Taiping

PERAK MUSEUM NOTES, NO. I.

ON THE

EXPERIMENTAL CULTURE

OF

SILKWORMS IN PERAK,

TOGETHER WITH A PAPER ON THE MALAYAN FISH POISON "AKER TUBA," AND A NOTE ON A LIGHTNING DISCHARGE IN TAIPING. ALSO A NOTE ON THE BLACK LIMESTONE AT KAMUNING.

BY

L. WRAY, JUN.,

M.I.E.E., F.Z.S., COR. MEM. P.S., ETC.

Taiping: Malay Peninsula

PERAK GOVERNMENT PRINTING OFFICE.

1893.

Price 25 Cents.

Perak Museum Notes, No. 1.

ON THE EXPERIMENTAL CULTURE OF
SILKWORMS IN PERAK, ETC.

ON THE

EXPERIMENTAL CULTURE

OF

SILKWORMS IN PERAK,

TOGETHER WITH A PAPER ON THE MALAYAN FISH POISON "AKER TUBA," AND A NOTE ON A LIGHTNING DISCHARGE IN TAIPING. ALSO A NOTE ON THE BLACK LIMESTONE AT KAMUNING.

BY

L. WRAY, JUN.,

M.I.E.E., F.Z.S., COR. MEM. P.S., ETC.

Taiping:
PERAK GOVERNMENT PRINTING OFFICE.

1893.

NOTICE.

From time to time, as material is available, it is proposed to publish, in pamphlet form, parts of a serial under the title of *Perak Museum Notes.* The papers in it will deal with and illustrate Museum and general scientific subjects connected with the State of Perak, its history, trade, industries, mines and products.

Communications and papers on the subjects indicated above are invited.

ON THE EXPERIMENTAL CULTURE OF SILKWORMS IN PERAK.

In November, 1889, a small Chinese company, after having cleared and planted up a few acres of land with mulberries at Ayer Kuning, in Larut, introduced from near Canton, in China, some silkworm eggs. These eggs hatched, and successive broods of the worms were raised and seemed to thrive in a perfectly satisfactory manner.

Mr. F. Light then planted up some land at Ayer Kuning with the same mulberries, and began breeding the worms from eggs given him by the original Chinese company.

CHINESE METHOD OF CULTURE.

The eggs are laid on sheets of common yellow Chinese paper, known in the shops as *kertas api*. When the time arrives for the eggs to hatch, the sheets of paper are laid on bamboo trays and lightly sprinkled with finely cut mulberry leaves, and the worms as they emerge from the eggs crawl on to the cut leaf and are removed with it to fresh trays. These trays are round, and are made of split plaited bamboo; they are from two to three and a half feet in diameter, and have a rim of about one and a half inches high. The worms are kept on these trays, at first on a few; as they grow and require more room, the number of trays is increased. The trays are put on rough round wood racks, about nine inches apart. Cut leaf is given for the first five or six days and then the worms, having grown large enough, are fed on uncut leaf. The trays are kept clean, the refuse leaves, dead and sickly worms, etc., being removed daily. The houses, which are of the ordinary high-pitched attap roofed Chinese pattern, are kept as much shut up as possible, to exclude the wind and sun. The west wind is thought to cause sickness amongst the worms. Lights are kept burning at night, and the houses are used as dwellings by the cultivators. Smoking, by the bye, is not allowed as it is thought to be prejudicial to the welfare of the worms. When they are full grown, and as they turn yellow, they are picked out of the trays and put on to the cocooning frames to spin. These are bamboo frames with thin strips of curled bamboo fastened to them on each side, and it is in the loops so formed that the worms spin. The frames are about two feet by three feet, and are stood up in pairs in the houses when required for use. The spinning completed, the cocoons are picked out of the frames by men armed with small steel forceps. The earliest of the spinners are reserved for breeding and the remainder are stifled. The cocoons kept for breeding are put in a single layer on the bamboo rearing trays. When the moths emerge they are allowed to pair, and in the evening the pairs are separated, the females being placed on a sheet of common Chinese paper on which a wooden frame is placed a little smaller than the size of a sheet of paper. These frames are about one and a half inches high. A board is laid on top of the first frame, then a sheet of paper, then another frame, which, having been filled with female moths, is covered with another board, and so on. As soon as the moths have laid they are thrown away, and the sheets of paper, densely covered with eggs, are dipped into hot water, the water being heated so that the hand can be borne in it. The sheets are then dried, the date of laying marked on each sheet, and they are rolled up and put away until they are ready for hatching. The dipping in hot water is a matter requiring great care, as if the water is overheated it kills the eggs. It is said to make the eggs hatch more evenly and is thought to be of great importance by the Chinese.*

TREATMENT OF THE SILK.

The cocoons not required for breeding are put into wooden drawers with perforated bottoms, arranged in a large chest, beneath which are put earthenware chafing-dishes, in which charcoal is burned. This kills the chrysalids and in a few days dries them up. Care must be taken, or the silk gets scorched, if the heat is too great. Another method of stifling used by the Chinese is to take the cocooning frames full of cocoons and heap them up and then cover them all closely over with cloths. The chafing-dishes with burning charcoal are then put underneath the pile and the stifling ensues.

---

* I have found that if the eggs laid by a pebrinous moth are washed, and the water examined under the microscope, the corpuscles of pebrine will be found in it; showing that these corpuscles were in the fluid used by the moth to stick the eggs on with, and it is conceivable that a moth which had become diseased late in life, and after the eggs were formed, might lay pure eggs, but that some of the young worms in eating their way through the shell of the eggs might contract the disease by eating the corpuscles on the exterior surface of the eggs. Can this have anything to do with the Chinese hot water process?

When killed and dried the cocoons are sorted into yellows and whites, or as the Chinese express it, gold and silver, all damaged cocoons being put by themselves, together with the pierced cocoons which have been used for breeding purposes.

The cocoons are sent to Hongkong and from there to Hangkau, where they are sold. A man being sent with each consignment of silk, the transport expenses are very considerable. In China the silk is reeled and sent back again past Penang to Europe. The price of well reeled silk in China is $5 per kati, while badly reeled silk only fetches $3.

An attempt was made to introduce some female reelers from China, but without success, owing to the difficulty of getting them out of the country. There is one woman in Larut who can reel, but she left China when very young and is therefore not an expert hand. The apparatus used in reeling is very simple, and only costs from $3 to $5.

In some observations that I made on the yeild of silk I found that the average weight of the cocoons when fresh was 10·75 grains, 651 going to the pound. I estimated that 5,833 cocoons would yeild one pound of reeled silk, besides the floss silk.

Mr. F. Light sent samples of the Ayer Kuning cocoons to Messrs. C. S. Tennent & Co., of Penang, who obtained the following interesting report on them from their correspondents at Marseilles. "We thank you for your cocoon samples marked L and D, which we have submitted to our broker. The cocoons you send are unpierced and are similar to what are received from Bengal, and very good samples of their kind. Our broker has never seen anything of exactly the same kind. You will notice that each cocoon has an outer envelope of tough silk, and this should be removed in Penang and shipped as silk waste: it is worth from 1 to 1.50 francs per kilo, landed terms (this is, about 17½ to 26 cents per kati). To give an exact valuation it is however necessary to know what the silk contents of your cocoons are, that is, the weight of cocoons required to give one kilo of silk, and before this is known it is impossible to say what the cocoons would fetch, as spinners themselves are in complete uncertainty before making a spinning trial of the cocoons. Bengal and China unpierced cocoons are frequently sold with the guarantee that 4 kilos weight of cocoons at a certain temperature shall give one kilo weight of silk, and if the 4 kilos weight of cocoons give, say, 1·100 kilos silk, the buyer pays 10 per cent over contract price, and *vice versa* if the silk out-turn is less than one kilo. There is a Silk Trade Association here and at Lyons, by which the spinning trials are made, and the spinners' names are unknown to either buyer or seller. Of course these are very complicated and delicate trials, and only people with a large experience in the article sell on these guarantee terms, though cocoons produced by silkworms from the same place, fed in the same manner and under the same climatic conditions, vary very little in the silk out-turns they yield.

