

## Return of the God of Plague: Schistosomiasis in China

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### Abstract

The history of schistosomiasis in China can be traced back with some accuracy for the past hundred years and with less certainty before this time. During the Maoist era China made great strides in attempting to eliminate schistosomiasis using a combination of techniques including snail eradication and mass chemotherapy. The rise in the number of infected persons since 1978 is due to new health and economic development policies. China has done little to turn the tide that has reached epidemic proportions and its future in the new century is clearly indicated by its recent past. This past experience is reviewed in the present paper.

Keywords: Schistosoma, China, Yangtze, Three Gorges Dam, Bilharzia.

### Introduction

On 30 June 1958, Mao Zedong read in the *People Daily* that *schistosomiasis* had been wiped out in Yukiang Province. "Thoughts thronged my mind," he would write "and I could not sleep. In the warm morning breeze next day, as sunlight falls on my window, I look towards the distant southern sky and in my happiness pen the following lines."

Farewell to the god of plague - July 1, 1958

*So many blue streams and green Hills, but to what avail?  
This tiny worm defied even the greatest physicians!  
Hundreds of villages choked with weeds. Men wasted away;  
Thousands of homes deserted, spirits chanted mournfully.  
Merely sitting here, daily I travel eighty thousand li a day,  
Surveying the sky I see a myriad of Milky Ways from afar.  
Should the Herdboy star ask tidings of the God of Plague,  
I'd reply, "His joy is gone as our sorrows."*

*The spring wind blows amid profuse willow wands,  
Six hundred million in this land all like saintly sires.  
Crimson rain swirls in waves  
Green mountains turn to bridges at our wish.  
Gleaming pick axes fall on all of China from the Five Ridges to the Yellow and Lo rivers;  
Mighty arms pound the rock to earth.  
We ask the God of Plague: "Where are you bound?"  
Paper boats lit by candles illuminate the sky taking the Demon God away (Mao, 1966).*

Mao's crusade against schistosomiasis was of particular importance to him. In 1949, when the People's Liberation Army occupied Shanghai during the Civil War against the Nationalists, the troops were required to learn to swim in order to prepare for future battles in the southern provinces. As a result, several thousand acute cases of schistosomiasis appeared, military training was suspended and barracks were transformed into hospital wards. Thus, according to an article in *Harper's Magazine*, the blood fluke had saved Formosa, now known as Taiwan and *Schistosoma japonicum* "turned out to be a precious ally of America and Nationalist China." In the six months that passed before the Chinese army returned to full fighting strength, the US Seventh Fleet had moved into the China Straits and the opportunity to destroy the Nationalists had vanished (Kierman, 1959).

Schistosomiasis is an infection with one of a series of related trematode parasites that are endemic to at least 76 tropical and sub-tropical countries. 200 million people have this disease; 120 million of them have symptoms, 20 million have severe illness and 600 million others remain at risk (Chitsulo et al., 2000). Four species routinely infect the human host and several others rarely do so. The majority of *Schistosoma haematobium* and *Schistosoma mansoni* infections are found in sub-Saharan Africa. *Schistosoma mansoni* remains endemic in parts of Brazil, Venezuela and the Caribbean. *Schistosoma mekongi* is found in Cambodia and Laos, along the Mekong River Delta. *Schistosoma japonicum* infection occurs in China, Indonesia and the Philippines (Patz et al., 2000).

Schistosomiasis is three of the 10 tropical diseases targeted for control by the Special Program for Research and Training in Tropical Diseases of the United Nations Development Program, the World Bank and the World Health Organization. The 54th World Health Assembly has set a goal of treating annually at least 75% of school-age children infected with schistosomes (Newman, 2001).

All species of schistosomes use freshwater snails as intermediate hosts that are essential to the completion of their life cycle. The infection is generally acquired by swimming or bathing in fresh water contaminated with the parasites. Schistosomes multiply inside specific types of water-dwelling snails that are released and swim free in the water. 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 can 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 ecology of schistosomiasis includes tropical lotic (lakes and reservoirs) and lentic environments (rivers). Controlling schistosomiasis is especially daunting, primarily because these parasites are thoroughly integrated into the ecosystems in which they occur. A notable exception is Japan, where *Schistosoma japonicum* was eradicated from all of its islands by 1976, largely based on ecological approaches. In contrast, most underdeveloped countries do not have the political stability, infrastructure, nor the funding to institute such control measures. Furthermore, civil unrest and war have also taken their toll; increasing the likelihood, that schistosomiasis will remain a health problem for some time to come in those chaotic environments. Despite major advances in control and substantial decreases in morbidity and mortality, schistosomiasis continues to spread to new geographic areas. Furthermore, there are reports of resistance to praziquantel, the mainstay of medical treatment (Patz et al., 2000).

