George Henry Falkiner Nuttall and the origins of parasitology and *Parasitology*

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SUMMARY

By the beginning of the twentieth century, most of the major discoveries concerning the nature and life cycles of parasites had been made and tropical medicine was beginning to establish itself as a discipline but parasitology still lacked any real cohesion or focus. This focus arrived in 1908 when George Nuttall founded a new journal, *Parasitology*, as a Supplement to the *Journal of Hygiene* in order to cater for increasing numbers of papers on protozoological, helminthological and entomological topics that were being submitted for publication to that journal, thus bringing these three subjects together under one heading and, in doing so, established the discipline of parasitology. The events leading up to and the subsequent development of the discipline are discussed.

Key words: G.H.F. Nuttall, history, parasitology, *Parasitology*.

INTRODUCTION

Anyone picking up this journal should immediately know from its title what sort of papers they might to expect to find among its contents but ask the same individuals how they would define parasitology and they would probably be at a loss for an adequate answer. Most would come up with a definition such as the scientific study of parasitism, the scientific study of parasites, the scientific study of parasites and their hosts or the scientific study of the relationships between parasites and their hosts, but the one most frequently cited would probably be the scientific study of parasites and parasitism. The problem with this definition is that it relies on the definitions of parasite and parasitism. Here again the definition runs into a number of problems. Firstly, what is a parasite? The earliest uses of this word in English date back to the early seventeenth century when it appears to have been used to describe individuals living at the expense of others, a meaning that is still in common usage today. The word arrived in the scientific literature a century later but was so all embracing that it encompassed all organisms that live in or on other living organisms including those that we now call saprophytes. It was not until the end of the nineteenth century when, after the abandonment of the theory of spontaneous generation and the establishment of the germ theory of disease, the word gained common usage. Some commentators have adopted the broadest possible definition of the word parasite to include all organisms that live in or on another living organism; a concept so wide that it embraces everything from viruses to cuckoos and mistletoe. Some definitions are much more restricted and include only helminths or, more often, in order to exclude bacteria and fungi, protozoa and helminth worms. Currently, the most frequently used definitions restrict the use of the word parasite to protozoa, helminth worms and insects and, occasionally, other arthropods and molluscs, groups with very little in common. From an immunological or epidemiological viewpoint, protozoa, being microparasites, have much more in common with bacteria than with helminth worms, neither helminths nor protozoans have any affinity with insects except possibly as vectors and insects, in their own turn, have more in common with parasitic and non-parasitic arachnids and crustaceans than with helminths.

However it is defined, the question remains as to what major discipline parasitology belongs or if it a discipline in its own right. Clearly it is a life science but is it a branch of medicine or zoology? It could be either or both but does not sit comfortably within either. It is probably best, then, to regard parasitology as a discipline in its own right, but this raises another question as to how a field of study with boundaries so elastic that they embrace protozoa, helminths and arthropods has become a coherent discipline that has spawned off so many university courses, journals and books. The medical historian, Michael Warboys, has discussed this question from a scholarly and historical point of view and has asked the very pertinent question alluded to at the beginning of this article, ''how did helminths get lumped

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together with protozoa in parasitology …?'' (Warboys, 1983). I should like to argue that this is due to one person in particular, George Henry Falkiner Nuttall, and the first issue of *Parasitology* in 1908.

PARASITOLOGY AT THE TURN OF THE 19TH AND 20TH CENTURIES

Before exploring this thesis further it is necessary to look back at the period around the turn of the nineteenth and twentieth centuries. The theory of spontaneous generation, the destruction of which had begun in 1842 with the publication of Japetus Steenstrup's influential book *On the Alternation of Generations* and had experienced its last gasp with Gros's description of the production of parasitic worms by spontaneous generation in 1847, was to all intents dead by the middle of the nineteenth century (Farley, 1977). This escape from the straitjacket of the spontaneous generation dogma and the promulgation of the germ theories of the cause of disease that stemmed from the work of Louis Pasteur in the 1860s made it possible for scientists to recognize parasites as the causes of infection and not merely as non-causal associations between two organisms. These related events set the scene for a rational understanding of host-parasite relationships and opened up the possibility of a new and respectable science specializing in the study of parasites.

