Journal of Communicable Diseases
Volume 51, Issue 3 - 2019, Pg. No. 62-76
Peer Reviewed & Open Access Journal

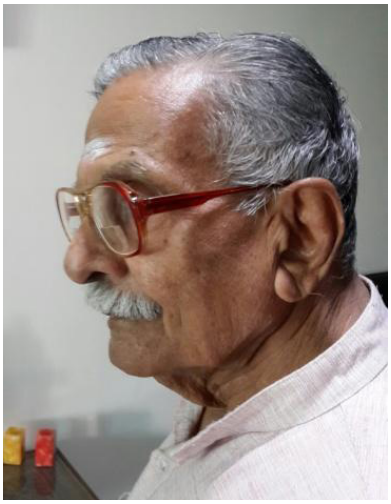
Review Article

An Entomologist's Adventures in Biomedical Research

Prof. (Dr.) P.K. Rajagopalan

Former Director, Vector Control Research Center, Indian Council of Medical Research and formerly: WHO STAC Member, WHO Consultant and WHO Expert Committee Member on Malaria, Filariasis and Vector Control.
DOI: https://doi.org/10.24321/0019.5138.201928

I N F O



E-mail Id:
leelaraj2004@gmail.com
Orcid Id:
https://orcid.org/0000-0002-8324-3096
How to cite this article:
Rajagopalan PK. An Entomologist's Adventures in Biomedical Research. *J Commun Dis* 2019; 51(3): 62-76.

Date of Submission: 2019-06-18
Date of Acceptance: 2019-09-21

"This is my life's experience with different aspects of my profession. My inspiration to write this is the late Dr. C.G. Pandit's book My Experience with Preventive Medicine."

I was born on 27 October 1930, in Mukteswar Kumaon, in the Himalaya, and came in 1935 for school education to Tattamangalam, a tiny village in the old Cochin State of present Kerala. There is nothing much to brag about. After 10 years in the village school, I moved, at the age of little more than 14 years, to Benares Hindu University (BHU), for two-year courses each for Intermediate, BSc, and MSc (both in Zoology) at the College of Science. After MSc, I spent another two years trying to work for a PhD degree.

The BHU was reputed to be one of the top-class universities in India patterned after the British educational system. I completed my MSc degree in 1951, in Zoology, with "First Class, and First in Order of Merit". But I must confess that I did not learn anything to help me in eking out a future career. The whole system of education was faulty, particularly in non-professional colleges at that time. In the College of Science, BHU, there were many departments apart from Zoology, such as Botany, Chemistry, Physics, Geology, etc. All these departments were headed by learned academicians, but no one was knowledgeable enough to teach the latest findings in science. To quote an example, although the exoerythrocytic cycle of the malaria parasite was discovered in the 1940s, the postgraduate students at BHU were not taught about this even in 1950! The professor himself was ignorant of the latest advancements. If this was the state of affairs in a well-known university like BHU, what about the others? There were very few students doing their Master's course in those days (in my batch we were only five students and the previous batch had three) compared to hundreds of students who get enrolled for each course these days. Very few jobs were available for those graduating with higher degrees. There were also not many places where one could pursue real research under an able guide. So many postgraduates, in the absence of any other alternative, stayed on at the same university in the name of "carrying out research". The normal period it took for getting a PhD then was about 5 to 8 years in most universities. We had little choice and students just blindly followed the dictum, "You are not to question why, you are but to do and die, into

the valley of death rode the six hundred" (as described in Tennyson's "Charge of the Light Brigade"). There were eight more PhD scholars along with me – all working on textbook-oriented problems allotted by the professor and all whiling away their time and looking for avenues to escape. Some spent this period preparing for competitive examinations for entry into the administrative and police services and succeeded. Others just rotted under the pretext of doing research. The professor, a distinguished scientist with a D.Sc from Oxford, became Registrar of the University, and was not easily approachable.

BHU was founded by the late Madan Mohan Malaviya (a great patriot who, along with Mahatma Gandhi, took part in the first Round Table Conference with the British) with generous donations from industrialists and Maharajas, and it was one of the well-known universities in India at that time. After Independence in 1947, politics set in, and the great philosopher-statesman, Sir S. Radhakrishnan, who was the Vice-Chancellor, moved to Delhi as India's first Vice President. He became also India's President later. After his departure the stewardship came under the control of Pt. Govind Malaviya, son of the founder of BHU, Pt. Madan Mohan Malaviya. But under the control of politicians, the standard of teaching deteriorated. The trend was reversed much later, after I left BHU, when Sir C.P. Ramaswamy Iyer became the Vice-Chancellor, and he ordered all scientist-administrators back to academics!

As research students, however, we enjoyed our stay in BHU. We had many advantages, though, compared to the present day, as the university had one of the best libraries. We could read Ray Lancaster's *Treatise in Zoology*, Adam Sedgwick's *Cambridge Natural History Series*, etc. I spent a large part of my time there. I improved my general knowledge in many fields; particularly in English language, which I admired. I read George Trevelyan's *History of the British Empire*, *World History*, all classics written by Alexander Dumas, Victor Hugo, Charles Dickens, R.L. Stevenson, etc. Being a holy city, I and my friends also used to go to the river Ganges every Sunday, first for a swim, and then to visit two of the famous temples, the Viswanath temple and the Sankat Mochan Hanuman temple. (I did this for eight long years, while at BHU.) Most of us lived virtually on credit - we owed so much money to the hostels as room rent but the university was very lenient. But none us did any research work! I am just describing the situation which generally existed in all north Indian universities in those days! The situation changed much later.

I was finally able to escape from this no-win situation - after two years of so-called research work! - which everyone in the department was hoping for. I was called in May 1952 for a personal interview for the post of a Research Assistant (the lowest rank in those days for a research job) in Entomology at the Virus Research Centre (VRC), Poona, a joint venture by the Rockefeller Foundation (RF) and the Indian Council of Medical Research (ICMR). Dr. Austin Kerr, who had worked all his life on yellow fever, was the Director of VRC. He along with Dr. C.G. Pandit, the first Director General of ICMR and a few others, were in the selection committee. They asked me about malaria – the only answer I knew (as taught by all universities at that time) was about *Anopheles* mosquito as the vector of malaria. When they questioned me further, I was bold enough to ask them, "Which university teaches anything more about malaria? I was taught about evolution of the horses, elephants, structure of the insect, etc."

An Indian member of the selection committee considered my answer impertinent. But Dr. Austin Kerr and Dr. C.G. Pandit asked me to wait. In the end, I was called again and appointed to the position. I was also complimented for telling the truth. Many years of frustration made me call a spade a spade; I maintain these traits even now and as a result I am disliked by many, also admired, may be, by some but never ignored, even today!

Virus Research Centre, Poona (1953-70)

I started my career as a Medical Entomologist (with the rank of a Research Assistant and a monthly pay of Rs. 160) at the Virus Research Centre, a new institute started by the Rockefeller Foundation and the Indian Council of Medical Research in 1952. It was the luckiest break I got for starting my career - primarily because the Centre was managed by well-known American scientists from the Rockefeller Foundation. I was less than 23. My life in VRC was like baptism by fire. Earlier, in 1949, the Rockefeller Foundation (RF) had done a serological survey in many places in India to detect antibodies to arboviruses, and the results were published in a paper by Smithburn, Kerr and Gatne. I think this paper was published in 1954 in the *Journal of Immunology*. The results had shown the presence of antibodies to several group B viruses. One of the main reasons for this survey itself was to find out why yellow fever had not been reported as a disease entity in India. This then led to establishing a research centre to study arboviruses. Dr. J. Austin Kerr, who was a well-known yellow fever expert, was the first Director of VRC. Dr. Harold Johnson was the chief virologist and Dr. C. Brooke Worth, the medical zoologist. Dr. T. Ramachandra Rao came on deputation from Bombay Public Health Department as medical entomologist. Dr. Austin Kerr was succeeded by Telford Work as Director, and it is no exaggeration to say that maximum development and expansion of the VRC took place during his time. Dr. C.R. Anderson later replaced him as Director.

Like his name (Work) he did work, very diligently. Dr. Harold Trapido, who was responsible for controlling

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

malaria in Sardinia, was the ecologist at VRC. But the most knowledgeable and experienced scientist to join the VRC was Dr. Jorge Boshell. He was a renowned epidemiologist and naturalist of world stature and had spent many years in the jungles of South America. I was privileged to work with him in the field for six long years, learning all aspects of ecology and epidemiology. I owe a debt of gratitude to Dr. T.R. Rao, from whom I learnt entomology, and to Dr. Jorge Boshell, from whom I learnt ecology and epidemiology (particularly of arboviruses), and last but not the least to Dr. Charles Anderson who taught me about integrity in scientific research, which has stood me in good stead. He was a great virologist and gave a lot of freedom and encouragement to even non-medical people like me to work on virology and was a great source of inspiration.

