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Zoo animals' disease pattern in a university zoological garden, Ibadan, Nigeria

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ABSTRACT

Objective: To investigate wildlife diseases in Nigeria spanning across 20 years, highlighting various conditions diagnosed in zoo/wild animals using conventional and ancillary pathological techniques.

Methods: The animals were closely examined for signs of illness by the attending veterinarian and clinical samples were taken as appropriate. Carcasses were submitted for detailed necropsy by the experienced pathologists and diagnostic samples were taken for cytological, microbial isolation, parasitic identification and histopathology.

Results: Between 1991 and 2014 about 262 carcasses of zoo animals were presented for postmortem comprising ruminants (12.2%), primates (16.8%), carnivores (11.5%), reptiles (20.6%), Equidae (4.2%), rodents (5%) and aviary (29.7%). Pasteurellosis and other forms of respiratory diseases were common in ruminants; pneumonia, trichuriasis and endocarditis were common in primates; tuberculosis and helminthiasis (ancylostomiasis) were common in carnivores; enteritis and impaction were common in reptiles; cholera, salmonellosis and Newcastle diseases were common in aviary.

Conclusions: It is important to know the causes of death in zoo animals and wildlife for purposes of preservation and conservation.

1. Introduction

Zoological gardens exhibit wild animals for aesthetic, educational and conservation purposes[1]. Information on diseases of wildlife and zoo animals is very scarce in Nigeria probably due to emphasis on the livestock industry needed to provide meat for her population. The majority of spontaneous cases either remain unpublished or often left in pathology files and laboratory archives. Such information is therefore not readily accessible to veterinarians, policy makers and others whose responsibility is the diagnosis of disease in both captive and wild animals. Access to information on captive and wild animals shall support development plans for the management of wildlife populations, this has been termed a '*sorta situ*' approach[2].

Zoological gardens provide an opportunity of a whole new world of hope to threatened species for the purpose of conservation and possible breeding from captivity to repopulate the natural

environment. Zoos also provide opportunities for studying the best practices in conservation, animal management and genetic resource of the threatened populations[3,4]. As habitat becomes more compressed, with migration routes cut off, small species gene pools are stranded in isolated, habitat fragments. These make wildlife more vulnerable than ever to the possibility of new or emerging diseases capable of wiping out a local population. The health problems observed in free-ranging wildlife today resemble those seen in captive wildlife[5]. Species are now vulnerable to encroachment, malnutrition, environmental pollutants, and epidemics from domestic animals and humans. Furthermore, the continuous degradation of ecosystems is leading to increased stress, immunosuppression and, therefore, greater susceptibility to disease[6,7].

The effects of captivity on the behavior of wild and domestic animals have been relatively well studied[8,9]. However, a few of the pathological conditions have been studied[10-15] and very little is known of the pathology and pattern of zoo and wildlife diseases in our environment. Emergence of key zoonotic and production-animal diseases derived from and within wildlife populations has increased awareness worldwide of the importance of zoological medicine and study of their diseases in protecting both livestock and public health[6].

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Disease investigation in wildlife in Nigeria is often unattended to probably due to funding priorities and financial structural support primarily for studies on commercial livestock and companion animals. This report highlights various conditions diagnosed in zoo/wild animals using both gross and histopathological examinations and ancillary techniques when needful.

2. Materials and methods

2.1. Animals in the university zoo

Animals used for this study were those kept at the University of Ibadan Zoological Garden. The University of Ibadan Zoo was established as a menagerie in 1948 and became a full-fledged zoo in 1974. Apart from displaying animals for teaching, research and the entertainment of visitors, the University of Ibadan Zoo is primarily for the conservation of endangered species. The garden is home to a wide array of animals comprising mammals, birds, reptiles and amphibians.

2.2. Retrospective and pathological studies

History of sick animals which died or were put to sleep in the zoo, complete necropsy and histological findings of major organs performed in the veterinary diagnostic laboratory were compiled. Secondary data and/or records from the zoo between June 1991 and December 2014 were also incorporated.

