STAGGERS IN SHEEP IN PATAGONIA.*

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INTRODUCTION.

During the past few years a nervous disorder of sheep has become more prevalent throughout portions of Patagonia. This disorder has been given a number of names; among the more common may be mentioned staggers, temblique, loco, and huecù. From present reports the disease seems to be widespread, for it exists throughout the pampa at least as far north as the Chubut Valley and extends southward to Deseado and from the eastern boundary of the pampa to the Andes. The incidence varies greatly with the condition of the food supply; when there is a liberal amount of grass the actual number of cases is small. After a long continued drought when the fine grass supply is short, the number of sick animals is large. The mortality varies considerably, young sheep seeming to suffer most. The disease is not confined to the ovine species alone; horses and cattle succumb readily to it.

Acosta, in his publications on huecù,1 discusses in detail the geographical distribution, symptoms, diagnosis, and prognosis of a disease similar to staggers.

* The field expenses of this investigation were borne by a sheep-farming company of London, which has not authorized the publication of its connection with the investigation, but which gave every facility for the work on its estancia in Patagonia. Here a small bunk house close to the settlement was converted into a temporary laboratory. Only the most necessary equipment and supplies were transported from New York.

1 Acosta, J. L., Producción experimental de una enfermedad de tipo nervioso, Rev. Zoot., 1914, v, 3; El “Huecù” o “Huaicù.” Enfermedad de tipo nervioso propia de los herbívoros de la Patagonia, Tesis Universidad Nacional de Buenos Aires, No. 86, 1914.
His experimental feedings of a coarse tuft pampa grass (*Poa denudata*) to a horse, a bullock, and two sheep resulted in the production of definite nervous symptoms. Acosta's experiments were not controlled and inoculations were not attempted. He states that symptoms develop from 12 to 24 hours after the first feeding.

Conversation with a number of ranchers has given us some valuable data. The manager of an estancia in Chubut Territory supplied us with many interesting facts concerning staggers. On this particular farm about 1,000 sheep are pastured on a square league (9 square miles). The estancia consists largely of pampa broken by many deep valleys. The water supply is excellent and consists of fresh springs coming from the hillsides close to the valley bottoms. There are many brackish water-holes as well. The herbage comprises several kinds of fine grass, two kinds of edible bush, and two coarse grasses, as well as several species of thorny bushes and a number of cacti.

Sheep were brought to this land in 1897. The land was at first unfenced and the sheep were herded. Lambs after weaning could be turned on virgin pasture. Even early in the history of the farm, employees would occasionally report a case of staggers, but it was only after the land had been fenced and animals permitted to feed over it for several years that the disease really became a menace. Beginning in 1910 more or less serious outbreaks of the disease have occurred annually. It affects lambs and hoggets (sheep under 1 year old), although adult sheep suffer to some extent. As a rule, the ewes lamb in August and the lambs are weaned in January and are then removed to separate paddocks. Early in February the malady may become epidemic and it may continue during the ensuing months until September. The incidence varies considerably with the general conditions of the pasture. When the seasons have been unusually dry and the herbage is sparse it is not unusual to see lambs affected at marking time. The disease often exists at shearing in December. Under these conditions the nourishment has been insufficient since birth and the young have been forced to feed on grasses otherwise unnecessary.

2 The term pampa in Patagonia is applied to the sandy plain beginning in the foot-hills of the Andes and sloping eastward toward the Atlantic Ocean. The vegetation of these plains is much sparser than that of those to the north.

3 When lambs are 6 weeks old they are docked, marked, and castrated.
When there has been plenty of moisture and the grasses are sufficient, cases of staggers are not usually seen, either at lamb-marking or shearing, but a few cases may be observed in March and April. In extremely bad seasons the incidence may reach 100 per cent in certain paddocks. At this particular estancia the average mortality is about 5 per cent but in one paddock it reached 25 per cent.

In horses and cattle, especially in the wild herds, the losses from staggers are severe. Foals and calves from 4 to 9 months old are especially susceptible. In all paddocks located on the pampa the disease abounds. There are a few low lying paddocks, 200 or 300 feet lower than the pampa, where the disease has never existed. Sheep farmers whose lands occupy the low belt of land between the pampa and the sea declare that staggers is unknown in their flocks, although only a five strand wire fence may separate them from heavily infected pastures.

