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A Retrospective Study Of Morbidity In Captive Columbiformes Housed In Bristol Zoo Gardens And Wild Place Project, United Kingdom From 2000 – 2017

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Abstract

Medical records from 860 pigeons and doves of 24 species housed in Bristol Zoo Gardens and Wild Place Project, United Kingdom, from 2000 to 2017 were reviewed to determine the causes of morbidity in captive columbiformes. Accounted 205 cases (51.25%), infectious disease was found as the primary cause of morbidity, followed by 133 cases of trauma (33.25%), 51 (8.9%) cases of non-infectious disease, and 8 (2%) cases of husbandry-related problem. The main cause of infectious disease was parasite infection with 35% over 31% of bacterial, 26% of undetermined etiology and 9% of fungal infection. More specific, nematodiasis was the most frequent parasitic disease found, presented in 49 (69%) cases and followed by 10 (14%) trichomoniasis of all parasite infection. Meanwhile, chlamydiosis was a leading cause of bacterial infection with 22 (35%) cases recorded of over 63 bacterial infections. These results highlight the importance of preventative medicine implementation in captivity which aims to detect the disease earlier hence reducing the worsening physical condition and minimising the risk of both zoonotic and non-zoonotic disease transmissions. In addition, these findings contribute to the limited information available regarding the captive columbiformes morbidity

Keywords columbiformes, morbidity, diseases, zoo, preventative medicine.

Background

Columbiformes is a bird order which is commonly found in zoos, which constitutes approximately 50% of all birds in captivity (Howard et al. 2002; Harlin and Wade 2009). It consists of over 40 genera and 300 species of domestic and wild pigeons and doves (Gyimesi 2015). The term "pigeon" is designated for larger species, while "dove" is assigned to the smaller ones, though those terms are often used interchangeably. Domestic pigeons are raised for human purpose such as for food, racing, exhibition (e.g. fancy pigeon), and for research. Feral pigeons originate from domestic birds that have escaped or been deliberately released (Harlin and Wade 2009). Wild or usually termed as exotic pigeons are those inhabiting natural habitat such as forest or coastal regions within the small islands or undisturbed areas. The conservation status is varied among species, ranging from 'Least Concern' to 'Extinct In The Wild' (Gyimesi 2015). According to IUCN, 109 columbid species are within categories of 'Extinct' to 'Near Threatened' (Camfield 2017).

Despite being commonly found in captive facilities, there has been very little epidemiologic study on the morbidity of columbid species. The objective of this retrospective study was to determine the most common causes of morbidity of several columbid species housed in two zoos under one management during a period of 17-year. This kind of study can be used to improve the health management of captive Columbiformes, preventing the outbreak of the disease, thus increasing their survivability and contributing to the species conservation efforts.

Materials and Methods

The morbidity events occurred in the columbiform bird populations between the year of 2000 to 2017 were obtained from a web-based medical and husbandry record system (Zoological Information Management System, ZIMS 2.3; Species360, Eagan, Minnesota, USA) and retrospectively

analysed. Morbidity was recorded when an individual was either presented as weak, injured or showed an abnormal or positive result of the test conducted during the series routine elective health examinations.

Routine elective health examinations included a post - arrival health examinations which were conducted when the birds first arrived at the zoo; pre-export health examinations that were carried out prior to send the birds to another collection; first health examinations which were held when the birds reached 6-12 months of age; and routine health examinations that were routinely carried out at varying intervals among individuals, ranging from annually to once every six years. Physical restraint was performed prior to the examinations. All examinations consisted of a thorough physical examination in either conscious or anaesthetised birds with at least one diagnostic test was undertaken. The procedure was initiated with the measurement of body weight, body score condition (BCS) and physiological data such as temperature, heart and respiration rate. Potential diagnostic tests included bloodwork (routine haematology and biochemistry); radiography (X-ray) or ultrasonography; parasitology examination for helminths, coccidian, *Tricohomonads*, and ectoparasites; and microbiology tests for *Candida, Chlamydia sp.*, enterobacteria such as *Campylobacter*, *Salmonella*, and *Eschericia coli*. The procedure often ended with prophylactic treatments for parasites. Only when necessary, endoscopy and biopsy were performed to reveal more diagnostic information.

