A STUDY OF THE PALATABILITY AND POSSIBLE TOXICITY OF 11 SPECIES OF CROTALARIA, ESPECIALLY OF C. SPECTABILIS ROTH

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INTRODUCTION

Various species of the genus Crotalaria have been found to be adapted culturally to the lighter sandy soils of the Coastal Plain and are comparable in composition at early stages of growth with other legumes used in feeding livestock. Since within the genus, certain species perhaps have value as feeds for livestock, a joint study was undertaken by the United States Department of Agriculture and the Florida Agricultural Experiment Station, to locate and investigate such promising species. An investigation was undertaken to compare, by means of grazing and feeding trials, the relative palatability of the green forage, the artificially dried hays, and the silages made from several species. Tests were made in 1931, 1932, and 1933. Indications of the toxicity of one species—C. spectabilis Roth—to cattle were observed among the animals used, as was stated in a previous publication (footnote, p. 621). In December 1931 Thomas encountered field cases of toxicity of the seeds of this species to chickens, and studied more closely in the laboratory the reactions of chickens, turkeys, quail, and doves to these seeds. The toxic principle was isolated by Neal and Rusoff, who described it and studied certain of its properties. Emmel, Sanders, and Henley recently found ground seeds of C. spectabilis to be toxic to swine.

Four species of Crotalaria are known to be toxic to livestock. Symptoms and lesions differ, indicating that the toxic principles are not the same in all species. Bessey and Stalker showed C. sagittalis L. to cause "Missouri River bottom disease", which resulted in death among horses. Seeds of C. juncea L., or sunn-hemp were fed to a healthy mature sheep in amounts of one-fourth pound daily for 14 days, and one-half pound for 12 additional days. Weakness, a tucked-up appearance, and catarrh developed shortly after the fourteenth day. Death occurred on the twenty-sixth day. According to Burtt-Davy (3), cattle fed C. burkeana Benth for 5 days became stiff in the joints, moved slowly, and were unable to stand ultimately. The hoofs lengthened and broke, and death resulted from starvation.

1 Received for publication Feb. 11, 1935; issued July.
2 This study is an outgrowth of a cooperative investigation of the feeding value of crotalarias conducted jointly by the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Departments of Agronomy and Animal Husbandry, Florida Agricultural Experiment Station. Feeding trials were conducted by the Department of Animal Husbandry, with forages grown and provided by the Agronomy Department and by the Division of Forage Crops and Diseases, U. S. Department of Agriculture. G. E. Ritchey was in charge locally for the Division of Forage Crops and Diseases.
3 Reference is made by number (italic) to Literature Cited, p. 922.
Theiler (8) fed as much as 46 pounds of *C. dura* Wood and Evans to horses in 23 days and observed symptoms of poisoning within 16 to 80 days. The main symptoms and lesions included fever, acute polypnoea, and subsequent dyspnea, destruction of the respiratory epithelium, leading to a vicarious emphysema, granulation tissue, and degeneration of the bronchii. A bull fed 2 pounds daily died in 64 days, and an ox was killed in extremis on the ninety-eighth day. Symptoms included complete loss of appetite, diarrhea with dark-colored feces, progressive weakness, and ultimate loss of animation. Autopsy revealed cirrhosis of the liver, thickened central veins, and fibrillar bundles which formed a lacework in which blood collected.

*Crotalaria striata* D. C. and *C. incana* L. have been indicated as possibly toxic to cattle, sheep, and goats in certain countries, but have not been observed to be injurious in the United States.

**PLAN OF INVESTIGATION**

Nine species of *Crotalaria* were planted in adjacent rows in a fenced 2-acre field in 1931 and in 1932. From time to time during the grazing season, two head of cattle were transferred to this field for a brief tour, usually 14 days and the extent of grazing on the separate species was estimated daily by two or more members of the staff. No supplementary feeds were allowed. Water was accessible. Also, some volunteer grasses and other plants, not killed by routine cultivation of the field, were grazed.

