An outbreak of perirenal oedema syndrome in cattle associated with ingestion of pigweed (*Amaranthus hybridus* L.)

R D Last[a*], J H Hill[a] and G Theron[b]

ABSTRACT

Forty seven of 150, 15-month-old long weaners died of an acute renal disease syndrome following introduction into an old maize field with a heavy stand of *Amaranthus* spp. The clinical syndrome was characterised by sudden onset neurological disease with ataxia and recumbency. Subcutaneous oedema, ascites and perirenal oedema with urine odour were the major gross necropsy findings. Renal histopathology revealed marked coagulative renal tubular necrosis of the proximal and distal straight tubules with intertubular haemorrhage. Acute renal failure and perirenal oedema has been described in cattle, pigs, horses and sheep associated with the ingestion of *A. hybridus* L. and *A. retroflexus* L. This perirenal oedema syndrome has been widely reported in the Americas, while in South Africa intoxication with the amaranths has only previously been associated with nitrate and possibly oxalate poisoning in cattle.

Key words: acute renal disease, *Amaranthus hybridus* L., *Amaranthus retroflexus,* bovine, perirenal oedema, renal tubular necrosis.

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INTRODUCTION

Amaranthus hybridus L. (smooth pigweed) and *Amaranthus retroflexus* L. (redroot pigweed) are erect annual weeds which are members of the Amaranthaceae family and belong to the same genus *Amaranthus* L.[8,24]. These plants occur in great abundance in the tropical and subtropical regions of Africa and the Americas[4,8,11,21]. They grow prolifically on disturbed soil sites such as ploughed fields, gardens, fallow farm lands and waste areas. Both species commonly occur together and cross-hybridisation between species has been documented[4,6,21]. Intoxication syndromes that have been described in animals associated with the ingestion of *A. hybridus* and *A. retroflexus* include renal disease, nitrate intoxication and oxalate poisoning[4,5,6,11,12,14].

Clinically the renal condition in cattle is characterised by rapid-onset weakness, trembling, incoordination, knuckling of pasterns, recumbency and death within 10 days of having access to the plant[4–6,13,22]. Gross pathology includes subcutaneous oedema, ascites, perirenal, perirectal and omental oedema and nephrosis[4–6,10,13]. Renal histopathology is characteristic of a toxic nephrosis with widespread renal tubular degeneration and coagulative necrosis; however, tubular basement membranes remain intact[6,10,13]. In the Americas, perirenal oedema syndrome is commonly reported in swine, infrequently in cattle and rarely in sheep and horses[6,9, 13–18,20]. In South Africa, *A. hybridus* and *A. retroflexus* have only been previously associated with nitrate and possibly oxalate poisoning in cattle. This report documents an outbreak of perirenal oedema syndrome in bovines in South Africa following ingestion of *Amaranthus hybridus* L.[7].

CASE HISTORY

One hundred and fifty head of 15-month-old, long weaner cattle were introduced into an old maize land, which contained a full stand of *Amaranthus* spp. Eight days after entering this field the 1st animals presented sick and a day later 8 were found dead. The clinical syndrome included fairly sudden onset ataxia, knuckling of the pastern joints and recumbency. Ventral abdominal, perirectal, perineal and subcutaneous pitting oedema was severe. Forty seven of the 150 cattle eventually died and 8 autopsies were performed.

Pathology

Gross necropsy findings included a distinct urine odour on opening the abdominal cavity, subcutaneous oedema of the ventral abdomen, perirectal oedema, perivaginal oedema with vaginal prolapse, ascites, mesenteric oedema and marked perirenal oedema (Figs 1–3). Kidneys were markedly swollen with a diffuse pale discolouration and surface petechiation (Fig. 4). Various tissues from two animals were collected into 10% buffered formalin and submitted for histopathology.

