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MOUNTAIN-LAUREL (KALMIA LATIFOLIA) AND SHEEP LAUREL (KALMIA ANGUSTIFOLIA) AS STOCK-POISONING PLANTS

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CONTENTS

INTRODUCTION

Kalmia latifolia and *K. angustifolia*, commonly known as mountain-laurel and sheep laurel, respectively, are among the most prominent stock-poisoning plants of the eastern part of the United States. They are widely distributed, well known to most people in the region where they are found, and prized because of their beauty. While many people recognize them as being poisonous, definite information in regard to the effect produced by them, the toxic dosage, and possible ways of treating poisoned animals or avoiding losses have not been readily available. Frequent inquiries are received by the Department of Agriculture concerning these plants, but there has been no publication by the department or by others which could be used to answer these queries.

The two plants produce the same effect and their poisonous properties are due to the same substance, andromedotoxin; therefore it seems advisable to discuss both of them in a single publication.

DESCRIPTION AND HISTORY

KALMIA LATIFOLIA

K. latifolia is shown in Figure 1. The following description of the plant is from Gray's New Manual of Botany, (*11, p. 633*)[1]:

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[1] Italic numbers in parentheses refer to Literature Cited, p. 21.

glandular, many-flowered; flowers rarely 1 cm. broad, crimson; calyx glandular; pod depressed, nearly smooth; pedicels recurved in fruit. Hillsides, pastures, and bogs, Lab. to Ont., and southw. June, July.

The plant is most commonly known as sheep laurel. Other names which have been applied to it are calfkill, lambkill, killkid, narrowleaf laurel, dwarf laurel, sheep poison, spoonwood ivy, ivy, wintergreen, and wicky. While the plant had been seen by preceding authors, Gronovius (*13*) and Catesby (*5*) in 1743, it was first given its permanent scientific name by Linnaeus in 1753 (*16*).

The first notice of its poisonous properties was by Colden in 1749 (*9*), who said that it was deadly to sheep. Kalm (*15, v. 2, p. 215–216*) in 1771 stated that it poisoned " sheep and other lesser animals."

As will be seen from the foregoing descriptions the two plants differ markedly in size, form of leaves, and color of flowers. The corymbs in *K. latifolia* are terminal, while in *K. angustifolia* they are lateral; this difference is clearly seen in Figures 1 and 2.

The plants are ordinarily called evergreen. This is not strictly true as the leaves are shed at the end of the second summer. Therefore, in the summer the plants have the leaves of two seasons and in the winter of one.

In both plants the corollas are salver shaped and the stamens bent over and attached in little pockets, as shown in Figure 1. The stamens are under tension, and when released by the movement of insects seeking honey throw the pollen with considerable force. This force is so great that the pollen is thrown upon other blossoms, and in this way and by the transfer of the pollen to other blossoms by the insects cross-fertilization is brought about.

EXPERIMENTAL WORK

Comparatively little experimental work has been done to determine the symptoms, dosage, and treatment of poisoning by these species of Kalmia. The following authors made some experiments with *K. latifolia:* Thomas (*19*), in 1802; Bigelow (*3*), in 1817; Crawford (*10*), in 1908; and Chesnut (*6, 8*), in 1898 and 1899. The only author who has reported experiments with *K. angustifolia* is Wood (*21*), in 1883. The results obtained by these authors will be alluded to later under Discussion and General Conclusions.

The experimental work of the writers was carried on at the Salina Experiment Station, Salina, Utah, in the years 1927, 1928, and 1929. The material used was collected in the eastern part of the United States and after drying was shipped to Salina.[2]

Most of the experiments were made by administering to the animals, by balling gun, weighed quantities of ground plant moistened with water. In a few cases the animals ate the plant which had been mixed with hay or bran. With *K. latifolia* there were 8 experiments with cattle, 5 with goats, and 16 with sheep. With *K. angustifolia* there were 7 experiments with cattle, 2 with goats, and 32 with sheep.

Tables 1 and 2 give a summarized statement of the experimental feedings. In these tables the dosage is given as green plant, it being assumed that the plant lost 75 per cent in drying.

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[2] Acknowledgment is made of the services of W. W. Eggleston and J. W. Kelly, of the Bureau of Plant Industry, who collected the plant material at various times in Maryland and Massachusetts.

