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Research article

A debilitating digestive condition in captive red panda *Ailurus fulgens* with animal welfare implications for the global population

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Abstract

Investigations into the possible cause of a recurring, debilitating digestive condition in a male red panda *Ailurus fulgens* held at Perth Zoo, and a subsequent global survey in 2012 of 76 institutions managing the species, indicate that similar signs are widespread amongst the global zoo population of red pandas. Neither medication nor dietary interventions appear to provide any significant relief for affected animals. There is a strong bias in the geographic distribution of affected animals (in terms of the country of their birth), suggesting that there may be either a genetic basis for or some factors associated with early-life dietary regime affecting the prevalence and current distribution of animals exhibiting the condition. The condition warrants further investigation which will inform future decisions on whether captive breeding for release of red pandas should include affected animals.

Introduction

The red panda *Ailurus fulgens* is a charismatic species represented at 313 institutions on the Species360 Zoological Information Management System global database (as at 9 March 2020). The taxonomy of red pandas is not settled, with two taxa recognised by Jones (2011) as distinct species (*A. fulgens* and *A. styani*), while the Species360 database (https://www.species360.org/) recognises two sub-species *A. f. fulgens* and *A. f. refulgens*. The red panda is listed as Endangered under IUCN Red List criteria (Glatston et al. 2015; IUCN 2019) at the species (*A. fulgens*) level but the assessment also includes reference to two sub-species *A. f. fulgens* and *A. f. styani*, with the latter considered a junior synonym.

The global zoo population on 9 March 2020 for both taxa was 820 (*A. fulgens* n=568 and *A. styani* n=139, with a further 113 animals not assigned to either sub-specific taxon). The captive population in zoos was founded on a very small number of animals (<50) taken from the wild during the period 1908–1940 (Jones 2011). In the 1980s and 1990s, additional wild stock was added to the zoo population (Glatston 2011). The captive population is managed under a global species management plan (for *A. f. fulgens*) (WAZA 2012). Recent research has proposed that the viability of captive collections of red pandas is probably not as secure as it could be due to lengthy generation time (6 years), limited breeding in captivity with a small number of individuals contributing a disproportionate amount to the reproductive output, and a high mortality rate in very young and very old animals (Northrop and Czekala 2011; Tanaka and Ogura 2018).

Primary case

Perth Zoo in Western Australia has held red pandas since 1995, and at the beginning of 2007 held one male and two female red pandas. The male [Global Accession Number (GAN) MIG12-2996554] was born in Erie Zoological Gardens, USA in 2005, and resided there for 12 months before being transferred to Cincinnati Zoo to undergo a 19-week quarantine period prior to being exported to Perth Zoo. He settled well and bred successfully on two occasions with one of Perth Zoo's female red pandas. Initially, this male red panda was in good health, but within a few months of arrival he presented with a condition typified by periodic inappetence, soft to liquid faeces that were often foul smelling, and bouts of general lethargy. These signs have been described in the published literature as affecting both red (AZA Small Carnivore TAG 2012; Bissel et al. 2004; Joost and Ramsay 2011) and giant *Ailuropoda melanoleuca* pandas (Liu et al. 2006; Williams et al. 2016). Dietary changes during weaning have also been shown to be important in red panda cub survival during the first year (Williams et al. 2018). The signs in the Perth Zoo animal lasted for periods of 1 to 3 days. As the animal grew older, both the frequency and duration of the bouts of illness increased (Appendix 1, Figure 1). Most bouts occurred during the austral spring and summer.

The two adult female red pandas that were housed in adjacent enclosures never presented with these symptoms of ill health, and nor had the signs been seen in any of the 28 red pandas that had been held at Perth Zoo prior to the arrival of the animal in question. Medical history reports obtained from the zoos where this animal was born and later transacted to prior to coming to Perth Zoo indicate no evidence of prior bouts of anorexia and lethargy.

Initial investigations into possible causes for the ill health of the male red panda concentrated on the high seasonal intake of fruit from the tree in his enclosure (Port Jackson fig *Ficus rubiginosa*) and possible faecal contamination from wild birds (rufous night heron *Nycticorax caledonicus*) that roosted in the trees in his enclosure. Faecal culture was undertaken on at least 15 occasions from 2007 to 2012, but there were no consistent findings, and many cultures demonstrated non-pathogenic intestinal flora. Potential pathogens isolated on various occasions include *Plesiomonas shigelloides, Escherichia coli, Campylobacter jejuni* and *Clostridium* spp.

