A Study of Bracken Fern Poisoning of Cattle on a California Forest Range

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On certain allotments of the Mariposa District of the Sierra National Forest, death losses of cattle have been abnormal over a considerable period. Reported losses were of two general types: (1) cattle that died on the forest range (Chowchilla and Soquel Allotments) and (2) cattle that died after removal to their foothill ranges (Iron Creek Allotment). Deaths on the first two allotments were attributed to poisoning from braken fern (Pteris aquilina), horsetails (Equisetum spp.), or laurel (Leucothoe davisiae). Deaths on the Iron Creek Allotment were attributed to hemorrhagie septicema, rabies, or unknown causes.

The author was introduced to the problem on October 5, 1939, when he was asked to help investigate the death of a yearling steer near the old Sugar Pine Mill on the Soquel Allotment. The animal had been dead about three days and no positive conclusion was reached on the cause of death. Bracken fern, which grew abundantly in the area, was found in the rumen contents, and was suspected of being the cause.

On August 3, 1943, in the same area, Dr. A. S. Robertson, County Veterinarian, and the author investigated the death of a grade cow that was in fair flesh and had just died. Autopsy findings were similar to those in bracken poisoning and the diagnosis was "death from a poisonous plant with bracken fern strongly suspected". On September 27, 1944, after investigating the deaths of

6 more cows, all in good flesh, it was decided to investigate the causes of cattle deaths in the area of the old Sugar Pine Mill in the Soquel Allotment. Laurel is not known there, and horsetail is so scattered and thin that it is not considered a danger. Bracken fern is the only other toxic plant known in the area.

Related Studies

The possibility that bracken contains substances poisonous to cattle was first reported by Penberthy (1893) and Storrar (1893). Stockman (1917) was apparently the first to prove that feeding bracken to cattle could be fatal, when an 8-month-old heifer died 30 days after the start of a 26-day period of being fed 10 pounds of fresh fern every other day. Hadwen (1917) proved that hay containing about about 30 percent fern was responsible for staggers in horses and even death. Bracken poisoning of cattle and horses is known to occur naturally, and Moon and Raafat (1951) have shown that sheep may be killed by feeding them bracken experimentally. Fletcher (1944) and Foggie (1951) presented evidence that sheep may be naturally poisoned by bracken.

The toxic factor to livestock in bracken has long been of interest. Storrar (1893) thought it was merely the ingestion of a highly indigestible food. M'Gowan (1915) concluded that it was actually an invasion of the animal by a common type of bacillus, and he isolated such an organism from an animal that

had died of the disease. Seddon and McGrath (1929) also considered the deaths to result from a microbic disease, hemorrhagic septicaemia, which sometimes occurred in cattle weakened from eating bracken. Langley (1944) thought the death of cattle, that developed laryngitic symptoms, was due to a secondary cause. The animals had eaten bracken roots, and the coarse fibers had excoriated the lining of the pharynx, allowing the entrance of Bacillus oedematis maligni organisms from the soil on the roots.

Stockman (1917) discounted M'Gowan's (1915) theory of a bacterial disease asserting that it is normal for bacteria of the type described to invade the blood from the intestines soon after death. Besides describing the symptoms of afflicted animals and post-mortem findings, he expressed his view that the "toxic principle" was present only in comparatively small amounts and is cumulative in effect. A certain time-even weeks after the poison had been withheld—was required to establish its full effects before severe illness might begin. Shearer (1945) isolated only bacteria that are common post-mortem invaders of bovine carcasses that had lain for some hours after death. He thought the poisonous principle was a decomposition product of eatechol tannin, and that a low plane of nutrition would tend to lower an animal's resistance to it. Carpenter, Phillipson, and Thomson (1950) failed to isolate any pathogenic organism from the carcass of a heifer that had died of a condition similar to bracken poisoning after being fed dried bracken hay.

