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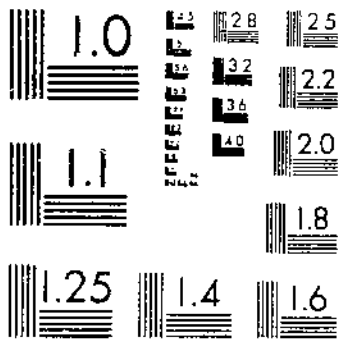
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COYOTILLO (KARNINSKIA HUMBOLDTIANA) AS A POISONOUS PLANT

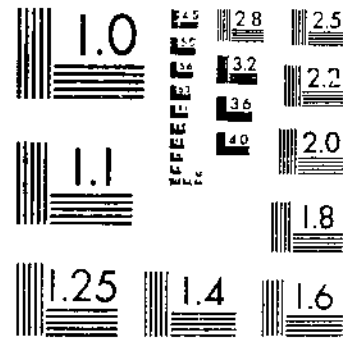
MARSH, C. D., CLANSON, A. B., ROE, G. C.

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NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

COYOTILLO (KARWINSKIA HUMBOLDTIANA) AS A POISONOUS PLANT

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HISTORICAL REVIEW

The first mention of the poisonous properties of *Karwinskia humboldtiana* was made by Clavigero in 1789¹ (1, p. 72) in the following statement (translation) regarding the plant in southern California:

There is another shrub in some places on the peninsula whose fruit is large as a vetch, round and black when ripe. The Indians (Cochimi) refrain from eating it because they well know that it is very harmful; but sometimes the children do not know it, or at least they fear nothing, so sometimes they eat it, led on by hunger or their desire. The effect which does not take place for some days remains in the meantime unnoticed; and afterwards other accidents happen to them which finally end their lives. Therefore the missionaries caused the destruction of all such plants. Notwithstanding, the Pericui eat the fruit without any bad results, first taking away the seed in which it is said is the whole trouble.

¹ Reference is made in italic numbers to "Literature cited," p. 25.

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In 1885 V. Havard (4, p. 509) wrote as follows:

The Coyotillo of the Mexicans on the Lower Rio Grande, common on the Pecos near its mouth and thence eastward to the coast. Shrub, with beautifully penninerved, ovate leaves, and brownish-black berries, said to be very poisonous. The virulent principle lies in the seed, the pulp being innocuous. The symptoms are those of paralysis of the spinal cord, primarily affecting locomotion.

Writing of the plant in Mexico, in 1890 Sosa (10) said that the fruit is eagerly eaten by boys and produces a paralysis that is easily cured. The sickness does not come on immediately, but after continued eating for several days.

In Engler and Prantl (2, p. 405), published in 1896, is the following sentence (translation):

The seeds contain a paralyzing principle and are used in Mexico for convulsions.

Rose in 1899 (9, p. 229-230) said that the leaves of this plant are crushed and soaked in water and the cold infusion used in cases of fevers. It has a wide use in Mexico.

Pammel (7, p. 124, and 8, p. 621) in his Manual of Poisonous Plants, published in 1910 and 1911, mentioned the plant as poisonous to goats, on the authority of Doctor Mitchell, of the United States Army.

Hernández (5) said that the bark of the root is powdered by the natives of Mexico and used as a laxative.

Standley (11, p. 717) made the following statement:

The fruit is sweet and edible, but the stones are harmful if swallowed. In people, especially children, paralysis, particularly of the lower limbs, is caused by eating stones, and similar effects are said to be produced in pigs and chickens. Palmer states that in Tamaulipas children thus paralyzed are taken to a slaughter pen, and stomachs of freshly killed cattle are wrapped about the parts affected, an outer covering being employed to retain the warmth. There is a prevalent belief that this mode of treatment is quite successful. The seeds are oily, and they contain some principle which paralyzes the motor nerves. They are employed in Mexico as an anticonvulsive, particularly in the case of tetanus. An infusion or decoction of the leaves and roots is used locally for fevers, and Palmer states that the hot tea is held in the mouth as a remedy for toothache and neuralgia.

The same author (12, p. 353) said of another species, *K. calderoni*, found in Central America:

Pigs are said to be paralyzed by eating the fruit, and similar properties are generally ascribed to the Mexican species.

A considerable volume of correspondence containing questions in regard to the toxicity of this plant has come to the Department of Agriculture. Among the notes which have been filed is the following statement made by Doctor Palmer in 1901:

Affects lower limbs. A man was lacerated with the black berries. Several children were brought to me at San Luis Potosi suffering from effects. One girl, aged about 15 years, lost use of limbs entirely. She was sent to Durango for treatment. Doctors said nothing could be done. They tried many remedies.

The investigations made by the Department of Agriculture were initiated as the result of correspondence in 1921 with H. Grafke,

inspector in charge, at Fort Worth, Tex., who sent some letters from J. C. McGill, Alice, Tex., which were accompanied with material of this plant. Mr. McGill gave a somewhat detailed statement in regard to the plant itself and the symptoms which were produced by it in goats, cattle, sheep, and hogs. In order that a nearer acquaintance might be made with the plant, a trip was made to Alice, Tex., where some of the localities in which the plant is abundant were visited, and arrangements were made for a considerable collection of both the fruit and the plant itself.² In 1923 letters were received from Evaristo Treviño, of Randado, Tex., in which he gave many details of the symptoms produced by the plant. He also forwarded a very generous quantity of the fruit.

From these correspondents a fairly definite volume of information was obtained which indicated that the poison produced by *Karwinskia* was not produced by the leaves but by the seeds in the fruit. It appeared, too, that goats, cattle, sheep, hogs, and human beings were affected by this poison. All the informants agreed that the principal symptom produced was a form of paralysis which led to the common name of "limber leg" as applied to the disease, and that the plant was sometimes known as "tanglefoot." The information gathered indicated not only that the plant was of considerable importance because of its relation to the poisoning of livestock but also because the rather peculiar symptoms of poisoned animals give it an unusual scientific interest.

DESCRIPTION OF PLANT³

KARWINSKIA

Shrubs or small trees; spineless; leaves opposite or nearly so, entire, thin, feather-veined, prominently nerved, dotted; flowers small in short-stemmed clusters in the axils of the leaves; calyx five-lobed, lobes acute; petals five, hooded, stamens five; style two or three lobed; drupe about three-eighths of an inch long.

An American group of seven or eight species.

KARWINSKIA HUMBOLDTIANA ZUCC.

Shrub or small tree, from 3 to 20 feet high. Twigs smooth or short-hairy; leaves oval to elliptical, 1 to 3 inches long, rounded or nearly heart-shaped at base, blunt or sharp at apex, smooth on both sides, green above, paler beneath, sometimes short-hairy beneath, edges somewhat rolled back, petioles short, slender; flower clusters smooth or sometimes short-hairy, short-stemmed, yellowish-green; drupe subglobose to ovoid brownish-black. This desert species is likely to be found in flower any month in the year, depending on weather conditions.

