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# Schistosomiasis and the Philippine campaign

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**Abstract**

Schistosomiasis is an infection with one of a series of related trematode parasites that are endemic to at least 76 tropical and subtropical countries. Schistosomiasis affects over 200 million people in tropical and subtropical regions of South America, Africa and Asia. This paper reported more than 1500 soldiers of US troops and 560 men of Australian Air Force were affected schistosomiasis japonicum in the Leyte of the Philippines during the liberation of the Philippines from Octorber 1944 to the early months of 1945. Many troops there were affected by contaminated water with snail hosts. At first, the medical corps knew little about the situations of the schistosomiasis japonica in the Leyte, no preventive measure was adopted. On December 23, 1944 CPT morris Goldberg discovered schistosomes first from the hospitalized soldiers while conducting a liver biopsy. Some soldiers with markedly signs and symptoms were admitted to hospital for treatment. Preventive measure was taken since. The US sent a lot of experts to Philippines for the research of schistosomiasis japonicum, including epidemiology, prevention, diagnosis, treatment and so on. Nineteen chemicals were used to control snail hosts. In clinical, schistosomiasis has acute and chronic stages, the manifestations are plenty and various, the liver, intestine, veins, spleen and skin etc are common sites of impingement. An extensive educational program was carried out in the troops through different means, which yielded remarkable effect, the new incidence of schistosomiasis dropped. Though hospitalized soldiers were a few, but there were scare and some morale and psychological problems among them and the other affected victims, they worried about their prognoses or being infected. Some patients were evacuated to United States for treatment after diagnosis, some patients were treated in Leyte. Before World War II, schistosomiasis was treated generally with trivalent antimony compounds, Fuadin and tartar emetic. In this event, no case died, relapses were rare. It was a successful campaign against schistosomiasis in the army.

**Keywords**: schistosomiasis; epidemiology; prevention; treatment; troop; United States; Leyte

## BACKGROUND

On October 20, 1944, General Douglas MacArthur, forced to wade ashore through the surf on the Philippine island of Leyte, announced to the populace the beginning of their liberation: "People of the Philippines, I have returned! By the grace of Almighty God, our forces stand again on Philippine soil[1]."

The last time he had seen the islands the Japanese army had routed him out of the islands in March 1942. He barely escaped Corregidor Island vía a Navy PT boat. As he left the Philippines, he vowed, "I shall return."

But it had not been easy. By May of 1942, the Japanese controlled every land mass from Burma to the Aleutians and threatened Australia.

American forces began fighting a desperate land, sea and air fight. In quick succession came victories at the Battle of Coral Sea and the astounding US Navy victory at Midway. Marines began fighting in the tropical hell of Guadalcanal. Army and Australian forces forced their way through the jungles of New Guinea.

Each month, American victories grew, and they took on the Japanese at Tarawa, Peleliu, Biak, Sai-

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pan, and Guam. Finally America was ready to redeem MacArthur's pledge to the people of the Philippines[2,3].

By the summer of 1944, with MacArthur's forces in New Guinea and those of admirals Ernest King and Chester W. Nimitz in the Marianas, two possibilities presented themselves for future action in the war. Japan could be reached by a two-pronged pincer attack through the Bonin Islands on the right and Formosa and China on the left. Or, as MacArthur favored, Japan could be reached by a more direct approach from New Guinea through the Philippines[4,5].

A return to the Philippines involved a compelling political dimension that did not apply to Formosa. The Philippine Islands had been a special concern of the United States since 1898 and the inherent politico-military responsibilities arising from that relationship could not be ignored so easily. General MacArthur and others insisted that the United States had a moral obligation to liberate the Republic's 16 million citizens from harsh Japanese occupation as soon as possible [2,3].

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In July 1944, a meeting was held in Hawaii that included General George C. Marshall, Chief of Staff; Admiral William F. Halsey, the commander of the Third Fleet; Admiral Nimitz; General MacArthur and President Franklin D. Roosevelt. After much discussion agreement was reached to take the Philippine route by first invading South Mindanao in November 1944 and then Leyte the following month[4].

In August, however, a group of fast-carrier forces under Admiral Halsey managed to bomb and shell Japanese air bases on Mindanao without opposition. As a result, a decision was reached to forego the invasion of South Mindanao and proceed directly north to Leyte[5].

At daybreak, on October 20, 1944, termed "A-day," American forces entered Leyte Gulf (see Figure 1). Landing near Tacloban, on the northern front of attack, the Xth Corps consolidated the beachhead before moving west, across the northern end of the Leyte Valley capturing Carigara on the north coast of the island[4].

On November 7, they reached "Breakneck Ridge," approximately 20 miles north of the Japanese headquarters at Ormoc and scene of the most vicious fighting of the campaign[4].

Meanwhile, the XXIVth Corps, after landing on the southern edge of the landing beach near Dulag, moved across the Leyte Valley and over the central range of hills to capture Dumulaan on the west coast of the island[4].

American progress was further impeded by a typhoon that began on November 8. Sweeping in from the west, high winds and heavy rains fell trees and created mud slides that helped enemy defenses and delayed supply trains[6].

However, fighting continued and on Christmas Day 1944, after the capture of Palompon, the last Japanese held port, an official communiqué announced: "The Leyte-Samar campaign can now be regarded as closed except for minor mopping up operations[5]."

Out of 257,766 men who took part in the operation, the US Army sustained 15,584 casualties with 3,504 killed. During the same period, 84 men had been admitted to the 118th Field Hospital with a disease due to a parasitic worm called schistosomiasis; by May 1945, the total number of cases had increased to nearly 1,000[7].

Schistosomiasis (also known as Bilharzia, snail fever and Katayama fever) is an infection with one of a series of related trematode parasites that are endemic to at least 76 tropical and sub-tropical countries. Schistosomiasis affects over 200 million people in tropical and subtropical regions of South America, Africa and Asia. Three species cause most of the cases of schistosomiasis in humans: Schistosomiasis haematobium infects the urinary tract and bladder and Schistosomiasis mansoni and Schistosomiasis japonicum infect the intestine[9,10]. Two other species, are Schistosomiasis mekongi and Schistosomiasis intercalatum are found more localized geographically, in Southeast Asia and central West Africa, respectively (see Table 1). In addition, other species of schistosomes, that parasitize birds and mammals, can cause cercarial dermatitis in humans.

Table 1. Geographic distribution of human schistosomes

| Species | Africa | Middle East | Asia | Americas | Caribbean |
|---|---|---|---|---|---|
| Schistosomiasis haematobium | + | + | + | + | + |
| Schistosomiasis intercalatum | + | – | – | – | – |
| Schistosomiasis japonicum | – | – | + | – | – |
| Schistosomiasis mansoni | + | + | + | – | – |
| Schistosomiasis mekongi | – | – | + | – | – |

Schistosomes multiply inside specific types of water-dwelling snails that are released to swim free in the water. When the cercaria escape from infected snails into fresh water, such as rice fields, swamps or ponds, they seek a susceptible host and either penetrate it or die within 24 to 48 hours. If the water drains into a river, the cercaria can be swept down the stream and in its course find a susceptible host. If they encounter a person's skin, they burrow in and migrate through the bloodstream to the lungs, where the schistosomes mature into adult flukes. The adults pass through the bloodstream to their final home in small veins in the bladder or intestines, where they may remain for years. The adult flukes lay large numbers of eggs in the walls of the intestines or bladder, some of which flow through the bloodstream to the liver. These eggs elicit an inflammatory response that blocks veins in the intestines, bladder and liver-resulting in ulcers, bleeding and scar tissue formation. Eggs produce enzymes that allow them to pass into the stool and urine. When people with the disease urinate or defecate in fresh water, these eggs are passed and the cycle begins again. The life cycle of the schistosome is depicted in Figure 1, Life Cycle of the Schistosome[8,9].