The VRC in the early 1950s wanted to look for the presence and distribution of different viruses pathogenic to man, and therefore all of its work was directed towards detecting arboviruses from mosquito, human and animal sources. First we had to get the experience, and I had to learn all about mosquitoes and other haematophagous arthropods. Apart from Dr. T.R. Rao who taught me the ABC of mosquito taxonomy, there was no one else in the Entomology Section. Having led a frustrated life for two years in BHU as a "research scholar", I was determined to make it good in life. At the time, I don't think I had any special aptitude for scientific research in particular. But I persevered. I, along with six other insect collectors, cycled to different places, doing mosquito collection in the morning; in the afternoon, we identified the mosquitoes, and prepared pools of different species for virus isolation. In the evening, we did outdoor resting and biting (landing) collections at dusk, and returned by 10 pm. This was a routine for several years. Can you imagine seven cyclists with kit bags cycling, every day, all the way to different places, to collect mosquitoes? Our team was often ridiculed for our appearance. I learnt the subject the hard way. It was the best ecological study ever carried out by any one "on mosquitoes of Poona district" and the results were published in the *Indian Journal of Malariology* (authors: Rao and Rajagopalan) and the paper had more than 50 pages. I was very proud of my first paper and my work was recognized by my bosses.

After Dr. Rao, who was on deputation from Bombay Government, left in 1954, I was made the "chief of Entomology section" while still a Research Assistant. Another few years of intensive field work in the rainy, leech-infested evergreen forests of Colaba and Ratnagiri districts of western Maharashtra enhanced my reputation as a field worker (which is not popular with our present-day air-condition - loving and computer-addicted white-collar entomologists who treat field work as "safari research"). I was then made head of a newly created Field Entomology Division. I was only 25 then, still a Research Assistant with a few scientists of higher rank working under me! Can you imagine such a setup in present-day India? Field work was given the due status it deserved at that time and my hard work was recognized, appreciated and amply rewarded by my American bosses. I also took part in the investigation of several fever episodes. And I gained a lot of experience by working on ticks and mites.

Ecosystem Studies in a Virgin Tropical Evergreen Rainforest

I must write about the detailed studies of a unique ecosystem undertaken in Devimane Ghat, situated on the Sirsi--Kumta Road in North Kanara District, Karnataka state, which was a virgin, tropical, evergreen forest. Very few people of the present generation know about this unique study. An ecological study (read ecosystem study) was undertaken to search for evidence of existence of arboviruses. The Rockefeller Foundation was almost getting frustrated, I think, about the absence of positive evidence for yellow fever in India. Devimane Ghat was similar to the deep jungles of Africa and South America where yellow fever was prevalent. A large plot of land on the roadside located in the Ghat Road, amidst forest surroundings, was selected and cleared for establishing a field laboratory. Tents were set up with all facilities for lodging, and a laboratory. A kerosene-operated refrigerator and a generator were also set up. The staff was very well looked after regarding their safety and living conditions, which was typical of the RF. I was the officer-in-charge, and was assisted by another Research Assistant named Lamba, a brilliant zoologist. We also had the services of insect collectors, field workers and technicians, etc.

We stayed there throughout the duration of the study, which lasted for a little over a year. The program included collection of blood samples from human and animal sources, for serological tests and virus isolation. Arthropod collections from different habitats were also made. Special emphasis was paid on stratification of mosquitoes. There were lots monkeys. One of the main studies was on indoor and outdoor resting and man-biting mosquitoes, and their vertical distribution in the forest. Several tree platforms at different heights were constructed deep inside the jungle and biting collections were made throughout day and night for several months. Previously such a stratification study was done only in Trinidad and in Entebbe (Uganda). The entire planning was done by Dr. Austin Kerr.

Previously such stratification studies were done in connection with yellow fever investigations. For yellow fever, there is the "sylvan cycle" with *Aedes africanus* in the Africas and *Haemogogus spegazzini* in South and Central Americas, transmitting yellow fever from monkey-to-monkey in the forest canopy, and monkey-to-man and

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

man-to-man transmission is carried out by other vector species. We did not find any distinct canopy biting mosquito in Devimane Ghat. The study in Devimane Ghat, if it had continued for a longer time, could have helped to understand important zoonotic cycles of many viruses. Unfortunately, the study was discontinued abruptly, as the personnel were shifted to Vellore to study Japanese Encephalitis (JE), which had broken out there. There was also the question of what happens to the virus in the inter-epidemic period.

In recent years there have been episodes of viral epidemics of dengue and chikungunya, and also Kyasanur Forest Disease (KFD). The epidemics die down after an outbreak in an area. It is in these silent years that one has to undertake a long-term detailed study of all components, living and nonliving, of the ecosystem. We have to first understand the term "ecosystem". The term "biocoenose" is often used to refer to species network -- it just means the mutual relationship between all living species within the ecosystem. A few arthropod-borne diseases are prevalent over very large areas, and most of them appear in more or less limited foci in which the disease may survive. Pavlovski described this relationship as the "natural nidality". His doctrine may be summed up in the following way: Just as an animal tends to have a habitat with definite association with other species, together making up a "biocoenose" within a particular ecosystem, so a disease tends to have a habitat. This is particularly so in the case of diseases which are dependent vectors for their transfer from one definitive host to another. Such diseases have natural habitats in defined ecosystems.

Unfortunately, these studies at Devimane Ghat were abruptly terminated, since the personnel had to be moved to another area. The results of these investigations are yet to be analyzed and published. Recently, questions are being asked about the inter-epidemic cycle of dengue and chikungunya viruses and the possibility of the existence of a zoonotic cycle for both these viruses. The results of studies in Devimane Ghat could have provided some leads to study and understand the important inter-epidemic zoonotic cycles of these two viruses. I had actually suggested a detailed study on these lines, and to include large and small mammals like monkeys, rodents (as in KFD) and birds (as in Western Equine Encephalitis and Eastern Equine Encephalitis) in 2013. But who is interested? The present-day system does not permit this. In-depth studies must be undertaken on a long-term basis, similar to one undertaken by the VRC at that time, if one has to understand the ecology and natural history of several of the neglected and emerging tropical diseases like dengue, chikungunya, scrub typhus, KFD, etc., so that a brake can applied in the chain of transmission. But now they want only project-oriented research and publications (with high impact-factors) and not problem-oriented research.

I must describe here what the set up of field stations under the RF was like. The field stations used to consist of small groups, professional and non-professionals, under an officer-in-charge (that is me). The RF had implicit faith in me, as an administrator and as a scientist. I was entrusted with getting the intended work done. And I was encouraged and given all the facilities. All the collected material was sent three times a week by special couriers to the main laboratory at Poona, by road and train. Imagine the organizational set up and the logistics involved! I was handling the entire show. I am also proud to say that I had a group of supporting staff, who were also excellent field workers. Monetarily also we were looked after very well by the RF -- by supplementing our field allowance (since the governmental rates were a pittance). The RF used to recognize and reward even simple achievements like isolating a virus strain from mosquitoes/ animals. For example, the then Director of VRC, Dr. Telford Work, asked me to reward the work of staff by financing a big party for them. Sincerity and loyalty of the staff were hallmark of all the field stations which I headed at that time. It is necessary to mention here that when I brought down a dying monkey from a tree top from the Kyasanur forest, and isolated the virus from all organs and blood of the monkey, he was so pleased that he asked me to get married soon, as he intended to send me for a Master of Public Health degree to University of California on a RF Fellowship, which includes sponsorship of the spouse also!

