

## THE OCCURRENCE OF WEIL'S DISEASE AMONG MINERS IN THE WEST OF SCOTLAND

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THE occupational incidence of Weil's disease is well recognized. In this country it is most usual in coal-miners, fish-cleaners and sewer-workers. In each of these occupations the association with rats and damp conditions is common, and since the proportion of infected rats in this country has been variously estimated at from 23 to 46% (Stevenson, 1922; Smith, 1924, 1938; Coppinger, 1936), the risk of workers coming in contact with *Leptospira* excreted by these animals must be considerable. The occurrence of leptospiral infection in the East Lothian coal-field has been recorded by Gulland & Buchanan (1924) and by Buchanan (1927), and in Northumberland and Durham by Swan & McKeon (1935, 1938*a*). Thirty-four cases in miners with six deaths have been collected from these and other sources by Alston & Brown (1937) in the period between July 1933 and February 1937. If the number of people engaged in coal-mining be considered, the recorded incidence of infection appears low, and the suspicion that numbers of unrecognized cases might be occurring was aroused by the fact that all the cases described by Buchanan, and all, except one, discovered by Swan & McKeon, showed jaundice; Schüffner (1934), who investigated a very large number of leptospiral infections, found jaundice in only 40%. Against this theory was the evidence produced by Swan & McKeon (1938*b*), who obtained sera from 101 men in two mines where Weil's disease had occurred and where there was likelihood of further infection. The sera were examined by Major H. C. Brown and only two gave a "positive" agglutination with *L. icterohaemorrhagiae* to a titre of 1:30 or over: the two men concerned gave histories of typical Weil's disease with jaundice. There was here no evidence of the occurrence of the milder, non-jaundiced case which experience suggested might be clinically unrecognized. To obtain further evidence on this point and to arrive at some idea of the incidence of Weil's disease in the west of Scotland I began testing sera from local miners. No cases had at this time been recorded though, as I learned afterwards, some had been recognized. During the course of the investigation a number of epidemic and sporadic cases were encountered. An account of these will be given first.

## METHODS

Sera were obtained from suspected cases in the hospital and from Lanark Public Health Department, and a large number of blood specimens came from miners admitted to the Royal Infirmary for various reasons, mainly surgical. Specimens received for routine Wassermann test from men other than miners were used as controls. Schüffner's sero-reaction was performed as described by Davidson *et al.* (1934) with a living non-virulent strain of *L. icterohaemorrhagiae* as antigen. This test has been found by many workers to be very reliable in detecting both present and past infections. Slight initial difficulties were experienced in reading tests when sera were haemolysed or full of lipoid material, but with more experience the test was found very easy and rapid.

## INSTANCES OF PRESENT INFECTION

*Mine A (Lanarkshire).* Two cases were treated in the Royal Infirmary, nos. II and V (Table I), and were proved to be leptospiral in origin by Schüffner's sero-reaction and by the isolation of pathogenic *Leptospira* from the urine by guinea-pig inoculation. Full clinical details of these cases, and an account of my bacteriological findings have been given by Middleton & McFadzean (1938). Further investigation led to the finding of a number of cases, the outstanding features of which are given in Table I.

Table I. *Recent epidemic in mine A*

Case	Onset of illness	Duration weeks	Jaundice	Character of illness	Sero-reaction highest titre recorded
I	Oct. 1936	13	+	Moderately severe; persistent headache	1:10,000
II	Jan. 1937	6	+	Moderately severe; petechiae present	1:1,000
III	„	8	0	Severe; massive haematuria	*
IV	„	6	0	“Influenza”; headache, vomiting of 2 weeks' duration; iritis 4th week	1:30,000
V	Feb. 1937	5	0	Moderately severe; vomiting +, slight haemorrhage	1:10,000
VI	„	6	0	Nausea, headache, haemoptysis, albuminuria, fever	1:30,000
VII	„	5	0	“Influenza”	1:3,000
VIII	Mar. 1937	3	0	“Influenza”; mild illness	1:30,000

\* This man had recovered and had left the district before blood could be obtained. The association with other cases and the character of the illness leaves no doubt of the diagnosis.

Five other men from this pit were examined with negative results; these men had slight indefinite malaise but were not off work for more than 2 days. The particular section of the mine from which all the cases arose had been open 2-3 years. Not much water had been found at first but, according to one of the men examined, water soon began to drain into it from another pit where “jaundice” cases had occurred. At the time of the outbreak it was certainly a wet pit and moderately rat-infested. I am indebted to Dr T.