A sheep farmer whose estancia was located at Lago San Martin, about 250 leagues southwest of Camarones, informed us that his land would support 3,000 sheep to the league. Sheep had been grazed on the land for 7 years. During the first years staggers did not exist, but as the grasses became more sparse staggers became prevalent although not alarming. He stated that the young animals were affected shortly after weaning. The greatest number of cases occurred in the paddocks close to the settlement when large numbers of sheep were pastured temporarily during shearing and dipping. The fine grass in these paddocks had become very close. When questioned about the prevalence of a certain grass he informed us that it grew in all of his paddocks except those that had an elevation of over 1,500 feet. The average elevation of the paddocks was about 900 feet. Further questioning brought out the important point that he had never seen the grass commonly called pampa or coiron growing on the pampa below Deseado.

Description of the Disease.

At first sight the animal may appear normal. Excitement becomes great when the individual is alarmed by the barking of a dog, voices, etc. On becoming frightened it stands with a wild, excited look. The
neck is extended and there is usually a marked trembling of the head. Muscular twitchings of the hind legs are a constant symptom; if the animal is driven it usually breaks into a panic-stricken run. After running a short distance, stiffness of the limbs becomes marked. This stiffness is usually more noticeable in the hind legs. It moves with short, convulsive strides, and suddenly plunges forward, falling with the hind legs extended backward, and often rolls on its side (Figs. 1 to 4). If the sheep falls on a hillside it is not unusual for it to roll over and over until a level plain is reached. It is quite common to observe a sudden stiffness of all four legs; when this occurs the individual may fall directly on its side. When the animal falls it displays extreme excitability; the eyes bulge and the pupils are dilated. The head is drawn back, the muscles of the neck are tense, and the legs are extended rigidly from the body, with the digits spread far apart. If a sharp sound is made the muscles become more rigid. If the sheep is permitted to lie undisturbed the muscles gradually become flaccid, and the animal rises to its feet with some difficulty and moves away, stiffly at first, but the gait soon becomes normal. If it is frightened the same phenomena are repeated. Often there is an impairment of vision; animals may shy away from fences or attempt to jump over objects which are at a considerable distance.

When an animal has fallen and through weakness is unable to rise, it is usually found lying on its side (Fig. 5). At the slightest alarm it will make peculiar cantering movements of the legs until seized by the usual convulsions. It is not unusual to see a considerable excavation which has been made by the feet of such an animal. Often they are killed or mutilated by birds or carnivora.

Even in advanced cases of the disease, the temperature remains normal. The pulse is usually regular and weak. A ramiform congestion of the vessels of the conjunctiva is ordinarily present and the conjunctivitis is accompanied by a mucopurulent exudate. The sick animals eat well when the opportunity is afforded. There is no diarrhea or constipation.

**Morbid Anatomy.**

*Macroscopic.*—The following autopsy notes reveal the usual type of lesions found:
Subject.—Yearling hogget; wether; had been down at least 2 weeks. Pulse 68; temperature 101°F.; respirations 21. Blood: hemoglobin 90 per cent; red cells 10,608,000; leukocytes 11,500. Animal killed by chloroform; much emaciated.

Heart.—The pericardium appears normal. The heart muscle is apparently normal. The right auricle and the right ventricle contain large dark red blood clots. The left ventricle contains a smaller clot. All the valves are normal.

Lungs.—Right: On the surface of the middle lobe is a dark purplish red discoloration measuring 9 by 6 cm., rather clearly demarcated from the usual bright pink lung tissue. On section it is found to involve the pleura and invade the subpleural tissue for a distance of 0.1 cm. The rest of the lung is normal. Left: Scattered over the posterior lobe of the left lung are many irregular, raised, indistinct, grayish white areas varying in diameter from 0.1 to 2 cm. They are discrete and crepitate on pressure.

Liver.—The liver is dark red in color and somewhat firm. On section the color is dark red. The consistency appears normal. The gall bladder is filled with dark bile.

Spleen.—Apparently normal.

Kidneys.—Right: Normal in size and reddish gray in color when viewed through the capsule, which peels off readily. On section the consistency is normal. The cortex and medulla are congested. Left: The left kidney presents the same picture as the right.

Pancreas.—The pancreas is slightly congested but otherwise normal.

Esophagus and Stomachs.—All appear normal.

Duodenum.—The vessels of the duodenum are congested. The mucosa is congested. The content is largely composed of mucus. The ileum, jejunum, cecum, and colon appear normal.