Investigation of the epidemic of Japanese Encephalitis (JE) in North Arcot (1954-57)

The reporting of Japanese encephalitis (JE) cases in Christian Medical College Hospital (CMCH) for the first time in India (1954) gave a shot in the arm to the VRC - and justified its existence. I am sure both the ICMR and the RF were wondering what to do in India. For the first time since the VRC was established, a vector-borne viral disease was discovered in India. It was of enormous importance and the RF became involved. Most of the work was done by the entomology team (under my leadership) and Dr. Dandawate who was responsible for the virology work. We started our working day at about 8 in the morning, collected mosquitoes till dusk, and later identified the species involved and prepared pools for each species. Many lakhs of specimens were collected, identified and processed for virus isolation. We finished each day's task late at night. We were encouraged very much by our Director, Dr. Telford Work, who knew each one of us by name and occupation - an unusual behaviour in a team leader at the time, let alone these days. Our efforts were rewarded by the isolation of the JE virus from mosquitoes. The human angle was studied by Dr. John Webb and Dr. Sheila Pereira

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

of the Pediatrics Department of CMCH, who did an excellent study of the clinical history of JE (mostly in children). The mosquito vectors implicated belonged to the *Culex vishnui* group. The results of this monumental work were later published in an article, entitled "An analysis of mosquito collections in Japanese encephalitis areas of North Arcot District, 1954-57" in the *Indian Journal of Medical Research.*

A decade or so later, I was summoned to investigate epidemics of JE in Tirunelveli (Tamil Nadu) and in Burdwan and Bankura districts (West Bengal). In a way, JE is an environment-related disease of seasonal occurrence. The epidemiology also varies somewhat in different places as studies have shown. The major vector, *Culex tritaeniorhynchus*, breeds profusely in rain/ flood water collections, and is primarily zoophilic (feeds on animals, including cattle) - you can call this the pullulator of the mosquito population, as distinct from an amplifier, which may be an animal (pig) or bird (fledgling ducks, etc). Drought conditions exist in many parts of India, followed by heavy rainfall, flooding and increased wet cultivation. It has been established that some species of migrant birds (e.g. grey herons) nest in these areas, bringing the infection with them. The epidemiology of the disease indicates that the vector control resorted to nowadays *after* the start of the epidemic is only a public relations measure by health departments, and is totally useless. Whether you spray insecticides at this time or not, the epidemic will be already declining. What is required is to predict an epidemic and take vector control measures at the start of the epidemic, and prevent transmission. This requires long-term studies on the ecology of the vector population in selected JE-prone areas and then studies on the vector population build-up so that epidemics can be prevented. We still do not have an effective single-dose vaccine; and even if you have one, what is the target population and in which area will you vaccinate?

When I wrote a paper detailing the epidemiology, and sent it to the authorities giving examples of practical methods of JE control, the "higher-ups" cynically laughed it off saying it is spicy. But one of the highly respected and well-known fortnightly magazines in India, *Frontline*, with a large circulation, published it in its issue dated 30 November 2012 with the title "Combating the Killer" and it had rave reviews. The authorities seem to be saying "Our minds are made up; do not confuse us with facts!"

I have always wondered what the aim of research is. The aim should be to find out new approaches which would be helpful to improve our understanding of the epidemiology and control of diseases. As it is, very little money (in terms of percentage of GDP) is allotted for research in India, and for biomedical research it is only a pittance. Whenever some serious epidemics (such as JE) occur in India and questions are raised in the Parliament, the government immediately allots money. Recently Rs. 4000 crores were allotted for control of JE. The sharks in the research administration convince the politician minister that more research is required and grabbed Rs. 2000 crores. What about known methods of control which are ignored? What are the practical methods to save lives? Unless there is a potent and easy-to-administer vaccine, the only other treatment is prompt hospitalization and symptomatic treatment. Unless you suggest some high-sounding costly research, no suggestions are accepted. But epidemics of JE continue to occur, and no one cares to find out why such epidemics recur in many areas with regular frequency.

I and my staff later moved to a field laboratory in Akivedu, West Godavari District, Andhra Pradesh, to study migrant birds coming to nest in the Colair Lake. It was suspected that these birds bring JE virus from abroad. This was a large lake formed by impounding Upputeru river in Eluru district. We virtually lived on boats, collecting mosquitoes, blood samples, and fledglings of migrant birds nesting there, mostly grey herons. We collected Laelaptid mites parasitizing the nests of these birds. All material was sent to the headquarters laboratory at Poona for further processing. It was a very hard life -- we were living on duck eggs and canal water. We must have stayed for about six months there. As far as I know the results of the work in Akivedu also has not been published - probably because the Centre had too many problems and did not have the necessary personnel. The work in Akivedu had to be terminated abruptly after six months, and we were suddenly transferred to Sagar, in Shimoga district of Karnataka state, to start investigations connected with (what was later named) the Kyasanur forest disease. When KFD broke out it was initially thought that yellow fever had broken out there, since both monkey and human mortality was reported. In both Devimane and Akivedu, the work was given up midway, because I was the only Field Entomologist with the VRC at that time.

Investigations on Kyasanur Forest Disease: (1957-70)

In March 1957, all of us working in Akivedu were transferred to Sagar. Typical of the working style of the then Director, Dr. Work, we received a seven- or eight-page telegram which virtually told us to close down the Akivedu Field Station, keep all the unmovable laboratory equipment with the local hospital, and move to Sagar (Shimoga), giving details of the road route we should follow. This was because an unknown disease had broken out there! An epidemic of fever had occurred among forest-frequenting villagers in Shimoga, coinciding with monkey deaths in adjoining forests. The etiological agent was found to be a group B virus, belonging to the Russian Spring Summer Encephalitis (RSSE) complex.

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

The virus was isolated from humans, monkeys, questing ticks found on the forest floor, and from ticks collected as ectoparasites on several species of mammals and birds. The virus was more akin to the Omsk Hemorrhagic Fever virus.

Since its discovery, more than 25,000 human cases and more than 7,000 monkey deaths have been reported. The disease in man is fatal unless recognized early and treated symptomatically. Investigations showed the involvement of many large mammals and birds, several species of ticks, several species of small rodents, shrews and an insectivorous bat. The complex natural cycle of the virus raised many questions. Why did the virus become suddenly active in the area? Was the virus introduced through migrant birds and their ectoparasites? What was the role of monkeys, cattle, birds, small mammals, shrews and their ectoparasites in the natural cycle of the viral epidemiology? Was there a change in the ecological inter-relationships (biocoenotic) among the different aspects of the ecosystem? These were (and remain even to this day) all very fascinating questions and attempts were made to answer them.

My stay in the KFD area (for 13 long years) was the most stimulating, interesting and educative part of my life. It was like the ancient *Gurukula Vasam* (students spending early life with their teachers in ancient India learning the *vedas*, music, etc). I learnt a lot, took my higher degrees (MPH from the University of California School of Public Health, Berkeley and PhD from Poona University). From a Research Assistant, I rose to the rank of Assistant Director. I even got married during this period!

Coming back to KFD, the isolation and characterization of the KFD virus was memorable in one sense -- it was the first time that the etiological agent responsible for a new disease was isolated and identified. It happened thus: There was a dead monkey hanging on top of a tree in the forest; Dr. Work was wondering how to bring the carcass down. I was only 27 then, and I climbed to the top of the tree, brought down the monkey carcass almost intact; all the organs were harvested and the KFD virus was isolated from every organ. Dr. Work was so happy that he asked me (in March 1957) to soon get married and told me that he would be sending me (along with my bride) to the University of California, Berkeley, to study for an MPH in Epidemiology! That was one of the greatest opportunities one could ever wish for. I quote verbatim here what Prof. Bill Reeves said about the training in Epidemiology the students get:

A wide variety of people came from Australia, New Zealand, India, England, Israel, Trinidad, Switzerland and many other countries. They came in and went through the mill of working with us. People who knew no entomology learned some entomology with us, and people who didn't know anything about virology learned virology. In addition to that sort of training, every summer for a period of years the State Health Department had a program where they took on twenty or thirty medical students for the summer to give them an experience working in some aspect of public health. So as many as four or five of those students were sent to Bakersfield for the whole summer, and we used them on flight-range studies on mosquitoes and follow-up of encephalitis cases in the hospitals. Whatever we wanted them to do, they were there for experience, and we gave it to them.

And the following is what Bill Reeves said about me, his favourite student, many decades later, at the time of his retirement:

Reeves, answering a question, said: No, most of them were junior people, but most of them rose to be senior, responsible people*. For instance, Dr. P. K. Rajagopalan came from Poona, India. He was sent by the Rockefeller Foundation Laboratory back in the fifties. When he finished up here, he went back to the Poona laboratory for a while but then was in charge of the Vector Control Research Center of the Indian Council of Medical Research in Pondicherry, India, which is the leading medical entomology research laboratory in that region. We still get their annual reports and hear from him periodically. He recently retired.*

I was very proud that such a great scientist as Reeves singled me out from among hundreds of his students whom he had trained. His general opinion of what he taught them, in his own words, was:

Put them to work. The best way to learn these things is to do them. We would put them through both field and laboratory aspects - some people only the laboratory, some people almost all of their time in the field, depending on what they were going to do when they went back. But everyone got rotated through the whole system. In almost every instance, these people would have some small project that we had been able to set up for them, and in the end they would have a publication with us on that study.

