مجلة جامعة شندي للعلوم التطبيقية

SHENDI UNIVERSITY JOURNAL OF APPLIED SCIENCE

مجلة علمية محكمة نصف سنوية
تصدر عن جامعة شندي

العدد الحادي عشر

ISSUE (11)



ISSN: 1858-9022

https://journals.ush.edu.sd/applied/

Table of Content

No.	Title	Pages
01	Assessment and measurement of Wild Animal welfare in captivity, case study: KuKu zoo , Khartoum state. Sudan	01-13
02	Adomian Decomposition Method for Application of Viscose Flows in Cylindrical Polar Coordinates	14-24
03	Homotopy Perturbation Method for Application Viscous Flows in Cylindrical Polar Coordinates	25-43
04	Antimicrobial, Antioxidant Activities and total phenolics contents of Cassia grandis., Leaves	44-50
05	Evaluating and Development of hospital performance using the goal programming (Case study of MakNimir University Hospital-Department of surgery) (2024)	51-65
06	The Spectro-Chemical Analysis of Some Sudan Soil	66-79
07	Use of Gel Permeation Chromatography in Studies of *Prosopis Chilensis* Gum	80-85
08	Comparison of Genotoxic effect and cellular changes in oral mucosal cells Between Water Pipe and Cigarette Smoker in Shendi town, Sudan	86-98

Assessment and measurement of Wild Animal welfare in captivity, case study: KuKu zoo , Khartoum state. Sudan

Samira Omer Mohamed Alfahal [(1)], **Ali Saad Mohamed** [(2)]

[(1)] Researcher Assistant at Wildlife Research Center, Animal Resources Research Corporation, Ministry of Animal Resources, Khartoum Bahri, AlaminAlkarib Street. **email**: sameeraalfahal2020@gmail.com , **tell:**249-118867897

[(2)] Retired Professor at college of science and technology of animal production, Sudan University for science and technology, Khartoum north. Tell: 249-918000302

Abstract:

This study aims to assess and measure the welfare of captive wild animals at Kuku Zoo, Khartoum State, Sudan. The survey has been conducted over a period of six months (September 2022 - February 2023) using direct observations and zoo records. A modified model was designed from Sherwin's (2018) version of the Five Domains Model for Animal Welfare Risk Assessment and was conducted at the cage or enclosure level, each cage representing a species. Five basic principles of animal welfare and their 22 indicators were designed and applied to 20 wild species/enclosures. The indicators were evaluated and represented as scores from 0 poor, 1 average to 2 good welfare status. The overall welfare score was calculated by averaging the scores of all indicators applied to 20 wild species/enclosures. All these descriptive statistics were analyzed using SPSS. The welfare score for Koko Zoo was (0.96), which was described as poor. When comparing welfare between species, the highest welfare score was recorded for the red-necked ostrich (1.5) and the lowest for the white-tailed mongoose (0.98). When comparing the principles, the expression of their natural behaviors was the highest (1.5) while the provision of veterinary care and the provision of a suitable environment were the lowest indicators (0.6). This study had three objectives as follow, give an overall numerical value to the level of welfare performance at Kuku Zoo as an institution, to know which wild species are affected by captivity conditions, and to know the weak points of the zoo by measuring different indicators.

Keywords: animal welfare, assessment, captivity, kuku zoo, Sudan, wild species.

المستخلص: تهدف هذه الدراسة إلى تقييم وقياس رفاهية الحيوانات البرية ألاسيرة في حديقة حيوان كوكو ، والية الخرطوم ، السودان. تم إجراء المسح على مدى ستة أشهر)سبتمبر - 2022 فبراير)2023 باستخدام مالحظات مباشرة وسجالت حديقة الحيوان. تم تصميم نموذج معّدل من إصدار(2018)Sherwin من نموذج المجاالت الخمسة لتقييم مخاطر رعاية الحيوان وتم إجراؤه على مستوى القفص أو العلبة ، كل قفص يمثل نوًعا. تم تصميم خمسة مبادئ أساسية لرفاهية الحيوانات ومؤشراتها الـ 22 وتطبيقها على 20 نوًعا/حاويات برية. تم تقييم المؤشرات وتمثيلها على أنها درجات من 0 فقيرة ، متوسط 1 إلى 2 حالة رفاهية جيدة. تم حساب درجة الرفاهية إإلجمالية بمتوسط درجات جميع المؤشرات المطبقة على 20 نوًعا/حاويات برية. تم تحليل كل هذه إإلحصاءات الوصفية باستخدام .SPSS كانت درجة الرفاهية لحديقة حيوان كوكو ،)0.96(والتي تم وصفها بأنها فقيرة. عند مقارنة الرفاهية بين ألانواع ، تم تسجيل أعلى درجة رفاهية للنعمة ذات العنق ألحمر)1.5(واألدنى بالنسبة إلى mongoose ذات الذيل ألبيض .)0.98(عند مقارنة المبادئ ، كان التعبير عن سلوكياتهم الطبيعية هو ألعلى)1.5(في حين كان توفير الرعاية البيطرية وتوفير بيئة مناسبة أقل المؤشرات .)0.6(كان لهذه الدراسة ثالثة أهداف تتمثل في إعطاء قيمة عددية شاملة لمستوى أداء الرفاه في حديقة حيوان Kuku كمؤسسة ، لمعرفة ألانواع البرية التي تتأثر بظروف ألسر ، ومعرفة نقاط الضعف في حديقة الحيوان عن طريق قياس مؤشرات مختلفة .