"The best way to get into the business is to ask Penang to send as soon as possible about 10 kilos ($16\frac{1}{2}$ katis) of L, and the same quantity of D, removing the outer envelope, and with these we will have spinning trials made by the Association, and will then have a basis for future business, and know the exact value of the cocoons. We will then be able to sell on *tale quale* terms, without guarantee.

"Your cocoons are known as unpierced spinning cocoons (*cocons non percés a filer*), and produce the so-called 'satin silk' (*soie satinée*). They might be worth about 5 to 6 francs per kilo, but until their silk yield is known, any valuation is very loose and variation liable."

THE VARIETY OF SILKWORM.

As has been previously stated, the breed was introduced from near Canton. They appear to be the variety known as *bombyx sinensis*, which is a small multivoltine species, inferior to some of the Indian breeds. It appears to be not a true multivoltine, as there is always a certain proportion of the eggs which refuse to hatch, and which assume the appearance of annual eggs, and evidently require the cold of a winter before they will germinate. Sometimes these annual eggs form a considerable percentage of the whole laying. It would appear that in China these worms lay multivoltine eggs during the summer, and in the autumn lay eggs which do not hatch until the following spring. A second importation of eggs was made from China, and I obtained a few and reared them for three generations, and then they died out in consequence of all the eggs being of the kind which require exposure to cold before they will hatch. Those eggs which only slightly darken to a yellow are the quick-hatching eggs. On the fifth or sixth day they turn to a pretty pale French grey, the heads of the worms then appear as black dots, and on the seventh day they hatch out. The other eggs, on the contrary, begin to darken soon after they are laid, and on the third or fourth day have become brown or purplish brown, and may then be kept for months without further change. The eggs which were brought from China were all of this character. They reached here in November, so were the autumn laying.

The life history of this worm will be seen by the following notes, made on some that I reared in 1890. From the laying of the eggs to the hatching took between six and seven days, the eggs being kept in a cool place. The first change of skin took place on the seventh day, the second on the tenth, the third on the fourteenth, and on the nineteenth day the worms attained maturity and began to spin.* The spinning took from two to three days, so that from the laying of the eggs to the completion of the cocoons takes about 30 days. It may therefore be assumed that two broods could be reared in three months, or eight in the year.

The silk varies in colour from pale greenish yellow to white. The Chinese, however, bred out the greenish and yellowish varieties, and the strain now in the country is almost pure white.

CHINESE MULBERRY CULTURE.

The mulberries were introduced from China, being brought here as cuttings. They are a big leaved, long fruited variety, and grow into bushes. The jungle was felled and the land was then stumped and dug over to remove roots, made into shallow ridges, and the cuttings planted on top of them at distances of about one foot apart along the rows, the rows being three feet apart. The land was all carefully drained by deep ditches and kept free of weeds by constant hoeings, the plants being manured by the refuse leaves, etc., from the rearing of the worms. The plants being so close, it is not possible to allow them to grow to any size, and they are therefore kept down by periodical severe prunings. As might be expected, by forcing the plants to grow under these very artificial conditions, the least neglect or disease tells very seriously on them, particularly when they are being continually stripped of their leaves to feed the worms.

DISEASE OF THE MULBERRIES.

In July of 1891 I went to Ayer Kuning and noticed tha all the mulberries were affected by a leaf disease much resem bling in its general appearance the well-known coffee leaf disease On the young leaves faint yellowish dots were to be seen, and these became larger and more yellow on the older leaves, and reached a diameter of about one-third of an inch. Beneath, these spots were more or less covered with bright yellow spores. The leaves dropped long before, in the natural course of events, they would have done, and the bushes looked very bare and miserable in consequence. Almost the entire plantation was affected, but the Chinese said that the worms would eat the diseased leaf, and I saw it being given to them, and they

* In November and December the worms change their skin once more than here stated, and are about five days longer in attaining maturity.

appeared to eat it the same as if it had been good leaf. The Chinese said that the worms were quite healthy and that deaths amongst them were very rare, but subsequent events showed that this information was incorrect. They admitted that in consequence of the disease they had been short of leaf, and had not been able to rear as many worms as they expected.

A microscopical examination of sections of the leaf showed that the disease was caused by a fungus growing entirely within its substance. A spore evidently settles on the under-side of a leaf, throws out a thread which penetrates into the first stomata it comes to, and then, finding nourishment, increases within the tissues of the leaf, which becomes yellow and considerably swollen at the centre of the spot. One or more of the stomata on this swelling become much enlarged internally, and filled with bright yellow spores, which eventually are forced by those beneath them out of the now expanded external orifice of the stomata.

The spores are rather irregular in form, some being spherical and others oval. They measure about $\frac{8}{10,000}$ inch in diameter. In water the transparent spore case becomes distended and separated from the granular yellow nucleus, which it then encloses, as the white of an egg does the yolk. When placed in a drop of water on a cover-glass, inverted over an open vasilined cell of a microscope slide, so that evaporation is prevented, the spores may be seen to swell as above stated and eventually to burst; the yellow contents then float out as separate granules, which each begin to swell until they attain nearly the size of the original compound spore, and in about four hours the swollen granules, which are spherical and are the true spores, begin to throw out slender, distantly jointed, waved threads, sometimes branched. Occasionally one or two of the yellow granules swell within a mother cell and germinate, and the mycelial thread or threads pierce the wall of the mother cell, which then has the appearance of being an actual spore; but I believe I am right in saying that it is not so in reality. I have not been able to continuously watch for hours a particular cell under the microscope, as should be done in investigations of this sort, but have only been able to devote spare minutes at odd times to the work, therefore it is just possible that I have misinterpreted the method of germination. It is nearly certain that the spores only germinate when in a drop of water, and attack the leaf only, when that drop happens to be on the under-side of a leaf.

The mulberry which has been planted at Ayer Kuning was introduced from China. The Chinese, however, say that they have no recollection of having seen the leaf disease on the mulberries in China, but perhaps the climate here may be particularly suited to the development of the fungus, while in China it is not, and the disease there may be sporadic, and do little or no damage. Mulberries were introduced into Perak from India at least eleven years ago, and I have examined a number of these trees and have not seen a single spot of disease on any of them. This shows that the disease is not indigenous to Perak, but that it was brought along with the cuttings from China, and I raised the question whether the two small plantations which had been started at Ayer Kuning, and which were both badly affected by the disease, should not be destroyed before it spread further, or at least measures taken to disinfect them.

Another question which suggested itself was, whether the mulberries which were introduced from India, and which are apparently both of different varieties to that recently introduced from China, are susceptible in the same degree to the ravages of the disease. To test this I gave young plants of both kinds of these Indian mulberries to the Chinese, and afterwards also to Mr. Light, requesting that they might be planted amongst the affected bushes. Some two months afterwards I examined these plants and found that they had contracted the disease equally with the Chinese mulberries amongst which they were planted, thus proving that they were not proof against the disease and that had the disease been indigenous to the country they would have caught it during the eleven years they have been here.

INSECTS DESTRUCTIVE TO THE MULBERRY.

So far, I have only noticed one insect which does any considerable amount of damage to the mulberry bushes. This is the common yellow and green diamond beetle. It damages them when in the imago state, by eating the leaves. At certain times of the year they are very abundant and do serious injury to orange, lime, lemon and pomeloe trees.

RAMI AS A FOOD PLANT.