Weswig, Freed, and Hagg (1946) were evidently the first to show that bracken fed to rats had an antithiamine activity. The application of these findings to fern poisoning in cattle was obscure, for the symptoms noted in rats were more suggestive of those reported in horses than those observed in ruminants. Vaughan (1949) and O'Moore (1949) found that Vitamin B1 was ineffective in treating bracken poisoning in cattle. Carpenter, Phillipson, and Thomson (1950) found that ponies suffered incoordination and bradycardia from eating bracken and were cured by subcutaneous injections of vitamin B₁. Similar treatment of a heifer failed to prevent her death. Moon and Raafat (1951) found vitamin B_1 injections ineffective in treating sheep and cattle suffering from bracken poisoning . McLauchlan (1951) noted that cattle suffering from bracken poisoning did not display the nervous symptoms shown by the rat and horse, which are usually associated with avitaminosis B1. Nicotinic acid deficiency in the cattle was suspected and recovery was rapid upon oral administration of 600 mg. of nicotinamide for two or three days.

A perplexity of the "toxic principle" of bracken with cattle is the great variability of its effects. Bracken is widespread over the world, and Stockman (1917) pointed out that the number of animals visibly affected, although considerable, is small in proportion to the plant's distribution. Some areas apparently have a long history of cattle poisoning from bracken; however, other areas have been grazed for decades without reports of ill-effects (Carpenter, Phillipson, and Thomson, 1950). In one area, cattle grazed for generations on a primeval forest without ill effects until a portion of the area was ploughed and seeded to a pasture mixture (Wells, 1949). A review of literature on experimental production of the disease shows extremely variable results, with little relationship between the quantity of bracken fed and the degree of bracken poisoning (Stockman, 1917; Hagen and Zeissig, 1927; Shearer, 1945; Moon and Pal, 1949; Perkins, 1950; and Carpenter, Phillipson, and Thomson, 1950).

Opinion is quite variable as to why some cattle incur bracken poisoning while others in the same herd show no apparent ill effects. Stockman (1917) thought there might be a variation in susceptibility, through natural development of immunization, but that cattle feeding too brusquely and continuously upon the fern are fatally stricken before acquiring resistance. The poison does not develop its explosive potentiality without some weeks of continuous feeding on the fern. Carr (1948) made the only report of cattle being poisoned by fewer than 30 days of continued ingestion of fern: 36 deaths in a herd of 100 Herefords that had eaten bracken for only about a week in mid-Mav.

Seddon and McGrath (1929), expounding the theory that cattle losses were due to hemorrhagic septicaemia rather than a plant poison, claimed that the fern produces harmful effects

only if the microbe gets into the bracken-weakened animal. Gleeson (1944) said that ploughed-up bracken roots were a common cause of poisoning and that withered, frosted tops of new fern growth were also poisonous to cattle. Fletcher (1944) said that old or withered bracken was most toxic but that young, tender shoots browned and withered by late frosts were also definitely toxic, especially growth in certain natural contours more affected by frost than others. Cattle may also be poisoned by withered fronds left from eradication attempts.

Experimental Area

The area around the old Sugar Pine Mill was logged from 1901 through 1924. The area east of the mill to the Nelder Grove of Big Trees was burned over in 1921. Thus, there is considerable variation in the regrowth of brush and trees. Growth of bracken is rank in thick patches along some of the branches of Lewis Creek, which drains the area, and in some of the more moist glades on the mountain slopes. Some open mountain slopes, being dryer also maintain a thin stand of short-growth fern, and scattered fronds oc-



FIGURE 1. Animal No. 253, Test 1, on the third and final day of illness, showing swelling of the jowls and depressed condition.

cur beneath the brush and trees. The rapid regrowth of brush and trees is discouraging bracken over the area.

Elevations vary from about 4,300 to 6,100 feet. Seasonal grazing of cattle occurs from mid-May to October. Cattle losses from year to year have been quite variable; the highest known losses occurred in 1944 when this study was started.