Eight of the eleven species of *Crotalaria*, as listed in table 1, were harvested, artificially dried as hay, and placed in adjacent compartments of an overhead rack in a small lot, where cattle were given free access to them. Observations were made daily by two or more staff members as to the order of preference and relative amounts of each species eaten by the cattle. These observations, as well as the growth habits of the plants, were used as a basis for selection of the most promising species for further study as a forage crop. During the course of these studies, indications of toxicity of one species were obtained upon the death of three experimental animals. An additional controlled-feeding trial and careful laboratory analyses were made to prove the definite toxicity of the species *C. spectabilis*. Pertinent details relative to the toxicity of this species are outlined in this paper.

**OBSERVATIONS OF CATTLE**

Two cows were used in each tour on the crotalaria grazing plots in 1931 and 1932, the several species employed being listed in table 1. Four cows and two pigs were employed in this manner during the first season. The pigs grazed none of the *Crotalaria* during the 15-day tour. During the last 4 days of the fourth tour (Sept. 25–28, 1931), when *C. spectabilis* was in the early bloom, two cows stripped a considerable number of green leaves from the plants, but ate none of the stems nor flowers. They were returned to the dairy herd at the end of the 2-week tour, as originally planned. No outward symptoms of ill effects were noted immediately, nor later, when again under daily observation on the hay trials. On the basis of these earlier observations, none of the plants under trial were suspected of being toxic.
Three of the cows mentioned above, and 11 heifers, were used shortly afterward in 1 or more of a series of 8 palatability trials in which artificially dried hay was used. *Crotalaria spectabilis* hay was eaten by the cows in only one of the trials mentioned above, the amount being 12 pounds. No untoward effects were noted from this amount. It may be mentioned that the cows weighed between 900 and 1,000 pounds, so that the intake per 1,000 pounds live weight was relatively small. In these palatability trials, *C. spectabilis* ranked at the bottom of a group of eight species of crotalaria hays. These observations ranged from 14 to 38 cow-days per individual animal on the grazing trials, and from 17 to 24 days per individual on the hay trials during the first year.

These palatability trials were repeated in the field and dry lot during 1932. *Crotalaria spectabilis* was rejected entirely by 5 different cows allowed access to the pasture during one or another of 5 tours. Three Jersey cows were used in the hay-palatability trials with eight species of *Crotalaria* from October 21 to November 16, 1932. These animals consistently left *C. spectabilis* in the rack as the last choice of the eight species. On November 16 three yearlings from the beef cattle herd replaced the cows in the dry lot, and at that time the latter animals were transferred to a maintenance trial on *C. intermedia* hay. Specific animals and the lengths of the tours on the several trials are outlined in detail in table 2. These summaries are compiled from the observations of cattle made daily by two or more station workers.

Four of the cows were changed from *Crotalaria intermedia* hay to corn silage and Bermuda grass (mixed) pasture on March 2, 1933. Cow no. 352 was autopsied for definite examination in search of any indications of toxicity of the forages eaten. The cows exhibited no symptoms of toxicity, nor were any gross or histological lesions evident in the organs and tissues upon autopsy, which was conducted by Drs. E. F. Thomas and C. F. Ahmann of this station. The feed of three of these cows had been limited strictly to *C. intermedia* from November 17, 1932, to March 1, 1933, inclusive—a period of 105 days, and they had had access to it previously, as noted in table 2.
TABLE 2.—Duration of feeding trials with cattle, and animals used, during the 1932 grazing season and the winter of 1932-33, the species of Crotalaria described in table 1 being used

<table>
<thead>
<tr>
<th>Nature and duration of trial</th>
<th>Feedings 1 given to animal 2 indicated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. 151</td>
</tr>
<tr>
<td>Palatability of green forages:</td>
<td></td>
</tr>
<tr>
<td>June 18 to July 2</td>
<td>X</td>
</tr>
<tr>
<td>July 28 to Aug. 13</td>
<td>X</td>
</tr>
<tr>
<td>Aug. 14 to Aug. 27</td>
<td>X</td>
</tr>
<tr>
<td>Oct. 4 to Oct. 20</td>
<td>X</td>
</tr>
<tr>
<td>Palatability of dried hays:</td>
<td></td>
</tr>
<tr>
<td>Oct. 21 to Oct. 28</td>
<td>X</td>
</tr>
<tr>
<td>Oct. 28 to Nov. 2</td>
<td>X</td>
</tr>
<tr>
<td>Nov. 2 to Nov. 7</td>
<td>X</td>
</tr>
<tr>
<td>Nov. 7 to Nov. 12</td>
<td>X</td>
</tr>
<tr>
<td>Nov. 12 to Nov. 16</td>
<td>X</td>
</tr>
<tr>
<td>Maintenance trial with C. intermedia:</td>
<td></td>
</tr>
<tr>
<td>Nov. 17 to Dec. 18</td>
<td>X</td>
</tr>
<tr>
<td>Dec. 17 to Jan. 17</td>
<td>X</td>
</tr>
<tr>
<td>Digestion trials with C. intermedia:</td>
<td></td>
</tr>
<tr>
<td>Jan. 18 to Feb. 11</td>
<td>X</td>
</tr>
<tr>
<td>Feb. 12 to Mar. 1</td>
<td>X</td>
</tr>
</tbody>
</table>

