Eradication of schistosomiasis in Guangxi, China. Part 1: Setting, strategies, operations, and outcomes, 1953–92

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Reported are the results of an analysis of a 40-year programme leading to eradication of schistosomiasis in Guangxi, China, a large, poor autonomous region of the country that had the heaviest global burden of the disease. We used historical county data and maps showing the initial distribution and density of Oncomelania *snails and the initial prevalence of schistosomiasis to assess the correlation between snail occurrence and human infection. All annual county schistosomiasis reports were collected and analysed, including information on snail abundance and infection, human and animal infection control, stool examinations and patient treatments, clinical and serology examinations, skin test surveillance, patient follow-up, patient treatments, animal examinations, water supply and sanitation, and environmental modification.*

The findings bear witness to the laborious, systematic and scientific basis of the control programme and how it changed over the 40 years. Of note is the continual search for and treatment of cases, the killing of snails, and the permanent alteration of their habitats using mass community participation and methods adapted to local conditions. The programme has freed more than 10 million people from the risk of schistosomiasis and boosted rural economic development and health. The persistence, good record keeping, evolving and locally flexible strategies, and the clear focus of the control programme were crucial to its eventual success.

Introduction

This article analyses policies, strategies, activities and outcomes of the programme leading to schistosomiasis eradication in Guangxi, a large autonomous region in south-west China. In many areas of China schistosomiasis has been eradicated (*1*), and reviews of the general features and substantial success of schistosomiasis control in the country have appeared (*1–8*). However, a detailed analysis of a successful regional programme and its subsequent maintenance has not been reported outside of the country. This article, and two others (*9*, *10*), close the gap in our knowledge of a public health success of great importance — schistosomiasis eradication in a large and generally poor region of the country which had the heaviest burden of schistosomiasis in the world (see Fig. 1).

This, the first article in the series, describes the setting and analyses activities and outcomes over a period of 40 years; the second analyses the political economy, management, and costs of the programme; and the third evaluates prospects, problems, and strategies for maintenance in the future, with a description of the three worst-affected counties. Our work led to community feedback in 1995 and 1996, resulting in several changes in current strategies, which are now kept under continuous review (*10–12*).

The experience accumulated during Guangxi's eradication programme, and the approach that led to its eventual success on such a large scale, despite limited resources and very low per capita income, are object lessons for other programmes attempting to control endemic schistosomiasis. This information will also benefit future public health workers in Guangxi: oncomelanid snail hosts for schistosomiasis persist in seven other Chinese provinces, and perhaps also (undetected) in isolated uninhabited areas of Guangxi itself.

Setting

Guangxi Zhuang Autonomous Region is the eleventh most populous (population, 44 million in 1994)

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and ninth largest (236600 km^2) of the 22 provinces, five autonomous regions, and four national municipalities in China (*13, 14*). The region lies in China's subtropical south (lat. 20°54′ N to 26°23′ N) and borders four provinces: Hunan (north-east), Guizhou (north-west), Guangdong (east) and Yunan (west). The South China Sea and Viet Nam form the southern border (see Fig. 1).

Along with Guizhou and Yunan, Guangxi forms part of south-west China, an area of widespread poverty, numerous ethnic minorities, difficult transport, poor communication, mountains, and large rivers. The national government singled out this area for priority in current development efforts: many improvements are emerging, including a rail link opened in March 1997 between the capitals of Guangxi and Yunan, connecting the south-west to the rest of China and to the growing port at Beihai.

Of the population of Guangxi, 39% is made up of 12 minority ethnic groups, including the Zhuang (34%), the largest and best integrated minority in China, and the mountain-dwelling Hmong, Yao, Dong, Maonan, Mulao, Jing and Yi groups. The remaining 61% are Han, China's main ethnic group (*15*). Before 1949 the average birth rate in Guangxi was 50–60 per 1000 per year. Between 1949 and 1983 the population grew rapidly from 18.42 million to 37.33 million. Family planning then slowed the growth rate, which is now below 2.5% per year. In 1994 the population reached 44.38 million, a density of 188 persons per km^2.