Procedure

Because of the wide-spread distribution of the fern, the thickness of brush and tree cover, and the variability in losses, it was apparent that the stock could not be prevented from eating the fern. Since the area is principally a browse area. the cattle possibly sought out herbaceous plants, consequently eating more fern than if herbaceous plants had furnished the bulk of their feed. If the factors responsible for the fern being more toxic at certain times than at others were discovered, it might be possible to prevent losses by proper range management. For this reason it was decided to compare in feeding tests fern growing in moist situations, fern from drier mountain slopes, first and second growth from these areas, early and mid-season growth from these areas, and frosted and unfrosted fronds collected late in the season. The feeding tests were conducted at the San Joaquin Experimental Range, O'Neals, California.

In the first feeding test the fern was cut and dried in the sun before feeding. Later the fern was harvested by stripping off the fronds, leaving the coarse stems the animals would not eat. The fern used in tests 2 through 9 was fed green. It was collected weekly and kept in an ice box until fed. The fern fed in tests 10 and 11 was dried in the sun before feeding. The results of the 11 feeding tests are summarized in Table 1.

Results

1944 Test

As a first step toward adding to information on the symptoms of bracken poisoning, and verifying diagnoses on animals that died on the range, an attempt was made to produce fern poisoning by feeding fern cut from the study area. Rank fern growth from moist areas along a creek was collected by cutting the main stem below the frond -71.5 pounds on September 14. 150.5 pounds on September 18, and 167 pounds on October 3. The last collection was slightly frosted, and drier and more mature than the two earlier collections.

The test animal was a twovear-old Hereford heifer weighing 727 pounds. Three pounds of dry fern were mixed daily with alfalfa hay. Throughout the test the heifer refused to eat the coarser stems. She also refused one feeding that had been wet by rain. The heifer became ill on the 36th day, after the first feeding, and ate little further food before her death three days later. During the first 35 days a total of 101.5 pounds of dry fern was fed (298.5 pounds, green basis), but actual consumption was reduced about 10 percent by refusal of the coarser stems. Until illness developed, the heifer ate well and appeared normal in every respect.

During the first day of illness the heifer had a temperature above 107° F. and spent most of her time lying near water. During the second day she commenced drooling rather profusely. She was depressed and often stood with lowered head. Later in the day she began discharging small, continuous streams of mucus from both nostrils and breathing with a rasping sound. There were no indications of hemorrhages in mouth, nose or anal discharges. Body temperature continued about 107° F. The morning of the third day her temperature dropped to 105.8°; she continued to drool and discharge mucus from both nostrils. and her respiration was still rasping. It was noted that her underjaw had commenced to swell (Figure 1). By early afternoon her tongue protruded, and she showed increasing distress. A small, bright clot of blood was noted in the oral discharge. By 6:00 p.m. respiration was quite raspy and labored, the throat and jowls were swollen tight with tongue protruding about 4 inches, and distress was great. Most of the time was spent lying with her head outstretched. She died shortly before 10:00 p.m., and an autopsy was performed the following morning.

The findings were as follows: The heifer had pleurisy, with the pleura markedly hemorrhagic. especially on the right side; lungs congested with consolidated blood but no evidence of pneumonia; heart normal except for several petechial hemorrhages; blood very dark; peritoneum hemorrhagic in interior dorsal region; spleen normal except for several large hemorrhages; liver friable, slightly swollen, and icteric; omasum normal except contents very dry and caked; abomasum congested; small and large intestines dysenteric; trachea and esophagus markedly reddened interiorly throughout; large blood vessels in thoracic region markedly reddened throughout; and severe suggillation involving base of tongue (which was markedly swollen at base, with tissue pulpy), with larynx, surrounding tissues, and all tissues immediately posterior to thoracic region edematous and congested. The above findings were in accord with some of the observations made on the range.

1945 Test

A 600-pound pregnant grade heifer about two years old was used. The fern was rank growth collected from flats along a creek. The daily feeding rate was maintained at over 5 pounds of green fern daily with alfalfa hay limited to keep her hungry.