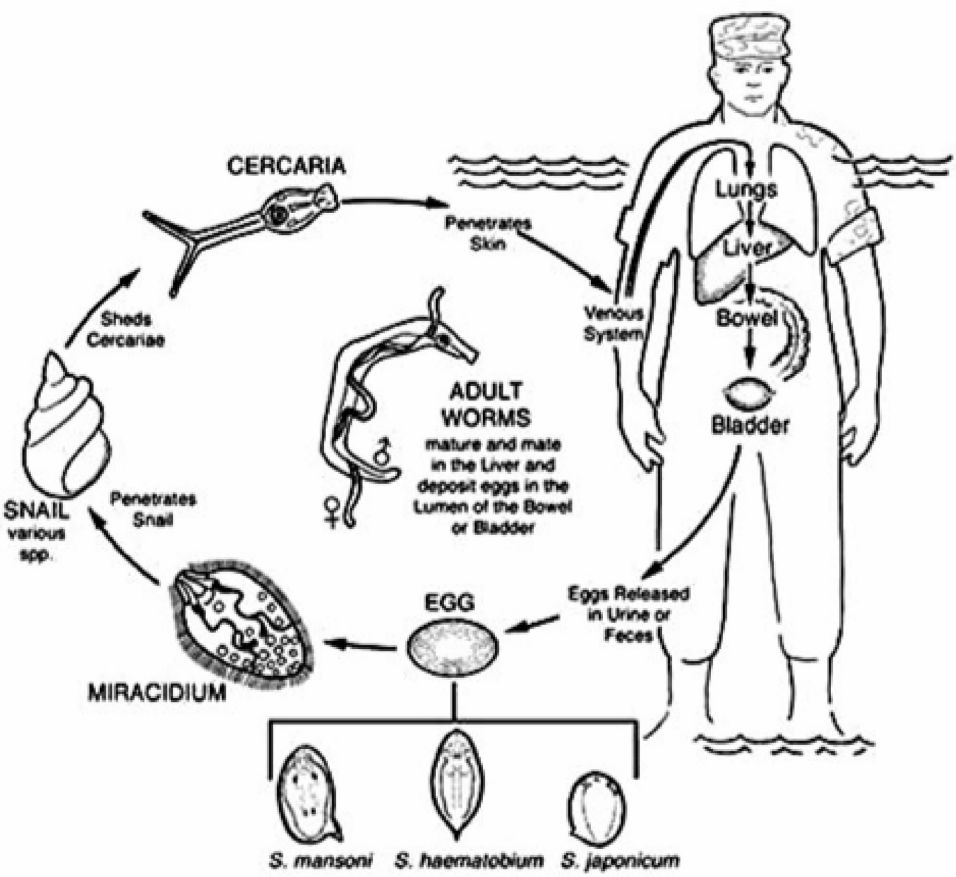


Figure 1 Life Cycle of the Schistosome

Source: Taylor, Diseases Transmitted By Food, Water, and Soil. In: Kelley, ed. Military Preventive Medicine: Mobilization and Deployment. Vol. 2 (39).

The US Army's principal contact with bloodfluke disease during World War II occurred during the liberation of the Philippines. Troops were exposed to the larvae of Schistosomiasis japonicum on Leyte from October 1944 to the early months of 1945.

Throughout history, military operations have been responsible for exposing troops to water containing schistosome cercaria. Just as World War I was breaking out in 1914, the life cycle of Schistosoma japonicum was being identified[11]. By the time of World War II, schistosomiasis japonica, was found in large areas of China, in a few foci in Japan, and on four of the larger islands of the Philippines[12]. It was also present on Formosa (Taiwan)[13] and there was at least one small focus in the Celebes (Sulawesi)[14]. Later, it would be discovered in French Indochina (Laos)[16] and Siam (Thailand)[17].

The first scientific observations of schistosomiasis japonica in the Philippines were reported in 1906, with the prediction that the disease would be found to be endemic throughout the islands. A series of studies published in Philippine journals during the 1920s and 1930s indicated the seriousness of the disease. Autopsies conducted by Maria Paz Mendoza Guazon led her to suspect that schistosomiasis japonica "is a menace to this country and is probably endemic[18]." In 1932, the intermediate host Oncomelania quadrasi was discovered by Marcos A. Tubangui[19,20,21]. By 1941, nearly 30 papers had appeared. Following a survey of the islands, in that year Tubangui and his associate revealed the extent of the problem. Schistosomiasis, they discovered, was endemic on the east side of Minoro, the whole of Samar, the northern tip of Mindanao and in the Leyte Valley (the coastal plain lying to the east of the central mountain chain of the island); 25,000 to 33,000 Filipinos, approximately 20% of the rural population were estimated to be infected[22].

Leyte, one of the larger islands of the Philippine archipelago, extends 110 miles from north to south and ranges between 15 and 50 miles wide. The interior of the island was dominated by a heavily-forested north-south mountain range, separating two sizable valleys. The larger of the two, Leyte Valley extends from the northern coast to the long eastern shore and, in 1944, contained most of the towns and roadways on the island. Highway 1 ran along the east coast for some forty miles between the town of Abuyog to the northern end of San Juanico Strait between Leyte and Samar Islands.

The other lowland expanse, Ormoc Valley is on the west side of the island, connected to Leyte Valley by a roundabout and winding road. From the town of Palo on the east coast, Highway 2 ran west and northwest through Leyte Valley to the north coast, then turned south and wound through a mountainous neck to enter the north end of Ormoc Valley. The road continued south to the port of Ormoc City, then along Leyte's western shore to the town of Baybay. There it turned east to cross the mountainous waist of the island and connected with Highway 1 on the east coast at Abuyog. Below Abuyog and Baybay, the mountainous southern third of Leyte was only sparsely inhabited and contained no areas suitable for development. Over 30 rivers and streams traverse Leyte.

Prior to the American invasion the potential dangers of schistosomiasis to troops had been minimized. Several technical bulletins issued by the War Department in the early years of the war suggested that only in Northeast China was schistosomiasis a "disease of special military importance." Elsewhere, including Southeast China, Japan and Egypt, the disease was downgraded to one of "potential military importance," whereas in Formosa and the Celebes it was considered merely as "a serious disease of nonmilitary importance but likely to affect small numbers of troops[23]."

Three months before the Leyte landings, another Army publication revealed that the disease in the Philippines Islands was confined to Mindoro, East Leyte and North Mindanao and that it, too, was "a serious disease of nonmilitary importance but likely to affect a small number of troops[23]"

Thus, little was known among medical personnel about schistosomiasis prior to the outbreak:

When the 118th General Hospital, the Johns Hopkins unit to which I (Dr. Josh Billings) was attached, arrived on Leyte Island two weeks after MacArthur returned, we had been overseas two and a half years. In the middle of a world-wide war, we all knew that we would be overseas until the war ended. That was a given. MacArthur's military force had fought and clawed its way up the Pacific from Australia over a three year period: New Guinea, beginning at Port Moresby and leapfrogging around Japanese positions there Rabaul battle of the Coral Sea

the Solomons, Guam, Peleliu, Iwo Jima - Saipan, and many other bloody battles, land and sea invasions. Islands occupied by the Japanese not strategically important were by-passed. By the time he decided to hit Leyte Island in the Phillipines (stet.) he had taken over control of the Southwest Pacific.

While his forces were engaged in this island-to-island struggle, his medical corps had become expert in understanding, managing and treating many tropical diseases: malaria, dengue filariasis, infectious hepatitis (stet.), amoebiasis, fungus infections and others. But they knew little or nothing of the liver fluke, schistosomiasis japonica, on Leyte. Probably a majority of the inhabitants are infected. It was even rumored that the military leaders had decided not to publicize the presence of this parasite, fearing that the troops would worry more about the infested swamps and streams than about combat with the Japanese.

## OUTBREAK OF SCHISTOSOMIASIS JAPONICA

Late in November and throughout December, American Soldiers were admitted to hospitals with symptoms that included hives, cough, abdominal pain, diarrhea, and fever and often had high white blood cell (eosinophil) counts. Although schistosomiasis may have been suspected by some ward officers, it was not recognized.

The first diagnosis of schistosomiasis occurred not on Leyte but on Biak Island, at the 132d General Hospital. On December 23, 1944 CPT Morris Goldberg discovered schistosomes while conducting a liver biopsy.