For the examinations held under anaesthesia, a general anaesthetic mask induction was initially performed with sevoflurane/ oxygen and subsequently maintained with isoflurane/ oxygen either via facemask or endotracheal tube (ET). Additional injectable analgesia such as ketamine and butorphanol was occasionally applied for endoscopy procedure. Body condition scoring was scored through palpation using the scale of 1-5 or 1-9. Detail BCS measurement system is provided in Table 1. Blood sample was obtained from cephalic or brachial vein. Methods applied for parasitology test included faecal sedimentation, McMaster and direct microscopic examination. Crop swab smear was carried out to detect *Trichomonads* under microscope. *Chlamydia* test was performed either by molecular method i.e. polymerase chain reaction (PCR) using a pooled faecal sample or swabs from choanae, coloaca, or conjunctiva, or serological method i.e. immunocomb using blood serum as sample. Prophylactic treatments for parasites comprised of fipronil spray (Frontline, Merial Animal Health, UK) for ectoparasites, subcutaneous injection of ivermectin (Panomec, Merial Animal Health, UK), febendazole p.o. (Panacur, MSD Animal Health, UK) and carnidzole tablet 10 mg p.o. (Spartrix^{TM}, Harkers Petlife, UK). A subcutaneous injection of warmed Hatmann's solution was applied to stabilise the birds' condition after examination.

The causes of morbidity were established during examination and were classified into the following categories:

a. Infectious disease: assigned for birds with a confirmed positive as infected by pathogens in microbiology or parasitology tests and/or for those that showed the signs of inflammation either physically or in a blood test.
b. Trauma: assigned for cases resulted from physical injury.
c. Non-infectious disease: assigned for birds with toxicosis, metabolic, nutritional, hormonal, neurological, degenerative, neoplastic, or hereditary diseases or for birds with miscellaneous conditions such as crop stasis or complications resulted from vaccination or anaesthesia.
d. Husbandry-related problems: assigned for those suffering from problems arising from husbandry management such as pest eradication, enrichment and enclosure design.

All data were managed in Microsoft Excel 2016 (Microsoft, Redmond, USA). The proportions of each morbidity cause category were calculated in IBM SPSS Statistics (version 23.0, IBM Sof-tware,

New York, USA) and were subsequently presented in a percentage unit.

Table 1. Body condition scoring systems (Barrows et al. 2017a).

Condition	Score 1-5	Score 1-9
Emaciated	1	1
Very underconditioned		2
Moderately underconditioned	2	3
Slightly underconditioned		4
Ideal	3	5
Slightly overconditioned		6
Moderately overconditioned	4	7
Very overconditioned		8
Obese	5	9

Result

A total of 864 medical records of birds of the order Columbiformes were reviewed. Only four birds were excluded from the study due to the incomplete records. Details of the species used in this study and its conservation status are given in Table 2. A total of 401 morbidity cases were recorded. Infectious disease was the main cause of morbidity, followed by non-infectious disease, trauma, and husbandry-related conditions respectively. A complete account of causes of morbidity is shown in Table 3.

Table 2. List of the species and its conservation status used in the study

Species Common name (scientific name)	Status*	Number
Socorro dove (*Zenaida graysoni)*	EW[1]	76
Pink pigeon *(Nesoenas mayeri)*	EN[2]	31
Victoria crowned pigeon *(Goura victoria)*	VU[3]	35
Mindanao bleeding-heart dove *(Gallicolumba crinigera)*	VU	109
Luzon bleeding-heart dove *(Gallicolumba luzonica)*	NT[4]	114
Sulawesi quail dove *(Gallicolumba tristigmata bimaculata)*	LC[5]	26
White-naped pheasant pigeon *(Otidiphaps aruensis)*	VU	25
Green imperial pigeon *(Ducula aenea paulina)*	LC	25
European turtle dove *(Streptopelia turtur)*	LC	62
Black-naped fruit dove (*Ptilinopus melanospilus*)	LC	58
Beautiful fruit dove (*Ptilinopus pulchellus*)	LC	9
Superb fruit dove (*Ptilinopus superbus*)	LC	11
Collared dove (*Streptopelia decaocto*)	LC	1
Wompoo fruit dove (*Megaloprepia magnifica*)	LC	7
Jambu fruit-dove (*Ramphiculus jambu*)	NT	2
Yellow-breasted fruit dove (*Ramphiculus occipitalis*)	LC	3
Nicobar pigeon (*Caloenas nicobarica*)	LC	59
Red-throated ground dove (*Gallicolumba rufigula*)	LC	1
Pied imperial pigeon (*Ducula bicolor*)	LC	70
Barbary Dove (*Streptopelia risoria*)	LC	100
Wonga pigeon (*Leucosarcia melanoleuca*)	LC	13
Crested pigeon (*Ocyphaps lophotes*)	LC	21
Green-naped pheasant pigeon (*Otidiphaps nobilis*)	LC	1
Namaqua pigeon (*Oena capensis*)	LC	1
Total		860

