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Case Report

Geophagia in a large felid in captivity: A case report of lethal gastrointestinal impaction in a Bengal tigress (*Panthera tigris tigris*)

Rodrigo S. Hernández-Aco[a], Morris Villarroel[b], Genaro C. Miranda-de la Lama[c,*]

[a] *Pathology Group, Institute of Agricultural Sciences (ICAP), Autonomous University of the State of Hidalgo (UAEH), Tulancingo, Hidalgo, Mexico*
[b] *CEIGRAM-Animal production, ETSIAAB, Technical University of Madrid, Madrid, Spain*
[c] *Animal Welfare Group, Department of Animal Production & Food Science, Faculty of Veterinary, Agri-Food Institute of Aragon (IA2), University of Zaragoza, Zaragoza, Spain*

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ABSTRACT

Deliberate geophagia or sand-eating behaviour has been widely documented in herbivorous and omnivorous mammals, but never in large felids at captivity. Here we report a case of apparent lethal gastrointestinal impaction from sand intake in a 10-year-old captive Bengal tigress. After 2 days of anorexia and prostration the tigress was admitted to the University Veterinary Hospital with abdominal distension and diarrhoea and died shortly afterwards. A post-mortem examination revealed oesophageal perforation, abundant liquid in the stomach and pyloric obstruction due to the presence of compacted sand and some masses of poultry bones. It is hypothesized that geophagy (of sand) may have been a strategy to alleviate indigestion by consumption of rotten poultry carcasses, but evolved into a compulsive/obsessive-compulsive disorder over time, possibly due to a restricted and barren environment. Zoo animal welfare involves a series of challenges that include an adequate diet in quantity and presentation, as well as complex behaviours such as the motivation to ingest non-food substances under certain contexts during life in captivity.

Introduction

Large felids have long been a part of zoo animal collections, however, displaying these animals in way that protects their welfare can be a challenge (Mohapatra et al., 2014). Life in captivity imposes a wide range of potential stressors, including abiotic environmental sources of stress, such as artificial lighting, exposure to loud or aversive sounds, unpleasant odours, uncomfortable temperatures and novel substrates (Morgan and Tromborg, 2007). These stressors can alter physiological parameters, generate abnormal repetitive behaviours and have important negative consequences on the health and welfare of the animals throughout their lives (Latham and Mason, 2010). Even though numerous wild species seem to cope and even thrive in captivity, most zoos house animals that express some degree of abnormal behaviour, including compulsive/obsessive-compulsive oral disorders such as self-mutilation, regurgitation, and especially pica (Breton and Barrot, 2014). Pica is defined as abnormal appetite or ingestion of non-nutritive substances, with potential side effects on the gastrointestinal tract (Li et al., 2020). Animals with pica commonly exhibit abnormal behaviour such as coprophagia, osteophagia, trichophagia, lignophagia, and geophagia (Nikvand et al., 2018).

Geophagy is the craving and intentional consumption of geosediment such as soil, stone, rock, clay or sand (Yamamoto et al., 2019). One of the most serious consequences of this disorder in captive animals is gastro-enteric impaction due to the accumulation of large amounts of sand (Abutarbush and Petrie, 2006). These animals present signs of inappetence, weight loss, reduced gastro-enteric contractions, tympany, discharge of sandy faeces or

* Address for reprint requests and correspondence: Genaro C. Miranda-de la Lama, Animal Welfare Group, Department of Animal Production & Food Science, Faculty of Veterinary, Agri-Food Institute of Aragon (IA2), University of Zaragoza, Miguel Servet 177, Zaragoza, 50013, Spain, Tel: +34 876 554 150; Fax: +34 976 761 590.

E-mail address: genaro@unizar.es (G.C. Miranda-de la Lama).

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constipation, lethargy, recumbency, all of which may eventually lead to death within a few weeks (Simsek et al., 2015). The active ingestion of geo-sediments is frequently observed in wild animals such as herbivorous and omnivorous mammals, birds and reptiles (Slamova et al., 2011). Geo-sediments are never consumed randomly within an animals' home range, but instead at specific sites (Klaus and Schmidg, 1998). In wild animals, geophagy has been thought to play a role in the detoxification of noxious or unpalatable compounds present in the diet, to alleviate gastrointestinal problems such as diarrhoea, to alleviate hyperacidity in the digestive tract or to supplement the body with minerals as zinc, iodine, calcium, magnesium and potassium (Wilson, 2003).

