Frothy bloat and serous fat atrophy associated with insufficient fibre intake in a giraffe (Giraffa camelopardalis)

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Frothy bloat and serous fat atrophy in a giraffe (Giraffa camelopardalis) with chronic respiratory disease

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Abstract

Malnutrition is a common cause of morbidity and mortality in captive giraffe (Giraffa camelopardalis). Frothy bloat, a nutrition-related disease of domestic ruminants, has not previously been reported in Giraffidae. A 10-year-old female reticulated giraffe (G. c. reticulata) had a chronic cough and died in February 2007 following a two-month period of weight loss. Multiple nutrition-related abnormalities were identified post mortem: frothy bloat appeared to have been the immediate cause of death; there was no fibrous material in the forestomachs; and rumen contents were mildly acidotic. There was also serous atrophy of multiple fat deposits and acute exudative interstitial pneumonia. The giraffe’s low (structured) fibre intake was associated with provision of ad libitum (ad lib) pelleted food, lucerne hay that had appeared unpalatable, and insufficient browse. The low fibre intake would have predisposed to frothy bloat and ruminal acidosis. Serous fat atrophy (emaciation) was probably due to inadequate overall food intake (associated with respiratory disease, frothy bloat and rumen acidosis) and increased energy demands (respiratory disease and winter temperatures). Sufficient fibre intakes in giraffe must be assured, by restricting concentrate provision and by feeding high quality, palatable roughage. Zoos should endeavour to find methods of feeding ad lib browse to giraffe.

Keywords

Giraffidae, browsers, malnutrition, acidosis, pneumonia

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Introduction

The giraffe (*Giraffa camelopardalis*) is a selective browser (Bush 2003; Hummel and Clauss 2006). Free-living giraffe browse trees such as *Acacia* species, consuming leaves and shoots in preference to other plant parts (Nowak 1999; Bush 2003; Hummel and Clauss 2006). The rumen of giraffe is anatomically adapted to a browse diet (Clauss et al. 2002), and, as the largest ruminant species, giraffe consume a large amount of food (Clauss et al. 2002; Hummel and Clauss 2006). The dietary specialisation of giraffe, and their large intake requirement, makes them challenging animals to feed in captivity (Clauss et al. 2002; Clauss et al. 2003). In most captive collections it is impossible to feed browse ad libitum (ad lib) because of the enormous quantities that would be required (Hummel and Clauss 2006). Captive diets are therefore a substitute for ad lib browse (Hummel and Clauss 2006).

Our understanding of the nutritional requirements of giraffe has improved considerably in recent years: diets must contain sufficient roughage to satisfy the animals’ behavioural and physiological needs (Hummel and Clauss 2006); the roughage should be highly digestible in order to maximise intakes (Clauss et al. 2002; Clauss et al. 2003); and roughage should be supplemented with specially-formulated concentrates to maximise energy provision (Hatt et al. 2005; Hummel and Clauss 2006). However, nutrition-related disease remains the most common cause of morbidity and mortality in captive giraffe (Clauss et al. 2006). Forty-eight per cent of giraffe that died in EEP collections from 1962 to 2003 were emaciated or in poor body condition, and serous fat atrophy (indicative of negative energy balance) was observed in the majority of these cases (Clauss et al. 2006).

Frothy bloat is a common disease of domestic cattle (Eddy 2004), which does not appear to have been reported previously in giraffidae. The following report describes a giraffe with chronic respiratory symptoms, in which frothy bloat, serous fat atrophy and acute interstitial pneumonia were diagnosed post mortem. A consideration of the nutritional diseases in this case highlights predisposing factors and dietary improvements that would be recommendable in this, and other, collections.