A paragraph having gone the rounds of the newspapers to the effect that it had been found that *rami* (China grass-cloth plant) had been successfully used as a food for silkworms, and that they not only throve on it but that the yield of silk was largely increased, I tried the experiment, and found that not only the worms that had been fed on mulberry, but also the newly hatched ones, which had not previously been fed at all, absolutely refused to eat it, preferring death by starvation. I tried cut and also crushed leaves with the same result. There would therefore appear to be no doubt that *rami* cannot be used as a food plant for the variety of worms now in Perak, though the annual varieties may possibly be induced to eat it.*

ENEMIES OF THE WORMS.

I have noticed two species of spiders, the common reddish coloured house ant, and a wasp as offenders; the most destructive being the ants, who on one occasion killed a tray of over fifty worms in an hour or two. None of the worms seemed to have been eaten, merely stung to death. Putting the tray stands in cups of water and enclosing the whole in netting would of course prevent loss from these insect pests.

The house lizard, rats, and the magpie-robin have also to be guarded against, as they will all devour the caterpillars whenever they get the chance, and they are most persistent in their attempts.

DISEASE OF THE WORMS.

I was informed in August, 1891, that there had been considerable losses amongst the worms at Ayer Kuning, and on visiting the original Chinese cultivators I found that the whole of their worms had died out, and they had not a single live one left on the place. Mr. Light stated that after attaining a size of about three-quarters of an inch in length the worms went off their feed and ceased growing, and that it was the opinion of the Chinese that the worms were diseased. I at first thought that the leaf disease might be the cause of the unhealthiness of the worms, as I failed by a microscopical examination of some of the young worms to detect any of the *bacteria* which cause the known silk-worm diseases. About ten days afterwards I again visited Ayer Kuning, and took some thirty of the weak worms, which had dropped off the cocooning frames, and which were

* "A discovery has been made by a lady in Columbia, S.C., that may have a marked effect upon two great industries. For a number of seasons this lady has amused herself by feeding silkworms and sending a few pounds of cocoons to the Women's Society for the Encouragement of the Silk Industry in Philadelphia. The extraordinary warmth of this winter caused the eggs to hatch far in advance of the season, and as the young leaves of the mulberry and the Osage orange had not put forth, our amateur was at a loss what to do. An account adds:—

"'Seeing that the foliage of the ramie in a neighbouring field was putting out, she gathered some and put the worms upon it. They fed ravenously, and she kept up the supply until the Osage orange leaves appeared. Then she divided her worms equally, feeding one set with ramie, the other with Osage orange. She kept the cocoons separate and sent them to Philadelphia. The experts there were astonished at the size of those spun by the ramie eaters, and wrote to the lady to know what she had done to secure them. They were not only larger, but the silk was finer.'" —*Kew Bulletin*, No. 44 of 1890, pages 174-5.

unable to spin properly, for examination, as these feeble individuals are sure to show disease, if present at all in a brood. All those that I examined under the microscope were swarming with *panhistophyton ovatum*, of Lebert, the bacterium which causes pebrine, the worst disease to which silkworms are liable, as it is not only infectious but hereditary. This disease could have no sort of connection with the mulberry leaf disease, but must have been imported from China, either in the eggs or by means of infected trays or cocooning frames, which were all brought from China, or it may have been contracted in the way which will be mentioned hereafter. On previous visits that I paid to Ayer Kuning I had been assured by the Chinese that they had had no deaths amongst their worms, but financial reasons may account for their not giving correct information on this point.

The micro-organism causing the disease is thus described by Mr. E. M. Crookshank in his *Practical Bacteriology*:—"*Panhistophyton ovatum*, Lebert (*nosema bombycis, micrococcus ovatus, corpuscles du ver à soie*), shining oval cocci, $\frac{2}{1,000}$ to $\frac{3}{1,000}$ mm. long, $\frac{2}{1,000}$ mm. wide, singly and in pairs, or masses; or rods, $\frac{2{\cdot}5}{1,000}$ mm. thick and twice as long. They multiply by sub-division. They were experimentally proved to be the cause of *pebrine, gattine, maladie des corpuscles*, or *flecksucht*; and were discovered in the organs of diseased silkworms, as well as in the pupæ, moths, and eggs."

I have not detected any of the three other principal silkworm diseases—grasserie, muscardine and flaccidity—amongst the worms in Perak.

FAILURE OF THE CULTIVATORS.

After repeated losses caused by the death of whole broods of worms, and by the much reduced quality of the silk yielded by the silkworms, both the original Chinese cultivators and Mr. Light abandoned the attempt of cultivating them in February of 1892, after having made a fresh importation of eggs from China at the end of 1891. These, however, as they were reared in the same rooms and on the same trays as the old ones, naturally contracted the disease and also died out.

EXPERIMENTAL BREEDING TO ELIMINATE THE DISEASE.

On 10th September, 1891, I wrote as follows on this subject: "Having proved the existence of pebrine amongst the worms here, it is a subject for the consideration of Government whether (*a*) they will take any measures to stamp it out, or (*b*) let the introduction of silk-growing in Perak become a failure, as it most surely will without Government intervention.

"The measures to be taken are as follows:—

(*c*). The destruction of all the worms now in the State.

(*d*). The disinfection of the houses and apparatus used.

(*e*). The introduction of fresh "seed," free from disease.

(*f*). The prohibition of the importation of other "seed."

"It is probable that the easiest way of carrying out these measures would be to get "seed" from the Government breeding establishment in India, but that would entail the sending of some one to bring it over, as the attempt already made to send it by post has failed, for reasons previously stated.

"A second way would be to get "seed" from China, and rear it under Pasteur's system.

"And a third way would be to select, by Pasteur's method, a healthy strain from the worms now in the country."

The Government decided to procure seed from India, but in consequence of hearing that the silk-breeding experiments undertaken in India had not proved a success, and that the eggs could not be guaranteed, this had to be abandoned, and in November I obtained permission to try the third course indicated above.

Shortly stated, the Pasteur system, which has saved the silk industry of Europe from the utter ruin which threatened it, is the rejection, for breeding purposes, of the eggs of those moths which, on examination, are found to be diseased.

This, in the case of the Ayer Kuning worms, could not be carried out, as all the moths when they came to be miscroscopically examined were found to be diseased. I therefore had to take advantage of a fact which has been noted by Pasteur, that although pebrine is hereditary, still that not all the eggs of a diseased mother will be infected. To carry out the suggestion contained in this observation, a number of small china cups were obtained, the least diseased eggs were used, and the worms on hatching out, were put four in each cup, and during their whole lives rigidly isolated from their fellows. The cups were frequently disinfected, and any worms which seemed diseased removed as quickly as observed. By these means a considerable number of quite healthy moths were produced. The microscopical examination, isolation of the worms and disinfection of the house and its contents were continued, and in the course of three generations, the disease entirely disappeared. This experiment has now been carried on for over nine months, and it goes far to prove that, given a healthy breed of worms to start with, silk culture could be successfully carried on in Perak, if proper precautions were taken to disinfect the rearing houses and apparatus, and to maintain the breed used for seed purposes in a healthy condition, by strict isolation and by submitting it to microscopic or other selection in the manner hereafter explained.

PEBRINE AFFECTING WILD MOTHS IN PERAK.

His Excellency the Governor some time back sent me, through the Acting British Resident, a number of the reports of the Indian Silk Committee, and in one of these papers it was inincidentally mentioned that pebrine, the disease which has been causing such havoc in Perak, affects other genera of the lepidoptera besides the genus to which the silkworms belong, and it occurred to me that an examination of the wild moths might be useful. With this object I began a microscopical enquiry, and on the evening of the 1st February found a common wild moth badly affected by pebrine. The bacteria were identical in form, size and refringence with those from the silkworms, with which they were carefully compared, and there appears no reasonable cause to lead to the supposition that they are not the same micro-organism, though the actual proof—viz., inoculation—is wanting, and rather hard to apply, with any hope of obtaining positive results.