Postmortem examinations were done as soon as possible after death. Tissues were fixed in 10% buffered formalin, processed by routine paraffin technique, sectioned and stained with haematoxylin and eosin (HE) and/or specific special stain, while further confirmation was done appropriately in the laboratory.

The ensuing data were analyzed descriptively and presented using tables and proportions (in percentage).

3. Results

3.1. Mortality patterns/incidence of wildlife diseases

An annual average of 11.4 necropsies of wildlife has been performed during the past 23 years under review.

A total of 262 animals were submitted for postmortem, comprising 12.2% ruminants, 16.8% primates, 5.0% rodents, 29.7% aviary, 20.6% reptiles, 4.2% Equidae, and 11.5% carnivores.

3.2. Species submitted for postmortem

3.2.1. Aves

Aves included 4 water birds (*Onychoprion fuscatus*), 7 geese (*Anser anser*), 5 long tailed parrots (*Psittacula longicauda*), 3 African grey parrots (*Psittacus erithacus*), 5 buzzards (*Kaupifalco monogrammi*), 1 pelican (*Pelecanus onocrotalus*), 5 ostriches (*Struthio camelus*), 11 stork birds (*Ciconia ciconia*), 1 emu (*Dromaius novaehollandiae*), 2 owls (*Athene noctua*), 17 ducks (*Anas platyrhynchos*), 2 peacocks (*Pavo cristatus*), 7 parakeets (*Psittacula krameri*), 1 vulture (*Necrosyrtes monachus*), 1 marabou stork (*Leptoptilos crumeniferus*), 1 feral pigeon (*Columba livia*), 1 crown crane (*Balearica regulorum*), 2 swamp

hens (*Porphyrio porphyrio*), 1 eagle (*Haliaeetus leucocephalus*), 1 guinea fowl (*Numida meleagris*).

3.2.2. Reptiles

Died reptiles were comprised of 6 African rock pythons (*Python sebae*), 1 Indian python (*Python molurus*), 4 royal python (*Python regius*), 3 cobras (*Naja naja*), 2 rattle snakes (*Crotalus cerastes*), 6 vipers (*Crotalus basiliscus*), 1 water snake (*Coluber caspius*), 1 brown snake (*Pseudonaja textilis*), 17 tortoises (*Aldabrachelys gigantea*), 2 terrapin turtles (*Trachemys scripta*), 5 crocodiles (*Crocodylus niloticus*), 6 monitor lizards (*Varanus niloticus*).

3.2.3. Carnivores

This group consisted of 13 lions (*Panthera leo*), 3 spotted hyaenas (*Crocuta crocuta*), 7 striped hyaenas (*Hyaena hyaena*), 4 jackals (*Canis aduscus*), 2 civet cats (*Civettictis civetta*), 1 mongoose (*Helogale parvula*).

3.2.4. Herbivores

Herbivores were comprised of 13 duikers (*Sylvicapra grimmia*), 9 gazelles, 1 antelope (*Neotragus pygmaeus*), 2 deers (*Odocoileus virginianus*), 1 snub-nosed monkey (*Rhinopithecus roxellana*), 3 horses (*Equus ferus caballus*), 6 donkeys (*Equus africanus*), 2 camels (*Camelus dromedaries*), 3 wart hogs (*Phacochoerus africanus*), 3 domestic pigs (*Sus scrofa*), 11 porcupines (*Hystrix africaeaustralis*), 2 English rabbits (*Oryctolagus cuniculus*).

3.2.5. Primates

Died primates consisted of 14 green monkeys (*Chlorocebus sabaeus*), 7 baboons (*Papio papio*), 6 mona monkeys (*Cercopithecus mona*), 13 patas monkeys (*Erythrocebus patas*), 1 chimpanzee (*Pan troglodytes*), 1 gorilla (*Gorilla gorilla*), 1 Drill monkey (*Mandrillus leucophaeus*), 1 mangabey (*Lophocebus ugandae*).