Brain.—The vessels of the dura mater are slightly congested. The superficial vessels of the cerebrum, cerebellum, and medulla are all highly congested. Along the anterior border of the cerebrum and extending 1.5 cm. on both sides of the median fissure is a triangular smoke-colored discoloration which is superficial and extends backward, reaching an apex 2 cm. from the anterior border. On the ventral aspect of the cerebrum, almost exactly opposite the dorsal
area, is another irregular patch of the same color, which measures 2 by 1.3 cm. On section the deeper vessels are congested.

The cerebrospinal fluid is pinkish gray in color. The spinal cord is slightly congested. The sciatic nerve appears normal.

In most animals autopsied the lesions were of about the same type. It is unusual to observe congestion of the duodenum. In a few individuals small hemorrhages had occurred about the superficial vessels of the brain. The cerebrospinal fluid varied from straw color to pinkish gray. In all cases there was a more or less marked congestion of the kidneys with a certain amount of granular degeneration of the cortex, and, in some instances, of the medulla.

The intestinal tract was always examined for worms. In only two instances were they found and then only in small numbers. Examination of the frontal and nasal sinuses usually revealed varying numbers of the larvæ of *Estrus ovis*. These were found as frequently in normal sheep as in those suffering with staggers.

Small pieces of muscle from the fore and hind legs and from the diaphragm were examined with M’Gowan’s method for the presence of Sarcomeria. They were present in only two samples and then in very slight numbers. Frozen section of these muscles failed to reveal the parasites to any great extent.

**Microscopic.**—Pieces of various organs from normal sheep and those suffering from spontaneous and experimental staggers were fixed in Zenker’s fluid. The sections were stained with methylene blue and eosin. The changes noted are slight and not specific.

The cardiac and skeletal muscles contain Sarcomeria in all classes of sheep examined.

The liver as a rule appears normal. The kidneys are usually pathologic. The lesions vary considerably from congestion to cloudy swelling. The cortex is usually the seat of the processes.

The brain is generally congested throughout. The meninges appear normal except for a submeningeal black pigment. The nerve cells

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4 At first these discolorations were regarded as possible lesions of staggers, but they were found in normal brains as frequently as in the brains of sick animals.

fail to show degenerative changes when stained with methylene blue. Congestion of the spinal cord is usually noted. In several instances small hemorrhages were visible within the gray matter. Too much stress cannot be placed on them, however, as the animals were usually killed by bleeding from the jugular veins and carotid arteries.

The spleen, lymph glands, lungs and trachea, pancreas, and adrenals fail to reveal abnormalities.

**Bacteriological Findings.**—Although inoculations from the internal organs and the central nervous system were made into various media and incubated both aerobically and anaerobically, in the main the cultures remained sterile. In animals that had been down for indefinite periods it was not uncommon to find several species of cocci in the brain, spinal cord, and cerebrospinal fluid.

Great care was taken in obtaining portions of the brain for cultivation. The skin was dissected away and the skull flameed with a gasoline blow-torch. A large sterile trephine was used for drilling the skull. Various portions of the brain were removed through the trephined holes. The cerebrospinal fluid was drawn immediately into sterile pipettes. Usually 15 cm. of the spinal cord were removed for inoculation into various media.

Films from the internal organs, brain, and spinal cord were prepared and stained with various aniline dyes. Bacteria were not uniformly present in any of them.

**EXPERIMENTAL.**

In order to ascertain whether this disease was transmissible from one animal to another, a series of experiments was undertaken. Although indications in the field seemed to point to some other etiological factor than microparasites, we undertook to establish this point definitely.

Our first series of five experiments consisted in attempts to transmit the disease by natural means and by inoculation.

*Experiments 1 to 5.*—Susceptible sheep were permitted to pasture with those suffering from staggers. The normal sheep remained so and those affected with the disease completely recovered.

Five yearling sheep and two young lambs were inoculated with normal salt
solution suspensions prepared from the central nervous system, viscera, and blood of sheep suffering from advanced staggers. The experimental animals were inoculated in various ways, some intraperitoneally, others intravenously, subdurally, and directly into the cerebral substance. The latter died promptly from shock. Chloroform anesthesia was resorted to when inoculations were made beneath the dura mater and into the brain substance. In a few of the inoculated individuals, considerable doses of the suspensions were introduced into the rumen with the aid of a stomach tube.

None of the inoculated animals developed suggestive symptoms. All remained healthy during our observation of over 2½ months. Adequate controls which were maintained throughout this series of experiments remained healthy.

Ten sheep from an outlying estancia on which staggers did not exist were purchased for experimental purposes. These animals were transported to the settlement and placed directly in disinfected pens. Some of these were used in the inoculation experiments and the others in the experimental feedings later.