Case report

Clinical history

A captive-born female reticulated giraffe (*G. c. reticulata*), of estimated bodyweight 550 kg, was housed with four conspecifics at ZSL Whipsnade Zoo, UK. The herd received ad lib lucerne (alfalfa) hay (sourced from a local farm)
and ad lib browser pellets (Browser Breeder). In addition, 750 g linseed pellets (Linseed Lozenges) and 10 g vitamin E and selenium supplement (Equivite® Vitamin E and Selenium) were fed daily with the browser pellets in each of five feed-bowls. Up to five chopped fruits and vegetables (e.g. apples, bananas and carrots) were fed three times a week, and mineral licks (Red Rockies®) and fresh water were constantly available. In summer months (April to October), several branches of browse (a deciduous species such as horse chestnut, ash, sycamore or hazel) were fed to the herd once or twice daily. The actual amounts of roughage (including browse) fed were not measured. Food intakes that were measured are noted in the text. The animals’ enclosure consisted of a large barn (126 m², ceiling height 10 m) and an outdoor concrete yard (300 m²). In summer, the group had access to the whole enclosure 24 hr daily. In winter (November to March) the animals were confined in the barn from 4 pm to 8 am daily. The group had daily access to a grass paddock when weather was permissible. In winter, wall-mounted radiators maintained the indoor temperature at approximately 15–20°C.

The giraffe of interest developed a cough, and started to lose body condition, in April 2006. The cough initially resolved following antibiotic treatment (3.75 g trimethoprim and 18.75 g sulphadiazine, once daily [s.i.d.] for five days, per os [p.o.]; Equitrim granules). The animal’s body condition, however, continued to deteriorate. The giraffe’s appetite appeared poor – its intake of lucerne hay appeared low, and its estimated daily concentrate intake was 2.5 kg (e.g. recommended food intake for a 600 kg giraffe: 5.7–8.1 kg DM/day; Hummel and Clauss 2006). In May 2006 the giraffe was examined in a crush: clinical examination was unremarkable. Blood was sampled from the left jugular vein, which revealed a hypoalbuminaemia (18.5 g/l; reference range 31 ± 6 g/l, N = 64; ISIS 2003) and hyperglobulinaemia (66.6 g/l; 54 ± 10 g/l, N = 64); other biochemical and haematological values were within normal limits. Courses of marbofloxacin (960 mg s.i.d. for 10 days, p.o.; Marbocyl P 80 mg) and flunixin (500 mg s.i.d. for 10 days, p.o.; Finadyne Granules) were subsequently administered. From June 2006, the giraffe was separated from the herd overnight in a gated stall within the barn, and it was fed extra foodstuffs: ad lib grazer pellets (Whipsnade Grazer), fresh-cut lucerne (wilted for several days prior to feeding) and additional browse.

Over the following month the giraffe’s appetite improved. It ate fresh-cut lucerne and browse in preference to other foodstuffs. The cough recurred in July 2006, and courses of antibiotic (2.5 g trimethoprim and 12.5 g sulphadiazine s.i.d. for 4 weeks, p.o.) and clenbuterol (320 µg s.i.d. for 6 weeks, p.o.; Ventipulmin Granules) were subsequently administered. By late August 2006 the animal’s body condition appeared to have improved significantly. Its appetite appeared good and its intake of fresh-cut lucerne and browse appeared
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To remain high. From late July to late October 2006 the giraffe’s daily intake of compound feed (grazer and browser-breeder pellets combined) was measured, and averaged 2.8 kg.

The cough recurred again in September 2006 and persisted, despite indefinite administration of clenbuterol from mid September (320 µg s. i. d., p. o.) and further antibiotic treatment from late September (3.75 g trimethoprim and 18.75 g sulphadiazine s. i. d., p. o., for four weeks). From late October 2006 fresh-cut lucerne and browse were no longer fed, as they were no longer available. The giraffe continued to be fed ad lib lucerne hay and ad lib (grazer and browser-breeder) pellets. In November 2006 the giraffe was examined under sedation in order to investigate the cough and perform a tuberculin skin test, and three weeks later it was anaesthetised for further diagnostic investigation. Following recovery from anaesthesia, the giraffe continued to cough occasionally.

From January 2007, lucerne hay was drenched prior to feeding. From mid January, a new batch of lucerne hay was fed that appeared less palatable to all the giraffe. (This hay had been harvested relatively late in the year, using equipment suited to harvesting grass hay rather than lucerne hay.) The giraffe’s intake of hay and concentrates declined visibly throughout January and February 2007, and it lost considerable body condition. It was found dead on the morning of 21st February 2007, having appeared dull the preceding day.