The distribution over the years is presented in Figure 1.

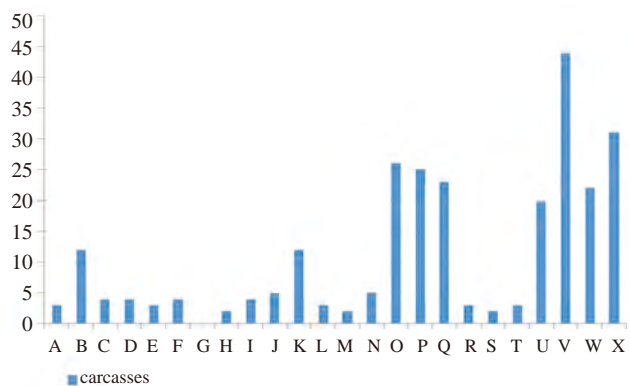


Figure 1. The distribution of annual wildlife mortalities in University of Ibadan Zoological Garden.

A to X represent years 1991 to 2014.

3.3. Description of major wildlife pathology

Clinically, all affected animals were recorded as having progressively decreased activity and weight loss prior to death/euthanasia.

3.3.1. Pneumonia

A total of 35.1% of the carcasses had varying forms of pneumonia. Bronchopneumonia was observed in the ruminants