Guinea pigs weighing 300 gm. were also inoculated with tissue suspensions from several cases of staggers. They remained well.

From the foregoing series of experiments it seemed well established that the disease could not be produced by permitting sick animals to come in contact with healthy ones. Moreover, in every instance when healthy susceptible sheep were inoculated with material obtained from advanced cases of staggers they failed to develop the disease.

Among certain individuals throughout the district, factors seemed to point to a grass as a possible cause for the disorder. The grass is commonly called coiron or pampa grass. Previously we have mentioned that staggers had not affected animals on low camps. The disease is confined to the pampa. It is well known that a coarse tuft grass grows in large quantities on the pampa at altitudes from 500 to 1,500 feet. The tufts may extend well down the sides of the valleys but they do not grow in the valley bottoms except close to the pampas where the canyons are shallow. It grows in tufts varying from 15 to 60 cm. in diameter. The height varies with the amount of moisture. Where the tufts have not been disturbed it may reach a height of 40 or 50 cm.6

6 The writers wish to acknowledge their indebtedness to Dr. A. S. Hitchcock, Agrostologist of the Bureau of Plant Industry of the United States Department of Agriculture, who has identified this grass as Poa argentina.
A series of experiments was started to test the effect of this grass when fed to normal sheep and to those that had recently recovered from staggers.

Experiment 6.—Sept. 16, 1916. Four native yearling hoggets were placed in two small pens and fed on pampa grass. Four other animals of the same age and from the same flock were fed on alfalfa hay and served as controls. The water supply was the same in all the pens. The following notes were made during the experiment:

Sept. 20. Sheep 1 shows muscular trembling. Sept. 25. Sheep 1 is very excitable; marked weakness of hind legs; falls on becoming violently excited. Sept. 30. More violent symptoms exhibited by No. 1. Sheep 2 and 3 are highly excitable. Oct. 3. Sheep 1, 2, and 3 show characteristic symptoms of staggers; i.e., short, jerky movements of the head from side to side. Sheep 1 on becoming excited loses use of the hind legs, crawls about with the fore legs, and drags the hind limbs (Fig. 6). Oct. 7. Sheep 4 shows slight shaking of the head, grinds the teeth, and has the characteristic stupid facial expression. Sheep 2 has become worse rapidly, showing the same symptoms as No. 1.

The notes of a complete physical examination of No. 1 were as follows (Fig. 6):

Sheep 1.—Half bred ewe; age 1 year. Muscular trembling, incoordination of the muscles of the hind legs, grinding of the jaws, constant defecation of hard feces during examination. The animal is slightly excited and restless. Temperature 104.8°F.; pulse 93, regular, full, and weak; respirations 116 (very warm day), rapid, shallow, and regular. The heart appears normal. The skin is loose and normal, the coat of wool excellent. The face is symmetrical with no evidence of inflammation of the lips, nostrils, or ears. There is a ramiform congestion of the conjunctiva accompanied with a mucopurulent exudate. The abdomen is distended. Micturition is frequent. Mental excitement is marked but the sensibility is normal. Muscular tremblings are constant and marked disturbances of the muscular sense are observed. The reflexes are normal.

The animal lies quietly during the examination. When assisted to rise and compelled to move, it trembles violently and appears weak. The hind legs are stiff and the fore legs are braced far apart.

Blood: hemoglobin 85 per cent; red cells 9,304,000; leukocytes 7,400.


Autopsy.—General condition good.

Heart.—The pericardium and heart appear normal.

Lungs.—Right, normal; left, contains one darkened area in the ventral lobe measuring 9 by 5 cm. It is clearly demarcated from the rest of the normal tissue. The lobe is somewhat congested.

Spleen.—Normal in size and consistency.

Liver.—Normal in size; the color is light brownish pink and the consistency firm. Superficially the intralobular markings are distinct. When cut the
liver appears firm and the lobules stand out clearly. The gall bladder is filled with bile.

**Kidneys.**—Both appear congested, otherwise normal. The bladder is empty. The suprarenals are normal.

**Pancreas.**—Apparently normal.

**Stomachs.**—All contain more or less partially digested grass; no evidence of inflammation.

**Intestines.**—The bowels appear normal until the jejunum is reached. Here the vessels are congested. The mucosa contains a few hemorrhagic areas varying in size from 0.2 to 0.4 cm.