[1]EW= Extinct in the wild, [2]EN= Endangered, [3]VU= Vulnerable, [4]NT= Near threatened, [5]LC= Least concern *resource: International Union for Conservation of Nature (https://www.iucn.org)

Table 3. Causes of morbidity of columbiformes during a period of 17-year observation.

Morbidity case	Number, percentage
Infectious	205 (51.25%)
Trauma	133 (33.25%)
Non-infectious	51 (8.9%)
Husbandry-related problem	8 (2%)

Infectious disease

The primary cause of infectious disease was parasitic infection which accounted for 71 (35%) cases followed by 63 (31%) bacterial infections, 53 (26%) unidentified cause of infection and 18 (9%) fungal infections consecutively. Among those that the etiology of infection was able to be identified, parasitic disease was mainly nematodiasis caused by Ascarids and *Tetrameres*, canker (*Trichomonas sp.*), coccidiosis, and mite infestation (*Dermanyssus*, *Knemidocoptes*, unidentified mites). Psittacosis caused by *Chlamydia psittaci* was the most commonly found bacterial infection, followed by *Campylobacter sp.*, *Enterobacter sp.*, *Yersinia pseudotuberculosis*, *Staphylococcus sp.* and *Salmonella spp*. The identified fungal disease were candidiasis and aspergillosis. Bacterial infections were treated with antibiotic such as enrofloxacin (Baytril®, Bayer, Germany), marbofloxacin (Marbocyl™, Vetoquinol, France), amoxilin trihydrate-clavulanic acid (Synulox®, Zoetis, New Jersey, USA). Chlamydiasis were treated with 20 mg doxycycline p.o. s.i.d. for 42 days. Meanwhile, for those with unidentified etiology of infection, respiratory-related condition such as pneumonia and air sacculitis dominated, followed by gastrointestinal tract infection, conjunctivitis, and urinary tract infection. Air sacculitis were treated with antiseptic solution nebulization (F10®, Meadow's Animal Health Care, England, UK) for 28 days. Fungal infections were treated with itraconazole. Antihelmintic such as febendazole was employed. A complete account of infectious disease is summarised in Table 4.

Table 4. Infectious disease occurred during a period of study.

Category	Disease	No. of case
Bacterial	Psittacosis	22
	Campylobacter sp. infection	5
	Staphylococcus sp. infection	2
	Avian pseudotuberculosis	3
	Enterobacter sp. Infection	4
	Colibacillosis	1
	Salmonellosis	2
	Unisolated bacteria	24
Parasitic	Helminthiasis	49
	Trichomoniasis	10
	Coccidiosis	6
	Mite infestation	6
Fungal	Candidiasis	13
	Apergillosis	3
Undetermined etiology	Respiratory tract infection	37
	Gastrointestinal tract infection	7
	Urinary tract infection	2
	Otitis, conjunctivitis	4

Trauma

Trauma was the second highest cause of morbidity of the studied birds. Causes of trauma were mostly related to the aggressive behaviour of cagemates (n=43, 32%), tissue wounds (n=39, 29%)), transport and capture injury (n=20, 15%), fracture and dislocation (n=15, 11%), ring