Before doing my MPH at Berkeley, I worked for six months at the Encephalitis Laboratory at Bakersfield, California. The unit was working on the Western Equine Encephalitis, under the direction of William C. Reeves (Professor of Epidemiology), who along with K.F. Meyer and W. Hammond, had discovered the WEE virus. This was one of the greatest opportunities one could get, with a non-medical entomologist (Bill Reeves) teaching another entomologist (me) basic epidemiology. I believe Bill Reeves was one of the great ecologists and epidemiologists of all times, having worked all his life on arbovirus ecology. It was he who coined the term "arbovirus" - indicating arthropod-transmitted viruses.

It was a great historical event how he and his mentor Dr. K.F. Meyer isolated the WEE virus from a horse for the first

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

time! Bill Reeves had his own field station at Bakersfield, located in Mohave Desert of Kern County, California and I spent several months working there - thanks to Bill Reeves and Telford Work, Director of VRC. This was the ideal place where one could learn what research work is and field epidemiology is. It was a glorious period for me - trapping wild birds (tri-colour Redwings) which were involved in the natural cycle of WEE, bleeding them, ringing them, releasing them and recapturing them, collecting and processing for virus isolation the mosquito *Culex tarsalis*, the vector of WEE, etc. Though it was very hard work in the desert heat of Kern County, the bird-trapping study was really very enjoyable. I was working with Glen Hudson, a biologist and an expert ornithologist. The two of us would leave very early morning to the desert, set up Japanese mist nets, and wait for migrating birds to get trapped in the net. We would extricate them, bleed each bird about 0.3mm of blood from its jugular, ring them, and release them. The art of bleeding all birds, including fledglings from the jugular without causing mortality, I learnt from Glen. It was not all work in the hot desert. We used to drink ice-cold beer carried in ice boxes, and munch sandwiches which kept us going for hours. We used to return when it becomes too hot, after winding up the show. I also learnt to bleed about 0.3 ml blood from tiny mouse and rodents by direct heart puncture without killing the animals.

Trapping of mosquitoes using dry ice, and various animal baits, etc were also routine.

The work timings were flexible. From the top boss to the lowest rank, there was comradely par excellence. The work ethics I learnt here were practiced after my return to India, in my various field stations, and this was the secret of my success as a top field ecologist. You must put all our present-day researchers in India wanting to work on mosquito vectors and vector-borne diseases in such surroundings in the field (and not in air-conditioned labs, fudging data by manipulation, publishing "quickies" - all to advance their careers by publishing papers with no value in solving real-world problems).

Apart from the Public Health course which I completed successfully, Dr. Reeves arranged that I should also get special training in malaria epidemiology (in 1958) under Lewis Hackett and in zoonoses with K.F. Meyer at the Hooper Foundation for Medical Research in San Francisco and other institutions. For the first time I learnt what is real epidemiology of malaria. This was in 1958, when India succeeded in bringing down malaria cases using DDT and was launching an eradication program. At that time itself (1959) the eradication plan was criticized by Hackett. Like the fireside chat of President Roosevelt, myself and another Philippine student spent many evenings at the residence of Lewis Hackett listening to this grand old man giving lectures on malaria epidemiology! The basic thing I was taught was that since both the malaria parasite and the mosquito had evolved ages (geological) before man, do not try to tamper with the process of evolution. Try to control malaria prevalence by keeping the mosquito population under check, more by environmental and naturalistic methods. Now, in 2019, while I write this I realize what golden words they were, and how we ignored those sane words in favour of so many new methods, proved only in small cages (like genetic control techniques) to follow the views of some who are pampered by WHO and other funding organizations.

Before returning to India, Bill Reeves and Telford Work arranged that I should have extensive exposure to many laboratories in USA and other parts of the world. I studied ticks and mites at the Institute of Acarology at College Park, Maryland; and also underwent a four-week course in ecology at the Bureau of Animal Populations, Oxford, under Charles Elton! He is considered the father of the science of ecology. I also studied bird migration at Bremerhaven and Williamshaven, islands north of Hamburg in Germany. I had also the opportunity to study ticks at the US Naval Medical Research Unit No.3, in Cairo, under the guidance of Dr. Harry Hoogstraal, the world's greatest living authority on ticks at that time! How fortunate I was to have had all these opportunities to study and learn!

On my return to India, I started working again on KFD. I was again fortunate to enter another paradise for education in the field. I had the proud privilege of working with two of the greatest stalwarts, Dr. Salim Ali, the world-renowned ornithologist, who guided me for my PhD work and Dr. Jorge Boshell, a very famous epidemiologist and naturalist. Dr. Boshell had worked for many years on yellow fever in South American forests, and discovered the sylvatic cycle incriminating the yellow fever mosquito, *Haemogogus spegazzini*, which was transmitting the zoonoses from monkey to monkey in the forest canopy. I learnt a lot from him, and I consider him my mentor in public health, field epidemiology, and a host of other subjects. For five long years people were used to seeing a machete-wielding foreigner, carrying a gun, and a young Indian, also carrying a gun, going day in and day out (except Sundays) to the forest - all the while the former recounting his lifelong experiences to an eager student (me) grasping every word of it. No one could have had a better practical training in epidemiology and ecology of arboviruses. Not many had this golden opportunity to learn so many things in their career. There was not a field which we had not touched in our discussions. They included mosquitoes, ticks and mites, small and large mammals, both domestic and wild; birds, bats, and their ectoparasites and most of all, the immensely important field of epidemiology of arthropod-borne viruses. At the time, I also learnt a great deal about how the forest ecosystem influenced the zoonotic cycles. It was a chance

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

of a lifetime! The KFD story was an investigation of an epidemic with an unknown etiology and which could be followed as an example in many situations.

When the Rockefeller Foundation withdrew from the VRC, in 1970 (which I felt was very tragic for Indian science), the KFD field station was also closed down and many important aspects like wild animal and tick reservoirs of the virus, etc, still remained to be studied. Scores of scientific papers were published during this period. My engagement at the VRC field station at Sagar (1957 March to 1970 June) also ended and I was transferred to the WHO--ICMR project on Genetic Control of Mosquitoes at New Delhi. My stay at the Virus Research Center (now it has been renamed National Institute of Virology) was one of the most enjoyable and educational. I left VRC as a fully qualified and experienced public health entomologist and vector ecologist, recognized the world over. I owe this to my association with some great scientists of the Rockefeller Foundation and to Dr. C.G. Pandit, the doyen of medical research in India and founder Director General of the Indian Council of Medical Research. No amount of praise would be too much for the way the Rockefeller Foundation ran the affairs of the VRC. They built it from scratch to an excellent research institution, with the necessary infrastructure. They developed a cadre of scientists and got them trained at the best universities and research centres in different parts of the world. At various times, apart from myself, other scientists like Dr. K.R.P. Singh, Dr. Kalyan Banerjee, Dr. C.N. Dandawate, Dr. M.K. Goverdhan, Dr. F.M. Rodrigues all had training abroad, sponsored by the Rockefeller Foundation. They encouraged them, and helped all of them to achieve higher goals in life, including getting higher academic qualifications.

I was one of the luckiest, I may say. I had the opportunity to study the work on dengue at Bangkok, Japanese Encephalitis (JE) in Japan, viruses at the Trinidad Regional Virus laboratory, ticks and mites at the Institute of Acarology at Maryland, many aspects of Eastern and Western Equine Encephalitis at various centres in the United States, bird migration on an island (Williamshaven/Bremerhaven) north of Germany and studies on yellow fever at the East African Virus Laboratory. In Bangkok, the US 406th SEATO Laboratory was doing excellent work on Dengue (DN) and Dengue Haemorrhagic Fever (DHF) and on the vector mosquito, *Aedes aegypti*, under Scott Halstead. This was in early 1958, when DN and DHF were not yet recognized as major problems of public health in India. I was at National Institutes of Health, Tokyo, for a few weeks studying their work on JE, where Dr. Kitaoka, Dr. Akira Oya and Dr. Osuno did excellent work on JE, in Gumma Prefecture. Pig farming was well regulated in Japan, unlike in Indian rural areas (pigs are amplifiers of JE virus), and it was easier to control JE by vaccinating the pigs rather than man as is being attempted in India. It is really tragic that there is no real progress in the control of JE in India even now, with the three-dose vaccine totally ineffective in the control of JE.