## Schistosomiasis in China

While schistosomiasis or bilharzia as it was once more commonly known was identified during the mid-19<sup>th</sup> century, the symptoms of the disease have long been recognized. Schistosome eggs have been found in Chinese mummies. Ancient Chinese writings described schistosomiasis. For example, in 400 BCE a "water poison attacking man ... like a poisonous insect but invisible" was described. In the seventh century, it was noted that in "hill regions south and east of Three Wu [corresponding to Suzhou in Jiangsu Province and Wuxing and Shaoxing in Zhejiang Province], there is [a] water poison disease in streams contracted easily in spring and autumn. . . . in [the] water, there are minute and invisible sand lice that penetrate human skin when [a] man is bathing in streams or in water from the streams ... [a] rash appears at the beginning, in the size of millet and is prickling upon touch ... onset with chill, headache and orbit pain (Mao and Shao, 1982).

Before 1924, virtually all studies in China were essentially case reports, with a few investigations of the distribution of infection (Warren and Newill, 1967). That year, Faust and Meloney's exhaustive 339-page monograph, *Studies on Schistosomiasis japonica*, appeared. Their investigations included:

- Research on the morphology and biology of the developmental stages of the worms
- The pathological effects of the worms on human and molluscan hosts
- The distribution of schistosomiasis in china, including the environmental conditions governing such distribution
- The treatment and control of the infection

With respect to its distribution, a questionnaire sent to Western doctors throughout China revealed that 70% of 13 suspected provinces had definite areas of infection; most importantly, the Yangzi flood area. Faust and Meloney studied the infection in rabbits and dogs and examined intensively 17 hospitalized patients with advanced hepatosplenic disease. They described emaciation, enlarged liver and spleen, ascites (fluid in the abdomen), dilatation of the veins of the abdomen, anemia and hematemesis (vomiting of blood). The treatment of choice at the time was toxic antimony drugs (Faust and Meloney, 1924).

From 1924 until 1958 there were few studies on schistosomiasis; most studies conducted were largely case reports and distribution studies. Concern about schistosomiasis and other parasitic diseases led to the establishment in 1950 by the Chinese Academy of Medical Sciences of the Institute of Parasitic Diseases in Shanghai.

In April 1952, the *New York Times* published an article on the extent of the epidemic in "Red China" thus bringing the disease to the popular press (1952).

*About 10,000,000 persons are now suffering from schistosomiasis in more than 100 counties and municipalities of Kiangsu [Jiangsu], Chekiang, Anhwei and Fukien [Fujian] provinces in East China, according to a Chinese Communist health official ....*

*In an article published by The Shanghai Liberation Daily on March 6, Kung Naichuan, Deputy Health Director of the East China Military and Administrative Commission, said that present efforts to combat schistosomiasis in his area were being hampered by a shortage of health personnel.*

*He said other difficulties included the rapidity with which the disease spreads, the peasants' "manner of living and habits of work" and lack of a "safe and convenient drug." Calling for an intensified mobilization of doctors and a large scale training of public health workers, he wrote:*

*"The greatest difficulty in our work is a shortage of cadres. There are only ten doctors or so who are regularly in charge of prevention work and treatment.*

*The East China health official threw a spotlight on schistosomiasis in the midst of the Peiping [Beijing] Government's nationwide "anti-epidemic mobilization" drive. This drive is paralleling continuing charges by Peiping Radio that United States planes have been dropping "germ-laden insects" into North Korea, Manchuria and Shantung province.*

*Mr. Kung said that in East China localities, where the incidence of schistosomiasis is especially high, as many as 97 per cent of the inhabitants have contracted the disease.*

*The health official noted that the East China authorities had issued a directive last Dec. 25 calling for a concerted drive against schistosomiasis.*

*Mr. Kung declared that the results had been "poor so far, both administratively and medically."*

*"Schistosomiasis has become a fierce and stubborn enemy that threatens the broad masses of the people in East China," he said. "We must strive to prevent and combat the disease and eliminate it with resolution."*

### **The Politicization of Schistosomiasis as a Health Issue**

Health care in the early years of the Communist government remained entrenched in the hands of Western-style Chinese physicians, trained at institutions such as the Peking Union Medical College, which after nationalization in 1951 became the Union Medical College of China.

