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RONALD ROSS AND THE CRUSADE AGAINST MALARIA (A TRIBUTE TO ROSS'S 150TH BIRTH ANNIVERSARY ON MAY 13, 2007)

(Ronald Ross dan Upaya Memerangi Malaria (Menyambut Hari Kelahiran Ross Ke 150 pada Tanggal 13 Mei 2007))

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Abstract

Ronald Ross (1857-1932) was the first to substantiate that mosquito transmitted malaria. One among the founding fathers of malariology, he was awarded the second ever Nobel Prize in Medicine in 1902 for his work on establishing the integral connectivity between mosquitoes, malarial parasite, and man. Today, his researches have regained immense significance in the light of the threatening resurgence of malaria. This article examines the events surrounding Ross's seminal discovery.

Key words: Anopheles, malaria vector, Plasmodium, malaria research, Patrick Manson, Ronald Ross

Abstrak

Ronald Ross (1887-1932) adalah orang pertama di dunia yang membenarkan bahwa nyamuk menularkan malaria. Satu di antara banyak perintis penemuan di bidang malariologi, Ronald Ross dianugerahi Hadiah Nobel Kedokteran pada tahun 1902 untuk karya ilmiahnya yang menegaskan hubungan integral antara nyamuk, parasit malaria dan manusia. Dewasa ini, hasil-hasil penelitiannya kembali memperoleh nilai penting dalam hal kemunculan malaria yang kembali mengancam dunia. Makalah ini mengungkap kejadian-kejadian sekitar penemuan Ross tersebut yang kemungkinan masih berkembang di masa depan.

Kata kunci: Anopheles, vektor malaria, Plasmodium, penelitian malaria, Patrick Manson Ronald Ross

Malaria and Mosquito: the Inextricable Link

When did you start your tricks, Monsieur?
- David Herbert Lawrence. The Mosquito (http://www.kalliope.org/digt.pl?longdid=lawrence2001061705, visited on July 16, 2006)

Malaria is an infection caused by the protozoan parasite *Plasmodium* and transmitted by mosquito species of the genus *Anopheles*. About 60 species of *Anopheles* can transmit human malaria. The four species of *Plasmodium* that infect man appear to have evolved from a common ancestor during the early Tertiary period (Reiter, 2001).

Fossils of mosquito up to 60 million years old, reveal that the malaria mosquito (*Ano-pheles*), was present well before the earliest history, and have affected human beings since their earliest days. It is reasonable to suppose that our primate ancestors were recognizably malarious before they were recognizably human (Harrison, 1978).

The word 'malaria' (Italian *mala aria*, bad air) – literally, 'bad air' – was first used in the early nineteenth century. Before that, terms such as 'ague', 'marsh fever' or 'intermittent fever' were used to describe malaria-like illnesses (Dobson, 1999).

Hippocrates (460-377 B.C.), the Greek physician, was the first to describe the manifestations of the disease, and relate them to the season of year and to where the patients lived. The association of malaria with stagnant waters (breeding grounds for *Anopheles*) led the Romans to start drainage programs, the first evidence of intervention against malaria (Lambert, 2006).

Today, malaria kills over a million people a year, and is second only to tuberculosis in its impact on world health. The parasitic disease is present in 90 countries, and infects one in 10 of the world's population - mainly people living in Africa, India, Brazil, Sri Lanka, Vietnam, Colombia and the Solomon Islands (BBC News in video and audio, 2003). Ninety per cent of all malaria cases are in sub-Saharan Africa where it is the main cause of death and a major threat to child health. Worldwide, a child dies of malaria every 30 seconds (Malaria.http://www.unicef.org/health/index_malaria.html, visited on May 27, 2006).

1857: Year of Seminal Events

The year 1857 was marked by two epoch-making historical events, India being the epicenter in both the occasions:

- The Indian Revolt, popularly known as the Sepoy Mutiny.
- The birth of Ronald Ross on May 13 at Almora in the foothills of the Himalayas (Gibson, 1997).

Readers may note the similarity in the two events – both of them being pioneering and seminal in nature. While the 1857 revolt can arguably be called the first movement that shook the mighty fabric of the British Empire to its very foundations (Majumdar, Raychaudhuri, and Datta, 1985), the birth of Ronald Ross (three days after the outbreak of the Indian Revolt) marked the beginning of an era in which the first major step in understanding a disease - that has been with man for thousands of years – was completed.