Most of the land in Guangxi lies >800 m above sea level (35%); tableland and terraced areas cover 8%, flatland 14%, and the rivers are so large and numerous that they cover 3%. The 69 rivers and tributaries stretch 34000 km, with a catchment area >1000 km^2. The rivers divide into three systems: those forming the Pearl (Zhu Jiang) entering the sea near Hong Kong Special Administrative Region, 30 others that are tributaries of the Yangtze (Chang Jiang), and several that flow directly into the South China Sea. The Pearl has its main source in the Nan Pan Jiang, originating from Ma Xiong Mountain in Zhan Yi county, Yunan Province. It flows through Guizhou Province into Guangxi as the Hong Shui Jiang (Red Water River), joins with several large rivers, and flows on to Guangdong as the Pearl.

Guangxi is one of China's important rice-growing areas, usually yielding two crops per year. Other important food crops are maize, sweet potatoes, wheat, soy beans and peanuts. Irrigation boosts production: the irrigated areas totalled only 7 million *mu* (0.47 million hectares) before 1949 but now comprise 20 million *mu* (1.34 million hectares). Guangxi is China's largest producer of cassava and second largest producer of sugar. Pigs are the most important livestock, followed by cattle and sheep (*15*). Until recently living standards were very low; a 1984 survey of 1020 rural households in 17 counties revealed an average net per capita income of only 267 *yuan* (<US$ 50) (*15*). The urban economy is now expanding rapidly along with the rest of southern China, but rural Guangxi still remains poor (*10*).

Guangxi has 84800 trained health workers (about 1 per 500 persons), mostly private village doctors (previously known as barefoot doctors); 94% of villages have primary health care centres. Over the last 50 years in Guangxi smallpox, schistosomiasis (1989) and filariasis (1994) have been eradicated and endemic goitre, dengue, Japanese encephalitis, poliomyelitis, measles, diphtheria, malaria, and other infectious diseases have been controlled. Liver fluke (*Clonorchis sinensis*) remains widespread, and endemic lung fluke infection with various *Paragonimus* spp. persists in some isolated areas (*16*).

Methods

We documented the 40-year history of the control programme from internal reports and published summaries (*17*) and by interviewing staff who had been with the programme since it began. All but one had retired. Historical county data and maps (*18*) showing the initial distribution and density of *Oncomelania* snails and initial prevalence of schistosomiasis were used to assess the correlation between snail occurrence and human infection.

Over 70% of annual county schistosomiasis report forms were retrieved and less than 10% were unusable. The forms recorded epidemiological settings, outcomes and measured control activities according to the following categories: county profile, snail control, snail distribution, snail habitat and infection, environmental changes, stool examinations and patient treatments, clinical and serology examinations, skin test surveillance, advanced patient follow-up, patient treatments by regimen, animal examinations, water supply and sanitation, and environmental modification. The data were entered on a computer using a Chinese version of FoxBase software. Files were constructed by category, each unit record being for one county and one year, and converted to SPSS format using DBMSCopy. Subsequently, the data were recoded to English variable names and Arabic numerals and analysed using SPSS software.

Results

History

Schistosomiasis has been known to be endemic to parts of Guangxi since 1938. The Guangxi government led a sustained control campaign from the early 1950s. A total of 19 counties, covering one-third of Guangxi, had endemic human schistosomiasis and enzootic infection of various wild and domestic mammals. A large workforce of nearly 500 health professionals provided technical support in this effort. They were organized into a network of control stations established in all but two of the affected counties and were supervised by the Guangxi Institute of Parasitic Disease Control through its central unit in Nanning.

During the early stages of the control programme, which coincided with the period immediately after the 1949 Liberation, people in the epidemic areas had long been affected by the feudal social structure and many superstitious beliefs. The local economy was very poor. Rural people lacked medical facilities and supplies and had no money to pay for drugs and services. In the early 1950s medical teams visited rural areas, detecting schistosomiasis cases and snails in Yishan and Luocheng counties in 1951.