Although food selection is critical to the survival of every species, it is not as readily apparent that animals can choose specific food to self-medicate (Franck and Farid, 2020). Several studies have shown that animals can recognize medicinal plants, soils, clays, fungi, and insects, and ingest or otherwise apply them to their bodies to help prevent or treat disease (Mejia-Fava and Colitz, 2014). Although very few reports are available on lethal sand impaction in herbivores, to the authors' knowledge there are no previous reports for captive carnivores. The objective of this case study is to report on 1 such case in a 10-year-old tigress kept in captivity in a small zoo in central Mexico, after the necropsy indicated multisystem failure as a product of gastrointestinal impaction by sand. Here we also discuss the possible causes and behavioural motivations that led to this pathology.

Case description

The tigress in this case report was 10 years old and lived in a public zoo located in the municipality of Tulancingo in the state of Hidalgo, Mexico. The tigress had been born in captivity and had lived in this zoo for 5 years. She was housed in an individual shelter with an exhibition area of 49 m^2 (with sandy soil and some grass area, a small pool and a fallen tree for climbing) and a night room of 8 m^2 (cement floor, drinker and feeder). Her daily diet was composed of 8 kg of beef and poultry carcasses (eviscerated and without feathers), and *ad libitum* access to drinking water.

A few weeks before acute symptoms, the zookeeper noticed that the tigress would hide some rations of poultry in the sand to eat them days later "dirty." This behaviour had not been seen at any moment during the previous 5 years. In October 2016, after 2 days of anorexia, prostration, depression and abdominal distention she was sent to the Veterinary Teaching Hospital of Autonomous University of the State of Hidalgo for examination (Figure 1). Her gingival mucosa was slightly bluish, with visible abdominal spasms and apparent pain on movement. The faecal consistency score was 5, based on the standardized faecal scoring system developed by the Felid Taxon Advisory Group (TAG) (range 1-5, where 1 is compact excrement and 5 is watery). There was no evidence in the rectum or in the transport-cage of bone-waste or prey-remains. The animal was sedated to take blood for analysis and perform an abdominal ultrasound, but she died shortly afterwards. Body condition was 2, based on the TAG score (range 1-5, where 1 is very thin, 5 is obese). A score of 2 is "underweight" and defined as "lean body, exaggerated limb delineations, poor muscling and cheeks and face gaunt."

Externally, the skin of the corpse in the autopsy amphitheatre was dirty, covered with a brown liquid coming from the perianal region, suggesting abundant watery diarrhoea (Figure 1). A first cut was made in the midline to remove skin, followed by a secondary incision, making 2 cuts to remove the sternum and abdominal muscles. Macroscopic examination in the thoracic cavity *in situ* showed bilateral pulmonary atelectasis, hypertrophic heart disease, and bullous emphysema in the right cranial lobe (approximately 3 cm in diameter). Bullous emphysema was observed in the pulmonary parenchyma with a circumscribed elevation in the middle lobe in the left apical region. Tissue elevation was also visualized forming a delimited elevation of the pleura with a bubble containing air. The heart showed loss of muscle tone and consequent right-sided elongation, in addition to a blood cyst in the tricuspid heart valve. Moderate endocarditis was observed, the tricuspid valve showed thickening of the leaflets and abnormal whitish coloration associated with the tissue inflammatory process. It is possible that the endocarditis was associated with the presence of a blood cyst, linked with the difficulty and obstruction of the leaflet circulation, leading to the accumulation of blood content in multiple or single sacs. No vegetative or verrucous lesions were found in the endocardium.

In the respiratory system, the lungs were bilaterally atelectic, with the presence of bullous emphysema, and mucous inside the trachea and pulmonary bronchi. When inspecting the oesophagus, lesions were compatible with esophagitis, with the presence of semi-pasty fluid. When reviewing the region of the cardia, there was a partial perforation of the oesophagus and the presence of several poultry bones, and grey-sandy foamy liquid. A prominent gastric distention was observed. A cut was made on the edge of the side of the stomach on the line of the cardia towards the lesser curvature, releasing 6-8 litres of dense gastric content smelling of ammonia. The pylorus was obstructed due to the presence of compacted sand (Figure 2). The intestines had distended loops with the presence of liquid and gas, which caused difficulty in digestive transit and partial retention of gastric content, but there was no evidence of sand.

