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Experimental poisoning by *Baccharis megapotamica* var. *weirii* in buffalo

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ABSTRACT. Experimental poisoning by *Baccharis megapotamica* var. *weirii* in buffalo. Pesquisa Veterinária Brasileira 32(5):383-390. Departmentamento de Patologia, Universidade Federal de Santa Maria, Camobi, Santa Maria, RS 97105-900, Brazil. E-mail: claudioslbarros@uol.com.br

Five male 6-8 month-old Murrah buffalo calves were orally dosed with the fresh aerial parts of *Baccharis megapotamica* var. *weirii* at doses of 1, 3, 4, 5 and 10g/kg body weight (bw) (~1-10mg macrocyclic trichothecenes/kg/bw). The *B. megapotamica* used for the experiment was harvested on a farm where a recent spontaneous outbreak of poisoning caused by such plant had occurred. Clinical signs appeared 4-20 hours and 4 buffaloes died 18-49 hours after the ingestion of the plant. Clinical signs were apathy, anorexia, and watery diarrhea, fever, colic, drooling, muscle tremors, restlessness, laborious breathing and ruminal atony, and dehydration. The most consistent gross findings were restricted to the gastrointestinal (GI) tract consisted of varying degrees of edema and reddening of the mucosa of the forestomach. Histopathological findings consisted of varying degrees of necrosis of the epithelial lining of the forestomach and of lymphocytes within lymphoid organs and aggregates. Fibrin thrombi were consistently found in sub-mucosal vessels of the forestomach and in the lumen of hepatic sinusoids. It is suggested that dehydration, septicemia and disseminated intravascular coagulation participate in the pathogenesis of the intoxication and play a role as a cause of death. A subsample of *B. megapotamica* var. *weirii* was frozen-dried and ground and analyzed using UHPLC (Ultra High Performance Liquid Chromatography) with high resolution Time of Flight mass spectrometry and tandem mass spectrometry, it was shown that the plant material contained at least 51 different macrocyclic trichothecenes at a total level of 1.1-1.2mg/g. About 15-20% of the total trichothecenes contents was found to be monosaccharide conjugates, with two thirds of these being glucose conjugates and one third constituted by six aldopentose conjugates (probably xylose), which has never been reported in the literature.

INDEX TERMS: Poisonous plants, *Baccharis megapotamica*, buffalo, experimental plant poisoning, necrosis in forestomach, lymphoid tissue necrosis, macrocyclic trichothecenes, chemical analysis.
macroscópicos mais consistentes estavam restritos ao tra-
to gastrointestinal (GI) e consistiram de graus variados de
dema e avermelhamento da mucosa dos pré-estômago.
Os achados histopatológicos consistiam de vários graus de
necrose do epitélio de revestimento dos pré-estômago e
de linfócitos em agregados e órgãos linfoides. Trombos de
fibrina foram consistentemente encontrados nos vasos da
submucosa dos pré-estômago e na luz dos sinusoides he-
páticos. É sugerido que desidratação, septicemia e coaug-
ulação intravascular disseminada participem da patogênese
da intoxicação e sejam fatores responsáveis pela morte
dos animais afetados pela intoxicação. Uma subamostra de
*B. megapotamica* var. *weirii* foi congelada a seco, moída
e analisada usando UHPLC (Cromatografia Líquida de Ultra
Alta Performance) com espectrometria de tempo-de-vôo
da alta resolução e espectrometria de massa em tandem.
Foi demonstrado que o material de planta analisado con-
tinha pelo menos 51 tricotopecenos macrocíclicos diferentes
num nível total de 1,1-1,2mg/g. Cerca de 15%-20% do
conteúdo total de tricotopecenos eram conjugados de monossa-
carídeos, sendo dois terços desses, conjugados de glicose e
um terço constituídos por seis conjugados de aldopentose
(provavelmente xilose), o que nunca tinha sido antes rela-
tado na literatura.

