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FIELD ENTOMOLOGISTS IN PUBLIC HEALTH?

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Mosquito-borne disease research in India has remained stagnant for decades, and will continue to remain. This is so as the hard work in the field by entomologists has given way to comfortable work in air-conditioned laboratories, with computer as the main tool. Critical reviews are being written by men not of science, and also others, but our government totally ignores them.

There are many vector-borne diseases (VBD) prevalent in India apart from malaria and filariasis, such as the Kyasanur-forest disease (KFD), Japanese encephalitis, scrub typhus, dengue and chikungunya. The control of all of them depends on an understanding of the natural cycles and epidemiology of their vectors. Malaria, for example, is ideal model system for explaining VBDs, because quite a lot of fieldwork was done by scientists all over the world. Notable among them were Fred Soper, Paul Russell, Thammajirao Ramachandra Rao, and several others in preindependent India. Their endeavours had led to a clear understanding of the ecology and behaviour of the vectors involved, which helped in devising appropriate management measures.

The most important landmark in malaria control was achieved by biologists and naturalists with a deep understanding of the environment. The first and foremost among them was Ronald Ross, who discovered that mosquitoes transmitted malaria in 1897, who showed that the transmission was very significantly influenced by many factors, including human activity. The relationships between vector control and transmission among the mosquito vector, the parasite, the environment, and the behaviour of human carriers have been extensively studied by many in the preindependence days. They laid emphasis on the environment and how it contributed to malaria, as indeed all the other vector-borne diseases. The studies covered local vectors, ecology, demography, agriculture, and so on. They found that local environmental conditions contributed to the disease, especially in specific zones and the link between parasite transmission and vector control predicated a need to understand the other factors that led to malarial transmission. Paul Farr Russell was one of the pioneers, who studied malarial transmission. Nicolaas Hendrik Swellengrebel coined the term 'species sanitation' to link the carrier anopheline species with specific habitats, which explained the connection between ecology and malaria. Factors such as availability of local vectors, ecology, demography, race and culture of humans were identified as key players in the transmission of the disease. According to Ross, what was required was not the total elimination of mosquitoes, but a reduction in their numbers below a threshold, now referred as 'critical density'. Ross also identified the 'human factor' in the transmission. Malcolm Watson of the Federated Malay States (presently Malaysia), Paul Russell and T Ramachandra Rao in India demonstrated for the first time the validity of critical density of the vector.

In preindependent India, most of the notable contributions were made by scientists such as Muirhead Thomson in Assam, Robert Knowles Ronald Senior-White and colleagues in Orissa (now Odisha), Mandayam Osuri Tirunarayana Iyengar and R N Sen in Bengal, Russell and Ramachandra Rao in South India, D K Viswanathan and Ramachandra Rao in the old Bombay State, and B Ananthasamy Rao in the erstwhile Mysore State. They contributed considerably to our understanding of the bionomics and ecology of vectors such as *Anopheles culicifacies*, *A. stephensi*, *A. minimus*, *A. fluviatilis*, *A. philippinensis*, and *A. sundaicus* (Diptera: Culicidae). In India, the time between 1930 and 1945 could be regarded as the golden era of studies on the bionomics and ecology of malaria vectors. The work by the Malaria Institute of India under the leadership of Gordon Covell needs to be remembered in this context. During the late 1930s, Russell and Ramachandra Rao used pyrethrum as a space-spray against anophelines in the malaria-affected areas of Pattukkottai (Thanjavur district, Tamil Nadu) where irrigation practices were defective. Pyrethrum sprays were used within human residences against the

adult *A. culicifacies*. Spraying of pyrethrum extracts as mist inside human dwellings during daytime killed the resting adult mosquitoes. They extended their work to North Kanara district of the old Bombay State in 1945, a high malaria-prone area. Then DDT appeared on the scene and revolutionized malaria management when it was sprayed on the walls and ceilings of human dwellings because the vector mosquito rested there after an infected blood meal. This method was successfully used to protect civilian populations by Viswanathan and Ramachandra Rao in North Kanara in 1945 and Senior-White in Odisha. Almost simultaneously, B A Rao and his team trialled it successfully in other parts of the country. In 1946, Viswanathan and Ramachandra Rao launched one of the largest malaria control projects in the rural India, seeking to protect over a million humans in the North Kanara and Dharwar Districts in the erstwhile Bombay State, and it proved a crashing success. DDT sprays were ineffective here, because the vector *A. fluviatilis* usually rested outsided human residences.

During the initial years, the control programme was a tremendous success, and was hailed all over the world. All other methods of mosquito larval control, such as the use of *Gambusia affinis* (Cyprinodontiformes: Poecilidae), larvicides such as the Paris green, and environmental management were given up as they did not seem necessary. But in the mid-1960s, malaria came back with a bang. Owing to the euphoria created by the success of vector management of the early 1960s, malaria research, which should have been continued, had practically come to a standstill. The Indian Journal of Malariology, a well-respected professional journal, had apparently lost its relevance and ceased publication.

Work of Amar Prasad Ray, the architect of India's successful malaria control programme, matched the classic work of Fredrick Lowe Soper, American epidemiologist, who led the successful malaria control programme in the Panama Canal zone in the pre-DDT era. But Ray failed us in the most important aspect. He relied much on the efficacy of DDT and could not foresee vector adaptation to the chemical's pressure. But insect resistance to synthetic chemicals was not known then. The initial success of DDT made him think that there would be no further need for entomologists in mosquito control work. Many were either diverted to family-planning operations or had their services terminated. Only the junior-support field staff were continued with DDT-spraying programme. For this policy decision, India paid a heavy price. There were no trained scientists left to quantify the extent of damage done by DDT-resistant vectors and reinstate a policy to minimize damage.