Post mortem examination

A post mortem examination, following standard guidelines (Emanuelson et al. 2004), was performed the morning the giraffe was found dead. The carcass weighed 523 kg.

There was marked wastage of pectoral, epaxial, cervical and hindlimb musculature. The lungs were heavy, and consolidated bilaterally with greyish yellow material. No normal fat tissue was evident in either of the body cavities: there was serous atrophy of pericardial, perirenal and omental fat (normal fat tissue was replaced entirely with translucent, gelatinous material). The left myocardium was pale on cross-section. The tracheal mucosa and oesophageal serosa were markedly congested. Over 26 ml of bloody peritoneal fluid were present. The adrenal glands were bilaterally enlarged.

The rumen was grossly distended, and contained a copious quantity of frothy liquid ingesta. There was no roughage in the rumen ingesta, which had a pH (Bayer Multistix® 10 SG Reagent Strips) of 6.5 (normal range in domestic cattle ante mortem: 6.2–7.2; Radostits et al. 2007). Roughage was also absent from the reticulum and omasum. The abomasum contained dry, fibrous material. There were petechial haemorrhages within the non-glandular abomasal mucosa, and a discrete area of congestion and oedema within the glandular abomasal...
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mucosa. There was mucosal congestion of the jejunum, ileum and proximal caecum, and small intestinal content was watery. A worm egg count was performed on rectal content sampled at post mortem: this was negative.

**Histopathology**

The histopathological appearance of the lung tissue was consistent with acute exudative interstitial pneumonia. No infectious agents were identified histologically. The congested area of abomasal mucosa was found to be ischaemic and appeared to be an ulcer.

**Bacteriology**

*Pseudomonas aeruginosa* was isolated from multiple sites, including the larynx, trachea, liver, spleen, and peritoneal and cerebrospinal fluids. No bacteria were isolated from the lung parenchyma.

**Discussion**

Post mortem findings indicated that frothy bloat was likely to have been the immediate cause of death in a captive adult giraffe. Other gastrointestinal abnormalities identified at post mortem included insufficient fibre ingestion and mild acidosis of rumen contents. The animal was emaciated: there was marked muscle wastage and serous atrophy of multiple fat deposits. The giraffe had had symptoms of chronic respiratory disease, which would have predisposed to its condition loss, and acute exudative interstitial pneumonia was diagnosed post mortem.

To the authors’ knowledge, this is the first report of bloat in a giraffe. There was marked distension of the rumen and a copious amount of froth, indicating bloat was likely to have occurred pre, rather than post, mortem (Eddy 2004; Gelberg 2007). Bloat is characterised by “an excessive accumulation of gas in the rumen… because of a failure to eructate” (Eddy 2004). Frothy bloat (or ‘primary rumen tympany’; Eddy 2004) is the most common form of bloat in cattle, and is often fatal (Gelberg 2007). Froth obstructs the expulsion of rumen gas into the oesophagus (Gelberg 2007); death occurs because the expanding rumen compresses the thoracic cavity, compromising respiration and obstructing venous return to the heart (Eddy 2004; Gelberg 2007). The pallor of the left myocardium in this case may have been due to rumen compression. In bloated animals there may also be peripheral vascular congestion due to decreased venous return; the tracheal, and particularly oesophageal, congestion observed in this case were typical of acute bloat (Eddy 2004; Gelberg 2007).
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The lack of roughage in the reticular, rumen and omasal contents indicated that the giraffe’s roughage (structured fibre) intake had been poor. Such a poor roughage intake is likely to have meant that the animal’s concentrate intake was disproportionately high, which would have predisposed to frothy bloat (Figure 1). Excess concentrate intake may predispose to frothy bloat by a number of means (Eddy 2004; Gelberg 2007). When concentrate is degraded in the rumen small particles are produced; these trap the gas bubbles produced by rumen fermentation, which predisposes to froth formation (Eddy 2004). In addition, concentrates are rapidly fermented, which increases the likelihood of froth formation (Eddy 2004).

