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Epidemiology of Malaria in the Philippines*

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THE epidemiology of malaria in the Philippines, although a relatively simple matter, is yet a subject of unusual interest. In the first place, classical references to the "marsh dragon," to paludic coastal swamps and stagnant pools, have no application in this country. Paradoxically, not low-lying but well drained areas are apt to be malarious, a fact recognized soon after the American occupation but overlooked and rediscovered several times. This is a second point of interest, namely, that standardized accounts of etiology have diverted the eyes of observers so that obvious facts have been discounted and the significance of the stream breeding vector of malaria sometimes entirely missed.

There are very few references to malaria in the Philippines prior to 1898, when the United States assumed responsibility from Spain. It can be said with reasonable certainty, however, that malaria was indigenous in 1521 when Magellan went to the Islands, and that it has remained prevalent. But there is nothing in the records to suggest that this disease ever has been such a menace to life and health in the Philippine Archipelago as it has been in nearby Dutch and British Malaya and in India. In particular, the largest cities, such as Manila and Cebu, have always been free of malaria. The fact that officials have resided largely in such non-malarious communities, where in the past cholera, dysentery, and smallpox were destroying their thousands annually, led to a belief that malaria was neither widespread nor important. This view still prevails and has handicapped efforts toward control, for, although malaria is not first in importance, it certainly belongs to the leading quartet of diseases and is doubtless responsible for some 10,000 to 20,000 deaths annually in a population of approximately 13,000,000. No reliable statistics are available, but it seems likely that there are at least 2,000,000 cases of malaria each year throughout the Islands.

Surveys have been made from time to time which bear out this estimate.

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For example, Barber and his colleagues [1] visited 14 provinces, examined over 4,000 blood smears and made over 5,000 spleen palpations. They found a parasite index of 11.0 per cent, and a spleen index of 13.3 per cent. Holt and Russell [2, 3] made 8,791 spleen examinations in 32 provinces, finding a spleen index of 18.8 per cent.

Recorded malaria mortality rates have fallen markedly in the Islands. For example, there were in 1905, 662 malaria deaths per 100,000 of population; in 1915, 297; in 1925, 218; and in 1932, 77. There is no evidence that larva control, quinine consumption, or use of bed-nets has been responsible to any great extent for this improvement. Doubtless more doctors and better hospital facilities have had a marked influence. Moreover, malaria control work on certain haciendas and at Army posts must have had some effect; but certainly the seemingly rapid decline in malaria deaths from 233 per 100,000 in 1924 to 77 in 1932 cannot be attributed, in my opinion, to the sharply limited malaria control program of the Bureau of Health. Probably changed diagnosis has been a large factor, as noted by Manalang.[4]

INSECT HOST

There are 25—in fact probably at least 28—species of Anopheles in the Philippines. The most recent list is that of Russell and Baisas [5] which gives the following species:

ANOPHELES IN THE PHILIPPINES

1. *A. aitkeni* var. *bengalensis* Puri, 1930
2. *A. annularis* van der Wulp, 1884 (Formerly called *fuliginosus*)
3. *A. baezi* Gater, 1933 (This may not be true *baezi* but a closely related variety. It is certainly not *umbrosus* as formerly called)
4. *A. barbirostris* van der Wulp, 1884
5. *A. filipinae* Manalang, 1930
6. *A. gigas* var. *formosus* Ludlow, 1909
7. *A. hyrcanus* var. *nigerrimus* Giles, 1900
8. *A. hyrcanus* var. *sinensis* Wiedemann, 1928
9. *A. insulaeflorum* Swellengrebel and Swellengrebel de Graaf, 1920
10. *A. karwari* James, 1903
11. *A. kochi* Dönitz, 1901
12. *A. kolambuganensis* Baisas, 1931
13. *A. leucosphyrus* Dönitz, 1901
14. *A. lindesayi* var. *benguetensis* King, 1931
15. *A. litoralis* King, 1932
16. *A. ludlowi* Theobald, 1903
17. *A. maculatus* Theobald, 1901
18. *A. mangyanus* Banks, 1907
19. *A. minimus* var. *flavirostris* Ludlow, 1914
20. *A. parangensis* Ludlow, 1914
21. *A. philippinensis* Ludlow, 1902
22. *A. pseudobarbirostris* Ludlow, 1902
23. *A. subpictus* var. *indefinitus* Ludlow, 1904
24. *A. tessellatus* Theobald, 1901
25. *A. vagus* var. *limosus* King, 1932

Three undetermined species were also mentioned in the list.