My experience at the Trinidad Virus Laboratory (TRVL) was unique, since Dr. Aitken was an experienced entomologist, working on yellow fever and dengue there. This was in 1964. The TRVL, along with the East African Virus Laboratory (EVRL) in Entebbe, Uganda, another laboratory in Belem in Brazil (which I could not visit), and the VRC in Poona, were all established by the Rockefeller Foundation at about the same time. The EVRL, headed by Dr. J.R. Haddow at that time, was famous for its studies on vertical distribution of mosquitoes, in connection with yellow fever epidemiology to know if there are distinct canopy biting mosquitoes, by constructing tree platforms at different heights in the forest. What foresight the RF had, as years later I carried out similar studies in KFD-affected forests to rule out mosquito involvement in KFD transmission! Dr. Haddow also felt, while at was in Uganda, that I should spend time at the Malaria Research Centre in Amani, Tanzania. One thing I learnt to my pleasant surprise was that African scientists working in all these laboratories are a hard-working group, working under trying conditions in deep forests. The Ugandan group stole a march over their Indian counterparts in the erstwhile VRC, in their investigations on the Zika virus (Frontline, November 25, 2016). The present-day Indian scientists only talk, walk briskly with their briefcases with laptops, and appear to be too busy with “safari research”. They are keen, like migratory birds, to attend one international conference after another, achieving nothing substantial.

I also spent a lot of time with the British Museum (Natural History) studying taxonomy of mosquitoes. The British Museum, with the taxonomy division headed at that time by P.F. Mattingly, was a unique institution. It can be compared with the Smithsonian Institution in Washington, DC, which I had also visited. I also spent time learning ecology under Charles Elton at the Bureau of Animal Populations, Oxford University, and with Harry Hoogstraal, US Naval Medical Research Unit, Cairo, studying ticks, etc. The Rockefeller Foundation made sure that I got the experience of working with stalwarts in different fields, so that I could tackle problems in India. Though the RF is not in India now, I am sure that their trust in me was fulfilled, as later events proved.

In recent years, there have been annual episodes of JE epidemics, particularly in Gorakhpur. These are well-documented. Nothing much has been accomplished by the National Institute of Virology (NIV), the successor to the old RF-administered VRC in Poona. Epidemics continue to occur routinely year after year, research papers continue to be published, and reports continue to be submitted to the government -- this has become a routine. Everybody, including the press and the government, are happy. The

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

authorities have opened a permanent Centre now. Again, all academic, paper-publishing-oriented research is being carried out there, and according to one wit the work (survival research) is *like grinding repeatedly wheat which has already been converted into a fine powder, year after year*! That means go on repeating the same old work, year after year. (I remember when I was Director of VCRC, the ICMR used to pester us repeatedly for some report or the other. My staff, in my absence, sent a very old report, my mistake, and surprisingly this was accepted! So it is all about reports - sent from the lowest level to the highest levels. Nobody reads them, but they are accepted and filed. Most of the reports are fudged, but at the highest level, including at the WHO, they are sanctified! This is how research under the government is done. All files and no substance!

Of course there are exceptional circumstances - such as organizations like the Rockefeller Foundation (for public health) or the Ford Foundation (for agriculture), or under some exceptionally competent body like the Indian Institute of Science, or Tata Institute of Fundamental Research (there may be a few more bodies, but not many) who have done remarkable work. An editorial in The Hindu dated 26 Jan 2012 under the heading "Cheating Science" should be an eye-opener. Starting from highlighting the malaise plaguing science, the number of researchers getting exposed for data falsification, fabrication and plagiarism, the paper has relied on recent articles in *Science, British Medical Journal* and *Nature*. It makes rather sad reading when one thinks of the affairs of some of the ICMR institutes, though the other research organizations like CSIR, ICAR etc, are not totally excluded. "If the availability of modern tools and the pressure to publish papers is forcing many researchers to resort to unethical means, there is also little to deter them from cheating," says the editorial. For reasons well known, universities and institutions have not been forthcoming in meaningful investigation. All one has to do is to find out why these things are happening in ICMR institutes. In some of my earlier letters written to the then Director General, Dr. V.M. Katoch, I had highlighted these matters, particularly after my experience as a member of the SAC of NIMR. The so-called sponsored research (from grants given by multinational companies and drug cartels, more to advertise their products) has become the order of the day. The scientists are virtually forced to publish more and more papers (high impact factors?) but these are of practically of no use in solving problems facing our nation. Why are so many thousands of malaria cases, dengue and chikungunya (including thousands of deaths) still occurring? There is no accountability. There is no performance audit.

WHO--ICMR Collaborative Research Unit on Genetic Control of Mosquitoes (1970--75)

In June 1970, I was transferred along with a few others to the above WHO project. I was appointed as Senior Scientist in charge of Ecology. This Unit was closed in June 1975 after a political controversy. Actually the Americans wanted to use the accumulated PL-480 rupee funds in India; they wanted to spend it on experiments on mosquito ecology and dispersal, the results of which could be used for several purposes, including planning biological warfare. Whether the work was planned for this purpose or not, only future events would have shown. But the Unit was closed down abruptly.

Whereas the avowed object of the Unit was to control the vectors of malaria and filariasis through genetic control methods, the major work was on the dispersal studies of mosquitoes including the yellow fever mosquito*, Aedes aegypti*. No work was done on *Anopheles* mosquitoes, the vectors of malaria. While a lot of work was done on the filariasis vector, *Culex quinquefasciatus*, the Delhi area was not endemic for filariasis. Quite a lot of work was undertaken which may not have any relevance to the control of filariasis, much less malaria. The Unit, which had to close down following a political controversy, created a storm in the Indian Parliament, and was quite embarrassing, to say the least, to scores of Indian scientists working there. The whole planning was done by the United States Public Health Service; they signed an agreement with the WHO, and the latter signed another separate agreement with the Indian Health Department. This was a very unusual arrangement in the history of Indian science, and proved to be controversial.

To detail the particulars here is beyond the scope of the present article. It will also hurt several people in India and abroad. Briefly: There was a rivalry between three foreign participating groups, one advocating chemo-sterilization and irradiation of mosquitoes, and the other two groups advocating genetic manipulation, cytoplasmic incompatibility and genetic translocation. One of the groups, led by Prof. H. Laven, published a news item in their embassy newsletter (German) that the chemosterilant used for sterilization of mosquitoes, thiotepa, is carcinogenic. This stirred a hornet's nest in the nationalist Indian press and one national daily (National Herald) wrote a big article. One of the leading science journalists (K.S. Jayaraman) came to investigate this. The WHO spokesperson (Dr. Rajinder Pal) at the GCMU, instead of explaining what is happening, tried to turn him away saying that the WHO policy did not allow giving any press interviews!

Investigations followed and an adjournment motion was tabled in the Parliament, and after a heated debate, was accepted. This was a unique instance in the Parliament's history. Later, two Public Accounts Committees, (PAC No. 167 and No. 200) investigated the matter and finally recommended that the Unit should be closed down. The PAC also gave strict guidelines for research involving foreign

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

collaboration. (This regulation, I have seen, is followed more in finding loopholes into it, and contravening the provisions). I know that in the 2010s, there are many foreign collaborative ventures. (Unlike the partnership with Rockefeller foundation, when young scientists were trained and they turned out to be world-class ones, the present day collaborators also become richer by acquiring laptops, go on frequent foreign trips, and have expertise in producing papers in the laboratories using computers! The government seems to be satisfied with reports, with colourful charts and histograms, and minutes glorifying what has been achieved).

Before going into the scientific achievements of the GCMU, which were quite substantial, I must say what went wrong. The sterile male technique which was used was applied for the first time in mid-western United States to control screw worm flies, which bored cattle skin, causing extensive losses to the leather industry. The females mate only once with the males (as also in the case of mosquitoes). Since there was marked difference in size between male and female puparium, they were able to mass-rear the flies, separate all the males at the puparium stage, chemo-sterilize them, and release millions of such sterilized males in the population. The mated females laid sterile eggs and thus, in course of time, the screw worm fly density was drastically reduced. This is called the sterile male technique. Some scientists wanted to apply this technique to control mosquitoes. Irrespective of whatever technique was used to sterilize the mosquitoes at the pupal stage, a 100 percent separation of sexes was not possible because there was not such a distinct difference between the male and female sexes. There was always a contamination of 2 to 5 percent, at the time of separation of males from females. When millions of males are released, 100 to 200 thousand females are also released and these are human-biting. This was biggest scientific flaw in the experiment. It was also found that the sterilized males, as well as the genetically manipulated males, were not competitive with the wild males, and therefore the results were very disappointing. Added to this was the controversy over whether the chemosterilant used, thiotepa, was carcinogenic or not.