A week later on December 30, 1944, Schistosomiasis japonicum ova were found in a stool sample of a Soldier on Leyte Island by LT Walter L. Barksdale, who was on detached service with the 36th Evacuation Hospital from the 19th Medical General Laboratory, Hollandia, New Guinea. The Soldier suffered an unexplained fever and marked enlargement and tenderness of the liver. The patient's physician, CPT David P. Gage on temporary duty with the 36th Evacuation Hospital from the 49th General Hospital, suspected schistosomiasis and encouraged a search for the ova. The Soldier was evacuated from Leyte to the 132d General Hospital on Biak Island where the schistosomiasis diagnosis was verified.

Biak, a coral island, was north of Dutch New Guinea at its eastern end, one degree south of the equator. An airstrip was created by scraping off the surface soil; the underlying white coral resembled cement….

When we set up our hospital in Biak, we received casualties by air from the Philippine war zone. The troops waded through freshwater streams which were infested with snails carrying the larvae of schistosome parasites, the cause of schistosomiasis japonicum, a disease which affects the liver. Our hospital made the first diagnosis of this disease in a live patient. We had a case of a very sick soldier with fever and an enlarged liver. A diagnostic laparotomy was done which showed little white nodules throughout the liver; inside each nodule was a schistosome parasite. Treatment consisted of giving an antimony compound, which resulted in his slow recovery[24].

By the last week of December 1944, 16 patients admitted to hospitals were found to have schistosomiasis. Most of these patients came from two organizations- the 51st Portable Surgical Hospital and the 50th Engineer Combat Battalion. During the next few days other cases were identified; by the end of January 1945, the totaled reached about 70. By March 1, over 300 cases had been admitted to hospitals.

During the early days of the invasion medical staff knew little about the infection or its endemicity throughout the island. On November 16, 1945, nine members of the 51st Portable Surgical Hospital, including two medical officers, left their bivouac at Dulag for Abuyog to obtain medical supplies. Upon reaching a destroyed bridge that crossed a slow moving stream, they decided to swim across. One of the medical officers jokingly commented before entering the water on the possibility of contracting schistosomiasis. Both medical officers were under the impression that there was minimal danger of infection in moving water. The officers and six enlisted men went into the water for approximately 30 minutes; another Soldier did not enter the water. Four weeks later symptoms of schistosomiasis developed among the eight who entered the water (the one who remained on the shore escaped). While no snails (Oncomelania quadrasi) were found in the surrounding area, higher up the stream, snails were later found.

Nurse Eda Teague was stationed at a hospital

three miles from the front lines at Burauen until May 1945.

During the early stages of the invasion (of Leyte) our patient count consisted of about 80 percent battle casualties and the remainder were illness-related cases. As the weeks wore on and the troops were exposed to the many tropical diseases prevalent on the island, we began treating as many illness cases as battle casualties. The tropical environment of the Pacific could be as deadly to our soldiers as the Japanese. The hospitals in the European theater treated combat wounds and the effects caused by bitter cold temperatures, while in the Pacific we had to treat combat wounds and many different types of tropical diseases. We treated everything from bullet wounds to jungle rot, dengue fever (called "break-bone fever" because of its painful side effects), malaria, dysentery, hookworm, and schistosomiasis (a parasitic disease caused by blood-fluke worms whose larvae are harbored by snails and infect humans who enter infected waters through the skin; the disease is characterized by a skin eruption at the site of entry, fever, diarrhea, and liver damage).

In a letter dated May 1945, I wrote about some of what we were experiencing on Leyte:

"Were really busy over in the hospital now-we´ve been admitting patients right and left. We have more patients now than we´ve ever had-they all come from islands up north. It´s surprising haw many are medical patients-I think we have more medical casualties than we do battle casualties. There are million different kinds of diseases caused by snails and worms around these islands-the worst is called schistosomiasis-the boys know it as blood flukes-then of course there is hookworm-loads of it."

For some of the disease we administered preventive measures, and the infantrymen in the field learned how to prevent illness as best they could[25].

The 118th Hospital Unit was at the forefront of the fight against schistosomiasis on Leyte. On November 18, the 118th General Hospital, manned by the medical staff of the Johns Hopkins Medical School commissioned in the officer reserve corps, landed in Leyte, set up their hospital in, Kaboynan 8 miles south of Tacloban and began admitting patients two weeks later.

The 118th was assembled following the attack on Pearl Harbor and included some 50 physicians from Johns Hopkins University. Upon reaching to Australia, the unit billeted at a racetrack in Sydney. The enlisted men slept in the stables, the officers were assigned to the ladies´room, "with cots again, and mirrors all around. And of course," Billings says, "we still weren´t seeing any sick people." In July 1942, the unit´s chief of surgical services, COL I. Ridgeway "Ridge" Trimble, and its medical director, James Bordley, succeeded in acquiring 400 beds at the Royal Prince Albert Hospital, Australia´s main teaching hospital[26].

Billings recalls, "everything clicked. We just melded together, the Americans and the Australians. It worked awfully well. We started getting our own patients from the front-more and more[26]."

Many of those most in need of care had come from the Battle of the Coral Sea, the huge naval confrontation fought in early May 1942 in the waters southwest of the Solomon Islands and east of New Guinea. With the influx of wounded, it soon became obvious there were too many to share the facilities.

In May 1943, the unit moved to a new, spacious hospital center at Herne Bay (dubbed "Hernia" Bay) outside Sydney. "They built us a real hospital, and finally we felt at home, kind of like we were back at Hopkins," Billings says. By November, the hospital had 1,700 patients.

As fighting intensified on New Guinea the medical staff of the 118th set up several

station hospitals near the war zones.

Assigned to cover the eastern half of New Guinea, Billings and Trimble traveled either by Dutch schooner or by cargo plane. "They packed us in like sardines," Billings remembers. "The planes were all overloaded, and the runways were very short," freshly carved out of the jungle. "Once every two or three days, one of these great, heavy freight planes would crash before it took off. Then one morning, they said, Well, we´re off."

The unit was to pack up for the Philippines. "They marched us all down to the sea to a huge harbor. Day and night, great searchlights were on while we loaded up battleships, cruisers, aircraft carriers and troop transport ships. Then we moved out-this huge armada."

Onward the 118th sailed, until reaching Leyte. On arrival on Leyte the 118th General Hospital, that now consisted of approximately 500 enlisted men set up shop. Although medical officers of this unit were aware of the existence of schistosomiasis on Leyte,

they underestimated the danger of infection from nearby streams. While streams in the area had been searched for snails, when none were found medical personnel in the unit believed that the water was free from cercaria.

Quickly the number of infected troops started to mount up. During January and February 1945, 300 additional cases of schistosomiasis were diagnosed on Leyte. While these soldiers were from all types of units, combat troops, engineers and artillerymen predominated.

Years later Dr. Josh Billings anecdotally described how easy it was to become infected[27].

Two episodes emphasized to us how easily one can be infected, and how deadly the infection can be. Five young soldiers in a jeep, passing over a swiftly running clear stream, stopped to take a swim. Four entered the water, swam and washed off. The fifth decided not to go in. Almost simultaneously, 18 days later, the four who had been swimming became sick and were found to have schistosomiasis. The fifth man was not sick.

A combat unit of flyers bivouacked around a beautiful pool at the head waters of the stream which ran beside our hospital. Our commanding officer warned the commanding officer of the flyers that the pool was infested with schistosomiasis, and not to allow swimming. The warning was ignored. Diving boards were set up. Three to four weeks later eight of the flyers were in the hospital. One died of cerebral involvement with schistosomiasis. The commanding officer was brought before a court martial.

When the first cases of schistosomiasis were identified on Leyte, ward officers were alerted to the symptoms of the disease and soon hospital laboratories were swamped with stool specimens for microscopic study.