The fern was of vigorous, luxuriant growth, dark green at the start of the test on July 6, with many plants still growing. The increasing maturity of the fern was noted at each weekly collection by the gradual lighter green color and by its increased bulkiness. In early August much of the fern growing in the area began turning yellow, and by the end of the month some fronds were drying. This was thought to be resulting from a shortage in soil moisture. Only the greener fronds were collected, but by September 7 even these were vellowish, and collecting the following week's feeding was difficult.

From July 7 to September 15 -72 days-472.5 pounds of green fern were fed, averaging 6.56 pounds daily. Although 6 cows died in the area during this period. none were found in time to conduct a post-mortem examination. A person who saw the last cow dying, reported that the droppings were black and contained fresh blood. The experimental heifer remained normal throughout the 72-day feeding period except on the 13th, 14th. and 15th days, when she had a mild diarrhea and the feces were blackish.

Near the close of the 72-day feeding period, a patch of bracken maturing spores was found in a cultivated apple orchard on the mountainside north of the creek area where the previous fern collections had been made. Since these were the only fronds seen actually producing spores, and since the last cow died in this area, this second feeding test was

Table	1.	Summation	of	bracken	fern	feeding	tests	with	young	cattle.	
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Test	No.	A	se	Weight	Source of Fern	Feeding Test Results
1.	H-253	2	yr.	725	Rank initial growth from moist areas along creek. Cut and dried in sun.	10/2-11/6/44, 35 days. Died 3 lb. dry fern fed daily mixed with alfalfa hay. 101.5 lb. fed (298.5 lb. green basis), 10% refused. Mostly stems.
2.	H-2	2	yr.	600	Rank initial growth from moist areas along creek and from old apple or- chard. Stripped from stems weekly.	7/6-9/30/45, 86 days. Neg. Av. daily feeding 6.6 lbs green fern mixed with alfalfa hay. 573 lbs. fed.
3.	H-477	17	mo.	533	Rank initial growth from moist areas along creek. Strip- ped from stems weekly.	6/23-8/4/46, 42 days. Neg. Av. daily feeding 5.4 lb. green fern with al- falfa hay. 230 lb. fed.
4.	S-481	17	mo.	585	Initial growth dry mountainside. stripped from stems weekly.	6/23-8/4/46, 42 days. Neg. Av. daily feeding 5.4 lb. green fern with al- falfa hay. 230 lb. fed.
5.	H-475	19	mo.	. 585	Second-growth from moist moun- tainside glade. Stripped from stems weekly.	7/2-8/7/46, 36 days. Neg. Av. daily feeding 5.6 lb. green fern mixed with alfalfa hay 203 lb. fed.
6.	H-4.9	20	mo	. 658	Rank initial growth from moist areas along creek. Strip- ped from stems weekly.	8/17-9/29/46, 42 days Neg. Av. daily feeding 5.7 lb. green fern with al- falfa hay. 240 lb. fed.
7.	S-408	21	mo.	728	Short initial growth from dry mountain- side. Stripped from stems weekly.	8/17-9/29/46, 42 days Neg. Av. daily feeding 5.7 lb. green fern with al- falfa hay. 240 lb. fed.
8.	S-467	20	mo.	485	Second growth, 143 lbs. from dry moun- tainside and 72 lbs. from moist moun- tainside glade. Stripped from stems weekly.	8/17-9/29/46, 42 days. Neg. Av. daily feeding 5.6 lb. green fern with al- falfa hay. 235 lb. fed.
9.	S-478	20	mo.	. 702	Short third growth from moist moun- tainside glade. Stripped from stems weekly.	8/17-9/29/46, 42 days. Neg. Av. daily feeding 5.7 lb. green fern with al- falfa hay. 240 lb. fed.
10.	S-481	21	mo	. 710	Initial and second growth from moist mountainside glade. Stripped from stems and dried in sun. Not frosted.	10/17-12/6/46, 50 days. Neg. Av. daily feeding 2.07 lb. dry fern mixed with alfalfa hay. 100 lb. dry fern fed (288 lb. green basis).
11.	H-475	23	mo	. 590	Initial and second growth from moist mountainside glade. Stripped from stems and dried in sun. Frosted.	10/17-12/6/46, 50 days. Av. daily feeding 2.06 lb. dry fern mixed with alfalfa hay. 109 lb. dry fern fed (291 lb. green basis).