This article discusses how Ronald Ross, the many-sided genius, proved to be the first in the scientific community to substantiate that the 'hatched-dappled' mosquitoes (Balaram, 2002), *Anopheles*, were the vectors that harbored, nurtured, and transmitted the malarial parasite, *Plasmodium*.

The Childhood and Adolescence

" A journey of a thousand miles begins with a single step."

– *Lao Tzu (Learning English – Moving Words. BBC Learning English.* http://www.bbc.co.uk/worldservice/learningenglish/movingwords, *visited on May 27, 2006).*

Ross was the first of ten children of Sir Campbell Claye Grant Ross, a Scottish officer in the British Indian army, and Matilda Charlotte Elderton. He lived in India until he was eight, when he was sent away to boarding school in England. He spent much of his childhood with an aunt and uncle on the Isle of Wight. After completing his early education in two small schools at Ryde, he was sent to a boarding school at Springhill near Southampton in 1869 (Kakkilaya, 2006).

At school he seemed to have been a dreamy imaginative boy whose main interest was in writing poetry, painting and composing music. When Ross was 14 years old, he won a prize for mathematics. The prize was a book titled *Orbs of Heaven* - one that inspired Ross to study mathematics in depth. In the later part of his career, he even applied mathematics to the study of malaria (See *Ross's Mathematical Model of Malaria Transmission* below).

At the age of 16, Ross was bracketed first in the Oxford and Cambridge local examination in drawing. He had made a pencil copy of Raphael's painting titled *Torchbearer* in just a few minutes! (Kakkilaya, 2006)

When he left school, his father suggested he went on to study medicine and finally join the Indian Medical Service that was well paid at that time and possessed many good appointments. So, in 1874, he joined the St. Bartholomew's Hospital in London in 1875. Most of his time in medical school was spent composing music or writing poems and plays. In 1879, Ross just managed to pass his Royal College of Surgeons examinations but flunked the qualifying examinations for the Indian Medical Service (Zephyrus Interactive Education on the Web. Ronald Ross (1857-1932), http://www.zephyrus.co.uk/ronaldross.html, visited on May 27, 2006). When his father threatened to cancel his allowance, Ross took a job as ship's surgeon on a vessel sailing between London and New York, and gained the Licentiate of the Society of Apothecaries. In 1881, he ranked seventeenth of twenty-two successful candidates in the qualifying examinations, and finally fulfilled his father's wish by entering the Indian Medical Service. With his not-so-impressive result, Ross was commissioned for the Madras service, the least prestigious of the three Indian Presidencies (Bengal and Bombay were the more desirable appointments) and worked in many places like Mysore and Madras, and also served in the Burma War and in the Andaman Islands (Ross and the Discovery that Mosquitoes Transmit Malaria Parasites. http://www.cdc.gov/malaria/history/ross.htm, visited on May 27, 2006).

Ross's Tryst with Malaria

When Ross was a small boy in India, he saw many people fall ill with malaria. At that time in India, as many as one million people succumbed every year from malaria. While he was in India, young Ross was witness to his father falling seriously ill with malaria.

During his studies at the St. Bartholomew's Hospital, Ross came across a woman from the Essex marshes who complained of headaches and pains in her muscles. He diagnosed her as suffering from malaria, which was unusual, as it was only found in hot tropical countries. Historical records suggest that malaria was endemic along the coasts and estuaries of south-east England, the Fenlands, and estuarine and marshland coastal areas of northern England from the fifteenth century onwards. His detailed diagnosis, however, frightened the woman away and she never returned. So, Ross was unable to prove his diagnosis (Zephyrus Interactive Education on the Web. Ronald Ross (1857-1932), http://www.zephyrus.co.uk/ronaldross.html, visited on May 27, 2006).

This experience, together with his background in India stirred Ross's interest in malaria.

When Ross returned to India as part of the British-Indian Medical Services, he was sent to Madras where he found that a large part of his work was treating soldiers ill with malaria. The treatment was with quinine which was quite successful, but many died because they failed to get treatment.

From the early days of his work in India, mosquitoes engaged Ross one way or the other. In 1883, Ross obtained the post of Acting Garrison Surgeon at Bangalore. He was irritated by the large number of mosquitoes that constantly buzzed around the rooms of the bungalow that was provided for his accommodation. He also noticed that there seemed to be more mosquitoes in his bungalow than in others and that there was a particularly large swarm around a barrel with water that was kept outside the window. When Ross looked in to the barrel, he saw a lot of mosquito larvae. So, he tipped the barrel to empty the water and found that the number of mosquitoes in the bungalow reduced. This started him thinking that if the places where mosquito bred were removed, it might be possible to eliminate them completely. Though he did not found a supporter around, Ross held these views on mosquito control till the very end (Kakkilaya, 2006).