The gastric content included liquid and large amounts of sand and poultry remains. The state of degradation of the poultry bones indicated they had been in the stomach for 6-8 days. Many of the bones had ridges that presumably injured the mucosa of the stomach. When the stomach was emptied, we observed small black stones of irregular shape and abundant sand between the gastric folds, along with gastritis, erosions and bleeding ulcers in the fundus and over the entire mucosa. No evidence of bezoars or fecalith was observed in the contents of the stomach or intestines. In the kidneys we found bilateral hydronephrosis of the renal cortex and medulla, which has a moderate effect on their function, in addition to the presence of purulent cystitis and thickening of the mucosa of the bladder due to chronic septic inflammation.

Discussion

Gastrointestinal impaction by geophagy has been widely described in herbivorous animals, including cattle (Hunter, 1975), horses (Johnston and Freeman, 1997), elephants (Warren et al., 1996), ostriches (Mushi et al., 1998), alpacas (Abutarbush and Petrie, 2006), and giraffes (Jegede et al., 2016). However, we have found no reports of gastroenteric impaction by geophagy in domestic or wild carnivores in captivity. Based on our findings, the pathogenesis of the events that led to the death of the tigress is thought to be due to the physical occlusion of the gastrointestinal lumen by the ingestion of poultry bones and large amounts of sand. That occlusion caused luminal blockage and exertion of force and tension on the luminal wall and associated structures including villi, submucosa glands, blood vessels and the muscular wall. As a result of the luminal blockage, some recently ingested poultry bones were found between the oesophagus and the cardia, which caused a large perforation injury and accelerated death. Gastrointestinal impaction by foreign bodies has been widely documented in domestic carnivores and in captivity. The clinical signs reported for those cases are similar to those reported in our case, including weight loss, lack of appetite, intermittent vomiting, and diarrhoea