This unlooked for and disagreeable discovery clearly indicates that the disease is endemic in Perak, and that, although it may be eradicated from all the silkworms in the State, or a perfectly pure breed be introduced, yet they will always be subject to re-infection from coming into contact with wild pebrinous lepidoptera, or the virus emanating from these diseased insects.

It was previously concluded that, owing to the isolated position occupied by Perak in regard to silk culture, infection was only to be feared from outside, and that, given a healthy breed of worms and proper precautions against the introduction of disease from China or India, that the worms would enjoy complete immunity from pebrine. This hypothesis is now apparently shown to be fallacious, and, instead of once eradicating the disease, it will be necessary to pursue a continuous course of selection of seed, if the cultivation is ever to be carried on successfully.

CONDITIONS NECESSARY TO ENSURE SUCCESS.

As the result of over two years' observation and experiment on the growth of silkworms in Perak, I have arrived at the following conclusions.

The houses used to rear the worms in should be small and detached from one another. They should not be too high, and be made fairly light. They should be used for only this one purpose and should not be used as dwelling-houses, nor stables, nor as stores for keeping cocoons. They should be subjected to thorough disinfection between the rearing of each brood, by fumigation with sulphur and washing all the trays, cocooning frames, tray-stands and baskets used to hold the leaves with a carbolic acid soap solution. The trays used in one house should not be moved to another house unless disinfected first.

All the refuse leaves, excreta, dead worms and sweepings of the rearing houses should be removed from the houses daily, and burned at once. On no account should they be used as manure for the mulberries until after burning.

The stands for the trays should be placed in the centre of the houses so that they can easily be protected from insects and be got at to disinfect, and if necessary, readily enclosed in netting. Houses of fifteen feet wide would be most convenient, with a six-feet six-inch stand down the centre, so as to use a double row of three-feet diameter trays six or seven tiers high, that is, that each fathom of length of tray stand would accommodate from 24 to 28 three-feet diameter trays, giving an area of from 169 to 197 square feet. A house 46 feet by 15 feet would therefore give 1,379 square feet of tray surface, which would be sufficient for the production of from one-and-a-half to two pikuls of cocoons per brood, or say eight pikuls per year.

The stifling, sorting, storing and packing of the cocoons should be done as far as practicable from the rearing houses, and all refuse from these operations should be carefully burned.

To be a success, a good variety of worm should be introduced, and apparently *bombyx Madrassi* would be the most suitable to the climate and conditions of Perak. I have already remarked on the inferiority of the *bombyx sinensis,* so that it need not be gone over again here.

Having obtained a good breed of worms, they should be subjected to careful treatment by the Pasteur system to eliminate any hereditary taint that they may have, before they are given to the cultivators. From what has already been said, it will be evident that it would be necessary to maintain a breeding establishment for the supply of pure eggs. This should be some way from any other establishment, and special precautions should be taken to avoid infection from wild moths, by the use of wire netting to all windows and doors of the rearing houses. With care in this respect there would only remain the rather remote chance of infection by means of the mulberry leaves used as food, having been soiled by some diseased wild moth or caterpillar. This no possible means could be taken to prevent.

As great difficulty has been experienced in India in the attempts which have been made, for some years past, by the

Silk Committee to apply the Pasteur system to the multivoltine worms, I will state here what my experience has been, the way I have carried out the system and the plan which I propose for adoption on a large scale.

The moths on coming out of the cocoons are allowed to pair, and in the evening are separated, the males being thrown away and the females being placed each in a small cone of paper, one corner of which is then turned in so as to close its mouth. These paper cones are strung up and the eggs laid in them. On the fifth or sixth day after laying, the moths are each taken and crushed in little china cups with a glass pestle. A drop of the fluid is transferred to a glass slide and a cover glass put over it. These slides are then examined with a quarter-inch object glass and high power eye-piece, giving a magnifying power of 630 diameters. The eggs of all diseased moths are then destroyed, and the healthy ones only reserved for breeding. On two occasions, starting with highly pebrinised worms, I eradicated the disease in from three to four generations by the above course of procedure.

PROPOSED SYSTEM FOR PASTEURIZING MULTIVOLTINE SILKWORMS.

The selection, by the microscope, of a large number of eggs, in the way above described, is a commercial impossibility, as there are only six or seven working days between the laying of the eggs and the hatching of multivoltine worms, instead of about as many months in the case of the annual silkworms cultivated in Europe.

My plan for overcoming this difficulty is to maintain a breed of say 3,000 worms, which for convenience may be called "firsts." This breed is to be kept distinct and to be microscopically selected every brood. Our microscopist could examine all the female moths of each brood of this number of worms, between the laying and hatching of the eggs. A certain number of the eggs from the best cocoons would be put aside for the next generation of "firsts," and the remaining eggs would be reared in separate houses, in which strict sanitary precautions would be maintained.

This brood, which would not be microscopically selected, may be called "seconds." On attaining maturity these "seconds" would lay, and it is their eggs which would be given to the cultivators.

They would therefore be always only once removed from the "first" or microscopically selected eggs. If 1,200 female moths out of the 3,000 above-mentioned were passed at a selection of "firsts," they would yield, say, 240,000 eggs,* or 120,000 female "seconds," which again would yield 24 millions of eggs for distribution. This number of worms would give 16·458 tons of "green" cocoons, or at four broods per annum, say 64 tons, as the outcome of the work of a single microscopist for a year. This is as much as a hundred microscopists could do, with multivoltine worms, if working by the ordinary method of selection as practised in Europe.

The whole system depends on guarding from external sources of contagion the generation after that which has been proved to be free from disease by microscopical examination. To do this, cleanliness, the free use of antiseptics, isolation, and the growing of the food in a place where it will not be infected by unhealthy worms, are the main points to be attended to. As a precautionary measure, the "firsts" might be divided advantageously, and kept in two separate houses.

From time to time it might be necessary to introduce fresh blood into the breed, and for this purpose the fresh worms should be microscopically selected for four or five generations before mixing them with the original "firsts," being kept during their probation in a house isolated from all the others. It may be mentioned here that I have found that a single selection, never mind how carefully it is done, is insufficient to eliminate pebrine from a race of worms. Therefore it follows that it is useless to attempt to produce "seconds" until the "firsts" have been thoroughly purged of all traces of disease, by repeated selections.

In an establishment such as is here suggested, the microscopist would be the only highly paid man. All the other work could be done, after a little time, by ordinary coolies, so that the cost of maintenance would be comparatively unimportant, and the eggs could be supplied at a low price.

I venture to think that this system, if carried out properly, will do for the multivoltine silkworms of the tropics what the system practised in Europe has done for the annual silkworms of temperate climates.

SELECTION BY LONGEVITY.

Mr. R. Blechynden communicated to me a plan he has been trying, to effect the selection of healthy worms for breeding

* A female of *bombyx sinensis* I find lays on an average 355 eggs, weighing 2·414 grains; 160 moths would lay one ounce of eggs, the standard ounce being 15 grams or 385·8 grains. In the above estimates it has been assumed that each moth will produce only 200 worms.

purposes, without the use of the microscope. The system consists of the placing of each female moth under a small cup inverted on a sheet of paper, on which it lays its eggs. The cups are suffered to remain with the eggs and moth beneath them until the eggs begin to hatch, and the eggs of all those moths which are alive at that time are taken to be healthy, and those which have died prior to the hatching of the eggs are thrown away as unhealthy. I have experimented with this system, and there appears to be a good deal to be said in favour of it; the moths which survive being almost without exception healthy; though it by no means follows that all that die early are diseased. To deal with the same number of moths as mentioned above would, however, involve the manipulation of about 150,000 china cups, and would require over 4,000 square feet of table surface to put them out on. It has the great disadvantage that the eggs cannot be distributed as eggs, and that the young worms could only be sent a short distance from the breeding establishment. In the system advocated above, either the cocoons of the "seconds," or their eggs could be distributed, and there would be plenty of time to send them long distances.

