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AN EXPERIMENTAL MYCOTOXICOSIS IN SHEEP AND GOATS CAUSED BY *DRECHSLERA CAMPANULATA*, A FUNGAL PATHOGEN OF GREEN OATS

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ABSTRACT

SCHNEIDER, D. J., MARASAS, W. F. O., COLLETT, M. G. & VAN DER WESTHUIZEN, G. C. A., 1985. An experimental mycotoxicosis in sheep and goats caused by *Drechslera campanulata*, a fungal pathogen of green oats. *Onderstepoort Journal of Veterinary Research*, 52, 93–100 (1985).

Field outbreaks of a syndrome of unknown aetiology associated with the grazing of green oats *(Avena sativa)* in the south-western Cape Province were characterized by diarrhoea, photosensitivity and death in goats and by diarrhoea and a reduction in milk production in cows. A phytopathogenic fungus, *Drechslera campanulata*, was isolated from conspicuous reddish-brown leaf spots on oat plants collected from both outbreaks.

Pure cultures on autoclaved maize of *D. campanulata* isolates from oat leaves implicated in both field outbreaks, as well as a Canadian isolate, proved to be highly toxic to ducklings, goats and sheep. Characteristic clinical signs of the fatal mycotoxicosis caused by *D. campanulata* culture material in goats and sheep were anorexia, apathy, diarrhoea and ruminal stasis. Photosensitivity, however, was not induced. Necrosis of the forestomach mucosa was the most characteristic gross pathological change. Histopathological findings included mild focal erosions to severe, diffuse, coagulative necrosis of the mucosa in the rumen, reticulum and omasum and congestion and haemorrhages in the abomasum. These results provide circumstantial evidence that green oat leaves infected by *D. campanulata* may cause outbreaks of a mycotoxicosis in grazing animals.

INTRODUCTION

Little information is available on the toxicity to animals of fungi belonging to the genus *Drechslera* Ito (previously known as *Helminthosporium* Link) and the related genera, *Bipolaris* Shoemaker and *Exserohilum* Leonard & Suggs. One isolate of *D. sorokiniana* (Sacc.) Subram. & Jain (referred to as *Helminthosporium* sp. K6) from *Tribulus terrestris* L. plants associated with an outbreak of the ovine photosensitization disease, "geeldikkop", in South Africa has been reported to be acutely toxic to day-old chickens and ducklings as well as to weanling rats (Gouws, 1965). Histopathological examination of the livers of the animals that died revealed areas of necrosis. Culture material of this strain was also fed to 3 adult sheep. Post-mortem examination of one of these sheep that died after 15 days and one that was slaughtered after 30 days "revealed necrosis in many tissues" (Gouws, 1965). This isolate [referred to as *Bipolaris* sp. IMI 115076 or *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoemaker MRC 93] was subsequently shown to produce sterigmatocystin (Holzapfel, Purchase, Steyn & Gouws, 1966; Rabie, Lübben & Steyn, 1976) as well as several polyhydroxyanthraquinones, including averufanin, bipolarin, curvularin and versicolorin (Aucamp & Holzapfel, 1970) in culture. Although *Drechslera* spp. produce several other metabolites, including cytochalasins A, B and F (Hesseltine, Ellis & Shotwell, 1971; Shotwell & Ellis, 1976), the possible effects on animals, grazing plants infected by *Drechslera* spp. producing these compounds, are not known.

In Australia, a disease of sheep known as "romulosis" and characterized by infertility, abortion and paralysis has been associated with the ingestion of *Romulea rosea* (L.) Eckl. plants infected with a leaf spot disease caused by *D. biseptata* (Sacc. & Roum.) Richardson & Fraser (Fisher & Finnie, 1967). Culture material of *D. biseptata* caused marked reductions in breeding efficiency of female mice and male guinea pigs (Fisher & Finnie, 1967), but it has not been confirmed as the cause of "romulosis" in sheep. Although *D. biseptata* is known to occur world-wide in association with grass seeds and cereal grains (Leach & Tulloch, 1972), this fungus has not been associated with outbreaks of toxicosis in animals grazing grass or cereal pastures.

