Susceptibility of Anopheles Quadrimaculatus To Korean Vivax Malaria

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During the summer of 1951, it became increasingly evident that many of the troops returning to this country from Korea were relapsing with malaria. In a personal communication dated September 15, 1951, Dr. Tom Whayne, of the Division of Preventive Medicine, Department of the Army, stated that during the 14-month period ended August 31, 1951, 6,642 cases of malaria had been reported in 100,618 individuals returned from the Far East Command, a reported incidence of 6.6 percent. The case histories indicated that the malaria was acquired in Korea.

The possibility of foreign malarias becoming established in this country is of vital concern to all health officials, especially at the present time, because of the current low incidence of indigenous malaria and the hopeful and progressive signs of its eventual eradication.

The object of the present study was to test the ability of the most important native malaria vector, *Anopheles quadrimaculatus*, to become infected with and to transmit the malaria relapsing in returned troops.

Methods

Veterans with clinical symptoms and positive blood smears volunteered for the tests. Only those soldiers whose histories indicated that their malaria had been acquired in Korea were used in the experiment. Fifty-three patients were tested.

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Table 1. Malaria infections in *A. quadrimaculatus* mosquitoes infected by biting 35 soldiers relapsing with *vivax* malaria acquired in Korea

Patient No.	Mosquitoes fed upon patients			Oocyst per infected gut (average)
	Number dissected	Number infected	Percent infected	
K–2	23	8	35	1. 0
K–3	14	4	29	1. 0
K–6	29	18	62	7. 9
K–10	13	4	39	1. 6
K–13	24	19	79	127. 0
K–14	22	21	96	261. 0
K–15	32	32	100	58. 0
K–17	20	12	60	2. 6
K–18	20	2	10	2. 0
K–19	20	19	95	27. 0
K–20	20	14	70	2. 9
K–21	20	1	5	1. 0
K–23	20	16	80	4. 8
K–24	39	36	92	267. 0
K–26	20	4	20	3. 0
K–29	27	24	89	13. 4
K–32	22	21	96	12. 2
K–33	43	40	93	38. 2
K–34	20	2	10	1. 0
K–35	20	15	75	111. 1
K–36	21	12	57	4. 6
K–38	20	15	75	13. 3
K–39	33	30	91	16. 8
K–40	20	12	60	3. 0
K–42	44	43	98	156. 7
K–43	20	16	80	16. 6
K–44	21	15	71	8. 0
K–45	20	2	10	1. 0
K–46	22	20	91	18. 2
K–47	25	24	96	35. 2
K–48	23	11	48	3. 9
K–50	10	10	100	43. 2
K–51	20	10	50	3. 3
K–55	25	8	32	2. 4
K–57	21	21	100	124. 0
Total	813	561		
Average	23. 2	16. 0	65. 5	39. 8
Median	21	16	75	8

A. quadrimaculatus, Q–1 strain, were allowed to obtain a single blood meal by biting the soldiers before treatment for malaria was started. The insects were then incubated at 76° F± 2°, at a relatively high humidity. Dissections were begun 6 to 8 days after the blood meal, to determine if malarial oocysts were present on the gut. If a group of mosquitoes proved to be infected, either moderately or heavily, some of the mosquitoes were incubated several days longer and then dissected to determine if sporozoites were present in the glands.

At least 10 mosquitoes from each group were dissected; the usual minimum number was 20.

Observations

Plasmodium vivax was the organism found in all the infections observed. Of the 53 patients tested, 35 (66 percent) were infective to *A. quadrimaculatus* (table 1); 18 lots of mosquitoes (1,192 individuals) showed no infection after biting the remainder of the patients in the tested group.

Some of the mosquitoes showed extremely heavy infections; those fed upon patient K–24 averaged 267 oocysts per gut. The infection in the mosquitoes followed a fairly normal pattern and completed the cycle, with sporozoites demonstrated in the salivary glands. The infected mosquitoes transmitted the malaria to persons with neurosyphilis when the latter were exposed to their bites.