injury (n=4, 3%), and collision-type injuries resulted from hitting the cage or mesh (n=3, 2%). Tissue injuries were mostly in the form of head trauma, scalping and laceration wounds. Therapy was varied between cases, depending on the severity of wounds. Traumatic injuries were treated with antibiotic, analgesia, anti-inflammatory drug, and dressing equipments such as Granugel and Granuflex (ConvaTex Ltd., UK). Some injuries required suture and intensive supportive treatment during recovery. Crop tubing was occasionally employed with Critical Care Formula (Vetark Professional, UK). Fracture and dislocation were probably caused by falling from the nest or perch, or as a result of congenital defect such as deformity of extremities. Treatments for these cases included splinting and the administration of analgesia and anti-inflammatory drugs. Meanwhile, capture and transport injuries were resulted from restraint process and transfer to vet clinic prior to health examination procedure. Those injuries were mainly minor wounds in cere, carpals, and wings, with treatments only required in two cases. Ring injuries were primarily tissue swelling and haematoma caused by Darvik ring. In the case of haematoma, a fine needle aspiration was performed to take out the blood clot. The swelling was treated with anti-inflammatory drug. The ring was thus subsequently removed and changed.

Non-infectious disease

Non-infectious diseases occurred during the study period were toxicosis (n=1, 2%), metabolic and nutritional disease (n=18, 32%), and miscellaneous conditions (n=32, 63%) such as lameness, neurological disorder, reproductive problems, aspiration pneumonia, cloacal bleeding, deformity of beak and extremities (limb, toe, digits), crop stasis, and complication resulted from *Yersinia* vaccination. Toxicosis was suspected to be lead poisoning. Metabolic and nutritional problems were emaciation, cachexia, renal and liver disease, and metabolic bone disease (MBD). The complications from vaccination were in the form of skin mass which some developed into abcesses that require surgical removal procedure. All neurological disorders occurred in pied imperial pigeon (*Ducula bicolor*) with the clinical signs of ataxia, torticollis, and poor flying. All of those birds were eventually euthanized. The latter postmortem examinations revealed neuro-axonal dystrophy was the cause of those neurological problems. Metabolic bone disease was noticed in five birds with one of them required euthanized, while three of the remainings were treated with Zolcal-D (Vetark Professional, UK). List of non-infectious diseases occurred in the studied birds is given in Table 5.

Table 5. Several non-infectious diseases occurred during a period of observation.

Category	Disease	No. of case
Toxicosis	Lead poisoning	1
Metabolic and nutritional	Emaciation, cachexia	6
	Metabolic bone disease	5
	Renal disease	4
	Liver disease	3
Miscellaneous	Anatomy deformity	5
	Ovarian disease	1
	Cystic ovary	1
	Neurological disorder	5
	Aspiration pneumonia	2
	Crop stasis	1
	Lameness	4
	Complication of vaccination	5
	Cloacal bleeding	1

Husbandry-related problems

The problems occurred from husbandry management were pododermatitis (n=7, 87.5%) and frostbite (n=1, 12.5%). A total of seven pododermatitis were recorded with four of them were in mild degree, two were moderate, and one was severe. In bird with severe pododermatitis, ulcerative chronic active pododermatitis caused necrosis which extended down to a digital bone and induced a reactive bone formation. The condition brought about systemic infection and death. Therapy applied for pododermatitis were antibiotic and anti-inflammatory drug with a subsequent correction of enclosure husbandry particularly perches. Frostbite was occurred once and treated with antiseptic ointment and antibiotic.

Discussion

Treating an extensive number of wild animals is difficult, and in most cases, animals tend to hide the symptom of illness (Miller 1999; Barrows et al. 2017a). The challenge of diagnosis and therapy is even more pronounced in birds, as birds instinctively conceal the symptom of illness in what termed as 'masking phenomenon' to avoid appearing weak in front of the predators (Walker 2000). The results presented above therefore highlight the importance of preventative medicine as foundation of a good zoological medicine, whereby if problems caught earlier, could be prevented from getting exacerbated and difficult to treat (Barrows et al. 2017a).

Infectious disease was the most frequently reported cause of morbidity with parasitism was the most prevalent infection. This is indeed common in zoological collections where they confined in a constant area, unlike those living in the wild, thus increasing probability of parasites being circulated around and recurrently infect the animals. In practice, this can be tackled by conducting a regular faecal examination and deworming (Fowler 1986).

Health examinations too are important to diagnose trichomoniasis earlier through microscopic exams using a crop swab as sample. Infection caused by *Trichomonas gallinae* is progressive. The high infestation of those organisms may block the birds' throat and prevent it from swallowing food (Tudor 1991; Borji et al. 2011).