TABLE 1.—*Summary of feeding experiments with Kalmia latifolia*

Animal		Date of feeding	Method of feeding	Part of plant used	Per cent of animal weight given	Place and date of plant collection	Result	Remarks
Designation	Weight							
Cattle:	*Pounds*							
No. 1120	700	Sept. 15, 1927	Balling gun	Leaves and a few flowers.	0.30	Lanham, Md., July, 1925	Not sick	
No. 1143	425	June 11, 1928	do	Leaves	.40	do	Symptoms	
No. 1136	425	June 14, 1928	do	do	.50	do	do	
No. 1135	475	June 15, 1928	do	do	.60	do	do	
No. 1140	385	June 19, 1928	do	do	.75	do	Somewhat sick	
No. 1146	495	June 28, 1928	do	do	.75	do	do	
No. 1142	520	Sept. 10 and 11, 1928.	With hay	do	.70	do	Symptoms	
No. 1202	550	July 8, 1930	Balling gun	do	.90	Clearfield, Pa., April, 1929	Sick	
Goat:								
No. 2	97.5	Aug. 5, 1927	With hay	do	.40	Lanham, Md., July, 1925	do	
Do	98	Aug. 19, 1927	do	do	.30	do	Not sick	
Do	95.5	Aug. 31, 1927	do	do	.50	do	Very sick	
No. 4	85	Sept. 15, 1927	do	do	.35	do	Not sick	
No. 17	57	July 12, 1930	do	do	.60	Clearfield, Pa., April, 1929	Sick	
Sheep:								
No. 1018	97.5	July 27, 1927	do	do	.60	Lanham, Md., July, 1925	Sick	
No. 1022	110.5	July 28, 1927	do	do	.50	do	Death	Linseed oil used as a remedy.
No. 1024	100	July 29, 1927	do	do	.40	do	Not sick	Symptoms possibly overlooked.
No. 1025	100	Aug. 1, 1927	do	do	.40	do	do	Do.
No. 1028	113.5	Aug. 8, 1927	do	do	.44	do	Somewhat sick	
No. 1029	109	Aug. 11, 1927	do	do	.42	do	do	
No. 1034	108	Aug. 14, 1927	do	Leaves and a few flowers.	.40	do	do	
No. 1038	105.5	Aug. 15, 1927	do	do	.20	do	Not sick	
No. 972	83.5	Aug. 17, 1927	do	do	.30	do	do	
No. 944	152	Sept. 14, 1927	do	do	.35	do	Symptoms	
No. 1038	110	Sept. 15, 1927	do	do	.60	do	Somewhat sick	Linseed oil used as a preventive.
No. 946	106	Sept. 17, 1927	do	do	.60	do	Not sick	Do.
No. 1000	80.5	Sept. 19, 1927	do	do	.60	do	Sick	Linseed oil used as a remedy.
No. 1008	64.5	do	do	do	.70	do	Not sick	Linseed oil used as a preventive.
No. 1021	87.5	Sept. 21, 1927	do	do	.70	do	Sick	Linseed oil used as a remedy.
No. 1027	82.5	Sept. 22, 1927	do	do	.80	do	Symptoms	Linseed oil used as a preventive.

Table 2.—*Summary of feeding experiments with Kalmia angustifolia*

Animal		Date of feeding	Method of feeding	Part of plant used	Per cent of animal weight given	Place, and date of plant collection	Result	Remarks
Designation	Weight							
Cattle:	*Pounds*							
No. 1151	440	July 20, 1928	Balling gun	Leaves	0.25	Amherst, Mass., July, 1928	Symptoms	
No. 1150	495	Aug. 21, 1928	do	do	.30	do	do	
No. 1155	590	Aug. 22, 1928	do	do	.40	do	Sick	
No. 1151	535	Sept. 11, 1928	do	do	.20	do	Probable symptoms	
No. 1187	648	June 20, 1930	do	do	.50	Foxboro, Mass., July, 1928	Sick	
No. 1199	622	July 7, 1930	do	do	.60	do	do	
No. 1159	600	July 12, 1930	do	do	.80	Amherst, Mass., July, 1928	do	
Goat:								
No. 11	81	Sept. 5, 1928	do	do	.25	do	Sick	
No. 15	57.5	July 10, 1930	do	do	.50	Foxboro, Mass., July, 1928	do	
Sheep:								
No. 1090	108	July 17, 1928	do	do	.25	Amherst, Mass., July, 1928	Symptoms	
No. 1091	94	July 19, 1928	do	do	.20	do	Not sick	
No. 1092	114	July 25, 1928	do	do	.26	do	Sick	
No. 1093	121	July 26, 1928	do	do	.24	do	do	
No. 1094	116.5	July 30, 1928	With hay	do	.25	do	do	
No. 1095	132.5	Aug. 1–2, 1928	With bran	do	.30	do	do	Sick after eating 0.26 per cent dose.
No. 1083	68.5	Aug. 5, 1928	Balling gun	do	.40	do	do	Sheep subject to fits.
No. 1049	75	Aug. 10, 1928	do	do	.50	do	do	
No. 1060	64.5	Aug. 17, 1928	do	do	.50	do	do	
No. 1064	105	Aug. 20, 1928	do	do	.20	do	Symptoms	
No. 1063	96	Aug. 21, 1928	do	do	.15	do	Slight symptoms	
No. 1069	132	Aug. 30, 1928	With hay	do	.40	do	Sick	
No. 1074	133	Sept. 3, 1928	do	do	.20	do	Slight symptoms	
No. 1073	111	Sept. 5, 1928	do	do	.18	do	do	
No. 1077	132	Sept. 6, 1928	do	do	.15	do	Not sick	
No. 1083	76.5	Sept. 10, 1928	Balling gun	do	.60	do	Very sick	Sheep subject to fits.
No. 1099	65	June 29, 1929	do	do	.25	do	Symptoms	
No. 1101	67	do	do	do	.25	Foxboro, Mass., July, 1928	Somewhat sick	
No. 1103	86.5	July 1, 1929	do	do	.15	do	Symptoms	
No. 1109	80.5	July 2, 1929	do	do	.10	do	Not sick	
No. 1110	79.5	July 8, 1929	do	do	.40	do	Sick	
No. 1112	102	July 12, 1929	do	do	.50	do	do	
No. 1117	91	July 16, 1929	With hay	do	.50	do	do	
No. 1120	109	July 25, 1929	Balling gun	Stems	.30	do	Symptoms	
No. 1121	80	do	do	Leaves	.60	do	Sick	
No. 1125	91	July 27, 1929	do	Stems	.41	do	Not sick	
No. 1127	80	July 29, 1929	do	do	.60	do	Symptoms	
No. 1138	87	Aug. 12, 1929	do	Leaves	.70	do	Sick	
No. 1146	91.5	Aug. 22, 1929	do	do	.90	do	Very sick	
No. 1107	95	Aug. 30, 1929	do	do	1.00	do	Sick	
No. 1124	78.5	Sept. 3, 1929	do	do	1.00	do	Very sick	
No. 1130	64	Sept. 13, 1929	do	do	1.20	do	Sick	