As Ray himself pointed out, all major malaria vectors in the country became resistant to the two commonly used and comparatively inexpensive insecticides, the DDT and benzene hexachloride (BHC). When the incidence of the disease was at its lowest in 1964-1966, slackness in the allocation of funds and procurement of insecticides strongly prevailed, leading to inadequate and untimely spraying in India. India, like many other developing countries, almost and always followed the advice of the World Health Organization (WHO). The WHO recommended organochlorine insecticides (e.g., DDT, BHC) first, then organophosphorous insecticides (e.g., malathion), then carbamates, followed by synthetic derivatives. Newer methods of application were suggested with the existing insecticides. Use of insecticide-impregnated nets (IIN) or variations of it were recommended by the WHO. These were supplied by multinational companies, enabling them to make big profits. However they financed research projects in India through the WHO. Many foreign universities sought collaborations with Indian institutions. There were also field trials with different kinds of prophylactic drugs. The present-day malarial mosquito research has been going on for the last two or three decades, with scarcely anything of significance coming out of it.

Vaccine for malaria? How do we vaccinate our rural populations, about 300 million of who live in areas where they are exposed to infection? How long will it take for the best of vaccines to provide even partial immunity to our vulnerable population? Why do we find mixed infections with two or three species of parasites in the blood of the same individual? Immunity from the malarial parasite is incomplete, so the vaccine has to be excellent. Even the most severe case of naturally acquired malaria does not protect most people from a second round of infection. In 1980s, Adetokunbo Oluwole Lucas of Nigeria, then Director of the WHO Tropical Diseases Programme, in an informal discussion with the WHO Expert Committee on Vector Biology and Control in Geneva, commented that a "malaria vaccine was just round the corner, and the committee will be able to concentrate on the problems of the other vector-borne diseases within a foreseeable future or the committee can wind up their effort and simply go home". Lucas was well aware how much money was being invested on this research worldwide, especially in the United States, which had an abundance of expertise

and resources. More than 50 years later, we are no nearer a breakthrough, despite many of the world's leading institutions working towards a vaccine. It is possible that the microbiologists and immunologists will ultimately be able to produce such a vaccine but, highly likely we may need to wait for many more years. Undoubtedly, research on this subject has to be greatly accelerated and financially supported. But the interest of governments and public health professionals in effective malaria management has waned, same with Japanese encephalitis, dengue, and chikungunya, whereas recently the pandemic of Covid-19 has caught up with everyone's attention!

Lack of a trained humanpower to execute any meaningful research is the stark reality of the day. The work culture almost everywhere in India, including in research institutions specially created for research on vector-borne diseases, has lost its momentum owing to neglect, ignorance, and poor planning. Medical entomology in early days was pioneered by trained personnel equipped with instinctive knowledge on developing tools to prevent the spread various vector-borne diseases. Their expertise was critical in guiding vector management. Scientists toiled in the field, in rain and shine, to gather most-essential and basic information on mosquito behaviour and which anti-mosquito tools to be applied. The late T Ramachandra Rao wrote the trailblazing Anophelines of India.

Lack of appropriate measures to management of many of the Indian endemic diseases because of the ineffective application of known procedures and unwillingness to address the root causes of failure. Our management efforts need focus on operational investigations. Prompt diagnosis, immediate hospitalization, and supportive treatment of the afflicted are direly necessary. The WHO has to take the major blame for the failure of mosquito management over the years. There was a Vector Biology and Control (VBC) division with the WHO, which did high quality work in the past. This was renamed the Division of Molecular Entomology, presumably with vaccine development in view. The outcome changed unfortunately from the field-oriented work to a laboratory-oriented work. In many medical research institutions, the entomology division has been either progressively downgraded or systematically disbanded.

The National Vector Borne Disease Control Programme in India has been facing a staff crunch—many positions of entomologists remain unfilled. In 1985, the Vector Control Research Centre in Pondicherry started a 2-year master programme in Medical Entomology, initially supported by the WHO. The programme generated many well-trained entomologists. But it was discontinued in the late 1990s, because the graduates hardly found jobs in India. Another master programme in Public Health Entomology, was started a few years ago in the same institute. This programme may also be abandoned soon as the awarded title has not yet been recognized by any of the potentially employing institutions.

The epidemiology of any vector-borne disease is complex. The parasite or pathogen (be it a virus, a bacterium, a protozoan or a helminth), the mosquito, the human victim, and the environment are intimately interconnected. In the instance of malaria, four (now five) species of human plasmodia with differing biologies are involved, and so are the vectoring anophelines, each with its own peculiar bionomics and ecology. Human susceptibility to the disease also varies with the environment, race, and culture. And finally, the environment has an infinite variety of features. Most of the arbovirus diseases are zoonotic in their origin. The latter does not figure in today's research priorities in India. In the instance of two common vector-borne diseases, dengue and chikungunya, although there is evidence of a zoonotic cycle, no meaningful work has been done. The KFD-transmitted by ticks-and the scrub typhus-transmitted by mites-are reemerging in India. Birds and bats, both small and large, and wild and domestic, are involved in the transmission. The forest is one environment with many-unknown-vectors.

We can only aim at managing VBDs because their total eradication is almost impossible. The key is to hold the vector population below a threshold. To do this, we must know all aspects of the vector populations and their buildup, their drivers, further to the environment and human ecology. The role of field entomologists is absolutely crucial in VBD management. But it looks like field entomologists have lost their criticality in modern India, where they are subjugated by medical professionals and microbiologists, to whom 'field work' is an anathema!