Gow Brown, of Lanark County Bacteriological Laboratory, for the information that various specimens, water 2, mud 3, earth, slime and fungus from timber, 1 each, obtained from the mine had been inoculated into guinea-pigs with negative results. No rats were obtained because the pit was fumigated with HCN when the nature of the illnesses was established. The pit, however, was closed in April 1937.

*Mine B (Lanarkshire)*, May 1938. One case. Illness began with violent headache, prostration and pains all over. Slight vomiting, moderate pyrexia, jaundice 8th day. Schüffner's sero-reaction: 1:1000 (9th day); 1:10,000 (13th day); 1:3000 (30th day).

This was the first case from a newly opened mine which was not particularly rat-infested nor very wet. It was situated near the Clyde and had an "ingoing eye" or sloping shaft giving easy access from the exterior. Two guinea-pigs inoculated with tissues of rats caught in the above pit were obtained from the Lanark County Bacteriological Laboratory, and *Leptospira* were recovered in pure culture from each.

*Mine C (Dumbartonshire)*, August 1938. One case. Illness began with malaise, frontal headache and nausea, followed shortly by severe aching pain in limbs. A slight haemoptysis occurred on the 3rd day and vomiting was a prominent symptom. Moderate jaundice was noted when patient was admitted to hospital on the 6th day. Schüffner's sero-reaction, 1:1000 (7th day); 1:10,000 (19th day).

This case was particularly interesting in that it came from a pit where there were no rats. It was worked by machinery and was entered by shaft and not by incline. Mice, however, were numerous and had probably entered years ago when horses were kept. The pit was mainly dry but had damp patches. The patient, however, was working at the coal-face which was dry. No mice have been obtained for examination and since this is the only case recorded from this pit some doubt must be felt that infection really occurred there.

*Note.* One other recent case in a miner (T. S.), aged 62, has been encountered. He was, however, unemployed at the time of his illness which was characterized by fever, jaundice in 2nd week, and general malaise. Duration 1 month. This case was associated with seven other cases, all children, which were clinically somewhat similar, but serologically negative. Schüffner's sero-reaction in case T.S. was 1:30,000 on the 4th week of illness and was still the same when tested 10 days later. The man is a Lithuanian and is unable to give particulars of the possible source of infection, but the serum titre is too high to mean anything but a present Weil's disease.

#### ISOLATION OF *Leptospira*

Only three cases were treated in the Royal Infirmary, the others being determined by sero-reaction alone. Blood taken on the 7th day of illness from two cases was inoculated into guinea-pigs. Two animals were used, one being killed on the 5th-7th day, and one on the 12th day. No evidence of lepto-

spirosis was found and tissues reinoculated into further pigs did not induce infection. From the first patient 1 c.c. centrifuged deposit of urine obtained on the 17th, 18th and 19th days was inoculated successively into the same pig. The animal was killed 7 days later with typical Weil's disease. *Leptospira* were recovered. A similar procedure was followed in the second case but the guinea-pig, killed after 12 days, showed no evidence of infection. Reinoculation of another animal with liver and kidney suspensions, however, produced death in 15 days with typical Weil's disease. No particular effort was made at this time to select young pigs for inoculation. In the third case urine alone was inoculated. 2 c.c. of deposit from a urine obtained on the 16th day of illness was inoculated into a 6-weeks-old guinea-pig. *Leptospira* were recovered by heart puncture on the 7th day after inoculation. Jaundice was noted on the 10th day and the animal was killed with typical signs of Weil's disease. It is of interest that the urine inoculated contained lytic anti-bodies to *L. icterohaemorrhagiae* to a titre of 1 : 8.

#### INSTANCES OF PAST INFECTION

For some of these I am indebted to Dr J. M. Lang, Medical Officer of Health, County of Lanark. Others have been discovered in the course of routine examination of sera from miners in hospital. All the cases are shown in Table II under separate letter headings for each mine involved, the letter "A" referring to a mine previously mentioned (Table I), the other letters to mines not previously mentioned.

Table II. *Cases of past infection*

Mine	Case no.	Date of illness	Duration weeks	Jaundice	Other symptoms	Sero-reaction 1938
A	1	1926	24	+	Jaundice 7 weeks; epistaxis and pains in limbs	1 : 300
D	2	1930	4	+	Very ill; delirium, prostration, etc.	1 : 300
	3	1930	8	+		1 : 1000
	4	1930	4	+	Very ill; epistaxis, petechiae, slow convalescence	1 : 1000
	5	1930		+	Moderately severe; headache, abdominal pain	1 : 300
E	6	1932	5	+		1 : 100
	7	1932		+		1 : 300
	8	1920	6	+		1 : 300
F	9	*	*	*	*	1 : 100
G	10	*	*	*	*	1 : 100

Blanks: no details obtained.