During the epiphytotic of southern leaf blight of maize (*Zea mays* L.) caused by *D. maydis* (nisikado) Subram. & Jain (= *Helminthosporium maydis* Nisikado) in the U.S.A. during 1970, considerable attention was given to the possible production of mycotoxins in infected maize (Hesseltine *et al.*, 1971). Maize naturally infected by *D. maydis* under field conditions was not toxic to cattle (Harland, Nair & Cardeilhac, 1971), poultry (Britton, 1971; Washburn & Britton, 1971), or mice (Ciegler, Richard, Ellis & Cysewski, 1972). However, extracts of cultures of several isolates of *D. maydis* proved to be toxic to mice upon intraperitoneal (i.p.) injection (Ciegler *et al.*, 1972). Extracts of *D. maydis* NRRL 3797 were toxic upon i.p. injection and topical administration to various animals, but oral administration of extracts to pigs or feeding of culture material of this isolate as the sole ration to mice caused no signs of toxicity. The mycotoxin produced by this isolate was partially purified and appeared to be a glycophospholipid. Histopathological examination revealed that upon i.p. injection the toxin acted as a severe irritant and caused death in experimental animals (Ciegler *et al.*, 1972). Another pathogen of maize, *Helminthosporium carbonum* Ullstrup, has also been reported to be toxic to mice upon i.p. injection of extracts of cultures (Hamilton, Nelson & Harris, 1968). Clinical signs in mice included reduced activity, piloerection, ataxia, prostration, respiratory distress and death. The chemical nature of the mycotoxin(s) produced by *H. carbonum* is unknown.

Extracts of cultures of *D. sorghicola* (Lefebvre & Sherwin) Richardson & Fraser isolated from grain sorghum [*Sorghum bicolor* (L.) Moench] in the U.S.A. (Diener, Morgan-Jones, Wagener & Davis, 1981) and of *D. oryzae* (Breda de Haan) Subram. & Jain isolated from rice (*Oryza sativa* L.) in India (Baruah, Baruah & Baruah, 1980) have been reported to be toxic to day-old chicks. The mycotoxin(s) present in these toxic extracts have not been identified.

D. campanulata (Lév.) Sutton [= *D. verticillata* (O'Gara) Shoemaker], the conidial state of *Pyrenophora seminiperda* (Brittlebank & Adam) Shoemaker, is a pathogen of oats *(Avena sativa* L.) and many other cereals and grasses in Australia, Canada, New Zealand, South Africa, and the U.S.A. (Alcorn, 1983; Ellis, 1971; Shoemaker, 1966; Sutton, 1976; Wallace, 1959).

This paper is the first report on the toxicity of *D. campanulata* to animals and on the possible association of oat leaves infected by this fungus with field outbreaks

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TABLE 1 Origin of *Drechslera campanulata* isolates and the toxicity of dried culture material on maize to day-old ducklings

Isolate No.	Origin	Mortality (No. dead/ No. tested)	Mean day of death (days)	Total feed intake (g)
MRC 2853	Oat leaves, Stellenbosch	4/4	5,0	10
MRC 2854	Oat leaves, Stellenbosch	4/4	6,0	34
MRC 2855	Oat leaves, Stellenbosch	4/4	5,0	14
MRC 3199	Oat leaves, Riebeek West	4/4	4,7	34
MRC 3132 (= DAOM 89350)	*Bromus* seed, Canada	4/4	5,5	48

of a mycotoxicosis in grazing animals. The mycology and phytopathology of *D. campanulata* is described elsewhere (Van der Westhuizen, Marasas & Schneider, 1985).

FIELD OUTBREAKS

Occurrence in goats

During August 1982 a disease in Boer goats characterized by diarrhoea, mortality and a few cases of photosensitivity was investigated on a farm at Klipheuwel, near Stellenbosch, in the winter rainfall area of the Cape Province.

A herd of 200 1-year-old Boer goats and 250 adult goat ewes were introduced into a 10 ha camp sown with the oat cultivar "Perdeberg". The animals were allowed to graze the oats during the day and were yarded at night. The owner noticed diarrhoea in 50 % of the herd 8 days after they were introduced to the oats. Seven goats died over the next few days and 8 more developed oedematous swelling of the head.

Examination of the field of oats revealed that the oats had been well grazed, that most of the plants appeared stunted, that many of the plants had conspicuous reddish-brown spots on the leaves and that many of the leaves were turning yellow and dying.

The animals were removed from the oat camp and no further disease developed. The herd of goats and 20 sheep were re-introduced to the camp 12 days later and no abnormal signs were noticed.

Occurrence in cattle

During September 1983, sudden diarrhoea as well as a 35 % drop in milk production occurred in the majority of 55 high producing Friesian cows on a farm near Riebeek West, Cape Province. The only change in the ration was that the supply of green oats which had been cut daily and fed *ad libitum* to the cows, came from a new field. When oats from another field was fed, the problem disappeared within 2 to 3 days.

On investigating the field of "Perdeberg" oats suspected of being toxic, it was found that the plants had seedheads emerging and reddish-brown spots were readily visible on the leaves. Some of the lower leaves were turning yellow and dying. When oats from this field were again fed to the cows about 2 weeks later, no abnormal signs were noticed.