So rapid and comprehensive were the possibilities opened up by the liberation from earlier dogmas, and the rate at which new discoveries were being made, that many observers believe that the last few decades of the nineteenth century were the golden age of tropical medicine which itself became almost synonymous with the study of parasitic diseases as can be seen from a casual perusal of the first edition of Patrick Manson's monumental work, *Tropical Diseases* (Manson, 1898). However, to attribute the birth of parasitology to discoveries made in the field of tropical medicine does the subject a disservice. Helminth worms, or entozoa, had already been studied in a systematic way by many eminent zoologists, mainly in Britain and Germany prior to the discovery of microorganisms, and later became integral parts of all university zoology courses sandwiched between the coelenterates and annelids, something that persisted well into the second half of the twentieth century. To most zoologists, the parasitic helminth worms were merely interesting examples of a somewhat unsavoury way of life. Arguably the first British zoologist who can be recognized as a helminthologist was Thomas Spencer Cobbold (1828–1886), Professor of Botany and Helminthology at the Royal Veterinary College in London, whose prodigious output included papers on helminths and other parasites of veterinary, medical and academic interest. The science of helminthology as we know it began with the discovery of the larval forms of *Dracunculus medinensis* in 1819, the incrimination of crustacean intermediate hosts in the life cycle of this worm in 1870, the discovery that mosquitoes transmitted filarial worms in 1877 and the discovery that snails were involved in the life cycle of *Fasciola hepatica* in 1882.

Protozoology had had an equally, but shorter, distinguished history beginning with the discoveries of Antony von Leeuwenhoek in 1681 and its massive expansion following Pasteur's discoveries and, with improvements in microscopical techniques, the discovery of more and more protozoa many of which inhabited the bodies of animals. The most significant advances in the field of protozoology, following Manson's incrimination of mosquitoes in the transmission of filarial worms, were the discoveries, all around the turn of the century, that ticks transmitted piroplasms, tsetse flies transmitted African trypanosomes and mosquitoes transmitted malaria parasites.

So what was our understanding of parasites at the turn of the century? The second half of the nineteenth century was probably the 'golden age' of parasitology; many parasite life cycles had been elucidated and the discoveries of previous centuries had been pulled together into coherent stories. So many important discoveries were made in this half century that it would be impossible to do justice to them all and here it is only possible to give a brief summary of the most significant events. Fuller accounts are given in Cox (2002, 2004, 2005), Foster (1965), Grove (1990) and Kean *et al*. (1978).

One of the parasites most frequently described in the earliest literature is the Guinea worm, *Dracunculus medinensis*. Carl Rudolphi discovered adult female worms containing larvae in 1819 and Forbes found the larvae in water in 1836 but it was not until 1870 that Alekej Pavlovitch Fedchenko discovered that crustaceans belonging to the genus *Cyclops* were involved in the life cycle and that infection was acquired by accidentally consuming them. Fedchenko's discoveries were controversial and remained so until they were confirmed by Manson in 1894. Fedchenko's discovery was followed by one of the most significant events in the history of parasitology; the discovery that filarial worms were transmitted by mosquitoes by Patrick Manson in 1877, an event that is widely regarded as the most significant discovery in tropical medicine, with implications that go far beyond helminthology into such diverse areas as malaria and the arboviruses. The discovery of the partial life cycles of *Loa loa* (eye worm) and *Onchocerca volvolus* (river blindness), both caused by filarial worms, owes much to the discoveries made by Fedchenko and Manson although the transmission of *Loa loa* by flies of the genus *Chrysops* spp. was only discovered in 1912 by Robert Leiper.

Our understanding of the life cycles of a number of other parasitic infections sometimes took a long time to establish. Our knowledge of the role of worms in hookworm disease began in the early nineteenth century when Angelo Dubini found the worms in a human in 1838 but the percutaneous mode of transmission was not elucidated until the experiments of Arthur Looss in 1911. The worms that cause schistosomiasis were discovered by the German parasitologist, Theodor Bilharz, in 1851 but it was not until 1915 that the role of the snail intermediate host was discovered by Robert Thomson Leiper.