respiration 22. The pulse and respiration were both regular, but the latter was forced, with a pause between inspiration and expiration. At that time the sheep was standing but moved with an unsteady gait. The head was extended forward and was drooped. At 1.35 p. m., the temperature was 105.2, pulse 64, respiration 28. She was still standing and there was no distinct change in her condition. This condition continued during the afternoon. At 3.15 p. m., she was given 5 ounces of raw linseed oil. At 7 p. m., the sheep defecated very watery, foul-smelling feces. At 9.50 p. m., the temperature was 106.2°, pulse 92, respiration 36. The respiration was still somewhat labored, but the animal was able to stand and even to walk about.

July 30, at 6.30 a. m., she was found dead, lying on the left side. The body was still somewhat warm, so she had not been dead very long. The autopsy was begun at 8.05 a. m. and showed congestion in the fourth stomach, duodenum, and ileum. The kidneys also were congested. There was an excess of serum in the pleural cavity. No other abnormal conditions were found.

TYPICAL CASE OF CATTLE 1140

Cattle 1140 was a short yearling steer in good condition at the time of the experiment, and weighed 385 pounds. June 19, 1928, between 1.35 and 1.50 p. m., he was given by balling gun 327.5 grams of dry, ground *K. latifolia* leaves, moistened with water. This dose was an equivalent of 0.75 per cent of the animal's weight, the plant being estimated on a green-weight basis. That morning at 8.10 his temperature was 101.4° F., pulse 60, respiration 16. No symptoms of the effect of the plant were noted until June 20. At 7.59 a. m., June 20, the temperature was 99.6°, pulse 64, respiration 16. At 10.30 a. m., the feces were observed to be soft; and in as much as this condition was a common symptom in cattle poisoned by *K. latifolia*, this was considered as the first symptom of the effect of the plant. At 11 a. m., the animal was forced to rise and seemed to have lost partial control of his hind legs, as he staggered when attempting to move about, but after a little walked more readily. At 3.25 p. m. he was lying down, and when made to get up moved about very awkwardly, crossing his legs one over another, apparently through lack of control rather than simply from weakness. As in the morning, after he had been up for a short time, he walked much more easily. The feces at this time were very liquid. At 4.27 p. m., the temperature was 102.3°, pulse 68, and respiration 32. The pulse was strong and regular, and the respiration was deep and somewhat labored. Muscular incoordination was noticeable, as earlier in the day. At this time the steer had a distinct diarrhea.

At 8.13 a. m. the following day, the temperature was 101.5° F., pulse 60, and respiration 16. The pulse was hard and rather jerky, but the respiration was deep and regular. His movements were much like those of the preceding day, but somewhat improved, and he was ruminating. At 1.35 p. m., his condition was about the same as at 8.13 a. m. At 5.20 p. m., the temperature was 102.5°, pulse 64, and respiration 20. The pulse was somewhat weak and the expiration rather pronounced. The feces were still soft.

At 8.31 a. m. June 22, the temperature was 101.3° F., pulse 58, and respiration 12. The pulse was faint and respiration shallow. The animal was dull but showed no indication of the leg weakness which had been so pronounced on the preceding day. At 4.18 p. m., the temperature was 101.8°, pulse 68, and respiration 20. The pulse was strong and the respiration deep. At 4.35 p. m., it was noticed that the feces were firm and that the general condition of the animal was very much improved.