CULTIVATION OF MULBERRIES.

From the experience acquired in Larut it would appear that the best way to cultivate mulberries would be to fell the jungle, burn and clear it as if going to plant padi or coffee. Then put in the mulberry cuttings, or better, the young plants, previously raised in a nursery, at distances of 12 feet by 12 feet, that is, 302 plants per acre. If it is wanted to begin picking early, they might be planted at 6 feet by 6 feet, or 1,210 per acre,and every other row, and the intermediate bushes of the remaining rows, being picked at first, the bushes which had been picked when young being afterwards cut out, as the unpicked ones grow larger and require more room. If these latter are allowed to grow to 6 feet in height and to become large spreading bushes, they will last for years; but when grown as the Chinese grow them, which is an attempt to violate all the conditions which the plant naturally requires to be fulfilled, they are very delicate and susceptible to the influence of over-picking, disease or neglect of weeding, and are very apt to die out. They should never be picked too close, as it is always to be remembered that the leaves are the organs which supply a plant with its principal food, that is, the whole of its carbon, and indirectly with all its other food, as without the leaves to exhale the watery portion of the sap, the roots cannot absorb moisture from the soil, and unless they absorb water they cannot acquire nourishment from the soil, as the water is the medium in which the nutritive parts of the earth are conveyed to the plant through the roots.

The bush varieties of mulberry have hitherto been only considered, but it appears that the tree varieties are in some situations to be preferred, or at least, might be advantageously planted in conjunction with the bush varieties. They need not be weeded after attaining some size, which to a Malay is a great consideration. They can be planted amongst other trees, and as hedges to fields, kampongs, etc. The worms appear to eat the leaves, and thrive on them. I have found no difference in this respect between the two varieties, except that the bush mulberry is more suited to the worms when very young, as the leaves are much softer.

The mulberries can readily be propagated by cuttings. These are best made when the plant is at rest, though they may, with care, be got to strike at any time of the year. Pieces about a span long are the best, and they should be cut at the bottom end, close beneath a joint, otherwise they are very apt to damp off. They grow best when planted upright, and with not more than three inches of the cutting beneath the surface of the ground. If treated as the Chinese and Javanese usually treat cuttings, that is, planting them diagonally with three-quarters of the whole length of the slips beneath the ground, not one in ten will strike; whereas if planted as recommended, not one in ten will fail.

Apparently, four or five broods of silkworms could be raised in the year. The mulberry appears to have two growing seasons during each year in Perak, but sufficient experience has not yet been acquired to enable it to be definitely stated when it would be best to rear the broods.

The refuse from the rearing houses should all be burned before it is returned to the land as manure, as it would appear by the experience gained in India that the disease germs contained in this refuse get on to the leaves and infect worms fed on them. This can be easily understood when it is remembered that the germs retain their vitality for a period of at least eight months.

LABOUR.

The main condition that must be fulfilled to ensure the successful breeding of silkworms in Perak, or anywhere else for that matter, is employment of cheap labour. The mining in this State has raised the wages of all classes, particularly amongst the Chinese, and though I have not been able to collect any reliable information on the subject, I do not think that silk could be produced by means of Chinese labour at a price that would be remunerative. If it is to be successfully grown, I believe it would be by the Malays, as amongst them the wages are lower, and women and children could be employed for all the light portions of the industry; which they can do not only cheaper, but actually better than men. The Kuala Kangsar and Krian districts are the most suitable, as in both places there is a comparatively thick Malay population, and very little mining near to raise the price of labour. If some Malay chief of weight could be induced to exert his influence on the people, silk culture might, I believe, easily be established amongst the Malays. It is essentially a peasant industry. To carry out this suggestion it would be necessary to form nurseries of mulberries in the district chosen for the experiment, so as to be able to supply plants to the Malays, who should be induced to plant them in their kampongs—not only those who are intending to rear the worms, but others, who could afterwards sell leaf to the actual keepers of the worms. On no account should the Ayer Kuning mulberries be used to propagate from, as the leaf disease would be propagated at the same time.

Having secured the planting of the mulberries, the next step would be to show, by an actual demonstration in the district, the way in which the culture is to be carried on.

Pure eggs would, of course, have to be supplied, but by the system already explained in detail, half a day's work with the microscope at each brood would be sufficient to supply all the eggs needed for a long time to come.

The silk when produced should either be reeled locally by the cultivators, or the cocoons should be sent to Europe for sale. If reeled locally it must be done well, or the price is seriously reduced. Reeling is almost always done by women, and here again the only people who would be suited to the work would be the Malays.

TAIPING,
September 21st, 1892.

EXPLANATION OF PLATE.

FIG. 1. Transverse section of mulberry leaf, through the centre of a disease spot. Magnified 51 diameters.

FIG. 2. A piece of the epidermis, of the under side, of the mulberry leaf, showing stomata. Magnified 230 diameters.

FIG. 3. (*a*). Germinating spores of mulberry leaf disease. (*b*). Four mother-cells, swollen by soaking in water. (*c*). Three mother-cells, before immersion in water. Magnified 230 diameters.

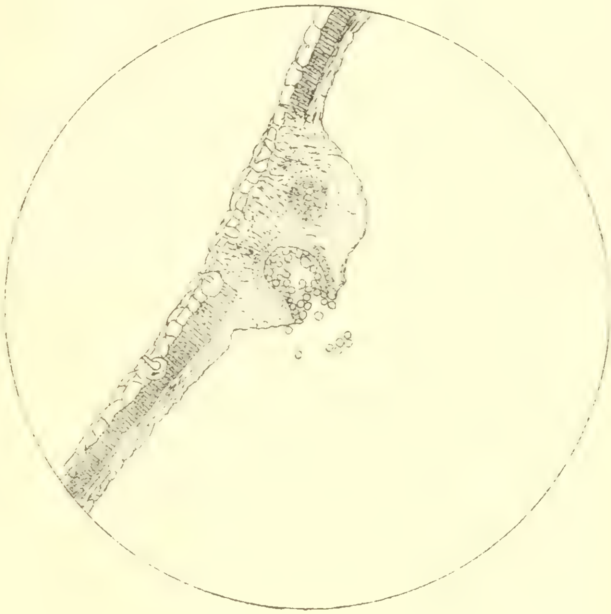


FIG. 1. X 51

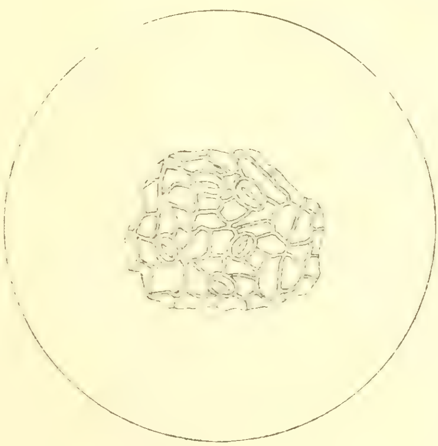


FIG. 2. X 230

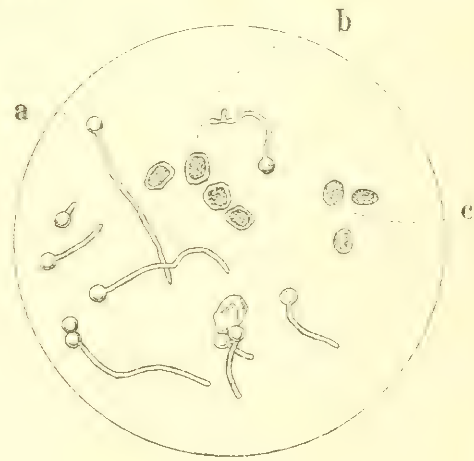


FIG. 3. X 230

—MULBERRY LEAF DISEASE—

ON THE MALAYAN FISH POISON CALLED "AKER TUBA," *(DERRIS ELLIPTICA.)**

The fish-poison known by the Malayan name of "aker tuba" is the root of a papilionaceous woody climber called *derris elliptica*, Benth. This plant bears bunches of pretty, fragrant, white flowers, tinted with pink and pale buff, which are followed by thin, flat, blunt-ended pods, $2\frac{1}{2}$ inches long by 1 inch broad, containing one or two seeds. The leaves are pinnate, with seven to thirteen leaflets, and are whitish beneath. It flowers in Perak in February and March, and the fruit ripens in May or June.