Hospital records revealed that most cases came from certain units. Sullivan and Ferguson showed that swimming and bridge-repair operations accounted for the exposure of most men. For example, in the 50th Engineer Combat Battalion, that eventually had 102 cases, bridge repair had led to the majority of the exposures. One hundred sixty four men from the 118th admitted contact with fresh water or with swamps in the area. By April 30, 1945, 75 Soldiers were diagnosed with schistosome ova in their stools. In nearly all cases exposure resulted from swimming. Others may have been found to have the disease at a later date or may have remained undiagnosed[28,29]. Sullivan and Ferguson write:

The attack rate for the battalion was 19.6 percent (102 cases as of 31 May 1945) which may be compared with an estimated XXIV Corps rate of 0.73 percent. The rates increase to 27 and 33 percent respectively as B and C companies, engaged in bridge construction, are considered separately. Moreover, the attack rate increases to the range of 41-53 percent as attention is focused on the specific platoons engaged in bridge construction. Finally as the rates are computed for the water-exposed bridge-workers themselves, these range from 71-89 percent in the various platoons of B and C Companies. Actually in dealing with the water-exposed bridge-workers it becomes a matter of trying to explain why 100 percent of them were not infected. Since a number were unfortunately not hospitalized or were not diagnosed because typical ova could not be demonstrated, the possibility of 100 percent infection in this group cannot be eliminated[29].

Nearly 1,000 Soldiers were admitted to hospitals on Leyte Island, between January and May 1945 for schistosomiasis[30].

Table 2. Leyte Hospital Admissions, 1945

| Month | Number of cases | Percent |
|---|---|---|
| January | 69 | 7.17% |
| February | 305 | 31.70% |
| March | 313 | 32.54% |
| April | 197 | 20.48% |
| May | 78 | 8.11% |
| Total | 962 | 100.00% |

One study of known cases among Eighth Army troops, the majority of which were diagnosed in January and February, out of 575 cases, 203 (35.3%) were from engineering battalions and 189 (32.8%) from numerous infantry units (see Table 3).

Table 3. Leyte Hospital Admissions by Unit, 1945

| Unit | Number of cases | Percent |
|---|---|---|
| Antiaircraft | 61 | 10.61% |
| Cavalry and Reconnaissance | 10 | 1.74% |
| Chemical | 4 | 0.70% |
| Engineer | 203 | 35.30% |
| Field Artillery | 54 | 9.39% |
| Infantry | 189 | 32.87% |
| Medical | 12 | 2.09% |
| Ordnance | 12 | 2.09% |
| Quartermaster | 4 | 0.70% |
| Signal | 15 | 2.61% |
| Special Service | 1 | 0.17% |
| Tank | 10 | 1.74% |
| Total | 575 | 100.00% |

Americans were not the only troops infected on Leyte. Swimming also accounted for proven cases of the disease in of 560 men in an Australian Air Force construction squadron that spent only 16 days on Leyte. One hundred forty-four members became infected after using a river adjacent to their camp for swimming and washing. A subsequent check revealed that nearly half of the squadron had eosinophilia[31]. But, as the Australian history explained, "The handling of the affected men aroused considerable discussion. On the one hand, the Royal Australian Air Force felt that the unit was isolated and was carrying out very good work with a high morale, that most of the men did not feel ill, and that their mild infections could be treated while they continued to work. On the other hand, the US troops affected were mostly sent to the 118th General Hospital on Leyte[31]."

Once hospitalized, these men were either detained for a lengthy examination or evacuated Stateside. As a result, some American Soldiers deliberately exposed themselves to contaminated water and a black market in infected stools quickly developed.

## RESEARCH ENDEAVORS

During World War II many physicians and allied health found themselves confronting numerous tropical diseases of which little was known. While, it is of interest to note that World War II was the first great conflict in which fewer American troops died of disease than of battle injuries and wounds, many pertinent problems in tropical medicine and epidemiology remained unanswered[8].

The Malarial Survey Units although tasked to research malaria expanded its purview as other diseases were encountered[32]. Thus, in February, the 5th Malarial Survey Unit and a Medical Research Unit arrived and were attached to the 118th. Their officers, including Frederik B. Bang[10,21,23,30,33-36], Nelson G. Hairston[33-35], Owen H. Graham[10, 33, 34, 37] and Malcolm S. Ferguson[10,23,29,33,34], were detailed to study the epidemiology of schistosomiasis, control of the snail host, chemotherapy and prevention of infection in the military.

The 5th Malarial Survey Detachment concentrated its survey activities on 164 cases diagnosed in the XXIVth Corps, of which half came from one engineer battalion alone. The figures were stark: 62% of those infected in the battalion were members of bridge and road construction units, although such personnel made up only 21% of battalion strength; as many as 89% of strictly bridge-building units came down with the disease.

Another survey undertaken in the region revealed the familiar story: 76% of villagers in two barrios had schistosome eggs in their stools[29].

In anticipation of the invasion of Japan, the Preventive Medicine Service of the Office of the Surgeon General decided early in 1945 that a group of schistosome researchers should go to the Philippines to study a number of militarily pertinent problems concerning schistosomiasis japonica. This project was approved by the theater commander and in April 1945 the Subcommission on Schistosomiasis of the

Commission on Tropical Diseases, Army Epidemiological Board, arrived on Leyte.

The Subcommission on Schistosomiasis objectives was similar to those of the 5th Malarial Survey Unit: to study the distribution and epidemiology of the disease, to develop methods of protecting the troops from infection, to control the snail host, and to improve diagnostic techniques.

Directed by Ernest Faust, the Subcommission consisted of Willard H. Wright of the National Institutes of Health; Donald B. McMullen, the Department of Preventive Medicine, University of Oklahoma School of Medicine; and Major George W. Hunter, III, with the Sanitary Corps.

Of these men, only Bang was a physician (MD degree from Johns Hopkins). The others had a broad set of qualifications and interests that was characteristic of tropical medicine in the United States. Graham (attached to the Malarial Survey Unit), for example, was an entomologist with the US Department of Agriculture, whereas Wright, with a degree in Veterinary Medicine and a Doctorate from George Washington University, was employed by the Public Health Service. Ferguson and Hunter both held Doctorates from the University of Illinois and McMullen had received his Doctorate at Johns Hopkins University. These men would soon put schistosomiasis on the academic map by publishing their wartime findings principally in the American Journal of Hygiene and the American Journal of Tropical Medicine.

It was immediately apparent to the Subcommission that combat-engineering companies involved with road construction and bridge building had been hit hardest by the disease. A road paralleled the landing beaches of the XXIVth Corps, on the west side of which lay a continuous marsh with numerous streams and sloughs. Some infantrymen became infected by wading and swimming across these watery barriers. But it was engineers, after standing for long periods in water while bridging these marshes and streams, that proved to be the major target for infection.

The Schistosomiasis Subcommission also focused attention on the snail host; they collected 16,447 snails from four stations in Leyte in order to determine their life cycles and pattern of infection. The snail species Oncomelania quadrasi breeds throughout the year, they reported, takes about four to five months to mature and is susceptible to infection immediately on hatching[37].

In May 1945, three naval officers comprising an epidemiological team from Naval Medical Research Unit No. 2, located on Guam, arrived on Leyte. Since only 16 known cases of schistosomiasis had appeared among Navy personnel no extensive investigations were planned by this group[38].

The Naval Research Unit turned their attention toward the spotty distribution of infected snails attracted the attention of. Not surprisingly, they reported that "infestation of snails takes place only near the immediate locality where human feces drain into the water inhabited by Schistosomorpha (Oncomelania) quadrasi." In one swamp, joined to a nearby village by a drainage ditch, they found 21% of those snails crawling among fecal material to be infected, whereas 30 feet away, only 3.1% carried the larval stages, and only 1.3% were infected at the edge of the swamp. Schistosomiasis was not a disease of rice workers, they noted, but of children. By 15 years of age, they estimated, virtually all of the children carried a worm load[38].

The overriding concerns of all three teams of investigators in Leyte were military. How could future outbreaks be prevented? Could chemical impregnation of uniforms prevent penetration of the cercaria How could infected troops best be cured?

Not surprisingly, members of the Subcommission believed that control was best achieved by eliminating the snail hosts. To test the efficacy of various chemicals, they constructed three types of outdoor test plots in a 12 acre field rich with snails: 85 sq in "small natural" plots, bordered on the sides by US Army-issue dehydrated food cans, were used to screen out chemicals that were of no value; 25 sq ft "natural" plots, and 25 sq ft "pond" plots, consisting of diked pits dug down below water level, into which two to three thousand snails were added, were used to test potentially useful chemicals.