The following day at 8.30 a. m., the temperature was 100.3° F., pulse 52, and respiration 12. The pulse was strong and the respiration deep. The feces were firm, and the animal was considered as recovered from the effect of the plant. He had lost condition somewhat since being fed on *K. latifolia*, as would be expected. He was turned into the pasture in the afternoon. This can be considered as a case of distinct poisoning, without the extreme effects that sometimes appear.

TYPICAL CASE OF GOAT 2

Goat 2 was an old doe, weighing 95.5 pounds at the time of the experiment. She had received two former feedings of *K. latifolia*, one on August 5, of 0.4 per cent of her weight, which made her sick, and one on August 19, of 0.3 per cent of her weight, which had no distinct effect. On August 31, from 8.13 to 8.19 p. m., she was given by balling gun 54 grams of dry leaves of *K. latifolia* moistened with water. This dose was equivalent to 0.5 per cent of animal weight of green plant. No symptoms were noted until 1.20 p. m., September 1. At that time considerable regurgitated material was found lying about the pen in which she was confined. At 1.23 p. m., she was down and regurgitating and showing distinct symptoms of nausea. At 1.27 p. m., the temperature was 102.8° F., pulse 84, respiration 16. The pulse was weak, the respiration somewhat irregular, the expiration being slightly forced. At 1.37 p. m., the goat was lying down and vomiting. She groaned with each expiration. At 5.16 p. m., her temperature was 102.6°, pulse 76, respiration 28. The pulse was regular and the respiration irregular. The animal had been salivating during the afternoon and apparently was in some pain.

September 2, 8.36 a. m., the temperature was 100.9° F., pulse too weak to count, respiration 20 and irregular. She was still salivating and groaning as though in pain. This condition continued during the day. At 4.31 p. m., the temperature was 101.7°, pulse still too weak to count, and respiration 16.

The next observation was made the following morning at 8.25 a. m. She had been vomiting during the night and green material was smeared around her mouth and nostrils. She was salivating and weak. Breathing was still somewhat forced, and expiration was accompanied frequently with a groan. At 9 a. m., when attempting to walk she showed very marked weakness and unsteadiness of gait. At 4.20 p. m., the temperature was 101.3° F., pulse 64, and respiration 16. The pulse was regular, but weak, the respiration deep and irregular. The animal appeared to be somewhat better but was still very weak. At 5.45 p. m., she attempted to eat the leaves of the service-berry bushes which had been thrown into the pen. This was the first time she had attempted to eat since receiving the *K. latifolia.*

DISCUSSION AND GENERAL CONCLUSIONS

SYMPTOMS

KALMIA LATIFOLIA

The symptoms noted in the sheep poisoned by mountain-laurel were depression, weakness shown in a staggering gait, and sometimes prostration, salivation, nausea accompanied by vomiting, irregular and sometimes forced respiration. The picture of sheep 1022 (fig. 3) shows the animal at a time when it was weak, nauseated, and the breathing labored. Sometimes the sheep would grate its teeth. While occasionally changes in temperature and pulse rate were noted, none of them were characteristic.

The symptoms in goats were like those in sheep.

One of the cattle vomited and exhibited distinct evidence of nausea. One was definitely salivating. Weakness was pronounced. All had soft feces and this in some cases became a diarrhea.

KALMIA ANGUSTIFOLIA

In general the symptoms of sheep poisoned by sheep laurel were like those affected by mountain-laurel. While the pulse rate, as in the *K. latifolia* cases, was not characteristic, in a number of the animals the pulse was noticeably weak. The picture of sheep 1117 (figs. 4 and 5) shows the attitude of an animal in which muscular weakness was especially pronounced.

In the goats, the symptoms were like those of the sheep; the vomiting was very profuse; Fig. 6 shows No. 11 when attempting to vomit.

The cattle had the same symptoms as those poisoned by *K. latifolia;* three of the four cases exhibited soft feces. Five of the cattle vomited, and two were salivating.

In general the symptoms produced by the two plants were almost identical. This, of course, would be expected, as both contain the same poisonous principle, andromedotoxin. The symptoms from the experimental feedings correspond to those described by preceding authors.

MICROSCOPIC CHANGES IN ANIMAL TISSUES

Only one animal, sheep 1022, died as a result of the experimental feeding. An examination of the tissues of this animal gave the following results:

The most important and apparently the primary injury was in the kidneys. Very severe acute parenchymatous nephritis affecting all the tubules had led to necrobiotic changes in some tubules and complete breaking down of others, with a pronounced disarrangement of the epithelial cells. These changes were accompanied with a severe congestion, edema, some hemorrhage, and pronounced degenerative changes in the blood. In the most severely injured areas, plasma cells and lymphocytes were abundant. The most pronounced changes were in the convoluted tubules.