The following is the botanical description taken from the *Forest Flora of British Burma*, by S. Kurz:—

"*Derris Elliptica*, Benth.—A large scandent shrub, the younger parts all rusty pubescent; leaflets, in four to five pairs, with an odd one, on a pubescent petiolule 2 lin. long, oblong to obovate-lanceolate, shortly and rather abruptly acuminate, 3 to 6 inches long, chartaceous, entire, glabrous above, more or less glabrescent beneath; flowers rather large, pinkish, on 2 to 3 lin. long, rusty villous at apex, bracteoled pedicels, peduncled-cymulose and forming an elongate, rusty, pubescent, narrow panicle in the axils of the leaves or above the scars of the fallen ones; corolla $\frac{2}{3}$ inch long, appressed, tawny silk-hairy; ovary, tawny villous; pods elliptic, compressed, rather acute, about 2 inches long by 1 inch broad, 1 to 2 seeded, puberulous and glabrescent, narrowly winged along the vexillar suture. Habitat, Tenasserim. Flowers, March; fruits, August."

Loureiro's genus *Derris* includes several other poisonous plants, of which *D. Uliginosa*, Benth., and *D. Forsteniana*, Bl.,† are also used as fish poisons in Malaya. Other nearly allied genera of the papilionaceous leguminosæ contain species employed for the same purpose, of which *Pongamia*, *Millettia* and *Tephrosia* may be mentioned.

* Reprinted from the *Pharmaceutical Journal* of July 23, 1892.

† This should probably be *D. Forsteniana*, Miq., which is now regarded as the same as *D. Uliginosa*, Benth. See *Journal Linnean Society*, Vol. IV., Supplement. [Ed. *Pharm. Journal.*]

Aker tuba grows apparently wild on the plains in Perak, and is also rather extensively cultivated. The roots, done up into bundles, are to be bought in many of the shops, and in Taiping, the chief town of Perak, it sells for about 35 cents per kati, or $9\frac{1}{2}d.$ per pound.

The root, which is the most virulent part of the plant, exudes, when cut, a white milky sap, which under the microscope is seen to be an emulsion. The roots have a rather pleasant aromatic resinous smell, bearing a slight resemblance to that of liquorice root.

It is used largely by the Chinese market gardeners as an insecticide, for which purpose the fresh roots are chopped up fine and then pounded and mixed with water, which becomes milky, and which is sprayed or brushed over the plants with a bunch of feathers.

The main use of the plant was, however, until the much-needed prohibition came into force, as a fish-poison,† for which purpose it is pounded or ground fine and mixed with stiff clay and crushed refuse shrimps or small fish, and the mixture is then made into balls and dried. These balls are thrown into the sea, like ground bait, and fish eating them become poisoned, rise to the surface, and are caught by the watching fishermen. This way of using it is probably not very harmful, though the same cannot be said of its use in fresh waters.

By the Malays it is used in the rivers in the following way:—One or more dug-out canoes, according to the size of the stream to be operated on, are partly filled with water and the pounded roots. The men then upset the boat or boats into the river, and allow the other boats to drift down with the current, whilst with nets and spears they secure the fish as they rise stupefied to the surface. It is a most destructive method of fishing, killing as it does all the fish, little and big, for some miles along a waterway. The young fish succumb much more readily to the poison than the larger ones. In ponds and pools the destruction of the fish is even more complete than in a river, and the Malays say it is years before they become tenanted with fish again. In all instances, besides the actual effects of the poison, the fouling of the water by the decomposition of the bodies of the fish and animals of all sorts has to be taken into consideration.

By experiment I have found that 20 grains of the green root will render one gallon of water sufficiently poisonous to kill fish.

* Fish poisoning is still, however, carried on. In March of the present year (1893) I saw a large party fishing in one of the rivers; fully 500 people were engaged, and many boat-loads of fish were caught and more destroyed. For over ten miles down the river dead and dying fish were to be seen. Dynamite is also used to a considerable extent in the State.

The first effects of the poison on a fish are to cause it to make violent efforts to escape, jumping out of the water, rapidly swimming about, etc. Then the breathing becomes laboured and there is a sluggishness and uncertainty of movement; the next symptom is an increasing inability to maintain the ordinary position; then the fish turns on its back, rises to the surface, and the breathing becomes slower and finally ceases. When fish have reached the stage of turning on their backs and rising to the surface, they will, if put into fresh water, slowly revive, and after the lapse of some hours appear little, if any, the worse for the experiment. I have three times poisoned a fish, allowing intervals for it to revive; and it has lived in an aquarium for days or even weeks afterwards.

The poisonous principle is not, as might be expected, an alkaloid. I at first tried the usual methods for separating these substances, but the residues from the exhaustion of both acid and alkaline aqueous solutions by ether and chloroform did not possess toxic effects. After many experiments I found that the poisonous principle, for which I propose the name "tubain,"* is a very brittle, reddish-brown coloured, resinous substance, quite insoluble in water, paraffin oil, and benzine, but soluble in alcohol, ether and chloroform. It has a specific gravity of 1·1662; is dissolved by nitric acid, forming a bright dragon's-blood red solution; and is unacted on by strong boiling solution of carbonate of soda. When heated in a glass tubes it melts, boils, and then carbonizes, a brown-coloured oil condensing on the cool part of the tube. It burns with a large smoky flame, leaving a quantity of carbonaceous ash. Fractional distillation and other means would perhaps break up the resin into several distinct substances, only one of which may be the virulent body; but my very limited laboratory appliances prevent me from carrying on the investigation further than I have done; and I must leave to others the further working out of the subject.

Tubain is most conveniently prepared by crushing up the chopped root and digesting it, with little heat, for some hours in alcohol acidulated with hydrochloric acid, filtering and evaporating on a water-bath at a low temperature until a gummy substance separates. When all the spirit has evaporated and water only remains, the tubain may be removed and pressed into a mass. This can then be washed by kneading in hot water and further

* The Editor of the *Pharmaceutical Journal* says in a note: "Mr. Wray appears to have worked in ignorance of Mr. Greshoff's discovery of "derrid." See *Pharm. Journal* (3) XXI., pp. 559-560." I was unaware of it, but I separated tubain nearly five years ago, and a sample of the poison has been exhibited under that name in the Perak Museum since March, 1888.

purified by re-solution in alcohol and repeating the above process. The result will be the resinous substance above described. The roots should be digested a second time in fresh alcohol. The dried root yields 9·42 per cent of tubain by the above process. When tubain is dissolved in spirits of wine and left to stand, a granular deposit of a dirty-white colour is formed, which is only sparingly soluble in cold alcohol, but is dissolved by hot alcohol, chloroform, and ether. This granular body redeposits on evaporation from ether as a pure white crystalline tasteless mass. From its solution in chloroform it is left as a clear white varnish. When heated it melts into a transparent white fluid, which on an increase of heat turns brownish-red and partly distils, unaltered. This substance when freed from all traces of tubain (by repeated recrystallization from hot alcohol) is not poisonous to fish. The acid aqueous solution left after the deposition of the tubain, and which contains presumably any alkaloids present in the roots, is also not poisonous.