Turning now to the protozoa. Our knowledge of the causes of malaria only became possible after the discovery of the parasite itself by Charles Louis Alphonse Laveran in 1880. This was followed by the elucidation of the life cycle, incriminating mosquitoes as vectors, as suggested by Manson, first for avian malarias by Ronald Ross in 1898 and then for human malarias by the Italian scientists Battista Grassi, Amico Bignami and Giuseppe Bastianelli in the same year. Half a century was to pass before Henry Shortt and Cyril Garnham in 1947 found that there was a phase of division in the liver preceding the development of parasites in the blood, thus completing our knowledge of the life cycle. Sleeping sickness had been known in Africa for centuries but little was known about the cause which at first was suspected to be a streptococcus or, on Manson's suggestion, a filarial worm, *Filaria perstans* (*Mansonella perstans*), until the real cause was identified when Aldo Castellani discovered trypanosomes in the cerebrospinal fluid of patients suffering from sleeping sickness in 1901. The trypanosome responsible for Gambian sleeping sickness, *Trypanosoma brucei gambiense*, was described by Everett Dutton in 1902 and the tsetse fly vectors were identified by David Bruce and his colleagues in 1903. The second human trypanosome, *Trypanosoma brucei rhodesiense*, was discovered by John William Watson Stephens and Harold Benjamin Fantham in 1910. The causative organism of amoebiasis, *Entamoeba histolytica*, was discovered in 1875 by Friedrich Lösch (also known as Fedor Lesh) setting the scene for the elaboration of the aetiology of this ancient disease.

So, by the end of the nineteenth century, although there was still much work to be done, most of the important parasitic helminths and protozoa had been discovered, the most significant parts of their life cycles had been elucidated, most of the pieces of the various jigsaws that had accumulated over centuries had been put in place and the importance of parasites had become widely recognized. In 1899 Manson was able to write 'To-day the protozoon and the helminth … are in the ascendant' (Manson, 1899).

By 1900, the study of parasites was here to stay but, throughout their histories, helminthology and protozoology had ploughed their own separate parallel furrows and what was needed was a jolt to bring them together. This jolt came at the beginning of the twentieth century and this is where George Nuttall came into the picture.

GEORGE HENRY FALKINER NUTTALL

George Henry Falkiner Nuttall was a true cosmopolitan. Born in San Francisco, California, on 5 July 1862 of a British father and American mother and educated in England, France, Germany and Switzerland he graduated in medicine from the University of California in 1884. After a year at the Johns Hopkins University in Baltimore he moved to Germany, first to Breslau and then to the University of Göttingen where he obtained his Ph.D., and it was here that he began to develop his life-long interest in parasites. In 1891, he returned briefly to Baltimore before once again returning to Germany in 1893 first to Göttingen and then to the Hygienic Institute in Berlin. A most significant and far-reaching event occurred in 1899 when he gave a course of lectures on bacteriology at the University of Cambridge, following which he was appointed University Lecturer in Bacteriology in 1900. His promotion at Cambridge was rapid, he was appointed Reader in Hygiene in 1906 and only a few days later was appointed Quick Professor of Biology with an obligation to devote himself to the ''study of Protozoa, especially such as cause disease''. Throughout his tenure as Quick Professor, Nuttall's modest research funding came from the Quick Fund which severely restricted the work of his department and in 1919 he appealed for funds to build an institute for parasitological research. As a result of this appeal Mr Percy and Mrs Elizabeth Molteno provided the money for this institution which opened in 1921 and, until 1987 when it became part of the Cambridge University Department of Pathology, was known as the Molteno Institute for Research in Parasitology. In 1931, Nuttall resigned the Quick Professorship and became Professor Emeritus in the University of Cambridge. He died suddenly in London on 16 December 1937.

Nuttall's scientific achievements are too numerous to detail here and are listed in his Royal Society obituary (Graham-Smith and Keilin, 1939). Between 1886 and 1938, he produced nearly 200 publications, some of which were in German, on immunology, serology, bacteriology, hospital hygiene, obstetrics, tropical medicine, protozoology and entomology and also a number of biographies of eminent parasitologists. Appropriately, his last paper was entitled ''Forty years of parasitology and tropical medicine'' (Nuttall, 1938).

While at Cambridge, Nuttall persuaded the Cambridge University Press to found two journals, the *Journal of Hygiene* in 1901 and *Parasitology* in

1908. At the beginning of the twentieth century hygiene meant something quite different from what it does today and was largely synonymous with infectious diseases and several major institutions still carry this title, for example the London School of Hygiene and Tropical Medicine, founded in 1899, and the (now Royal) Society of Tropical Medicine and Hygiene, founded in 1907. Institutes of Hygiene flourished on the Continent of Europe, in the United States and throughout what were then the colonies. Over the years the word hygiene gradually changed its meaning and the *Journal of Hygiene* became *Epidemiology and Infection* in 1987. Before all this happened, however, it was the success of the *Journal of Hygiene* that led directly to the foundation of *Parasitology* and parasitology as a discipline.

