History

Royal Navy Surgeons and the transmission of Brucellosis by goats' milk

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The Royal Navy was at its most powerful at the end of the 19th century, with a mighty Fleet based on Malta cruising the shores of the Mediterranean. But there was a serious medical problem which sapped its strength. Every year, seamen and officers fell sick with Malta or Mediterranean Fever, now known as Brucellosis after David Bruce, the discoverer in 1887 of the causative bacterium, a micrococcus now named Brucella melitensis. Mediterranean Fever was a debilitating chronic illness with the complication of rheumatism, for which many servicemen were invalided each year.

Although the early work on the fever was done by military doctors and the disease 'aptly nicknamed the [Royal Army Medical] "Corps Disease"', the Maltese doctor and polymath, Themistocles Zammit found that goats were silent carriers of the bacteria and that transmission was by goats' milk. However, surgeons of the Royal Navy played a significant, but forgotten, role and came very close indeed to solving the mystery of transmission.

The Senior Service

In 1900 the Medical Director-General of the Navy directed Staff-Surgeon P. Bassett-Smith RN to investigate the disease. In 1903, Surgeon E.A. Shaw RN was posted to Malta and continued his work on the fever begun with Professor Almoth Wright at the Army hospital at Netley in 1897 (see below).

Surgeon Dalton RN, at the naval hospital in Malta, found the organism in urine. Bassett-Smith reported 'the significant fact that the organism grows freely in milk without producing external change'. Both Bassett-Smith in 1900 and Shaw in 1901 contracted the disease while working with it. In 1903, Shaw and Surgeon R.T. Gilmour RN showed that the micrococcus was present in the peripheral blood of five out of eight patients.

Early experiments using goats

Goats had been used for some years as a source of supposedly immune sera. Professor Wright had devised the agglutination test for M. melitensis and had injected animals to raise antibodies against the organism or its supposed toxin. Eyre in his Milroy lectures of 1908 said 'In 1895 Wright infected goats and in 1896 a horse' and treated 50 cases with antiserum from the horse.

Shaw at Netley had used goats: 'Goat (male) worked up from Oct 12 [18] 96 to Feb 5 97. Agglutinations done. Feb 15 10 cc of plasma from this [goat] injected

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It is amazing that the patients did not die of anaphylactic shock.

The use of goat antiserum for patients must have been known by many army and navy doctors, although none suspected that the goat might be linked to the disease or could carry an inapparent infection. Goats were merely docile, cheap, easy to feed mammals which produced quantities of blood. The bacterium was grown in milk though whether this was for culture in the laboratory or to test whether contamination of milk was possible is not clear, but probably both were in the minds of Kennedy 'I have now ...... found MM in milk (MM urine added) up to the 16th day' and Shaw, 'MM lived in Litmus milk 32 days and longer'.

The Mediterranean Fever Commission

After letters in January 1904 from the Secretary of State and others, the Tropical Diseases Committee of the Royal Society voted on 17 February 1904, to appoint a Sub-Committee, with Colonel David Bruce RAMC as chairman. The Commission appointed by The Admiralty, The War Office and the Civil Government of Malta, to investigate Mediterranean Fever under the supervision of an advisory committee of the Royal Society, was given the shortened title of Mediterranean Fever Commission (MFC). The members were Major W.H. Horrocks RAMC then at Gibraltar, Staff Surgeon E.A. Shaw RN (pictured opposite) already in Malta, Dr. T. Zammit of the Board of Health, Malta and Dr. R.W. Johnstone of the [UK] Local Government Board. Later they were joined by Captain Kennedy RAMC, already in Malta. Bassett-Smith was a member of the Sub-committee in London.

The Naval Enquiry had shown that the bacteria were probably excreted in the urine and were very resistant outside the body so perhaps the bacteria remained dormant in the soil and were transmitted by dust. Numerous experiments led to no clear conclusions. Johnstone had extended the enquiries to goats: 'Many of the persons did not know whose goats supplied them, being in the habit of hailing the first goat herd who passed the door...More particular enquiries as to sources of milk supply in relation to Mediterranean Fever are now being made immediately upon notification.' Nevertheless, he continued 'The evidence, so far as it goes, seems to show that food and drink have no marked connection with the spread of the fever.' The 'particular enquiries' may have been made by Dr. Caruana Scicluna, the Medical Officer of Health, Malta. After a year, the Commission seemed stalled. Bruce wrote to Shaw in March 1905, 'I don't see that we have arrived any nearer to preventing the disease.' and again in April: 'I am afraid we are not getting on too swimmingly.' Shaw replied 'As you say we are not getting on too swimmingly, but for the life of me I cannot see any new line of attack, much as I have worried about it.' to which Bruce replied in May 'We are scarcely nearer out [our] goal of prevention than we were before we started.'