From 1954 to 1956 peasants were asked by local leaders to search for and report the presence of snails or illness indicative of schistosomiasis in their areas. Questionnaires were mailed to every county township and village asking about patients with symptoms of schistosomiasis, as outlined in vignettes, and the oncomelanid snail was described and sketches of it were provided. Community leaders at every level received pre-stamped return-addressed envelopes containing questionnaires and were asked to send suspect snails found by villagers if the focus had at least five snails. Mail was carried by foot and took many days to reach most endemic areas.

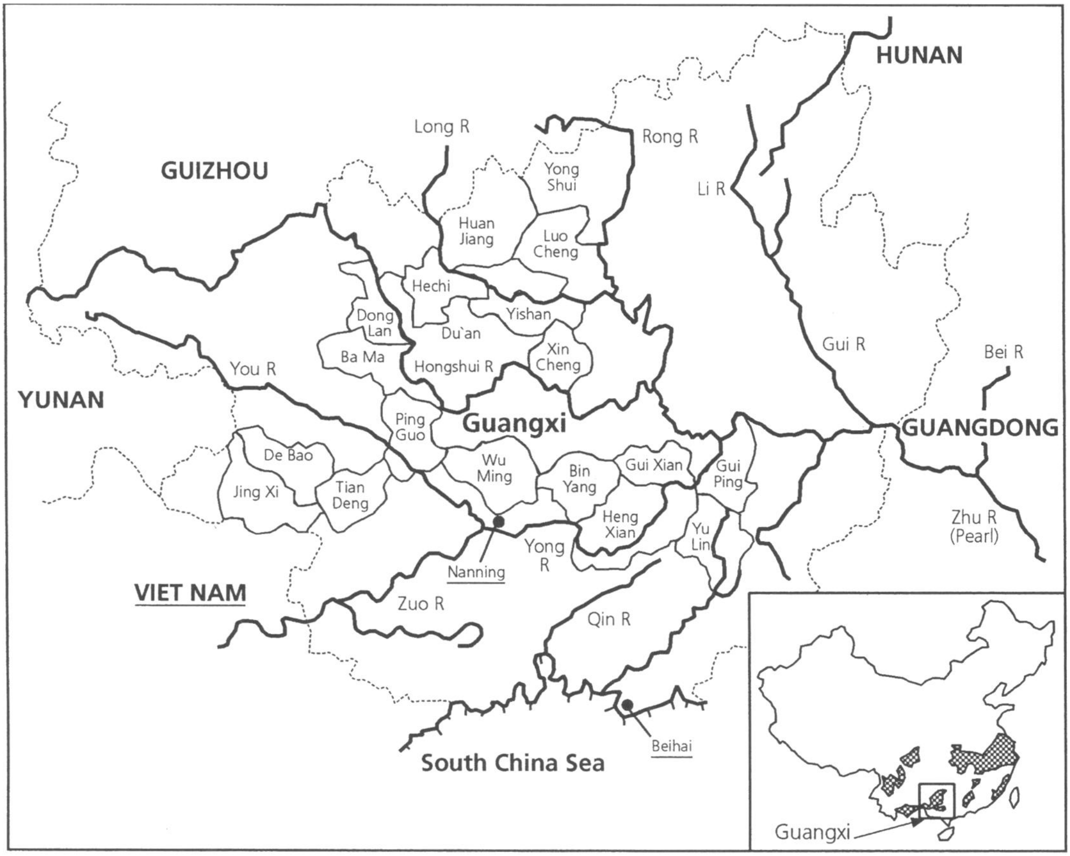
The community response was enthusiastic and completed questionnaires and a large number of snails were returned from rural areas to Nanning over the following 2 years. As a result, the following additional endemic counties were identified by the end of 1956. Hechi, Huanjiang, Xincheng, Yongshui and Du'an, in 1954; Bama and Donglan in 1955; and Tiandeng, Pinguo, Wuming, Hengxian, Jingxi and Debao, in 1956. In 1972 one more endemic county was discovered (Guixian) and two more were found in the early 1980s: Yulin (1983) and Guiping (1985) (Fig. 1).