This is an imposing array, but to date only 2 of all these anophelines have been incriminated as vectors of malaria. These are *A. minimus* var. *flavirostris* and *A. maculatus*. Manalang [6] reported over 50,000 dissections of various Philippine wild-caught Anopheles, only *A. minimus* being found infected (" excepting a heavily infected stomach of *A. vagus* Dönitz, out of over 10,000 dissections of this species "). King [7] reclassified the *funestus-minimus* sub-group, and it seems probable that Manalang's infected *minimus* mosquitoes were *A. minimus* var. *flavirostris*. King and Russell [8] reported discovering the latter species infected in 2 instances and I have since amply confirmed the fact that it is indeed a carrier, finding it infected in nature with sporozoites in the salivary glands 10 times in 3,242 dissections (0.3 per cent). On epidemiological grounds also Holt and Russell [2] concluded that this species is the chief vector. As regards *A. maculatus*, Ejercito [9] has found it infected in nature up to 0.3 per cent in one locality. But it is chiefly a zoöphilous species and seems rarely to have spread malaria in the Philippines.

Apparently the chief factors involved in making an anopheline a purveyor of malaria are: (1) its relative prevalence, (2) its susceptibility to infection, (3) its house frequenting habits, and (4) its feeding proclivities. *A. minimus* var. *flavirostris* satisfies all of the criteria fairly well but not superlatively so. In the first place, it is prevalent in all malarious areas of the Islands. In the second place, Walker and Barber [10] found that their *A. febrifer,* which I believe was chiefly *A. minimus* var. *flavirostris,* was the most susceptible species tested by experimental infections. Thirdly, although *minimus* var. *flavirostris* is rarely taken in houses in the daytime,[11] night-catching experiments [12] and catches in mosquito nets poorly constructed or used,[1] indicate that this species certainly frequents houses at night. Finally, as regards its food preferences, Laurel [13] has shown by precipitin tests that it will feed with about equal avidity on either man or water-buffalo. In fact, it may imbibe blood at one time from man and at a subsequent feeding from a water-buffalo.[14] Thus it is not difficult to understand, in the first place, why it is the chief carrier and, in the second place, why it is only a moderately potent one. If it were decidedly androphilous, instead of being somewhat indifferent as to whether or not it will take man's blood, doubtless malaria would be a much more serious matter in the Philippines.

As to other habits of this chief carrier, Manalang [4] has shown that it bites quietly at night, causing such a faint skin reaction that in the morning one may find no evidence of its depredations. Russell and Santiago [15] have shown that it can fly up to 2 kilometers but it seems unlikely that its effective flight range is often over 1 kilometer.

Its preferential breeding habits are of great interest. *A. minimus* var. *flavirostris* breeds chiefly in small streams and flowing irrigation ditches, more often in shady than open places, and in clear rather than in turbid water. Clean, fresh, flowing, and slightly shaded water is distinctly preferred, especially if bamboo roots are available for sheltering larvae. Occasionally it has been found in wells and pools but never in brackish or sea water, never in rice fields, and never above 2,000 feet altitude.[2]

Thus malaria in the Philippines is chiefly prevalent in the foothills. Coastal swamplands, flat agricultural plains, and high plateaus are definitely not malarious, but wherever there are foothills drained by small streams there malaria is found. When these streams are flushed out by heavy rains, or when they become dry, malaria transmission ceases because the vector is not being propagated. Hence it is correct to state that malaria is a disease of transitional zones and transitional seasons. That is to say, it is found in that belt of land between plains and mountains, namely, the foothill zone, and is most abundant in those seasons, twice a year, between the wet and dry months. Where there are no pronounced wet and dry periods, malaria is perennial.

It seems highly probable that this band of foothill malaria, separating lowlands from mountains, has in the past been the chief reason why people of the hills were kept distinct ethnologically from those of the plains. In days of slow and laborious transport when lowlanders tried to penetrate the foothill jungles, they were turned back by malaria. So, too, mountain folk who tried to descend through the zone of *minimus* var. *flavirostris* were deterred by this disease bearing insect.[16]

It is notable that as far back as 1904 Crosby and Whitmore [17] of the

Army recorded at Fort Stotsenburg that malaria was associated with running and not stagnant water. Craig[18] in 1909 referred to the foothills as being malarious. Whitmore[17] in 1904 made what were undoubtedly the first dissections of Anopheles in the Islands, and he noted that 30 per cent of what he called *Myzomyia funesta,* in 200 specimens were infected. He concluded that *Myzomyia funesta* was probably " the one mosquito that carries malaria infection at this station." It seems very likely that he was dealing with *minimus* var. *flavirostris* for I have found this species in the stream breeding places he described at Stotsenburg.