Yet Shaw and Zammit had already started the experiments which were to lead to success. In this first year, goats were used in four separate experiments. Shaw and Zammit had tried to infect goats with cultures. Gilmour was using goats (see below) and two other naval surgeons, Ross and Levick, had deliberately drunk goats' milk laced with large numbers of Micrococcus. Bruce and Horrocks were aware of the experiments at the time, even if they later forgot (see below).

Experiments with goats

Gilmour at Bighi RN Hospital, which had a very high prevalence of the fever, had offered his spare time at the service of the MFC. On 6 October 1904 he wrote to Bruce 'If I only had monkeys and a goat or two I would carry out some feeding experiments with milk. I cannot afford to pay for them myself, as already my research work must have cost me nearly £20' [Gilmour's underlining]. Bruce included this letter and a bill to Sir A. Geikie, the Secretary of the Royal Society. It is unclear whether Gilmour actually fed any goats or why he wanted to. He was unlucky: 'Forbidden by superior to do any more animal experiments - or publish any! Experiments going on for over 5 years without a word when suddenly I am stopped.' Bruce replied that it was because questions about vivisection were feared in the House of Commons. Gilmour had only two short papers published in the Reports, 15 pages on cultivating the bacteria from blood and further experiments.

Shaw's experiments with goats

Shaw was attached to a depot ship in the harbour in 1903, but on his secondment to the MFC he was posted to the Superintendent of the Dockyard.
and probably continued working with Gilmour at Bighi. Bighi was across Grand Harbour from Valletta, crossed by liberty boat or Maltese dghajsa [small rowing boat] so Shaw and Gilmour may have seen little of the other members of the MFC [see below].

Bruce was in Malta from 13 June to 14 July 1904 to set up the Commission.\(^2\) Two weeks later on 30 July, Shaw bought a goat and kid which were negative for blood agglutination. He would have known that Bassett-Smith had suggested ‘protection of milk from infection by dust, and possibly contaminated water’\(^2\). Shaw injected the goat on 8 August, noting a rise in temperature and he injected it with more cultures of the Micrococcus on 20 and 29 August and 10 October. The agglutination titre rose to 1 in 3200, but he recovered no organisms from the urine. He also plated samples of milk from 28 August on, but because the plates were overgrown with Staphylococcus he failed to recover the Micrococcus. Hefed a monkey with milk from the goat on 28 August, but the monkey died on 4 September and the organs and blood yielded no colonies. ‘The milk of this goat was examined from time to time, but the pus persisted till 25 April 1905, by which time the milk was drying up.’ Shaw did not plate the milk again until 24 June, when it yielded colonies in abundance. This was, however, after colonies had been found on the plates which had been inoculated with milk from Zammit’s goats. He recovered the Micrococcus from the blood in November 1904 and tested the blood for agglutination in most months up to 12 June 1905. He also infected the kid, with similar results.

Shaw had submitted an ‘interim report’ which included ‘various inoculations on different animals’, which was published in the first Report, March 1905.\(^23\) He had included the first of the goat experiments, but then asked that the paragraph be deleted as he thought the observations were incomplete. The experiments were detailed in his paper of February 1906 in Part IV of the Reports, with a footnote by the Secretary of the Royal Society.\(^24\) The Secretary had added

\[he \text{[Shaw]} \text{recognised and stated the goats, which were extremely numerous in Malta, might possibly be instrumental in transmitting the infection of Malta Fever.}\]

This footnote is also included in the reprint of the paper in the Journal of the Royal Army Medical Corps July 1906\(^25\). Bruce was editor, but later appeared to have forgotten this work. It was the Secretary who had added the note and not Bruce. Bruce wrote to Sir Archibald Geike on 5 January 1906:

‘If you have Shaw’s MS. on Malta fever I would be glad to have it. He has been complaining to his head office about treatment of his papers and I have offered to let the Director-General’s Secretary have a look at the manuscript and compare it with our corrections’\(^26\).

Shaw had submitted his reports, not to Bruce, but to the Director General of the Navy who forwarded them to the Secretary of the Royal Society.\(^27\) Why had Shaw asked for these experiments to be deleted? I suggest that he had lost his nerve - and his place in history — because of negative experiments by fellow RN surgeons.