The liver cells were swollen, and some albuminous degeneration was present. This, however, was by no means so severe as the

for goats was 0.4 per cent, 0.3 per cent producing no effect. The minimum toxic dose for sheep was 0.35 per cent, 0.3 per cent producing no effect.

Sheep 1022 was killed by 0.5 per cent. As sheep 1018, which received 0.6, was only sick, 0.5 per cent is the probable minimum lethal dose. The lethal dose was not determined for goats and cattle; goat 17 recovered from a feeding of 0.6 per cent. Cattle were fed as high as 0.9 per cent of their weight and were only sick. The lethal dose for cattle is evidently considerably higher than that for sheep and goats.

Cattle, goats, and sheep are about equally susceptible to the effect of the plant so far as poisoning is concerned, but goats and sheep are more likely to succumb than are cattle.

KALMIA ANGUSTIFOLIA

From Table 2 it appears that the minimum toxic dose of *K. angustifolia* for sheep was 0.15 per cent of animal weight, as found in sheep 1063 and 1103. Sheep 1077 received 0.15 per cent and sheep 1091 0.2 per cent without effect. The lethal dose was not determined, but it must be something over 1.2 per cent, as sheep 1130 received that quantity and recovered.

A goat was made sick on 0.25 per cent.

There were seven feedings of cattle, the minimum effective dosage being 0.2 per cent. The largest dose given to cattle was 0.8 per cent, which only made the animal sick.

So far as these experiments go there is nothing to indicate any marked difference in toxicity of the plant for cattle, sheep, or goats.

A considerable number of feedings with sheep (16 with *K. latifolia*, and 32 with *K. angustifolia*) makes it possible to draw inferences in regard to the comparative toxicity of the two plants. The experiments with cattle and goats were too few for such a comparison, although goats are probably affected much like sheep. Since the minimum toxic dose of *K. latifolia* for sheep is 0.35 per cent and *K. angustifolia* 0.15 per cent, it seems clear that *K. angustifolia* is decidedly the more toxic. However, it is much less likely to cause death, as is shown by the fact that 1.2 per cent of *K. angustifolia* failed to be fatal, although 0.5 per cent of *K. latifolia* was lethal.

Preceding published information in regard to dosage of domestic animals is very slight. Crawford (*10*) in 1908 gave details of feedings of dry leaves of *K. latifolia* to three sheep of which the weight was given. These feedings were of dry, powdered leaves. Reducing his data to percentages of animal weight of green material, he had the following results: One sheep, receiving 0.596 per cent of its weight, was poisoned and recovered; one sheep, receiving 1.508 per cent of its weight, was poisoned and died; one sheep, receiving 1.469 per cent of its weight, was poisoned and died. His toxic dose was comparable with the results at the Salina station as one of the experimental sheep there received 0.6 per cent of its weight without a fatal result. Evidently his lethal doses were larger than the quantity necessary to produce death.

Thomas (*19*) in 1802 poisoned dogs with decoctions and tinctures of the plant, but as he did not mention the size of the dogs, or whether the leaves were green or dry, this dosage can not be compared with others. Observations made by Thomas on the effect of both *K. angustifolia* and *K. latifolia* on man indicated that 6 grains (0.4 gram) of green leaves was toxic.

The only other statement published in regard to the dosage of *K. angustifolia* is by Wood (*21*), in 1883. He made a decoction of 1 pound of leaves and fruit boiled down to one-half pint. Six and one-half ounces of this decoction was given to a sheep, weighing 23 pounds. This dose, the equivalent of 3.48 per cent of the animal's weight, made the animal sick but did not result in death. In comparison with the experiments at the Salina Experiment Station it was an extremely heavy dose and should have caused death. It seems possible that the method of preparation may have lessened the toxic properties of the plant.

TIME FROM FEEDING TO APPEARANCE OF SYMPTOMS

The average time from the feeding of mountain-laurel to the development of symptoms was: For cattle, 16 hours and 50 minutes; for goats, 16 hours and 47 minutes; and for sheep, 14 hours and 44 minutes.

Most of the experimental feedings were made in the evening, and the first symptoms were noted at the early morning observation, no observations being made during the night. Therefore it is probable that the actual time elapsing before symptoms appeared was shorter than that found in the averages. This is indicated in the fact that the minimum time for cattle was in the case of No. 1142 which was fed at 9.10 a. m., and symptoms appeared at 4.32 p. m. Several sheep that developed symptoms are not listed in Table 3 as it seemed proper to exclude those animals which received linseed oil before symptoms appeared.

TABLE 3.—*Time from feeding Kalmia latifolia to development of symptoms*

Animal	Hours	Minutes	Animal	Hours	Minutes
Cattle:			Sheep:		
No. 1143	18	40	No. 1018	19	21
No. 1136	22	26	No. 1022	17	22
No. 1135	20	34	No. 1028	19	39
No. 1140	20	40	No. 1029	13	15
No. 1146	17	20	No. 1034	10	16
No. 1142	7	22	No. 944	18	32
No. 1202	10	50	No. 1000	10	13
Goat:			No. 1021	9	18
No. 2 (Aug. 5)	23	20			
No. 2 (Aug. 31)	17	1			
No. 17	9	20			

In the case of sheep laurel the average time for symptoms to develop in cattle was 14 hours and 8 minutes, and in sheep 10 hours and 40 minutes.