Abdominal ultrasound examination in 2009, conducted 29 d after the most recent bout of illness, demonstrated evidence of mild scarring of the pancreas, suggestive of previous bouts of pancreatitis. However, no active pancreatitis was present at the time of ultrasound and no other abdominal abnormalities were detected. Histopathology of full thickness punch biopsy samples, taken from the animal's stomach, duodenum and colon 9 d after a bout of illness, were largely unremarkable. The only abnormal finding was that the lamina propria of the colon was mildly and diffusely oedematous.

The presumptive veterinary diagnosis was that the panda was suffering recurrent episodes of pancreatitis or colitis. Presumptive treatments for these conditions were given including oral metronidazole (two-week courses when diarrhoea was seen), oral salazopyrin (two courses of continuous medication for four and seven months), probiotics and symptomatic treatment on some occasions with antibiotics (generally amoxicillin/clavulanic acid) and prednisolone. There appeared to be some remission in 2009 at a time when the animal was under treatment with metronidazole, but overall, there were no marked changes in the frequency and duration of sickness episodes associated with ongoing or symptomatic treatments. Monitoring the response to treatment was complicated by the red panda's variable compliance with taking oral medication and by the long periods he spent out of sight at the top of the tree in his enclosure.

The red panda continued to show episodic signs of illness until his sudden death in September 2012 at 7 years and 3 months of age. Post-mortem examination revealed focal erosive colitis and dysbacteriosis (*Enterococcus* sp. light growth, non-haemolytic E. coli light growth, *Clostridium* sp. moderate growth, *Salmonella* spp. negative, *Lawsonia* spp. negative, *Clostridium difficile* negative). There were no histological abnormalities in the small intestine nor in the pancreas. The final diagnosis was inconclusive.

To get a better understanding of what might have been causing the ill health of the male red panda, contact was made with the Global Species Management Program (GSMP) co-ordinator, based in the Netherlands, and with the staff responsible for red pandas at Knoxville Zoo, USA. In those discussions, a general condition in red pandas similar to what had been observed in the Perth Zoo

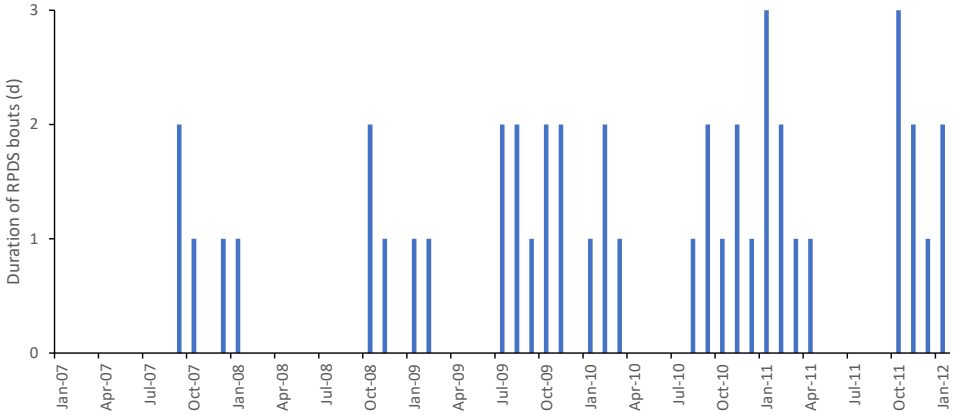

Figure 1. Timing, frequency and duration (days) of bouts of red panda digestive syndrome (RPDS) in male red panda (GAN MIG12-2996554) at Perth Zoo during 2007–2011.

animal was described and had variously been referred to as the 'summer slump' or 'panda blahs'. Hereafter in this paper, this condition is referred to as red panda digestive syndrome (RPDS).