الكلمات المفتاحية: السر، السودان ,تقييم ،حديقة كوكو , حيوان بري ,رفاه الحيوان.

1. Introduction:

In the1960s and 1970s the zoo concept has changed .This was in response to a growth in public awareness of environmental issues and growing interest in wild animal's welfare. The initial zoos of the modern era followed in the footsteps of their predecessors and were created with an emphasis on allowing the public to see the animals rather than on needs of the animals and with little or no concern given to animal rights or conservation (Carr and Cohen, 2011). So, many humane individuals and organizations have taken the position that if animals are to be kept in captivity, society has a duty to provide the best possible care for each individual animal throughout its life, leading many countries to amend and update specific animal welfare regulations (Kohen, 1994). Animal welfare refers to the physical, behavioural and social well-being of animals through the provision of appropriate conditions for the species in question, including but not limited to housing, environment, diet, veterinary care and social contact (EAZA (2014). There are five domains of animal welfare which include nutrition, health, environment, behaviour and mental domain. These provide a more comprehensive basis on which welfare assessments can be built (Mellor et al, 2020). The term 'welfare assessment' applies to the routine assessment of all animals to check for any health or welfare issues (NC3Rs, 2014) and is important for improving our understanding of the needs of animals in order to improve housing and husbandry practices. There is no single direct way to measure animal welfare; therefore, assessment requires attention to a number of variables. Two approaches to assessing animal welfare as stated by Sherwin et al (2018) are resource-based welfare assessments such as housing, food and water. Based on the assumption that if appropriate resources are provided, animals will be well cared for. Animal-based assessments based on indicators of physical condition, physiological status and behaviour. Many organization and researcher was recommended a multidisciplinary and evidence-based approach, like EAZA and Sherwin. For example, providing effective veterinary care, meeting nutritional requirements, providing individuals with the opportunity to perform their species-specific behavioural repertoire and promoting positive emotional states. Different techniques have been used to assess welfare in zoos,

typically using checklist or checklist rating

systems (Barrows, 2017). In Sudan, several animal welfare studies have been conducted, such as management, nutritional, behavioural or production studies in captivity. Therefore, this study aims to assess animal welfare at Kuku Zoo as a step towards future studies on animal welfare to create detailed legislation and standards for zoo inspection.

2. Material and **Methods:**

This study was conducted at Kuku Zoo, located in Khartoum North, at longitude (132, 59 East), and latitude (15,623 North), which was established in 2008. It contains (six) species of birds, (eleven) species of mammals and (three) species of reptiles. The survey was conducted over a period of six months (from September 2022 to February 2023). A model was designed to include the five main domains as measures of animal welfare.)provision food and water, provision suitable environment, provision veterinary care, the ability to expression their natural behaviour and protection from fear and distress). Each measure has a number of indicators that are evaluated qualitatively and are shown as numerical scores. The Sherwin (2018) model was modified and designed in a tabular form for ease of application, with space to enter any comments. Figure (2.1). A team was formed to complete the evaluation process and team members were distributed among the cages in rotation. Group judgments were made on each indicator through scoring, using the team's best understanding of the natural biology of the species as an important criterion. During the evaluation, the team discussed each indicator for each species until an agreement was reached on a score. Assessments were made at the pen level regardless of the number of individuals of the species within it and based on the animal that received the lowest score. For example, if one individual in the group repeatedly displayed abnormal behaviour, the cage would receive a score of 0 for this measure. The survey was conducted by direct observation by walking through the cages three times a week, walking twice in the morning and evening to note any changes in the values given in the morning. In each cage, the ratings were entered directly into the form and a value was given from 0 (poor) to 1 (average) and 2 (good). For the final mean values, the value was described as poor or good depending on the integer of the value.

For the final mean values, the value was described as poor or good depending on the integer of the value. Using SPSS, descriptive measures such as averages were obtained. Averages were used to investigate institutional changes and any differences between species. In addition to assessing the data at the pen or species level, data were also analysed at the indicator/measure level. Average welfare scores for the indicators/principles were calculated by averaging all cage scores for that indicator/measure. Average scores were calculated for each area of wellbeing to assess performance levels in each area. The lowest scoring indicator/measure was considered the lowest performing for that year and the highest scoring indicator was considered the best performing

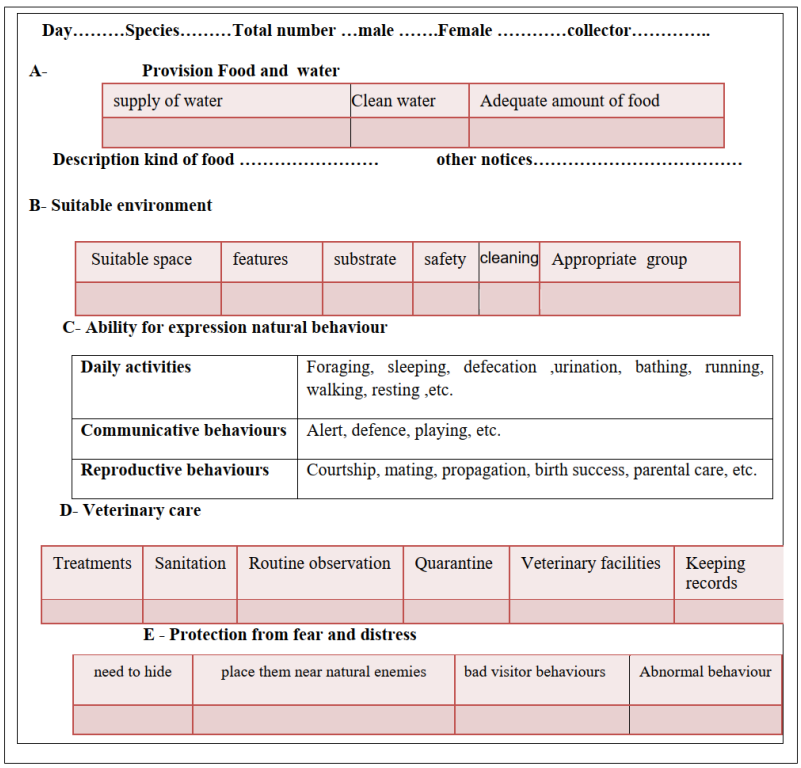
3 -Result and Discussion

3.1/ provision food and water principle:

According to AZA Lion Species Survival Plan (2012), the animals' diets should be of a quality and quantity appropriate to the nutritional and psychological needs of each animal. At Kuku Zoo, carnivores are fed three times a week with a portion of meat or live prey in some cases. The quantity depends on the species and their numbers in the cage, and herbivores are fed almost daily with different types such as grains and bananas. The amount of the meal is not regulated, it depends on the consumption of the animals. In general, the diets clearly lack diversity and necessary nutritional supplements. Therefore, the food provision indexes were rated as moderate (1.5). The water provision index was rated as moderate (1.4). Although some species do not get enough water. Moreover, most of the automatic drinkers do not work. The cleanliness of the water, especially the water containers, is very poor, as algae and small insects accumulate and are not changed and cleaned daily. This situation is inconsistent with the AZA Lion Species Survival Plan (2012) which stated that fresh water should be available at all times and should be checked daily by keepers to ensure that the water is clean and that automatic drinkers, if used, are working properly. Therefore, this indicator was rated as Poor (0.5). For all the discussion of the indicators above, the principle of food and water provision was rated as 1.1 overall. Comparison of the index scores shows that food provision is

the highest indicator, while water cleanliness is the lowest. (Figure 3.1) This means that it needs more attention. By comparing the species, the red-necked ostrich was rated as moderate (1.7), while the white-tailed mongoose was rated as poor (0.8). (Figure 3.2). This may be a suitable explanation for its weakness and death.

Figure no 2.1: a model which has been used in data collection in kuku zoo.



Day……Species……Total number …male …….Female ……collector……..

A- Provision Food and water

supply of water	Clean water	Adequate amount of food

Description kind of food …… other notices……

B- Suitable environment

Suitable space	features	substrate	safety	cleaning	Appropriate group

C- Ability for expression natural behaviour

Daily activities	Foraging, sleeping, defecation ,urination, bathing, running, walking, resting ,etc.
Communicative behaviours	Alert, defence, playing, etc.
Reproductive behaviours	Courtship, mating, propagation, birth success, parental care, etc.

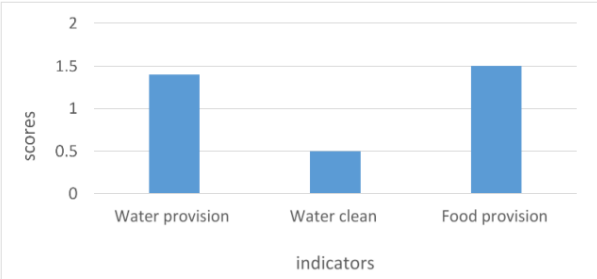
D- Veterinary care

Treatments	Sanitation	Routine observation	Quarantine	Veterinary facilities	Keeping records

E - Protection from fear and distress

need to hide	place them near natural enemies	bad visitor behaviours	Abnormal behaviour

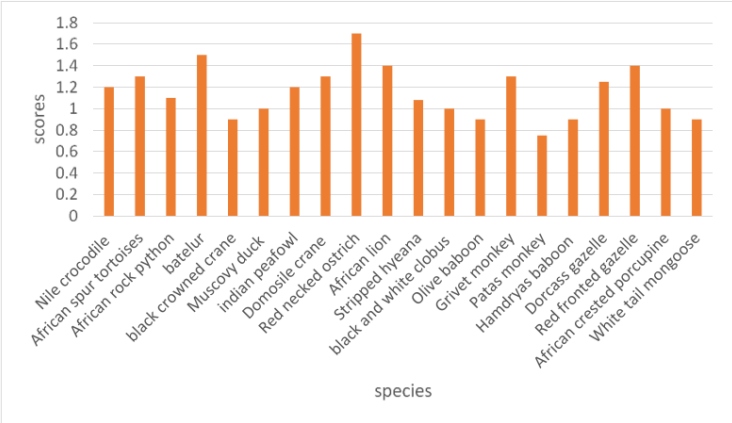
Figure No.3.1: comparison between indicators for provision food and water.