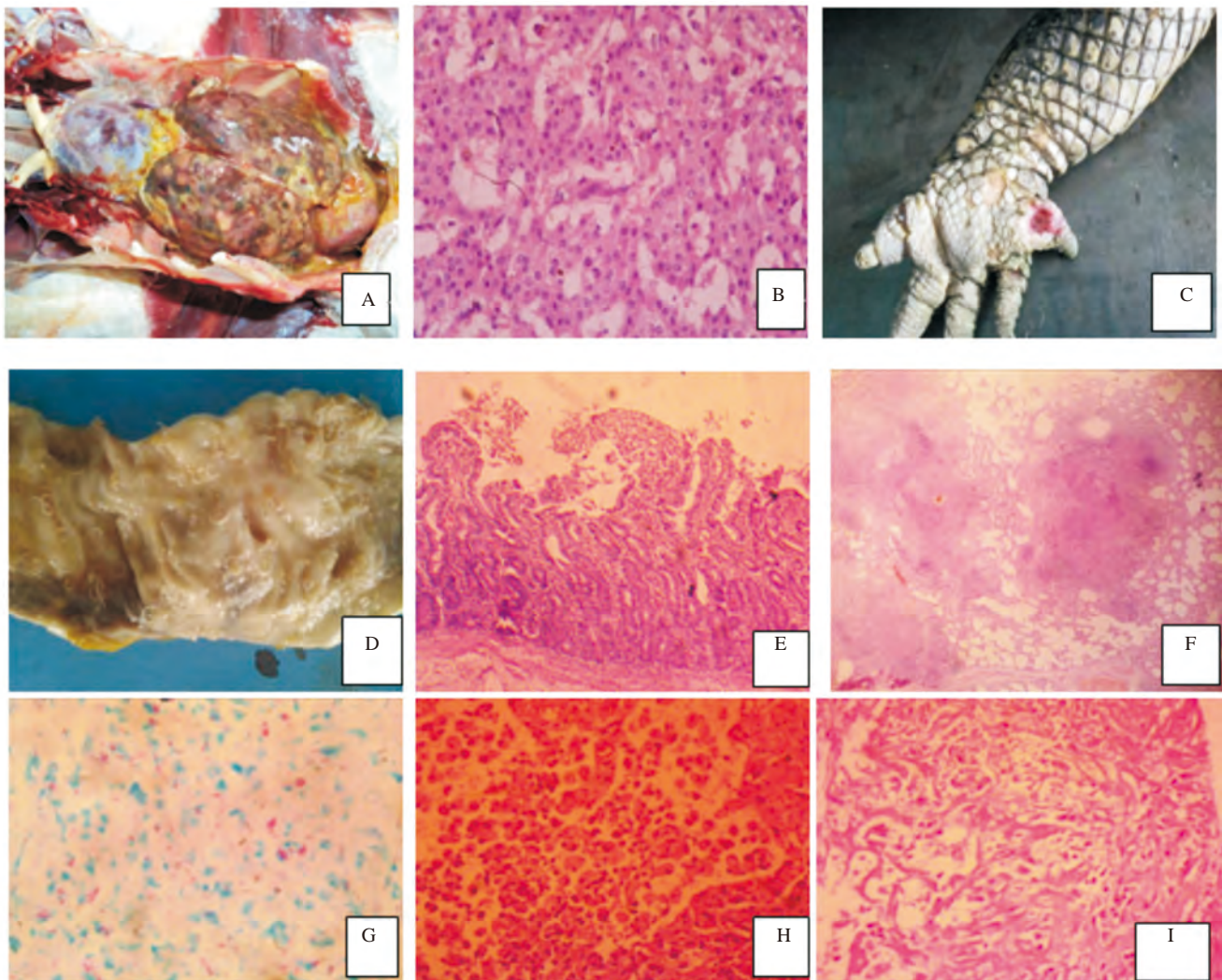


Figure 2. Some diseases found in the died wildlife animals.

A: Hepatic tumour in stork bird; B: Hepatocellular carcinoma; C: Pododermatitis in crocodile; D: Trichuriasis in Patas monkey; E: Acute enteritis; F: Granulomatous pneumonia (HE); G: Granulomatous pneumonia (Ziehl–Neelsen stain); H: Alveolar histiocytosis and pneumocyte hyperplasia; I: Interstitial pneumonia (HE, $\times 100$).

(8) while hypersensitivity pneumonitis was usually observed in the carnivores (3). Grossly, the lungs are usually non collapsed, congested with firm to rubbery texture.

3.3.2. Parasitic gastroenteritis

9.7% of the carcasses died of severe Helminthosis. Ancylostomosis was common in the carnivores (2) and while almost all the Monkeys posted had severe Trichuriasis (6).

3.3.3. Nutritions

About 6.7% of the animals presented forms nutritional abnormality including rickets in a civet cat (1), brans disease in a horse (1) and general malnutrition in a few other animals.

3.3.4. Other pathological conditions

In the aviary, diseases diagnosed included pasteurellosis (13.8%), aspergillosis (10%), hepatocellular carcinoma (7%) (Figure 2A, B), peritonitis (7%), pulmonary abscesses (7%), salmonellosis (13.8%), Newcastle disease (13.8%), gout (7%) and chronic respiratory disease (7%). Those in the reptiles included parasitic enteritis (20%), hepatic rupture (13.3%), intestinal impaction

(20%), fibrinonecrotic enteritis (13.3%), pododermatitis (Figure 2C) and malnutrition. In the herbivores, pneumoenteritis (15%), pasteurellosis (15%), ruminal impaction (10%), congestive heart failure (10%) and trypanosomosis (15%). In the carnivores, granulomatous and interstitial pneumonia (17%), ancylostomiasis (10%), haemorrhagic enteritis (10%) and rickets (3%) were common. In the primates, pneumoenteritis (14%), measles (9%), congestive heart failure (9%), trichuriasis (14%) (Figure 2D, E), and generalised tuberculosis (3%) (Figure 2F, G). Alveolar histiocytosis and interstitial fibrosis were also observed in carnivores (Figure 2H, I).

The pathological conditions observed in zoo animals at the postmortem are as shown in Table 1. Many of the ruminants were observed to have died of pasteurellosis (3) and or pneumonia (9). Trichuriasis (4) and endocarditis (4) were common in primates. Anti-coagulant poisoning/snake bite (3), tuberculosis (5) and helminthiasis (ancylostomiasis) were observed in carnivores. Enteritis and impaction (9) were observed in reptiles. Cholera, salmonellosis and Newcastle diseases (6) were common in aviary while malnutrition, seldom and different forms of pneumonia were observed in virtually all animal groups examined.

