 1995, Warwick and Steedman, 2023). Studies on spatial requirements of captive reptiles have tended to focus on snake species as many believe that only ‘active’ snake species require sufficient space to fully extend their body length (Kaplan, 2014, Divers, 2018, Warwick et al., 2019) It is likely that this belief extends to iguanids, which can spend over 80% of their day inactive, resting or basking (Goodman, 2007, Christian et al., 1986). Although the AWA is designed to be a regular welfare audit, it was beneficial to conduct the assessment while the iguanas were in a temporary enclosure so that the major spatial and environmental mitigations (e.g. height, improved ventilation) could be incorporated into the new permanent enclosure design before it is built. The lack of environmental preference tests conducted with iguanids and similar reptiles is a challenge for evidence-based management, which is important for animal welfare (Oonincx and van Leeuwen, 2017, Melfi, 2009).

Many recent studies have focused on identifying opportunities to provide positive emotions for captive reptiles**.** The provisioning of positive affective states to promote 'a life worth living' is currently one of the key principles of animal welfare science (Green and Mellor, 2011, Mellor, 2016, Ahloy-Dallaire et al., 2018, Whittaker and Marsh, 2019). Enrichment is commonly used by zoos to give captive animals the opportunity to exhibit natural behaviours which they would carry out in the wild (Newberry, 1995, Maple, 2008). This creates positive emotions and alleviates stress in captive animals (Carlstead and Shepherdson, 2000). Several studies have demonstrated that scent- and food-based enrichment increases exploratory behaviour and reduces hiding behaviour in lizards and turtles (Therrien et al., 2007, Manrod et al., 2008, Phillips et al., 2011, Waterman et al., 2021, Londoño et al., 2018). Furthermore, object play has been observed in more metabolically active reptiles such as Komodo dragons (*Varanus komodoensis*) and Nile soft-shelled turtles (*Trionyx triunguis*) (Burghardt, 2005, Burghardt, 2015, Burghardt et al., 1996). While it does not specifically refer to enrichment, the AWA is rooted in the same principle by promoting animals which thrive rather than simply survive. The recommendations made in the project enrich the environment by allowing a greater choice of species-specific natural behaviours (Mellen and Sevenich MacPhee, 2001). For example, it was recommended that the iguanas were given the choice to feed directly from shrubs or bushes, which provides the opportunity for natural foraging behaviour. While studies are limited, the current evidence suggests that enriched environments have a positive effect on reptile welfare. This supports the recommendations made in this project and suggests that the method is valid for promoting positive affective states in reptiles.

This study also allowed for identification of areas where research is limited. There is no relevant literature on sensitivity to noise, light and vibration for captive *I.delicatissima* or similar species. Investigation into *I.delicatissima* senses may play a role in the development of food-, scent- or colour-based enrichment, which has had a positive impact on welfare in other reptile species (Manrod et al., 2008, Therrien et al., 2007, Thomson et al., 2021, Bryant and Kother, 2014). Furthermore, there were no available studies on the activity budgets of wild or captive *I.delicatissima.* Development of this indicator was based on wild studies from similar iguanids (*Cyclura nubila* and *Iguana iguana*) (Goodman, 2007, Christian et al., 1986). Further study is required to determine normal activity budgets of *I.delicatissima* due to the importance of the proportion of time spent basking for ectothermic reptiles (Yeates and Main, 2008, Warwick et al., 2013). Research is also lacking with regards to routine veterinary procedures for iguanids. Husbandry guidelines suggest that regular measurements of stress-related corticosteroid/cortisol levels, baseline blood chemistry, Vitamin D3 and hormone analysis should be taken to confirm normal physiological functioning in West Indian iguanas (Lemm et al., 2010). However, normal parameters for these measurements are unknown in *I.delicatissima* and most other reptile species (Lemm et al., 2010). The points mentioned here are limitations of the current knowledge of *I.delicatissima* rather than of the method, but could help improve the accuracy of welfare assessments in the future.