The plant is found on dry, gravelly hills, in Brazoria County, Tex. It is abundant from Corpus Christi and Brownsville along the Rio Grande River to the mouth of the Pecos River, Mexico, and in Lower California.

Figure 1 shows the leaves, flowers, and fruit. Figure 2 shows the growing bush and Figure 3 the distribution of the plant.

² Acknowledgment is here made of the helpful assistance rendered by J. C. McGill and H. E. McGill in the collection of material for the investigation.

³ The description of the plant was prepared by W. W. Eggleston, of the Bureau of Plant Industry.

The plant is most generally known in Texas as coyotillo; other names are callotio, coyotio, cayote, rivendore, margarita, cacahila, and gallita bush. Sosa (10) says it is known in Mexico as tullidora or capulincillo.



FIG. 1.—*Karwinskia humboldtiana*, showing leaves, flowers, and fruit

EXPERIMENTAL WORK

The experimental work on which this bulletin is based was carried on in the years 1921 to 1927, inclusive. Special attention was paid to the feeding experiments with fruit, inasmuch as the fruit was

supposed to be especially poisonous. Feeding experiments were also made with the leaves, with the seeds, with the stones and seeds, and with the pulp of the fruit.

In the work with fruit 8 sheep were used, of which 5 were poisoned; 5 head of cattle were fed, 3 being poisoned; of 3 experi-



FIG. 2.—*Karwinskia humboldtiana*, showing growing plant

mental goats 1 was affected; 9 out of 12 chickens fed were poisoned; and 8 of 14 experimental guinea pigs were poisoned and died.

In the feeding experiments in which leaves of the plant were used, 3 out of 30 sheep and 3 out of 10 cattle were poisoned.

In experiments to test the poisonous effect of the seed, guinea pigs only were used. Of the 3 fed, all were poisoned and died.

In experiments in which stones and seeds together were fed to chickens, the 3 chickens used showed evidence of toxic effect.

The pulp of fruit was fed to 9 chickens, 6 being affected; and 6 guinea pigs were fed the same products with no effect.

With the exception of the guinea-pig experiments and of certain experiments in feeding pulp to chickens, all the experimental work was carried on at the Salina (Utah) Experiment Station. The results of these experiments are summarized in Table 1.

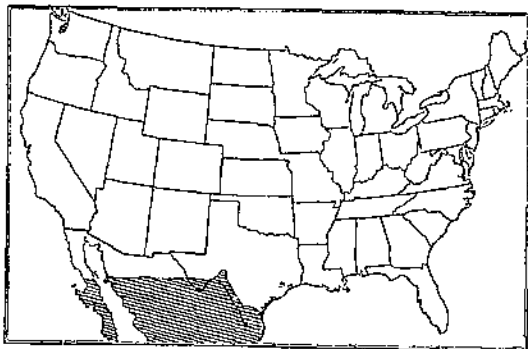


FIG. 3.—Distribution of *Karwinskia humboldtiana*, as shown by shaded area

TABLE 1.—Summary of feeding experiments with *Karwinskia humboldtiana*

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 (pounds)				Green	Dry	Average daily dosage			
Sheep:										
684	52.5	June 16, 1922	Balling gun	Ground fruit		0.225	Duval County, Tex., Jan., 1922	Death		
739	75.25	July 10, 1923	do	do		.15	Randado, Tex., Apr., 1923	Very sick		
750	105.0	July 18, 1923	do	do		.2	do	Death		
713	74.5	Aug. 1, 1923	do	do		.075	do	Not sick		
843	45.0	June 17, 1924	do	do		.15	do	Sick	Lamb.	
832	40.0	June 27, 1924	do	do		.075	do	Not sick	Do.	
790	52.5	July 15, 1924	do	do		.2	do	Sick	Do.	
806	45.0	July 30 to Aug. 3, 1924	do	do		.2	do	Not sick	Do.	
649	113.0	Aug. 18 to Sept. 1, 1921	In hay	Leaves	21.125		1.4	Duval County, Tex., July, 1921	Death	
653	92.25	Aug. 20-25, 1921	do	do	.5		.083	do	Not sick	
582	110.25	Aug. 20-27, 1921	do	do	4.29		.536	do	do	
603	114.5	Aug. 20-30, 1921	do	do	13.97		1.27	do	do	
653	92.25	Aug. 20-25, 1921	Balling gun	do	2.0		.33	do	do	
615	107.0	Aug. 29, 1921	do	do	3.0			do	do	
617	121.0	Aug. 31 to Sept. 4, 1921	In hay	do	3.31		.66	do	do	Refused to eat Karwin- skin after the first day.
628	111.5	Sept. 1, 1921	Balling gun	do	3.48			do	do	
626	134.75	Sept. 1-8, 1921	In hay	do	3.73		.47	do	do	Ate little after first day.
619	119.0	Sept. 9-13, 1921	do	do	5.88		1.18	do	do	
643	113.0	Sept. 12-21, 1921	Balling gun	do	33.33		3.33	do	do?	Repeated forced feedings 1 to 3 a day.
675	100.5	July 5, 1922	do	do	6.0		6.0	do	do	
670	117.5	July 5-10, 1922	With hay	do	5.96		.99	do	do	
693	110.5	July 20, 1922	Balling gun	do	8.0		8.0	do	do	
697	114.25	July 25-28, 1922	do	do	17.12		4.28	do	do	Nausea at last feeding.
616	120.5	July 31 to Aug. 2, 1922	With bran	do	5.92		1.97	do	do	
641	113.5	Sept. 17-19, 1922	With hay	do	Less than 2 lbs.			do	do	641 and 671 fed together.
671	67.5	do	do	do	do			do	do	
679	81.25	Sept. 18, 1922	do	do	None enten.			do	do	
699	127.0	Sept. 19-20, 1922	do	do	3.15		1.58	do	do	
719	81.0	Aug. 3-20, 1923	Balling gun	do	23.5		1.31	do	Death	