**TERMOS DE INDEXAÇÃO:** Plantas tóxicas, *Baccharis megapotama-
ica*, búfalo, intoxicação experimental por planta, necrose dos
pré-estômago, necrose do tecido linfóide, tricotopecenos macróci-
clicos, análise química.

**INTRODUCTION**

The *Baccharis* genus (Asteraceae: tribe Asteraceae) inclu-
des nearly 500 species. All are found in the New World with
the exception of *B. halimifolia*, which was introduced into
Australia from the United States (Jarvis et al. 1991). This
species is suspected of poisoning cattle in both countries
(Everist 1981) and proved toxic when administered expe-
rimentially to chicks (Duncan et al. 1957). *B. glomerulifoli-
a*, another North American species, was experimentally
toxic to mice and chicks (Duncan et al. 1957), and *B. pteronioid-
es* has been associated with cattle poisoning in the south-
western United States (Marsh et al. 1920, Stegelmeier et
al. 2009). *B. pteronioides* toxicity was produced in hams-
ters dosed with 100-200mg of the plant (Stegelmeier et
al. 2009). *B. artemisioides* causes disease in cattle in a restric-
ted zone of Argentina, northwest of Buenos Aires and sou-
theast of Cordoba (Rizzo et al. 1997).

Nearly 120 species of *Baccharis* have been recorded in
Brazil; of those, only *B. coridifolia* (Tokarnia & Döbereiner
1975, Barros 1998) and *B. Megapotamica* (Tokarnia et al.
1992, Driemeier et al. 2000, Pedroso et al. 2010) have been
proven to be toxic to livestock. Both *B. megapotamica* and
*B. coridifolia* are found in southern Brazil, but they occu-
py different habitats; *B. megapotamica* is found in marshy
areas (Tokarnia et al. 1992) whereas *B. coridifolia* grows
in pastureland (Barros 1998). Two varieties of *B. mega-
potamica* with essentially the same distribution and toxic
effects on livestock are known, namely *B. megapotamica*
var. *megapotamica* and *B. megapotamica* var. *weirii* (To-
karnia et al. 1992).

*B. coridifolia* and the two varieties of *B. megapotamica* cau-
se a severe acute poisoning in livestock characterized by
degeneration and necrosis of the epithelial lining of gas-
trointestinal tract and necrosis of lymphocytes in lymph
nodes, spleen, tonsils, and several lymphoid aggregates
(Tokarnia & Döbereiner 1975, Tokarnia et al. 1992, Barros
1998, Varaschin et. al. 1998, Varaschin & Alessi 2003). *B. megapotamica* (Kupchan et al. 1977) *B. coridifolia*, (Busam
& Habermehl 1982, Habermehl et al.1985) and *B. artemi-
sioides* (Rizzo et al. 1997) contain a series of potent cyto-
toxic agents belonging to the highly cytotoxic macrocyclic
trichothecene complex previously believed to be produced
only by fungi (Jarvis et al. 1996). In the case of *B. mega-
potamica*, the macrocyclic trichothecenes accumulate in the
plant as baccharainoids ( B1, B2, B3, B4 etc.), roridins inclu-
ding their glycosides, and miotoxins (Jarvis et al. 1996).
To date, no macrocyclic trichothecenes have been detected in
*B. halimifolia*, *B. pteronioides*, or *B. glomerulifolia*.