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
scores	3	.5	1.4	1.100	.5196
Valid N (listwise)	3				

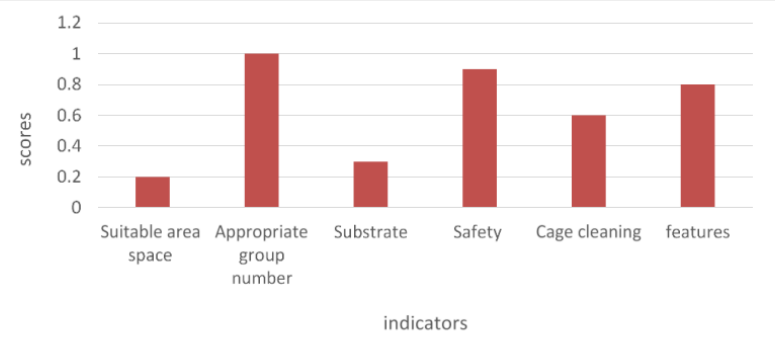
Figure No. 3.2: comparison between species for provision food and water measure



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
scores	20	.8	1.7	1.154	.2425
Valid N (listwise)	20				

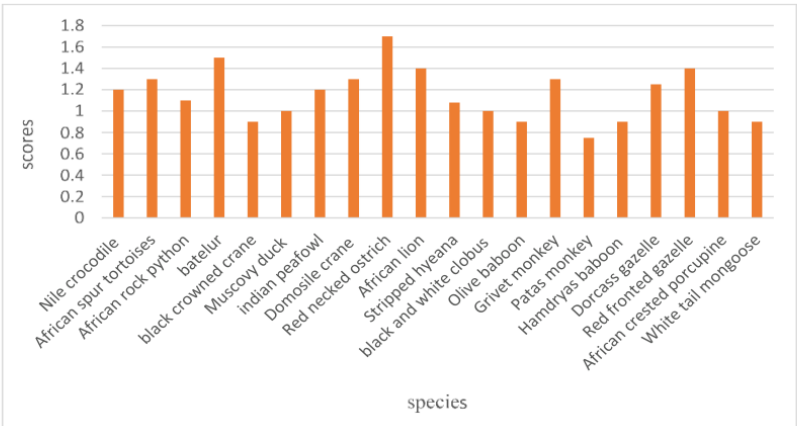
Figure No.3.3: comparison between indicators of provision suitable environment.



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
scores	6	.2	1.0	.633	.3266
Valid N (listwise)	6				

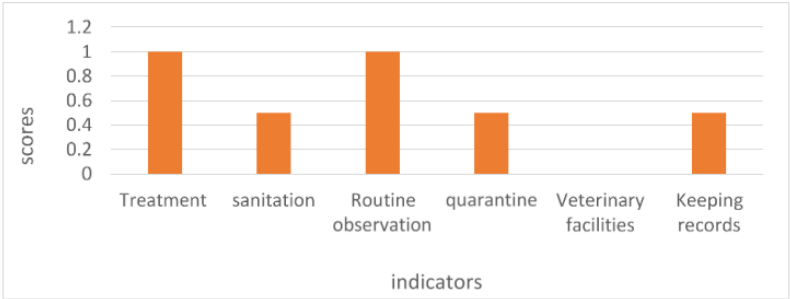
Figure No. 3.4: comparison between species for provision suitable environment measure.



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
scores	20	.2	1.3	.668	.3695
Valid N (listwise)	20				

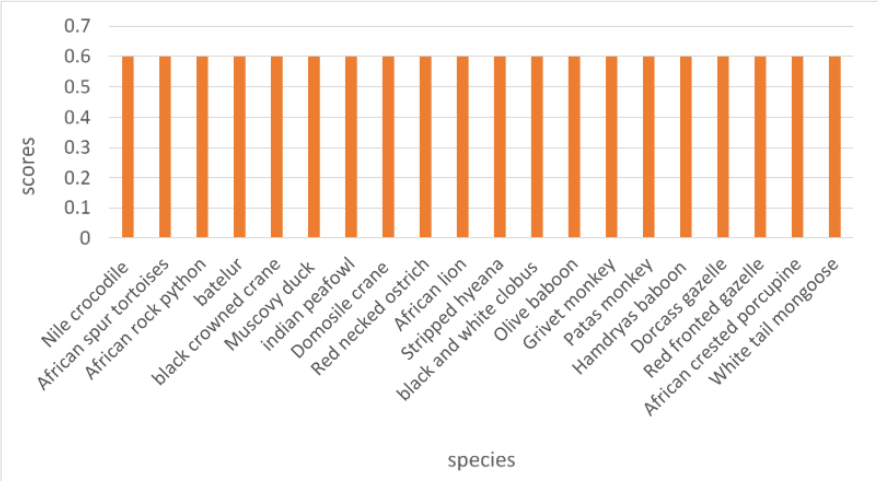
Figure No.3.5: comparison between indicators of provision veterinary care.



Descriptive Statistics

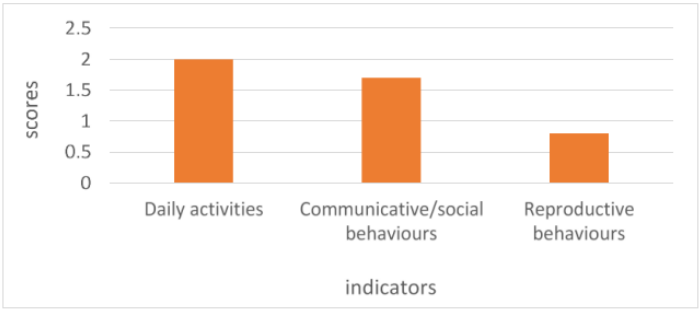
	N	Minimum	Maximum	Mean	Std. Deviation
scores	6	.0	1.0	.583	.3764
Valid N (listwise)	6				

Figure No. 3.6: comparison between species for provision veterinary care measure.