One part of tubain in 350,000 parts of water proves quickly fatal to fish, and water containing the extraordinarily small quantity of one millionth—*i.e.*, 1 grain in 143 pounds of water, will kill fish in from one-quarter to half an hour, according to species. There is a considerable difference in the susceptibility of various kinds of fish to the effects of the poison, and the *siluridæ*, or cat-fishes, appear to be the most tolerant of any. It has been stated that fish killed by aker tuba are sometimes unwholesome, but when we see the extremely small amount of poison which is required to produce a fatal result, it seems improbable that any ill effects can be produced by eating fish so killed; the more so as tubain distils over with the steam from boiling water, and would be, in part at least, eliminated in cooking.* The crushed roots when boiled with water in a retort yield an opalescent distillate, smelling strongly of the root and actively poisonous. The Malays say that fish killed by means of aker tuba very quickly go bad; but unless the poison acts as a chemical ferment, which seems unlikely (as tubain added to milk causes no change, and, if anything, rather retards its turning sour) it is more probable that the idea arises from comparing fish caught alive and remaining so in the bottom of a boat for some hours perhaps before they actually die, with those killed by the root at the time they are taken out of the water. In the case of fish, the poison is evidently absorbed by the gills, and passes at once into the circulation of the blood, which probably accounts for the infinitesimal doses which are enough to produce lethal results; for

* I have taken one-fourth of a grain of tubain without experiencing any ill effects. The resin was dissolved in a few drops of spirits of wine and added to about an ounce of water.

with most poisons this is by far the most effective way of administering them. Owing to the insolubility of tubain, it may be eaten by a fish with impunity. I have seen a fish eat enough to kill a score, without any ill effects; but when a solution of it in spirits of wine is added to water, although the tubain is at once precipitated as a bluish-white cloud, still it is then active. Presumably, the fine state of subdivision enables it to be assimilated by an animal organism. In the sap of the plant it exists as an emulsion; and the sap, having no tendency to coagulate, may be diluted to any extent with water. By this means it becomes an extremely attenuated emulsion. When the roots have become dry, this only takes place to a very limited extent; and a solvent is then necessary to bring the tubain into a form in which its poisonous qualities can be applied.

There appears to be no reason why we should not take the hint from the Chinese market gardeners and apply the poison to the destruction of the many insect pests to which garden and green-house plants are subject.

From what has been said as to the nature of the substance it will be apparent that the dried roots would be of little or no good for the purpose, and either the tubain must, after being extracted from the root, be converted into an emulsion or into some chemical combination easily dissolved in water. By the aid of a small quantity of spirit it may easily be emulsified with soap, which on solution in water presents the poison in an active form. I think it may also be saponified if mixed with oil before it is treated with alkali. My attempts in this direction have been only partially successful as yet. In both cases potash, or soft soaps, would be the most convenient vehicles with which to combine it, as they are so much more readily miscible in water than the soda soaps. The extraction of the poison from the roots in a large way would not be costly, as by suitable apparatus the spirit could be distilled off and used over and over again; and doubtless some cheaper method of extraction could be found. The plant grows readily in the Straits Settlements. The roots are dug up from time to time and the stumps and suckers are replanted and soon throw out new roots. The stems also contain the poison, though in not so great a proportion, but still worth extraction. It is probable that the best time of year to harvest the root would be January, as the plant is then at rest and nearly leafless. This is a subject which seems to be well worth the attention of the makers of insecticides and of floriculturists and horticulturists generally.*

TAIPING, 12*th March*, 1892.

---

* See also *Kew Gardens Report*, 1877, p. 43, and *Pharm. Journal* (3), XVII., p. 5.

NOTE ON A LIGHTNING DISCHARGE IN TAIPING.

During a thunder-storm on the afternoon of Sunday, the 5th March, 1893, two trees in the garden of Colonel Walker, at Taiping, were struck by lightning. The case is worthy of record, as there were several points of considerable interest connected with it. The trees which were struck are both what the Malays call "pulai" (*alstonia scholaris*). They are not large ones, and there are several considerably taller close by. They are situated in a small hollow surrounded on three sides by high ground, the slopes of which are dotted over with trees, while on the top of the rising ground are three buildings furnished with lightning conductors. The buildings are Colonel Walker's house, the magazine on the fort, and the Secretary to Government's quarters. The two pulai trees are therefore in no way conspicuous objects, and it is hard to understand why they should have been struck when the visible aspects of the situation are alone taken into account; but the state of the atmosphere may have been such that a path of lower electrical resistance was opened to the discharge through these trees than through the higher ones close by.

Tennyson aptly describes this condition in the lines—

> "The ragged rims of thunder brooding low,
> With shadow-streaks of rain,"

These shadow-streaks, which are such a noticeable feature of tropical rain-storms, offer an easy explanation of the otherwise unaccountable occasional selection by lightning of inconspicuous objects. They often cover, with their bases, quite a small area of ground, and their density is such that they must offer very much less resistance to the passage of an electric current than the surrounding air.

The trees themselves were not injured, except that the top shoot of one was broken and that some twigs and leaves were cut off and scattered about. The bark was neither stripped off nor were there any marks on it, and, beyond the slight damage to some of the leaves and twigs already mentioned, there was nothing to show that a powerful discharge had traversed them. On the ground surrounding the trees, however, were evidences of an unusual character. Around and between the bases of the trunks the earth was torn up to a depth of a foot or more, and from these excavations, eight distinct sinuous branched trenches were cut in the ground. The two longest of these were some fifty-eight and fifty-four feet, the latter of which terminated in a piece of water. Two of the other trenches also terminated in water; the others diminished in size as they extended from the trees and gradually died out. Near the bases of the trees the furrows were from nine to twelve inches deep and about a foot wide. The roots in the earth were all cut through, and the earth, pieces of root and turf had evidently been thrown out with great force and scattered all over the place.

It is quite likely that the damage to the leaves and twigs of the trees may have been caused by this ejected earth, for in a case in which a building in Taiping was struck some years back, part of the discharge passed between the bricks and the plaster of the wall of one room and the plaster was thrown with such force that it did a large amount of damage to the contents of the room, which was then used as the Museum. The velocity of some of the particles of plaster was so great that they pierced glass bottles at a distance of twenty feet, making clean-cut holes in them. In that case it may be mentioned that the particles of plaster were thrown at right angles to the line of discharge, and if the same thing happened in the present instance the earth would have been projected vertically upwards.

In places, tunnels were cut in the earth for a length, in some cases, of eight or ten feet. At the three points where the discharge left the earth and entered the water, the earth was ejected as if the direction of the impelling force was from the trees towards the water, in other words as if the flash came from the cloud to the earth. Two of the trenches leading to the water ended in tunnels and one in an open furrow. The tunnels were round pipe-like excavations about three inches in diameter, with their orifices on a level with the surface of the water.

The accompanying rough sketch shows the furrows and their sinuous, branched character; the dotted lines indicate the tunnels. As will be seen, the place was nearly surrounded by water, and the mere fact of the trees being pulai will be sufficient to show that the spot was low-lying and damp—in fact, the natural water-level in the soil is only about eighteen inches beneath the surface.

On looking at the sketch it will be noticed that five of the trenches start from excavations at some distance from the bases of the trees. There were no signs of tunnels connecting them with the bases of the trees, so that it would appear that the lightning must have branched before it reached the ground.