continued with this fern. The fern was nearing maturity, growth was moderate, and the fronds still had a good green color. A total of 100.5 pounds of the green fern was collected and fed over the following 14-day period, averaging 7.18 pounds per day. There were no apparent ill-effects.

On September 3 the remains of 5 dead cows were found in the brush on the mountainside below and west of the Nelder Grove of Big Trees. Though the remains had been considerably worked over by bear, the deaths had evidently occurred the previous month. There were several seep or bog areas on this mountainside, and some of these areas contained considerable growth of red mimulus (Mimulus cardinalis). During this investigation a sick cow was observed eating some of the flowering tips of these plants. The animal had a severe watery-gaseous diarrhea with feces abnormally lightcolored and without evidence of blood. The following day the cow was found near-by, browsing upon sweet birch (Ceanothus integerrimus), and appeared well on the road to recovery, with almost normal-looking droppings.

Some stockmen suspected the red mimulus of being toxic to cattle. For this reason 9 pounds of the green plant material consisting mostly of the stem tips with buds, flowers, and immature seed capsules, was collected on September 8 and spread in the sun to dry. This dried mimulus was fed over a 4-day period to an eight-month-old steer weighing 285 pounds. No ill effects were observed.

1946 Tests

This year nine feeding tests were conducted (Nos. 3 to 11). Areas selected for fern collection were those where the fern grew fairly thick in patches. Manpower was not available for collecting the scattered growth among the brush and thickets of growing trees. The experimental animals were grade Hereford steers and heifers, varying in age from 17 to 23 months. Two of the animals were used in two different feeding tests. In each test the animals also received a good-quality alfalfa hay.

Tests 3, 4, and 5 were concerned with feeding green fern in early summer before the period when cattle usually died in the area. In test 3 the fern fed was tall, initial growth from a moist site (same as in tests 1 and 2) along a creek. In test 4 the fern fed was short initial growth from a dry site on the adjacent mountainside. In both tests there was a 42-day feeding period (June 23 to August 4), with a total of 230 pounds, 5.4 pounds daily, of green fern fed in each test. At the start of these tests. most of the fronds on both sites were growing and were quite succulent. By the end of the period they had reached full size and maturity. The fern used in test 5 was second growth from a moist mountainside glade that was fenced. The moderate to tall initial growth had been mowed on June 11. This test was conducted over a 36-day period (July 2 to August 7), with 203 pounds of fern fed, averaging 5.6 pounds daily. Throughout the feeding period the fern fed was quite succulent. At the start all the fronds were in a rapid stage of growth, very tender, and only partly unfurled.

Throughout test 3 it was difficult to get heifer No. 477 to eat her daily ration of fern. Consequently she did not receive much alfalfa hav. This heifer remained in normal condition until the 36th day, when it was thought she was quieter and spent more time lying down than usual. On the 39th day she again appeared quieter than normal and displayed little relish for her small allotment of alfalfa hav. The morning of the 40th day her nose was dry, she appeared depressed, and often worked her jaws as if something bothered her throat. At noon she had a temperature of 101.8° F., and her condition remined unchanged into the

evening. The morning of the 41st day her condition was almost normal again. However, she continued to work her jaws somewhat in the morning. The test was terminated after the 42nd day, and there were no further developments. The animals used in tests 4 and 5 ate their fern well, and attempts were made to feed them alfalfa hay in amounts just short of their wants. Both animals remained normal.

