Original Articles.

AN INVESTIGATION INTO THE CAUSATION OF LATHYRISM IN MAN.

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IN August 1921, Major H. W. Pierpoint, I.M.S., invited me up to Sutna to investigate the disease lathyrism, a type of spastic paraplegia, common amongst the inhabitants of North Rewah.

The paralysis is regarded by the people as due to eating an exclusive diet of *kesari dâl* (Lathyrus sativus).

Major Pierpoint assured me that the disease was very prevalent in this part of the State and during the few days I had at my disposal, I ought to have no difficulty in examining at least a couple of hundred cases. He wanted to know what measures to take to prevent this terrible affliction which crippled for life so many of the subjects of this State.

I was anxious to collaborate, but Major Pierpoint requested me to conduct my own investigations on this disease, for he was only too glad to have given me the lead. I am therefore indebted to him, not only for having instigated this research, but also for his help during the clinical examination of these cases, and furthermore for obtaining the necessary information from the various State officials about the harwar system and other factors that play so large a part in the causation of this disease.

Three species of lathyrus are regarded as causing epidemic and endemic poisoning in man and animals. They are:—

(1) *Lathyrus sativus.*—Generally known in India as *kesari dâl, teora, or buttorah ka dâl.* The peas are of two sizes, the larger known as lakh is grown on dry wheat land, and the smaller lakhari is cultivated on wet rice fields.

In Rewah, the larger grain lakh which is imported from Bhagalpur, is regarded as more poisonous than the smaller indigenous vetch.

The *kesari dâl* is taken in various ways by the common people. It may be ground into flour, and eaten raw; the raw flour is moistened with water; salt and chillies added, and the mash is known as *sutto;* or the flour may be made up into hand-bread or *chappaties,* and baked on an iron plate.

The vetch is also boiled in water with salt and onions, the thick pea soup is known as *dâl,* and eaten with the hand-bread; or the boiled vetch may be made up into small thick cakes, fried in clarified butter (ghee), or oil and called *puris.* The vetch is used both as a food for cattle, as well as for man, and owing to its cheap price, it is eaten all the year round by these people.

In times of plenty it is eaten as a *dâl,* with wheat hand-bread, or rice, or as *puris,* but in times of famine owing to the high price of wheat and rice, their diet is forced to consist only of *kesari dâl.* Vegetables, etc., are unobtainable during the drought.

(2) *Lathyrus cicera.*—The dwarf chickling is grown in France, Italy, and Algeria, and is used as fodder for cattle. When wheat is dear, it is used instead of flour to make bread.

(3) *Lathyrus clymenum.*—The Spanish vetch, is grown in Spain, North Africa and the Levant.

In India, we are only concerned with the Lathyrus sativus or *kesari dâl.* Some believe that the *dâl* itself is not poisonous, but that the seeds decompose, or some parasitic growth takes place, and the poison is produced in this way; similar to the production of ergot. Others consider that the symptoms are due to the *Agrostemma githago* (the corn-cockle), or to the *Lolium temulentum* (the darnal).

In 1883, Astier isolated an alkaloid which he regarded as the poison, but gave no experimental evidence in support of his view. In 1917, Stockman also isolated an alkaloid, but only in very minute quantities, and he was unable to obtain a sufficiently large amount to analyse its molecular formula. Furthermore Dr. Sudamoy Ghose, M.Sc., has been working on the chemical aspect of the subject and has isolated a non-toxic amine which gives most of the alkaloidal tests.

The chemistry of the amine produced in the grain during germination will be dealt with separately, as the research is still not complete.

People will not live on an exclusive diet of *dâl* or vetch unless compelled to by famine, and I will show that the problem of the prevention of lathyrism is simple enough by my finding that the poison is water soluble, *i.e.*, it can be removed by soaking the grain in three changes of water during the 24 hours. Yet when we are dealing with a half starved illiterate population who are forced by circumstances to live on a partial or exclusive diet of this vetch, the soaking of the grain, even if it were carried out, would interfere with the making of flour.

The solution is therefore a sociological one, and should consist as I will show, in the abolition of the harwar system, the controlling of food prices and relief during famine years, and the utilisation of the mineral wealth, which at present is practically unworked as concessions are rarely granted to companies.

Aetiology.—The disease is very common in some parts of Central India and the United Provinces. Irving, 1857, in the North-West Province, now the United Provinces, considered that in some districts as many as 6 per cent. of the population were affected whilst A. Buchanan, 1904, estimated that about 7,600 persons were affected in the Saugor district alone.

From Sutna to Rewah a distance of 30 miles, I kept count of the number of persons we met

walking on the road side. We saw 94 individuals of whom 8 were suffering from lathyrism, two of these cases were returning home after we had examined them at the hospital. This would correspond to Irving's 6 per cent., and would mean that there were about 60,000 lathyrism cases in North Rewah.

I carefully examined 204 individuals, who were chosen at random, in order to ascertain the various factors that played a part in the causation of this disease. Some of the cases were collected by Major Pierpoint, but the majority were seen at the Sutna lime works and I am indebted to Mr. Holden the Manager for all the help he gave me in getting together these individuals.

In the lime works, two or three hundred of these men and women are employed in breaking up the lime stone, before it is burnt in the kiln. The large boulders of lime stone are placed before them in heaps, and they smash them into small pieces, the crushed stone is taken away in small baskets by the able bodied men and women.

Each individual was examined separately, in order to prevent any errors in their answers. These ignorant people are apt to be very suspicious of any examination, and to save themselves from thinking or to possibly avoid trouble later, would merely repeat the answer they had heard given by the person in front of them.

For this reason, they were collected in a courtyard and examined one at a time, and then allowed to go away, so that there was no communication between the persons examined and those waiting their turn.