Renal histopathology showed widespread renal tubular nephrosis with coagulative necrosis of clusters of tubules, intratubular hyaline casts and intertubular haemorrhage (Fig. 5). The coagulative renal tubular necrosis was most prominent in the proximal and distal straight tubules (Fig. 6). No oxalate crystals were observed under bright field or polarised illumination. Periodic acid-Schiff (PAS) staining confirmed that the tubular basement membranes of renal tubules examined remained intact. Masson trichrome staining revealed minimal interstitial fibrosis.

Implicated plant material collected from this farm was forwarded to the Natal University Herbarium, School of Biological and Conservation Sciences, University of KwaZulu-Natal, Scottsville, Pietermaritzburg, where it was identified as *Amaranthus hybridus* L.

DISCUSSION

Amaranthus hybridus/retroflexus poisoning in cattle is considered rare as these plants are only ingested in large quantities when other more suitable and palatable forage is not available[4,6,11,17,18]. All other reported outbreaks of pigweed toxicity in cattle in South Africa have been associated with nitrate and possibly oxalate poisoning[11]. Perirenal oedema has never been previously documented[11]. The causative mechanism of the renal syndrome remains undetermined, but nitrate and oxalate do not appear to be involved[4–6,10].

Perirenal oedema syndrome in cattle and pigs follows ingestion of leafy mature

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fresh plants or regrowths of cuttings and signs develop after animals have been feeding on the leaves of the plants for several days or more (5–10 days)[4–6]. Nitrate poisoning is usually seen within 6 to 24 hours of ingesting toxic quantities of nitrate, which is at its highest level in the stems of the dried plant and is therefore more often associated with pigweed-contaminated hay[4–6,13,22]. Mortality due to nitrate poisoning is generally limited to ruminants with swine rarely experiencing lethal nitrate toxicity.[4–6,10,13,22] Nitrate poisoning involves the conversion of haemoglobin to methemoglobin with resultant tissue hypoxia/anoxia due to the inability of methaemoglobin to transport oxygen[4,10,11,13,22]. The clinical syndrome is usually peracute or acute and may be fatal within minutes to hours after ingestion, with few clinical signs[4,11,22].

Renal histopathology associated with nitrate poisoning is non-specific but features hypoxic renal tubular nephrosis with patchy involvement of renal tubules and damage to tubular basement membranes (tubulorrhexis)[10,13,22]. The histopathological changes of the perirenal oedema syndrome are distinctly different with multifocal, segmental, tubular coagulative necrosis, which is particularly severe in the proximal and distal straight tubules with associated intertubular haemorrhage, but the tubular basement membranes remaining intact[4–6,9,10,13,17,18,20].

Oxalates, which are readily accumulated by *Amaranthus* spp plants, are known to have nephrotoxic effects through accumulation of calcium oxalate crystals within renal tubules[4–6,11]. Degeneration, necrosis, and loss or renal tubules with intraluminal oxalate crystals, interstitial fibrosis, and multifocal mild lymphocytic interstitial nephritis, characterize the histopathological changes of oxalate nephrosis[10,11,13]. However, renal tubular oxalate crystal accumulation is not a feature of the histopathology of perirenal oedema[4,6,10,13]. In addition, perirenal oedema has been produced experimentally when animals were fed *Amaranthus retroflexus*, but the syndrome could not be reproduced when fed other oxalate-accumulating plants.[4,10] Therefore, a plant-derived oxalate-induced nephrosis seems unlikely in the case of the perirenal oedema syndrome.

Owing to the extensive renal tubular necrosis induced in the perirenal oedema syndrome, there is tubular obstruction, damming back of urine resulting in increased transcapsular lymphatic drainage and leakage into the perirenal connective tissue and hence the marked perirenal oedema. This is the hallmark gross pathological feature of the syn-