At the First National Health Conference in 1950, three major policy decisions enacted threatened the status quo. In the future, the conference resolved, attention would be placed upon the health of workers, peasants and soldiers; there would be an emphasis on preventive medicine; and traditional Chinese and modern medicine would be combined. The head offices of the Chinese Medical Association moved from Shanghai to Beijing and, at the same time, the Chinese Medical Journal announced that all papers were to be written in Chinese, with the editor selecting those that would be translated into English. Medical personnel were urged also to "cultivate interests outside their specialization" and to learn "political and social sciences, for this is [the] only way through which science can develop along the right track (Editors, 1951)."

The Party quickly gained control of the Ministry of Health and of the profession. By 1953, F. Lien-chang, President of the Chinese Medical Association and a leading figure in the Red Army hospital system, announced that members of the medical profession had been "called to duty." According to him, they were working in factories and mines and in border regions beyond the lure of big cities. They were involved also in practical research, working jointly with practitioners of traditional medicine.

Physicians were also urged to follow the guidelines of dialectical materialism. According to Lien-chang, Soviet medicine was the most advanced in the world and only by mastering dialectical materialism, could the Chinese understand physiological phenomena, investigate causes of disease and carry out correct preventive measures. "Disease is related to both the body and the environment," he wrote, but medicine in the old days "was founded on idealism and mechanical materialism and was, therefore, in many respects, unscientific and divorced from the needs of the people (Lien Chang, 1953)."

Further undermining of the influence of Western-style medical professionals occurred with the formation of special health committees answering only to the Party. However, in reality medical policies changed little. The Party remained dependent on the skills of those trained in Western ways.

From 1951 to 1956, massive surveys were conducted using both stool examinations and skin testing and 10,407,000 infections were reported. Severe schistosomiasis that devastated entire regions, was also reported, primarily in the Shanghai region. Villages described mortality rates of 50% to 75%, with more than 90% infection rates. The famous "Village of the Widows" now contains a museum and a shrine to the victims of this disease:

*Tzeshih village of Kiangning county, Hupei province, where the disease levied such a heavy toll on the inhabitants that 12,000 mu [mu = one-sixth of an acre] of fertile land which once made the village famous for rice production, were overgrown with weeds. Scourged by famine, the people survived on seaweed in spring, wild herbs in summer, husks in autumn and handouts in winter. Many ended the nightmare of their existence with suicide (Cheng, 1971).*

Unable to control its spread, in 1955, the Chinese Government recognizing the great strides in the control of schistosomiasis achieved in Japan, asked the Japanese Society of Parasitology to advise them on control methods. A Japanese medical delegation spent about two months in China and published its recommendations in 1957. These put a major emphasis on prevention, the principal aim of which was elimination of the snail vector (Komiya, 1957). This approach became one of the major control strategy used in China.

Another approach involved the use of chemotherapy. Late in 1955, the anti-schistosomiasis campaign was removed from the control of the Ministry of Public Health and put in the hands of a 9-man "Leading Group" set up by the Chinese Communist party Central Committee. Mass chemotherapy was introduced by that group. In 1956 and 1957, some nine hundred thousand persons were treated with sodium antimony tartrate, essentially the same treatment in use since the 1920s (Aburayah, 1993). A 3-day intensive treatment introduced in 1958 was reportedly used on as many as 5 million infected persons between 1958 and 1962 (Geerts and Gryseels, 2000).

Meanwhile, changes were beginning to take place in the rural health field. During the first four years of the Communist government, the number of research papers on schistosomiasis nearly doubled over what it had been in the previous 40 years (Warren, 1988). Some of this research was of the standard fare: testing various molluscicides, from copper sulfate to Paris green and DDT; testing various antimony drugs for their therapeutic effects; surveying reservoir hosts; and searching for more reliable diagnostic methods.