True to his style, Ross composed this verse about his first impressions of malaria that killed

millions:

In this, O Nature, yield I pray to me.
I pace and pace, and think and think, and take
The fever'd hands, and note down all I see,
That some dim distant light may haply break.
The painful faces ask, can we not cure?
We answer, No, not yet; we seek the laws.
O God, reveal thro' all this thing obscure
The unseen, small, but million-murdering cause (Kakkilaya, 2006).

The Quest Continued

After working for 7 years in India, Ross returned to England on a furlough in 1888. He took a course of Diploma in Public Health from the Royal College of Physicians and Surgeons in London, acquainted himself with microscopic skills and laboratory techniques, and took a course in bacteriology under Professor E.E.Klein. In April 1889, he married Rosa Bessie Bloxam, and returned to Bangalore in India with her for duty as a staff surgeon at a small military hospital. Ross now began to formulate theories of malaria.

During this time, Alphonse Laveran was working on identifying the role of black pigment particles found in the blood sample of a 24-old soldier suffering from malaria at the military hospital of Bône in Algeria (North Africa). During his investigations, Laveran also found some entirely unknown bodies with certain characteristics that led him to suppose that parasites were involved. He found the same bodies in the blood of people suffering from marsh fever in Italy. Thus, his hope of having found the malarial parasite became a certainty. In 1884, Laveran published his first great work *Traité des fièvres palustres avec la description des microbes du paludisme* on these parasites, and this work is believed to be the foundation on which subsequent investigations of marsh fever are based (Bradley, 1999).

Back in India, Ross hypothesized that the cause of malaria was probably some form of poisoning from the bowel and published his first paper with this claim. He was ignorant of Laveran's investigations, and even when he learned of them in 1892, he was not convinced. He pricked the fingers of anyone who came to him with fever, and spent hours peering through his microscope at blood smears, yet was unable to see the 'crescents'. Ross was thoroughly exasperated, so he strongly questioned the soundness of Laveran's observations. This inability to confirm Laveran's work, a problem shared by many investigators, was apparently due to the crude microscopic techniques of the day and the inferior illustrations in the original articles.

'Follow the Flagellum'

By the time he took his second furlough to England in 1894, Ross believed he had accumulated overwhelming evidence that Laveran was incorrect. His colleagues informed him that the parasites did indeed exist, and sent him to Sir Patrick Manson (1844-1922), the foremost authority on tropical diseases in London and considered by many as the father of tropical medicine. Nicknamed 'Mosquito Manson', he was the first person to demonstrate, in 1878, that a parasite that caused human disease could infect a mosquito. In Amoy, China he discovered the role played by mosquitoes in the transmission of human filariasis (Bradley, 1999).

In April 1894, Ross called on Patrick Manson. "Within a few minutes," Ross wrote, "he showed me the Laveran bodies ... in a stained specimen of malaria blood, and I recognized at once that no such bodies could exist in healthy blood. My doubts were now removed...." (Kakkilaya, 2006). Then Ross spent many hours following Manson on ward rounds at the Seamen's Hospital and in Manson's private laboratory. Manson was impressed with this eager, capable student and chose to expound upon his ideas to Ross. In 1894, one November afternoon at "half-past two", as they were walking down Oxford street on the way to the hospital, Sir Patrick Manson told Ross: "Do you know, I have formed a theory that mosquitoes carry malaria just as they carry filarial (Kakkilaya, 2006)." This was to change

Ross's life forever. Ross saw himself as the man to prove that malaria was transmitted by mosquitoes. Manson suggested that the filaments in the crescents were actually living bodies and the mosquito sucked the filamented crescents into its stomach while feeding on the blood of a malaria patient. The filaments proceeded to travel through the stomach into the insect's tissues. After the mosquito died laying its eggs, the "flagellated spores" emerged into the water, ready to infect anyone who came to drink (Bynum, 1999). These theories sent the young Ross into raptures of ecstasy. Ross returned to India in March 1895, determined to prove what he called Manson's "grand induction" and went about it with an almost manic enthusiasm to "follow the flagellum". Between 1895 and 1899, Ross and Manson exchanged as many as 173 letters that described in detail the progress and results of Ross's elucidation of the mosquito-malaria cycle.