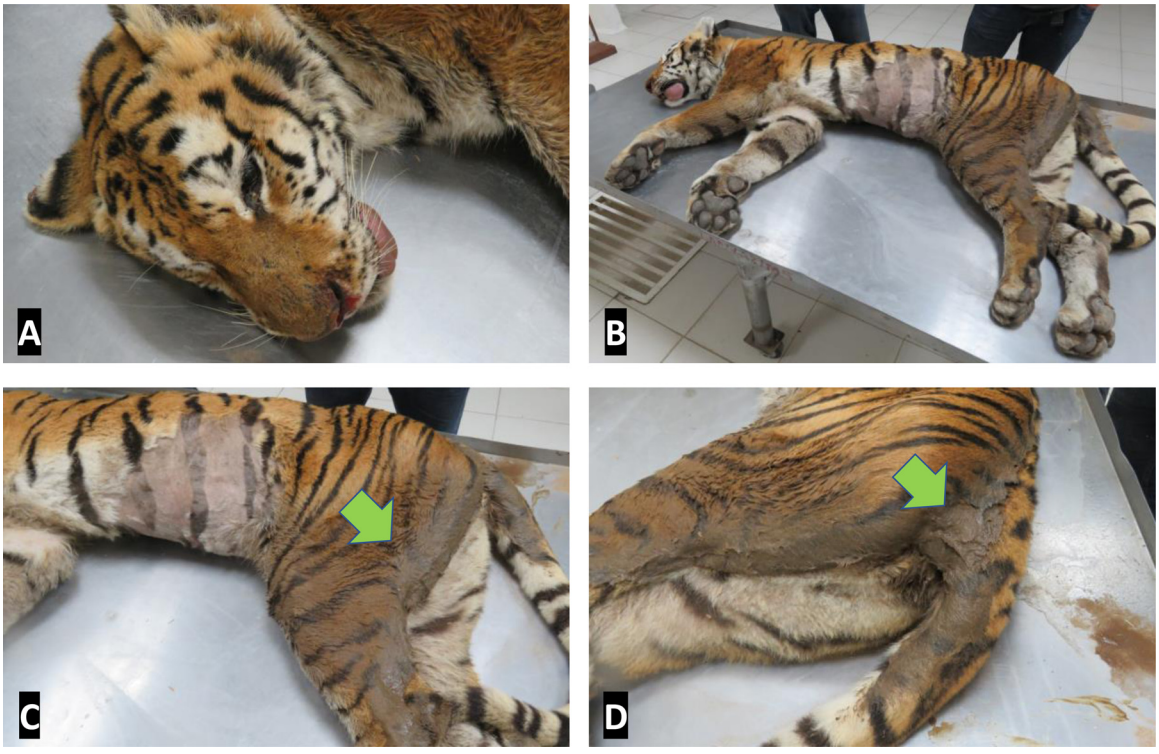

Fig. 1. Photographs from the post-mortem examination of the tigress in the necropsy amphitheatre. (A and B) General external appearance of the animal with showing emaciation; (C) presence of severe and watery diarrhoea on the hindlimb, and (D) in the caudal and anal region.

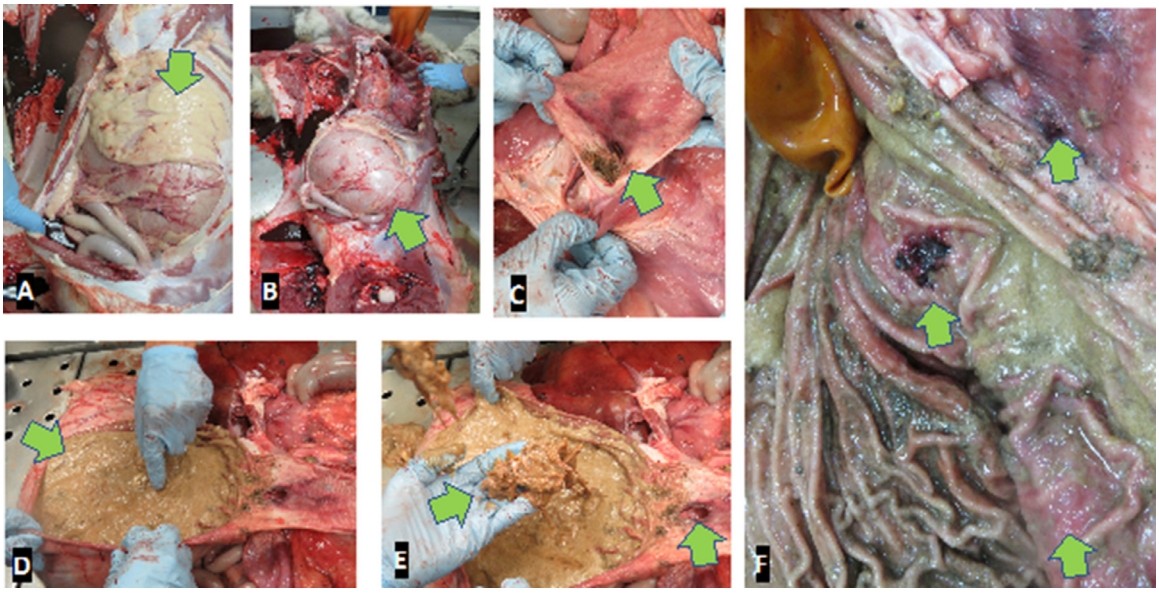

Fig. 2. Different aspects of the necropsy: (A) Access to the abdominal area where the original position of the organs is observed, with the presence of epigastric fat; (B) Gastric dilation due to impaction; (C) Penetrating lesion in the oesophagus and poultry bones in the cardia; (D) gastric content apparently composed of wet sand; (E) When extracting the sand, many poultry bones were found that were at least 7 days old, along with oesophageal perforation; and (F) Presence of ulcers in the fundus and over the entire gastric mucosa.