Spontaneous poisoning by *B. coridifolia* occurs fre-
cently in cattle (Rissi et al. 2005) occasionally in sheep
(Rozza et al. 2006) and rarely in horses (Alda et al. 2009)
Isolated reports of spontaneous outbreaks involving *B. me-
potamica* var. *weirii* have been reported in cattle (Drie-
meier et al. 2000) sheep (Pedroso et al. 2010) and buffaloes
(Oliveira-Filho et al. 2011). There are also some anecdotal
accounts of spontaneous toxicosis by *B. megapotamica* var.
*weirii* in cattle. Typically, the toxicosis in livestock occurs
when naïve animals raised in areas free of *Baccharis* spp.
are transferred to pastures infested by the plant. The sus-
ceptibility increases considerably if the animals are subjec-
ted to such stress factors as fatigue, hunger, or thirst (Bar-
ros 1998). Interestingly, cattle that are raised in pastures
where *Baccharis* spp. exist will graze it very rarely if ever,
although in the case of *B. megapotamica* var. *weirii* there are
anecdotal accounts that particularly hungry cattle familiar
with the plant, may, on occasion, ingest it and get poisoned.

A recent outbreak of *B. megapotamica* var. *weirii* poison-
ing in buffalo diagnosed at our laboratory (Oliveira-Filho
et al. 2011) prompted the undertaking of the current expe-
rimental study to determine the clinical and pathological
aspects of the *B. megapotamica* var. *weirii* poisoning in buf-
faloses, the pathogenesis of the toxicosis and the toxic prin-
ciples involved in this plant.

**MATERIALS AND METHODS**

Five male 6-8-month-old, 122-143 kg Murrah buffaloes identified
by numerals 1-5 were used in the experiment. Each buffalo was
force-fed orally with a single dose of fresh *Baccharis megapota-
onica* var. *weirii* respectively at doses of 1, 3, 4, 5 and 10g/body
weight (bw) (Table 1). Only the top 10cm of the aerial parts of
the plant were fed to the buffaloes. Just before the administra-
tion of the plant and every four hour after the dosing, the buffaloes
were clinicaly evaluated for the following parameters: respiratory
and cardiac rates, rectal temperature, time of capillary filling, ruminal
movements, posture, ambulation and behavioral changes. During
the whole duration of the experiment the buffalo were kept in a
fenced paddock and were offered Tifton hay and water *ad libitum*.

For the experiment, specimens of *B. megapotamica* var.
*weirii* were harvest in a farm in the municipality of Diler-
Table 1. Experimental poisoning by Baccharis megapotamica var. weirii in buffalo

| Buffalo | Weight (kg) | Dose of plant administered (g/kg) | Time spent in the administration of the plant | Severity of clinical signs | Time between the termination of the ingestion of the plant and death |
|---------|-------------|----------------------------------|---------------------------------------------|---------------------------|---------------------------------------------------------------|
| 1       | 143         | 10g                              | 2h15min                                    | +++c                       | 18h30min                                                      |
| 2       | 132         | 5g                               | 55min                                      | +++                       | 19h45min                                                      |
| 3       | 135         | 4g                               | 1h05min                                    | +++                       | 49h5min                                                       |
| 4       | 122         | 3g                               | 1h33min                                    | +++                       | 21h40min                                                      |
| 5       | 146         | 1g                               | 30 min                                     | +                         | Survived                                                       |

*All administrations of the plant were in single doses, (+) (+) (+) marked, (+) mild.

RESULTS

Chemical analysis of the plant revealed 51 one different major macrocyclic trichotheccenes; the major peaks are

Identification of the plant as Baccharis megapotamica var. weirii was made by Prof. José Newton Marchiori from the Departamento de Ciências Florestais, Centro de Ciências Rurais, Federal University of Santa Maria, Brazil.
shown in Figure 1. All five treated buffalo showed clinical signs and four of them died. Data regarding the time elapsed from the ingestion of the plant, the severity of clinical signs showed by each buffalo and the time elapsed between ingestion of the plant and death of the animal are on Table 1. The onset of clinical signs varied from 4 hours (Buffalo 1) up to 20 hours (Buffalo 5) after the ingestion of the plant. The time elapsed from the ingestion of the plant to the death of the animal varied from 18 hours and 30 minutes (Buffalo 1) to 49 hours and 5 minutes (Buffalo 3).