	N	Minimum	Maximum	Mean	Std. Deviation
species score	20	.6	.6	.600	.0000
Valid N (listwise)	20				

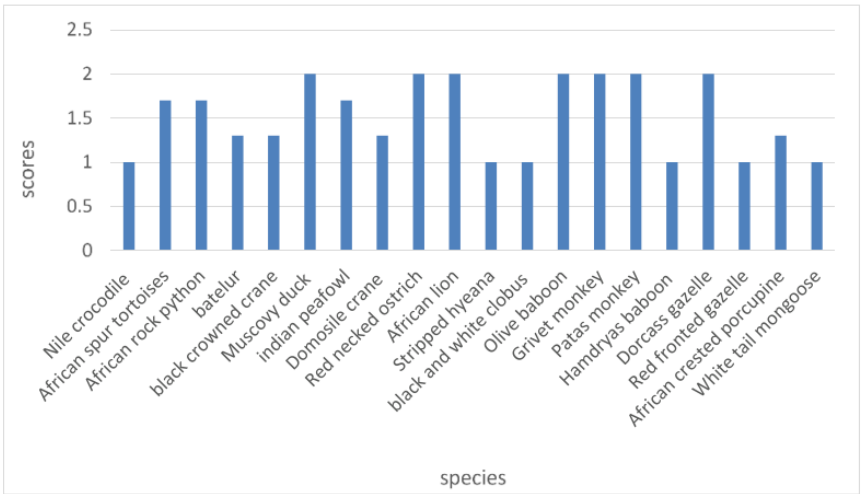
Figure No.3.7: comparison between indicators of expression their natural behaviours



Descriptive Statistics

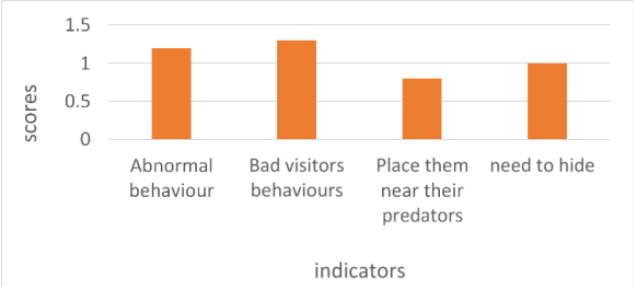
	N	Minimum	Maximum	Mean	Std. Deviation
scores	3	.8	2.0	1.500	.6245
Valid N (listwise)	3				

Figure No. 3.8: comparison between species for expression natural behaviours measure



	N	Minimum	Maximum	Mean	Std. Deviation
species score	20	1.0	2.0	1.515	.4308
Valid N (listwise)	20				

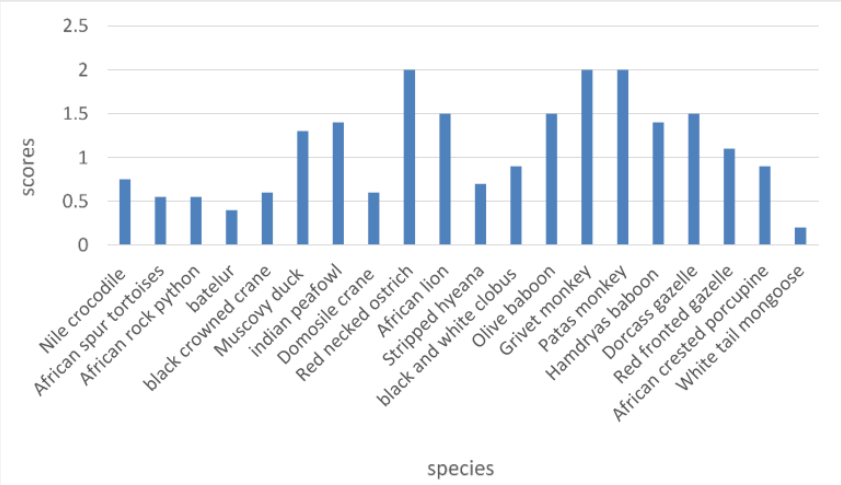
Figure No.3.9: comparison between indicators of protection from fear and distress



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
indicators scores	4	.8	1.3	1.075	.2217
Valid N (listwise)	4				

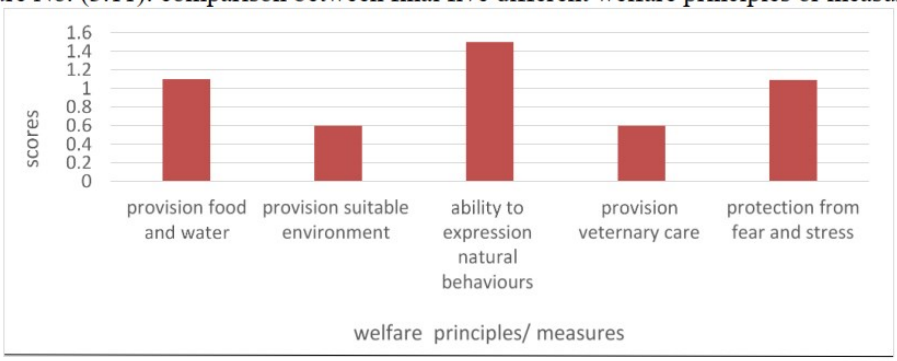
Figure No. 3.10: comparison between species for protection from fear and distress measure



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
scores	20	.2	2.0	1.092	.5571
Valid N (listwise)	20				