When initial surveys revealed endemic schistosomiasis, local governments held meetings to educate and mobilize township and village cadres, masses, militia, and women. They also printed and distributed pamphlets on how to prevent and treat schistosomiasis, the life cycle of schistosomes, and how schistosomiasis spreads; and hung posters on the life cycle of schistosomes on walls. Warning placards were erected at snail breeding sites, along highways, under trees, and beside streams and pools to warn people about schistosomiasis. Exhibitions were held at meetings for county, township and village cadres, at evening schools and at mass literacy classes. Rabbits and mice infected with schistosomes were dissected to demonstrate the worms and enhance the effect of the information campaign. Also, animals infected with schistosomiasis and samples of infected tissue and worms were sent to schools to be displayed, and all students had classes on schistosomiasis control. Films and slides on schistosomiasis were shown in towns and villages, and didactic short plays, songs, and dances were performed. Eventually, sceptical peasants accepted the persistent education on the causes and consequences of schistosomiasis and cooperated with the control programme.

From the outset the control measures integrated detection and complete elimination of snail foci and the discovery, examination, treatment and follow-up of all patients and sick cattle, and the control of faeces and water. The snail countermeasures employed were matched to the ecological characteristics of habitat types. The principle was to transform the environment making it unsuitable for snails or easy to detect them for subsequent killing. The snail and environmental measures encouraged mass participation by local peasants and were integrated with the agricultural sector from the start. This ensured that elimination of schistosomiasis also boosted agricultural production. The methods used included the following: boring holes through mountains to drain waterlogged land, reclaiming wasteland, digging and lining new canals and filling up the old water courses, building dams to store water, destroying weeds, composting, burning, and use of molluscicides.

Humans and livestock were examined and treated to reduce the numbers of patients and sick cattle, boost agricultural production and decrease the parasite population. Also, the programme detected, treated and followed up all infected people and animals, continued annual snail and infection surveillance in all areas that had once been positive for schistosomiasis, and carried out water and sanitation improvements. To control faeces and protect domestic water supplies, communal septic tanks were built to kill schistosome eggs and prevent transmission, especially when night soil was used as farm manure. Wells were built to reduce contact with in-

Fig. 1. **Map of Guangxi showing counties where schistosomiasis was endemic.**



fested water, and other water improvements such as sand filters were introduced.

Two new areas of endemic infection were discovered in the 1980s but these were quickly eradicated and the whole of Guangxi was declared snail- and schistosomiasis-free in 1989. Snails returned to some foci but were re-eradicated and none have been found, despite careful monitoring, since 1992. Infection surveillance of schoolchildren and meticulous inspection for snails continues in the 1990s, although the costs are rising for this activity.

Snail surveillance was modified in the 1990s (*10–12*). The focus is now on high-risk sites for the rapid detection of snails should they reappear; any foci will be re-eradicated rapidly, as happened in Du'an, Luocheng, Yishan, Jingxi and Debao counties when snails re-appeared after they had been eradicated there. Vigilance will continue to keep Guangxi snail-free for another 15–20 years until economic progress, good hygiene and living conditions, safe livestock management and mechanized farming make domestic animal or human transmission unlikely.

Recognition of schistosomiasis and its control has declined among the 11 million people living in the 19 endemic counties in Guangxi. Despite the effort required to abolish all known snail foci, some areas have again become environmentally vulnerable through the creation of potential snail habitats when canal banks collapsed or small rivers silted up. Some communal water supplies and public sanitation systems have fallen into disrepair and people now want individual private systems. The social transformation caused by the great economic reforms of the 1980s ended voluntary mass community participation in schistosomiasis control. Fortunately, Guangxi had eradicated the disease before the advent of market socialism in China made it impossible to use mass action for further environmental work.