The first observed clinical signs were apathy, anorexia, and watery profuse diarrhea (Fig.2). Fever was observed in all experimental buffalo, except Buffalo 5, and reached 40.9°C in Buffalo 1. The clinical signs evolved rapidly to colic (tenesmus), drooling (Fig.3), muscle tremors, restlessness, and loss of strength of ruminal movements eventually terminating in complete ruminal atony, laborious breathing, and dehydration, seen as sunken eyes in the orbit pockets and loss of normal cutaneous turgidity. Tachycardia and increased time of capillary filling were also observed. With the exception of Buffalo 5, the capillary filling time was up to 5 minutes. Of the 5 buffaloes fed *B. megapotamica* var. *weirii*, only Buffalo 5 which was fed 1g/kg/bw of the plant, survived after running a short clinical course consisting of moderate liquid diarrhea and apathy. After 48 hours of the onset of the clinical signs this buffalo recovered and was euthanized in the following day for necropsy.

The most consistent gross findings were restricted to the gastrointestinal (GI) tract and consisted of varying degrees of edema and reddening of the mucosa of the forestomachs especially of the rumen (Fig.4) and reticulum (Fig.5). Mucosal reddening of the rumen was more intense in the cranial pillar (3 out of 5 buffalo examined), ruminal antrum (3/5), coronary pillar (1/5) and dorsal sac (1/5). Marked edema was observed in the reticulo-ruminal fold (3/5) and omasum (1/5). Petechiae and paint-brush hemorrhages were observed, mainly in the dorsal sac (3/4 buffalo).

Varying sized recent ulcers were observed in the abomasum of Buffalo 1 ad 3. In all the four buffalo that died spontaneously diffuse reddening was observed in the mucosa of the duodenum, jejunum, ileum, and cecum. In this latter viscus dark-red fetid content was found. Additional, in Buffalo 2 and 4, similar reddening was observed in the mucosa of spiral colon. Linear ulcers were observed in the distal third of the esophagus in Buffalo 4. Buffalo 2-4 had enlarged gastric and jejunal lymph nodes which were red and juice to the cut surface.

Histopathological findings in the forestomach consisted of varying degrees of necrosis of the epithelial lining. This variation occurred from animal to animal and even within the same animal. In some instances only the basal layer was affected (Fig.6), in others both the basal and squamous layer were affect and still in other the whole thickness of the ruminal squamous stratified epithelium was affected (Fig.7). These changes were associated with hyperemia, edema, and inflammatory infiltrate predominantly neutrophilic, bacterial aggregates in the submucosa. Bacterial ag-
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Fig. 4. Reddening of the mucosa of the forestomach from Buffalo 3 experimentally poisoned by *Baccharis megapotamica* var. *weirii*.

Fig. 6. Necrosis of the basal layer of the lining squamous stratified of the ventral sac of the rumen of Buffalo 2 experimentally poisoned by *Baccharis megapotamica* var. *weirii*. HE, obj.40x.

Fig. 8. Reticular fold of Buffalo 4 experimentally poisoned by *Baccharis megapotamica* var. *weirii*. Bacterial aggregates can be observed surrounding blood vessels of the submucosa which is marked edematous. HE, obj.20x.

Gregarines were found over the forestomach epithelial deprived submucosa and in one case surrounding blood vessels of the submucosa (Fig.8). Fibrin thrombi were consistently found in submucosal vessels of the forestomach and in the lumen of hepatic sinusoids. These thrombi were positive for fibrin by the Fraser-Lendrum method (Fig.9).

Fig. 5. Reddening of the mucosa of the reticulum from Buffalo 1 experimentally poisoned by *Baccharis megapotamica* var. *weirii*.

Fig. 7. Necrosis of the full thickness of the ruminal squamous stratified epithelium of the dorsal sac of the rumen of a Buffalo 3 experimentally poisoned by *Baccharis megapotamica* var. *weirii*. HE, obj.40x.