Victory at last
Can I not overtake you?
Are you one too many for me
Winged Victory?
Am I not mosquito enough to out-mosquito you?
- The Mosquito
(http://www.kalliope.org/digt.pl?longdid=lawrence2001061705, visited on July 16, 2006).

Back in India, Ross immediately threw himself into malaria research, acquiring routine skills at identifying the parasite, and more specialized skills in dissecting the mosquitoes. He spent hours observing the plasmodium in its various forms as well as discovering that several parasites, such as gregarines, now known to be unconnected with malaria, could be found in mosquitoes. However, his progress was hampered by the Indian Medical Service which ordered him to a malaria-free environment in Rajputana. Ross threatened to resign but, following representations on his behalf by Manson, the Indian Government put him on special duty for a year to investigate malaria and kala azar (visceral leishmaniasis).

Following Manson's instructions, Ross captured the mosquitoes and tried to induce them to bite malaria patients. He made the mosquitoes raised from the larvae bred in captivity to feed on persons carrying malaria crescents in their blood, by putting the patient under a mosquito net and releasing the insects into it. He then expressed their ingested blood on a glass slide, and examined it with his microscope. Just as Manson had prophesied, there were the parasites. To be certain of the results, Ross tried the same experiment with six more mosquitoes the next day. "Every point that you predicted seems to come true," he wrote to Manson. "Certainly there is nothing contrary to the theory. The parasites are present in the blood of the mosquito, and what is even more, they appear to be there in greater numbers than in blood from the finger. Also, the development of the crescents, and the formation of the flagella, seem to be favored by conditions in the mosquito's stomach. Yes, the crescent-sphere-flagella metamorphosis does go on inside the mosquito to a much greater degree than in control specimens of finger blood (Kakkilaya, 2006)."

Manson immediately wrote back with more instructions. "Let mosquitoes bite people sick with malaria," he advised, "then put those mosquitoes in a bottle of water and let them lay eggs and hatch out grubs. Then give that mosquito-water to people to drink." So Ross allowed four mosquitoes to feed on a patient named Abdul Kadir. These insects were then kept in a bottle full of water until they died. After the promise of a suitable emolument, Lutchman, Ross's native servant, and two others were persuaded to drink the sample of water in which mosquitoes had died. Lutchman developed a fever, but recovered three days later, and Ross could not find any malaria parasites in his blood; the other men remained healthy (Kakkilaya, 2006).

Ross was thoroughly discouraged. Manson desperately tried to re-energize him: "Above everything, don't give it up. Look upon it as a

Holy Grail and yourself as Galahad and never give up the search, for be assured that you are on the right track. The malaria germ does not go into the mosquito for nothing, for fun, or for the confusion of the pathologist. It has no notion of a practical joke. It is there for a purpose and that purpose, depend upon it, is its own interests—germs are selfish brutes." Manson was also worried that someone else who would give him no credit might appropriate his precious theory. "The Frenchies and Italians will pooh-pooh it, then adopt it, and then claim it as their own," he warned Ross in one letter, "see if they don't. But push on with it, and don't let them forestall you. They won't have this autumn, and they will not have a chance to work seriously at the matter until next June or so. You have got a year ahead of them."

But his superiors had other ideas for Ross. He was transferred to Bangalore on the 9th September 1895 to combat a serious outbreak of cholera. During his eighteen months stay at Bangalore, he tried to continue his work on malaria finding time in between with great difficulty. Finding that he was unable to transmit malaria through the 'mosquito water', he wrote to Manson at the end of May 1896: "The belief is growing on me that the disease is communicated by the bite of the mosquito... She always injects a small quantity of fluid with her bite - what if the parasites get into the system in this manner." To test this idea, Ross allowed mosquitoes that had fed on a malaria patient to bite a healthy man. Nothing happened. The experiment was repeated again and again but in vain. Unfortunately, as he was using *Culex* mosquitoes, which do not transmit malaria, experiments to test this theory came to nothing. Writing to his wife he said: "I have failed in finding parasites in mosquitoes fed on malaria patients, but perhaps am not using the proper kind of mosquitoes ". On the other, Manson, who believed that the mosquito bit only once during its life, was not convinced about that Ross's idea. "Follow the flagella," he wrote back, and forget this crazy idea. Ross obediently went back to dissecting mosquitoes and in February 1897 was able to observe the true fate of the flagella. Within a blood smear he saw two parasites near each other. The first was giving off flagella, while the second, which was spherical and unsegmented, had a single flagellum wiggling slowly inside. He surmised that the single wiggling flagellum was trying to escape the sphere rather than fertilize it. When McCallum in Baltimore correctly interpreted the process a few weeks later, Ross was deeply humiliated, and "always felt disgraced as a man of science" for incorrectly interpreting his own observation (Kakkilaya, 2006).