Age.—The age interval is given in 5 yearly intervals for the first thirty years of life, because these people when young usually estimate their age in 5 year intervals. After 30 years of age, the age is generally reckoned in ten year intervals. The following table gives the age of onset of lathyrism according to their statement.

TABLE 1

Age and Onset.	3—5.	6—10.	11—15.	16—20.	21—25.	26—30.	31—40.	41—50.	51—60.	TOTAL.
No. of Cases	10	11	34	46	52	38	9	2	2	204

The earliest age at which the disease was stated to have occurred was three years of age, and fifty-eight the oldest age. The majority of cases, *i.e.*, 170 out of 204 occurred between the 15th and 30th year, when the individual is most active, and after marriage has to leave his parents in order to earn a living wage for himself and family in a poor country.

Sex.—Amongst the 204 cases examined, 181 were men, and 23 women. This difference is not due to any difficulty in getting the women to come for examination, as they were all of the lowest *Sudra* class, and both men and women work in the quarries as stone breakers. An explanation that was given to me by the more intelligent men employed as overseers, was that during famine years, the women eat less in order to save the food for their husbands and children, and consequently many die from starvation. The women that survive by eating less *kesari dâl* get less of the poison.

Occupation.—All these cases, with the exception of two poor Brahmin beggars, were of the lowest *Sudra* class, Teli, Kachi, Koals, etc., and practically everyone of them had been bondmen (*luguwars*). Their wage as harwars (literally ploughmen), is two annas a day, and during famine years they are paid in kind (*kesari dâl*). If they become affected with lathyrism and cannot plough, or be of use on the land, they are turned out by their masters (Kasans), and have to earn their living by begging, stone breaking, etc. Many of them migrate to the larger cities, Patna, Benares, Bombay and Calcutta, and form a large percentage of the beggar population.

Relation to famine years.—The last hundred cases were more carefully examined on this point and they invariably stated that when they became paralysed there was a famine in their district.

The rainfall in Rewah is not evenly distributed over the State and the official years of famine are when a drought prevailed over the whole of the State. The Home Member, Rewah State, informed me that the famine years were 1896-97, 1899-1900, 1907-08, 1918-19, 1919-20, whilst Major Colvin, I.A., Acting Regent in his D. O. No. 7464, d., 29th September, 1921, gave the famine years since 1890 as 1896-97, 1908-09, 1918-19, 1919-20. These illiterate people were usually very hazy about the actual year in which they got the disease. The usual answers were, about 2—3 years ago, 10—12 years, 20—25 and so on. The following table (table 2.) gives the year of onset according to the patients' statements.

The official famine years are shown with an asterisk. This table does not show that marked association with famine years which one would have expected from the patients' statements, and is due to their faulty reckoning of the year of onset. They invariably stated that a famine was present in their village, and that in famine years a large number of cases occurred in the district.

Thus a fairly intelligent overseer stated that in his village, Kermani in North Rewah, during the famine of 1907, in the month of July, the wind suddenly changed and came down from the hills. On that day all the men in the village were stricken with lathyrism including himself, and those women who were working in the fields.

The month of onset.—The majority of cases stated that the disease came on during the rains

TABLE 2.

Date of year.	1920-21 *	1919-20.*	1918-19.*	1917-18.	1916-17.	1915-16.	1914-15.	1913-14.	1912-13.	1911-12.	1910-11.	1909-10.*	1908-09.*	1907-08.*	1906 07.	1905-06.	1904-05.	1903-04.	1902-03.	1901-02.	1900-01.*	1899-1900.	1898-99.	1897 98.	1896-97.*	1895-96.	1894-95.	TOTAL.
No. of years	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
No. of cases	1	16	10	7	3	1	6	2	1	32	..	26	2	3	39	3	..	7	..	25	8	1	..	..	8	..	1	204

The asterisk denotes the famine years as reported by the state officials.

especially in the month of (*Asar*), July. The distribution was as follows:—See table 3.

TABLE 3.

Month of Onset	April	May	June	July	August	Sept.	October	Nov.	TOTAL.
	5	10	19	122	21	10	12	5	204 cases.

The tehsildar informed me that in most years the local crops in Rewah are exhausted by March or April, and *kesari dâl* is imported from Bhagalpur as the food supply becomes scarce by July. The common people have therefore to subsist on the cheapest article of diet, *viz., kesari dâl,* if the monsoon fails in June, then all the fresh food supplies, *e.g.,* vegetables, etc., are unobtainable except at very high prices, and the people have to subsist on an entirely vetch diet.

When the local crops of rice and wheat have failed owing to a bad monsoon, *kesari dâl* is planted and ripens in October. The absence of cases during the months of December to March is very suggestive of one of two factors.

(1) The indigenous small grained *kesari dâl* is not poisonous, or (2) the diet is sufficiently varied with other articles, *e.g.,* local grasses, etc., so that the amount of *kesari dâl* is kept below poisonous limits.

Both factors play a part in preventing lathyrism during these months, as I will show later. With the advent of April the first few cases are seen, whilst in July over 50 per cent. of the cases occur during the month. The evidence this table shows is :—

(1) That the disease is associated with eating imported *dâl* (Bhagalpur dâl) as the incidence coincides with the importation of this vetch in March and April and is maintained until October and November when the local *kesari dâl* is gathered for consumption.

(2) The high incidence of the disease in July is probably associated with the production of poisonous amines during germination. The large Bhagalpur vetch germinates more readily than the local small grain which sprouts with difficulty.

(3) The association with an exclusive diet, which occurs during famine years, suggests that the toxin is only present in small quantities in the grain.

The association with chills.—In many of the cases, the people are quite definite that cold or chill predispose to the disease. I have already quoted the overseer's evidence that the disease was caused by the cold wind blowing from the hills. Other state that they were at work in the fields and got wet, when they came back home they noticed that they were unable to walk properly.