4.2. Appraisal of the ZSL Animal Welfare Audit

Successful welfare assessment tools should be practical and easy to apply, should not cause unnecessary stress, and should assess both animal- and resource-based measures (Sherwen et al., 2018). Overall, the AWA met these criteria. Perhaps the most important advantage of the method is that welfare is assessed based on long-term observations, which may provide a more accurate view of welfare for less active taxa such as reptiles. The AWA assesses similar criteria to adaptations of the Welfare Quality® and Five Domains model which have already been validated in zoo-housed animals (examples; Sherwen et al., 2018,

Salas et al., 2018, Benn et al., 2019), but contains an additional 'Husbandry and management' criterion. This increases the method's positive impact on welfare as reptiles are particularly susceptible to acute stress in response to inappropriate husbandry, particularly handling and veterinary check-ups (Beck, 2022, Hellmuth et al., 2012).

Husbandry manuals and best practice guidelines were suitable for sourcing most of the information required to adapt the method. As well as outlining captive conditions of *I.delicatissima*, the manuals used also contained information on the species' natural conditions which was required for both the 'Environment' and 'Behaviour' principles (Lemm et al., 2010, Goetz et al., 2023). However, complete husbandry guidelines are not available for many reptile species. This means that the AWA may be more difficult to adapt and apply to some reptiles, particularly the 'Stressors' principle which is based almost completely on captive conditions. In this case, the assessor may need to supplement the protocol with information from species experts or zookeepers who are experienced with the animals. This is supported by several studies which used knowledge from zookeepers and zoo veterinarians to adapt welfare assessment tools (Benn et al., 2019, Sherwen et al., 2018, Skovlund et al., 2021, Maher et al., 2021).

The AWA assesses more animal-based than resource-based criteria, which several studies suggest is a more accurate reflection of animal welfare (Maple, 2008, Mellor, 2016, Whitham and Wielebnowski, 2013). Generally, all criteria were readily applied, and it was not time-intensive to assign scores and make recommendations once all the required information was collected. The 'Environment' principle required more time and effort to assess due to an initial period of data collection (See section 2.3). However, environmental records can be taken daily during husbandry routines, which will negate the need for additional data collection when applying this protocol in the future. Similarly, the 'Behaviour' principle required a five-week period of data collection (See section 2.3). This is a limitation for this project, as the iguanas in this study were not used to being observed continuously for 2-3 hour periods and this may have led to abnormal behaviour. However, the guidelines of the AWA recommend that the assessment is conducted by a zookeeper rather than an external individual, as was done in this present project. Zookeepers observe animals regularly and in a variety of contexts, which means that they are familiar with an animal's 'normal' behaviour (Whitham and Wielebnowski, 2009). Many studies have suggested that keepers are able to estimate the emotional states of captive animals based on subtle behaviours (Gold and Maple, 1994, King and Landau, 2003, Less et al., 2012, Wielebnowski, 1999). This suggests that the AWA can be successfully applied by a zookeeper without conducting an ethogram.

4.3. Conclusions

This project is as an appraisal of the ZSL's Animal Welfare Audit tool, which has not previously been published, and its validity for assessing reptile welfare. The results suggest that this method can be readily applied to many reptile species. The protocol developed for this study can be used in future welfare audits of *I.delicatissima*. The method is consistent with the key principles of animal welfare science, which promotes animals which thrive rather than simply survive. Therefore, it can be a valid, practical and accurate tool for assessing welfare if adapted thoroughly using the provided guidance. The accuracy of reptile welfare assessments can be improved with further research into species-specific welfare indicators. For *I.delicatissima*, research is particularly lacking with regards to senses, activity budgets and routine veterinary care. It is recommended that zoos which already use the AWA tool publish their results and adapted species-specific protocols, to improve the accuracy of the tool and help to standardise welfare of different zoo-housed species across different institutions. (Word count: 4364)

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