In 1897, he went to the Sigur Ghat near the hill station of Ooty. Three days later he went down with malaria, despite having slept under a mosquito net and behind closed windows. Feeling depressed with no success in sight, he wrote poetry:

What ails the solitude?
Is this the Judgment Day?
The sky is red as blood;
The very rocks decay
And crack and crumble, and
There is a flame of wind
Wherewith the burning sand
Is ever mass'd and thin'd
The world is white with heat;
The world is rent and riven;
The world and heavens meet;
The lost stars cry in heav'n

Then one day, his attention was drawn to a mosquito that was sitting on a wall in a peculiar posture and had what he called "dappled-wings". He was inspired again and was reminded of the fact that only one species of mosquito among the four found in Amoy, *Culex fatigans*, was capable of carrying filariasis. Manson had also suggested that each form of the malarial plasmodia might require a particular mosquito species. Ross suddenly realized he had used the wrong species of mosquito.

He returned to Secunderabad in June 1897 but was down with cholera, only to recover with a cup of hot tea. Once up, he commenced work by making a careful survey of the various kinds of mosquitoes. He continued his study

by examining the dissected mosquitoes under the microscope. After feeding on patients, the gorged insects were collected in small bottles containing a little water and were kept for several days before being dissected. Almost every cell was examined under the microscope, even the integument and legs were not neglected. With the facilities that he had in the hot Secunderabad weather, Ross really toiled hard. On the 15th August, 1897, one of his assistants brought a bottle of larvae, many of which hatched out next day and among them he found several "dappled-winged mosquitoes". Delighted with this capture, on August 16th, he fed them on his malaria patient, Husein Khan,with crescents in his blood. (Husein Khan was paid 1 anna per mosquito he was bitten by; he came away with 10 annas.) That evening he wrote to his wife: "I have found another kind of mosquito with which I am now experimenting, and hope for more satisfactory results with it." On the 17th he dissected two of these mosquitoes but found nothing unusual. On the 19th he killed another and found "some peculiar vacuolated cells in the stomach about 10 microns in diameter." On August 20th, a dull, hot day, Ross went to the hospital at 7 A.M., examined his patients, dealt with his correspondence and had a hurried breakfast in the mess. One of his mosquitoes had died, and this he dissected without noting anything significant. He had two mosquitoes left of the batch fed on Husein Khan on the 16th and at about 1 P.M. he began to sacrifice one. Dissecting it he scrutinized the tissues micron by micron, when suddenly, in the stomach wall he "saw a clear and almost perfectly circular outline of about 12 microns in diameter. The outline was much too sharp, the cell too small to be an ordinary stomach-cell of a mosquito. He changed the focus of his microscope and there within each of these new cells was a cluster of black pigment. He made rough drawings in his notebook, sealed his specimen, went home to tea and slept for an hour (Kakkilaya, 2006).

The pigment puzzled him, for the flagella contained no pigment, but the thought struck him that if the cells were really parasites they should grow in size in the last remaining mosquito during the night. He spent the night in agony lest his last remaining mosquito should die and decompose before morning. Next day he killed and dissected this remaining specimen. There were the cells again, twenty-one of them, just as before, only now much larger... The cells were therefore parasites, and, as they contained the characteristic malarial pigment, were almost certainly the malaria parasites growing in the mosquito's tissues. He wrote to Manson with his exciting news: "Now prick up your ears because the hunt is up again." Next morning Ross wrote a poem which he sent to Manson on Aug. 22, **1897 (?):**

This day relenting God
Hath placed within my hand
A wondrous thing; and God
Be praised. At his command,
Seeking his secret deeds
With tears and toiling breath,
I find thy cunning seeds,
O million-murdering Death.
I know this little thing
A myriad men will save,
O Death, where is thy sting?
Thy victory, O Grave?

Since then, August 20th continues to be celebrated as the 'Mosquito Day' (Bhattacharya and Gupta Biswas, 1998).

The Recognition

Ross put together his observations in a historic paper, *On Some Peculiar Pigmented Cells Found in Two Mosquitoes Fed On Malarial Blood*, and this was published in the British Medical Journal on December 18, 1897 (Gibson, 1997).