However, other aspects of this research such as finding methods of killing schistosome eggs in feces stored for fertilizers and testing native herbal drugs for their therapeutic and molluscicidal effects had a uniquely Chinese flavor. Croton oil emulsion, for example, a powerful purgative drug, was found to kill snails. *Platycodon*, the balloon flower with a bitter-tasting latex; *Piper*, the pepper plant, containing a powerful stimulant and irritant; *Gleditschia*, with poisonous alkaloids in the leaves and bark; *Chrysanthemum* and *Stephania*, the moonseed with bitter-tasting roots - were found to have therapeutic effects. Many labor-intensive physical methods, such as grass burning, burial in soil and reclamation of low and flooded land by dike building, was effective in rendering areas free from the amphibious snail host, *Oncomelania*.

Su Delong, vice rector of Shanghai First Medical College had worked in a highly endemic village in Jiangxi as early as 1942. A group was formed to deal with the problem and Dr. Su was appointed Vice

secretary. Later he studied schistosomiasis around Shanghai and found a very high rate of infection. In 1955, Chairman Mao showed a particular interest in the problem and the following year an official commission was organized. Mao's interest according to Dr. Su was, "Because he deals with so many of the people and soldiers suffering from this disease." On 7 July 1957 Dr. Su was summoned by the Chairman, who asked him to describe the situation and review what could be done about it. After hearing Su's report, "Mao's response was, 'Well, can we eradicate this disease within seven years?' I [Su] said I didn't know, perhaps the time is too short. He changed his idea. He said, 'How about twelve years? It is slightly better. It is better.' He issued an order saying this disease must be wiped out in twelve years. At that time, his order was heard, high authority, you see. Everybody has to obey his orders (Hsin-chung, 1958, Sandbach, 1977)."

However, 12 years proved to be too long a wait. In 1958, to revitalize agriculture and to accelerate agricultural production that had been lagging behind, the Communist government initiated the Great Leap Forward. The anticipated rise in agricultural productivity resulting from this plan would provide, they predicted, the finances for massive rural health campaigns, in which traditional Chinese medicine would play a vital role.

### The First Campaign

The Great Leap Forward period (1958-60) began a period of intense study of schistosomiasis. Nonprofessional cadres of middle-level health workers dominated the campaign against schistosomiasis, initiated by the Nine-Man Schistosomiasis Subcommittee and carried out by Party committees at the local level. Seventeen thousand specialized workers in 1,282 prevention and treatment units, working out of 197 centers and 42 research institutes, carried out the anti-schistosomiasis campaign "according to the principle of science integrated with mass movement and prevention and treatment integrated with production (Hsin-chung, 1958)." The traditional three to four week treatment with antimony tartrate was cut to two or three days, with a cure rate reported to be over 85%. Logistical improvements speeded up the examination and diagnostic procedures to such an extent that health teams claimed to have examined 2,800,000 Chinese in the first nine months of 1958. One health inspection team stretched credulity to the breaking point by claiming to have examined 1,200 patients in a single day! In these same nine months, the Chinese claimed to have reduced the contamination of soil by schistosome eggs with the construction or repair of 67,270,000 latrines. However, most impressive of all, thousands of peasants' reclaimed swampland, dug new drainage ditches, buried snails under the earth, burned grass and applied chemicals.

"Thanks to these effective measures," Ch'ien Hsin-chung announced at the end of 1958, "schistosomiasis has been basically wiped out in more than half the endemic areas in the country (167 counties and cities, including the whole of Jiangsu and Fujian provinces and Shanghai). The day is not far off when schistosomiasis will be basically or completely wiped out in the whole country (Hsin-chung, 1958)."

Yujiang County in Jiangsu Province was the first to claim total elimination of the disease, while, in adjacent Anhwei, 10 million peasants cleared snails from 11 counties. In an anti-schistosomiasis campaign was launched "simultaneously with their efforts to develop production and their struggle against the traitorous Chiang Kai-shek clique entrenched in Quemoy and Matsu Islands," 96% of 45,000 patients with the disease were reported cured and 13 million square meters cleared of snails (1958). A former lake in Hupei Province, Wei Pen-po reported, was flooded in the summer and full of weeds and snails in winter. Those who used the lake to grow crops died. But, during the campaign the lake bed was ploughed three times, the snails buried and the land reclaimed for cotton. By this integration of a mass movement with science and technology, he argued, "the Party can cure what the powers above have failed to do." With political guidance, he reported, 120,000-150,000 peasants in Jiangsu Province, working day and night, buried snails, drained water, improved irrigation and increased the amount of arable land (Wen-po, 1958).