The great predisposing cause of lathyrism is *the harwar system or system of bondage.* I will therefore give a brief description of how the system was carried out in the State.

The owners (Kasanah), are generally Brahmins or Thakurs who owing to caste prejudices are unable to plough their own land. The bondmen (*luguwars*) are taken on during the month of May, Rs. 8—10 are advanced for boys, and Rs. 30—40 for adult men. Should they want to be freemen, they have to pay the owner about Rs. 15 more than advanced to them. The bondmen, if not married, are lent the purchase money for a wife Rs. 20—30, and whilst they are in bondage the children of the marriage become the property of the master. The Kasanah, if he wishes, can sell these children as soon as they are old enough to work in the fields.

During the régime of a British Regent, the practice has been suspended as far as the law is concerned, but previously the court could issue an order compelling the bondman to return to his owner.

These bondmen are not usually paid in money, but given their food. In times of famine the owners themselves have barely sufficient to live upon, and the bondmen must be fed in order to work, so they are given the cheapest food, *viz., kesari dâl.*

The helplessness of these poor people is pitiable: on questioning one of them why he persisted in eating *kesari dâl* when he knew it was bad for him, he replied, "Sahib, one has to eat to live, even though the *dâl* is poisonous and produces paralysis."

I was astonished to find this blind spot in the all seeing eye that ever watches to suppress slavery in civilized countries.

Symptoms and Signs.—The onset of the disease practically always comes on suddenly. The

men state that they were working in the field, ploughing, cutting grass or wood, mending the roofs of their houses, and even whilst at stool. A few state that the onset came on gradually, they got ill with fever, and when they got up and tried to walk, they found that they were paralysed in the lower limbs.

As far as I am aware the actual onset of the disease has never been observed by any competent investigator. The following is a typical account by an intelligent overseer.

"During the famine year of 1908-09, whilst ploughing, I suddenly noticed that my legs were weak, there was no pain, but I had difficulty in sitting down and getting up from a squatting position. I did not know I was paralysed, until my friends told me that I had lathyrism. On that day 15—20 men of my village also became paralysed. I realised that I was suffering from lathyrism because I fell down when I tried to run; a few days later I felt pain in the calf muscles."

The gait is very typical and depends on the degree of involvement of spinal tracts, a single attack leaves the patient paralysed as is depicted in Plate I, figs. 1 or 2, the worst cases, figs. 3 or 4, have usually suffered from two or more attacks.

For descriptive purposes I have described the gait as seen in this disease, in four stages:—*see* Plate I. figs. 1 to 4. In the earliest stage (Plate I. fig. 1.) the patient can walk without any aid, or only requires a short walking stick. The knees are flexed; with each step the shoulder is thrown forward; as he rises from the ground on his toes, the movement ends with a peculiar spring owing to the spastic condition of the gastrocnemius. The feet are kept apart, and as the spasm of this muscle still persists, the heel is well raised off the ground, so that when the foot is advanced for the next step, the toes just clear or drag across the ground. There is no stamping as is seen in locomotor ataxia, nor is the foot swung round as in the flaccid paralysis of a hemiplegia.

The characteristic point about the gait is its peculiar hesitating springy character as the patient walks on tip toes. Progression is very bad when the patient starts walking, but improves somewhat after he has gone a little distance.

In the second stage (fig. 2), a long stick has to be used as a support. The body and the shoulder on the same side are thrown forward with each step. The knees are more flexed, and they walk more on their toes; the foot is slightly turned in, and owing to the adductor spasm, one foot is brought in front of the other. The gait becomes much more hesitating owing to the marked spasm of the gastrocnemius and post-peroneal group of muscles.

In the third stage (fig. 3), two long sticks have to be used to enable them to walk at all. The body is thrown well forward, and the muscles of the arm and chest are well developed as they have to support the weight of the body. The knees are acutely flexed, and owing to the marked adductor spasm the knees are drawn one in front of the other (scissors progression). At this stage these patients usually walk with the foot well inverted, caused by the spasm of the posterior-peroneal group, so that the outer toes and the extreme end of the outer part of the sole only touch the ground. Occasionally the foot may be everted instead of inverted.

In the last stage (fig. 4), the knees are flexed almost on to back of the thighs, so that progression is only possible by crawling on the hands and knees, or by using wooden shoes for the hands.

There is never any loss of consciousness, nor is there any involvement of the bladder or rectum. On examination of the legs, there are no sensory disturbances present, on pressing the muscles of the calf and thigh no tenderness is elicited although the patients complain of muscular pain.

On closing their eyes with the feet together in the erect posture, no ataxia is seen. The knee-jerks are increased, ankle clonus is well marked, and when the skin of the soles of the feet is not too thick and horny, an extensor response of the great toe is given on stroking the sole.

Major Pierpoint pointed out to me that on tapping the adductor muscles of the thigh a marked reflex contraction occurs. I found this adductor reflex present in every case I examined, and consider it a characteristic sign in this disease.

There is no paralysis, but a spastic condition involves the following muscle groups, quadriceps extensor, adductors, gastrocnemii and posterior peroneals. The trunk and upper limbs are unaffected, and the chest and arm muscles are usually well developed owing to the extra work that is thrown on them.

Pathological Anatomy.—These cases rarely die during the acute stages, and post mortem examinations are impossible to obtain owing to religious prejudices. The nature of the lesion has therefore largely to be surmised from the signs and symptoms.

As the knee jerks are increased, ankle clonus and Babinski's sign are present, the lesion is an *upper neuron lesion.*

The posterior columns of Goll and Bardack, and the posterior root ganglia are not involved as is shown by the absence of hyperaesthesia, girdle pain, stamping gait, etc.

There is no ataxia so the cerebellar tracts are intact.