The high prevalence of Avian psittacosis caused by *Chlamydia psittaci* implies the significance of undertaking the Chlamydia test routinely. Psittacosis in Columbiformes can be either clinical or asymptomatic. In asymptomatic case, birds can serve as carriers and spread the virulent bacteria (Tudor 1991). Additionally, avian psittacosis is an occupational hazard and hence public health concern with control and prevention measures enacted in specific legislation. Human infection can occur following contact with either the sick or with carriers and produce a flu-like symptos to severe pneumonia (CDC 1998; Boseret 2013).

Similarly, the morbidity caused by *Yersinia pseudotuberculosis* highlights the necessity of performing microbiology tests during routine health examinations. Although in practice vaccination can prevent avian pseudotuberculosis, it must be noted that vaccination itself may yield side effects such as skin masses shown in this study. Other cases such as aspergillosis and respiratory problems with unidentified pathogen could be detected and prevented earlier through health examinations. In this case, an X-ray procedure is able to visualize the condition of lung and air sacs, thus if abnormalities are caught, treatment can be given, husbandry can be improved, and the development of late stage and outbreak can be prevented (Tudor 1991).

Cagemate aggression was the leading cause of morbidity. This is common to occur, given the dominance hierarchy within groups of columbid birds which makes them rather intolerant to each other. Aggressive behaviour is even more pronounced during the the reproductive cycle. In practice, this issue can be minimized by providing an appropriate aviary with an adequate visual barrier and roosting place (Gyimesi 2015). The high prevalence of capture and transport injury were recognised as the risk of handling and

restraining birds for procedure such as treatment and health examinations (Barrows et al. 2017a). However, since the injuries were minor, this might not constitute a significant threat to the birds. In practice, capture and transport injury can be minimised by shortening the restraint duration and placing the birds into padded and darkened crates during transfer to clinic for examinations (Gyimesi 2015). Training birds to enter the crates can be one solution to reduce the stress and capture injury too. Nevertheless, there has been no study evincing the success of this method as applied in Columbiformes (Heidenrich 2004). In addition, the ring injury implies the necessity to consider components such as the size, material, and the frequency of the ring replacement when ringing the birds.

Conditions such as emaciation and cachexia highlight the importance of examining the weight and regularly monitoring BCS through close examinations. Poor BCS is difficult to assess because of thick feather coverage, hence palpation is required during comprehensive physical exams (Barrows et al. 2017a). In some cases, those conditions could be the manifestation of behaviour problems such as difficulties to integrate into a new enclosure, or of chronic diseases such mycosis and parasitism (Harlin and Wade 2009; Barrows et al. 2017a). Metabolic bone disease can be caused by factors such as low vitamin D intake and UVB exposure. This disease can be diagnosed earlier through the examination of bone thickness in X-ray procedure. Young birds are thought to be significantly more prone to develop MBD than mammals, therefore suggests the importance of closely monitoring the health of young individuals (Cousquer et al. 2007).

Neuronal dystrophy found in pied imperial pigeons was among the interesting degenerative and inherited diseases for which a definite diagnosis could only be established during postmortem. This disease is recognized as congenital which of an importance for captive breeding, with possible preventions including stopping breeding with those having close lineage with the affected pigeons (Barrows et al. 2017b).

Pododermatitis demonstrates the importance of conducting a regular health examination to prevent the development of this progressive disease which is difficult to treat once it develops into the advanced stages. In practice, once the early phase of pododermatitis is caught, correction of perch and enclosure can be made and treatment can be delivered (Poorbaghi et al. 2012; Barrows et al. 2017a).

The limitation of this study was the subjectivity of veterinarians in establishing diagnosis. Diagnosis in medicine is commonly known as an art of a science and in the zoo where veterinarians deal with extensive species, diagnosis is not easy. Consequently, one finding such as an elevated white blood cell was considered by one veterinarian might not be considered so by other veterinarians, and thus recorded as such.

Conclusion

This study is the first epidemiologic study of captive Columbiformes. The results highlight the importance of preventative medicine as a cornerstone of zoological medicine. This study provides information of the trend of morbidity in columbid species which can be used to improve the health and welfare of columbid species.

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