Snail distribution

Guangxi has 90 counties and of these, the 19 with endemic schistosomiasis cover 26% (61 520 km²) of the total area. All the counties with *Oncomelania hupensis* snails also had cases of human schistosomiasis. The initial snail density for communes strongly and significantly correlated with the initial prevalence of human infection (Pearson's r = 0.5613, one-tailed $P < 0.0001$), despite the substantial measurement errors that must have affected both indices (Table 1). The number of snail foci known in Guangxi was first recorded as 144 in 1955, peaked at 4716 in 1958–60, and fell steadily thereafter to 13 in 1986–91, two in each of 1990, 1991 and 1992, and none since.

The snail distribution in Guangxi is unusual and scattered. The infested areas consist of the following topographies: low-lying land with ridges; valleys surrounded by peaks; and corroded plains. Two strains of the tiny snail intermediate hosts, with smooth or ribbed shells and belonging, respectively, to the hill or plains type of the Chinese subspecies *O. hupensis hupensis* (*19*), had colonized Guangxi, permitting focal transmission of schistosomiasis across a large and mostly remote area (Fig. 1). Within the 19 infested counties, snail-positive zones covered 14 354 km², equivalent to one quarter of the area of these counties and 6% of Guangxi (Table 1). Within snail-positive zones, the foci of detected snails were scattered and almost always discrete. The area covered by the foci was 26.9 km² (ca. 0.2% of the designated positive area), revealing the complexity and scale of the task of finding and destroying the snails.

Snail control

Over the period of the control programme the number, source, dissection findings, and infection status of snails found were recorded. Idle pools and ditches yielded snails with the highest sporocyst positivity rates; snails were most abundant in ditches and fallow fields (Table 2). Snail positivity rates fell progressively from an initial level of 21.3%, based on

Table 1: **Total population, area initially snail-infested, and initial prevalence of human infection in the 19 counties with endemic schistosomiasis, Guangxi, China**

County	Population in 1990[a]	Area infested (km²)	No. of communes: Infested	No. of communes: Infected	Mean severity:[c] Infested	Mean severity:[c] Infected
Luocheng	339 718	2 433 (33)[b]	2	2	1.0	2.0
Yishan	567 728	2 314 (60)	6	6	2.2	2.5
Du'an	604 609	2 559 (13)	3	1	2.7	1.0
Donglan	270 872	2 400 (25)	2	2	2.5	1.0
Bama	224 033	6 469 (50)	4	4	3.8	1.8
Hechi	289 844	4 074 (10)	2	2	3.0	2.0
Huanjiang	325 931	3 533 (5)	1	1	5.0	3.0
Jingxi	545 111	2 340 (85)	13	8	3.7	3.7
Debao	337 380	3 465 (11)	2	1	4.0	1.0
Pingguo	412 861	4 553 (10)	1	1	2.0	3.0
Hengxian	961 788	3 331 (33)	7	5	3.1	2.6
Binyang	849 636	2 618 (40)	4	4	2.8	1.8
Wuming	614 964	2 485 (20)	4	3	3.3	2.3
Tiandeng	384 307	4 664 (20)	2	2	2.0	1.0
Xincheng	380 114	2 175 (25)	2	2	3.0	3.5
Yongshui	442 061	3 366 (5)	1	1	2.0	3.0
Guixian	1 387 939	2 541 (6)	1	1	3.0	3.0
Yilin	1 323 410	3 463 (14)	3	3	1.0	1.0
Guiping	1 378 724	2 737 (7)	1	1	1.0	1.0
Means/Totals	11 641 030	61 520 (25)	61	50	2.3	2.9

[a] Population Census Office of Guangxi Zhuang Autonomous Region, 1992.
[b] Figure in parentheses is the percentage of county area initially infested with snails (see ref. *18*); for Yilin and Guiping the data came directly from Guangxi Institute of Parasitic Disease Control.
[c] Severity category codes:
Snail infestation (initial density/100 m²):
1 (≥5000); 2 (1000 to <5000); 3 (500 to <1000); 4 (50 to <500).
Schistosome infection (initial per cent prevalence of human population):
1 (≥15); 2 (10–14); 3 (5–9); 4 (2–4); 5 (>0 to 1); 6 (0).

dissection of all 155 snails found in the 2 years of preliminary work carried out in 1951 and 1952, to an overall mean of 4.8% up to 1958 and 3.8% up to 1961. The downward trend in snail positivity resumed after interruptions when additional counties were discovered with snails in 1972, 1983, and 1985, with snail positivity rates finally reaching zero in 1986 (Table 3). The small residual foci found sporadically in five counties from 1986 to 1992 were all uninfected.