1 X signifies feedings given on the dates mentioned.
2 Dates of autopsies: No. 151, May 2; no. 228, Mar. 31; no. 296, Mar. 23; no. 350, Apr. 14; no. 352, Mar. 2.
3 No C. spectabilis eaten.
4 C. spectabilis rated last in relative palatability.
5 No C. spectabilis hay offered.
6 Naturally cured C. intermedia hay.
7 Artificially cured C. intermedia hay.

No chronic symptoms had developed between the termination of the maintenance trials and the dates of autopsies of these animals. Indications of toxicity particularly sought in these cases included loss of appetite, dejection, blood in the feces, and nasal hemorrhage. Gross and histological examinations upon autopsy were made particularly upon the liver, heart, kidneys, mesenteric blood vessels, and the fatty tissues. The autopsies were attended and tissues examined by four or more persons including the authors, Drs. E. F. Thomas, C. F. Ahmann, and others of the experiment station and the United States Department of Agriculture staffs. No symptoms were observed, either acute or chronic, of toxicity of the species of Crotalaria eaten in these trials other than C. spectabilis.

Three native yearling cattle—2 steers and 1 heifer—were used in continuing the test of the relative palatabilities of artificially cured crotalaria hays. Previous to this time, these animals had received carpet, centipede, and mixed native pasture grasses. The log of these palatability trials is given in table 3.

TABLE 3.—Relative palatability of 8 species of artificially dried crotalaria hays, as indicated numerically according to order of preference and rate of consumption by 3 yearling cattle in 1932

<table>
<thead>
<tr>
<th>Duration of trial</th>
<th>Numerical palatability rating of indicated species of Crotalaria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intermedia</td>
</tr>
<tr>
<td>Nov. 16 to Nov. 23</td>
<td>1</td>
</tr>
<tr>
<td>Nov. 23 to Nov. 29</td>
<td>1</td>
</tr>
<tr>
<td>Nov. 29 to Dec. 5</td>
<td>1</td>
</tr>
<tr>
<td>Dec. 6 to Dec. 12</td>
<td>1</td>
</tr>
<tr>
<td>Dec. 12 to Dec. 19</td>
<td>2</td>
</tr>
<tr>
<td>Dec. 19 to Dec. 23</td>
<td>1</td>
</tr>
<tr>
<td>Dec. 23 to Dec. 27</td>
<td>2</td>
</tr>
</tbody>
</table>
June 1, 1935  
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The last hay-palatability trial terminated on December 27, 1932. The 3 yearling cattle used in the last 7 trials died on January 7, 18, and 20, 1933, respectively. They showed almost total loss of appetite, lack of abdominal fill, no bloat, or hoven, blood in the feces, and two had nasal hemorrhage. Autopsy disclosed hemorrhage from blood vessels in the mesentery, heart, muscle coronary and body fat, and in the mucous layer and submucosa of the trachea; a mottled appearance of kidneys and liver; and hemorrhage in the nasal sinuses of two animals.

Although *Crotalaria spectabilis* had been withdrawn from the feeding rack on December 28, 1932, the second yearling steer showed intestinal hemorrhage, as evidenced by bloody feces on January 12, 1933, which increased in severity on the 13th. The two animals surviving at this date became less animate; ate less of the crotalaria hays, and their feces were still darker on January 16. Nasal hemorrhage was apparent in the second steer on January 17. This animal was killed for autopsy on January 18, shortly prior to the approaching natural death. The yearling heifer died on January 20.