It was at this time that Mao Zedong read that schistosomiasis had been wiped out in Jinjiang County and he penned his famous lines "Farewell to the God of Plague."

By 1960 progress in public health has been rapid. Under the inspiration of "getting all out, aiming higher and getting greater, quicker, better and more economical results to build socialism," the Minister of Public Health claimed that schistosomiasis had been cleared from 65% of previously affected areas (Teh-chuan, 1959). Under the reactionary Kuomintang, reported a member of the Nine-Man Schistosomiasis Subcommittee, "this beautiful land was literally turned into a hell on earth." Today, in

contrast, "desolate villages are filled with children and laughter." The anti-schistosomiasis campaign has "invigorated the national spirit," he argued and raised "political consciousness":

*What the Gods failed to cure is not insurmountable to the Communist Party. With the Communist Party and the people's communes there is nothing on earth that cannot be done.... It is our firm belief that if we resolutely oppose rightist deviation and exert all our efforts, a decisive victory will soon be won (1960).*

In the early 1960s, as agricultural and industrial production started to fall, these mass public health activities began to collapse. Mao's influence eroded, commune sizes were cut and, with depleted resources, the health-unit teams decreased in size. In famous Jinjang County, for example, the number of health workers decreased from 3,900 in 1960 to only 300 five years later.

Through the cacophony of the eradication campaigns and their claims of success within various time frames (one, seven and twelve years), it has been difficult for outsiders to assess the success of this program. From the very beginning, experts on schistosomiasis had concerns that the program could succeed; *Schistosomiasis japonica* is theoretically the most difficult of all the forms of schistosomiasis to control. First, the snails are amphibious rather than purely aquatic. Second, there are a large number of different reservoir hosts, both domestic and wild; and third, it is the most difficult form of schistosomiasis to treat, requiring large amounts of highly toxic drugs. A major assessment of the programs conducted in 1971 noted the frequent claims of spectacular successes in the Chinese literature. He described a series of highly successful localized campaigns but concluded, "In my opinion, China's struggle against schistosomiasis is by no means won and her vaunted seven-year plan for nationwide schistosomiasis eradication has fallen behind schedule (Cheng, 1971)."

In 1975, a delegation of American experts visited the People's Republic of China to assess the schistosomiasis control campaign. "Unfortunately, we were unable to evaluate with confidence the degree to which transmission has been reduced" they concluded (American Schistosomiasis Delegation, 1977).

### **The Impact of Post-Maoist-Era Reforms on Schistosomiasis**

In January 2005, China held its national conference on public health in Beijing. Gao Qiang, Executive Vice Health Minister lauded the accomplishments of the last 50 years of China's health care system boasting that China had lowered its infant mortality rate from 200 to 25 deaths per 1000 live births and raised life expectancy from 35 years to 72 years. He emphasized the importance of the country's health in relation to its economic and socialist development and urged the people to create a competent health care workforce. Gao advocated the continued need for government leadership in shaping the nation's health care system and advocated reform as the country's impetus for health care development (Liu, 2004).

These are continuing themes for China's leadership. Indeed, one of the most notable achievements of the Maoist era was the dramatic improvement in health care. Yet, while Mao had made great strides in eliminating schistosomiasis, the grand Maoist-era experiments in restructuring the Chinese economy, in particular the late 1950s Great Leap Forward and the political violence that occurred during the Cultural Revolution proved disastrous. This was crucial in determining the outcome of the political struggles that occurred after Mao's death. The pragmatists, in particular Deng Xiaoping, rose to a position of greater control because of the perception that Mao's successors created political chaos and personal suffering by their own pursuit of dominance. The trial of the so-called Gang of Four was a pivotal moment in this decisive shift of power away from the leftists to the pragmatists.