732	90.0	Aug. 22-25, 1923.	do.	do.	12.0		3.0	do.	Not sick	
742	83.5	Aug. 26 to Sept. 1, 1923.	do.	do.	18.0		2.57	do.	do.	
867	106.0	July 10-30, 1924.	do.	do.	22.5		1.5	do.	Death	
876	85.0	July 30 to Aug. 18, 1924.	do.	do.	20.0		1.0	do.	Not sick	
805	58.0	do.							do.	Lamb, used milk of sheep, 876.
885	07.0	June 19 to July 3, 1925.	Balling gun	Leaves	20.0		1.33	Duval County, Tex., July, 1921.	do.	
902	79.25	July 15-25, 1925.	do.	do.	14.00		1.33	do.	High temperature, rapid pulse.	Symptoms not due to Karwinskia.
915	91.5	Aug. 4-17, 1925	do.	do.	20.0		1.44	do.	Not sick	
884	82.5	Aug. 24 to Sept. 2, 1925.	do.	do.	20.0		2.00	do.	do.	
Cattle:										
1027	265.0	June 13, 1924	In bran	Ground fruit		.15		Randado, Tex., Apr., 1923.	Death	
1024	241.0	June 24, 1924	do.	do.		.075		do.	Very sick	Remedy, strychnine, Aug. 8 to Sept. 16.
939	560.0	Aug. 7-10, 1922	With hay	Leaves	3.93		.98	Duval County, Tex., July, 1921.	Not sick	
954	405.0	Aug. 14-16, 1922.	do.	do.	5.82		1.94	do.	do.	
929	650.0	Aug. 21-24, 1922.	do.	do.	3.7		.92	do.	do.	
998	336.0	Aug. 8-12, 1924.	With hay and bran	do.	3.28		.66	do.	do.	
1006	505.0	Aug. 18, 1924	do.	do.	.72			do.	do.	
1016	503.0	Aug. 18 to Sept. 19, 1924.	do.	do.	20.8		.6	do.	Death	
1036	448.0	June 22, 1925.	With hay	do.	1.78			do.	Not sick	
1040	380.0	June 22-27, 1925.	do.	do.	5.26		.88	do.	do.	Ate too little for experiment.
1049	352.0	July 7-25, 1925.	Balling gun	do.	18.9		.095	do.	Death	Remedy, strychnine.
1068	500.0	July 20 to Aug. 3, 1925.	do.	do.	15.0		1.0	do.	Weakness	
1123	488	June 16, 1927	With bran	Ground fruit		.05		Randado, Tex., May, 1925.	Symptoms	
1124	485	do.	do.	do.		.025		do.	Not sick	
1116	710	Aug. 8, 1927	Balling gun	do.		.05		Randado, Tex., Apr., 1923.	do.	
Goat:										
3	58	July 13, 1927	do.	do.		.15		do.	do.	
5	61	do.	do.	do.		.075		do.	do.	
1	90	Aug. 3, 1927	do.	do.		.2		do.	Sick	
Chicken:										
35	3.97	Aug. 24, 1923	Force fed	do.		.2		do.	Loss in weight (?)	
40	2.535	Aug. 1, 1924	do.	do.		.3		do.	Sick	
41	2.69	Aug. 4, 1924	do.	do.		.6		do.	Very sick	
42	2.421	do.	do.	do.		.5		do.	Sick	
43	2.443	Aug. 5, 1924	do.	do.		.4		do.	Somewhat sick	
44	2.310	Aug. 5-10, 1924.	do.	do.		.6	.1	do.	Sick	

¹ The leaves were fed as dry material. In computing green weight, 75 per cent was allowed for moisture lost in drying.

² Under observation a few days only; might have become affected.

TABLE 1.—Summary of feeding experiments with *Karwinskia humboldtiana*—Continued

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 (pounds)				Green	Dry	Average daily dosage			
Chicken— Contd.										
45	2.381	Aug. 5-11, 1924	Force fed	Ground fruit		0.7	0.1	Randado, Tex., Apr., 1923.	Death	
56	2.142	Aug. 25, 1925	do	do		.2	do	do	Not sick	
66	3.22	July 5, 1926	do	do		.3	do	do	do	
67	2.99	do	do	do		.4	do	do	do	
68	3.10	do	do	do		.5	do	do	Sick	
55	2.62	Aug. 25, 1925	do	Unground fruit		.6	do	do	Death	
47	2.551	July 17, 1925	do	Ground stones and seed.		.564	do	do	do	Seed and stones from 1 per cent dose of dry fruit.
50	3.031	July 20, 1925	do	do		.28	do	do	Very sick	Seed and stones from 0.5 per cent dose of dry fruit.
48	3.04	Aug. 10, 1925	do	do		.6	do	do	Death	Seed and stones from 1.07 per cent dose of dry fruit.
49	2.209	July 17, 1925	do	Pulp		.436	do	do	Sick	Pulp from 1 per cent dose of dry fruit.
51	3.042	July 20, 1925	do	do		.217	do	do	Slight leg weakness.	Pulp from 0.5 per cent dose of dry fruit.
46	3.505	Aug. 10, 1925	do	do		.6	do	do	Not sick	Pulp from 1.36 per cent dose of dry fruit.
61	3.03	Mar. 11, 1926	do	do		.217		Randado, Tex., Jan., 1926.	do	
62	3.79	do	do	do		.217	do	do	Affected	
58	3.9	do	do	do		.436	do	do	Not sick	
63	3.65	do	do	do		.436	do	do	Slightly affected	
59	3.75	do	do	do		.6	do	do	Affected	
64	3.16	do	do	do		.6	do	do	do	
Guinea pig:										
196	1.25	Jan. 27, 1922	do	do		.082		Duval County, Tex., Jan., 1922.	Not affected	Pulp partly dried.
198	1.11	do	do	do		.046	do	do	do	Do.
196	1.26	Feb. 7, 1922	do	do		.68	do	do	do	
240	1.14	Mar. 3, 1926	do	do		.68		Randado, Tex., Jan., 1926.	do	
239	1.04	do	do	do		.85	do	do	do	

237	.77	do	do	do	1.00	do	do	Died but death not caused by Karwinskia.
226	.84	Feb. 15, 1926	do	Ground fruit	.025	do	do	
228	1.01	do	do	do	.05	do	do	Do.
230	.99	do	do	do	.075	do	do	Do.
232	.70	do	do	do	.087	do	do	Do.
234	1.2	Mar. 3, 1926	do	do	.55	do	Death	
235	1.28	do	do	do	.312	do	do	
233	1.3	do	do	do	.156	do	Not affected	Died, but not from Karwinskia poisoning.
242	1.63	Mar. 30, 1926	do	do	.2	do	Death	
243	1.47	do	do	do	.25	do	do	
244	1.43	Apr. 2, 1926	do	do	.2	do	do	
246	1.33	do	do	do	.25	do	do	
248	1.54	Apr. 16, 1926	do	do	.15	do	do	
249	1.53	do	do	do	.15	do	do	
250	1.32	do	do	do	.15	do	do	
197	1.29	Feb. 16, 1922	do	Seed	.35	do	Not sick	
198	1.27	Mar. 1, 1922	do	do	.21	Duval County, Tex., Jan., 1922	do	
203	1	Mar. 20, 1922	do	do	.09	do	do	
Pl 31	40.5	Aug. 24, 1923	In bran	Ground fruit	.2	Randado, Tex., Apr., 1923.	Not sick	

TYPICAL CASE OF HEIFER 1024

Heifer 1024 was a healthy animal weighing 241 pounds at the time the experiment commenced. She was kept in corrals under observation from June 21 to June 24, 1924.

June 24. At 5.30 p. m. the animal was given 0.18 pound of finely ground *Karwinskia* fruit in bran. This was equivalent to a dosage of 0.075 per cent of the animal's weight. The material had been consumed at 6.50 p. m. From this time the animal was kept in the corrals and fed hay, but showed no symptoms until July 1.