Fig. 9. Histopathology of the liver of Buffalo 1 experimentally poisoned by *Baccharis megapotamica* var. *weirii*. Fibrin thrombi are observed in the lumen of hepatic sinusoids. Fibrin are stained red, erythrocytes appear orange, and scant collagen appears green. Fraser-Lendrum stain, obj.40x.
The necrosis in the epithelial lining of the forestomach were more intense in the following order of decreasing intensity: reticular fold, ruminal ventral sac, ruminal caudal ventral blind sac, ruminal cranial pillar, reticulum, caudal dorsal blind sac, dorsal sac, and omasum. In reticular fold of one animal (Buffalo 1) there was also necrosis of the smooth muscle layer beneath the areas of epithelial necrosis. Mild necrosis (Buffalo 2 and 3) were observed in the parietal cells of the abomasal mucosa.

Hepatic necrosis was observed in the four buffalos that died due to the intoxication. It consisted of multifocal individual foci of necrosis or individual hepatocellular necrosis. In one animal (Buffalo 3) the necrosis was more prominent in the hepatocytes adjacent to the portal triads. In two cases (Buffalo 1 and 3) diffuse moderate cytoplasmic vacuolization was observed.

Necrosis of lymphocytes (Fig.10) was observed in all four buffalo dying from the intoxication and in all lymphoid organ/tissues sampled. The intensity of lymphocyte necrosis was dose dependent and varied depending of the type of lymphoid tissue examined, being more prominent in the gut associated lymphoid aggregates and in the jejunal and mesenteric lymph nodes.

**DISCUSSION**

The clinical signs, clinical course, gross findings and histopathology observed in the buffalo of the current study are similar to those described in the naturally occurring *Baccharis megapotamica* var. *weirii* poisoning by in buffalo (Oliveira-Filho et al. 2011) in cattle (Driemeier et al. 2000) and sheep (Pedroso et al. 2010) and the experimental intoxication in cattle with this plant species (Tokarnia et al. 1992). The lesions are also similar to those produced by *B. coridifolia* in cattle (Tokarnia & Döbereiner 1975, Barros 1998, Rissi et al. 2005) and sheep (Rozza et al. 2010) and the experimental intoxication by *B. megapotamica* var. *weirii* in cattle (Driemeier et al. 2000) in sheep (Pedroso et al. 2010) and the experimental intoxication (Oliveira-Filho et al. 2011) in cattle (Tokarnia & Döbereiner 1975, Barros 1998, Rissi et al. 2005) and disseminated vascular coagulation (Stegelmeier et al. 2009) could play a part. Data from the current experiment suggest that several of these mechanisms of disease production could act concomitantly or in sequence in the pathogenesis and cause of death of buffalo experimentally poisoned by *B. megapotamica* var. *weirii*. Dehydration was clearly a participant as judged by the hemoconcentration as demonstrated in Table 2 by radi marked elevation in the packed cell volumes and total protein concentration in the serum. These are classical signs of dehydration (Smith & Magdesian 2002, Fettman 2006) and were not observed only in the one buffalo (Buffalo 5) which developed just a mild form of intoxication and survived.

Evidences of disseminated intravascular coagulation (DIC), a serious manifestation of abnormal coagulation (Morris 2002) was observed in all experimental animals excepting Buffalo 5. This was reflected in the sharp increase in fibrin degradation products which were detected in the serum of the four buffaloes that died. DIC is a severe break down in the hemodynamic homeostasis caused by the generation of excess thrombin. There are many causes, inducing diffuse vascular damage which results in exposure of blood to tissue factor (Mosier 2011). In the case of the four buffalo that died it was possible to detect thrombi formation in the liver by the method of Fraser-Lendrum and those are associated with foci of liver necrosis; thus generation of tissue factor in response to