\* No illness.

*Mine A (Lanarkshire)*. One case of infection prior to the epidemic recorded in Table I was found. This miner worked in a different section of the pit and stated that no other men were affected at that time.

*Mine D (Lanarkshire)*. The four cases were involved in an outbreak of Weil's disease among men working in a particular section of that colliery.

Eleven cases were recorded at that time, and all showed some degree of jaundice and symptoms recognizable as those of Weil's disease. The infected section had an "ingoing eye" or sloping approach, and was wet and rat-infested.

*Mine E (Lanarkshire).* The two cases (6) and (7) were apparently the only ones recognized in the 1932 outbreak in this colliery. According to patient (8) ten or twelve men were jaundiced in the 1920 outbreak, and the illnesses were particularly prevalent when they were opening up old workings. The pit was wet and rats were numerous. Admission to the mine was by a vertical shaft.

*Mine F (Unknown).* This miner had worked in several rat-infested pits other than those already mentioned; they were, however, mainly dry. He had never suffered from any illness at all suggestive of leptospiral infection.

*Mine G (Unknown).* Miner, aged 57. The only illness recorded in this case was typhoid fever at the age of 18. Widal was still positive to *S. typhi* "H" 1:50. No history of T.A.B. inoculation. The man had worked in mines in many parts of the country, mainly in the west of Scotland; several of the mines were wet and rat-infested, but he had no illnesses.

#### EVIDENCE OF INFECTION IN GENERAL GROUP OF MINERS

An examination was made of 290 sera from miners admitted to the Royal Infirmary for medical or surgical treatment. Proved cases of Weil's disease were excluded. Sera were tested routinely against *L. icterohaemorrhagiae* and *L. canicola* in dilutions of 1:10 and 1:30, and any positive sera were tested to full titre. Five cases were encountered, and are shown in Table II, nos. A (1), D (5), E (8), F (9), G (10). Histories of typical Weil's disease were obtained from the first three cases, but not from the last two who may be instances of subclinical infections such as were encountered by Smith & Davidson (1936) among Aberdeen fish-workers. Sera from 300 men, not miners, were also tested for antibodies to *L. icterohaemorrhagiae* by Schüffner's method. Evidence of leptospiral infection was not found.

#### SEROLOGICAL SPECIFICITY OF *Leptospira*

It has been suggested (Schlossberger *et al.* 1935) that several strains of *Leptospira* should be used in serological tests to detect all infections. Seven of the positive sera from past and present infections were each tested against three strains of *L. icterohaemorrhagiae*, a non-virulent stock strain, strain "Oxford" (Nat. Collection of Type Cultures) and a strain isolated from one of the cases. Titres were approximately equal in every case. Three sera were tested against their own infecting strain, and one serum against two strains of *Leptospira* obtained from rats in the mine that miner worked in. All titres corresponded to that obtained against the stock leptospiral strain and no evidence of serological heterogeneity was observed. There was, however, a

slight difference in agglutinability of cultures. Typical readings of a serum against its homologous and heterologous strains is given in Table III.

Table III. Serum from case V, Table I

Leptospira strain		Serum dilutions							
		1 : 10	1 : 30	1 : 100	1 : 300	1 : 1000	1 : 3000	1 : 10,000	1 : 30,000
"Stock"	A	+	+++	+++	++	+	+ <sup>-</sup>	0	0
	L	0	0	0	0	+	+	+ <sup>-</sup>	0
Homologous strain	A	Tr.	+	+ <sup>-</sup>	+ <sup>-</sup>	0	0	0	0
	L	0	0	0	+	++	++	+ <sup>-</sup>	0
"Oxford"	A	+	+	+ <sup>-</sup>	Tr.	0	0	0	0
	L	0	0	0	+	++	+	+ <sup>-</sup>	0
<i>Canicola</i>	A	++	+	0	0	0	0	0	0
	L	0	0	+ <sup>-</sup>	0	0	0	0	0
<i>Hebdomadis</i>	A	0	0	0	0	0	0	0	0
	L	+ <sup>-</sup>	Tr.	0	0	0	0	0	0
<i>Biftexa</i>	A	0	0	0	0	0	0	0	0
	L	0	0	0	0	0	0	0	0

A = Agglutination.