MATERIALS AND METHODS

Isolation and culture of fungi

Fungi were isolated from leaf spots (Van der Westhuizen *et al.*, 1985) on oat leaves associated with field outbreaks of a syndrome of unknown aetiology in goats in Stellenbosch during August 1982 and in dairy cattle in Riebeek West during September 1983 (see Field outbreaks). Small pieces of leaf tissue bearing leaf spots were placed on moist filter paper discs in Petri dishes. The leaf pieces were incubated at 20 °C under near ultraviolet light (NUV) radiation until profuse development of *Drechslera* conidia occurred on the leaf spots. Single-conidial isolates on potato dextrose agar (PDA) and carnation leaf agar (CLA) (Fisher, Burgess, Toussoun & Nelson, 1982) were prepared from the *Drechslera* conidia that had developed on the leaf spots. Three species of *Drechslera* were isolated from these specimens, i.e., *D. campanulata, D. avenae* (Eidam) Scharif, and the *Drechslera* state of *Cochliobolus spicifer* Nelson.

Subcultures of 4 single-conidial isolates of *D. campanulata* (MRC 2853, 2854, 2855 and 3199) on CLA slants were incubated at 20 °C under NUV radiation until sporulation occurred. Suspensions of conidia in sterile water were used to inoculate autoclaved, moistened, yellow maize kernels. The cultures on maize were incubated at 25 °C for 21 days, dried overnight at 45 °C, ground to a fine powder in a Wiley mill, and stored at 0 °C until used. Cuture material on maize of a Canadian isolate of *D. campanulata* (= *D. verticillata*), DAOM 89350 (= MRC 3132), received from Dr R. A. Shoemaker, was prepared in the same way.

Cultures of the above 5 isolates of *D. campanulata* are being maintained in the collection of the South African Medical Research Council, Tygerberg, South Africa

TABLE 2 Toxicity of dried, milled *D. campanulata* culture material to sheep and goats

Case No.	Species	Age	Mass (kg)	Isolate No.	Dose g/kg/day	Period dosed (days)	Total dose (g)	Duration of experiment (days)	Fate
1	Sheep	5 m	26	2853	5,0	3	390	5	Died
2	Sheep	6 m	29	2854	5,0	3	435	5	Died
3	Sheep	2 y	46	2854	2,5	2	230	6	Died
4	Sheep	3 y	53	2853	0,625	5	957	19	Died
					1,25	6			
					1,875	4			
5	Goat	5 m	23	2853	1,0	20	460	23	Euthanized in extremis
6	Goat	4 m	20	2854	1,0	16	520	31	Euthanized in extremis
					2,0	5			
7	Goat	1 y	38	2855	0,6	5	202	8	Died
					1,2	2			
8	Sheep	4 m	16	2855	0,45	29	324	43	Died
					0,9	8			
9	Sheep	10 m	33	3132	5,0	4	660	5	Died
10	Sheep	10 m	27	3199	5,0	4	500	4	Died
11	Sheep	8 m	24	2855	5,0	3	360	3	Died
12	Sheep	10 m	37	Autoclaved maize meal	5,0	5	925	7	Killed
13	Goat	4 m	14	—	—	—	—	31	Killed

TABLE 3 Chemical pathological changes in the blood of sheep and goats dosed with *D. campanulata* culture material

Case No.*	Days after beginning of dosing regime	γ-GT (iu/ℓ at 25 °C)	AST (iu/ℓ at 25 °C)	Total bilirubin (μmol/ℓ)
1	2	147	185	32,0
	3	112	159	82,0
2	2	59	80	9,7
	3	57	86	39,0
3	0	32	26	6,4
	2	28	41	5,3
	4	25	84	3,6
4	0	32	31	1,6
	4	28	85	1,8
	6	32	79	1,7
	8	27	65	2,6
	11	32	84	2,9
	13	29	79	2,3
	15	66	280	5,0
	18	90	225	31,4
5	1	15		3,0
	4	19		2,9
	8	16		6,3
	11	19		2,0
	15	19	104	2,2
	18	17	122	2,5
	23	32	195	15,7
6	1	23		4,5
	4	24		5,4
	8	23		3,5
	11	22	67	2,5
	15	25	80	2,9
	18	25	70	3,3
	23	91	167	8,3
	25	70	158	7,0
	29	37	78	5,3
	31	25	99	18,2
7	1	37	24	3,8
	5	42	38	5,8
8	1	29	54	2,9
	5	38	110	8,4
	7	26	104	5,0
	16	32	151	2,1
	21	32	99	3,5
	26	24	84	1,7
	40	31	85	11,5
	42	28	133	63,8
13	1	21		6,1
	4	20		3,6
	8	19		3,5
	15	21	28	2,9
	18	17	19	2,9
	23	17	24	2,1
	25	19	19	2,4
	29	19	13	2,1

* See Table 2

(MRC), and have also been deposited in the American Type Culture Collection, Rockville, Maryland, U.S.A. (ATCC). Dried cultures of these fungi as well as herbarium specimens of the oat leaves from which they were isolated have also been deposited in the National Fungus Collection, Plant Protection Research Institute, Pretoria (PREM).