**Ovaries.**—Apparently normal.

**Uterus.**—Contains a large well developed fetus.

**Brain.**—The meninges appear normal. The superficial vessels of the brain are engorged with blood. There is a grayish black discoloration on the anterior portion of both lobes of the cerebrum. This discoloration begins a distance of 2 cm. posterior to the anterior border and extends forward and downward to the ventral aspect. It is clearly demarcated from the rest of the tissue and lies only on the surface. The cerebellum and medulla appear normal. There is a normal amount of clear straw-colored cerebrospinal fluid. The superficial vessels of the spinal cord are congested.

**Bone Marrow.**—The bone marrow of the humerus and the femur appear normal. The marrow of the shaft is a dull pink color and of a stiff gelatinous consistency. That of the heads is spongy and bright red in color.

In certain tubes of the media inoculated with small pieces of brain, cocci appeared after incubation. All inoculations from the heart and liver remained sterile. Salt solution suspensions of various organs of this animal were used to inoculate the sheep employed in Experiment 5.

The other animals in the experiment gradually became worse, all developing symptoms of advanced staggers, finally falling down and becoming unable to rise.

Oct. 25. Sheep 3 fell down. Nov. 7. Sheep 2 and 4 unable to rise.

The autopsies of these animals failed to show any more characteristic lesions than those found in Sheep 1. Although careful examinations of the intestines and stomachs were made, intestinal worms were not found. A common occurrence among the sheep autopsied was the presence of the larvae of *Estrus ovis* in the frontal sinuses.

In all these animals examinations of the muscles with M'Gowan's method for the presence of Sarcosporidia were made. In one or two instances they were present, but in very small numbers.

Unfortunately the preceding experiment was carried out with native stock. Doubtless these animals had been exposed to the disease. The results seemed to justify a repetition of the experiment with the substitution of animals which had never been exposed to staggers.
Experiment 7.—Oct. 5, 1916. The sheep used were of the same lot as those described under the inoculation experiments. Adequate controls were kept.

Within 3 days after starting to feed the grass one animal exhibited suspicious symptoms. 2 days later two animals revealed characteristic symptoms of staggers. The other two sheep developed staggers 10 and 15 days respectively after the feeding had been begun.

One animal (No. 8) after showing distinct symptoms of staggers was unable to maintain itself on the grass and was therefore killed. The others became progressively worse, falling down at the slightest excitement (Figs. 7 and 8).

The following results were noted when the urine of the three surviving animals was examined.

Sheep 6.—Amount, 10 cc.; reaction alkaline; color golden yellow, turbid; albumin present; sugar, bile, blood, and casts absent.

Sheep 7.—Amount 8 cc.; reaction alkaline; color golden yellow, turbid; albumin present; sugar, bile, blood, and casts absent.

Sheep 8.—Amount 8.5 cc.; reaction alkaline; color golden yellow, clear; albumin present; sugar, bile, blood, and casts absent.

All the animals were finally autopsied but failed to reveal more characteristic changes than those recorded.

In Experiments 6 and 7 the pulse, respiratory rate, and temperature of each animal were recorded before and during the experiments. The temperatures varied slightly and the rate of the pulse and respiration remained practically the same.

Experiment 8.—Nov. 7, 1916. In Experiments 6 and 7 the grass used was gathered from a paddock and stored in large bags until ready to feed. The grass tufts were cut close to the bottom and the whole tussock was used. A large proportion of the tufts consist of a dry, dead center surrounded by a more or less profuse belt of green freshly growing grass. Although we had never seen sheep eat this dry center, nevertheless it was believed by many that the dry portions were responsible for the disorder. To prove definitely whether this was responsible for the malady we determined to feed only green grass from young tussocks. In the young tufts the whole mass is green and only begins to dry as the seed ripens. Every morning 5 kilos of this fresh green grass were gathered and fed to two sheep of the same lot as those used in Experiment 7. Two animals fed on alfalfa in an adjoining pen served as controls.

After 2 days' feeding on the grass both animals showed suspicious symptoms; i.e., twitching of the muscles of the hind limbs, slight shaking of the head, and twitching of the ears. At the end of 1 week's feeding they had developed severe symptoms of staggers (Fig. 9). 14 days after feeding had been begun both animals fell on the slightest excitement.

Examination of the urine gave the following results:
Sheep 9.—Amount 45 cc.; reaction acid; color golden yellow, clear; specific gravity 1.060; albumin present; sugar, blood, bile, and casts absent.

Sheep 10.—Amount 150 cc.; reaction acid; color light golden yellow; specific gravity 1.021; albumin and sugar present; blood, bile, and casts absent.