But the main reason a controversy erupted was because of the extensive work done on *Aedes aegypti*, particularly the studies on dispersal patterns, and the plans to mass-release them in an industrial township (Sonepat). Scientifically speaking, however, five years of very extensive and intense studies were carried out at the GCMU, in which several well-known international and national scientists participated. Among the scientists were Drs. Carol Smith, Paterson, Yasuno, La Breque, Gerry Brooks, K.R.P. Singh, V.P. Sharma, Reuben and myself. Outstanding work was carried out on ecology, bionomics, dispersal patterns, and genetics of *Culex quinquefasciatus* and *Aedes aegypti.* The results were all published in the WHO/ VBC monograph series (since the project was a WHO-sponsored one). The Unit also trained and produced a team of highly qualified and experienced scientists who ultimately formed the bulk of the research staff of three ICMR institutes: (1) the Vector Control Research Centre in Pondicherry (VCRC), (2) the Malaria Research Centre in Delhi (MRC) and later (3) the Centre for Research in Medical Entomology in Madurai (CRME).

Vector Control Research Centre, Pondicherry (1975-1990)

Unlike many research institutes, Vector Control Research Centre (VCRC) was not planned to be established, and of all the places, in Pondicherry. Following a political controversy, the WHO--ICMR Collaborative Research Unit on Genetic Control of Mosquitoes (GCMU) had to close down its operations in Delhi in June 1975. Apart from a few WHO scientists, the majority were Indians and among them only three or four had permanent positions at the Virus Research Centre, Poona, who could go back to their old positions. All the rest would have lost their positions. It is due to the farsightedness of Dr. C. Gopalan, the distinguished Director General of ICMR at that time, that he wanted to utilize the services of trained scientists, and the VCRC was thus established. There was no regular budget or program, except that since most of the scientists were entomologists and were working on mosquito control techniques at the GCMU, it was decided to shift the staff to a new institute for vector control. Dr. Gopalan decided to start a field division of the VCRC at Pondicherry. I, being a vector ecologist, was appointed as its new head. At the same time, a laboratory division was also established at Delhi (in the campus of NICD) with the late Dr. K.R.P. Singh, an experimental entomologist who was also from the GCMU, as its head. This was according to the directions given in the 200th Report of the Public Accounts Committee of the Parliament, as a purely temporary measure pending a final decision by an Expert Committee to be formed by the government. The total budget per year for the two units was estimated at that time as Rs. 1 lakh, to be met from the left-over funds of the GCMU until 1 April 1977. Both the field and laboratory units of the VCRC were functioning without a regular budget, or even a staffing pattern, and several junior technical staff were recruited on daily wages. During the transition period (July 1975 to March 1977), Dr. N. Veeraraghavan, retired Director of Pasteur Institute, Coonoor, was asked to look after the establishments pending a decision. The Governing Body of ICMR then made the VCRC a permanent institute under the Council from 1 April 1977, under my charge. During the course of the following year, the laboratory division was separated into a distinct unit and named the Malaria Research Centre (MRC) at Delhi, with Dr. K.R.P. Singh in charge. This is the authentic

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

story of how the VCRC came to be established. The entire credit for this development belonged to Dr. Gopalan (DG, ICMR), who was a visionary in every respect, and to Dr. T. Ramachandra Rao. I would like to mention here that when the decision to move to Pondicherry was taken, many rickety old vehicles, along with old furniture and other laboratory stuff, were moved by road to Pondicherry like a caravan, with only the knowledge that they were expected to go to the Jawaharlal Institute of Medical Research (JIPMER), a central government postgraduate medical institution. We were told to assemble under a tree to await further instructions! Actually, JIPMER offered only two rooms to establish the newly formed VCRC. I remember that the Lt. Governor of Pondicherry, Mr. Cheddy Lal, telling us that in Pondicherry, a small union territory, "we will be a patch, whereas in any other part of India we will only be a dot." He was also good enough to arrange a huge old French-style mansion, called ENI Bungalow, to establish our institute. Subsequently one or two more buildings were also hired, so that some scientific work could be started. Before regularizing the institute, from 1 April 1977, the governing body of the ICMR gave the following guidelines and objectives:

While the VCRC should have the opportunity and freedom to work on any vector-borne disease as it became necessary, it needed however to concentrate on malaria and filariasis as a matter of priority." Specific projects relating to vector control with scientifically based approach was of utmost importance to enhance the management of the two major diseases. The design and execution of various components had to be accurate. Our approach was of immense practical significance -- without a proper understanding of the vector ecology, the ecosystem in which the species operated, seasonality and host preferences, it would have been difficult to predict the seasonal transmission patterns and the levels of disease endemicity.

For any institution working on vector-borne diseases, the above directions were like the Bible. (Unfortunately these objectives are flouted these days and everyone is engaged in sponsored research - i.e. do jobs for organizations whether this is relevant or not, and this is not only encouraged but insisted upon now a days.) During my leadership of the VCRC, these were our guiding principles. Every effort was made to stick to them as far as money and manpower allowed us to do. (After my retirement from the service in 1990, these directives were totally ignored. Survival research took over and became the norm.) From July 1975 to March 1977 was a period of stabilization and consolidation, and also a period for building infrastructure for the new institute. I had one senior scientist, the late Dr. Reuben, and four junior scientists (P.K. Das, P.K.B. Menon and K.N. Panikker) to assist me, aided by several technical and laboratory personnel already on the ground in Pondicherry. I had to recruit additional scientific and technical staff for the Center. I was able to fulfill the mandate of the newly established research centre with the encouragement and full support of Dr. Gopalan.

Pondicherry at that time was highly endemic for Bancroft an filariasis, with microfilaria rate of above 20%, and malaria in pockets of the villages. But in neighboring Tamil Nadu, in Salem District, *Anopheles stephensi*-transmitted urban malaria and *A. culicifacies*-transmitted riverine malaria were prevalent. I opened a field station in Salem (with Dr. Reuben in charge) to work on urban and riverine malaria. Since filariasis was endemic in Pondicherry area, an extensive two-year study was started on all aspects of filariasis transmission.

These studies were intended to provide entomological and epidemiological data, so that effective control measures could be planned. There was excellent cooperation from the Pondicherry health department and from the Tamil Nadu state department of public health. I must mention here that Dr. V. Sambasivam, Director of Public Health, Pondicherry, was a great source of help and support on all matters connected with the VCRC, including giving land on long-lease for construction of a new building for the VCRC. Similarly, Dr. V. Kapali, the Director of Public Health, Tamil Nadu and Mr. A.V. Ganesan, the then Chief Entomologist of Tamil Nadu, offered unstinting support to the VCRC for its work in Salem and later in Rameswaram, where island malaria was highly prevalent. These studies were taking place simultaneously in these places and the local health departments were helped by the VCRC in controlling malaria. Several papers were published on malaria control.

A few words about sponsored research here. Let us take the example of insecticides in the post-DDT era. So many small companies produce products. They approach the WHO to get them tested. The WHO offers grants to research institutes asking them to test these products. When the institutes accepts these grants and do the work, it is sponsored research. Many universities abroad offer collaborative projects to institutions to get raw material for their research work. Thus, none of the sponsored research does anything which is useful for the country. A lot of time of our scientists is actually wasted in proving hypotheses floated by foreign organizations and such work is actually encouraged by the head of research organizations! We talk about new techniques for control/elimination of malaria/ filariasis -- all sponsored by foreign organizations, including drug companies. Many years ago *Nature* published an article saying that the WHO is a salesman for multinational companies. Collaboration with foreign bodies is considered creditable these days.

It must be mentioned here that in the late 1970s, when I was in Pondicherry, there was an outbreak of Japanese

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

Encephalitis (JE) in Burdwan and Bankura districts of West Bengal, and Dr. Gopalan wanted the VCRC to investigate. This work was done with the collaboration of the School of Tropical Medicine, Calcutta, where the materials collected were tested for virus isolation/ antibodies. A significant finding was that *Culex bitaeniorhynchus* played an important role as vector of JE in certain situations, and that fledgling ducks could also harbour the virus and act as amplifiers in the absence of pigs. Subsequently, the VCRC team led by me also investigated JE epidemics in Tirunelveli district of Tamil Nadu, where the epidemiological situation was similar to that of North Arcot district, which was also investigated by me as part of the team from Virus Research Centre in 1954-55.