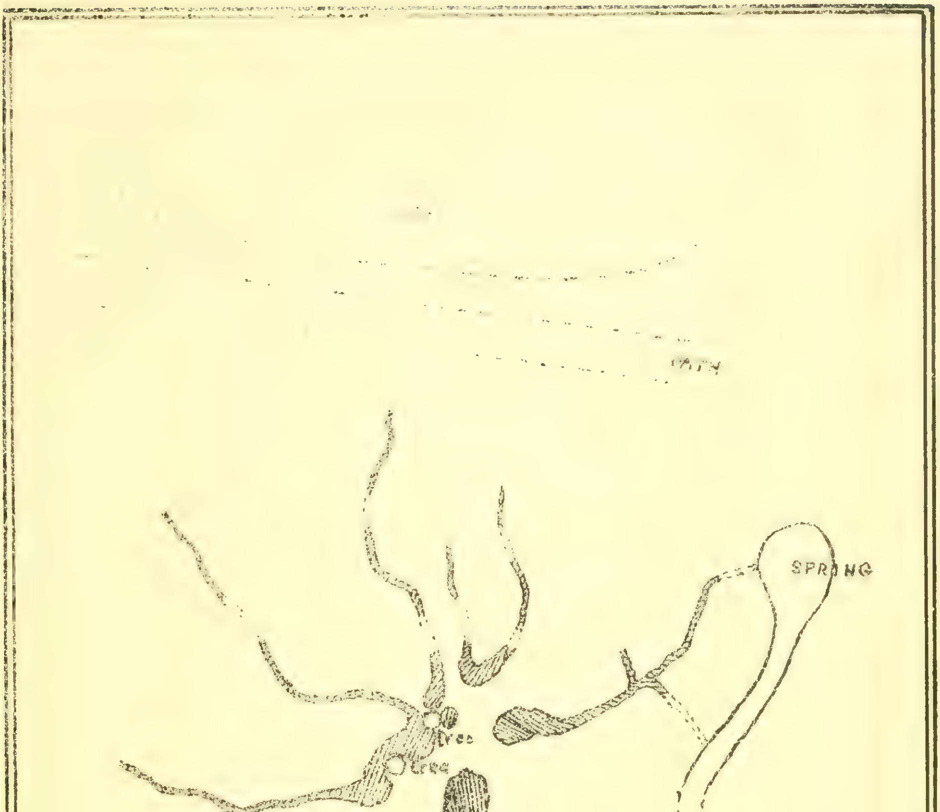
Another point shown by the sketch is that the trees must have been nearly, if not quite, in the centre of the charged area of ground. This is indicated by the even way in which the furrows radiate from the bases of the trees. The area of ground covered by the furrows—that is to say, which is enclosed by drawing a line so as to connect their outer extremities, is about 3,500 square feet in extent.

There had been heavy rain before this particular flash (which occurred at a few minutes to six o'clock in the evening) and the surface of the ground must have been very wet. Over one inch of rain fell during the thunder-storm, and certainly more than half of it fell prior to the trees being struck. The rainfall for the week preceding was as follows:

February 25th	... ...	2·15 inches.
,, 26th	... ...	0·47 ,,
,, 27th	... ...	0·25 ,,
,, 28th	... ...	Nil ,,
March 1st	... ...	,, ,,
,, 2nd	... ...	,, ,,
,, 3rd	... ...	,, ,,
,, 4th	... ...	,, ,,
,, 5th	... ...	1·02 ,,

It will be seen that there were three wet days, with a total rainfall of 2·87 inches, followed by five dry days. Before the rain commenced on the afternoon of Sunday, the 5th March, the surface of the ground for some few inches in depth must therefore have been fairly dry, and at the time of the flash it is probable that there was still a layer of dryish earth between the wet surface and the saturated subsoil. It was through this top layer of wet earth that the lightning passed, and the less moist layer beneath it seems to have proved an effective insulator.

A study of this discharge tends to cast doubt on many of the ideas respecting lightning and lightning-conductors. It seems to show that the charge is strictly confined to the surface of the ground, and that the discharge under certain circumstances spreads out disruptively on the charged surface and does not penetrate into the earth, although, as in this case, it would only have had to go through a few inches of damp earth before reaching the water-level. Instead of this it will be seen that some of the furrows ran for a distance of over fifty feet, just



Plan shewing the Trenches cut in the Ground by a Flash of Lightning.

beneath the surface of the ground, to reach charged pieces of water, throwing out branches on their way to discharge the intervening surface of the ground.

When anything similar to this takes place on or near a building on which there is a conductor, it is at once put down to a bad earth-connection, while apparently it is due to the wet surface of the ground being a better conductor than the stratum lying between the subsoil and the charged surface.

Cases in which large numbers of sheep, cattle or people have been killed by lightning are easily comprehended, after looking at this sketch. It is evident that had a number of people or cattle been standing beneath these trees and occupying the space covered by the furrows, that they would have constituted the charged surface and that the discharge would have passed through their bodies instead of, as in this instance, through the ground.

The practical deductions to be drawn from this case seem to be that all surfaces which are liable to become charged should be put in communication with the system of conductors on a building. In other words all roofs should be connected by their ridges and gutters. While, as much as possible, lightning conductors should be arranged so as to be lightning distributors. For this purpose all the conductors on a building should be connected together, and the earth-plates so spaced round it that the discharge may be spread out over as large a surface as possible.

ON THE BLACK LIMESTONE AT KAMUNING.

On the road between Enggor (on the Perak River) and Ipoh, and at about nine miles from the former place, is a picturesque limestone hill called Changkat Kamuning. It is perhaps some 600 to 800 feet in height, and is composed of a black limestone differing in many respects from that of a similar colour found in other parts of the State.

The limestone is nearly black in colour, with occasional veins of pure white. It is soft and is easily cut with a knife, yields a grey powder, and has an uneven fracture, dull in the direction of the grain and minutely sparkling across the grain. It blackens the hands when handled, and when rubbed with a hard substance presents a polished black surface. In thin sections under the microscope it is seen to be made up of white crystalline carbonate of lime, enclosing opaque black shining scales and irregular masses. When a fragment is put into dilute acid the lime dissolves, leaving a black powder, which under the microscope presents the appearance, in miniature, of pieces of coke. The grains are of different sizes and very diverse shapes. The powder is slightly gritty between the fingers, from admixture of a small amount of quartz sand. The particles of this substance, by their appearance, suggest the idea that they have been in a plastic state and that the crystallization of the enclosing calcite gave them their present form. This is best shown in a decalcified section of the rock.

The black powder when rubbed on paper, or between the fingers, presents the characteristic appearance of plumbago, while before the blowpipe it behaves in the same way as that substance, and if heated with nitre it deflagrates. It is therefore carbon in the form of graphite.

The rock has a specific gravity of 2·66 at 84° F., and consists of—

Carbonate of Lime	91·4
Carbon (graphite)	8·1
Silica	·5
	100·0

Including the carbon in combination with the lime, there is nearly 20 per cent of that substance in the rock.

When dry, the stone is a fairly good conductor of electricity, and if a piece of it and a slip of zinc are applied to the tongue, the well-known sensation produced by the passage of a weak current of electricity will be felt.

From the occurrence in the immediate neighbourhood of the upper beds of the schistose rocks which underlie the limestone formation of Perak, it would appear that the Kamuning beds belong to the lower part of the calcareous series. It should be stated, however, that the limestone which rests on the underlying beds, as far as has been observed in other parts of the State, is not carbonaceous. Whether this is a sign of unconformity, or is simply due to local causes in operation at the time of the deposition of these beds, is, in the present state of our knowledge, impossible to determine.

Limestones containing graphite have been found in Canada and the northern parts of the United States. These rocks are of the archœan period, and it is in them that the much disputed *Eozoön Canadense* occurs.

In the schistose beds beneath the limestone, graphite has been found at Batu Gajah, in the Plus Valley, near Tapah and in Bernam. It is mostly disseminated in scales and grains through the body of the rock, but at Batu Gajah there is a well-defined vein of it. This vein was cut in making the new road to Lahat, and more recently again in sinking a well in the hospital grounds.

A consideration of the characteristics of these schistose and crystalline calcareous formations seems to point conclusively to their belonging to the archœan period; and it may be stated that the whole of Perak, where the granitic rocks have not burst through and come up to the surface, is covered by beds of the Laurentian formation, as no rocks of less age are known to exist, except the very recent quaternary drifts and alluvial deposits.

Perak Government Printing Office.