Toxicity tests in ducklings

Mouldy meal prepared from the respective single-conidial isolates of *D. campanulata* was mixed with commercial chicken mash (1:1 m/m) and fed *ad libitum* to groups of 4-day-old Pekin ducklings for 14 days. Control diets consisted of meal prepared from autoclaved, non-inoculated yellow maize mixed (1:1 m/m) with commercial chicken mash.

Toxicity tests in sheep and goats

Mouldy meal prepared from 5 single-conidial isolates of *D. campanulata* was dosed to sheep and goats by stomach tube as indicated in Table 2. The experimental sheep and goats as well as the 2 control animals (No. 12 & 13) were kept at the Regional Veterinary Laboratory, Stellenbosch, on kikuyu grass (*Pennisetum clandestinum* Hochst. ex Chiov.) pastures. One control animal (No. 12) was dosed with autoclaved, non-inoculated maize meal. The second control animal (No. 13) was not dosed, but was kept on the same pasture as the experimental animals. The animals were examined daily.

The following routine chemical pathological determinations were done periodically on the sera of all cases except No. 9, 10, 11 & 12: gamma glutamyl transpeptidase (γ-GT), aspartate aminotransferase (AST) and total bilirubin.

Autopsies were performed following death or euthanasia. Selected tissue specimens of various organs were collected, fixed in 10 % buffered formalin and processed according to standard procedures. Sections were cut at 4 μm and stained with haematoxylin and eosin (HE).

RESULTS

Toxicity test in ducklings

The 3 isolates of *D. campanulata* from Stellenbosch (No. MRC 2853, 2854 and 2855) were acutely toxic to ducklings, and so was the single isolate (MRC 3199) from Riebeek West (Table 1). The Canadian isolate DAOM 89350 (= MRC 3132) was also acutely toxic to ducklings. All 5 isolates caused 100 % mortality of ducklings within a mean time of 5,2 days, following the

TABLE 4 Gross pathological findings in sheep and goats dosed with *D. campanulata* culture material

Gross lesion	Relative severity of lesions*												
Case number**	1	2	3	4	5	6	7	8	9	10	11	12	13
Pulmonary oedema	1	1	3	4	0	0	1	1	1	1	1	0	0
Pulmonary congestion	1	1	3	4	0	0	1	0	0	1	1	0	0
Liver degeneration	2	2	1	2	1	1	2	1	2	2	2	0	0
Kidney degeneration	2	2	1	0	0	0	1	0	2	1	1	0	0
Rumen atonic; contents abnormally fluid	4	4	4	4	3	4	4	4	4	4	3	0	0
Contents caecum and colon abnormally fluid	0	0	4	4	0	4	2	4	2	2	4	0	0
Necrosis of rumen mucosa	1	1	1	1	2	3	2	3	3	4	2	0	0
Necrosis of reticular mucosa	1	1	1	1	2	3	2	3	3	4	2	0	0
Necrosis of omasal mucosa	1	1	1	1	3	3	3	3	3	4	3	0	0
Necrosis of abomasal mucosa	0	0	0	0	0	0	0	0	0	0	0	0	0
Necrosis of mucosa of caecum and colon	0	0	0	0	0	0	0	0	1	0	0	0	0
Congestion of abomasum	1	1	3	0	0	0	3	2	1	1	3	0	0
Icterus	1	0	0	1	0	0	0	1	0	0	0	0	0
Congestion of small intestine	1	1	2	0	0	0	2	2	0	1	0	0	0
Congestion of large intestine	1	1	2	0	0	0	2	2	0	1	0	0	0
Gall bladder wall thickened	0	0	1	1	2	0	3	1	0	0	0	0	0

* 1–4 = Relative severity of lesions
0 = absent

** See Table 2

FIG. 1–4 Gross pathological changes in the forestomach of sheep and goats dosed with culture material of *D. campanulata*

FIG. 1 Necrosis and suppuration of ruminal and reticular mucosa. Goat 6

FIG. 2 Necrosis of ruminal mucosa. Sheep 10

FIG. 3 Submucosal haemorrhage and necrosis of omasal mucosa. Sheep 10

FIG. 4 Congestion of forestomach and necrosis of ruminal and omasal mucosa. Goat 7

consumption of small amounts (10–48 g) of culture material.