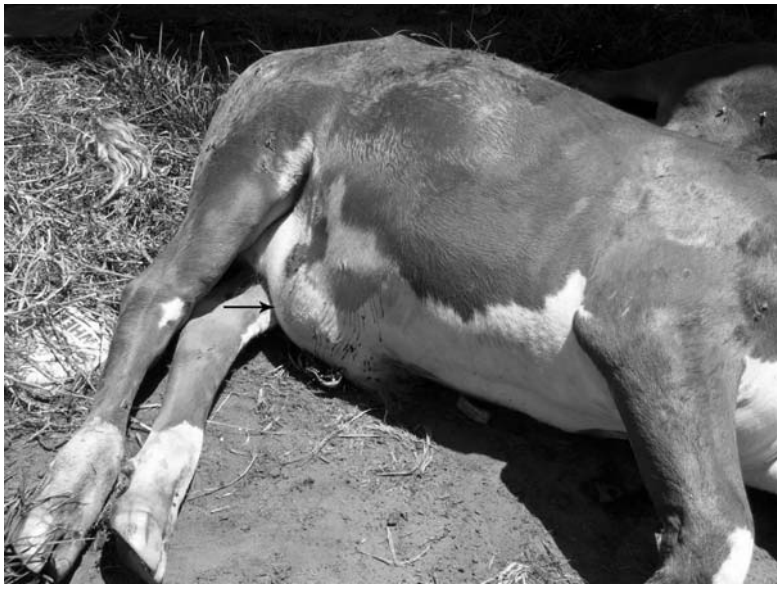

Fig. 1: **Subcutaneous ventral oedema** (arrow) **extending from the inguinal area caudally to the sternum cranially.**

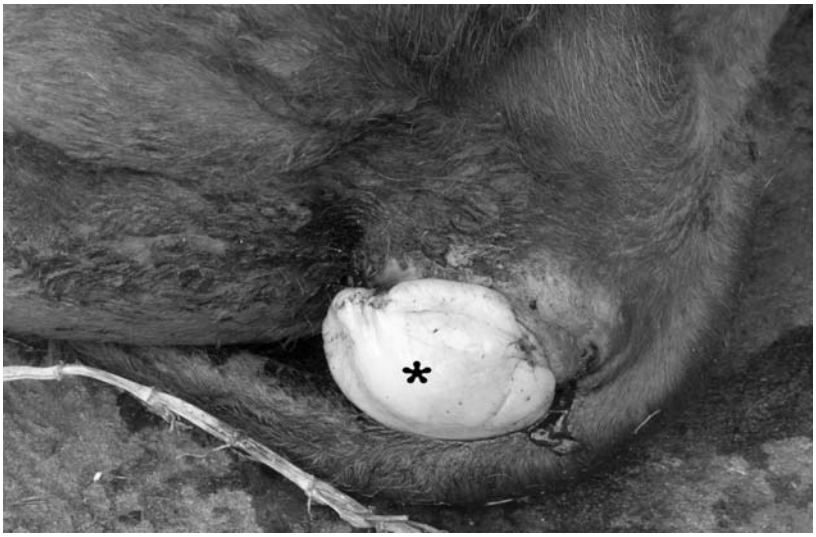

Fig. 2: **Perirectal oedema with vaginal prolapse** (asterisk) **and faecal staining of perineum.**