The absence of any bladder or rectal trouble, either at the onset or in the advanced stages of the disease shows that the lesion *is outside or below these centres.* The involvement of the quadriceps extensor, adductor, gastrocnemius and post-peroneal group indicates that the lesion is *below the second lumbar root.* There is no loss of consciousness during any stage of the disease, confirming the opinion that the site of the lesion is not in the cranium.

So far we have deduced that the lesion is an upper neuron lesion situated below the second lumbar root, involving the motor tracts as is evidenced by the increase in the reflex arc and Babinki's sign.

Now the upper neuron motor path consists of main conducts (see Plate 2, fig. *b*).

(1). *The cortico spinal motor system.*—Consisting of the crossed and direct pyramidal tracts, lesions of which are associated with flaccid paralysis followed by tonic rigidity, and increased reflexes.

(2). *The strio-spinal motor system.*—Consisting of Monakow's bundle, the tecto-spinal and vestibule-spinal bundles, lesions of which are associated with no loss of movement, rigidity of voluntary muscles, no alteration in reflexes.

The increased reflexes show that the pyramidal tracts are damaged, but the absence of paralysis indicates that the *lesion is only partial,* and not complete. This is further exemplified by the patient, who after walking a short distance begins to improve in his gait. The rigidity of the voluntary muscles indicates that the strio-spinal motor system is also involved. In the early stages of the disease the rigidity of these muscles is only observed during voluntary movement and hence the damage is only partial. In the advanced stage of the disease (Plate 1, fig. 4) the rigidity is constantly present showing that the whole strio-spinal motor system has been destroyed as the result of disease. We have therefore deduced from clinical signs, that *the lesion of the cortico-spinal system is always partial, and never complete, but that the strio-spinal motor system may be completely destroyed in advanced cases of the disease, and that the lesion is below the second lumbar root.*

The nature of the lesion.—We have already seen that the disease comes on suddenly, often whilst at work.

The sudden onset suggests that the cause may be due to one of the following: embolism, hæmorrhage or thrombosis.

Embolism can be dismissed at once, owing to the invariable selection of such a minute vessel as a spinal vessel, and there is nothing in the heart sounds to suggest valvular disease.

On an analogy with ergot poisoning, one would at first expect that hæmorrhage would be a very likely cause of this lesion, but the patients give no history of bleeding from any other vessels, and it is difficult to conceive why the fine branches of the anterior-spinal vessels should be selected as a site of rupture rather than vessels in other parts of the body.

Thrombosis is finally left for consideration and as I will show that there is a good deal of evidence in support of this view. We know that a bilateral spastic paraplegia can occur in this situation of the cord in certain grave forms of anaemia, and toxic conditions. The lesions are considered to be due to thrombosis caused by end-arteritis, or a very low state of the blood pressure. I consider that the anatomical arrangement of the blood supply in this region is a predisposing cause of lathyrism. The anterior-spinal artery below the lower thoracic region becomes extremely fine and attenuated, and is only preserved in its downward course by fine reinforcements from the dorsal and lumbar arteries. Plate 2, fig. *a* shows a section of the spinal cord of a rabbit with the capillaries injected with a gelatine-carmine mass. One sees that the grey matter of the cord, *viz.,* the anterior and posterior horns are richly supplied with numerous capillaries. The white matter consisting of the various motor and sensory tracts is not so well supplied as the grey matter. Of the various columns of the cord the posterior columns are more richly supplied with blood than the lateral columns, and the poorest supply is given to the anterior columns. (See Plate 2, fig. *a*).

Thrombosis if it occurs in this region of the cord is more likely to select the avascular regions rather than those more richly supplied with blood, *viz.,* the antero and antero-lateral tracts. In these two areas of the cord are found the two motor systems—the cortico-spinal and strio-spinal systems. The direct pyramidal tract at the second lumbar root has practically disappeared as a tract. The lesion is probably due to a thrombosis cutting off the blood supply of the antero and antero-lateral tracts and causing degenerative changes which only partially affect the crossed pyramidal tract, and partially or wholly the strio-spinal system. From experimental evidence on animals, Stockman and myself did not find any microscopic lesions such as embolism or hæmorrhages. The thrombosis is probably due to an arterial spasm of these vessels as the paralysis in animals comes on suddenly, and if the diet is changed, it disappears within a few days, leaving no permanent damage of the cord. Clinically in man, we have the evidence that these persons only suffer from the disease in times of famine, *i.e.,* semi-starvation with low blood pressure, and that wet or chill precipitates the disease by inducing arterial spasm, which is directly caused by the toxin in *kesari dâl.*

Evidence that kesari dâl is the cause of the disease:—

(*A*). *Clinically.*—The first thing that one had to exclude in this investigation was the possibility of any other food causing the disease. The following grasses and pulses are eaten by these people from the end of August, when the imported *kesari dâl* gets scarce, until the ripening of their crops in October.

(1). Samai (See Plate 3, fig. 1) a wild grass which ripens at the end of August to the beginning of September, and lasts for about a fortnight's food supply.

(2). Samah (See Plate 3, fig. 2) is generally sown and ripens about the end of August or September, and gives about two months' food supply.

(3). Luptowah or Narwal (See Plate 3, fig. 3) a small grass seed which ripens in September; the women collect it by brushing the seeds into baskets, this lasts for about three weeks or so.

These grass seeds are ground into flour and are used to make hand-bread. The difference is marked between the yield of the cultivated and wild heads of these grasses as is seen in Plate 3.

(4) Puchchoar (See Plate 3, fig. 4) a wild pulse which grows all over the place, and ripens in September. The seeds are generally spoken of as *jungly mungh*. It is used as a *dâl*, and lasts for about three weeks.