In late 1978, Deng Xiaoping and the Chinese leadership began moving the economy from a sluggish, inefficient, Soviet-style centrally planned economy to a more market-oriented system. Whereas the system operates within a political framework of strict Communist control, the economic influence of non-state organizations and individual citizens has been steadily increasing. The authorities switched to a system of household, village responsibility in agriculture in place of the old collectivization, increased the authority of local officials and plant managers in industry, permitted a wide variety of small-scale enterprises in services and light manufacturing and opened the economy to increased foreign trade and investment.

These policies succeeded in accelerating economic growth. Measured on a purchasing power parity basis, China in 2005 stood as the second-largest economy in the world after the US, although in per capita terms the country is still poor. Agriculture and industry have posted major gains especially in coastal areas near Hong Kong and in Shanghai, where foreign investment has helped spur output of

both domestic and export goods. The leadership, however, often has experienced - because of its hybrid system - the worst results of socialism (bureaucracy and lassitude) and of capitalism (growing income disparities and rising unemployment) (Central Intelligence Agency, 2006).

Among the economic effects of the market-oriented system has been a significant rise in cases of schistosomiasis. This is a result of two major actions. First, the impact of privatization in health care financing and delivery systems. The second is due to large hydroelectric dam construction projects.

### **Health Care Privatization and Its Impact on Schistosomiasis Control**

Privatization efforts in health care began to wipe out the advances in Schistosomiasis abatement. During the 1980s, the rural people's communes were dismantled, as was the cooperative medical system. During the period most of China's rural areas, health care shifted to a fee-for-service system, in which the former rudimentary arrangements for health and medical insurance have not been preserved (Aburayah, 1993). Most rural areas lack the resources necessary to purchase the same amount of health care previously provided by the commune system.

The lack of financial resources for the cooperatives also resulted in a decrease in the number of barefoot doctors, that meant that health education and primary and home care suffered and that in some village's sanitation and water supplies are checked less frequently. Additionally, the failure of the cooperative health-care system limited the funds available for continuing education for barefoot doctors, thereby hindering their ability to provide adequate preventive and curative services. The costs of medical treatment increased, deterring some patients from obtaining necessary medical attention. If the patients could not pay for services received, then the financial responsibility fell on the hospitals and commune health centers, in some cases creating large debts.

The social pitfalls of this system were laid bare in a 1998 United Nations-led survey, that found that almost half of those who had fallen below China's poverty line did so only after suffering from a major disease.

By 2005, just 15% of the population had health insurance. China is the only one of the 37 nations in the western-Pacific region that requires its citizens to pay for routine childhood immunizations. "During the past 20 years of reform, the government only focused on economic development," says Song Wenzhi, a professor at the Peking University Public Health Institute in Beijing. "It neglected social issues, such as health." No surprise, then, that a 2000 WHO study that ranked the health systems of 191 member countries placed China 144th behind Indonesia and Bangladesh.

By the early 1990s, local health workers no longer had a budget to spray anti-snail pesticide. Free schistosomiasis checkups and medicine stopped as well. Funding for local clinics once proudly designated as "anti-snail-fever bureaus" also dried up; to make ends meet, many clinics converted to moneymaking clinics for sexually transmitted diseases and osteopathy. Consequently, just as China was proudly announcing that it had defeated snail fever, the mollusk began returning. In 2004, according to statistics from the Ministry of Health, 810,000 people contracted schistosomiasis, more than double the number of cases in 1988.

### **The Three Gorges Dam**

The most dramatic increase in cases of schistosomiasis infections has been along the Yangtze River. According to a published report there are now more than 210,000 infections in Hunan Province alone. On April 27, 2004, the Chinese Ministry of Public Health stated that there were about 810,000 infected cases in China and the susceptible population reaches 60 to 100 million. However, experts caution that the real figure is much higher and could spiral further upward upon completion of the Three Gorges Dam.

Because of the Three Gorges Dam, the ecology of central China has changed substantially in ways that affect the distribution and transmission of schistosomiasis (Sleigh and Jackson, 1998). This giant impoundment across the Yangtze River is nearly 135 m high. Upon its completion, it will reach its full height of 185 m and begin to generate 18,600 MW of power for the whole of China (Jackson and Sleigh, 2000). It will also help to control the lower Yangtze floods that cause periodic disasters. But, it will create a lake behind the dam that will stretch 600 km upriver, with shorelines suitable in many areas for schistosomiasis. The lake is located between the two key transmission zones of schistosomiasis, Sichuan and Hubei and Hunan provinces. The downstream schistosomiasis-free buffer is only 40 km and the upstream buffer is 500 km.