July 1. In the morning it was noticed that she showed weakness in the legs. She appeared in good condition otherwise, but walked with a staggering motion, slightly dragging the hind legs, which seemed to be more affected than the forelegs. This weakness was much more pronounced in the afternoon, and the animal moved very little of her own accord and seemed somewhat sluggish. The leg weakness was especially pronounced in the hocks. In the succeeding days this weakness gradually increased.

July 3. The animal was unable to get on her feet. Most of the time she was in the breast position, and occasionally attempted to get up, but was unable to do so. She ate and drank readily and ruminated, but could not move herself about. The weakness was much more pronounced in the hind legs. She raised the body slightly with the forelegs, but had very little use of the hind legs. This condition continued with very little change, the animal perhaps gradually growing weaker, until July 9.

July 9. In order that the heifer might be raised, a sling was constructed and she was lifted from the ground. The legs at this time were almost useless. Figure 4 shows the condition of the animal at this time. Beginning July 9 the animal was kept in the sling for a short time once or twice a day until July 26. During this period she was fed and watered regularly and little by little regained, to some extent, the use of her legs.

July 18. It was noted that the forelegs could be moved readily, although at this time the hind legs were stiff and capable of very little action.

July 20. On this day the heifer made attempts to rise, placing her forefeet at various positions and drawing herself about to some extent.

July 21. It was observed that the animal was capable of much more movement with the hind legs, and that after being suspended in the sling for three and one-half hours she did not show great weariness.

July 22. When released from the sling she was able to support her entire weight on her legs when the hind legs were braced apart.



FIG. 4.—Heifer 1024, July 9, in a sling.
Animal unable to use her legs

Figure 5 shows the condition of the animal at this time when lying down.

July 25. When the sling was removed the heifer not only stood, but walked about a little.

July 26. This was the last day the sling was used.

July 27. Figure 6 shows the heifer on this date while on her feet. She could stand and walk about but was unable to rise without assistance. In the afternoon she was standing and moving about for 1 hour and 10 minutes, the longest time that she had been on her feet. The improvement continued very gradually.

July 28. The animal got to her feet without assistance for the first time during the illness.

July 30. The heifer was kept in the grounds around the corrals, in order that she might have a chance to get some grass. She was lying down most of the day but was able to get about in a stumbling, staggering manner.

During the succeeding days the improvement gradually continued, and August 9 was the last day on which she was helped to her feet. She was kept under observation from this time until September 25. Figure 7 shows her condition August 23. During this period there was continuous though slow improvement, but on September 25 the animal was still weak and her general condition was such that she was unable to take care of herself. She was placed in a wagon and taken to a farm at Redmond, Utah, for further observation. Unfortunately, not long after being placed on this farm she was mired in a ditch and died.

Whether the animal would have made a complete recovery is very doubtful. During the whole period of illness she apparently suffered no pain, had a good appetite, and gained somewhat in weight, as on September 25 she weighed 280 pounds. She received hypodermic injections of strychnine from August 18 to September 7. It is possible that the administration of strychnine may have aided in her

partial recovery, but there was nothing in the general condition of the animal to show that the convalescence was hastened by the use of this drug.

TYPICAL CASE OF SHEEP 739

Sheep 739 was a yearling ewe received at the station June 2, 1923. On July 5, 1923, she was taken into the corrals and kept under observation until July 10.



FIG. 5.—Heifer 1024, July 22. Animal better than in Figure 4, but having only slight use of her legs



FIG. 6.—Heifer 1024, July 27. Animal able to stand, but could not get upon her feet without assistance

July 10. The animal, weighing 75.25 pounds, received in the morning 0.113 pound of ground Karwinskia fruit administered by a balling gun. This quantity was the equivalent of 0.15 per cent of the animal's weight. After the feeding she was kept in the corrals until July 15.

July 15. The sheep was turned out with the other animals in the pasture. These animals were brought into the corrals at night, so that she was kept under observation from day to day. No



Fig. 7.—Steifer 1024, August 23, much improved

symptoms appeared until July 28.

July 28. In the morning the sheep staggered somewhat when walking and moved with stiff joints, stepping high. She did not at this time show any weakness, and so far as general health was concerned seemed to be all right. While she staggered occasionally, she would run about with no difficulty. From this date the sheep was kept in the corrals, fed with hay, and was under constant observation.

From July 29 to August 7 the symptoms of partial paralysis in-

creased. Her movements during this time were very interesting, but somewhat difficult to describe. She had lost to a considerable extent the control of her legs. Figure 8 shows the attitude assumed by the animal when walking. She was uncertain in the use of her legs and in this picture it may be noticed that the left forefoot is raised in an abnormal manner. The legs frequently were raised with a jerking motion and put down with some difficulty. The animal had lost control of the muscles to such an extent as to be unable to place the feet in an attempt to walk.

(Figs 9, 10, 11.) Figure 10 shows the animal with the left forefoot raised in this spasmodic manner and Figure 11 shows the same convulsive movement of the left hind foot. Frequently, in attempting to walk, the legs would be crossed, so that the animal had difficulty in maintaining an erect position. Sometimes the forelegs would move together in the spasmodic manner shown in Figure 11. At other times the hind legs would



Fig. 8.—Sheep 739, July 30, shows lack of complete control of the leg

be used together in the same way, and the animal in attempting to go forward would go by jumps. In fact, the animal was unable to control her legs sufficiently so that she could move forward, and frequently, in attempting to walk, would go back instead of forward. One observer remarked that the animal moved as if she had hobbles on her feet. Clinical observations were made upon the sheep twice a day, but no abnormal characteristics of temperature, pulse, or respiration were noted. The sheep had a fair appetite and ate readily, and, except for the lack of muscular coordination, was in

very good condition. These symptoms continued with very little change until September 24. While the animal did not gain in weight during this period, she lost very little. On September 24 she was shipped to Washington for further observation.

October 23. On this date the animal was very much improved. She was stronger than when shipped from Salina and the awkward movements of the legs were not so distinctly marked.

November 2. The animal weighed 10 pounds more than when shipped from Salina and appeared fairly well except for some lack of muscular coordination in the hind legs.

January 7, 1924. The sheep was very much better at this time than at the former observation.

February 25. While there was still a little uncertainty in the movements of the hind legs, the animal in her general condition was greatly improved. She weighed 93.5 pounds, and was considered as practically recovered from her experience with coyotillo poisoning.

February 24, 1926 (two years later), this animal appeared perfectly normal. She weighed 102½ pounds and had raised a fine lamb. This was a clear case of complete recovery.



FIG. 9.—Sheep 739, August 1, showing spasmodic movement of forefeet, so that the animal moved by jumps

TYPICAL CASE OF HEIFER 1049

Heifer 1049 was received at the Salina Experiment Station June 2, 1925. At the time of the experiment she weighed 352 pounds. The experimental feeding with *Karwinskia humboldtiana* was commenced July 7. The animal had been kept in the corrals for observation from June 25.