Nineteen chemicals were tested, including older molluscacides standbys such as, copper sulfate and Paris Green (copper(II)-acetoarsenite) and the new wonder chemical DDT. DDT was found to be ineffective, whereas dinitrocyclo-hexyl-phenol and Paris Green proved to be more effective snail killers than copper sulfate, copper carbonate, copper guanylurea, calcium arsenate and calcium cyanamide.

In terms of cost effectiveness however, calcium cyanamide, a fertilizer, was the least expensive:

$.54 per 100 sq ft compared to $.72 for copper sulfate and a little over $1.50 for Paris Green. Using any of these chemicals, they concluded, would reduce the snail population to a degree where "the possibility of an infection reached a vanishing point." Thereafter it would be necessary only to dust or spray small foci of snails that remained after the initial campaign[37].

Appropriate tropical clothing, soaked in certain chemicals and passed through numerous washes, prevented the movement of cercaria. Anesthetized rats were placed inside cloth bags to be tested. "This arrangement," they noted, "was comparable to a man with trousers closed at the bottom standing in infested water."

The combination of new cotton khaki and dibutyl phthalate proved to be the most effective barrier, capable, for example, of preventing movement across the barrier after ten washings. Protection, members of the Malarial Unit concluded, would best be achieved by impregnating uniforms with dibutyl phthalate, benzyl benzoate, or a mixture thereof, and by smearing these chemicals on exposed skin[33]. The Subcommission reached these same conclusions after a set of very similar experiments[39,42].

These initial findings were reported back to military authorities in Washington during the war, and published in the Bulletin of the US Army Medical Department soon after the war's end. In 1945, the War Department published TB MED 167, "Schistosomiasis japonica," that provided an excellent summary of what was known of the disease at that time, much of it derived from work at Leyte.

The Army and Navy research teams remained on Leyte until after the war's end. In late October, some members of the Subcommission on Schistosomiasis proceeded to Japan where research continued.

## DIAGNOSING THE DISEASE

Diagnosing a patient entails generalizing about a patient's condition. Manifestations refer to data that can be gathered including symptoms, signs and laboratory abnormalities. When first infected with schistosomiasis, many individuals fail to experience symptoms. It usually takes four to six weeks for symptoms to appear. The first symptom of the disease is an overall general ill feeling. Within twelve hours of infection, an individual may complain of a tingling sensation or light rash, commonly referred to as "swimmer's itch," due to irritation at the point of entrance. The rash that develops can mimic scabies and other types of rashes. Other symptoms generally occur two to ten weeks later and can include fever, aching, cough, diarrhea or gland enlargement.

Billings describes the symptoms of schistosomiasis:

Combat troops, slogging their way through swamps and streams, engineers building bridges and airports, service troops washing vehicles, even bathers and recreational swimmers were all exposed to parasites before it was known that fresh water on Leyte Island was heavily infected. A sanitary officer, Lt. Ferguson, examining the stools in Tacloban, first discovered the ova of schistosomiasis. Suddenly, the cause of the serious disease developing among the troops on Leyte was understood. Fever, malaise, rashes, shortness of breath, asthma, abdominal tenderness, all were present. The spleen, liver and lymph nodes enlarged. The severity of illness in each individual depended upon the number of parasites which invaded him. These symptoms and signs are caused by the defense reaction of the body to dissemination of the ova in the tissues. They are recognized as foreign and thus should be disposed of[27].

"Swimmer's itch," was the first indication of infestation and occurred very soon after exposure to water infested with cercaria. Billings[4] and his associates[34, 36, 40, 41,43] turned their attention toward the manifestation and early course of schistosomiasis among American Soldiers.

Billings carefully questioned three groups of patients about itching immediately after contact with fresh water. The incidence varied as follows: 1 in 42, 4 in 41, and 9 in 75 occurring 8.8% among the 158 patients.

Following a latent period during which the parasite develops to adulthood, the onset of symptoms was usually abrupt and included headache, chills, fevers, cough, hives (urticaria), aches and weight loss of varying severity. In some cases, the onset was harmless and the symptoms in some of these remained mild throughout the symptomatic phase. In others the symptoms were intensified after several days.

Another primary condition, called Katayama fe-

ver, may also develop from infection with these worms, and it can be very difficult to recognize. In intestinal schistosomiasis, eggs become lodged in the intestinal wall and cause an immune system reaction called a granulomatous reaction. This immune response can lead to obstruction of the colon and blood loss. The infected individual may have what appears to be a potbelly. Eggs can also become lodged in the liver, leading to high blood pressure through the liver, enlarged spleen, the build-up of fluid in the abdomen (ascites), and potentially life-threatening dilations or swollen areas in the esophagus or gastrointestinal tract that can tear and bleed profusely (esophageal varices). Rarely, the central nervous system may be affected.

Based on the intensity and severity of symptoms, temperature and the duration of the fever, 337 cases were divided into four groups (see Table 4).

Table 4. Intensity and Severity of 337 Cases, Leyte, 1945

| Severity | Cases | Percent |
|---|---|---|
| Severe | 21 | 6.23% |
| Moderately severe | 123 | 36.50% |
| Mild | 168 | 49.85% |
| Asymptomatic | 25 | 7.42% |
| Total | 337 | 100.00% |

From this group Billings analyzed 75 cases in detail. The incidence of the chief symptoms shown in Table 5, was made on clinical observations only. It is not known whether the severity of symptoms correlated with the degree of infection.

Table 5. Incidence of symptoms in 75 patients with acute schistosomiasis japonica

| Symptoms | Patients Affected | Percent |
|---|---|---|
| Fever | 75 | 100.00% |
| Headache | 69 | 92.00% |
| Weight loss | 69 | 92.00% |
| Malaise | 67 | 89.33% |
| Anorexia | 66 | 88.00% |
| Pain in upper quadrant of abdomen | 60 | 80.00% |
| Stiff neck | 57 | 76.00% |
| Abdominal cramps | 52 | 69.33% |
| Cough | 48 | 64.00% |
| Generalized aches, backaches and arthralgia | 45 | 60.00% |
| Urticaria and angioneurotic edema | 39 | 52.00% |
| Chills | 37 | 49.33% |
| Diarrhea | 21 | 28.00% |
| Constipation | 18 | 24.00% |
| Pain in chest | 17 | 22.67% |
| Itching (after exposure to infested water) | 9 | 12.00% |
| Testicular aching | 9 | 12.00% |
| Neurologic complications | 7 | 9.33% |
| Nausea and vomiting | 6 | 8.00% |
| Asthma | 6 | 8.00% |

Asymptomatic cases. Twenty-five Soldiers developed the disease without displaying any symptoms; these cases were not included among the 75 cases studied in detail. The disease was suspected among this group because of known exposure to infested water or because of the discovery of an abnormally increased number of eosinophils in the blood (esonophilia), either during a routine survey of military units in which other members were known to have schistosomiasis or during hospitalization for another disease.

Mild cases. The majority of Soldiers infected with schistosomiasis fell into the mild category (49.8%). In most cases the symptoms and physical findings of the disease were minimal. Patients generally complained of occasional cough, light fever, malaise, headache, fatigability and weight loss. Occasionally, they had mild discomfort in the upper quadrants of the abdomen and scattered aches and pains. Some Soldiers complained of a "crick" in the neck.

Many Soldiers went days or even weeks without seeking medical attention, attributing their symptoms to their being unaccustomed to the tropical environment.

Often when a Soldier reported to sick call in the morning, his temperature was normal and he felt well, so that the infection was easily overlooked. In fact, these vague and variable symptoms sometimes led to the diagnosis of psychoneurosis in several patients before schistosomiasis was diagnosed. Indeed, "During recent years it has become increasingly fashionable for physicians to ascribe disorders of unknown origin to psychoneurosis. In some circles of the armed services there is an increasing tendency to minimize known organic and physical defects as cause for complaints… Persons with psychoneurosis may have an independent organic disease[53]".

Moderately severe cases. Symptoms among troops in this category (36.5%) began suddenly with fever, chills and headache. Generalized aches and pains, soreness and stiffness of the neck, as well as discomfort in the upper part of the abdomen was accompanied by weight loss, hives and an irritating dry hacking cough. Some of these symptoms lasted from one to eight weeks.

In 14 cases, high fever subsided partially or entirely between two to eight days. Thereafter, the symptoms persisted in mild form, or remained in abeyance for a week or two, and then recurred.