Table 1

Some of the common pathologies observed at postmortem.

Common pathology	Avian N = 29	Reptiles N = 15	Ruminants N = 20	Carnivores N = 30	Primates N = 33	Equidae N = 7	Total n (%)
Bacteria pneumonia	10	-	8	3	4	2	27 (20.0%)
Viral pneumonia	3	-	1	3	5	1	13 (9.7%)
Septicaemia	6	5	7	6	6	2	32 (23.9%)
Bacterial enteritis	5	6	-	2	4	2	19 (14.2%)
Viral enteritis	3	-	1	3	3	1	11 (8.2%)
Helminthosis	-	2	1	4	6	-	13 (9.7%)
Nutritional	2	1	1	3	-	-	7 (5.2%)
Tuberculosis	-	0	1	5	1	-	7 (5.2%)
Impaction	3	3	2	2	1	1	12 (9.0%)
Tumour	2	-	2	-	1	-	5 (3.7%)
Poisoning/snake bite	-	-	0	3	-	-	3 (2.2%)
Cardiovascular disease	1	-	2	1	7	-	11 (8.2%)
Traumatic injury	-	1	-	-	1	-	2 (1.5%)
Piroplasmosis	-	1	3	1	-	-	5 (3.7%)
Mycotic	2	1	-	-	-	-	3 (2.2%)
Gout	1	-	-	-	-	-	1 (0.8%)
Nervous	-	-	-	-	-	-	-

4. Discussion

This study enumerated the various pathological conditions commonly diagnosed at postmortem in captive wildlife, the findings further re-emphasised the reports of Anga and Akpavie[13] that the disease problems in captive animal is more to husbandry related issues. This is similar to reports of Sutton from postmortem of 130 carnivores in London Zoo[16]. Adetunji and Adesopeth also highlighted influence of seasonal variation[15].

These patterns of mortalities were observed by Sharma *et al.*[17] in Indian zoo, and by Bichitra and Apurba in non-human primates[7]. The diseases observed in the aviary are also commonly observed in the domestic birds.

Diets lacking necessary vitamins and minerals were a source of many pathological conditions, such as osteodystrophia fibrosa in the horse, which was also observed as gross cranial thickening in three captive young baboons *Papio* sp.[7,8]. Du Boulay and Crawford also looked at nutritional bone disease in a sample of 31 South American primates, of which 25 showed changes observable in radiographs, these were concluded to be due to a diet deficient in calcium and vitamin D3[18].

Baker and Lyon[19], observed changes in lion *Panthera leo* skulls, including thickening of the cranial vault (especially the parietals), cranial asymmetry and herniation associated with increasing paralysis and eyesight loss. However, Chandra *et al.*[20] provided more evidence for cranial thickening in lions, especially of the parietals and the tentorium cerebelli, and reviewed the evidence that vitamin A deficiency may cause this type of problem. Other possibilities included genetic predisposition, but there is, as yet, no consensus on the cause of this malformation. Progressive limb paralysis and cerebellar degeneration has also been noted in captive-bred cheetahs *Acinonyx jubatus*, but it appeared that no examination of the crania of these animals has been carried out and the cause remains unknown[21,22]. These call for intensive investigation as to the cause of death in the captive wild animals.

Tooth pathologies have been noted in captive animals. These range from those caused by trauma to developmental defects such as dental enamel hypoplasia. In a study of wild and captive primates, Molnar and Ward found that all animals had some level of microstructural tooth defects, including hypoplasia, but their incidences were higher in captive individuals[23]. Franz-Odenaal has studied the incidence of hypoplasia in the teeth of wild and captive giraffes *Giraffa*

camelopardalis and found that those of wild giraffes lacked defects, while those of captive animals showed lines that corresponded with periods of stress such as weaning[24]. Fagan *et al.*[25] discussed the incidence of traumatic breakages of elephant *Loxodonta africana* and *Elephas maximus* tusks caused by the captive environment, and noted similar occurrences in walrus *Odobenus rosmarus* and babirusas *Babyrousa babyrussa*.