Dislocations of over 1 million people, immigration into areas settled by 19 million people along the lake and increased river traffic could introduce both parasite and intermediate host into the lake. The lake will provide an opportunity for hybridization by two subspecies of the intermediate host. Once schistosomes establish in the lake, they will be difficult to eradicate.

In addition to the problems posed by the new lake, the downstream area is undergoing massive change in ways that also affect schistosomiasis. Downstream flows will be higher in winter and lower in summer. The marshlands will expand. Silt deposition will change; some areas will become more suitable for intermediate-host snails and other areas will become less suitable. This is certain to alter the distribution and endemicity of schistosome infection in unpredictable ways.

Over the past 20 years throughout the tropics, wide spread dam construction has been the rule. While dams allow for the possibility of creating massive irrigation schemes, large reservoirs for supplying drinking water and, in some cases, the generation of hydroelectric power, they also have inadvertently increased snail habitat and mosquito and black fly breeding sites. For example, in Senegal, recently constructed dams and irrigation projects have led to the spread of *S. mansoni* into previously uninfected areas.

## Results

The collective effort to understand and control schistosomiasis japonica in China since the 1920s has been enormous. In areas where it was possible, the transmission environment was modified to make it resistant to the snail hosts. Toxic drugs were used to cure infection and those infected were monitored for years until cure was certain. Great progress was made and the awful toll taken on affected human populations was greatly reduced (Geerts and Gryseels, 2000).

The inability to eradicate the parasite from large areas of the lake and marshland zones of the middle Yangtze and from the upper reaches of that river, together with ecological changes soon to arise throughout the Yangtze basin due to construction of the Three Gorges Dam, make it imperative to develop new strategies for control (Ross et al., 2001). Foremost among these is the development of human and animal vaccines.

China and Japan both had endemic schistosomiasis at one time. Today, China still has the infection, while Japan does not. Japan solved their problem using several approaches, none of which involved either drugs or vaccines. Water buffalo were the commonly used animal in rice paddy farming. By switching to horses, a far less susceptible host, the incidence in the reservoir went down significantly. Littoral vegetation was removed from the sides of canals feeding irrigation projects and the incidence went down further. Finally the institution of good sanitary practices in controlling human excrement finally brought the number of infected people down below the limit necessary for transmission. In 1976, Japan declared itself schistosome-free, both in its citizens and in its animals. All of this effort required well-coordinated public health education, remarkable outreach to farmers and extensive knowledge of the ecology of the snails that are involved in the parasite's life cycle. Most importantly, there was the political will to do so, a stable government to implement and coordinate control programs and more than adequate funding for them, insuring their success.

In 2003 Time (Beech, 2003) magazine noted that Xinmin village in Hunan province is on the verge of extinction. Nearly every resident in this hamlet of about 1,000 is infected with *Schistosoma*. That is the grim fate awaiting Xinmin villager Wang Zengkun. The 45-year-old rice farmer first experienced the stomach cramps and bloody diarrhea that signal schistosomiasis in 2001. For a while, Wang fought the disease by spending his life savings, some \$4,830, on medication and operations that removed calcified egg deposits and polyps from his body. But, by 2003, when doctors told Wang that he needed more surgery, he had to forgo it. He had no money left. Wang is not alone. Four of his neighbors who lived along the fetid stream have died. "The government does not care about us farmers, only about economic development," says Wang, cradling his distended belly with gnarled hands. "There's no one to protect us anymore."

Nearby on Dongting Lake, a reed cutter surnamed Song is resigned to the worms invading his body. During the colder months, he serves as the plantation's caretaker, living in a makeshift lean-to made of reeds. One of the few ornaments inside his cramped quarters is a portrait of Chairman Mao. Outside, the ground is littered with the shells of snails. Song's drinking and washing water, drawn from a brackish pit near his hut, also teems with *Schistosoma* worms in the summer. Naturally, Song has snail fever. He does not feel the symptoms yet, but he knows they will come—as they have for nearly everyone, he knows.



"I will get sick," says Song, who cannot afford proper treatment. "But I have no other choice for a job." The God of Plague has returned to Mao's home province, with a vengeance.

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