Addressing welfare issues that affect captive animals in small breeding programmes is important to ensure that as many animals as possible are available to contribute to the sustainability of the species management program, regardless of whether specific welfare issues directly influence reproduction (Greggor et al. 2018; Salas et al. 2018; WAZA 2005). The tenets established by the World Association of Zoos and Aquariums' Animal Welfare Strategy (Mellor et al. 2015) make it clear that any animal held in a zoological collection should be managed to achieve optimal welfare at all times. This paper describes the results of a questionnaire sent to zoological institutions around the world to determine whether our observations were singular, and if not, to what extent red pandas are affected.

Methods

A simple questionnaire (Appendix 1) was designed to identify which institutions kept red pandas (or had done so in the recent past) and which of those animals had shown similar signs to those experienced by the animal at Perth Zoo. Information was only sought at the species level, with no attempt to allocate responses to either of the recognised subspecies. At the time of the survey, the Species360 database was not in operation, but the system was accessed retrospectively in 2019 to determine which subspecies were being held by respondent institutions at the time of the survey.

The questionnaire was prefaced with a brief covering letter outlining the identity of the author (BLT) and the reason that the questionnaire had been devised and was being circulated. A brief description of the signs that had been observed in the male red panda at Perth Zoo up until December 2011 were provided, along with a graph showing the frequency and duration of bouts of ill health, a precursor to Figure 1. The questionnaire was circulated to institutions known to hold, or thought to be holding, red panda on 15 September 2012 via the GSMP coordinator on behalf of Perth Zoo. The recipients were given until February 2013 to respond. More specific questions about diet or plants growing in enclosures were only directed at facilities that had experienced cases similar to that described above; therefore, it was not possible to evaluate whether these characteristics differed between facilities that did and did not experience the problem. Some of the responses were evaluated statistically using an online statistical package (GraphPad quickcalcs: www.graphpad.com)

Results

A total of 76 responses (34% of the total number of institutions known to be holding red panda in 2012; Species360 2014) were received from 20 countries (Table 1). Eight of the responding institutions held only *A. styani*. Twenty-seven of the responding institutions (35.5% of respondents located in seven countries) reported that at least some of the red pandas held in their institutions suffered from signs similar to those manifesting in the male red panda at Perth Zoo. Twenty-one (77.8%) of those institutions reported that animals exhibited signs consistent with RPDS on an annual basis. More than 80% of red panda exhibiting signs of RPDS were born in the USA or Japan (Table 1).

The Species360 database showed that for the 76 responding institutions that were holding taxa or subspecies (Table 2), there was no significant difference (Fisher's exact test P=0.179) in the presence or absence of signs of RPDS with regard to taxon (*A. fulgens, A. f. fulgens, A. f. refulgens* or unspecified).

Table 1. Number of institutions holding red panda that reported cases of animals with red panda digestive syndrome (RPDS) symptoms, by country of birth of the red pandas. Figures in parentheses are the percentage of institutions that reported observations of the syndrome by country of origin.

Country	Number of institutions holding red panda	Number (percentage) of institutions where cases of RPDS were observed
Australia	6	1 (3.7)
Belgium	1	
Canada	1	1 (3.7)
Czech Republic	1	
Denmark	3	1 (3.7)
France	4	
Germany	5	
Hungary	1	
Ireland	3	
Japan	14	8 (29.6)
Netherlands	2	1 (3.7)
New Zealand	1	
Norway	1	
Poland	3	
Slovenia	1	
Spain	2	
Sweden	1	
Switzerland	1	
UK	4	1 (3.7)
USA	21	14 (51.8)
Total	76	27

Table 2. Number of responding institutions (n=76) that reported red panda digestive syndrome (RPDS) signs, according to taxon held.

	Ailurus fulgens ssp. not specified	*A. f. fulgens*	*A. f. refulgens*	Unknown
Red panda with RPDS signs	2	13	3	7
Red panda without RPDS signs	9	32	5	5

The institutions keeping red panda reported that they had held the species at their institution for an average of 21±17 years (mean±s.d., range 2–80 years, n=76). Of the 27 institutions that reported on the season and frequency of occurrence of RPDS, 21 (77.8%) reported recurring bouts of illness. Sixteen respondents reported on the seasons when bouts occurred, with 6 (37.5%) observing them during summer, 9 (56.2%) in autumn, 4 (25.0%) in winter and 8 (50.0%) in spring. Note that no information was sought to determine the housing conditions in which the red pandas were kept during winter months (i.e. indoors or outdoors).