Sheep 9 fell on the 15th day of feeding and could not rise. It was killed and autopsied on Nov. 22. Unusual changes were not noted.

The other animal, although badly affected with staggers, was able to stand, and after two feedings of green alfalfa it was turned out with two other sick animals (see Experiment 11).

Experiment 9.—Feeding of pampa grass to sheep that had recently recovered from staggers. Sept. 30, 1916. The feeding of pampa grass was begun with two sheep that had completely, and one that had partially recovered from staggers. These animals were part of a flock in which the disease had existed. They, with nine others, had been isolated in a small paddock about 2 weeks before our arrival and were to have furnished material for our investigation. Of these twelve animals, nine had recovered, two had become worse, and one had partially recovered. The partially recovered animal still showed extreme excitability and muscular trembling.

Oct. 5. One of the recovered sheep revealed unmistakable symptoms of staggers. The partially recovered animal had become much worse and fell on becoming excited. 2 days later the other hogget developed staggers. These animals all became worse and were either autopsied or used for other experiments.

When the three preceding experiments are reviewed it will be noted that of ten yearling sheep whose diet consisted of pampa grass all developed staggers. The controls fed on alfalfa hay remained well. Another striking feature is that both animals fed on fresh green pampa grass showed symptoms of the malady as rapidly as any of the others. The latter observation eliminates the theory of an infestation of the grass by a toxin-producing mold. The green grass we fed was free from mold.

It has been stated that old animals do not usually suffer from staggers unless they have been reared on low land and moved to the pampa. In instances of this kind, the losses may be severe. In the main, older animals that have been pastured on pampa cannot be said to suffer from the malady to any great extent. We are informed that the guanaco, a native member of the deer family, does not suffer from staggers. Indications on all upland paddocks visited showed that considerable coiron is eaten by animals. Often the green blades were kept well cropped. Knowing that more or less of the grass is eaten by older animals and that comparatively few cases of
Staggers make their appearance in these flocks, we assumed that a tolerance to the toxic properties of the grass must have been developed. To test this point it was determined to feed the grass to older animals.

**Experiment 10.**—Nov. 14, 1916. In this experiment it was decided to feed adult animals on pampa grass. A 6 year old ewe with a 3 months old lamb, and two 2 year old wethers were fed upon pampa grass. The ewe could not support herself and the lamb on the diet and was discarded. The lamb showed symptoms of staggers within 8 days.

After 23 days of feeding on the grass, neither wether had developed staggers. Since it was necessary to return to New York, we requested the manager to continue feeding the grass and to telegraph us when the symptoms developed.

On Dec. 28, 45 days after the beginning of the feeding, he telegraphed us that both animals had staggers.

When young animals were fed on the grass, the average time for the first appearance of definite symptoms of the disease was 10 days. At the end of 23 days neither of the older animals revealed suspicious symptoms; in fact, 45 days of actual feeding were required to produce the disease. It seems that a considerable tolerance is developed in adult animals that have pastured on land on which the grass grows. The results of this experiment readily explain why these sheep do not suffer from the disorder to any great extent. In all probability the guanaco, through generations, has developed an immunity against the toxic substances of the grass.

**Experiment 11.**—In spontaneous outbreaks of the disorder the mortality is usually slight when compared with the incidence. In fact, in certain outbreaks all the animals recover if there is sufficient green fodder.

Sept. 16, 1916. Three yearling rams were brought into the settlement by the manager and placed in a small corral; these animals presented all the symptoms of staggers and would fall on becoming frightened (Fig. 10). They were of value for breeding purposes and the manager determined to treat them. Sept. 16 and 17. Each was given a pint of oatmeal gruel and permitted to eat rolled oats and both dry and green alfalfa. The bulk of the diet consisted of alfalfa hay. Within 1 week the improvement was marked; even when they were driven by dogs they did not fall. The symptoms rapidly disappeared and within 18 days all had recovered (Fig. 11).

In another instance, two animals, the lamb from Experiment 10 and a hogget from Experiment 8, together with a spontaneous case, were allowed to run in a small paddock where the finer grasses were plentiful. One of the animals could not be driven but had to be carried to the paddock; at the least excitement it
would fall and only rise with difficulty. Within 8 days all symptoms had dis-
appeared and all three sheep had completely recovered.

Experiment 12.—Attempts were made to extract some substances from the
glass that would cause the symptoms. Acosta was unable to state definitely
whether the plant itself contained an alkaloid or whether a toxin was produced
by the action of a mold. The former seemed more plausible as Patagonia is
an exceedingly dry country. Moreover, the experiment in which we fed green
glass which was not moldy seems to point to an alkaloid.