He was transferred to Calcutta on January 29, 1898. He managed to get a dilapidated laboratory of a recently retired physiologist. Now Ross advertised for assistants who would be paid from his own pocket. Of the twenty or so job applicants, Ross chose one Mohammed Bux, because "he looked the most rascally of the lot and was therefore likely to have consid-

erable intelligence. Bux was devoted to Ross and climbed through the sewers, the drains, the stinking tanks that abounded in Calcutta and brought back all kinds of mosquitoes (Kakkilaya, 2006).

To test Manson's hypothesis that the parasites were ingested with water in which the mosquitoes had died while laying eggs, Ross fed the infected mosquitoes to healthy sparrows but the birds remained free of malaria. Now convinced that malaria did not spread that way, he continued to study infected mosquitoes. On the 2nd July 1898, he found in the thorax of a mosquito a large cell which contained within it several of the thread-like bodies. On July 4, 1898, examining the insect's head, he found the part of the mosquito to which these bodies were destined - the gland lay in the neck and upper thorax and it was the salivary gland. By July 8th, he was very sure: Malaria was passed back to the birds in the mosquito's saliva during the act of biting. The exact route of infection was thus revealed (Kakkilaya, 2006).

In 1899, Ross decided to return to England. Manson had arranged a post for him at the Liverpool School of Tropical Medicine and Ross became their first lecturer in tropical disease. He remained involved with the Liverpool School of Tropical Medicine from 1899 to 1912. In 1901, Ross was elected a Fellow of the Royal College of Surgeons of England, and also a Fellow of the Royal Society. In 1902 (Pradhan, 2005), Ross was awarded the Nobel Prize for Medicine (the second Nobel for Medicine) "for his work on malaria, by which he has shown how it enters the organism and thereby has laid the foundation for successful research on this disease and methods of combating it". His work was endorsed by the Italian scientists Bignami, Bastianelli, and Grassi, who demonstrated the sporozoites of human malaria in the salivary glands of *Anopheles* (Kakkilaya, 2006).

Ross's Mathematical Model of Malaria Transmission

Ross pioneered in developing the first mathematical model of malaria transmission (Mckenzie and Samba, The Role Of Mathematical Modeling In Evidence-Based Malaria Control. http://www.ajtmh.org/cgi/content/full/71/2_suppl/94, visited on July 16, 2006). The Role Of Mathematical Modeling In Evidence-Based Malaria Control., and underlined "the mathematical method of treatment is really nothing but the application of careful reasoning to the problems at issue." His model is based on the assumption that at any given moment an entire population can be divided into distinct compartments, of the susceptible, the infected and the infectious, and that infection spreads by random contact between the appropriate susceptible and infectious "compartments" of the human and mosquito populations.

Ross suggested "...to counteract malaria anywhere we need not banish *Anopheles* there entirely...we need only to reduce their numbers below a certain figure." The uniqueness of Ross's model lies in its attention to detail. Ross used his model to conclude that integrated mosquito control programs that combined vector reduction, drug treatment, and personal protection were much more likely to succeed than efforts that relied on just one of the intervention measure.

Using his model, Ross was able to demonstrate that if mosquito density was reduced below a threshold level, the rate of getting new infections would fall below the rate at which infected people recover, so that malaria would gradually die away. This 'threshold' theory has stood the test of time well.

The Way Forward

"Malaria, in tandem with HIV/AIDS, stands in the way of social progress and better standards of life at every level, from children's intellectual and physical development to the growth of national economies."
– *Carol Bellamy, Executive Director of UNICEF (Malaria.* http://www.unicef.org/health/index_malaria. html, *visited on May 27, 2006)*

Like the plague bug, the malaria parasite,

too, tends to disappear and recur in human populations with no apparent rhyme or periodicity. The pestilence thus remains persistent, especially in the dark-skinned world, where it is favored by the prevalence of blind faith. The occasion of Ross's 150th birth anniversary has provided us with a suitable opportunity to restructure the war strategy against mosquitoes, the 'Winged Victory', that has survived the test of natural selection so well (Bhattacharya and Gupta Biswas, 1998).

As David Bradley correctly remarked (Bradley, 1997), "Ross,..., has left a range of intellectual legacies that have carried through even to our generation. His ideas can often guide and always inspire us even today." It is the responsibility of each one of us to ensure that his vision to free the world of the huge burden of malaria is accomplished".

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