The experiments of Surgeons Ross and Levick

Surgeon Edward Halford Ross RN, then serving on HMS Lancaster in the Mediterranean Fleet, wrote to his brother Major Ronald Ross on 8 July 1904 from Malta\(^28\). Although he was about to begin a three month cruise, he had visited Zammit who had offered him a place in the Public Health Laboratory. He wished to pursue the role of mosquitoes in the transmission of the fever and to join the MFC. Later, 26 February 1905, Ross wrote to Bruce offering the services of three Naval surgeons and two others, all non-immunes in Malta, as well as his brother Surgeon Hugh Campbell Ross (then in England and known as Bluey in the family) for experiments modelled on the work of the Americans on yellow fever.\(^29\) Ross enclosed a copy of a paper by him and his colleague G Murray Levick, sent through the Admiralty and published in the British Medical Journal on 1 April 1905. It detailed negative experiments on transmission by direct contact, fomites, inhalation of infected dust and by mosquitoes. The two authors also drank diluted urine from a patient, but were not infected\(^30\). They repeated the experiments in more detail and published these in the August 1905 issue of the Journal of the Royal Army Medical Corps\(^31\). Almost all of this paper was devoted to the thesis that transmission was by insects, probably mosquitoes. However, four non-immunes had drunk infected urine diluted in water and added to fresh goat’s milk: none became sick. Some of this work was done while in Malta, as fresh goat’s milk was used and Zammit was thanked for his help with the bacteriology.
Visit of Bruce to Malta May to June 1905

The only recorded meeting of the researchers in Malta, apart from group photographs, was in May 1905 when Bruce, Horrocks, Shaw, Zammit and probably Kennedy were present. Zammit's experiments with goats were discussed and Bruce allowed him further experiments on a few goats, although 'It must be confessed the Commission had little hope that an examination of these animals [goats] would yield anything.' Bruce and Horrocks appear to have been very surprised that Shaw and Zammit had been infecting goats, but Horrocks had written to Bruce in January 1905: 'Zammit is now continuing his mosquito experiments and attempting to infect goats by feeding....I am plating the urine of his [Shaw's] infected goats for him'. "Zammit is also trying to infect a goat by feeding it on Micrococcus Melitiensis, and if he succeeds we intend to repeat [my emphasis] the experiment of feeding a monkey its milk.' Horrocks was, I believe, writing here in his role as supervising officer of Zammit's experiments.

Zammit wrote to Bruce on 10 January 1905: 'I am conducting feeding experiments on goats so far with positive results.' However, Bruce did not comment on this in his reply of 16 January. It would seem that Bruce and Horrocks were not very interested in goats and had forgotten these experiments.

Bruce may have been sceptical of the results of infecting goats for, in his first editorial in the Journal of the Royal Army Medical Corps, he had written 'Wright also attempted to give the disease to [monkeys] by feeding them a suspension of the micrococcus in milk and also failed. Experiment is therefore against the micrococcus gaining access to the body by food or water.' There is nothing in the minutes to suggest that the Subcommittee in London under Bruce had ever considered goats. However, Bruce as editor knew that Eyre, a member of the Sub-Committee in London had abandoned experiments on a goat: '...difficulty to estimate the amount, or indeed the presence of protective bodies in the serum of animals treated with cultivations of the organism — so troublesome a process in fact, that after attempting, during the early part of last year [1904] to prepare an anti-serum from the goat, I suspended my experiments...' Bruce knew of the first negative experiment of Ross and Levick from Ross's enclosure and the British Medical Journal.

When, in May 1905, Zammit explained his experiments with infected goats, Bruce would have reminded him that Wright had failed to infect a monkey, Eyre had abandoned his work with goats and now direct ingestion of infected urine had failed to infect four men. Bruce had been lukewarm at best and Horrocks uncommitted. Both Shaw and Zammit might have doubted the relevance of their experiments with goats if these important negative findings had been discussed.

Later that year, Shaw pleaded for recognition of his work and Bruce wrote to Horrocks: 'When I was in Malta last May we talked a great deal about goats and discussed Zammit's report of experiments, but I cannot remember that Shaw said anything at the time about priority.' Horrocks replied on 28th December: '...It appears that he [Shaw] recovered the M.M. from the blood of the experimental goat on November 7, 1904, so that he really showed the goat suffered from the infection. It is most extraordinary [Horrocks' underlining] that he did not mention this very important discovery to you when we met in May. You told Zammit the goat investigation was not of any value until the M.M. had been recovered from the blood or excreta, yet Shaw said nothing, nor did he make any remarks when Zammit and I told him about the recovery of M.M. from the blood of the apparently normal goats [in June 1905].'

Shaw's silence and further work

I suggest that Ross and Levick knew of Shaw's experiments with the goats and only because of this knowledge did they drink infected urine and milk. Their good health after drinking the urine might have caused Shaw to withdraw his observations from the proofs. Ross and the others probably drank the infected goat's milk before the May meeting and these negative experiments and those of Wright and Eyre (see above) must have convinced Shaw that goat's milk was an unlikely source of infection and induced him to remain silent. He must have regretted his silence because a few days after colonies of the micrococcus were grown from the milk of one of Zammit's goats, Shaw finally obtained colonies from the milk of his infected goat.