Tests 6, 7, 8, and 9 were conducted over a 42-day period, from August 17 to September 29. A total of 240 pounds (5.7 pounds daily) of green fern was fed in each case except test 7, in which a total of 235 pounds (5.6 pounds daily) was fed. No frost damage occurred during the period, for there were only a few extremely light frosts in the colder spots. At the start of these tests the ferns on our supposedly moist site along the creek were showing the effects of drought, and about 15 percent were yellow. In the spring the area contains sufficient moisture to promote rank fern growth, but the soil is apparently rapidly depleted of moisture available to the fern. It has been noted that the fern growing on this area becomes more drought-stricken each year. This may be due to the rapid regrowth of forest trees on the site. These effects were not noted in the other areas where fern was collected.

In test 6 initial tall fern growth from the moist area along the creek was fed until the supply was exhausted on the 35th day. As the trial progressed increasing amounts of this fern turned yellow, but only the greener fronds were fed. The fern fed the final week was tall, initial growth from the most moist portion of the mountainside glade. The fern fed in test 7 was short, initial growth from the dry mountainside. The fronds from this site retained a fair green until the final days when they were turning yellowish. In test 8 second-growth fern from the dry hillsides was fed. This fern however, was exhausted by the 27th day, and the test was completed with second growth from the dry portions of the mountainside glade. The fronds were short but fairly succulent throughout the test. Test 9 was concerned with thirdgrowth fern from the mountainside glade. These fronds were of fair size and quite succulent. The supply was exhausted just before the close of the test, and a mixture of second and fourth growth was fed on the last day.

All four animals in tests 6, 7, 8, and 9 ate their fern fairly well and received substantial feedings of alfalfa hay in addition. They remained in normal condition throughout the test and afterwards.

Tests 10 and 11 were respectively concerned with unfrosted and frosted fern that was sundried before feeding. In each case the fern consisted of initial and second growth from the mountainside glade. This fern was of average growth and of good color. The unfrosted fern was collected on September 17 and the frosted fern on October 7. In the latter collection some of the more succulent fronds had been either partially or entirely killed by frost. Steer No. 481, from test 4, was used in test 10, and heifer 475, from test 5, was used in test 11.

Tests 10 and 11 were conducted over a 50-day feeding period with an average daily feeding rate of 33 oz. of dried fern followed by limited feeding of alfalfa hay. The steer in test 10 received 100 pounds of dry fern (288 pounds green basis), and the heifer in test 11 received 109 pounds (291 pounds green basis). Both animals remained normal throughout the tests and afterwards.

It is interesting to note that in 1946 there were no reported cattle deaths in the study area or areas surrounding it. The year was droughty, and cattle on this forest range consumed large quantities of bracken. They began eating it in small quantities when first turned on the range in June and ate increasing amounts as the season progressed. It was, therefore, decided that further tests would be held in abevance until a season when deaths from bracken again occurred on the range. From that date through 1957 no further deaths on the range have been attributed to bracken poisoning. although in every year the cattle have consumed large quantities of the fern.

Summary

Bracken fern was suspected of being responsible for cattle deaths over a several-year period in an area where bracken fern was abundant. Considerable bracken was eaten each year, but the losses were quite variable.

Following several deaths in 1944, bracken was harvested from a moist site and sun-dried before feeding to a two-year-old heifer. She died with symptoms typical of those observed on the forest range. The following year green fern fed to a two-year-old heifer gave negative results. Cattle deaths on the forest range that year were attributed to bracken poisoning.

The third year, bracken collected from moist and dry sites, initial and second growth from these sites, early and mid-season growth from these sites, and unfrosted and frosted fronds collected late in the season all gave negative results when fed to short two-year-old cattle.

No deaths were attributed to bracken poisoning on the forest range that year, nor have there been further such deaths to this date (1957), even though the cattle have continued to eat large quantities of the fern.

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