The word discipline as applied to fields of scientific endeavour requires some explanation. The most widely used definition is a branch of knowledge or an academic subject but social historians go further than this and suggest that disciplines are actually social institutions (Lemaine *et al*. 1976), a topic that is discussed further in the context of parasitology by Warboys (1983). The question that then arises is when does a field of study become a discipline? This question is easy to answer with respect to subjects such as entomology or palaeontology in which groups of individuals, originally amateurs in these examples, interested in the subject, came together to share and exchange ideas in a convivial atmosphere and to publish their ideas with the main objective of informing one another. Tropical medicine almost certainly arose as a discipline in the early years of the twentieth century as a result of the formation of societies such as the Society of Tropical Medicine and Hygiene that allowed like-minded individuals to meet together and to exchange ideas through the pages of their journals and scientific meetings. At the beginning of the twentieth century, parasitology had no such focus because nobody had defined what the subject actually encompassed. Warboys has argued that parasitology became established in the period between 1914 and 1940 when scientists began to call themselves parasitologists, parasitological institutes were formed and parasitology began to be studied in universities. I suggest that the discipline actually began 6 years earlier with the publication of the first issue of *Parasitology*.

PARASITOLOGY VOLUME 1

Parasitology first appeared as a supplement to the *Journal of Hygiene* and it is the foreword to this Supplement that, I believe, spelled out the parameters within which the discipline we call parasitology came in to being. Parts of this foreword are worth quoting at length:

''When the *Journal of Hygiene* was founded it was announced that papers on Parasitology ''in relation to hygiene and preventive medicine'' would be published in its pages. It has, however, been felt that the Journal was becoming unduly burdened with papers dealing with the anatomy of mosquitoes, fleas, protozoa and other parasites – of great importance in themselves – but having only an indirect relation to hygiene and preventive medicine.''

''It is proposed in future to relegate all such papers to *Parasitology*.''

''Thus, a knowledge of the structure and biology of mosquitoes, biting flies and ticks is necessary for a comprehensive knowledge of the etiology of malaria, trypanosomiasis, spirochaetosis and piroplasmosis, and a knowledge of fleas and their habits is essential in the study of plague. Further, recent discoveries relating to parasitic worms, especially those which produce filariasis, ankylostomiasis and various intestinal diseases, have given a great stimulus to the study of the entozoa''.

''Papers on the subjects we have mentioned are now scattered in journals of widely different character, into some of which they are but grudgingly admitted. We trust that *Parasitology* will fulfil the purpose the editors have in view, of encouraging the study of parasitology especially relating to disease by providing a means for the publication of papers relating to pathogenic and disease-transmitting parasites.''

''It is therefore hoped that this publication will appeal not only to medical men at home and abroad, but to veterinarians, zoologists and agriculturalists''.

Despite the rather negative connotations, 'unduly burdened', 'relegate all such papers', 'grudgingly', this was the first time that the scope of parasitology had been clearly set out in that the aim of the new journal was to encourage the publication of papers relating to pathogenic and disease-transmitting parasites with particular reference to protozoa, entozoa and arthropods. The study of these three hitherto disparate groups was to be brought together under one heading, parasitology, and the subject was to have its own journal. The scene was now set for the development of the subject and parasitology had become a discipline. Universities set up courses in parasitology and established chairs in the subject, parasitological societies were formed, new journals emerged, the subject developed a literature of its own and national, regional and international conventions were held. To return to Warboys' question ''… how did helminths get lumped together with protozoa in parasitology?'' It was because Nuttall felt that these groups, together with the arthropods that transmitted them and those that were parasites in their own right, no longer fitted into the concept of hygiene and deserved their own journal.