The autopsy findings, as summarized by Drs. E. F. Thomas, A. L. Shealy, and C. F. Ahmann, are as follows:

**History.**—Three cattle had been feeding on crotalaria hay. They showed loss of appetite for several days. Bloody feces, and a tinge of blood from the left nostril (of the second steer) were evident.

All mesenteric fat contained numerous petechial hemorrhages. Anterior portion of the frontal sinus showed ecchymotic areas; blood clots in posterior frontal sinus. A few worms were embedded in wall of esophagus (not identified). Extensive hemorrhages along the mucous membrane and submucosa of the trachea.

Endocarditis; myocarditis, and epicarditis (especially along the interventricular groove). Pericardium showed numerous petechial hemorrhages. Liver finely mottled with red. Gall bladder showed numerous petechial hemorrhages. Spleen probably enlarged slightly. Wall of abomasum showed the mucous membrane edematous. Mucous membrane of the small intestines appeared normal.

Submucosa of small intestine showed ecchymosis and petechial hemorrhage.

**Large intestine.**—No hemorrhage of mucous membrane, but an abundance of blood clotted in the lumen. Fecal matter was firm; some hard. Urinary bladder showed a hemorrhagic area. The brain was congested, with gelatinous material in the sulci (grooves). Lymph glands showed very little congestion. All body fat was very yellow, and showed petechial hemorrhages throughout.

Tissue from the liver, kidney, and spleen was fixed for examination.

Typical lesions of *Crotalaria spectabilis* poisoning may be seen in the left view of the heart (fig. 1), liver (fig. 2), gall bladder (fig. 3), inner surface of the trachea (fig. 4) and mesentery (fig. 5) of the yearling steer which was killed just prior to natural death. These photographs show the hemorrhages resulting from leakage of blood from the vessel walls. The lesions compare closely with those produced in chickens by Thomas, Neal, and Ahmann (10), using *C. spectabilis* seeds, and also the alkaloid extracted from the seeds, leaves, and stems of this plant.

**Autopsy of Third Case**

The third yearling (heifer) died January 20, 1933, probably about 10 hours prior to autopsy. She had been off feed for 13 days, and had passed considerable blood with the feces during the last 2 days.

The mesenteric fat showed little hemorrhage. Petechial and ecchymotic hemorrhages were present in the submucosa of the intestines. The lungs apparently were normal. There was a severe
hemorrhagic condition of the heart muscle. The liver showed a few hemorrhagic areas. The gall bladder had several ecchymotic areas, and there also were numerous ones in the spleen. The urinary bladder appeared normal. The lumen of the large intestine contained blood and blood clots. The pericardium showed numerous petechial hemorrhages. Amber fluid was present in the pericardial sac. Numerous subcutaneous petechial hemorrhages also were present.

It is to be noted particularly that none of the cows that refused to eat *Crotalaria spectabilis* in the grazing-palatability trials, or in the trials with artificially cured hays, showed any indications of *Crotalaria* poisoning, either in life, or upon autopsy. However, the three yearlings that changed their order of preference of these species, and consumed 98 pounds of *C. spectabilis* hay between November 16 and December 28, 1932, died of *Crotalaria* poisoning between January 7 and 20, 1933. Since they also had access to other feeds, and since there could still be a question as to *C. spectabilis* specifically, a supply of the artificially dried hay was preserved pending availability of a suitable animal for an exact trial.
SPECIFIC TEST OF CROTALARIA SPECTABILIS

E-53, a dun and white native steer just under 8 months of age and weighing 300 pounds, was supplied from the native herd at the experiment station. This animal had suckled its dam from birth, and had been on mowed-grass pastures during its lifetime. It had not had access to *Crotalaria spectabilis* previously, insofar as is known. The animal was healthy and extremely vigorous.

![Image of a liver affected with chronic *Crotalaria spectabilis* poisoning](image)

Artificially dried *Crotalaria spectabilis* hay prepared in 1932, was offered to this calf, which refused to eat it. The chopped hay was mixed with other feeds, which it still refused to eat. Water was available in the dry lot at all times. A stomach tube was passed, weighed quantities of ground *C. spectabilis* hay were suspended in
water, and the animal drenched therewith. The record of these feedings of *C. spectabilis* hay was as follows:

<table>
<thead>
<tr>
<th>Date</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec. 12</td>
<td>0.5</td>
</tr>
<tr>
<td>Dec. 13</td>
<td>4.0</td>
</tr>
<tr>
<td>Dec. 14</td>
<td>3.5</td>
</tr>
<tr>
<td>Dec. 15</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9.5</strong></td>
</tr>
</tbody>
</table>

Blood was present in the feces the morning of December 14 and the animal died about 4:30 p.m. the next day.