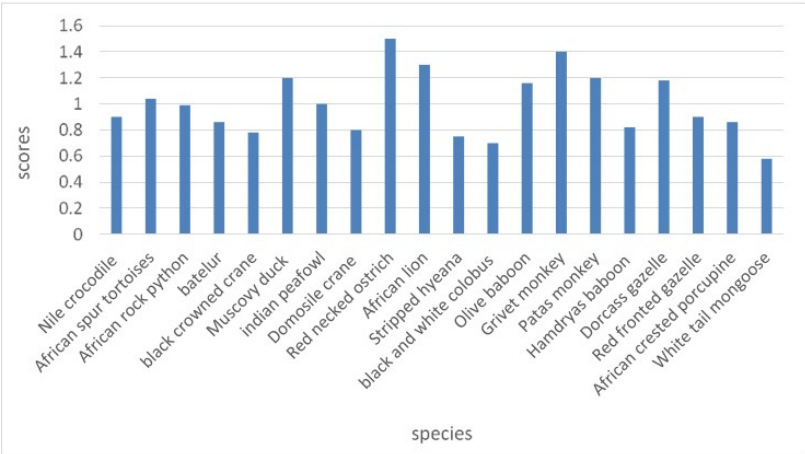
Figure No. (3.11): comparison between final five different welfare principles or measures



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
scores	5	.6	1.5	.960	.3782
Valid N (listwise)	5				

Figure No. (3.12): comparison between final welfare scores for different species



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
scores	20	.6	1.5	.996	.2458
Valid N (listwise)	20				

3.2/Provision suitable environment:

According to the AZA Advisory Group on the Taxonomy of Old World Monkeys (2012), all animal cages should be of sufficient size and complexity to provide the physical, social and psychological well-being of the animal; exhibit enclosures should include provisions to enrich the animals' behaviour. At kuku Zoo, the suitability or inadequacy of cage spaces for the animals under study was judged by measuring the cage spaces of the animals under study and comparing them with recommended spaces for each animal worldwide. The suitability or inadequacy of the number of individuals within a cage for the same species was judged by referring to the behaviours of the species in nature and their social structure. We found that cage spaces were not suitable for all species except for the red-necked ostrich and the Muscovy duck, which fared slightly better. Therefore, they were rated as poor (0.2). Housing should take into account the natural habitat of the species and seek to meet the physiological and psychological needs of the animal. Enclosures should be equipped according to the needs of the animals with bedding materials, branch work, burrows, nesting boxes, pools, substrates, plants and other enrichment materials designed to assist and encourage natural behaviour patterns and reduce any abnormal behaviour. (Defra, 2012). At kuku Zoo, not all enclosures provide additional features or tools to stimulate wild species behaviour. Therefore, it was rated as poor (0, 8). Cases of keeping only one individual in the cage, whether male or female such as the Abyssinian monkey and the gazelle were observed, which is not entirely consistent with (AZA Old World Monkey Taxon Advisory Group, (2012)) who stated that animals should be displayed in sufficient numbers to meet their social and behavioural needs. Therefore, the appropriate group indicators were rated as moderate (1). All the cages in the park had cement floors except for the red-necked ostrich, the Nile crocodile, and the African tortoise. Although many organizations concerned with the care of animals in captivity have often recommended natural substrate in their research for some species such as the Association of Zoos and Aquariums (AZA) in their care manuals for different species. The reason may be due to the

fact that cement substrate can cause many diseases, especially with inadequate hygiene. In addition, some species need to dig or wallow and various other purposes. Therefore, it was rated as poor (0.3) in the Kuku Zoo. Regarding the safety indicator, (Defra, (2012)) stated that the gates and doors of the enclosures should be securely closed to prevent unauthorized opening. In kuku Zoo some animals escaped from their enclosures such as the rock python. On the other hand, visitors can easily access most of the animal species through the wide opening in the cage. Therefore, it was rated as poor (0, 9). As (Defra, 2012) stated, special attention should be paid to proper cleaning to reduce the risk of disease. In kuku Zoo, cleaning was done by sweeping the floor with no use of disinfections. For all of the above, the appropriate environment was evaluated and measured as 0.6 overall. Comparison of these six indicators showed that the appropriate group indicator was the highest (1) while the appropriate cage space indicator was the lowest (0.2). (Figure 3.3) which is a important indicator of poor welfare conditions at Kuku Zoo. Comparing the performance of different species with respect to this measure or principle, it was found that the Moscovey duck had the highest score (1.3) indicating a somewhat acceptable situation, while the indian peafowl, the black and white colobus, the Hamadryas baboon, and the white-tailed mongoose showed the lowest score (0.2). (Figure 3.4).

3.3/Provision of appropriate veterinary care:

a full-time staff veterinarian is recommended, however, in cases where this is not practical, a consulting/part-time veterinarian must be under contract to make at least twice monthly inspections of the animal collection and to any emergencies (AZA Lion Species Survival Plan ,2012). There were a non-resident veterinarian at Kuku Zoo and the workers or supervisors report to the veterinarian if there is any disease or abnormality, to conduct the necessary examination and treatment. However, most of the workers are not sufficiently aware of the behaviours and diseases of wild animals. Therefore, routine observation was rated as moderate (1). Financial problems sometimes arise due to the lack of necessary medicines and medical equipment. In case of need for medical

imaging, other laboratories are contacted which is not in accordance with (AZA Lion Species Survival Plan, 2012) which indicated that veterinary coverage should also be provided at all times. Therefore, the treatment indicator was rated as 1 (moderate). Both the veterinarian and supervisors at Kuku Zoo record medical issues, deaths, births and nutritional records and this is an important element in animal welfare. (AZA Lion Species Survival Plan, 2012) stated that animal records should be updated and data recorded daily. However, the recording of information was not adequate at Kuku Zoo and lacked the most important information that should be measured such as the weight of the animal. Therefore, the record keeping index was rated as 0.5 (poor). All quarantine procedures must be supervised by a veterinarian and must be formally written and made available to staff working with quarantined animals (AZA Lion Species Survival Plan (2012)). However, there is no specialized quarantine at Kuku Zoo and when there is a situation requiring isolation, empty cages are used. Therefore, the quarantine index was rated as 0.5 (poor). There were no specialized veterinary facilities at Kuku Zoo. Therefore, these indicators were rated as 0 (poor). There was no adherence to a satisfactory sanitation program. Therefore, this indicator was rated as 0.5 (poor). For all the above discussion, the provision of appropriate veterinary care was rated as (0.6) for all species (Figure 3.6). Comparing the indicators, the highest score was found in the Routine observation and Treatment indicator. The lowest score was found in the Veterinary Facilities indicator (Figure 3.5).