Besides these articles of diet, in famine-stricken years, the *mowah* fruit various roots, etc., are eaten by the people. July is the month that has the greatest incidence of lathyrism, and these food stuffs are not available until the end of August or September. They therefore cannot play any part in the production of this paralysis.

The question of adulterants had next to be considered. Three other seeds are sometimes present. (1) The ordinary dried pea. (*Pisum sativus. etc.,*) and (2) gram or *chunnar,* (*Circer. Arietinum*) both of which we know to be non-poisonous. A third (3), a small black grain called *Akri* (*Withania coagulans*) which grows wild and ripens in October, is a slight adulterant, but if seen, is always removed during the cleaning and fanning of the *dâl*. So we can exclude the possibility of an adulterant of *kesari dâl* causing lathyrism.

The possibility that this vetch may be attacked by a fungus at once suggests itself to the mind owing to the analogy with ergot. The following evidence may be quoted against this view :—

(1) Stockman found that all the samples of *kesari dâl* he tested contained the poison, but in varying amounts.

(2) One specimen of the large grained *kesari* (lakh) contained a large quantity of this poison compared with the other samples tested.

He does not mention having noticed any obvious signs of disease in any of his samples of this vetch.

(*B*) *Experimental Evidence.*—Stockman has conclusively shown that if susceptible animals, *e.g.,* monkeys are fed on an exclusive diet of *kesari dâl,* they develop paralysis at varying intervals depending on the toxicity of the grain on which they are fed. On my return from Sutna I placed nine ducks on a diet of *kesari dâl.*

(1) First group of three ducks were given the crushed grain soaked for 24 hours in a sufficient quantity of water to make it soft, otherwise the ducks could not masticate it.

On the 18th day the first duck showed signs of paralysis, which increased in intensity ; on the 22nd day it could not rise from the ground. It was killed and there were no signs of hæmorrhage in the cord. The second duck showed symptoms on the 20th day and the third duck on the 22nd day. Neither of these ducks were so badly affected as the first one.

(2) The second group of three ducks were fed on an exclusive diet of *kesari dâl,* but the grain was washed in three changes of water during the 24 hours. None of these ducks showed the slightest symptoms of paralysis.

(3) The third group of three ducks were fed on washed grain as in group (2) but they were given some chopped vegetables in addition. They were quite well up to the 60th day of the experiment, and I considered the experiment practically finished. On the 80th day one duck showed symptoms of paralysis which may have been due to the fact that I was not then supervising the washing of the grain.

This experiment shows that the poison is water soluble, and the paralysis is not due to any deficiency in vitamines caused by living on an exclusive vetch diet, because all the ducks in group 2 remained perfectly well during the experiment.

Stockman considered the poison to be an alkaloid in nature, as it gave all the chemical tests and the crude alkaloid produced paralysis in animals. The following points may be advanced against this view :—

(1) Most alkaloids are not very soluble in water.

(2) In a plant the alkaloid is fairly evenly distributed in the leaves, etc. We know that the leaves are not poisonous to cattle.

(3) Few alkaloids have a cumulative effect in the system. To explain the high incidence during the month of July we would have to assume a cumulative effect. I am in favour of the toxin being an amine for the following reasons :—

(1) Amines give all or most of the alkaloidal tests.

(2) They are all water soluble.

(3) The amount of amines in the seed is increased during germination, *e.g.,* Hordenine in barley.

(4) The high incidence of lathyrism in July would correspond to the conditions necessary for germination, *viz.,* temperature and humidity.

(5) The toxicity of the large grain *kesari dâl* (lakh) could be explained similarly, as the large grain germinates in 24—48 hours in the presence of moisture at 37 degrees C. The small grain even at the end of four days shows no signs of sprouting.

(6) Many of these amines cause a marked contraction of involuntary muscle and blood vessels.

Dr. Sudhamoy Ghose is working at the chemistry of this poison. For several months he followed Stockman's technique and practically got no yield from large quantities of this vetch. From grain that was not germinating he got a fair amount of a non-toxic amine in a pure state. Thirty mgrms. of this amine had no effect on the guinea-pig. We are now attempting to isolate the toxic amine from germinating seed, as well as commencing feeding experiments on ducks.

Differential Diagnosis.—Most medical men in Calcutta have been taught that the disease is a primary lateral sclerosis of unknown origin,

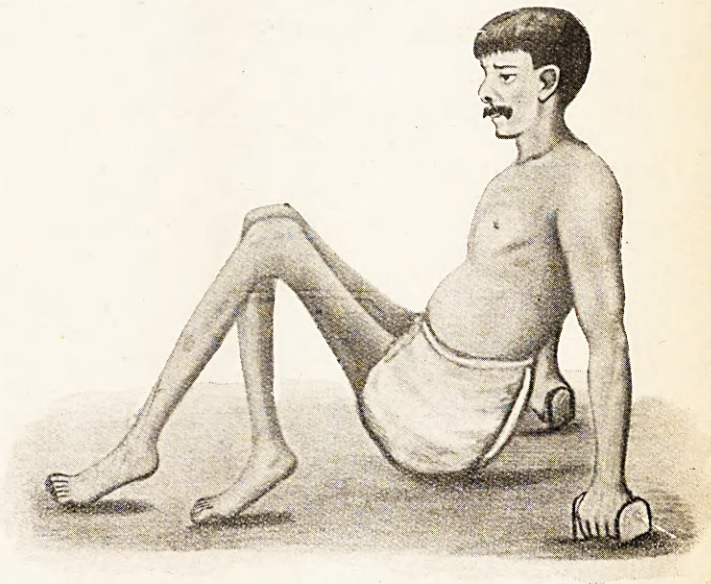
PLATE I.

The character of the gait in the different stages of Lathyrism.