FIG. 10.—Sheep 739, August 10, showing jerking movement of the foreleg

From July 7 to July 25, inclusive, she received by balling gun 18.9 per cent of her weight of leaves of *K. humboldtiana*, estimated as green material, in daily doses of 0.995 per cent of her weight. While receiving this feed she was kept in the corrals and fed liberally with hay. No symptoms were noted until about July 15. From this date the animal began to lose weight rather rapidly.

July 25. The respiration was somewhat irregular. Beginning on this date the animal was turned out into the yard surrounding the corrals in order that she might get some green feed.

July 28. When the heifer was locked up at night to be driven into the corral she was found down in a dry ditch and had to be helped out. While being driven in she stumbled and went down on her knees.

August 6. The heifer showed increased weakness, reeled when walking, and there was a slight lack of control of the hind legs, this

lack of control apparently being due to weakness rather than to any paralytic effect.

August 7. The weakness in the hind legs and the weaving in walking was much more marked.

August 16. The weakness had increased, being especially marked in the hind legs. The heifer was in very poor condition, weighing only 253 pounds. There was some slobbering during regurgitation. She still ate fairly well.



FIG. 11.—Sheep 739, September 8, showing the spasmodic action of the hind leg

August 19. The weakness had continued and increased. The heifer stood in humped attitude and had difficulty in getting up and down. Much liquid was running from her mouth, although it could hardly be said that she vomited.

August 22. Figure 12 shows the animal as she appeared on this date when she was on her feet. This shows the humped position the animal assumed when standing.

August 23. Two hypodermic injections of one-tenth of a grain of strychnine sulphate were given. In connection with the breathing there was a rattling noise in the animal's throat.

August 24. The rattling in the throat continued, and there was a continual running of liquid from the mouth. Two hypodermic injections of one-tenth of a grain of strychnine sulphate were given.

August 25. The weight of the animal had become reduced to 190 pounds. At 4 p. m. she was found dead. The autopsy followed immediately. The trachea contained considerable froth. At the edge of the left lung were two hepatized areas. In the dorsal portion of the main lobes on each side there were two large cavities nearly 3 inches in diameter distended with air. The tissue surrounding the cavities was reddish and thickened. These cavities were not directly connected with the bronchi. The first stomach contained very little liquid and in its contents were many bezoarlike masses of vegetable material. The mucous surface of the fourth stomach was greatly inflamed and swollen. The inflammation was also present in the jejunum. There was nothing abnormal in other parts of the alimentary canal. The spleen was small and thin. The liver was congested and the gall bladder large and distended. The bile was somewhat viscid and dark. The centers of the abdominal lymph glands were somewhat darkened.

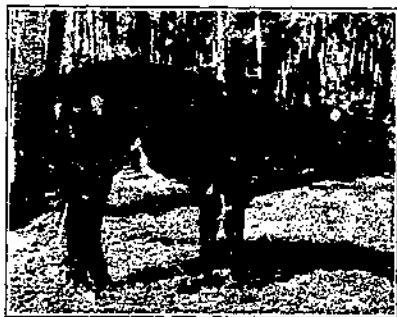


FIG. 12.—Heifer 1049, August 22, poisoned by *Karwinskia humboldtiana*, leaves animal weak and "humped up"

DISCUSSION AND GENERAL CONCLUSIONS

SYMPTOMS FROM FRUIT IN SHEEP AND CATTLE

The first symptom noted was in the movements of the hind legs. This was shown in leg weakness, in dragging the feet, and muscular incoordination. In mild cases this is shown only in a little uncertainty of movement. In more pronounced cases it results in a "high-stepping" action, a leg being jerked up and set down in a haphazard way, as shown in Figure 13. The animal may move in a spasmodic manner, sometimes apparently going backward when it intends to go forward, because it is unable to control its muscles. In attempting to walk it may go by jumps. The lack of coordination may be extended to the forelegs. This is shown in sheep 739. The lack of coordination may be accompanied with weakness so that the animal almost or quite loses the use of its legs and becomes completely prostrated, as shown in steer 1027. (Fig. 14.) In Texas the disease resulting from coyotillo poisoning is sometimes called "limber leg."



FIG. 13.—Lamb 790, August 21, showing jerking movement of right hind leg

The trouble, apparently, does not produce pain. The animal may have a good appetite and eat readily if feed is provided; this condition was especially marked in steer 1027, which seemed perfectly contented, although entirely unable to get on its feet. In cases of recovery the paralysis disappears very gradually.

There were no pathological characteristics of temperature, pulse, or respiration.

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There were no pathological characteristics of temperature, pulse, or respiration.

SYMPTOMS FROM LEAVES IN SHEEP AND CATTLE

The experiments of 1923, 1924, and 1925 show that *K. humboldtiana* leaves do not produce the paralytic symptoms especially characteristic of the fruit.

Two of the three sheep, Nos. 719 and 867, affected by *Karwinskia* leaves exhibited nausea. A third,



FIG. 14.—Steer 1027, June 20, almost completely paralyzed

sheep 915, which received the plant but was not certainly affected by it, vomited, but there was some reason to think that this animal may have been a spewer, that is, poisoned by *Helonium hoopesii*.

Sheep 902 had a high temperature and pulse, showing no other symptom. As the other animals did not have any abnormal temperature or pulse rate, it is doubtful whether the condition was due to *Karwinskia*. So far as can be judged from the small number of cases,

Karwinskia leaves have no definite effect on temperature, pulse, or respiration.

The general effect was to produce a chronic condition of unthriftiness, depression, progressive weakness, and loss of weight, resulting eventually in death. Figure 12, of heifer 1049, taken three days before her death, shows the typical appearance of an animal poisoned by *K. humboldtiana* leaves.



FIG. 15.—Chicken 40. The legs are weakened so that the bird rests on the metatarsals

the bird would fall. Sometimes fowls would feed resting on the metatarsals or move over the ground on them. Sometimes they assumed a stilted attitude when walking. The pictures of chicken 40 (fig. 15) and chicken 43 (fig. 16) show attitudes assumed by poisoned birds. Figure 17 shows a group of sick chickens. Eventually they may become almost completely paralyzed, so far as the legs are concerned, and partially so in the wings, and may even be unable to move at all. While some of the birds showed depression and became dull and stupid, many were in fairly good condition, except for the paralysis, and ate readily. Most of the chickens doubtless would die, but by careful feeding many will live a long time and some may recover.

SYMPTOMS IN GUINEA PIGS

The symptoms in guinea pigs were not so marked as in the other animals which were the subject of experiment. Probably the only diagnostic symptom was the paralysis of the legs, most noticeable in the hind legs. Other less noticeable symptoms were loss of weight, depression, and general weakness.

AUTOPSY FINDINGS IN SHEEP AND CATTLE

The lesions produced by *Karwinskia* were not of a specific character. Autopsies were made on 5 sheep, Nos. 684, 750, 649, 719, and

SYMPTOMS IN CHICKENS

In the feeding experiments with chickens whole fruit, ground seeds and stones, and the pulp of fruit of coyotillo were used.