Toxicity tests in sheep and goats

Clinical signs

All the animals dosed with culture material of *D. campanulata* became visibly ill within 12–48 hours after the first dose, and died or were killed within 3–31 days (Table 2). The most consistent clinical signs were anorexia, apathy, ruminal stasis and diarrhoea, with faeces sometimes containing streaks of fresh blood. Ruminal distension was noticed in all cases during the 24 hours preceding death or euthanasia. None of the dosed animals showed clinical signs of photosensitivity. No abnormal signs were seen in the 2 control animals (No. 12 & 13).

All 5 isolates of *D. campanulata* were found to be highly toxic. The minimum lethal dose for sheep and goats was *c.* 1 g of dried culture material per kg per day (Table 2).

Chemical pathology

Chemical pathological findings in the 9 cases tested are given in Table 3. The levels of AST activity were elevated markedly in all cases tested, except No. 7, of animals dosed with culture material of *D. campanulata*. In the case of No. 7, however, the last blood sample was analysed 3 days before death. The level of γ-GT activity was elevated markedly shortly before death in No. 1, 2 & 4 only. The level of No. 6 was elevated 8 days before death, but then declined. The total bilirubin level increased sharply during the 24–48-hour period preceding death in all the cases tested, except No. 3 & 7. No abnormal chemical pathological changes were recorded in the control animal tested (No. 13).

Gross pathological findings

The gross pathological findings are summarized in Table 4. The most consistent and severe lesion found was necrosis of the mucosa of the rumen, reticulum and omasum (Fig. 1–3). The rumen was filled with fluid in all cases. In most cases, whitish necrotic debris filled the space between the folds of the omasum. Submucosal haemorrhage in addition to necrosis of the omasal mucosa was found in No. 10 (Fig. 3).

The abomasum was severely congested (Fig. 4) in No. 3, 7 & 11 and slightly congested in No. 8 & 10. Haemorrhages varying from pin-point to 3 mm in diameter were present on the mucous membrane of the abomasum of No. 11 and the colon and caecum contained some coagulated blood.

Most of the livers were slightly swollen, friable and diffusely yellowish-brown. Variable degrees of oedema were noticed in the gall bladder walls of 5 cases and 1 was also congested. Mild icterus was seen in No. 1, 4 & 8.

No gross pathological changes were seen in the control animals (No. 12 & 13).

Histopathological findings

Rumen: The lesions varied from mild focal erosions to severe, diffuse coagulative necrosis and ulceration of the mucosa (Fig. 5 & 6), accompanied by an inflammatory reaction which was predominantly fibrinopurulent with oedema. The stratum granulosum and stratum spinosum were generally affected (Fig. 7), with the stratum basale