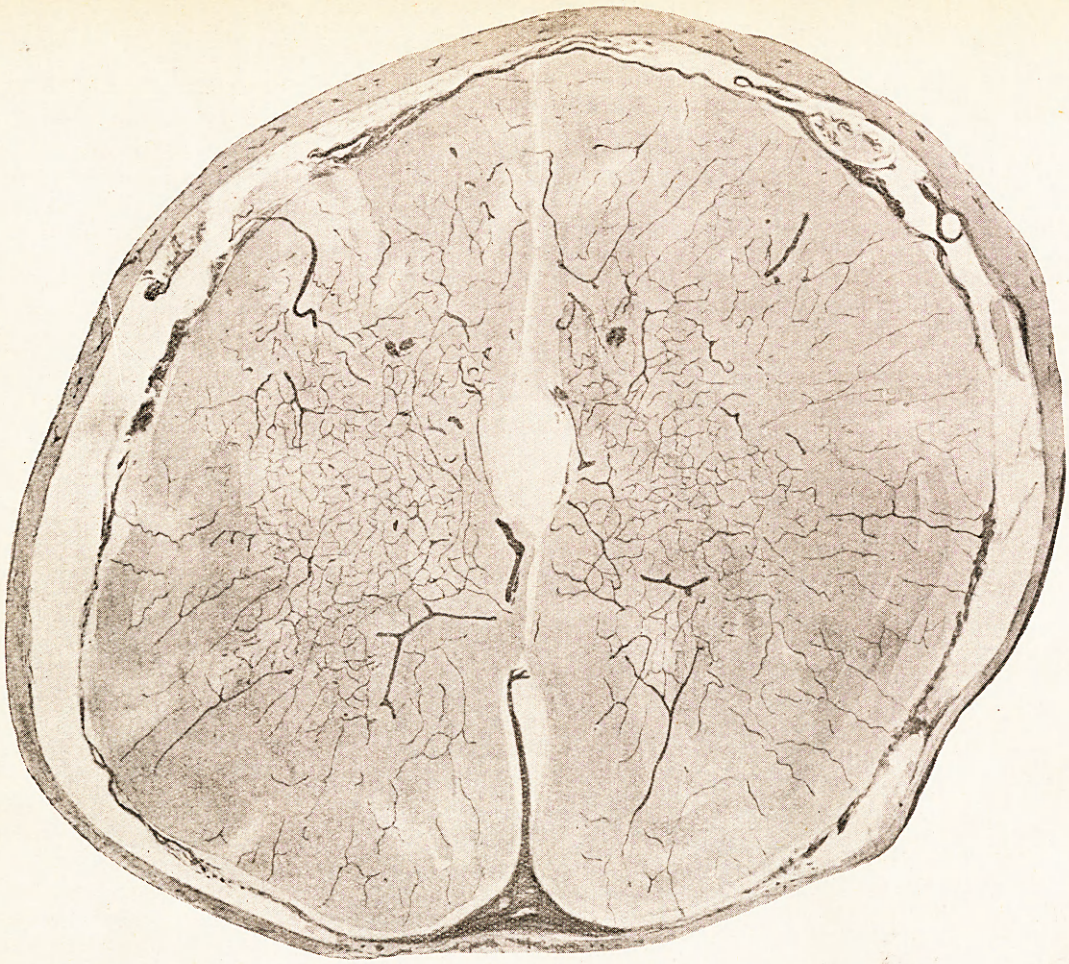
1st Stage.

2nd Stage.

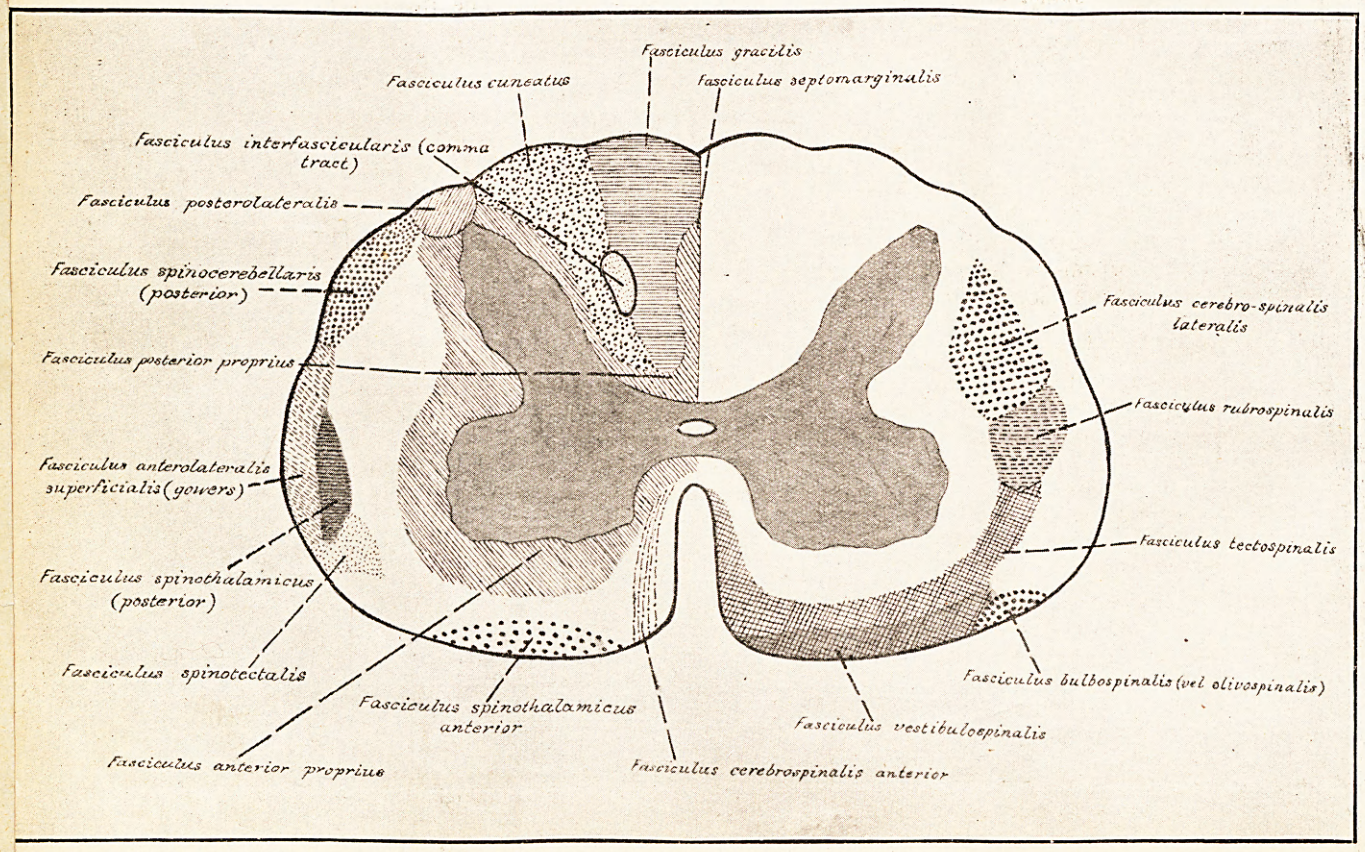
3rd Stage.