Most patients in this category complained of fever, chills, headache, cough, and hives with or without swelling in the deep layers of the skin (angioneurotic edema). Within a few days to two weeks, the urticaria and cough subsided. But pain in the upper quadrants of the abdomen, loss of weight, headache, fatigue toward evening, stiff neck, and varied muscular pains (myalgic) and joint pains (arthralgic) persisted.

The febrile stage lasted from one to eight weeks with the temperature rising sharply in the evening to between 102°F and 104° F. Except for rare exceptions fever returned to normal or below normal in the morning. Likewise, during the day the majority of patients felt better or "tolerably" well in the morning but worse in the afternoon and evening, when all symptoms were characteristically intensified.

Hives (urticaria or angioneurotic edema) were identified in 52% of the patients. These varied from an occasional small and fleeting wheal to large lesions.

Most patients (76%) complained of soreness and stiffness of the neck. Usually, it developed suddenly and lasted from 24 to 48 hours, then subsided only to recur several days later. One patient was incapable of any head movement, for a period of two weeks.

Nearly 90% of Soldiers experienced anorexia and discomfort in the upper quadrants of the abdomen. Indeed some Soldiers loss as much as 40 pounds. Billings noted that while abdominal cramps were frequent, diarrhea occurred in only 28% and then it was not clear whether it was due to the disease or to another type of infection, as attacks of diarrhea were fairly common among the troops on Leyte.

More frequently, bowel movements were constipated, sometimes severely. Blood in the stools was rarely found and only in the occult form

Cough was sometimes accompanied by a bubbly sound called (rales).

Severe cases. Twenty one patients (6%) were classified as severe. Soldiers in this category were often prostrated and semicomatose; the temperature was high and spiking; and the headaches, generalized aches and pains, cough, and anorexia were se-

vere.

Enlargement and tenderness of the liver was more pronounced and the spleen was uniformly enlarged. In several patients mild anemia was observed. Several in the group also had neurological manifestations.

## PREVENTION MEASURES

Schistosomiasis is a preventable disease. That schistosomiasis is a preventable disease in military forces was stated by Leiper, on the basis of his studies in Egypt in 1915. He wrote: "With the information at the disposal of troops, bilharziasis should now be treated as one of those diseases for which the individual is mainly, if not entirely, personally responsible[44]."

When plans were originally prepared for the recapture of the Philippines strictest secrecy was maintained for security reasons. Consequently, medical personnel responsible for health problems were not informed of the proposed invasion of Leyte until a short time before it occurred. While medical planning officers knew that schistosomiasis was endemic on Leyte, there was no real awareness of the danger that lay in the path of the invading troops.

According to Ferguson, American medical personnel were not told of the change of plans that resulted in the early invasion of Leyte. But even if they had, there is little evidence to suggest that they would have done very much about the situation. "Before December 1944," Ferguson wrote, "interest in schistosomiasis had been to a certain extent academic. It was felt by some Medical Department personnel that the disease would not be of military importance in Leyte[23]." Indeed, of course, that was exactly what happened: 1,000 cases out of a force of 257,766 men represented only 0.38% of the total American troop strength in Leyte.

Another medical officer has provided a vivid description of preventive efforts on Leyte[45].

While I was stationed at the San Francisco Port of Embarkation early in 1945, orders came for me to join the Army's Seventh Infantry Division which was then battling for Leyte in the Philippines. Having successfully made the attack on Attu in the Aleutians and then on Kwajelein in the mid-Pacific, the Seventh Division had been selected for that task. Later, examining my route on a C-47 plane to Leyte via Hawaii and Kwajelein to join the Division, I gave profound thanks for that airplane crew's navigational and piloting competence. Arriving one evening with no knowledge of the Seventh Division, completely ignorant of combat, and with no training for it, I reported to Division headquarters carrying orders to be the preventive medicine officer.

My introduction to the situation came the first night when I stood up to urinate. Whispered, colorful expletives from my new comrades promptly taught me where I was and what not to do. Especially at nighttime, never do anything that might attract attention to one's location because doing so might invite Japanese sniper fire. Urinate immediately before you lie down for the night, and if you can't wait till the morning, just roll over a few feet. Indoctrination into battle culture continued with learning how to bathe with water in a helmet, and how to wash one's clothes in a river.

The Headquarters staff did not know what a preventive medical officer should do, and I wasn't too sure myself. As a physician, however, my first point during the intense battle was to ascertain how I could help care for the heavy casualties that were flowing into the clearing station, a quasi-hospital for the Division's approximately 15,000 soldiers. Our situation was akin to that depicted in the TV MASH program-except that our unit included no female nurses. Having essentially no competence in the surgical treatment of battle trauma, as my new medical colleagues disappointedly but immediately confirmed, I was assigned to the "shock tent." There we received the severely wounded soldiers who needed blood transfusions and other preliminary treatment. We cared for the worst cases, mostly those with bloody, dirty, penetrating wounds, aiming to keep the soldiers alive a few hours until the surgeons could provide further treatment.

My preventive medicine role on Leyte began when we encountered an epidemic of schistosomiasis. Noting that several soldiers from the Division's engineer battalion reported suffering severely from chills, severe headache, fever, and often dermatitis, I suspected schistosomiasis because the engineers had been building bridges across slow streams, and that work necessitated their spending hours in the river water where they had possibly been exposed

to the causative agents. These agents pass one stage of their life cycle in snails that flourish in shallow, slow-moving water, and then escape to bore into a passing human´s skin and proceed to the intestine and liver, where they cause extensive pathology. Human (or animal) excrement then reinfects the water where the snails pick up the organisms again. Though schistosomiasis occurs on several continents and islands, a particularly virulent form (S. japonicum) prevails in the Southeast Asian areas. The tropical medicine training course had emphasized the condition, and I had been on the lookout for it.

Examining the patients´blood smears with a microscope I found a very high eosinophilia rate. This type of white blood cell increases sharply in parasitic infections such as schistosomiasis. Observing the typical symp- toms, ascertaining the eosinophilia count, and noting that the disease outbreak affected only men who had been exposed to slow-moving water made it easy to conclude that we were dealing with schistosomiasis. It attacked several dozen men in that engineer's battalion for whom I recommended evacuation because their illness would continue for several weeks. That was hardly complete preventive medicine, but at least it was recognition of a disease exotic to American medical officers.

In early January, with schistosomiasis rampant directives concerning its prevention were issued. Typical was the letter issued on January 22, 1945 by the commanding general of Base K on Leyte. This letter read in part:

1. Experience with this dangerous tropical blood fluke reveals that it is extremely common in this Base. The civilian population is heavily infected, and many cases have occurred in Army personnel, some of which have been fatal ….

3. …. The following precautions will be observed: (a) All water used by troops will be obtained from approved water points …. This is meant to include water used for drinking, bathing, laundry, and washing of vehicles or floors. (b) Wading, bathing, and washing of clothing by troops in any fresh water river, swamp, pond, or rice field is prohibited ….

4. …. All unit commanders will inform their personnel of the contents of this directive, and will be held responsible for the rigid enforcement of the measures in paragraphs 3 a and b.

With contamination in full swing an extensive educational program got under way with posters, cartoons, radio broadcasts, and mobile demonstration laboratories. Their messages were clear: "Stay out of freshwater streams, ponds and rice paddies," "Don1t wade or bathe in unsafe waters," "Don1t drink unpurified water," and "Don1t wash vehicles in unsafe water[26]."

During late January 1945, an intensive educational program got under way. The Chief, Professional Services, Office of the Surgeon, United States Armed Forces in the Far East, was largely responsible for the direction of this program. He insisted it be emphatically stressed to the troops that they must stay out of all fresh water.

Coordination work was done by the Malariologist, at Base K. Posters were distributed. Numerous roadside signs were posted by the 5th Malarial Survey Unit. Short, pertinent items regarding the disease were brought to the attention of troops by means of radio and unit newssheets. The malaria detachments reported to unit commanders any personnel found washing vehicles or bathing in fresh water and were active in disseminating information about schistosomiasis.