At first we attempted to extract a substance from the plant with alcohol,
but on account of our small supply of that chemical we were compelled to dis-
continue this portion of the experiment.

We next attempted to extract some substance aqueously. This was done in the
following manner: 3 kilos of grass were washed twice and then covered with
water and allowed to boil for 2 hours. The liquid was then poured off and used
to cover a second 3 kilos of washed grass. This was repeated a third time. The
dark brown liquid thus obtained was evaporated to 1 liter. It was necessary
to prepare a large quantity 3 or 4 days before the administration of the liquid
was begun, to enable us to continue the supply.

Two yearling hoggets were chosen for the experiment. The fluid was admin-
istered directly into the rumen by means of a stomach tube. Each animal
received 1 liter before feeding in the morning and another liter in the evening,
so that each animal was receiving daily the infusion from 18 kilos of grass. The
experiment was continued for a period of 33 days, but symptoms failed to de-
velop in either of the sheep.

Guinea pigs, when injected intraperitoneally with heavy alcoholic or aqueous
extracts of the plant, usually died within 15 minutes. Controls inoculated with
similar preparations from non-toxic grasses died as promptly. It was impossible
to attempt to purify the products and it seemed that these results may be ac-
counted for by an excess of salts in the fluids.

A young hogget was injected intraperitoneally with a large dose of a heavy
grass infusion. It developed peritonitis and died within 12 hours. Symptoms
of staggers were not observed.

It seemed that animals affected with staggers or those that had recovered
might react when a few drops of liquid thought to contain the toxic substance
were placed in the eye. Both alcoholic and aqueous extracts were evaporated to
dryness and the residue was taken up in distilled water. Normal, affected, and
recovered animals received two drops of these solutions in each eye. All failed
to react.

Probably only more refined and exhaustive chemical methods will
be able to decide the nature of the substance which is responsible
for the symptoms.
DISCUSSION.

There seems to be very little doubt that staggers in Patagonia is caused by ingestion of a coarse tuft grass. This plant is called pampa or coiron grass. Its botanical name is *Poa argentina* (Fig. 12). All young sheep (yearlings) when fed on this grass developed characteristic symptoms of the disease. Besides our experimental evidence, there exists a number of other facts which corroborate our findings. Certain of these can best be illustrated by a map of an estancia on which staggers is prevalent (Text-fig. 1).

The larger paddocks consist of broken pampa; i.e., pampa intersected by valleys. In all of them except the Windmill Paddock, the water supply is natural. The windmill wells have been driven. In all the upland paddocks staggers exists. The pampa grass grows well. On this property there are three low paddocks (Nos. 1, 2, and X) where this particular grass does not grow. These paddocks are at least 200 or 300 feet lower in altitude than the pampa. No matter how sparse the herbage may become in them staggers never develops in any of the sheep ranged there. This company owns a piece of land six leagues to the eastward and only a few feet above sea level; on this tract the disease does not exist and the coiron grass is not found. When a flock of 2 year old ewes was moved from these low camps to the mixed pampa paddocks, staggers broke out.

The question may be raised whether the symptoms may be caused by a lack of some vital substance in the diet; i.e., whether staggers is an insufficiency disease. There are several facts which lead us to believe that the disorder is not of such a nature. When horses are brought on the pampa from other districts they often come down with staggers within 24 hours. We have seen sheep reveal symptoms after two feedings of pampa grass. In years of drought many animals die of starvation in the low camps where the pampa grass does not grow but the other food is the same. These sheep do not develop nervous manifestations.

Theiler, Green, and Viljoen⁷ have shown that even after long periods

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horses, cattle, and sheep fed on a diet of ten parts of polished rice and one part of autoclaved hay failed to develop symptoms of an avitaminosis.

It would seem that the solution of the problem lies in the eradication of this particular grass (Fig. 13). When the fact is considered that this grass is abundant from the foot-hills of the Andes to the eastern boundary of the pampa, one gets an idea of the magnitude of the problem. During the summer months when the grass is seeding, the prevailing winds are from the west and it is not unusual for them to blow steadily for 3 or 4 days. At one time during our stay the wind reached a maximum velocity of 84 miles an hour. Even though this grass is eradicated from eastern portions of the land it would soon reappear. One land owner tried burning off a portion of land but this failed to kill the coiron. Unless another grass can be substituted, the eradication of this particular species might work considerable havoc. There is no doubt that old sheep that have become tolerant eat it without harmful effects. Probably during periods of drought many animals are dependent on it for certain nourishment. Without the substitution of some other bulky food the losses from

![Diagram of Paddocks and Windmill Paddock](image)

**Text-Fig. 1.** Map of an estancia on which staggers is prevalent.
starvation might well equal the losses occurring from staggers in continued periods of drought.