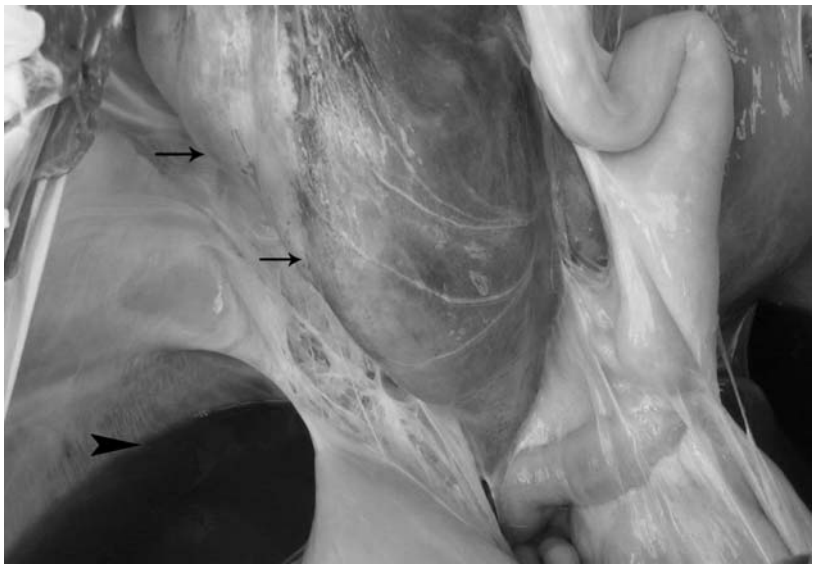

Fig. 3: **Abdominal cavity opened to reveal perirenal oedema** (arrows) **visible through the oedematous mesentery. Prominent ascites, with free-lying golden-yellow fluid in the abdomen** (arrowhead).

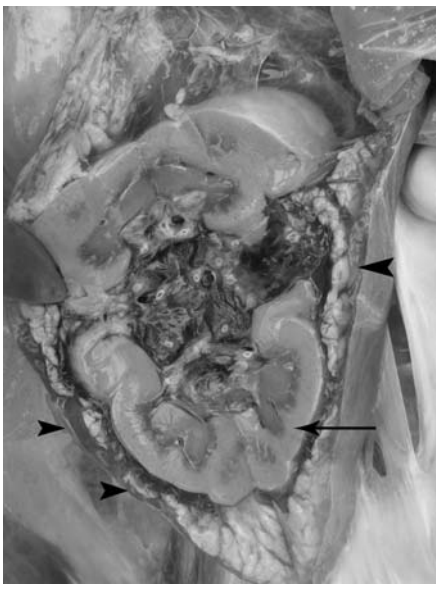

Fig. 4: **Kidney, cut surface, *in situ* within the abdominal cavity. Severe perirenal oedema encompasses the kidney** (arrowheads) **and the renal pelvis. Diffuse renal cortical necrosis** (arrow) **with diffuse pale discoloration of the full thickness of the cortex.**

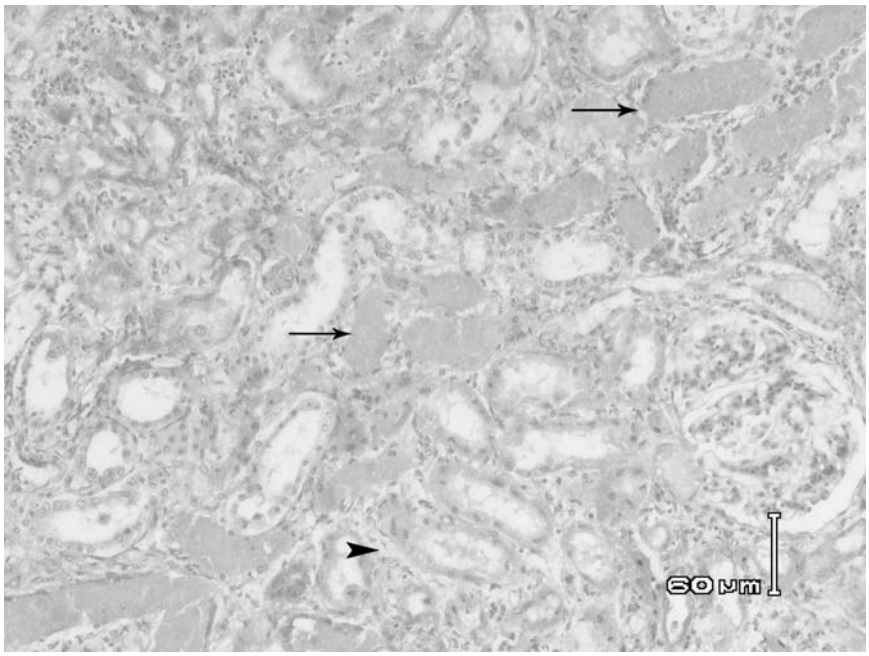

Fig. 5: **Kidney. Coagulative necrosis of clusters of proximal convolutes tubules with loss of cytoplasmic and nuclear detail** (arrows). **Intertubular oedema** (arrowhead) **with minimal fibrosis. Glomerulus visible is largely unaffected.** Haematoxylin and Eosin stain. Scale bar = 60 microns.