These careful studies by Whitmore were made only 6 years after Ross's discovery but unfortunately were never published. They were buried away in the medical record book of the Fort. Here was the key to the malarial situation not only at Stotsenburg but throughout the entire archipelago. It remained hidden for 10 years, and even at the Fort in the same record book we read, in later pages, of " stagnant water," " pools," " tin cans," and " bamboo joints," as " breeding places for malarial mosquitoes." In 1914 Walker and Barber[10] rediscovered this basic fact in the epidemiology of malaria in the Philippines. But although their report was published, another 10 years passed before the Bureau of Health could cast aside ancient ideas of malariogenic stagnant water and marsh land. Even as late as 1921 the annual report of this bureau referred to malaria as " due to the continuous standing of stagnant water in the rice paddies and the thick vegetation surrounding almost every district and barrio." Not until 1925 was any malaria control in the Islands based definitely on this fundamental fact that the disease is carried by a stream breeding anopheline found only in the foothills.

PLASMODIA

All 3 common species of plasmodia are found in the Philippines. Holt and Russell[2] found in 544 positives among 2,302 examinations the following species percentages:

P. vivax	60.3
P. falciparum	34.9
P. malariae	1.1

Thus it would appear that quartan malaria is uncommon. Craig[19] has noted that in 1900 he found *P. ovale* in the blood of soldiers returning from the Philippine Islands. It has not been reported again, nor have *P. tenue* forms been encountered.

BLACKWATER FEVER

Blackwater fever has been very uncommon in the Philippines. Craig[20] noted its almost complete absence. Stephens[21] recorded a few cases. My own surveys in all but 2 of the 49 provinces led me to believe that while blackwater fever definitely does occur in the Philippines, it is a rare disease.

MALARIA CONTROL

As early as 1906 the Bureau of Health in the Philippines, aided by schools, post offices, and prominent citizens, facilitated free distribution of quinine in malarious districts. A vigorous educational campaign was carried on through schools. What was gained from this attempt to control malaria by drugs, no one knows. But the 1912 report of the bureau stated that it was " impossible to say whether quinine had influenced the death rate or not." Later, the 1914 report stated that " at best, of course, quinine distribution can only be palliative and the problem resolves itself into preventing the breeding of mosquitoes that carry malaria." There is no indication that drug prophylaxis has been successful in the Philippines any more than elsewhere. Costs of such control and practical difficulties of distribution are always serious handicaps. Recently a successful attempt has been made to cultivate cinchona in the Islands and it is planned to make totaquina as a cheap febrifuge.[22] There, as elsewhere in the tropics, quinine is a "rich man's remedy" and most country people are unable to purchase it in therapeutic doses. Such efforts to provide cheaper quinine are laudable in that they reduce suffering and death; but malaria is not yet controllable with drugs.

Mosquito nets were used by the Army from the first days of occupation, but the early netting was usually of 14 mesh, size and quality being poor. Moreover, in the field, soldiers tended to neglect such prophylaxis. Yet there is evidence that subsequent to 1906, when these nets were improved, this method of prophylaxis materially lowered malaria morbidity rates of the Army.[17] Recently there has been an attempt to popularize nets made very cheaply from hand-woven native simamay cloth.[23]

As to fish, Seale[24] introduced *Gambusia affinis* into the Hawaiian Islands from Texas in 1905 and from thence to Manila in 1913. These fish have persisted in artificial ponds at the Bureau of Science but have disappeared elsewhere and have been of no value at all against malaria.

Paris green seems most suitable in the Philippines for combating this disease. It was first suggested for local use in 1915 by Barber.[1] He and his colleagues concluded as regards control that

> . . the best single measure is the destruction of larvae of malaria carriers, and in this work the breeding places of the stream-breeder should receive first attention. Our own experience and that of others in the destruction of stream-breeders by means of larvicides leads us to believe that this measure is a practical one in the Philippines and that it is within the means of many malarious communities in the archipelago to reduce the amount of malaria by this measure.

Nothing was done to follow out these suggestions until years later when the Army began to use Paris green at Fort Stotsenburg. The success of this work has been notable.[17] Malaria admissions to the Stotsenburg hospital dropped from 415 in 1924, to 10 in 1930, with nearly the same strength of personnel.