3.4/Ability to expression their natural behaviours:

In zoos, behaviours are essential to inform an evidence-based approach to animal husbandry and population management. By first observing behaviours, and secondly trying to interpret meaning, we can compare captive and wild behaviour, understand animals' behavioural needs, cognitions and preferences, increase reproductive success, modify enclosures to allow a greater range of behavioural expression, understand aspects of enclosure provision and wider animal husbandry that are important to the animal and reduce the impact of captive stressors (Rose,

Riley, 2021). In this study, we handled twenty-one wild species, recording natural behaviours through repeated surveys between 9am and 5pm. Different types of behaviours were collected as indicators of the animals' ability to perform their natural behaviours such as reproductive behaviours (mounting, ritual displays, mating, parental care, etc.), social behaviours (vocalization, fighting, grooming, head rubbing, licking, pecking, preening, playing, caring for young, etc.) and daily activities which included inactive behaviours (sleeping, sitting, lying down) and territorial behaviours (scratching, rubbing, rapid urination, defecation, fighting, etc.). Solitary species cannot engage in social activities and mating behaviours, such as the hamadryas baboon, the Nile crocodile, the black and white colobus, and the red-fronted gazelle. Not consistent with (Defra, (2012) who recommended that animals of naturally social species should be kept in compatible social groups. Therefore, social behaviours were rated as 1.7 (moderate) overall. Most animals do not produce new offspring for various reasons, such as being alone without a partner, as mentioned above, such as the male Hamadryas baboon and the Red fronted gazelle. Some animals were productive, but lost their partner and were left alone, and their production stopped, such as the male Nile crocodile. Some did not produce offspring even with a partner, due to unsuitable captive conditions. Some species succeed in producing new offspring/eggs but die in a short time, probably due to unsuitable substrate especially for birds or different weather conditions. We cannot ignore the fact that most animals are shy and reproduce out of sight. In addition, nutrition plays a role in reaching sexual maturity and the success of offspring. In general, mammals are more productive than other species in kuku Zoo. African Lion, Patas monkey, Green monkey, Olive baboon and Dorcass gazelle produce continuously. As for birds, only Indian peafowl and red-necked ostrich produce. In reptiles, production has stopped. For the above discussion, all indicators of production behaviours were rated as 0.8 (poor). Daily activities were rated as 2 (good

score). For all the above discussion, the ability of animals to express their natural behavioural principle was rated as moderate (1.5). Comparing the indicators, daily activities show

the highest score (2) while reproductive behaviours had the lowest score (0.8). (Figure 3.7). Comparing between species, the highest score (1) appears in Muscovy duck, red-necked ostrich, African lion, olive baboon, Grivet monkey, patas monkey and Dorcas gazelle, while the lowest score appears in Nile crocodile, stripped hyena, black and white colobus, hamadryas baboon, red-fronted gazelle, and white-tailed mongoose (Figure 3.8).

3.5/Protection from fear and distress:

Behavioural abnormality can include: stereotyping, increased aggression, increased frustration or conflict behaviour, and increased fearful behaviour (Tribe, 2008). Repetitive behaviours are indicators of poor care. Apathy can occur in animals housed in arid and/or stressful environments, especially when animals are unable to exercise any form of control over their environment. (Manteca. etal, 2016). At the Kuku Zoo, most animals exhibit various types of abnormal behaviours such as various types of stereotypical behaviours (lion, gazelle spp), apathy (stripped hyeana) and increased fearful behaviour (gazelles spp, cranes spp), increased aggression toward each other and visitors (baboon spp, ostrich), frustration (biting the barren (gazelles, birds, lion, monkeys), and feather plucking (Domosile crane). Reptile's exhibit little deviation expect in African spur tortoises which eat her faeces once. Reptile husbandry is complex; signs of pain or illness can be difficult to recognize, and behaviours is not always well understood. (Amelia, 2019). To assess these indicators, if any individual in the cage showed any abnormality, it was rated as 2 as present and the value was described as weak. The final score was 1.2, which in this case was rated as weak. Enhancing the sense of safety and security by providing a place to escape, is recommended in (module 21, 2014). At Kuku Zoo, most wild species do not have the opportunity to escape from people or hide, even to act out their various natural behaviours, because most cages are designed for the animals on display rather than to meet the animals' needs. To assess these indicators, any cage that had a place to hide

was scored as 2, regardless of the size of the place. Therefore, the overall score was (1), which is considered moderate. (Defra, 2012)