As in the case of *K. latifolia*, most of the feedings of *K. angustifolia* were made in the evening, no night observations being made. For cattle the minimum time was in the case of 1151, which was fed from 11.23 to 11.30 a. m., and the symptoms were noted at 4.56 p. m. For the sheep the shortest period was with No. 1069, which was fed at 9.55 a. m. and showed symptoms at 4.43 p. m. Doubtless, if there had been continual observations in all cases of Kalmia feeding, the average time from feeding to symptoms would have been shown to be somewhat shorter than Tables 3 and 4 would indicate.

TABLE 4.—*Time from feeding Kalmia angustifolia to development of symptoms*

Animal	Hours	Minutes	Animal	Hours	Minutes
Cattle:			Sheep—Continued		
No. 1151 (July 20)	5	26	No. 1069	6	48
No. 1150	13	3	No. 1074	12	25
No. 1155	14	50	No. 1073	22	37
No. 1151 (Sept. 11)	15	54	No. 1083 (Sept. 10)	10	5
No. 1187	19	10	No. 1099	12	15
No. 1199	20	50	No. 1101	9	25
No. 1159	9	40	No. 1103	10	6
Goat:			No. 1110	8	45
No. 11	11	8	No. 1112	9	38
No. 15	8	20	No. 1117	12	20
Sheep:			No. 1120	10	26
No. 1090	18	55	No. 1121	8	40
No. 1092	12	50	No. 1125	8	17
No. 1093	10	20	No. 1127	9	54
No. 1083 (Aug. 5)	9	6	No. 1138	9	5
No. 1049	8	38	No. 1146	8	20
No. 1060	8	15	No. 1107	8	50
No. 1064	9	58	No. 1124	8	39
No. 1063	12	13	No. 1130	11	12

In comparing the effects of the two plants it appears, so far as these figures are concerned, that in the three classes of animals used, cattle, sheep, and goats, symptoms were developed somewhat more quickly with *K. angustifolia*. This is what would be expected from the fact that, as shown on p. 14, *K. angustifolia* is somewhat more toxic.

The only preceding data in regard to the time of development of symptoms are in the papers of Crawford (*10*) and Thomas (*19*). Of the three sheep poisoned by *K. latifolia*, reported by Crawford one became sick in 45 minutes, one in 1 hour and 30 minutes, and the third in 14 hours and 40 minutes. Thomas, in his experiments on dogs, found that five of the dogs poisoned by *K. latifolia* showed symptoms immediately, three in a few minutes, and the others in 30 seconds, 3 minutes, and 6 minutes, respectively.

DURATION OF SICKNESS

Tables 5 and 6 for the duration of sickness give the time from the first symptom to the last, as recorded in the experimental notes. As stated before, it is probable that many of the animals were somewhat sick before the observations were made, and it is also true that the actual period of illness may have extended beyond the last-noted symptom. Therefore, the periods recorded may be somewhat less than the actual time. The sheep that received linseed oil are not included in Table 5.

TABLE 5.—*Duration of sickness in cattle, goats, and sheep in cases of Kalmia latifolia poisoning*

Animal	Hours	Minutes	Animal	Hours	Minutes
Cattle:			Goat—Continued.		
No. 1143	0	55	No. 2 (Aug. 31)	75	16
No. 1136[1]	--------	--------	No. 17	8	40
No. 1135	24	20	Sheep:		
No. 1140	46	14	No. 1018	25	13
No. 1146	26	18	No. 1028	1	10
No. 1142	29	27	No. 1029	2	15
No. 1202	11	15	No. 1034	12	30
Goat:			No. 944[1]	--------	--------
No. 2 (Aug. 5)	32	8	No. 1027[1]	--------	--------

[1] One observation.

In cases of poisoning by *K. latifolia*, the maximum duration of sickness in cattle was 46 hours and 14 minutes; in goats, 75 hours and 16 minutes; and in sheep, 25 hours and 13 minutes. The average duration of sickness in cattle was 19 hours and 47 minutes, and of the sheep 6 hours and 51 minutes.

In cases of poisoning by *K. angustifolia*, the maximum period of illness in cattle was 72 hours and in the sheep 122 hours and 5 minutes.

The average duration of sickness for cattle was 28 hours and 44 minutes, for sheep 40 hours and 52 minutes, and for goats 22 hours and 35 minutes. It is not thought that any especial significance attaches to the differences in period between cattle and sheep on account of poisoning caused by either plant.