A total of 113 male and 117 female red pandas were being kept by the 76 respondents at the time of the survey, of which 34 (30%) of the males and 31 (26%) of the females were reported as exhibiting signs of RPDS, indicating that the sex of the animals was not a significant factor in expression of signs (χ^2=0.366, P=0.54).

Five respondents reported that nine affected animals had been hand-reared, compared with 25 respondents who reported keeping 54 parent-reared affected animals. Of those respondents who provided information on the duration of parent rearing of affected animals, the average duration ranged from 7.8 ±1.3 months (n=4 animals) to 1.0 ±0.1 years (n=12 animals).

The responses to the question regarding the age at which the red pandas first showed signs of RPDS indicated that the onset of signs could occur at any age from less than 12 months, right through to the end of life (around 10+ years). There was no significant difference (t=0.738, P=0.501) in the age of first onset of signs between the sexes.

There was no significant effect of season on the reported incidence of RPDS (χ^2=1.92, P=0.590). Twenty-one of the twenty-six survey respondents that reported RPDS also answered the questions relating to the presence of vegetation in the animals' enclosures. Two respondents indicated that there was no vegetation in their red panda enclosures and three respondents did not specify what type of vegetation they provided in enclosures. The information provided by the 21 respondents indicated that the vegetation incorporated into enclosures housing affected red pandas was quite variable, ranging from grasses through to plants that provided flowers, leaves and fruits on which the pandas could feed. Since we did not ask institutions that did not observe RPDS about the plants in their enclosures or diets, no conclusions about a relationship with enclosure plants or diet can be drawn at this stage. Nineteen of twenty-seven respondents who answered the question on housing arrangements reported that various species of free-ranging wildlife had access to the red panda enclosures. Wildlife species with routine access to red panda enclosures included birds (several species), rodents (squirrels and chipmunks), racoons *Procyon* spp., small felids, small cervids (muntjac), snakes and brush-tailed possums *Trichosurus* spp.

Ten (40%) of the 25 institutions holding red panda showing signs of RPDS reported giving medical treatment to affected animals. Treatments were varied and included oral electrolytes, probiotics, herbal and vitamin supplements, anti-inflammatories (meloxicam), antibiotics (enrofloxacin, orbifloxacin, amoxicillin/clavulanic acid), anti-parasitics (ivermectin), anti-emetics (metoclopramide), butyric acid and gastric ulcer treatments (famotidine, cimetidine).

Information provided by respondents on the diets fed to red pandas generally indicated that a mix of commercial pellets, fruit (especially pears) and bamboo made up the bulk of the diet in most institutions. Only eight (32%) of the twenty-five respondents who observed RPDS indicated that they altered diets in response to the red pandas showing ill health. Those changes varied from decreasing the amount of food offered to reduce wastage, to increasing the fluid intake, increasing the amount of dry food, either increasing or decreasing the amount of fruit and increasing the amount of bamboo.

Only 10 respondents provided feedback on whether the treatments (veterinary or diet manipulation) provided an improved welfare outcome. Five of these ten respondents felt that improved welfare ensued. Those five respondents who indicated that treatments did work, confirmed that the regime worked on all red pandas to which it was applied. Three respondents found that the affected animals recovered quickly once they were provided with additional fresh bamboo or bamboo powder in their diet.

Discussion

This study has demonstrated that at the time of the survey (late 2012), RPDS was both widespread amongst the zoological institutions (n=27) holding red panda, and common (27% of the 230 red pandas reported on). There appears to be a preponderance of affected animals in North American and Japanese institutions, but it is not clear whether this is simply a reflection of where most of the founding and extant captive populations were held and the locations to which the progeny from those founders have been distributed. It is noteworthy that affected animals are very uncommon in European institutions or in institutions in the southern hemisphere. Research into the pedigree and husbandry of animals in institutions with affected and healthy red pandas is required to shed further light on whether this condition is inherited, passed from mother to offspring, or can be linked to specific husbandry conditions. We were not able to investigate this issue further as at the time of our survey, the studbook feature within the Species360 software system had not been developed and deployed. The availability of pedigree data held in the Species360 Zoological Information Management System may allow a more detailed assessment of this issue.