drome[12]. This acute renal failure causes the clinical nephrotic syndrome with subcutaneous oedema, mesenteric oedema, perirectal oedema and accumulation of fluid in body cavities[4–6,10,13]. This sudden loss of adequate renal function results in the inability to clear metabolic wastes and maintain normal fluid and electrolyte balance, with metabolic acidosis and hyperkalemia being the 2 most serious manifestations of this function loss[1,3,19]. Excretion of potassium ions is severely affected by renal tubular injury with marked hypercalaemia developing with increased risk of cardiac derived lethal toxicity[1,2,7]. Mortality in cattle is though to be the consequence of hyperkalaemic cardiotoxicosis and case fatality rates in excess of 50 % have been reported.[4,13,23]

A plant poisoning with a very similar clinical syndrome and pathology to the perirenal oedema syndrome in cattle is oak poisoning (*Quercus* sp.)[4,9,12]. The macroscopic pathological features of ascites, hydrothorax, hydroperitoneum, subcutaneous oedema, mesenteric oedema and gut mucosal oedema described are virtually identical to those of *Amaranthus*[4,5,10,13]. The renal histopathology of groups of tubules showing complete necrosis with intratubular haemorrhage and the presence of gastrointestinal erosion, distinguish *Quercus* sp. from the perirenal oedema syndrome[6,10,11,13].

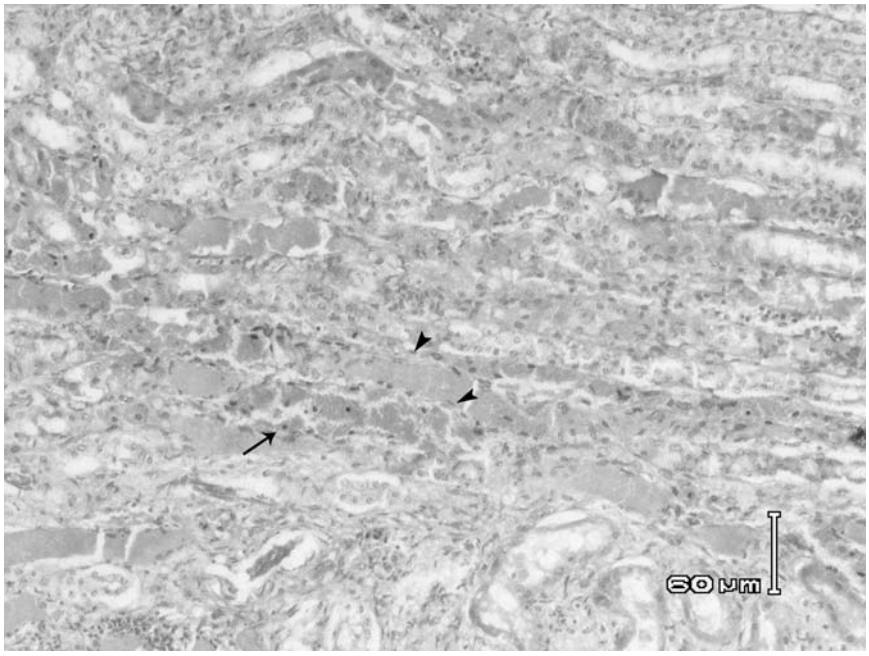

Fig. 6: **Kidney. Coagulative necrosis of distal straight tubules with loss of nuclear and cytoplasmic detail, but tubular basement membranes remain intact** (arrowheads). **Multifocal intertubular haemorrhage** (arrow). Haematoxylin and Eosin stain. Scale bar = 60 microns.

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