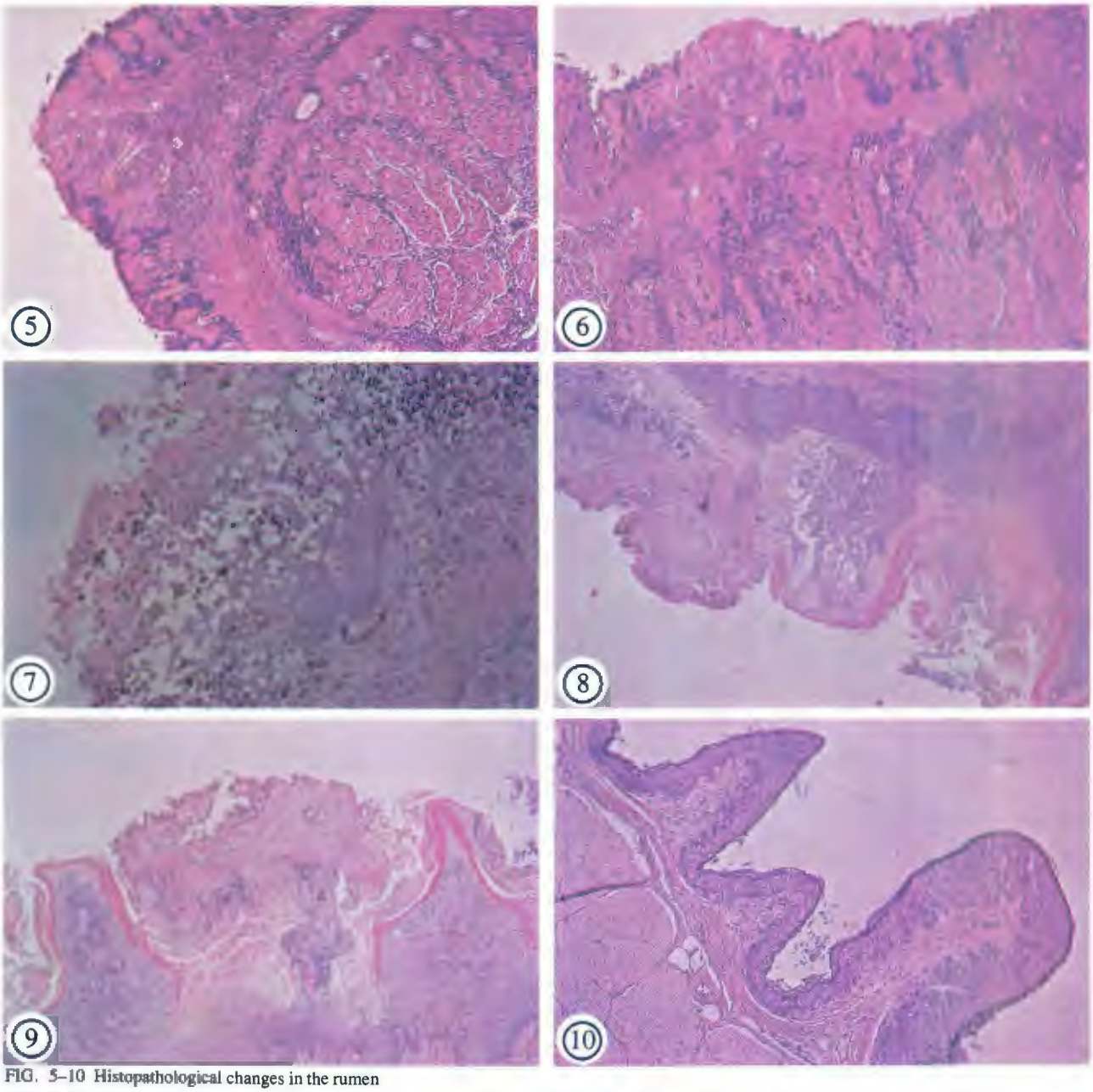

FIG. 5–10 Histopathological changes in the rumen

FIG. 5 Severe coagulative necrosis of papilla with neutrophil and bacterial infiltration. Sheep 11. HE × 100

FIG. 6 Coagulative necrosis of mucosa, focal bacterial colonies in necrotic tissue and focal haemorrhages in submucosa. Sheep 11. HE × 100

FIG. 7 Oedema, necrosis and neutrophil infiltration of especially the middle layers of the mucosa. Goat 5. HE × 100

FIG. 8 Superficial necrosis with debris between papillae. The stratum basale is still intact. Goat 6. HE × 40

FIG. 9 Necrosis between papillae with fibrin and cell debris forming a layer between papillae. Goat 5. HE × 40

FIG. 10 Rumen from control. Sheep 12. HE × 40

relatively normal and stratum corneum often intact. In cases where ulceration was severe, the whole mucosa and some papillae were totally necrotic, with debris layered between papillae (Fig. 8 & 9). The mucosa between papillae was often less severely affected than that covering papillae. The submucosa was oedematous with thrombosis and leucostasis in blood vessels and prominent neutrophil infiltration present (Fig. 5–8). Bacteria were plentiful in areas of necrosis (Fig. 5 & 6). None of these changes were seen in the control animals (Fig. 10).

Reticulum: The lesions resembled those seen in the rumen, but were generally milder.

Omasum: The general pattern of lesions resembled those described for the rumen (Fig. 11 & 12), but tended to be more severe. A fibrinous exudate with necrotic debris overlaid the damaged mucosa. Where ulceration extended to the submucosa, leucostasis, thrombosis (Fig. 13), neutrophil infiltration and fibrin were prominent. In 1 goat, the omasal mucosa was completely necrotic (Fig. 14 & 15). Similar changes were not present in the controls (Fig. 16).

Abomasum: Congestion was evident, and in some cases the superficial mucosa contained small haemorrhages.

Small intestine: Necrosis of villus tips was noted in some acute cases, and villus atrophy and evidence of crypt regeneration were seen in others. Infiltration of round cells was prominent in the lamina propria. Lymphoid depletion was apparent in the Peyer's patches of many cases and lipofuscin pigmentation in macrophages was prominent.