TABLE 6.—*Duration of sickness in cattle, goats, and sheep in cases of Kalmia angustifolia poisoning*

Animal	Hours	Minutes	Animal	Hours	Minutes
Cattle:			Sheep—Continued.		
No. 1151 (July 20)	15	30	No. 1063[1]	--------	--------
No. 1150	50	35	No. 1069	49	45
No. 1155	49	45	No. 1074	2	25
No. 1151 (Sept. 11)	8	25	No. 1073	2	35
No. 1187	2	20	No. 1083 (Sept. 10)	49	51
No. 1199	2	32	No. 1093	9	34
No. 1159	72	0	No. 1101	59	42
Goat:			No. 1103	33	50
No. 11	34	34	No. 1110	34	40
No. 15	10	25	No. 1112	74	2
Sheep:			No. 1117	50	25
No. 1090	4	30	No. 1120	32	57
No. 1092	23	30	No. 1121	53	20
No. 1093	26	3	No. 1127	26	0
No. 1094	32	24	No. 1138	120	48
No. 1095	14	0	No. 1146	74	0
No. 1083 (Aug. 5)	37	40	No. 1107	82	27
No. 1049	34	26	No. 1124	122	5
No. 1060	8	15	No. 1130	82	38
No. 1064	2	15			

[1] One observation.

Comparing the effects of the two plants, it seems apparent that *K. angustifolia* produces a somewhat more prolonged sickness.

When a comparison is made between the size of the dose and the length of illness, it is found, as may be expected, that with some exceptions there is a distinct correlation; that is, the larger doses generally speaking produced more prolonged illness.

Crawford (*10*), in 1908, gave data of duration of illness in three sheep poisoned by *K. latifolia;* two of them died, one in 2 hours and 6 minutes, and the other in 7 hours and 15 minutes; the third animal recovered in 33 hours and 15 minutes.

REMEDIES

KALMIA LATIFOLIA

Many remedies have been suggested for poisoning by *Kalmia latifolia*, some of which are rather fanciful. As in practically all cases of plant poisoning, many farmers believe in bleeding. The authors have known of many using linseed oil with beneficial results.

Thomas (*19*), in 1802, found that if lard was mixed with the laurel the toxic symptoms were lessened.

Rafinesque (*17, v. 2, p. 17*), in 1830, said: "Sheep, if not soon relieved by oil, will swell and die."

Grennell, Bushnell, and Knox (*12*), in 1861, recommended a drench of milk and castor oil with pellets of lard. Crawford (*10*), in 1908, suggested lard and a purgative like Epsom salt; he also recommended apomorphine hydrochlorate to induce vomiting. In the National Stockman and Farmer, in 1922 (*1*) a writer considered the best remedy to be sweet milk and exercise. Mrs. Belle Miller of Columbia, S. C., in correspondence has reported good results from the use of mineral oil.

The earliest reference to the use of oil or grease as a remedy was by Colden (*9*), in 1749, whose account may be translated as follows: "A ball of butter of suitable size thrust into the throat, if given at the right time, is a quick remedy for sheep, as I have proved."

While the authors, from the literature on the subject, and their own experience, felt confident that the administration of grease or an oil could be expected to aid poisoned animals in recovery, it seemed wise to try some definite experiments to test it.

Sheep 1022, which died from the effects of *K. latifolia*, received a single dose of 120 c. c. of linseed oil, which evidently was not effective. Later, six of the experimental sheep, Nos. 946, 1038, 1027, 1021, 1008, and 1000, were given *K. latifolia* in doses from 0.6 to 0.8 per cent of their weights. The quantities given were larger than the lethal dose of 0.5 per cent. Linseed oil was given to all these animals in a drench. In the case of sheep Nos. 1038, 946, 1008, and 1027 the administration of oil was commenced immediately after the feeding of the plant. With No. 1000 it was commenced about 23 hours after the feeding and with 1021, 10½ hours after; both of these animals exhibited symptoms before the oil was given. The dosage of oil was repeated at intervals varying from approximately one to three hours. The total quantity of oil given to an animal varied from 300 to 600 c. c. Three received 300 c. c., one 360 c. c., one 390 c. c., and one 600 c. c. Reference to Table 1 shows that two animals were sick, one somewhat sick, one showed symptoms, and two were not affected at all. In as much as all received doses of the plant which might have been fatal, the experiment seems to be sufficient to prove the beneficial effect of administering linseed oil. Probably in the case of 1022, the dosage of oil was too small to prevent death. As to the quantity of oil which should be given perhaps a desirable dosage would be 4 fluid ounces (120 c. c.), repeated at intervals of two or three hours.

KALMIA ANGUSTIFOLIA

While there has been no experimental work with remedies for poisoning by sheep laurel, oil doubtless would be equally effective with this plant.