A very significant contribution to the educational program was made by two mobile laboratories that were equipped and sent from unit to unit by the Office of the Surgeon, Base K, to acquaint troops with the disease. Two enlisted men, one the driver and the other a man qualified to discuss the disease, accompanied each truck and gave demonstrations and lectures before thousands of troops during a period of about four months.

Schistosomiasis, or "schisto" as the disease was commonly known, became a byword with troops in the field. The adoption of this term permitted the men to avoid use of a long word that was difficult to remember and pronounce. It was also much more appropriate than the term "snail fever" that was first proposed by the US Navy and later used by the Office of the Surgeon General in posters.

Meanwhile, work at the 118th Hospital showed how little schistosomiasis therapy had changed in 25 years: Tartar emetic was the drug of choice. "Patients treated with tartar emetic," their physicians reported, "had fewer recurrences than a comparable group treated with Fuadin[46,47]."

By April 1945, the number of new cases of schistosomiasis had dropped to a low level. The educational program and directives leading to strong command action were remarkably effective in limiting the number of new infections acquired in 1945. R

## Morale and Psychological Impact

Many Soldiers with complications of schistosomiasis experienced low morale due to the long periods of hospitalization, the uncertainty of the medical officers as to the value of antimonial drugs used and the possibility that the disease might later assume a chronic phase.

This apprehension was not entirely confined to hospital areas. It carried over somewhat to healthy troops as well. This was particularly true of men who had been exposed to fresh water, either in line of duty or while bathing, and who had developed no clinical symptoms.

Although, only 30 of the schistosomiasis cases admitted to hospitals were considered severe, so many troops suffered from an unexpected degree of invalidism that a psychiatric evaluation was conducted on 50 patients who had been hospitalized for an average of 105 days following treatment. The shortest period of hospitalization was slightly over two months and the longest nearly five months. Most men had been cleared for light duty and only 13 showed physical symptoms characteristic of the disease. But "subjective" symptoms such as fatigue, shakiness, headaches, abdominal cramps and blurred vision were rampant[48].

Nothing was known, wrote Frank about the effects of the disease on patients after brief exposure. "One did not know," he wrote, "how to be sure a patient was cured, or what part of the symptoms of a given patient at a given time were due to the parasite, what part to the treatment, and what part to the emotional reactions." As a result, he concluded, an atmosphere abounded "in which rumors flourished and disability-producing attitudes throve[48]."

All the patients were confused about the disease and resentful of the treatment they had received, the psychiatrist explained. Many felt that they were "guinea-pigs" in an experimental drug program, and few had any confidence in the medical officers. "I guess they're writing a book about it," one Soldier told the psychiatrist. Another reported, "I know I'm being used as a guinea pig. I felt kinda peeved at first, but I can't do much about it."

Nearly half of patients (46%) believed that treatment had not helped; 44% were uncertain; the remaining 10% believed that treatment had left them worst of than they were before. Many believed that they were being investigated on. Some Soldiers suggested that this was not necessarily bad: "We have been guinea pigs of necessity. Experiments have been made with our welfare in mind."

But this was the exception. Most commented that they were not sufficiently informed about treatment: "I'm disgusted. Nothing ever seems to be done. We just keep around and they keep doing something to us and we don't know what's going on."

Thus, several patients developed resentment toward the physicians. "The talk is going around," commented one Soldier, "that the physicians were trying to make a name for themselves at the patients' expense."

They were also faced with confusing information. Outside the hospital, in an attempt to dissuade men from swimming in freshwater, highly alarmist radio broadcasts talked of the "disastrous effects of schisto." But, as another Soldier said, "They tell you in the hospital schisto isn't serious. On the radio they say it kills. That breaks down the morale of the fellows who got it. Either the radio or the doctors are screwed up about something."

The psychiatrist concluded that special attention must be devoted to the emotional reactions to the disease. Physicians must not only attack the worm, but also, maintain "the proper therapeutic atmosphere" of faith in the physician and an expectancy of recovery. The patient, the report stressed, should rely on the physician for information on the disease, and the physician, in turn, should emphasize "those aspects of the disease which lend themselves to an optimistic interpretation."

Only one-third of the patients fully understood, he noted, that flukes cannot multiply in the body. Ten patients of the 50 interviewed had only meager and generally inaccurate information. But optimism, he warned, must be "consistent with accuracy"; patients gain no confidence in a physician who tells them that schistosomiasis is no worse than a common

cold.

Physicians, he cautioned, must be consistent with one another and with other authorities; vacillation about prognosis, which keeps the patient "in a demoralizing turmoil of hopes and fears," should be avoided; and, above all, "the obvious first requisite is to regard each patient as an individual."

## EVACUATED PATIENTS

Beginning in January 1945, some patients were evacuated to the United States as soon as the diagnosis of schistosomiasis was made while others were evacuated after one course of treatment with an antimonial drug. Still, other patients were treated and held under observation for long periods on Leyte.

Finally, in July 1945, the Surgeon, United States Armed Forces in the Far East, directed that all patients with schistosomiasis japonica be evacuated to the United States within a period of 120 days after initial diagnosis. This evacuation policy was seized upon by a few individuals as a possible means of getting home. Some of these men were known to have willfully exposed themselves to infection by swimming in streams considered dangerous. Others who were patients in hospitals for other causes were known to have attempted to purchase stools positive for schistosomiasis, and submit these contaminated stool samples as their own.

On reaching the United States, patients were sent to either Moore General Hospital in Swannanoa a small town near Ashville, NC or Harmon General Hospital in Longview, TX. Each hospital received approximately 600-650 patients with schistosomiasis. Three reports of the disease in these hospitals were prepared for publication by Most and his associates[49] and by Mason and his associates[50].

At first, both the Army and the US Public Health Service were concerned about the possibility that raw sewage from these hospitals flowing into streams might create a hazard if viable schistosome eggs were being discharged and suitable snail hosts of Schistosomiasis japonicum were present in these waters. At Harmon General Hospital no precautions were required because the sewage flowed into brackish water, but at Moore General Hospital the raw sewage was chlorinated for a brief period.

In August 1945, the chlorination procedure was discontinued by the Corps of Engineers because it was believed chlorination could not be relied upon to kill eggs or miracidia. Furthermore, no suitable snail host for Schistosomiasis japonicum had been found to exist in the surrounding areas.

At Harmon General Hospital, Most conducted a thorough evaluation of 300 patients diagnosed and treated overseas. These patients represented a cross section of all those received at the two tropical disease centers.

Most of the 300 patients received at Harmon General Hospital were in excellent physical condition. None were acutely ill, although 255 (85%) had co-morbidity complaints including abdominal discomfort (155), weakness (75), and headache, muscle pain, and nervousness (186). Positive stool samples were obtained in 76 (30%) of the 255 patients. Among 46 (15%) patients with no complaints, positive stools were obtained in 17 (38%). The liver and spleen were palpable in 32 patients with complaints and 4 patients without complaints, respectively. All patients had lost weight. The general condition of the 300 patients was such that only 6 had furlough delayed beyond the initial 2-week period of evaluation.

Abdominal complaints present in 155 of the 300 soldiers were limited to the upper quadrants of the abdomen and varied from an indefinite awareness of soreness to intermittent mild to moderate cramping pain in the region of either the epigastrium or the liver.

Although moderate and marked leukocytosis is a common feature during the acute phase of the disease, in the latent phase after evacuation to the United States positive stools were no more common in those with leukocytosis than in those with normal numbers of white blood cells. Marked eosinophilia was also more characteristic of the acute than of the latent phase, although there was a small correlation between the level of the eosinophilia and the likelihood of finding ova in the stool.

Proctoscopic examinations of these 300 patients resulted in the demonstration of lesions due to schistosomiasis in only 3. This is in striking contrast to the high incidence of lesions of the lower bowel in the acute phase.

## TREATMENT AND RESULTS

The schistosomiasis epidemic on Leyte brought the

Army Medical Department face to face with the challenging problem of determining what the best treatment method. If existent methods of therapy were not effective, new ones would have to be developed.

Before World War II schistosomiasis was treated generally treated with trivalent antimony compounds, Fuadin (stibophen) and tartar emetic, that contain 13.6% and 36% antimony, respectively.