At the Iwanig Penal Colony by the Bureau of Prisons, and on several haciendas, Paris green has been used to good advantage so that, although the Bureau of Health has shown no enthusiasm for larvicides, it seems clear to most observers that the only hope of effective malaria control in those places in the Philippines where finances permit it, is through systematic destruction of the larvae of *A. minimus* var. *flavirostris*. The cost is not beyond the means of numerous malarious communities.

However, it appears to be true that, economically, malaria prophylaxis in much of the rural tropics is not feasible. Many barrios in the Philippines, for example, could not afford more than $.05 per capita per annum for malaria control. So far as I know malaria has never been controlled in rural areas for so little. In the United States costs average $.70 to $.80 per capita the first year and from $.20 to $.30 thereafter. In the Philippines costs have not been below $.25 per capita per year and usually have been higher.

The longer one observes malaria in the tropics the more one is forced to conclude that, so far as average rural areas are concerned, the problem of control is still unsolved. Malaria prevention in the tropics by means of drains and subsoil pipes, larvicidal oil, and Paris green is entirely feasible at the present time, without further research—in cities, organized industrial and agricultural centers, such as mines, rubber plantations, sugar haciendas, and tea gardens, in military cantonments, in communities of government employees or prisoners, and in certain prosperous rural towns; but for most malarious rural areas in the tropics it appears that we have no economically feasible control methods. In such places naturalistic or biological methods eventually may prove to be useful. Such devices as automatic flushing or sluicing of small streams as practiced by Scharff in Malaya, salting a marsh as done by Hackett in Albania, intermittent irrigation of rice fields as tried by Drensky in Bulgaria, cultivating shade vegetation as by Ramsay in Assam, and altering the flora of fish ponds as done by Walch in Java—all these methods and others come under this heading of naturalistic control.

It may be recalled that Ross's discovery led to the dictum "No mosquitoes—no malaria." Grassi and his Italian colleagues narrowed this to "No Anopheles—no malaria." But anopheline species are so numerous that it is an impossible aim to destroy even all Anopheles. So the great German Koch said, "Ignore the mosquito. Sterilize the blood of man, then mosquitoes cannot become infected." This seemed relatively simple but proved to be impossible. So far as I know, the drugs quinine, plasmochin, and atabrine have never eradicated malaria from an area or even from a single town. It may be that synthetic remedies, easy to take, quickly effective, specific against sporozoite, schizont, and gametocyte alike, may some day be manufactured. Koch failed with quinine, and just about this time, when the whole problem seemed insoluble, Watson in Malaya came along and said, "Species control. Ignore all Anopheles except the carriers." This idea was brought to the United States by Darling and has been used widely against *A. quadrimaculatus* in the South. Elsewhere throughout the world it has been most useful.

Even species control is impossible for economic reasons in much of the rural tropics, if the usual larvicides or ditching are used in the ordinary ways. So now malariologists are investigating naturalistic methods of species control in the hope of finding cheap automatic procedures, especially those which will lead directly to improved agricultural yields. To such methods the rural tropics must turn.

Dependence must be on time rather than money, and malariologists in the tropics must visualize inexpensive but continuous programs extending over decades of time. Perfection and speed in any line of human endeavor are expensive. Certainly, this is true of malaria control programs. It is probably a mistake for the tropical malariologist to strive for perfection, because the tropics are too poor to pay for it. Rather there must be constant striving for continuity of modest effort. *Time* more than *Money,* and *Continuity* rather than *Perfection*—these must be the mottoes guiding malaria control in the tropics.

So, if in the Philippines there has been very little malaria control, except in military and hacienda communities, the reason lies only partly in official apathy. It is partly because we do not yet know how to control malaria in much of the rural tropics at a cost the people can bear.

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NOTE: The author from 1929 to 1934 was director of Malaria Investigations, Philippine Islands, a project jointly supported by the Bureau of Science, Manila, and by The Rockefeller Foundation.

The Science Researcher

"WHAT determines the rank of the science researcher is the uncolored virginity of his approach, free even from sympathy with his own hypothesis, ruthless toward any attempt to implicate his findings with their effect on a possible bystander. The moment he takes the bystander into account, or attempts to interpret discovery in terms of the average mind, he must abandon this fine inviolateness and shift his facts so that they are patterned around the lacunae in the minds of his audience rather than by their intrinsic relation to discoverable truth. The scientist who does this once, successfully, will not be able to resist the temptation to do it again, and after a third time it will be left for his brother scientists to remark that the chilled edge of his mind never comes back to him."—Mary Austin, in *The Humanizing of Knowledge,* by James Harvey Robinson, 1924.