Excess concentrate intake also causes rumen acidosis (Clauss et al. 2002), which may itself predispose to frothy bloat (Gelberg 2007) (Figure 1). Rumen contents in this case were, indeed, mildly acidic (pH 6.5), and may well have been more acid pre-mortem than the dipstick test indicated since the pH of rumen contents rises post mortem (Eddy 2004). The abomasal ulceration and petechial haemorrhage were suggestive of chronic acidosis (Eddy 2004; Gelberg 2007). It has been recommended that the ingested forage : concentrate ratio in giraffe should be maintained above 2:1 (Hummel and Clauss 2002). If concentrate intake exceeds forage intake, ruminal acidosis and diarrhoea are more likely to occur (Clauss et al. 2002; Potter and Clauss 2005; Hummel and Clauss 2006), as are behavioural problems such as oral stereotypies (Hummel and Clauss 2006), which had been observed at a high frequency in this animal in a previous study (Black 2006) (Figure 1).

In domestic ruminants frothy bloat is often associated with excess legume intake – it is common in herds that graze pasture containing a high proportion of leguminous plants (McDonald et al. 2002; Eddy 2004). Breakdown products of legume fermentation, particularly proteins, increase the viscosity of rumen fluid and predispose to foam formation (McDonald et al. 2002). Despite its palatability, fresh lucerne should therefore be fed with caution to giraffe, because of the risk of frothy bloat (Hummel and Clauss 2006). As in this case, it should be wilted for a few days prior to feeding so that its protein content declines (McDonald et al. 2002); and introduced gradually to the diet (Hummel and Clauss 2006). Lucerne hay is recommended as forage for giraffe because it is more digestible than grass hay (Hummel and Clauss 2006): its rumen passage rate is therefore quicker than grass hay, which maximizes food intakes and reduces the risk of rumen ‘blockage’ (Clauss et al. 2002).

This giraffe’s low roughage intake was likely to have been associated with the provision of ad lib concentrates, lucerne hay of poor palatability and insufficient browse (Figure 1). Concentrates are formulated to be highly palatable and giraffe will often eat them in preference to hay (Hummel and Clauss 2006). Roughage intakes may therefore be inadequate when concentrates are fed ad
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Figure 1: Flowchart illustrating a hypothetical pathway for pathogenesis of bloat, serous fat atrophy and other abnormalities in an adult female reticulated giraffe (*Giraffa camelopardalis reticulata*).

lib (Rose et al. 2006). The batch of lucerne hay fed from mid January appeared less palatable to all the giraffe than previous batches (probably because it had been harvested too late in the year, using inappropriate equipment). Giraffes’ forage intakes are strongly influenced by the forage’s palatability (Clauss 1998; Christman 2004; Potter and Clauss 2005): unpalatable (poor quality) hay will not be eaten readily (Clauss 1998; Potter and Clauss 2005), whereas fresh forage tends to be eaten in preference to concentrates (as this case demonstrated). The low quantity of browse fed reduced the animal’s forage intake further. Palatable browse will usually be eaten in preference to other foodstuffs (Hatt et al. 2005), and, ‘diets high in browse guarantee a reasonable forage intake’ in giraffe (Hummel and Clauss 2006).

Serous fat atrophy (emaciation) was indicative of a negative energy balance (Potter and Clauss 2005; Clauss et al. 2006). This was probably due to both insufficient overall food intake and increased energy expenditure (Potter and Clauss 2005; Hummel and Clauss 2006) (Figure 1). Chronic respiratory disease,
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Frothy bloat and chronic ruminal acidosis would have reduced the animal’s appetite (Eddy 2004; Hummel and Clauss 2006), so that its overall food intake was suboptimal. Winter temperatures (which were not recorded) would have increased the animal’s energy demands; cold temperatures have been implicated in a majority of cases of serous fat atrophy (Potter and Clauss 2005). In addition, the severe pathology (chronic respiratory disease, acute interstitial pneumonia and probable \textit{P. aeruginosa} septicaemia) and probable chronic stress (indicated by enlarged adrenal glands) would have increased energy demands further.