Activity levels appear to have a great effect on captive animals. Many animals tend to live longer in captivity than they do in the wild. For example, gorillas (*Gorilla gorilla*) survive for more than 50 years in captivity compared with 35 years in the wild[26]. However, changes such as arthropathies have been observed in captive animals as normal age-related changes and possibly due to lack of activity, different nutrition, chronic infection or other environmental factors. Rothschild *et al.*[27] found spondyloarthropathy in both wild and captive big cats, but osteoarthritis and calcium pyrophosphate deposition disease were only found in captive animals. Spondyloarthropathy is likely to result in a decrease in activity for the affected animals, and would eventually compromise survival in the wild. Kolmstetter *et al.*[28] reported degenerative spinal disease in eight of 37 big cat skeletons from Knoxville Zoo.

The reasons for the higher incidence in the zoo include (a) the drive for acquisition of animals from January 2011 however some did not outlive the quarantine period; (b) the postmortem record also showed increased compliance from the zoo for necropsies as most of the cases in zoo record were submitted for full diagnostic workup. Flooding occurred on August 26th 2011, a tragic flood in Ibadan which took human lives and damaged public and private properties also affected the zoo. This accounted for increased mortalities in 2012, as was also observed in Halle[29]. International Institute of Tropical Agriculture automatic rainfall gauge recorded an all-time high of 187.5 mm rainfall for August 26th. Some animals drowned by flood could not be presented for postmortem.

Some of these diseases may have exacerbated in the captive animals because of the restrictions. Emotional, psychological and mental (behavioural) diseases occur in zoo animals more than their counterparts in parks or in the wild[30].

Adequate measures and housing have been put in place including enclosure upgrading, enrichment, wildlife clinic, up to date zoo records, case notes for all animals, and compounded feed for animals, increased breeding and survival of animals, training and retraining sessions for staff.

The use of multivalent vaccines has been proposed as a good solution to major upper respiratory disease constraints[31]. Mucoadhesive drug delivery system offers several advantages, the success achieved with the bioadhesive formulations increases drug concentration gradient at the absorption site and therefore improved bioavailability of systemically delivered drugs and also target local disorders at the mucosal surface (*e.g.* mouth ulcers) reducing the overall dosage required and minimize side-effects that may be caused by systemic administration of drugs.

The increase in emerging infectious diseases (EIDs) in wildlife and their potential spillover to domestic animals and humans are a major threat to global health. Emerging infectious diseases also devastate economies and their impact on developing countries is especially severe, where vaccine coverage and availability of new drugs is lowest, and where governments are swamped with other priorities[5]. A key understanding is that health connects all species and that veterinarians have an important role to play in working on the interactions of wildlife health, human health and ecosystem health. In addition,

training linked to veterinary ethics and to the science of animal welfare as it applies to the zoo and wildlife field may be required as already advocated by Carpenter and Miller^[32] and Stoskopf^[33].

In conclusion, comprehensive veterinary care should be instituted at the zoo and other means for husbandry should be prioritized so as to alleviate wildlife diseases and mortality. Non-invasive approach to treatment against diseases such as helminthosis, conventional vaccinal strategies harnessing mucosal surfaces against diseases such as pneumonia, and need to supplement animal feed with minerals and vitamins should also be emphasized. Likewise, the inclusion of zoo and wildlife veterinarians as resident staffs is indispensable in addressing these health problems. Our findings may serve as complimentary in the study of wildlife diseases in Nigeria and across Africa. As policies regarding wildlife health remain critical in the zoological gardens.

Conflict of interest statement

We declare that we have no conflict of interest.

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