Final Stage.



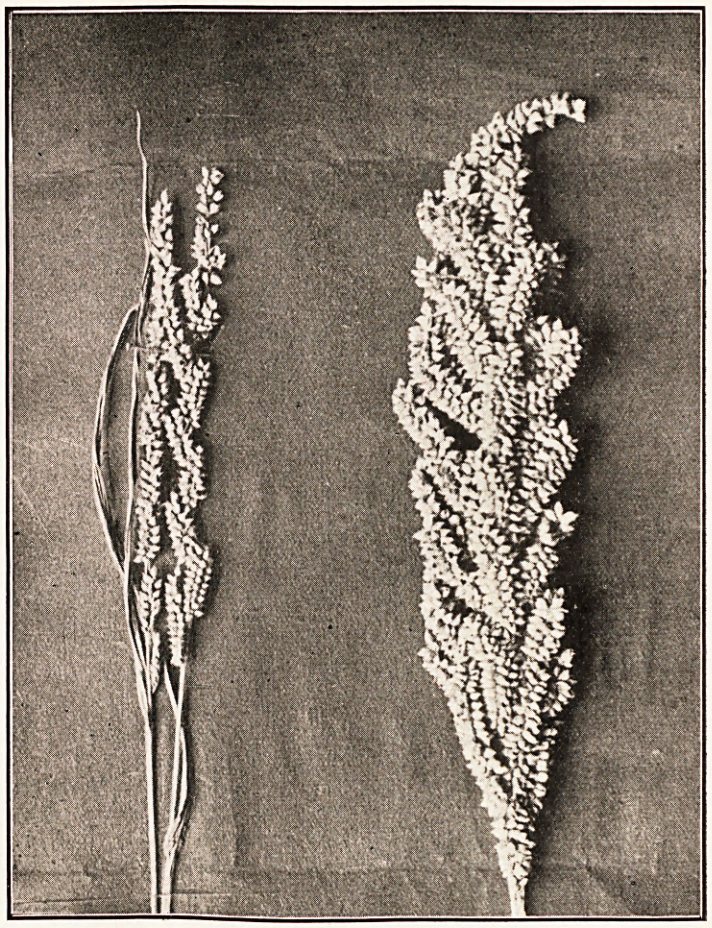
(*a*) Microscopical drawing of a section of the cord of a rabbit, to show the arrangement of the blood vessels and finer capillaries.



(*b*) Diagrammatic section of the spinal cord showing the arrangement of the different tracts.

PLATE III.

Grasses.



(*b*) Fig. 1. (*a*)

Samai.
Panicum Crus-galli *L.* var. frumentaceum.
(*b*) Panicum colonum *L.*

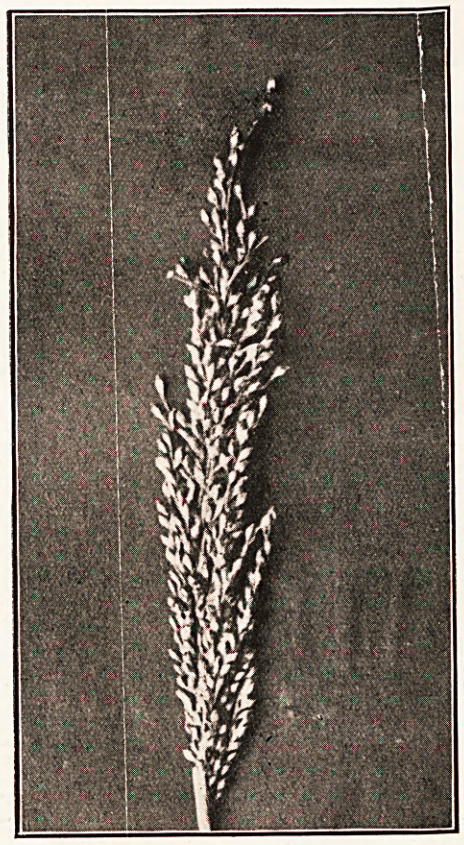


Fig. 2.