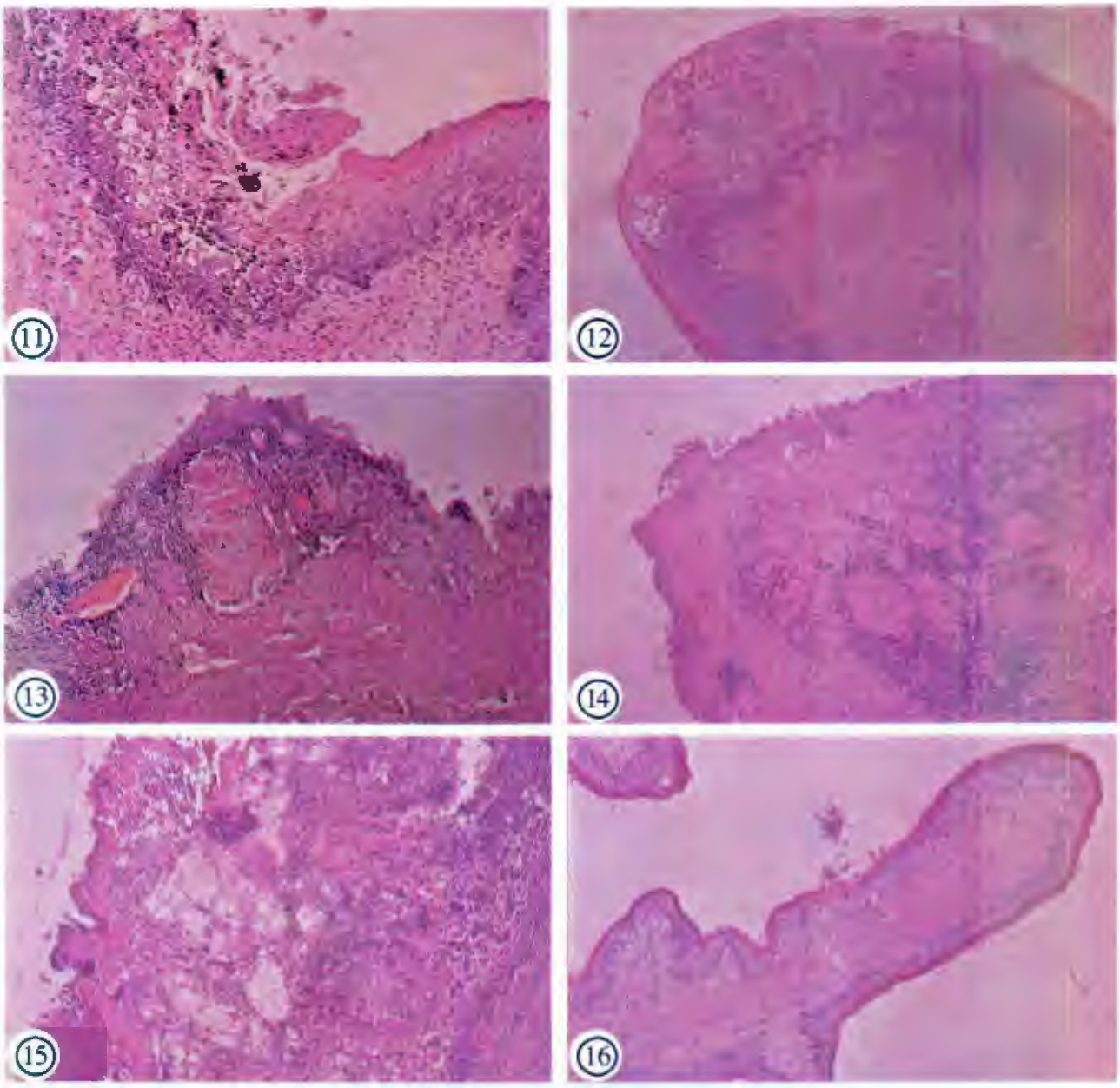

FIG. 11–16 Histopathological changes in the omasum

FIG. 11 Necrosis of the middle layers of the mucosa. Goat 5. HE × 100

FIG. 12 Focal necrosis and microvesicle formation in tip of omasal lamina. The stratum corneum and stratum basale remain intact. Goat 6. HE × 100

FIG. 13 Venous thrombosis with necrosis of the mucosa. Goat 7. HE × 100

FIG. 14 Severe necrosis of the mucosa and submucosa. Sheep 11. HE × 100

FIG. 15 Severe mucosal necrosis with neutrophil infiltration. The stratum basale is still intact. Sheep 11. HE × 100

FIG. 16 Omasal lamina from control. Goat 13. HE × 40

Large intestine: Round cell infiltration into the lamina propria was prominent in chronic cases.

Mesenteric lymph nodes: These were oedematous and many follicles appeared atrophied whilst others were lymphoid depleted.