Gradual restriction of concentrate feeding has been instigated in the giraffe herd in light of this case. Efforts are being made to ensure a sustained supply of high quality lucerne hay, and there are plans to introduce sainfoin as additional forage. Sainfoin is a highly palatable legume that is unlikely to induce frothy bloat. This is because it contains a high proportion of tannins, which bind protein and reduce its availability in the rumen (McDonald et al. 2002); it can therefore be fed fresh. It is hoped that these collective measures will lead to a sustained improvement in roughage intakes, and overall food intakes, in the giraffe herd.

Other measures are recommendable in order to monitor, and safeguard, the nutritional health of captive giraffe. The quality of roughage should be monitored regularly using laboratory analyses (Hummel and Clauss 2006) and the weights and/or body condition scores of individual giraffe should be recorded regularly (Potter and Clauss 2005; Hummel and Clauss 2006). Daily food intakes of individual giraffe should be ‘spot checked’ at regular intervals (Potter and Clauss 2005; Hummel and Clauss 2006). The temperature in indoor enclosures should also be checked regularly in winter months: temperatures should not be allowed to fall below 20 °C unless energy intakes are adequate (Christman 2004; Potter and Clauss 2005).

The specialised dietary requirements of giraffe are associated with their alimentary adaptation to an almost 100 % browse diet (Clauss et al. 2002; Clauss et al. 2003). No other foodstuffs can adequately replicate the structural and physical properties of browse (Clauss et al. 2002; Clauss and Dierenfeld 2008), so nutrition-related health problems and stereotypies in captive giraffe remain common (Clauss et al. 2002; Hummel and Clauss 2006). Captive collections must endeavour to feed substantial quantities of browse to giraffe year-round, despite the logistical difficulties and economic costs this may entail (Clauss et al. 2003; Hummel and Clauss 2006; Clauss and Dierenfeld 2008). Browse plantations, in particular, should be established where practicable (Hummel and Clauss 2006).
Conclusions

1. Frothy bloat appeared to have been the immediate cause of death in an adult female giraffe that had had symptoms of chronic respiratory disease.

2. Frothy bloat was associated with other nutritional abnormalities (insufficient fibre intake, rumen acidosis and abomasal ulceration), serous fat atrophy and acute exudative interstitial pneumonia.

3. Frothy bloat and rumen acidosis were likely to have been caused by an insufficient intake of structured fibre (roughage).

4. The animal’s roughage intake was low because of the ad lib provision of pelleted feed, the provision of unpalatable lucerne hay and insufficient browse.

5. Sufficient fibre intakes in giraffe must be assured, by restricting concentrate provision, and by feeding high quality, palatable roughage.

6. Collections must endeavour to find methods of feeding ad lib browse to giraffe.

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Products mentioned in the text

Bayer Multistix® 10 SG Reagent Strips: urinalysis strips, manufactured by Bayer plc., Newbury, Berkshire, RG14 1JA, UK

Browser Breeder: compound browser pellets, manufactured by Special Diet Services, Witham, Essex, CM8 3AD, UK

Equitrim Granules: trimethoprim and sulphadiazine granules, manufactured by Boehringer Ingelheim, Bracknell, Berkshire, RG1 8YS, UK
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Equivite® Vitamin E and Selenium: vitamin E and selenium supplement, manufactured by Spillers Speciality Feeds Ltd., Milton Keynes, Buckinghamshire, MK12 5PZ, UK

Finadyne Granules: flunixin granules, manufactured by Schering-Plough Animal Health, Lancaster, LA1 5Q1, UK

Linseed Lozenges: manufactured by I’Anson Brothers Ltd., Ripon, North Yorkshire, HG4 4JB, UK

Marbocyl P: marbofloxacin tablets, manufactured by Vétoquinol UK Ltd., Bicester, Oxfordshire, OX26 4UL, UK

Red Rockies®: manufactured by Rockies Mineral Salt Licks, Winsford, Cheshire, CW7 3PG, UK

Ventipulmin Granules: clenbuterol granules, manufactured by Boehringer Ingelheim Ltd., Bracknell, Berkshire, RG12 8YS, UK

Whipsnade Grazer: compound grazer pellets, manufactured by Charnwood Milling Company Ltd., Framlingham, Woodbridge, Suffolk, IP13 9PT, UK

References


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