Poisoned chickens exhibited the same characteristics as poisoned sheep and cattle. Generally speaking, the first symptom was a slight difficulty in walking, resulting in occasional staggering. As the trouble progressed the fowl gradually lost control of the legs. When it attempted to walk the legs would give way or become crossed so that



FIG. 16.—Chicken 43, showing stilted gait of a poisoned animal

867, and 2 cattle, Nos. 1027 and 1049. Two of them exhibited petechiae on the heart. There was an inflamed condition of the fourth stomach in 4, and of the duodenum and jejunum in 3. The lungs were congested in 4. The pancreas was congested in 3. The liver was abnormal in 3. The kidneys were congested in 4. In 6 cases many of the lymph glands were swollen, congested, and edematous. There was evidence of an abnormal condition of the suprarenals in 3.

In general the effect of the plant was shown in the mucous membranes of the alimentary canal and in the principal glands of the



FIG. 17.—A group of poisoned chickens

body, and it was especially marked in the lymphatics. There was no clear distinction between the effect of the fruit and that produced by the leaves.

AUTOPSY FINDINGS IN CHICKENS

Of 6 chickens on which autopsies were performed 2 showed no abnormal conditions. The leg muscles of 1 were atrophied; this was probably true of others, also.

MICROSCOPIC CHANGES IN TISSUES

In the microscopic examination of the tissues only such changes have been observed as would seem to be secondary, and these possibly occurred largely during the period shortly before death when the animals were in a moribund condition. The following results are based on a study of the tissues from 5 animals, 2 of which were cattle and 3 sheep. Of these animals, 1 of the cattle and 2 of the sheep were poisoned by the fruit, while the other 2 animals were leaf cases.

The most pronounced changes were found in the livers. In the least-marked case there was congestion of the intralobular blood capillaries accompanied by a few minute hemorrhages, and a cloudy

swelling of the hepatic cells. In the most severely changed livers the hepatic cords of the central zone of the lobule were broken up and many of the hepatic cells were necrotic. In one of these cases leucocytes were abundant throughout the lobules.

The kidneys were somewhat injured, the condition being that of acute parenchymatous degeneration of a somewhat mild type. In all the cases the convoluted tubules were affected. This varied between a mild swelling with an increased affinity for eosin to a pronounced granular degeneration with some disintegration and accumulation of debris in the lumina. In a number of tubules in all cases the epithelial cells were loosened and disarranged. A similar but less marked condition existed in the other tubules. In the mildest cases no change, other than a slight swelling of the epithelial cells, was noticeable in the glomeruli. In the more extreme cases some of the capillary loops were necrotic and considerable debris was present in the space between the tufts and the capsule wall. The kidneys might or might not be congested.

The lungs from all the cases were more or less congested. In two the congestion was mild and occurred only about certain groups of alveoli. In the others it was more general throughout the sections and was accompanied by pulmonary edema, diapedesis of erythrocytes, some swelling of the epithelium of the alveoli, and outwandering of polymorphonuclear leucocytes. The disturbance in two of the cases was centered about the terminal bronchi. In these sections foreign material was present in some of the bronchi, and had caused an acute, inflammatory reaction.

Indications of irritation were present in the walls of the ventricles of the heart in all the cases. This varied between a slight outwandering of leucocytes and some diapedesis of erythrocytes in the mildest cases, and a slight increase in connective tissue, more pronounced outwandering of leucocytes, and some fatty infiltration in those that were further advanced. In the more pronounced cases scattered muscle fibers of the myocardium had undergone degenerative changes. While a general capillary congestion did not exist in any of the sections, in all of them isolated small veins and capillaries were greatly distended, and minute hemorrhages were found in most.

Lymph glands very generally throughout the body had reacted to an irritant. A very few were only slightly stimulated. Most of them were congested or even hemorrhagic. In many the endothelial cells were greatly swollen or exfoliated, serous fluid was present in abundance and had often coagulated, and leucocytes had accumulated in great numbers. In some the lymph channels were packed full of swollen and degenerated endothelioid cells and leucocytes, the capsule was edematous, and the spaces filled in with leucocytes. In a few cases considerable infiltration had occurred in the connective-tissue areas. In general the lymph glands of the anterior portion of the body were more affected than the posterior ones.

The organs or tissues in which changes were observed were the liver, kidneys, lungs, heart, and lymph glands. The changes were pronounced in the liver and many of the lymph glands, but were less marked in the other tissues. They were mostly acute in character and probably secondary rather than primary.

TOXIC AND LETHAL DOSES

In most cases the observations on experimental animals were carried on only during the four summer months. Inasmuch as some animals do not show the effect of the plant until a considerable period has elapsed after the feeding and are sick for a long time, the final result of the feeding is in many cases unknown. Consequently, no definite statement can be made in regard to the lethal dose.

TOXIC AND LETHAL DOSES OF FRUIT

SHEEP

The minimum toxic dose for sheep was 0.15 per cent of animal weight of dry material. Sheep 739, in 1923, and sheep 843, in 1924, were made sick by this quantity. Sheep 750, in 1923, was killed by a 0.2 per cent dose.

CATTLE

Heifer 1123 was poisoned by 0.05 per cent of animal weight and steer 1027 was killed by 0.15 per cent. As cattle 1116 was not affected by 0.05 per cent, this may be considered as the minimum toxic dose. The minimum lethal dose is probably not far from 0.15 per cent.

GOATS

Of the 3 goats used, Nos. 5 and 3 received, respectively, 0.075 and 0.15 per cent of animal weight without effect, while in No. 1 marked symptoms were produced by 0.2 per cent, this quantity being about the probable minimum toxic dose.

CHICKENS

The minimum dose of ground fruit producing sickness was 0.3 per cent in the case of chicken 40. As 0.2 per cent had no effect on chicken 56, and on chicken 35 produced no result unless the loss of weight is considered a symptom, it is probable that 0.3 per cent is close to the minimum toxic quantity for chickens. The only bird that died directly from the feeding was chicken 45, from a feeding of 0.7 per cent. Chickens 40, 41, 42, and 43 were killed for autopsy at the end of the season, and all but No. 43 were in bad condition, and probably would have died. It is probable that there is little difference between the toxic and lethal doses and that 0.3 per cent or more is likely to produce a fatal effect. One chicken, No. 55, received unground fruit and was killed by a dosage of 0.6 per cent.

PIGS

Only one pig was used and this was not affected by a 0.2 per cent dose. This animal was under observation one month. Inasmuch as symptoms sometimes occur after a long period, it can not be said positively that this dose was without effect.

GUINEA PIGS

The experiments with guinea pigs showed that the minimum toxic and lethal dose was 0.15 per cent of animal weight.

TOXIC AND LETHAL DOSES OF LEAVES

SHEEP

The smallest toxic dose of leaves for sheep was 21.125 per cent in the case of sheep 649. This dose not only produced sickness but also death. As sheep 876 was not affected by 20 per cent, it may be assumed that 21.125 per cent is about the minimum toxic dose and that the toxic and lethal doses are practically the same.