Shaw was not in daily contact with Zammit and Horrocks as he said that four [not five] of Zammit's goats gave positive reactions. Shaw was the first to make practical use of the new knowledge: 'After discussing the matter with Deputy Inspector-General Bentham of the Naval Hospital at Bight, we decided that I [Shaw] should at once begin an examination of all the goats supplying milk to this hospital.' He began on 29 June and by 14 July had examined 91 goats of
which the blood of 30 was positive and milk from 9 of these yielded colonies of *M. melitensis*. ‘The implicated animals’ [possibly only those whose milk yielded colonies as there remained 74 goats, see below] were eliminated from the herds supplying the Naval Hospital, and the most stringent measures were taken to ensure that all milk entering the hospital gates was hencewith boiled. However, Shaw re-examined the same goats in March 1906 and found that of 74 goats in the herds, 8 were secreting the bacteria in their milk. Shaw’s work was nullified by more goats secreting the bacteria and laxity in boiling the milk.

Staff-Surgeon Clayton maintained that ‘for a long time, a standing order that [goats’ milk] should be boiled before issue to the patients’ and that the order was repeated in July 1905. In 1906, Fleet Surgeon Bassett-Smith wrote that ‘since the milk has been subject to careful sterilisation the incidence of cases in the hospital [Bighi] has not [Bassett-Smith’s emphasis] appreciably diminished.’ He suggested three methods of infection: infected unsterilised milk, direct inoculation through the skin by mosquitoes or by infected excreta etc. Colonel Davies of the Commission also wrote ‘that milk could [not] have any important part, or indeed any part at all, in disseminating the specific poison during the epidemic amongst the troops’ and the Navy [quoted and discussed in reference 3].

That goats’ milk conveyed Mediterranean Fever infection was not accepted by everybody for several years. Ross and Levick reported that they and other non-immunes had drunk infected water and goats’ milk without effect and were convinced that ‘the fever is not conveyed by any of these means’ Ross repeated these and other arguments in the British Medical Journal. It is unclear why Ross and Levick were not infected in their experiments.

Conclusion
All members of the Commission deserve credit for its success, but those who persisted in looking at the goat must also be remembered. On 16 June 1904, his fourth day in Malta, Bruce had written from the Royal Hotel to Sir Archibald Geike, Secretary Royal Society ‘I don’t know how Zammit and Shaw will turn out as workers, but at present I hae ma doots’ Perhaps he later recognised that they had had the right ideas from the start, while he and the Sub-Committee in London were still pursuing dust and urines.

Shaw was the first to show by serum agglutination and fever that an inoculated goat had been infected. He was the first to isolate bacteria from the serum and to test (unsuccessfully) the milk of a goat. He was the first to inoculate a monkey with milk from an infected goat and, later, the first to take practical measures. Shaw’s work has never been recognised. If he had bought another goat, if his monkey had not died, if his goat had not had mastitis, he would have solved the problems in 1904. He must be the unluckiest of microbiologists.

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APPENDIX
Staff-Surgeon Ernest Albert Shaw RN entered King’s College, Cambridge in 1886, won an Exhibition in 1887 and was then an Assistant Demonstrator in Anatomy and Physiology. He graduated BA in 1888 and MB, BC in 1890. After posts in Manchester, Cambridge and St Mary’s, London, he entered the Royal Navy as a Surgeon in 1891. In 1900 he ‘withdrew from HM Service with a gratuity of £1000’ which was then cancelled and the ‘officer reinstated in former position’. In 1903, he was promoted Staff Surgeon for conspicuous Professional Merit, backdated to 26 March 1899.

He was promoted to Fleet Surgeon in 1907 and posted to Hong Kong at the end of 1908. He retired from the Navy in 1912, but was recalled for shore duty in the First World War, retiring as Surgeon Captain in 1919 with an OBE. He received an MD Cantab in 1912, although there is no record of this, or its title in the university.

He died in 1938 leaving a widow and only the address of a bank which was destroyed with its records in 1940. I have found no obituaries: he may have retired abroad, but not to Malta.

Rear-Admiral Sir Percy Bassett-Smith 1860–1927 was known affectionately as ‘the little gentleman’. He was President of the Royal Society of Tropical Medicine and Hygiene and very active in tropical medicine. Curiously, his obituary in the Lancet did not mention his role with the MFC.

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29. CMAC. WTI/RST/G9 Letter #91 Ross to Bruce 26 February 1905.


32. CMAC. WTI/RST/G9 Letter #142 Bruce to Horrocks 8 December 1905.


34. CMAC. WTI/RST/G9 Letter #15 Horrocks to Bruce 13 September 1904.

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