The human resources devoted to snail control varied over the 1953–91 period (Fig. 2). Searching for or killing snails peaked at a mean of 51302 person-days per year in the 1956–60 period and fell to as little as 790 person-days per year in the 1986–91 period. Overall, the number of counties where snail surveys were carried out twice a year (in spring and autumn) rose progressively to reach 19 by the early 1990s. However, since the number of person-days devoted to the task fell over the period, the area examined by each worker per day rose substantially. The prevailing snail density, expressed as the number of snail foci found per km^2 examined or re-examined each year, fell progressively to reach low levels by 1975, remained low in the 1980s and reached zero by 1992 (Fig. 3). Only the most expert workers are now involved in snail surveillance, with procedures modified to make them more efficient (*10–12*).

Table 2: **Overall abundance and sporocyst infection rates, by habitat, for *Oncomelania hupensis* snails, Guangxi, 1952–88**

	Total number of snails:		
Location	Found	Dissected	Positive
Ditch	341551	136499	2025 (2.4)[a]
Fallow field	103569	24086	496 (1.9)
Rocky field	13782	5553	70 (1.4)
Idle pool[b]	26292	4607	237 (4.3)
Springs	4013	948	0 (0)
Muddy field	19312	3600	52 (1)
Swamp	832	99	0 (0)
Unusable lowland	6663	2358	8 (0.5)
Total	516014	177750	2888 (2.0)

[a] Figures in parentheses are percentages of snails that were positive for sporocyst infection.
[b] Not used for fish farming.

Environmental change

Of the 19 counties that had endemic schistosomiasis, six (Wuming, Binyang, Hengxian, Guixian, Yulin and Guiping) were predominantly in plains regions in the middle reaches of the Guangxi tributaries of the Pearl river, while the remaining 13 counties were in hilly regions in the junctional and upper reaches of that river system. All areas had complex geography, especially the hilly zones. In all snail-positive zones vegetation was cleared, farmers were consulted, and the geography, agriculture and human behaviour were assessed before environmental changes were made after local consent had been given.

The principal environmental methods used to eradicate snails were burying their habitats and digging ditches or tunnels. To bury snails, the workers covered their habitats with at least 40 cm of snail-free soil for at least a year or flooded them with water to a depth of several metres (deep water kills snails quickly). From the 1960s a small amount of molluscicide, usually sodium pentachlorophenate applied before the snails were buried, was found to increase the eradication efficacy. Burying integrates well with other agricultural improvements, so it has been the most used method in both plains and hilly regions. In hilly regions, rocky mountains surround-

Table 3: **Trends in snail sporocyst positivity rates, by habitat and period, Guangxi, 1951–88**

	Mean % of sporocyst-positive snails, by habitat:							
Period	Ditch	Fallow field	Rocky field	Idle pool[a]	Spring head	Muddy field	Swamp	Unusable lowland
1951–52	21.3	—	—	—	—	—	—	—
1953–57	5.2	3.8	4.8	4.6	0.0	—	0.0	—
1958–60	1.9	1.6	0.0	7.6	0.0	1.0	—	1.0
1961–65	2.0	1.0	0.0	0.0	0.0	0.3	—	0.4
1966–70	2.6	0.0	—	1.8	—	2.0	—	0.0
1971–75	0.9	9.4	0.0	—	—	—	—	—
1976–80	0.3	0.0	—	—	—	1.2	—	—
1981–85	0.9	1.6	4.2	6.9	0.0	—	—	—
1986–88	0.0	—	—	—	—	—	—	—

[a] Not used for fish farming.