In my opinion, a significant and unique work, though relatively small in magnitude, was carried out by Dr. Panikker in Pudukuppam, a coastal village in Pondicherry, where malaria broke out in epidemic form among the fishermen community. On investigation it was found that a sea water--breeding mosquito, *Anopheles subpictus,* found among algae, was the main vector. In fact the mosquito breeding depended on the presence of algae. By motivating the community, algae were removed regularly and the local Aurobindo Ashram made handmade paper out of it. It was a profitable venture for those involved, vector control became a commercial venture on a sustainable basis, and malaria control was achieved. This was technology in action. This actually became a sort of guideline for future vector control operations and was followed very successfully in Shertallai, where a technology-based project was carried out to control Brugian filariasis.

Coming back to urban Bancroft and filariasis, the massive data collected during the two-year study in urban Pondicherry (1975-77) showed that the high microfilaraemia in the population was due to very high biting-density of the vector, *Culex quinquefasciatus,* breeding profusely in open drains, and that drastic reduction in microfilaria rate could be achieved by controlling mosquito breeding significantly. The basic studies carried out were unique, and were patterned after the studies in Rangoon carried out by Hairston, DeMeillon, Jacobski and others. I cannot think of any other study in India or anywhere else similar to this. These findings were utilized for control of filariasis. A five-year Filariasis Control Demonstration Project was launched in January 1981 in Pondicherry and was inaugurated with great fanfare by the then Union Minister for Health, Shankeranand, presided over by the Lt. Governor of Pondicherry, and attended by Prof. Ramalingaswamy, DG, ICMR.

The then Prime Minister of India, Smt. Indira Gandhi, sent a special message. The campaign was planned following Fred Soper's work in the Panama Canal Zone. As Soper had said: "It was not a campaign that introduced new techniques, but a campaign that illustrated what could be accomplished by application of already known techniques, and applying them more vigorously than ever before, coupled with political sagacity and bulldog tenacity."

Essentially, we had planned the project on the pattern of Fred Soper's *Aedes aegypti* eradication project in the Panama Canal Zone to control yellow fever. Dr. P.K. Das was put in charge of this project, with special funding liberally sanctioned by the then DG, Prof. Ramalingaswamy. I was given full freedom to operate (very rare in the present-day ICMR) with full support and no interference. The project attracted worldwide attention and was visited by experts from abroad. For the first time, there was a change in the attitude of WHO. The Vector Biology and Control Division had a new Director, Dr. Chandra Pant. He came and saw the entire operations, which was a special five-year project. He started sending many scientists from South East Asian and African countries to see and learn. For the first time, integrated methods of vector control were used on such a large scale. Many people, particularly our detractors in NMEP (National Malaria Eradication Programme), even ridiculed the venture. The NMEP at that time headed by Dr. G.K. Sharma felt that our work in Pondicherry was doing something unique and which was a challenge to the national programme. But Dr. Ramachandra Rao, the famous malariologist, gave us support and encouragement which we badly needed, by writing to me:

The integrated control and environmental work are most important developments. However, they will require a lot of dedication and hard work. If successful, as they are bound to be, they will be a new watershed in our battle against vectors… They will undoubtedly be expensive in the beginning and will attract adverse comments. Already, some people call it utopian, but all new developments appear to be utopian.

The project was a great success and the results, already published, showed that it is not necessary to eradicate mosquito breeding (which is impossible in Indian urban situations) to eliminate filarial infection. If the biting density of the vector could be drastically reduced by integrated control methods, we could achieve a drastic reduction in microfilarial rate in the community. At the end of the five-year period, there were only three microfilaria cases in children under five years of age! The most important by-product of these studies was the creation of a highly trained cadre of young scientists. In trying to tackle Bancroftian filariasis in most urban situations, it is worthwhile to remember what Sir Ronald Ross said and I quote:

Great is sanitation, the greatest work, except discovery, I think, that a man can do…What is the use of preaching high moralities and policies…to people who dwell in appalling

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

slums? You must wipe away those slums, that filth, these diseases…We shall reach the higher civilization, not by any of the politicians' shibboleths…and the rest, all of which have failed - but first by the scientific ordering of cities until they are fit for men of the higher civilization to dwell in. We must begin by being cleansers.

I was able to show that Ronald Ross was absolutely correct, when we demonstrated the success of his methodology in Pondicherry. Follow-up investigations five years after completion of the cleanup operation produced dramatic results. It showed: (1) that filariasis transmission was reduced to negligible levels and very few new cases of microfilaria carriers were found and (2) in spite of the very poor infrastructure in Pondicherry, integrated vector control methods did result in a drastic reduction of the mosquito population. This was no mean achievement, and the outcome was applauded by both the people and the government of Pondicherry. It was also concluded that, (3) in urban areas with poor sanitation and infrastructure, it was not necessary to completely eliminate the mosquito population; even 60 to 70 percent level of reduction in biting-mosquito density can be achieved mostly by environmental sanitation and manipulation, and this could dramatically reduce the disease transmission rate in an overcrowded urban area. A low-level microfilaraemia in the population can be adequately treated by that wonder drug, Di Ethyl Carbamazine (DEC), used very successively all over the world, either singly or in combination with other antihelminthic drugs, or medicated with common salt.

In Rameswaram Island, drug resistant *P. falciparum* was being transmitted by *Anopheles culicifacies* breeding in innumerable pits where water was being stored for watering coconut plantations. Also the behaviour of fishermen, frequently moving from place to place, meant that they became accidental carriers of the malaria parasite and spread the infection to other communities through their travels. A team of brilliant scientists lead by Dr. Jambulingam (the current Director of VCRC), Dr. Sabesan and others unraveled the modus operandi of the disease transmission and their results were published in the British *Journal of Social Sciences*, at the request of its editor, who also wrote a forward to the article. This island was contributing to more than 20% of all malaria cases in the whole state, and the Tamil Nadu Health Department used it as a model for their malaria control programmes.

After attaining its objectives the Rameswaram field station was closed five years later. This study enabled the Centre to train a large group of young malariologists. Dr. Jambulingam was transferred to an assignment to study tribal malaria in Koraput, Orissa, and Dr. Sabesan to Shertallai in Kerala, to study *Brugia malayi* transmitted filariasis.

The field station in Koraput district, Jeypore, Orissa, was opened in 1985 to study malaria among the tribals there. It was a difficult terrain populated by unsophisticated and sometimes hostile tribals. Malaria due to *P. falciparum* and *P. vivax* had been persistent in this region for many years, with many deaths. Many areas like the Bonda hills were inaccessible. To gain the confidence of the tribals, I appointed a lady doctor, Dr. Govardhini, to attend to all health needs of tribal women, including gynecological care. The VCRC distributed free medicines for all types of illnesses at their doorstep. This helped the VCRC to gain the confidence of the tribals. The team did a lot of excellent work, including finding, in addition *to P. vivax* and *P. falciparum*, several cases positive for *P. malariae* and a few cases for *P. ovals.* This field station was the pride of VCRC because it showed how quality work could be done in very adverse and dangerous situations. We were able to carry out long-term ecological studies on mosquitoes. What was happening was that there were many gametocyte carriers which escaped detection because the area was remote. And the tribals were a fierce people. But under the dynamic leadership of Dr. Jambulingam, excellent long-term ecological studies were carried out. A brilliant piece of work was by Dr. Gunasekharan, whose studies on *A.fluviatilis* were outstanding. This station also helped to train several more malariologists by the VCRC.

The project on Malayan filariasis control in Shertallai, also started in 1985, was initially a Technology Mission Project under the Planning Commission of India from which the VCRC withdrew later, a move fully supported by the then DG, Prof. Paintal. This was due to a lack of understanding of the problem by one of the influential but ignorant bureaucrats who evaluated the progress. Malayan filariasis is caused by a nematode, *Brugia malayi,* and is transmitted by *Mansonia* mosquitoes, which breed in association with aquatic vegetation, mainly of *Pistia* species. The terrain is sandy, being near the coast, and only coconut trees are extensively grown in the area. There are innumerable pits which get filled with rain water and which is the main source of water for the coconut plantations. All these pits supported luscious growth of *Pistia*. The siphons of the larvae of vector mosquitoes are attached to the root and stem of the vegetation for their breathing. If the vegetation is removed, the mosquitoes can't survive. Thus the main strategy adopted was to get the vegetation removed regularly, by the people themselves. They use the vegetation as manure, so a profitable alternative was provided. This was thanks to the National Board for Agriculture and Rural Development (NABARD), which was involved in the program. They helped the villagers find an alternative source of manure for their coconut trees, and the giant *Gourami* was extensively grown in the pits where the *Pistia* plants were once grown.