It may be noted that sheep 643 received a much larger quantity—33.3 per cent—and was not affected. But this animal was under observation for only six days after the conclusion of the feeding, and, as the effect of the plant is frequently very much delayed, it is possible that a longer period of observation would have shown that this animal was poisoned.

CATTLE

Heifer 1068 showed only weakness from a 15 per cent dose. This is probably about the minimum toxic dose. Heifer 1049 was killed by a dose of 18.9 per cent and steer 1016 by 20.8 per cent. These are probably not far from lethal doses. There is no marked difference between the toxic and lethal doses.

TOXIC AND LETHAL DOSES OF STONES AND SEED

CHICKENS

Three chickens, Nos. 47, 48, and 50, were given the stones and seed of the fruit ground. All were affected and two died, the minimum lethal dose being 0.56 per cent of animal weight. Chicken 50 was made very sick on a 0.28 per cent dose. As the minimum toxic dose of fruit was considered to be about 0.3 per cent, it appears that the toxic dose of whole fruit and of seeds with stones is about the same.

TOXIC AND LETHAL DOSES OF SEED

GUINEA PIGS

Three guinea pigs were fed on seeds, that is, fruit from which the pulp and stones had been removed, the smallest dose being 0.09 per cent of animal weight. All three died. The minimum toxic and lethal doses were not determined, but as the minimum dose of fruit is 0.15 per cent it is evident that the seeds are more poisonous than the whole fruit.

TOXIC DOSE OF PULP

As stated in the introduction, Havard says that the poisonous properties of the plant are in the seed and that the pulp of the fruit is innocuous. This is the general belief among stockmen acquainted with the plant. As chickens had proved to be good test animals for *Karwinskia* poisoning, a few feedings were made to check up on this belief in the nonpoisonous character of the pulp.

From a quantity of dry fruit representing 1 per cent of its weight, chicken 47 received the stones and seed and chicken 49 received a similar dosage of pulp; chicken 47 was killed by 0.564 per cent of its weight of stones and seed and chicken 49 was made sick by 0.436 per cent of pulp.

Chicken 50 received stones and seed in a dosage representing 0.5 per cent of animal weight of dry fruit and chicken 51 a similar dosage

of pulp. Chicken 50 was made very sick by 0.28 per cent of its weight of stones and seed and chicken 51 was affected in a less degree by a 0.217 per cent of pulp.

Chicken 48 received stones and seed in a dosage representing 1.07 per cent of animal weight of dry fruit, and chicken 46 received pulp in a dosage representing 1.36 per cent of animal weight of dry fruit. Chicken 48 was killed on 0.6 per cent of its weight of stones and seed and chicken 46 was not affected by the same quantity of pulp.

These experiments showed that while the pulp is not so toxic as the stones and seed it is still quite poisonous, and that the minimum toxic dose is probably not far from 0.217 per cent of animal weight, although in one case 0.6 per cent was given with no effect.

The preceding experimental feedings of pulp were made at the Salina Experiment Station. Further tests were made in which six chickens received pulp in the bureau's animal room in Washington, D. C. The dosages, which were based on that found to be effective at the Salina station, were 0.217, 0.436, and 0.6 per cent of animal weight, two chickens being used on each dosage. Four of the chickens were affected, 1 on a 0.217 per cent, 1 on a 0.436 per cent, and 2 on a 0.6 per cent dose. These results confirmed those obtained at the station.

Four guinea pigs, receiving from 0.046 to 0.85 per cent, showed no effect.

TIME FROM FEEDING TO APPEARANCE OF SYMPTOMS

Table 2 shows the length of time which elapsed between feeding of different parts of the coyotillo plant and the development of symptoms in animals. Table 1 may be consulted for additional details concerning the experiment.

TABLE 2.—Time elapsing between feeding and the appearance of symptoms

Animal and number	Part of plant fed	Dose	Time elapsed from feeding to development of symptoms	Animal and number	Part of plant fed	Dose	Time elapsed from feeding to development of symptoms
		Per cent animal weight	Days			Per cent animal weight	Days
Sheep 684	Fruit	0.225	2.3	Guinea pig 235	Fruit	.312	2.8
730	do.	.15	18.0	234	do.	.55	2.8
750	do.	.2	5.0	Sheep 649	Leaves	21.1	5.0
790	do.	.2	18.0	719	do.	23.5	4.5
843	do.	.15	47.5	867	do.	22.5	3.0
Heifer 1024	do.	0.75	6.5	Steer 1016	do.	20.8	1.5
1123	do.	.05	15.6	Heifer 1040	do.	18.9	7.0
Goat 1	do.	.2	2.9	1068	do.	15.0	1.0
Steer 1027	do.	.15	3.0	Guinea pig 107	Seeds	.35	2.3
Chicken 40	do.	.3	27.0	198	do.	.31	8.9
41	do.	.6	16.5	201	do.	.00	1.9
42	do.	.5	22.0	Chicken 47	Seeds and stones	.504	10.0
43	do.	.4	27.8	48	do.	.6	.8
44	do.	.6	10.0	50	do.	.28	7.0
45	do.	.7	7.0	49	Pulp of fruit	.436	14.8
55	do.	.6	34.0	51	do.	.217	20.7
68	do.	.5	45.0	62	do.	.217	33.7
Guinea pig 218	do.	.15	3.0	63	do.	.436	31.7
240	do.	.15	6.0	59	do.	.6	33.7
242	do.	.2	3.8	64	do.	.6	
244	do.	.2	2.8				
245	do.	.25	2.8				
246	do.	.25	3.0				

With the exception of sheep 806 and chickens 44 and 45, the experiments with fruit were made by a single feeding, whereas the experiments with leaves were made by feedings extending over several days, and the time for the appearance of symptoms was computed from the last feeding. The feedings of fruit also were estimated in air-dried material, while the feedings of leaves were estimated as green material.

Attention may also be called to the fact that while the total number of feedings was rather large, the numbers for special animals and under identical conditions were small. The average periods of time between the last feeding and the appearance of symptoms were as follows:

	Days
For sheep receiving fruit.....	18.2
For cattle receiving fruit.....	8.4
For chickens receiving fruit.....	23.7
For guinea pigs receiving fruit.....	3.4
For sheep receiving leaves.....	5.0
For cattle receiving leaves.....	3.8
For chickens receiving seed and stones.....	4.2
For guinea pigs receiving seed.....	4.1
For chickens receiving pulp of fruit.....	23.6

The striking thing about the plant is that a considerable period ordinarily elapses between the feeding and the appearance of symptoms. This time reached a maximum of 47.5 days in the case of sheep 843. It is difficult, therefore, when animals are on the range, to determine definitely that sickness and death are caused by the coyotillo, for an animal, when symptoms first appear, may be a long way from the source of trouble.

A similar delay in the appearance of symptoms from plant poisoning was noted by Theiler (13) in regard to the effect of *Crotalaria dura*, by Maleval (6) in regard to *Lathyrus*, and by Hagan and Zeissig (3) in cases poisoned by bracken fern and soy beans.