The disease affects the sexes equally and can first manifest itself at any age from yearling to more than 10 years of age. Once red pandas first show signs, bouts typically recur for the remainder of the animal's life. Information provided by the respondents to our survey indicates that a range of veterinary interventions have been applied to affected red pandas, but that most were supportive in nature and none appeared to provide a permanent solution to the problem. An equally wide range of dietary manipulations have been applied once the animals began to show signs of RPDS, but again the results have been variable. Given that the duration of bouts is typically only 1–3 days regardless of whether 'treatment' is applied, it is difficult to determine whether dietary manipulations provide any useful relief.

The various charters or strategies under which the regional and global (World Association of Zoos and Aquariums) representative zoological institutions operate have a common theme of striving for the highest quality of animal welfare for collection animals. The fact that red pandas that are affected by RPDS are able to breed successfully and do not appear to have significantly shorter lifespans does not mean that the syndrome should be ignored. Given the observation that affected animals suffer recurring bouts, and our observations with the single affected red panda at Perth Zoo that both the frequency and duration of the bouts increase with time, there is clearly an animal welfare issue requiring further investigation.

Prior to the sudden death of the Perth Zoo animal, abdominal ultrasound of the other two red pandas held at Perth Zoo identified one individual with abnormal pancreatic echogenicity, consistent with pancreatic scarring. This finding contrasts with the ulcerative and necrotising suppurative colitis reported in giant pandas showing mucoid faeces (Williams et al. 2016). In domestic carnivores, this finding suggests that the animal has had previous bouts of pancreatitis from which it has recovered. A second zoo in the Australasian region has also undertaken pancreatic sonography of its red pandas and has likewise found one of four

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individuals with pancreatic abnormalities consistent with scarring (S. Young, personal communication). None of the animals with sonographic abnormalities appeared to be clinically unwell, nor were significant clinical signs reported. This reflects the situation in domestic cats, where a high proportion of apparently healthy cats may demonstrate pancreatic lesions at necropsy (Černá et al. 2020). This finding suggests that further diagnostic workup on affected individuals should include evaluation of pancreatic digestive enzymes and abdominal ultrasound, and possibly also pancreatic biopsy.

An association between inflammatory bowel disease, cholangitis and pancreatitis (referred to as 'triaditis') has been postulated in cats. The aetiology of this syndrome is poorly understood; clinical signs may be overlapping and non-specific, and include anorexia, lethargy, dehydration and weight loss (Černá et al. 2020). The post-mortem evidence of colitis in the Perth Zoo red panda, and the sonographic evidence of pancreatic scarring, may be consistent with a similarly multi-systemic syndrome.

Haematology and serum biochemistry changes in cats with triaditis, and domestic carnivores with pancreatitis, are often non-specific. The Perth Zoo red panda demonstrated mild increases of pancreatic enzymes (amylase and lipase) on several occasions, but there were few consistent abnormalities in the blood picture.

The types of vegetation incorporated into enclosures housing red pandas suffering from RPDS were varied, and some included plant types that would not be expected to contribute to digestive complaints. The natural diet of the red panda consists almost exclusively of bamboo, which is high in fibre, low in fat and low in simple sugars. In contrast, the diets of the red pandas in this survey were more variable, had a lower percentage of bamboo and generally also included readily digestible pellets and fruit. Zoo diets with a relatively low bamboo component may therefore predispose susceptible red pandas to maldigestion, inflammatory intestinal disease and dysbiosis, which could potentially precipitate episodes of pancreatitis. In the case of the Perth Zoo red panda, this may also explain why signs were most often seen in summer and autumn (i.e. during the fig fruiting season), and why there was anecdotal evidence in survey results of a positive response to an increase in bamboo content in the diet.

Considering the current small size of the global zoo population, and no information as to whether the syndrome is found in representatives from one or both taxa in the wild, it is worth considering whether such a small global zoo population could sustain a radical change such as omitting all affected animals from future breeding efforts. This may not be an issue for studbook keepers if captive breeding to support reintroduction of red pandas into natural habitats is not a current goal of the GSMP. If there is no intention to breed for release to the wild, but rather to simply maintain insurance populations in captivity, then it may not matter whether there is a genetic basis for a predisposition to this disease as long as the animal welfare aspects of the condition can be adequately managed.

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