Discussion

Malarial infections in the troops tested were undoubtedly delayed primary attacks or relapses, probably the latter. The histories indicated that the relapsing patients had been in Korea during the malaria season of 1950 or 1951, usually the former year. A single tablet containing 0.5 gm. chloroquine diphosphate (equivalent to 0.3 gm. of the base) had been given weekly as a suppressive treatment (*1*). Sometimes this weekly dose was missed because of the exigencies of battle. As a rule, the first frank attack of malaria did not occur until suppressive drugs were discontinued, either during or after the soldier's return to the continental United States.

The military personnel tested by us were bitten by mosquitoes within a few hours after a definite diagnosis of malaria was made. Two-thirds of them were infective to mosquitoes, about one-half of them highly so. Past experience (*2*, *3*) has shown that malarious patients may be infective to mosquitoes for several days before the first frank malarial paroxysm or during asymptomatic periods. Therefore, it is likely that some of these soldiers were capable of infecting mosquitoes before a diagnosis of malaria was made.

It is evident from our results that the malaria in returning troops is infective to a mosquito vector. The pattern of the relapses so far is such that most of them occur during the malaria transmission season in the United States. As a result, the potential exists for the establishing of foci of malaria. On the other hand, because of the present awareness of this danger by local, State, and Federal health authorities and by the officials of the armed services, who are employing control measures in the vicinity of hospitals, the danger of establishment and spread of this foreign malaria is greatly lessened. The weakest link in this chain of protection is the individual veteran who has malaria. The Korean veteran with whom we have had contact does not seem to be as well indoctrinated as the veteran of World War II in the possibility that he may develop or relapse with malaria. When the World War II veteran relapsed, he would often suggest malaria to the physician as the cause of illness, but, in general, the Korean veteran does not appear to have this awareness of malaria. However, the Army recently has begun to inform veterans returning from Korea that they may develop malaria. These troops are given a prepared statement to that effect, to be presented to a doctor if malaria symptoms occur.

The relapse pattern suggests that the Korean *vivax* malaria differs from the South Pacific malaria which was imported following World War II. At present, studies are under way to determine certain biological phenomena of the Korean malaria, such as characteristics of the primary infection, natural and acquired immunity, and the comparative infectiousness of Korean malaria to various vectors.

Summary and Conclusions

1. Fifty-three returned veterans with *Plasmodium vivax* infections, apparently of Korean origin, were bitten by *Anopheles quadrimaculatus* mosquitoes. In 35 of these cases the mosquitoes developed malaria.

2. The *A. quadrimaculatus* mosquitoes appeared to be highly susceptible to the malaria tested; in favorable cases, 100 percent of the insects were infected; and the infections developed to maturity. Transmission to susceptible persons by mosquito bites was successful.

3. The potential for the establishment of foreign malarias is present. The weakest link in the chain of control is the apparent lack of appreciation of the danger of relapse with malaria on the part of the infected veteran. With the present awareness of the danger by health authorities and officials of the armed services, the chances of this malaria becoming established are greatly lessened.

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Radiological Health Training Courses

Training courses in radiological health will be given by the Public Health Service at its Environmental Health Center in Cincinnati, Ohio, beginning January 21, 1952. The program has been instituted to aid professional workers in the related fields of radiation to achieve a broader understanding of its hazards and problems.

Candidates should have a degree in medicine, engineering, physical science, or biological science, and experience in work relating to public health.

Basic courses are scheduled for January 21 to February 1, March 10 to 21, and April 21 to May 2, 1952.

Intermediate courses are scheduled for February 4 to 15, and May 5 to 16, 1952.

The subjects outlined for the basic course are the theory of radiation and detection instruments, use and maintenance of instruments for measuring radiation, the detrimental effects of radiation, methods used for protection and shielding against radiation, and the recommended permissible dosage.

Intermediate courses for those having completed the equivalent of the basic curriculum provide 2 weeks of training in the operation, maintenance, and repair of radiation detection devices used in the monitoring of personnel and in the monitoring of water, food, and other samples.

Additional information concerning the curriculum and application procedure may be obtained from the Chief, Radiological Health Training Section, Environmental Health Center, 1014 Broadway, Cincinnati 2, Ohio.