Little about the toxicity of large amounts of trivalent antimony or about its parasiticidal properties against Schistosomiasis japonicum was known before the Leyte epidemic. After the outbreak, trivalent antimony was used carefully and with amounts now known to be much less than adequate for a complete cure.

Among the 300 patients diagnosed as infected based on positive stool examinations, only 31% were found to have positive stools on their arrival at Harmon General Hospital[51]. At Moore General Hospital, closer to 45% of patients had positive stools. Table 5 presents a summary of most of the treatment schedules used, with treatment results.

Winkenwerder[41] while still on Leyte, reported treatment results of 184 patients given small amounts of Fuadin. These results however, were inconclusive because the follow up period was not long enough. One-third of the patients treated suffered a relapse before evacuation to the United States.

These unsatisfactory results using trivalent antimony were reconfirmed at the two Army tropical disease centers[47]. If trivalent antimony compounds were to be effective at all, they would have to be given in larger doses. Consequently, several methods of treatment were used, employing one or the other of the two drugs, Fuadin and tartar emetic, and gradually increasing the amounts administered to each patient as more and more was learned of the individual's tolerance to the drug and the parasite's resistance to its effects.

A clinical trial was designed that used twelve treatment schedules (see Table 6):

Table 6. Treatment schedule and results of treatment of patients infected with Schistosomiasis japonicum, using increasing amounts of trivalent antimony compounds

| Treatment schedule | Trivalent antimony compound | | Gram of antimony | Number of patients treated | Treatment failures | | Where treated |
|---|---|---|---|---|---|---|---|
| | Faudin (6.4% solution) cc | Tarter emetic (0.5% solution) cc | | | Number | Percent | |
| 1 | 40 | – | 0.35 | 165 | 55 | 33.33% | Leyte |
| 2 | 65 | – | 0.57 | 44 | 38 | 86.36% | Harmon |
| 3 | 5 | – | 0.57 | 15 | 15 | 100.00% | Harmon followed at Moore |
| 4 | 70 | – | 0.61 | 44 | 34 | 77.27% | Moore |
| 5 | 100 | 0.87 | 32 | 8 | 25.00% | Moore | |
| 6 | 105 | – | 0.91 | 15 | 6 | 40.00% | Harmon followed at Moore |
| 7 | – | 290 | 0.52 | 51 | 26 | 50.98% | Moore |
| 8 | – | 320 | 0.58 | 59 | 11 | 18.64% | Harmon |
| 9 | – | 320 | 0.58 | 18 | 10 | 55.56% | Harmon followed at Moore |
| 10 | – | 360 | 0.65 | 100 | 20 | 20.00% | Moore |
| 11 | – | 416 | 0.75 | 44 | 3 | 6.82% | Moore |
| 12 | – | 416 | 0.75 | 41 | 7 | 17.07% | Harmon followed at Moore |
| Tota | | | | 628 | 233 | 37.10% | |

1. Fuadin (6.4% solution) intramuscular injections on alternate days of 1.5 and 3.5 cc, then 5.0 cc for 7 doses to a total of 40 cc in 17 days

2 and 3. Fuadin (6.4% solution) intramuscular injections on 5 successive days of 1.5, 3.5, 5.0, 5.0, and 5.0 cc, then on alternate days 5.0 cc for 9 doses to a total of 65 cc in 23 days

4. Fuadin (6.4% solution) intramuscular in-

jections on 3 successive days of 1.5, 3.5, and 5.0 cc, then on alternate days 5.0 cc for 12 doses to a total of 70 cc in 27 days

5. Fuadin (6.4% solution) daily intramuscular injections of 2, 4, 6 cc, then 8 cc for 11 doses to a total of 100 cc in 14 days.

6. Fuadin (6.4% solution) intramuscular injections on alternate days of 5.0 cc to a total of 105 cc

7. Tartar emetic (0.5% solution) intravenous injections on alternate days of 5, 10, and 15 cc, then 20 cc for 13 doses to a total of 290 cc in 31 days.

8 and 9. Tartar emetic (0.5% solution) intravenous injections on alternate days of 8, 12, 16, and 20 cc, then 24 cc for 11 doses to a total of 320 cc in 29 days

10. Tartar emetic (0.5% solution) intravenous injections on alternate days of 10 and 20 cc, then 30 cc for 11 doses to a total of 360 cc in 25 days

11 and 12. Tartar emetic (0.5% solution) intravenous injections on alternate days of 8, 12, 16, 20, and 24 cc, then 28 cc for 12 doses to a total of 416 cc in 33 days

Tartar emetic was found to be a more effective drug in the treatment of schistosomiasis japonica than Fuadin. This conclusion is based on results using methods 2, 3, 8 and 9. The most effective treatment was the one that used the largest amounts of tartar emetic and 0.75 gm. of antimony. Fuadin was less efective.

Relapses were rare. In several patients symptoms recurred. In patients that relapsed, ova reappeared in the stools between 4 to 11 weeks after ending treatment. Both Moore and Harmon General Hospitals arbitrarily set a 3-month follow up period as sufficient time to allow for the reappearance of ova. This time limit was set after following many patients without relapse for much longer periods of time. The researchers however did suggest that follow up of these patients by the Veterans´Administration will indicate that relapse can occur months after the completion of a course of treatment. This was the case for example of Portuguese soldiers that had fought in the Congo during the early 1960s[28].

## CONCLUSION

Schistosomiasis is a parasitic disease found in tropical and semitropical regions. It requires freshwater snails as intermediate hosts for development of the larval forms that can infect humans. Since biblical times schistosomiasis has been implicated as a factor in military operations.

During World War II, approximately 2,500 cases of schistosomiasis were recorded among US Army Soldiers. Approximately 850 of these infections were Schistosomiasis mansoni in Puerto Rican soldiers who had acquired the fluke on the island before entering military service[23]. Only 20 cases of schistosomiasis haematobium were identified in US Soldiers who became infected in 1943 during the North African campaign[23]. Additionally, more than 120 US prisoners of war interned in southern Mindanao contracted Schistosomiasis japonica .

The epidemic of schistosomiasis japonica developed on Leyte during that campaign late in 1944 and early in 1945 and resulted in about 1,500 cases reported among US troops. From the medical viewpoint, the acute nature of the disease among American troops in Leyte made this outbreak particularly significant. For the first time, the disease was seen in its very early stages, not in its chronic form. Indeed, in many cases the disease was recognized even before the worm eggs had reached the feces, and disease symptoms were noticed that had rarely been reported before, and never in such quantity.

In connection with any military operation there are factors that tend to modify the preventability of a disease such as schistosomiasis. Changes in tactics, military reverses, unavoidable accidents, the loss of protective equipment and so forth, can make the amount of contact with infested water unpredictable. On Leyte most Soldiers exposed to schistosome cercaria occurred through swimming and other noncombat activities. Probably not more than 10% of the infections resulted from combat activities.

Sullivan and Ferguson's study of the activities of the large number of combat engineers who became infected while building or repairing bridges on Leyte, work that called for long periods of exposure, indicated that most, if not all, of their disease could have been prevented if rubber boots, waders, flat-bottomed boats and protective applications for the hands had been provided[29].

The length of time spent in infested water and the amount of clothing worn by the individual were also found to be important. Eight men from a medi-

cal unit who went swimming in a stream on Leyte for only half an hour all became infected. In contrast, of the thousands of fully clothed infantrymen who must have waded in streams, swamps, and flooded rice fields in the Leyte Valley, only a relatively small number developed schistosomiasis. These observations suggested that clothing, even though not treated with chemicals, is highly protective against cercaria. As early as 1914, Laning suspected the value of clothing in preventing infection[52].

Information concerning the disease was not generally disseminated. Troops who were aware of the dangers of exposing themselves to fresh water tended to minimize the hazard or to ignore it almost completely. Out of the first 100 consecutive patients with schistosomiasis treated in the 118th General Hospital, only about 15% admitted ever having heard of the disease or of blood worms or flukes.

The field and laboratory studies carried out by the malaria survey detachments and special investigators during the Leyte campaign yielded useful information regarding schistosomiasis. During the aftermath of World War II the U. S. military would continue to play a paramount role in schistosomiasis research especially in Japan and to a lesser degree in Viet Nam.

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