Samah.
Panicum ramosum *Linn.*

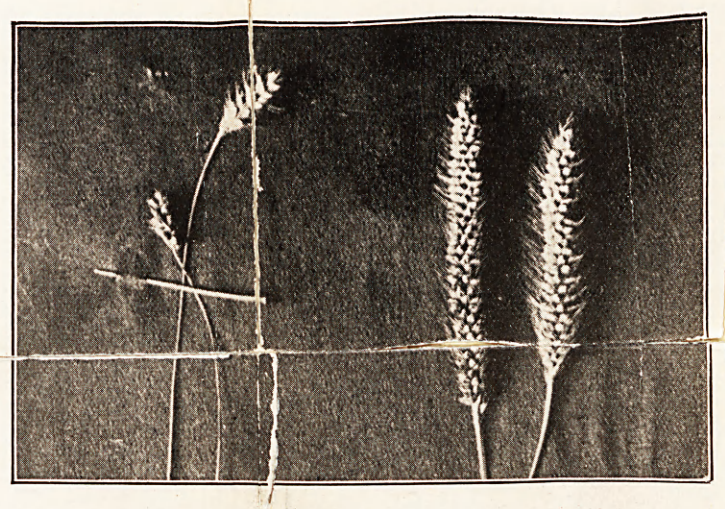


Fig. 3.

Luptowah or Narwal.
Setaria glauca *Beauv.*

system

Fig. 4.

Jungly Mungh.
Phaseolus trilobus *Ait.*

possibly syphilitic in nature. The peculiar hesitating springy gait, the throwing forward of the body with each step, the increase in the reflex arc and a marked adductor reflex, are however characteristic and peculiar to this type of paralysis.

Prognosis.—The degree of paralysis that is produced by the original attack remains permanent for the rest of their lives. In a very small percentage of cases some improvement occurs in the gait after a few months or years, but the people are very definite in their statement that complete recovery is impossible. The first attack produces the degree of paralysis shown in the gait by Plate 1, figs. 1 and 2. Two or more attacks cause an extension of the injury to the cord and produce the gait shown in Plate 1, figs. 3 and 4

Prevention of the disease.—In 1907 the late Maharajah of Rewah attempted to prevent this disease in his State. He issued an order dated the 29th November, 1907, in Hindi and it was read out to me by the Home Member. The gist of the order was as follows :—The paralysis chiefly affected the labouring classes, more particularly those of small caste and especially those who were given their wages in food (harwars). It was due to the eating of *kesari dâl* there spoken of as *butturah,* which was cheap in famine times. He forbade the cultivation of this vetch, and placed import and export duties on the grain. As the vetch was the staple food of the population, it was impossible to prevent its cultivation in out-lying villages. In a year or so the order was forgotten, and now the *dâl* is cultivated without any restraint. The preventive measures should consist in.—

(1) The abolition of the harwar system, because in times of famine the bondmen are compelled to subsist on a diet composed entirely of *kesari dâl.*

(2) To decrease the amount of *kesari dâl* consumed by the population by instituting famine reliefs during the years of a bad monsoon, as well as controlling the price of wheat, rice, and *dâl,* so that the poor can afford to buy these articles of food.

(3) To increase the popular knowledge regarding the toxicity of this grain. (*a*) The poison is water soluble so that soaking the grain for twenty-four hours in three changes of water removes the poison, and the grain can be used for making *dâl* or *puris.* (*b*). The small grained *kesari* is less toxic than the large grained Bhagalpur *dâl,* so that every effort should be made to grow a sufficient quantity of the indigenous grain to meet local requirements. (*c*) During the hot damp months of July and August, the grain should be stored in a dry place to prevent germination.

(4) By improvements in the agricultural methods now employed. The system of cultivation differs considerably in North and South Rewah. In the North, the inhabitants largely rely on the bund system, *i.e.,* an embankment 4—5 feet high is thrown up to enclose a square area in order to catch the monsoon rain. When water is required for the fields, the embankment is cut and the water allowed to run into the field. If the monsoon fails, no water is available and the crops fail. The people are then compelled to live on *kesari dâl* and hence lathyrism is very common in North Rewah. In the South, the Gonds do all their cultivation by forest clearing, and irrigation from streams, with the result that lathyrism is rare in this portion of the State, as the crops of rice, wheat, etc., rarely fail. The State is rich in mineral wealth, if this source of revenue was allowed to be opened up, it would afford an occupation which is independent of rainfall, and so largely prevent lathyrism in North Rewah.

This research has been a most fascinating one from every point of view. An investigation carried out amongst a poor illiterate population is impossible without a good command of their language. The backwardness of this state was well exemplified by the antique high sprung barouche with its two horses, accompanied by a bevy of four red-coated, brass belted attendants who drove me back to the station. The statistical enquiry made clear the relationship during times of famine between an exclusive *kesari dâl* diet and the harwar system : whilst it demanded an explanation for the high incidence of the disease during the month of July, the suddenness of the onset, and the peculiar distribution of the cord lesions. The water soluble nature of the toxin is a most satisfactory result from the point of view of the prevention of the disease. The surmounting of difficulties in any problem makes the solution more precious than those that are easily won. For months Dr. Sudhamoy Ghose, M.SC., laboriously worked to obtain a sufficient quantity of the alkaloid that Stockman considered to be the toxin in *kesari dâl.* Whilst working on the nature of Shiga toxin, Major Boyd was able to isolate an amine for me similar to histamine in its effect on isolated guinea-pig's uterus. Since then Dr. Chatterji has been able to isolate a similar amine from a broth culture of the cholera vibrio. This amine also causes a very marked contraction of uterine muscle. The production of an amine (Hordenine) during the germination of barley, at once suggested itself as a possibility in the case of *kesari dâl* and lathyrism, and I have given the evidences in favour of this view. The isolation of the toxic amine from the other non-toxic amines in the grain still requires a good deal of labour before the problem can be solved. In India one publishes results and waits patiently for years to see them carried out into practice. Ultimately there will be the satisfaction of knowing that the work has been the means of saving many of these poor oppressed people from a life-long paralysis. Even if only the harwar system can be abolished, it alone will do great deal towards the prevention of this paralysis.