Over the last 100 years a lot has happened. It is of some interest to note that the original intention was that *Parasitology* should be issued as a separate 400–500 page Supplement to the *Journal of Hygiene* ''when sufficient material has accumulated''. In fact

the new journal was so successful that in the first year there were 4 numbers totalling 415 pages. By the time that Nuttall had retired as editor in 1933 the number of pages had exceeded 500 but these were still contained within 4 issues, a number that rose to 6, 10, 12 and now 14. It is, nevertheless, salutary to look at the first volume. There were papers on fleas, mosquitoes, leeches, ticks, schistosomiasis, filarial worms, amoebiasis, kala azar, piroplasms, trypanosomes and spirochaetes none of which, apart from possibly the latter, would have been out of place in *Parasitology* a century later. The list of authors in the first volume included some of the most distinguished parasitologists of the time including Nuttall himself, Aldo Castellani, Clifford Dobell, Harold Fantham, A. D. Imms, Robert Leiper, Arthur Shipley and Charles Morley Wenyon and, over the next 3 decades, the names of Ann Bishop, Patrick Buxton, Asa Chandler, Cecil Hoare, S. P. James, Kenneth Mellanby, George Salt, P. Tate, Ernest Tyzzer and many other eminent scientists featured among the authors and, subsequently, nearly everybody who had made significant contributions to parasitology has published influential papers in *Parasitology*.

PARASITOLOGY AS AN ESTABLISHED DISCIPLINE

The contents of the first volumes of *Parasitology* set the scene for the development of parasitology as a discipline because practitioners in the field could at long last identify with a series of criteria that defined their field and brought together protozoology, helminthology and entomology (including ticks and mites). As time went by the journal began to publish papers on other parasites such as crustaceans and molluscs that had hitherto only appeared in the pages of zoological journals and, in doing so, further defined the discipline of parasitology. It is possible that without this stimulus the subject might well have diversified into protozoology merging with microbiology on the one hand and helminth worms, insects, arachnids and other multicelluar animals remaining clearly within the remit of zoology. It is also possible that the outcome would have been the same, i.e. the emergence of parasitology as we know it. We shall never know. What is certain, however, is that following the publication of the first number of *Parasitology* the subject quickly took off. Warboys has stated that ''... the period 1914–1940 is when parasitology was established; that is when scientists began to call themselves parasitologists, when parasitological institutes and associations were founded, when a parasitological education, usually postgraduate, became available and when journals began to proliferate and were founded in the major scientific nations'' (Warboys, 1983). This might be a valid historical assessment but to professional parasitologists I would suggest that the science of parasitology actually began to become established in 1908, not 1914, but did not reach full flowering until about half a century later towards the end of the 1950s rather than 1940.

The immediate aftermath of the Second World War, 1939–1945, left Europe reeling, the United States in a state of shock and the former colonies in turmoil. It was only when the world had settled down that parasitology really came into its own. An established discipline requires a literature of its own and following the publication of the first volume of *Parasitology* the *Journal of Parasitology* appeared in 1914, but it was only after 1950 that the other 2 of the 4 major English-language parasitology journals (to quote Warren *et al*. 1983) arrived on the scene, *Experimental Parasitology* in 1951 and the *International Journal for Parasitology* in 1971. There are now over 20 journals listed as parasitological, some general like the major 4 and others more specialized, for example *Parasite Immunology* and *Molecular and Biochemical Parasitology*. One indication of how much the world has changed can be seen from the fact that French and German journals, that once published the most important parasitological papers, and Japanese journals, have adopted English names and now publish in English. Another indicator of an established discipline is the number of learned Societies that it supports, and here parasitology is very rich and virtually every country with a thriving scientific community has its own society. One of the largest outside the United States is the British Society for Parasitology, founded in 1962, which publishes a symposium based on one of its annual meetings in *Parasitology*. One final sign of an established discipline is its ability to support international meetings and International Congresses of Parasitology (ICOPA) have been held regularly since 1964.

CONCLUSIONS

Although most of the major discoveries concerning the nature and life cycles of parasites had been made by the first decade of the twentieth century and parasitology was beginning to emerge as a discipline it still lacked a distinctive focal point. This focus came in 1908 when George Nuttall founded a new journal, *Parasitology*, as a Supplement to the *Journal of Hygiene*, in order to cater for increasing numbers of papers on protozoology, helminthology and entomology that were threatening to swamp the *Journal of Hygiene*. This brought these three subjects together formally under one heading for the first time and established the discipline of parasitology. The next half century witnessed a massive increase in interest in parasitology with the foundation of university departments, new journals and books and national and international conferences mainly reflecting the three separate areas, protozoology,

helminthology and entomology. Today, parasitology has changed out of all recognition with developments in biochemistry, molecular biology, genetics, immunology and ecology but still remains true to its roots, the incorporation of protozoology, helminthology and entomology within a single discipline as can be witnessed from the contents of textbooks, the programmes of parasitological meetings and the pages of its major journals including *Parasitology*.

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