**Figure 3.**—Gall bladder from a yearling steer affected with chronic *Crotalaria spectabilis* poisoning, showing numerous petechial hemorrhages. The bile appeared normal in color and consistency.

E-53 was photographed a few minutes prior to death (fig. 6). Death occurred quietly, the animal lying on its side, the only struggle being a slight paddling of the feet. The autopsy was made on the warm body before the onset of rigor mortis.

The blood had not clotted, nor did it clot readily upon the severing of the jugular vein. The subcutaneous blood vessels, those in the adipose tissue and along the small intestines, were enlarged. The thymus and spleen appeared normal. A slight amount of straw-
colored fluid had accumulated in the peritoneal cavity. Urine in the partly filled bladder was of a normal pale-amber yellow color.

Petechial hemorrhages were present in the mesentery, on the cecum, and in the gall-bladder wall. Mesenteric lymph glands were enlarged. The lumen of the lower small intestine, all of the large intestines, and rectum contained the bloody material mentioned previously as appearing in the feces. No hemorrhages were apparent on the stomach compartments nor in the lungs. The kidneys were darker, with a slight turkey-egg mottling. The liver also was a dark red-blue color, and quite friable. The gall bladder wall was thickened and spongy in texture. The bile appeared normal in color and consistency.

The heart showed petechial hemorrhages in the coronary fat, on the auricles and along the interventricular groove. Parts of the inner wall of the heart, the papillary muscles and some of the chordae tendineae showed marked hemorrhages, as seen in figure 7.
The case of E-53 is considered acute, whereas those of the three animals dying previously were chronic.

**FIGURE 5.** Mesentery and intestines of a yearling steer affected with chronic *Crotalaria spectabilis* poisoning, showing numerous petechial hemorrhages in the mesenteric fat, on the outer surface of the small intestines and the apex of the cecum. The submucosa of the small intestines showed ecchymoses and petechial hemorrhages. There was an accumulation of clotted blood within the lumen of the large intestines.

**FIGURE 6.** An 8-month-old steer photographed less than half an hour before dying from acute *Crotalaria spectabilis* poisoning. Loss of appetite and lack of animation were evident in the acute and chronic cases alike. Dried blood from a nasal hemorrhage is visible below the right nostril. The hair is harsh and unkempt.

**TRIALS WITH SILAGE**

In 1932 four species of *Crotalaria*, including *C. spectabilis*, were ensiled in 1-ton laboratory silos (7) for use in comparing the relative palatability of these species. *C. intermedia* was first choice of the
cattle, and was eaten liberally. The *C. spectabilis* ranked third in order of preference by the cattle. The latter silage had a dark color, and animals eating it voided dark-colored feces. These silages were offered to 30 cattle over a 16-day period. No irregularities were observed with these cattle other than the temporary discoloration of the feces.

Two palatability studies conducted in 1933 dealt with six species of *Crotalaria* as silage. These were of 11 days' duration each, and involved 51 cattle. As noted in table 1, no *C. spectabilis* was offered at this time, nor were indications of toxicity observed in the cattle during, or after, eating these species of *Crotalaria* as silage.

Twenty-five tons of *Crotalaria intermedia* were ensiled in a commercial silo, and fed to dairy cows in a 90 days' double-reversal feeding trial, and to four steers over periods of 59 and 31½ days in a study of coefficients of digestibility. No indications of either acute or chronic toxic influences were observed in any of the cattle used in investigations on the *C. intermedia* silage.

**SUMMARY**

Grazing and feeding trials indicate that at least 8 out of 10 introduced species of *Crotalaria* are probably not toxic to cattle. *C. retusa* was not grazed. *C. spectabilis* is definitely toxic to cattle.

One acute and three chronic cases of *Crotalaria spectabilis* poisoning in cattle are discussed, with symptoms and lesions as noted. *C. spectabilis* Roth is added to the list of species of this genus definitely proved toxic to domestic animals.
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