During the five years, Dr. Sabesan and his colleagues

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

demonstrated total interruption in transmission, by combining vector control through people's participation, along with mass drug administration of a single dose of DEC (mass drug therapy). This was achieved with community participation based on a people's movement named FILCO (Filariasis Control Movement) which took over the day-to-day operations. It was also demonstrated that early stages of elephantiasis could be cured. Massive rallies were organized (similar to the political rallies held these days) propagating community health through community participation. The incentive given was free treatment including for chronic cases. The results were perceptible after five years when the transmission chain was broken and no new microfilaria positive cases were recorded in children below five years of age. The work was published, and universally acknowledged. Thus the Shertallai studies proved a great success; it demonstrated how people's participation could play a role in successfully managing the disease.

The VCRC demonstrated different models for vector control. In Pondicherry, the entire operation was carried out by the VCRC. In Rameswaram, the VCRC controlled malaria with the assistance of the state government, and the success was also repeated with control of urban malaria in Salem and riverine malaria in Sathanur. The coastal malaria control programme in Pudukuppam and the one for *Brugia malayi*-transmitted filariasis in Shertallai were done with community participation and the people shared additional economic benefits. Following these success stories, the VCRC prepared "Master Plans" for vector control in Bangalore, Visakhapatnam, Neyveli Township and Cochin. But unfortunately, these plans were never implemented in any of these places, under one pretext or another. In my opinion there was no political will to implement these plans, which depended more on environmental methods. The insecticide lobby was too strong.

In the early 1980s, VCRC sought and obtained affiliation from both Madras University and Pondicherry University. To fulfill the manpower needs of the country, the VCRC started a two-year MSc Medical Entomology course, with an intake of 12 students per year. The syllabus was carefully drawn up to suit the needs of both research and control of vector-borne diseases. Initially sponsored by the WHO, later on it was taken over by the ICMR. The WHO and some other foreign governments sponsored students from abroad. The Centre was also recognized for the award of PhD degrees in Epidemiology, Medical Entomology, Chemistry, Microbiology and Biostatistics. The faculty included invited guest lecturers and specialists from India and abroad, in addition to the scientists of VCRC. Till 1990, the VCRC turned out more than a hundred MSc and PhDs. Apart from these, there were many training programs in vector control, medical entomology, microbiology, chemistry, etc, which attracted many people from outside VCRC and the rest of India, and from many universities and organizations including the WHO. The WHO had recognized the VCRC, in the early 1980s, as its collaborating centre for integrated methods of vector control.

In conclusion, I would like to state that the duration of my engagement in Pondicherry (from 1975 to 1990) was an era of challenges, and I was entrusted with the responsibility of building up a world-class research institute. I was helped greatly by the then Directors-General, Dr. Gopalan, Prof. Ramalingaswamy, and Prof. A.S. Paintal, whom I rate as three of the most distinguished Directors-General of ICMR, and under whom I had the privilege of working as Director of the VCRC. They never said no to any good suggestions, and adequate powers and finances were given. The deep devotion and dedication to the cause of VCRC on the part of many of my junior scientific colleagues, and the support given by technical and administrative staff, etc., all these made it possible for VCRC to become a world-class research institution. Dr. Paintal, the last Director General under whom I worked, called the VCRC as the pride of ICMR! I am quoting below what two of the great scientists, both Directors-General of ICMR, wrote to me:

The VCRC is one of the most remarkable institutions that has developed, under your inspiration, an ability to link up the science of entomology with environment, the lifestyles of people with public health engineering….I wish to pay a tribute to you and to your colleagues for your dedicated work.

So wrote Prof. Ramalingaswamy on the eve of his retirement on 23 January 1986.

The second one was written by Prof. A.S. Paintal on 29 Oct 1990, on the eve of my retirement on 31 October 1990:

The time has now come to say thank you for your services to the Council and to the cause of science for over three decades. A person of your temperament cannot retire from active work -- nor will it be so in your case. It was your own choice that you are retiring instead of continuing in the Council's service for some more time as we wished. During your tenure at NIV, Pune, GCMU Delhi and at VCRC Pondicherry, you have undoubtedly left a mark of excellence in the scientific activities you undertook, more so during the decade you have headed the VCRC, and brought it up from its small stature to the present giant status recognized both in the national and international spheres. You have clearly established and demonstrated what can be achieved with limited resources, given proper initiative, drive and leadership.

Both these letters were unsolicited.

While working as Director at the VCRC, I became a member of the Scientific and Technical Advisory Committee of the

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928

WHO TDR programme; later, a member of the WHO Expert Committee on Malaria, Filariasis; member of the Steering Committee on Filariasis, and on Biological Control of Vectors. I was also WHO consultant in Indonesia, Vietnam and Sri Lanka. During this association I acquired a fair idea of how the WHO works (which is certainly not very complimentary – their decision-making is as bad as it is in India). But then they pay so well, people vie with one another to join WHO. Many top executives of our government, while in service, make sure they get placement in WHO after their retirement. We have seen national bureaucracy, but WHO is a working example of international bureaucracy, with the donor countries calling the shots. Science has always taken a back-seat at the WHO. The WHO has always operated by consensus. All scientific decisions in the meetings are also taken by voting by participants. I had seen a few participants always would wait till the last minute to see which way the top bosses voted. Science had no relevance at all. But I also came across many honest scientists - and the friendship with these scientists I still cherish. Notable among them was Dr. Mani Pillai, a well-known Professor of Microbiology at the University of Otago in New Zealand. We shared our love for scientific truth and for Indian science.

I retired from service on 31 October 1990, after serving the ICMR (Virus Research Centre, 1953--1970, the WHO--ICMR Research Unit on Genetic Control of Mosquitoes, 1970--1975, and finally the VCRC, 1975--1990) for 38 years. It was a lifetime career full of learning, opportunities and challenges and I enjoyed every year of my work for the ICMR. Since retirement, I have served for nearly a quarter of a century as member of many scientific committees, including my tenure as member of the Scientific Advisory Committee of the VCRC for nearly a quarter of a century, where I have received only goodwill and affection from the Director and scientists.

I have tried to recall my impressions of my scientific career for 38 long years (in service with ICMR) and 20 years thereafter. Starting my career in 1952, when the doyen of Indian scientists and founder Director-General of ICMR, Dr. C.G. Pandit, recruited me when I was just a boy of 23, I have engaged myself in the cause of science for about 60 years now. I have the full satisfaction of having served under no fewer than three of ICMR's greatest Directors General. Another DG, who joined ICMR long after I had retired, a very knowledgeable scientist, is Prof. N.K. Ganguly. I admired him for his erudition and the way he listened to people. He was attentive to the problems of the institutes, and one could have a scientific discussion with him on any subject. I am proud to say that he had high regards for me.

When I retired, I left behind a research institution with highly qualified and competent world-class scientists to run it and with all infrastructures fully developed. I feel proud that I accomplished a lot. I was honoured with many titles and medals - the Om Prakash Bhasin Award; The Charles University, Prague, Gold Medal for Outstanding Research; and the coveted Padma Shri award from the Government of India, all during my stay in Pondicherry. I have received Lifetime Achievement Awards from the Association of Medical Microbiologists of India, from the National Congress of Parasitology, and from the Anna University Department of Biotechnology. I am still engaged in occasional teaching (at SRM University, Chennai) and do write a lot on science, religion and sociology, all for pleasure and to keep my brain active. In 2014, I was honoured by the School of Public Health, SRM University, and Chennai at the First Global Public Health Conference for my lifelong contributions to public health. In January 2016, the National Vector Borne Disease Control Programme and the Indian Association of Epidemiologists, at their meeting at Bangalore, conferred another Lifetime Achievement Award on me. On 27 February 2017, the National Academy of Vectors and Vector Borne Diseases and the Central University of Tamil Nadu at Thiruvarur, at a glittering function, gave me their Lifetime Achievement Award, presented by Dr. Soumya Swaminathan, the Director General of the ICMR.

The one regret I have is that in my country, we just do not have any more visionaries as in yesteryears to guide and direct the institutes. The DGs in my time provided sound advice and directions to all the participating ICMR institutes. My friend, Dr. K.S. Jayaraman, a nuclear scientist-turned-journalist (whom I used to call the Jack Anderson of India) - who exposed what turned out to be a suspected clandestine biological warfare research programme being pursued at the GCMU - used to say that "science is a mug's game in India".

How true it is.

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.201928