The time elapsing between the feeding and the appearance of symptoms is greater in the case of fruit than of leaves, especially with sheep. This may be largely accounted for by the fact that the leaf feedings continued for a considerable period, and the time to the appearance of symptoms is computed from the last feeding.

When symptoms appear they generally develop somewhat suddenly, without premonitory indications, and the maximum effect produced by the fruit occurs comparatively soon after the first evidences of intoxication.

DURATION OF SICKNESS

As stated elsewhere, *Karwinskia humboldtiana* produces prolonged illness from which, in severe cases, recovery rarely takes place, the only positive cases of complete recovery being those of heifer 1123, chicken 68, and sheep 739. In a few of the cases there was fairly positive evidence of the time when improvement commenced. Table 3 gives these data:

TABLE 3.—Time elapsing from the appearance of first symptoms to first noted improvement

Animal and number	Part of plant fed	Time from observance of symptoms to first improvement (days)
Sheep 739.....	Fruit.....	88.0
Sheep 790.....	do.....	36.0
Sheep 841.....	do.....	20.0
Heifer 1024.....	do.....	21.5
Chicken 08.....	do.....	7.0
Heifer 1008.....	Leaves.....	2.0
Chicken 49.....	Pulp of fruit.....	27.0

In the case of heifer 1068, for which the time of two days is given, it should be stated that the only evidence of an improved condition at the end of two days was a slight increase in weight, this increase being continuous after that time. Heifer 1123, which showed only slight symptoms, was considered normal 28 days after first symptoms were noted. In the other animals, not including chickens, the time before improvement was noted varied from 20 to 88 days. Put in a general way, it may be said that the animals were sick for three weeks or longer before any change for the better was noted.

CUMULATIVE EFFECT OF THE POISON

Of the sheep fed with fruit No. 806 was the only one which received the plant on successive days. This animal received 0.2 per cent of its weight in five days and was not affected. Two other sheep, Nos. 750 and 790, each received a similar quantity in one day—No. 750 being killed and No. 790 made sick. Two sheep, Nos. 739 and 843, were made sick by a dosage of 0.15 per cent. So far as the sheep are concerned, there was evidently some elimination and it is not clear that there was any cumulative effect.

Of the chickens fed with the fruit, No. 44 received 0.6 per cent of its weight in six days and was sick, and No. 41 received 0.6 per cent in one day and was very sick. In these cases the effect was about the same whether the material was given in a single dose or spread over a period of days.

So far as can be judged from the chicken experiments the poison is cumulative with very little elimination. The fact that symptoms are apt to occur at a considerable period after the feeding indicates that there is little elimination.

Of the sheep fed with leaves three were poisoned—No. 719 by a dose of 23.5 per cent given in 18 days, No. 867 by a dose of 22.5 per cent given in 15 days, and No. 649 by a dose of 21.125 per cent given in 15 days. None of the other sheep fed with leaves received so large quantities as these three animals with the exception of No. 643, which in nine days received 33.3 per cent. This animal, however, was kept under observation only a few days, and as symptoms from leaves frequently appear after a long interval, it is not clear that this sheep was not affected. Inasmuch as all the affected animals

received nearly the same quantity in approximately the same time, no conclusions can be drawn as to accumulation.

Of the three cattle poisoned by leaves, No. 1016 was killed by a dose of 20.8 per cent given in 33 days, No. 1049 by a dose of 24.9 per cent given in 19 days, and No. 1068 was made sick by a dose of 15 per cent in 15 days. In these animals, as in the fruit cases of chickens, the elimination was small, as, apparently, the length of time during which the feeding was continued made very little difference in the toxic dosage.

Taking all the experiments under consideration it appears that, while there may be some elimination, there is, in some cases, a distinctly cumulative effect.

SUSCEPTIBILITY OF DIFFERENT KINDS OF ANIMALS

In the experimental work it was shown that sheep, cattle, goats, guinea pigs, and chickens may be poisoned. Reports received by the Department of Agriculture indicate that the losses of goats have been especially heavy. There are reports also of the poisoning of swine and horses. As previously stated, children are said to have suffered from eating the fruit.

The effect of the fruit shows a marked difference between the susceptibility to poisoning of sheep, cattle, and chickens. Cattle are much more readily affected. It takes twice the cattle dose to poison a sheep and four times that quantity to poison a chicken. Goats are somewhat less readily poisoned than sheep. From the small number of guinea pigs it is inferred that they are about as susceptible as sheep.

The effect of the leaves shows less difference between sheep and cattle, but the cattle are more easily affected. There were no experiments with feeding leaves to chickens or goats.

PROGNOSIS

Generally speaking the prognosis of animals poisoned by *Karwinskia humboldtiana* is distinctly bad. Of the sheep poisoned, one No. 739, made complete recovery after a period of seven months. Sheep Nos. 790 and 843 made improvement during the period of observation, two months in one case and three in the other, and when turned back to the owner showed only slight symptoms. They may therefore be considered as possible recoveries.

Of the cattle, heifer 1068 made complete recovery and heifer 1024—a very bad case—after a period of paralysis so complete that it was entirely unable to use its legs, gradually improved until it could get about. It accidentally fell into a ditch and died. While it is possible that this animal, with good care, might have reached complete recovery, it does not seem probable. Of the experimental chickens, No. 49 recovered.

It may be significant that among the cattle Nos. 1068 and 1024 were yearlings and that sheep Nos. 790 and 843 were lambs. It is possible that the young animals are more likely to recover.

Taking into consideration all the experimental work, it appears that *Karwinskia humboldtiana* produces a form of intoxication the effects of which continue for a long time, and that there is little prospect of recovery in severe cases.

REMEDIES

In most cases of plant poisoning it is considered that anything that will increase elimination, like a laxative or purgative, will aid in effecting recovery. In the *Karwinskia* cases, however, there was no indication that the eliminative work of the alimentary canal or kidneys was interfered with, these organs ordinarily performing their functions in a normal manner, so that there was no occasion to use this form of medication. Strychnine was used in two cases, those of heifer 1024 and heifer 1049, but this did not appear to have any effect on the course of the disease.

The data obtained thus far give no indication of any remedy which can be successfully used.

SUMMARY

Karwinskia humboldtiana is a plant growing in southwestern Texas and in Mexico which, previous to the experiments of this study, was reported to produce paralysis in some domestic animals.

Experimental work has shown that it affects cattle, sheep, goats, guinea pigs, and chickens, producing a more or less complete paralysis, the effects being especially pronounced in the posterior limbs. There are reliable reports to the effect that *Karwinskia* poisons swine and horses also.

The effect of the plant is peculiar in that the symptoms do not ordinarily appear until a considerable time after the feeding and continue for an indefinite period. In severe cases recovery seldom takes place.

The reported cases of poisoning are from eating the fruit. It has been found that the leaves are also poisonous but that the resulting symptoms are different from those produced by the fruit.

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