ANIMALS AFFECTED BY THE PLANTS

The published statements about animals poisoned by *K. latifolia* and *K. angustifolia* are largely in relation to cattle and sheep and the more important losses have been of these animals. Goats are readily poisoned by both plants, although there is no preceding publication stating that they are poisoned by *K. angustifolia.* Chesnut (*6*), in 1898, was the first to mention that goats are poisoned by *K. latifolia;* in fact, Castiglioni (*4*), in 1790, stated that goats eat it with no harm. Probably the reason that the poisoning of goats by these plants was not mentioned earlier is that comparatively few goats have been kept in the regions where the plants grow.

Kalm (*15, v. 1, p. 335–40*), in 1770, stated that horses as well as sheep and cattle are poisoned by *K. latifolia.* Barton (*2*) in 1802 made a similar statement and added that—

> many of General Braddock's horses were destroyed by eating the leaves and the twigs of this shrub, in the month of June, 1755, a few days before this unfortunate General's defeat and death.

Later authors mention that horses may be poisoned, but no specific cases have been reported, and it seems probable that, while horses may be poisoned, the plant should not be considered as particularly dangerous to them. No experiments of feeding the plants to horses have been made.

As previously mentioned experimental results have shown that man may be poisoned by both *K. angustifolia* and *K. latifolia.*

Kalm (*15*), in 1770, stated that deer are not affected by *K. latifolia,* and this statement has been repeated by some later authors. The belief doubtless arose from the fact that no deer were found that presumably died from eating the plant.

Recently E. B. Forbes, director of the Institute of Animal Nutrition, and S. I. Bechdel, professor of dairy research of the Pennsylvania State College, in cooperation with the Pennsylvania Board of Game Commissioners and in consultation with the United States Bureau of Biological Survey, have been carrying on some experiments in the feeding of mountain-laurel and rhododendron to deer. In the last few years many deer have been found dead in the Pennsylvania forests, and Vernon Bailey of the Biological Survey has shown that they had been eating largely of the laurels. The results obtained by Forbes and Bechdel (*20*) are published in Bulletin 12 of the Pennsylvania Board of Game Commissioners. They have shown that deer may be fed an exclusive diet of mountain-laurel and rhododendron for several weeks without being poisoned, but that they may be fatally poisoned by heavy forced feedings of the mountain-laurel.

Kalm also stated that grouse feed on the fruit of *K. latifolia* in winter and are not poisoned. This has been repeated by others, but with no experimental evidence. From the fact that doves have been poisoned by andromedotoxin and the lethal dose determined, it seems probable that birds may be susceptible to the effect of the plant. Cats, dogs, mice, and rabbits have also been poisoned experimentally by andromedotoxin.

While from the practical standpoint of the farmer the danger from these plants has been mostly with cattle and sheep, losses of goats, fully as great, may be expected if they are kept in any considerable numbers in the regions where the laurels grow.

CONDITIONS UNDER WHICH POISONING OCCURS

While it is evident that *K. latifolia* and *K. angustifolia* may be considered to rank among the more important poisonous plants, it is also true that the actual numbers of domestic animals killed by the plants are not very great. This is in spite of the fact that the plants are widespread in their distribution and in many localities grow in great profusion. This is especially true of the *K. latifolia*, which in the mountain districts is frequently found in masses. The losses are relatively small because, doubtless, in common with most poisonous plants, these laurels are not sought by livestock but are eaten in quantity only when other forage is scarce. Season after season, cattle and sheep feed in pastures liberally supplied with laurel, with no harm whatever when the pastures have plenty of feed. Many of the losses occur in the spring after the animals are turned into pastures in which grasses and weeds have not had time to grow.

Other losses may occur later, if the pastures have become overgrazed and little is left but the laurels.

POISONING BY FLESH OF ANIMALS WHICH HAVE EATEN KALMIA

Kalm (*15*) said that dogs were made sick by eating the entrails of deer which had been feeding on *K. latifolia.* It has been reported that persons have been poisoned through eating the flesh of pheasants and partridges that had fed on Kalmia. Chesnut (*6*), in 1898, experimenting with andromedotoxin, gave to a chicken doses which, from experiments in other animals, might be expected to be fatal. The chicken showed no effects; it was then killed, the entrails removed, and the flesh boiled. The flesh was fed to two kittens, both of which became very sick. This experiment would seem to confirm the belief expressed by others that birds are not readily poisoned by these plants, but that their flesh may become poisonous to susceptible animals.

SUMMARY

K. latifolia and *K. angustifolia*, plants growing abundantly in the eastern part of the United States, have been recognized as being poisonous to livestock since the middle of the eighteenth century, the first detailed description of their effects having been published in 1770.

The animals most affected are cattle, sheep, and goats. Horses are said to have been poisoned. Both men and monkeys may be poisoned.

There is no definite evidence that wild animals are ever poisoned from grazing on these plants, although deer are susceptible to heavy forced feedings of mountain-laurel.

The actual losses are mainly of cattle, sheep, and goats; for those animals the effective dosage, the time for development of symptoms, and the duration of sickness have been determined.

Methods of avoiding losses are indicated and it is shown that oil or grease is an effective remedy in treating poisoned animals.

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