Liver: Changes in hepatocytes ranged from cloudy swelling to hydropic degeneration to mild fatty metamorphosis. In some cases, single necrotic cells were disseminated throughout, and in others, hyaline droplet degeneration was evident in many hepatocytes. Thrombosis of portal and central veins was occasionally present. Periportal oedema, mild bile duct hyperplasia and periportal fibrosis were also seen. Leucostasis, bile stasis and sinusoidal fibrin occurred occasionally.

Gall bladder: Mucosal oedema and focal erosions were frequently evident. Lymphoid tissue tended to be prominent in the submucosa, and plasma cell infiltration was observed.

Kidney: Mild to moderate nephrosis, which was characterized by hydropic degeneration of the proximal tubules and dilation of the distal tubules, was present in all cases. Congestion was common, and protein casts were often seen. No changes were detected in the urinary bladder.

Lung: Changes were limited to mild oedema and congestion. A mild interstitial pneumonia, which was attributed to concurrent *Muellerius capillaris* lungworm infestation, was present in many cases.

Heart: Occasionally, focal hyaline myocardial necrosis was seen in both acute and chronic cases.

Spleen: Congestion was present in all cases. In 1 sheep, karyorrhexis of lymphocytes in splenic lymphoid follicles was seen.

Adrenal: In most cases, adrenal cortices were hyperplastic and in some there was cortical haemorrhage.

Discussion

The common characteristic of the 2 field outbreaks in goats and cattle grazing green oats was severe diarrhoea. In both outbreaks, reddish-brown leaf spots were conspicuous on the oat leaves suspected of being toxic, and *D. campanulata* was isolated from at least some of these spots. Pure cultures of *D. campanulata* isolates from oat leaves implicated in both field outbreaks caused severe diarrhoea and death when dosed to experimental sheep and goats. The most characteristic gross pathological finding in animals dosed with culture material of *D. campanulata* was necrosis of the mucosa of the forestomach. Unfortunately, it is not known whether necrosis of the forestomach mucosa was a feature of the field outbreaks or not, since carcasses from field cases were not available for necropsy. The finding that pure cultures of *D. campanulata* were toxic to sheep and goats suggests that green oat leaves infected by this fungus may cause field outbreaks of a mycotoxicosis in grazing animals. Confirmation of this would require dosing oat leaves artificially inoculated with pure cultures of *D. campanulata* to experimental animals. The toxicity of other *Drechslera* species isolated from leaf spots on oat leaves implicated in the 2 field outbreaks, particularly *D. avenae* (Van der Westhuizen *et al.*, 1985), also requires further investigation.

The finding that a Canadian isolate of *D. campanulata* caused pathological changes in experimental animals identical with those caused by local isolates suggests that the mycotoxicosis suspected of being caused by green oat leaves infected by this fungus may occur wherever *D. campanulata* is present.

The clinical signs of photosensitivity which were seen in the field outbreak in goats were not reproduced by dosing the *D. campanulata* culture material. In the light of the hepatic injury, however, the possibility that *D. campanulata* can cause photosensitivity merits further investigation.

In both field outbreaks, no abnormal clinical signs developed when animals were reintroduced to toxic camps after a withdrawal period of 12 days or more. This indicates that the toxic principle may be labile and that *D. campanulata*-infected oat leaves may lose their toxicity within days under field conditions.

The lesions produced by cultures of *D. campanulata* in the forestomach of sheep and goats are similar to those described for kikuyu poisoning in cattle (Martinovich & Smith, 1973; Newsholme, Kellerman, Van der Westhuizen & Soley, 1983; Van Heerden, Williams, Van Rensburg & Ipland, 1978). *D. campanulata* is a pathogen of cereals and grasses, but has not been reported on kikuyu grass *(Pennisetum clandestinum)*. Experimental mycotoxicoses with clinical signs and pathological changes similar to those of kikuyu poisoning have also been induced in cattle and sheep with culture material of *Myrothecium verrucaria* (Alb. & Schw.) Ditm. and *M. roridum* Tode isolated from pastures and of *Phoma herbarum* West. var. *medicaginis* Rabenh. isolated from lucerne *(Medicago sativa* L.) in New Zealand (Martinovich, Mortimer & Di Menna, 1972). Brefeldin A and cytochalasin B have been isolated from culture material of *P. herbarum* var. *medicaginis* that caused inappetence, diarrhoea and death, with marked necrotic changes in the mucosa of the forestomach of sheep (Mortimer, Di Menna & White, 1978). Brefeldin A was the major toxic metabolite, and it caused identical clinical signs and pathological changes when dosed to sheep.

Investigations are in progress on the chemical nature of the mycotoxin(s) produced by *D. campanulata*.

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