stated that any direct physical contact between animals and the visiting public should only be for limited periods of time and under conditions that are consistent with the animals' welfare, and are unlikely to cause them discomfort. Kuku Zoo receives dozens of school and kindergarten students, as well as families, almost daily, from 8:00 am to 6:00 pm. This creates a lot of noise and stress for most of the animals, which are known to be sensitive to loud noises, such as gazelles and cranes. Visitors engage in bad practices, such as throwing empty bottles, plastic bags and sticks into the cages, or banging on the fence, shouting and trying to provoke the animals. These attempts have resulted in injuries, frightening and escape attempts. To measure this indicator, any bad behaviour by visitors was scored as 2 as high disturbance. Overall, this indicator scored 1.3 and was considered weak. Given the fear instinct of predators, we should not replace them near their predators to reduce the effect of fear. As mentioned above, their attempt to escape causes them harm. This indicator was scored as weak (0.8). For this discussion, the principle of protection from fear and distress at kuku Zoo was rated as medium (1.09). The indicator of bad visitor behaviours was the highest while placing animals near their predators was the lowest. (Figure 3.9) The most affected species were the red-necked ostrich, grivet monkey, and patas monkey, while the white-tailed mongoose was the least affected. (Figure 3.10). The overall welfare score was 0.98 at Kuku Zoo. This means that it needs more discipline and commitment .Comparing by final measures scores, ability to expression their natural behaviour is highest while provision veterinary care and provision suitable environment were lowest indicators. (Figure no. 3.11) This result attribute to lake of money in kuku zoo. As (Kohin, 1994) mentioned that Lack of knowledge and lack of money can still result in maltreatment of captive animals, even when no cruelty is intended. Comparing welfare by species, red necked ostrich was highest and white tailed mongoose was lowest welfare level. Figure no. (3.12). this result attribute to great variation in how animals respond to captivity as

mason, (2010) mentioned that Captive animals are often healthier, live longer, and more fertile than animals of the same species that

live freely, but for some species the opposite is true.

This study revealed animals' welfare in Kuku Zoo was poor situation. So, we hope that this study has shed light on the various weaknesses so that they can be corrected. This study followed the simplest methods so that those interested will find a simple tool that is easy to apply for the purpose of improving the administrative performance of zoos and even on farms. We hope that regulations, legislation and laws will be enacted that concerning of wild animals' welfare in captivity to implement the licensing and inspection of zoos and even farms of wild animals' species in Sudan.

References:

- Amelia,(2019) Review of Welfare Assessment Methods in Reptiles, and Preliminary Application of the Welfare Quality Protocol to the Pygmy Blue-Tongue Skink, Tiliqua adelaidensis, Using Animal Based Measures. Multidisciplinary Digital Publishing Institute (MDPI). Animal (basel).2019 jan: 9(1):27.
- AZA Lion Species Survival Plan, (2012). Lion Care Manual. Association of Zoos and Aquariums, Silver Spring, MD. p. 143.
- AZA Old World Monkey Taxon Advisory Group, (2012). Colobus Monkey Care Manual. Association of Zoos and Aquariums, Silver Spring, MD. (pp.96)
- Barrows,(2017) welfare assessment in zoo animals. The Veterinary Record; London Vol. 181, Iss. 6, (Aug 5, 2017): 141. DOI:10.1136/vr.j3583
- Carr. Cohen. (2011) The public face of Zoos :Image entertainment ,education ,and conservation. DOI: 10.2752/175303711X12998632257620
- Defra, (2012). Secretary of State's Standards of Modern Zoo Practice. Department for Environment, Food and Rural Affairs, Bristol, England.
- Eaton, (1981). An overview of zoo goals and exhibition principles. International Journal for the Study of Animal Problems, 2 (6), 295-299.
- EAZA, (2014) .Standards for the Accommodation and Care of Animals in Zoos and Aquaria. European Association of Zoos and Aquaria. 21 PAGES.
- Kohin, (1994). Zoo animal welfare. Rev. sci. tech. Off. int. Epiz., 1994,13 (1), 233-245,13PAGE.
- Ma. etal,(2022). Animal Welfare Assessment in 16 Zoos in South Korea Using the Modified Animal Welfare Assessment Grid. Frontiers in Veterinary Science. 9. 860741. 10.3389/fvets.2022.860741. - Manteca,etall. (2016). assessing welfare in zoo animals: animal-based indicators. Zoo animal welfare education centre. Cab Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources DOI:

10.1079/PAVSNNR201611010. (1-10) pages.

- Mason,(2010) Species differences in responses to captivity: stress, welfare and thecomparative method. Trends in Ecology and Evolution Vol.25 No.12

- Mellor etal,(2020) The 2020 Five Domains Model: Including Human–Animal Interactions in Assessments of Animal Welfare. *Animals* **2020**, *10*(10), 1870; https://doi.org/10.3390/ani10101870

- Module 21(2014). Module 21 Wild Animal Welfare: Management of Wildlife Concepts in Animal Welfare © World Animal Protection 2014. Unless stated otherwise, image credits are World Animal Protection.

- NC3Rs, (2014). Welfare assessment. National centre for replacement, reduction and refinement of animals in research. Available at: https://macaques.nc3rs.org.uk/welfare-assessment(1-10-2022) - Rose. Riley, (2021).Conducting Behavioural Research in the Zoo: A Guide to Ten Important Methods, Concepts and Theories.J. Zool. Bot.Gard.2021, 2,421–444. https://doi.org/10.3390/jzbg2030031

- Sherwen, etall (2018) An Animal Welfare Risk Assessment Process for Zoos. Animals, 8(8), 130. Doi: 10.3390/ani8080130)

- Tribe, (2008). Zoos and Animal Welfare. University of Queensland, Gatton Qld 4343, Australia. 10pages.