**Table 2. Laboratory data from blood of five buffalo poisoned by Baccharis megapotamica var. weirii in buffalo**

|                | PCV α | Total plasma protein | AST β | FDPs γ |
|----------------|-------|----------------------|-------|--------|
|                | PE    | AE                   | PE    | AE     | PE    | AE     |
| 1              | 54    | 91                  | 566   | 917    | 6.5   | 8.5    |
| 2              | 35    | 42                   | 7.2   | 8.9    | 5.497 | 2.211  |
| 3              | 40    | 54                   | 7.3   | 647    | 3.796 | 9.171  |
| 4              | 40    | 37                   | 7.5   | 339    | 6.592 | 4.139  |
| 5              | 40    | 37                   | 7.5   | 339    | 6.592 | 4.139  |

αPacked cell volume, βaspartate transaminase, γfibrin degradation products, †pre-experiment sample, ‡sample taken after the administration of the plant a just hours before death of the buffalo.
necrosis endothelial cells and hepatocytes is a distinct possibility, resulting in tissue factor-induced activation of extrinsic coagulation to produce thrombin. Thrombin causes platelet aggregation and activation of coagulation factors V, VIII, and I to form fibrin, could result in the widespread microvascular clots observed in threees cases. Concurrently, the high levels of thrombin stimulate clot dissolution by binding to thrombomodulin to activate protein C, by converting plasminogen into plasmin, and by binding to anti-thrombin III to become inactivated. The widespread nature of the coagulation response results in the consumption of these and other factors, resulting in widespread hemorrhages. Although hemorrhages were not seen in the buffalo of this study, this could be explained by the extremely short course of the disease.

Evidences of septicaemia could be observed in Buffalo 1 from which bacterial culture of the blood yield non-enterococci *Streptococcus* Group; Bacteria of this group D can cause septicaemia, among other clinical dysfunctions (Greene & Prescott 2006). Some findings in the experimental buffalo of this study as fever and bacterial aggregates surrounding blood vessels or associated with b reached ruminal epithelium are consistent with septicaemia plain a role in this intoxication.

UHPLC with high resolution Time of Flight mass spectrometry proved to be a powerful technique for the analysis of the macrocyclic trichothecenes in plant extracts detecting 51 different major macrocyclic trichothecenes. The major findings were Baccharin B2/B1/4, Baccharinoid B12/B17, iso-baccharin/baccharin and the conjugate xylo-seroridin L-2. Out of 14 available trichothecene standards only 2 (roridins E and A) could be detected in the samples. Trichothecenes found in the sample with no possibility of standard matching were identified tentatively on the basis of the MS/MS with spectra showing a fragmentation pattern (accurate mass) consistent with macrocyclic trichothecenes (Nielsen et al. 2011). These identification points included several water loss ions as well as the m/z 231 and 249 ions seen from macrocyclic trichothecines, or m/z 229 and 247 seen in case of hydroxylation of the trichothecene skeleton. Interestingly neither verrucarins nor roridin L-2 were detected. Expressed as roridin A equivalents the 51 macrocyclic trichothecines summed up to a total content of 1.1-1.2 mg/g which is in the same range found by Jarvis et al (1996) where 0.04-0.7 mg/g was detected. Using MS/HRMS and in-source fragmentation, 15-20% of the total trichothecenes contents was found to be conjugated to a glucose (seen by the loses of a glucose moiety) also found by Jarvis et al. (1996) and one third constituted by 6 aldopentose conjugates, probably xylose conjugates, which was also partly confirmed by better retention of these compared to their glucose analogues. These aldopentose derivatives have to our knowledge has never been reported in the literature. All these monosaccharide derivatives could easily be identified as they only produced [M+NH4]+ and [M+Na]+ pseudomolecular ions, whereas the normal trichothecenes produced these as minor ions and [M+H]+ as the major ion. The monosaccharide conjugate fraction of 15-20% fits well with the finding of Jarvis et al. (1996), and toxicology wise it is not known if these are toxic in vivo as the case for deoxynivalenol-3-glucoside (Berthiller et al. 2011).

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