Individual treatment is valueless on large estancias at the present time. Many of the valleys in this district are admirably suited to the raising of alfalfa after proper treatment of the soil. Generally two good cuttings may be obtained annually after a few years. In the future when the value of sheep has advanced it may pay to cultivate portions of the better valleys and either use the alfalfa as a green forage or store it as hay or ensilage and feed it in times of stress. It is recognized at this time that this procedure is impracticable, although it may become necessary in the future.

Sheep raisers have long recognized the advisability of not exciting flocks in which many cases of staggers exist. Usually when flocks in which the incidence is heavy are driven by men and dogs, the sheep, becoming violently excited, attempt to run and many of them fall down. Of those that fall many are unable to rise and ultimately die of starvation or are killed or mutilated by animals or birds. Quiet is essential when many are sick. On the other hand, it may be advisable to move sheep to another pasture early in the outbreak if this is possible.

Acosta recommends the use of nose bags when sheep are driven through lands on which the grass exists. When it is considered that two or three men with dogs usually drive bands of a thousand or more sheep, such a procedure seems impossible.

Staggers affects horses and cattle as well as sheep. Acosta was able to produce the disease experimentally in both species by feeding Poa denudata. Apparently Poa denudata and Poa argentina differ in but one or two minor characteristics. Opportunity for experiments along this line was not afforded to us.

CONCLUSIONS.

After observations and experimental work both in the field and laboratory, the following conclusions seem justified.

1. Staggers is a non-infectious disorder affecting horses, cattle, and sheep.

2. The disease is characterized by weakness, muscular twitching, irregular movements of the head, stiffness of the limbs, and transient
motor paralysis, accompanied with spastic spasms on excitement. There is also a derangement of vision and conjunctivitis.

3. The postmortem lesions are not characteristic.

4. We readily produced the disease by feeding susceptible sheep on a coarse tuft grass commonly known as coiron or pampa grass (Poa argentina).

5. The time required to produce definite symptoms by feeding the grass varied. Two animals developed typical staggers after two feedings; in another instance a period of 21 days of feeding was required. The average time for the production of unmistakable symptoms in our experiments was 10 days.

6. Many sheep recover from staggers spontaneously. A complete change of diet will usually effect a cure within 2 weeks.

7. Older animals that have pastured for long periods on lands where the grass grows become tolerant and are rarely affected with staggers.

8. The grass is toxic to sheep at all seasons of the year. We fed late winter and early spring grass and grass in flower, and produced staggers in every instance. The young green grass is as toxic as any edible portion of the plant.

EXPLANATION OF PLATES.

PLATE 62.

FIGS. 1 to 5. Spontaneous staggers.

FIG. 1. Animal about to fall on its side; the fore legs are rigidly extended and the digits spread far apart.

FIG. 2. The transient motor paralysis of the hind limbs occurring after violent exercise and excitement.

FIG. 3. Sheep about to fall. All four legs are extended rigidly. The momentum gained was sufficient to carry the body forward. The animal appears to plunge forward while falling.

FIG. 4. The gait of sheep with staggers; note the apparent rigidity of the hind limbs.

FIG. 5. The usual position of an animal down with staggers.

PLATE 63.

FIGS. 6, 7, and 8. Experimental staggers.

FIG. 6. Sheep 1, Experiment 6. Note the stiff carriage of the hind limbs and the depression of the hind quarters.
Fig. 7. Sheep 7 and 8, Experiment 7. Typical standing position of sheep affected with staggers.

Fig. 8. Sheep 8, Experiment 7. This plate was exposed ½ second and shows the characteristic shaking of the head.

Plate 64.

Fig. 9. The sheep fed on green pampa grass (Poa argentina) in Experiment 8.

Fig. 10. Young rams affected with staggers (Experiment 11).

Fig. 11. The same animals as in Fig. 10, completely recovered after feeding for 18 days on a mixed diet of alfalfa and rolled oats.

Plate 65.

Fig. 12. Pampa grass (Poa argentina) in flower.

Fig. 13. The grass growing on the pampa close to the edge of a valley.
(Jones and Arnold: Staggers in sheep.)
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