(Albernaz et al., 2017). Diarrhoea in cases of partial obstruction of the pylorus is associated with the osmotic effects of unabsorbed substances and the secretory action of enterocytes (Papazoglou et al., 2003). Also, foreign bodies are often associated with complications, such as perforation of the oesophagus or other gastroenteric structures, stricture, inflammation and aspiration pneumonia, all compatible with what was observed in our necropsy. The abscess formation and perforations found in the tigress are among the most common complications associated with oesophageal foreign bodies (Hayes, 2009).

Large felids have a large, non-compartmentalized stomach compared to the rest of their gastrointestinal tract, which allows them to ingest large quantities of food (AZA, 2016). In contrast, their small and large intestines are short compared to other carnivores. Additionally, transit is rapid to tolerate high exposure to bacteria and the passage of large components of the diet such as bones,

skin and hair (Anderson et al., 2018). In the wild, tigers occupy a wide variety of ecosystems with different feeding regimes and it is known that their feces may contain soil and other inorganic materials (Patel et al., 2021). It is possible that geophagy in small quantities can help improve food intake through modification of the conditions in the digestive tract, such as pH, buffering capacity, osmotic pressure, and the dilution rate of food (Slamova et al., 2011). That is especially important in tigers that consume large quantities of bones, hair and skin. However, in captive animals, the consumption of non-food substances has been highlighted as a compulsive disorder resulting from restrictive and barren environments. It is possible that the consumption of small fragments of soil or sand as a self-medicating process can be exacerbated by negative mental states such as frustration, boredom, pain and suffering in captive animals.

Cognitive, psychological, and behavioural complexity are relevant to an individual's experience in captivity because greater cognitive complexity increases the need for a complex environment and experiences (Marino et al., 2020). The motivation of the tigress to ingest sand may have been to alleviate the indigestion produced by the poultry bones in the stomach, causing the impaction. Fouling the poultry with soil could have produced regional relief, but in this case proved lethal. Another factor to take into account is the age of the tigress and gastric ulcers, which suggest a history of digestive problems. It is possible that the consumption of sand could have been gradual. In captive carnivores, gastric ulceration is often caused by prolonged stress, as well as being associated with the bacterium *Helicobacter pylori* (Marino et al., 2020). Gastric disorders such as ulcers have also been associated with oral stereotypies and is a common cause of death of captive orcas (Jett et al., 2017). Likewise, the constrained housing and lack of environmental stimulation may have helped in the development of the disease. However, any definite conclusions regarding the latter depend on behavioural data in the weeks leading up to the critical condition, which are not available. It would have also been advantageous to perform a bacteriological culture. However, more research is needed to determine underlying physiological and emotional factors that may motivate captive large felids to ingest certain amounts of soil or other housing substrates.

Every year, zoos around the world are visited by millions of people attracted especially by the so-called charismatic megafauna, such as the large felids (Von Essen et al., 2020). There is evidence that the popularity of these species helps zoos to fulfil their conservation mission, both by increasing the funding available for conservation and by contributing to education and awareness of conservation issues among the public. However, these animals also attract the concern of public opinion, animal rights organizations and the media (Hosey et al., 2020). In this context, our findings show that although geophagy is an occasional behaviour in large wild felids, in captivity it can pose a risk to their health and welfare. Therefore, keeping large felids in captivity should be restricted to zoos or sanctuaries with sufficient space, specialized facilities and proven experience in their breeding and management. Without these conditions, the keeping of large felids in zoos is incompatible with health and welfare and should be phased out (Ward et al., 2020).

Conclusions

The lethal gastrointestinal impaction that led to the death of the tigress was related to underlying gastrointestinal disease (ulcers) and the voluntary ingestion of large amounts of sand. The result suggest that care should be taken when feeding captive felids excessive amounts of bones or carcasses, especially older animals in fairly barren environments. Animal welfare in captivity involves a series of challenges that go beyond providing an adequate diet in both quantity and presentation and involve understanding complex behaviours such as the motivation to ingest non-food substances. Further investigation is needed to determine why felids may choose to ingest geo-sediments and whether that behaviour reflects an underlying self-medication strategy or behavioural disorder.

Authors' Contributions

The necropsy and associated report were performed by RSH. The case report was conceived and written by MV and GCML.

Ethical considerations

Ethical considerations are applicable in this case report because it is the product of a necropsy.

Conflict of Interest

None of the authors have any conflict of interest to declare.

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