L = Lysis.

## CASES OF APPARENT INFECTIVE JAUNDICE OTHER THAN WEIL'S DISEASE

Several cases of acute jaundice of apparent epidemic nature were encountered. The first group occurred at the same time and in the same district as the case of Weil's disease (miner "T.S.", see under *Present Infections*). Seven cases were encountered in children aged from 4 to 9 years; three cases were found in separate households and the other four in one household. The clinical features were closely similar in all cases; the onset was fairly sudden with slight fever, anorexia and vomiting. Diarrhoea was not a constant symptom. The appearance of jaundice varied from the first day of the illness to the end of the second week. The illness lasted from a few days to several weeks and varied considerably in severity.

The second group came from a Fever Hospital. Several nurses suddenly developed jaundice with slight fever and minimal subjective disturbance. The illnesses lasted only a few days but were sufficiently alike to warrant the suggestion of a common infecting agent. Four bloods were tested.

Several sporadic cases of jaundice were also encountered, mostly in children, but were not particularly interesting.

All sera examined were negative to *L. icterohaemorrhagiae* and to *L. canicola*.

## DISCUSSION

To determine the incidence of leptospiral infection among miners one must first eliminate any suggestion of selection. Miners admitted to hospital for general medical and surgical treatment should satisfy this criterion. In the 290 sera examined evidence of leptospiral infection was found in five (1.5%), and the incidence of such infection in the general mining population of the area seems low. The miners in this investigation, however, came from a very

large number of pits over a considerable area. The following counties were represented: Lanark (194), Dumbarton (14), Ayr (12), Stirling (8), Argyle (1), Clackmannan (1) and full details could not be obtained from 60. Numbers of specimens from individual mines were therefore small. The astonishing fact now becomes evident that only eleven sera were examined from miners working in pits known by the occurrence of recognized cases to have been infected. Of these three were positive. This suggests that although the general incidence of leptospiral infection is low the local incidence may be quite high. Further evidence supporting this possibility is obtained from the records of known Weil's disease. In mine "D" eleven cases are known to have occurred some years ago and in mine "E" at least twelve cases. All these cases showed definite jaundice, yet in mine "A" where a recent outbreak was investigated only two out of eight cases were jaundiced. This suggests that many unrecognized cases may have occurred in the former mines.

Mines likely to be affected are those where the combined factors of infected rodents and damp conditions occur and where soil acidity is not likely to interfere with the viability of *Leptospira*. Pits entered by a sloping approach or tunnel are more open to rat invasion than those entered by a vertical shaft and are therefore most likely to be infected. Three of the mines mentioned in this paper have this type of entry. Evidence of a seasonal incidence of infection has not been obtained.

In the problem of prevention of leptospiral disease the factor of rat infestation is likely never to be solved properly. The introduction of machinery in place of horses and the careful disposal of all food refuse will do something to make the pits less attractive to rodents, but the ultimate solution to the problem appears to me to lie in other directions. Ground conditions may be made unsuitable for the persistence outside the body of the rat of living *Leptospira* by chemical means such as employed by the Japanese workers (Inada *et al.* 1916) or by Davidson & Smith (1936) in fish-curing yards at Aberdeen. Then the miners themselves may be made resistant to infection by immunization. The first method is unlikely to be successful on account of local difficulties and therefore I feel that voluntary immunization of all workers exposed to infection should be tried. Vaccination proved fairly successful in the hands of Wani (1933) and it is likely that, with experience, an even more satisfactory technique would soon be evolved.

#### SUMMARY

Eleven cases of Weil's disease in miners from the west of Scotland have been encountered in the years 1937 and 1938. Only five showed jaundice.

Ten cases of infection previous to this period have been determined by serological means. Eight were jaundiced.

Information pointing to the occurrence of about eighteen more cases has been obtained from the Lanark public health authorities and from patients' statements.

The occurrence of leptospiral infection appears limited at the moment but is quite serious in certain areas.

All available evidence points to the infections being due to one specific strain of *Leptospira*.

I should like to thank the Physicians and Surgeons of the Royal Infirmary for permission to obtain sera from miners in their wards, and in particular Prof. A. W. Harrington, Dr J. C. Middleton and Dr J. N. Cruickshank for clinical details of cases. In addition, I would express my indebtedness to Dr J. M. Lang, Medical Officer of Health, Lanark, for the opportunity to investigate suspected cases, past and present.

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