Fig. 2. **Annual averages for snail control activities, Guangxi, 1953–91.**

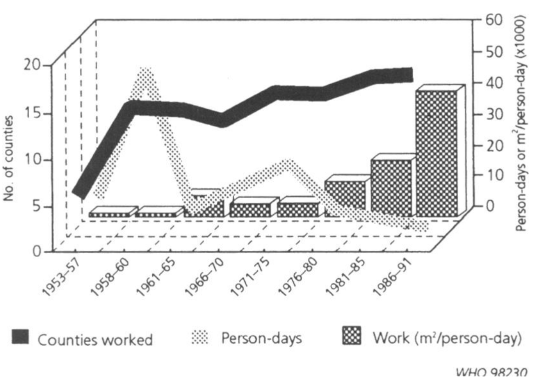
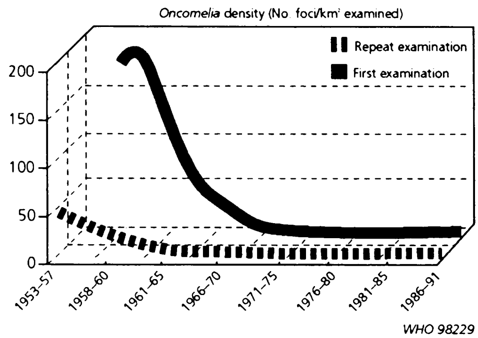


Fig. 3. **Mean annual snail density, Guangxi, 1953–91.**



ing some snail habitats were tunnelled to drain water and dry the area; in other hilly zones and plains regions small dams were built to flood the habitats with water after first ensuring that the margins were snail-free. In plains areas workers dug and lined straight new irrigation ditches, removed the clean soil, and used it to fill adjacent irregular ditches harbouring snails; this buried them, while improving irrigation and drainage. For canals or the tributaries of more important rivers, workers lowered the water level to expose snails, dug a trench 50-cm deep along the bank below the snail line, filled the bottom of the trench with snail-ridden surface soil from higher up the bank, before covering the trench with snail-free soil and restoring the water level.

The environmental work was carried out steadily over 40 years, with the procedures used being gradually altered as progress was made (Table 4). Initially, vegetation was cleared extensively to permit accurate ecological assessment. Ditch and tunnel work peaked in the 1970s, a period of mass community participation, once environmental risks had been fully defined by the work carried out previously. Overall, 72.2 km² of land were improved as a direct result of the control programme. This work included digging 217.3 km of new ditches requiring the removal of 3.1 million m³ of earth. Also, 0.8 million m³ of low land and unsafe water courses were filled and the construction work consumed 0.7 million m³ of stone, 0.1 million m³ of sand, 14.5 tonnes of lime, and 14.2 tonnes of cement. Removal of rocks and blasting of water drainage tunnels required the use of 0.9 million tonnes of explosives. The labour

Table 4: **Distribution of environmental changes, by category and 5-year periods, Guangxi, 1953–91**

	Area (m²):								
Environmental change	1953–57	1958–60[a]	1961–65	1966–70	1971–75	1976–80	1981–85	1986–91	Total
Reclaim wasteland	1317139	862058	555484	458396	1016779	1281596	636520	484161	6612133
Earth-fill pit for rice	—	109460	88075	43125	35411	497510	75619	4000	853200
Build dam	—	116948	—	82563	75148	96410	116835	—	487904
Dig new ditch, fill old	785077	457977	32489	444872	382737	1393545	5948	—	3502645
Divert ditch	356607	308079	69570	44943	239180	468768	3950	—	1491097
New flood-control tunnel	—	—	2550	35196	196660	3829	—	—	238235
New flood-reduce ditch	—	448850	4900	16999	37242	529937	49344	—	1087272
Build fish pool	74141	4000	2100	9700	—	93674	36411	143452	363478
Clear rocky field	5400	25262	66441	170049	5337	13733	52736	—	338958
Burn weeds	3554169	9622182	6111636	4539375	2775367	1789079	555159	—	28946967
Develop crop field	—	—	—	—	—	14800	—	700	15500
Change rice-field to dry land for corn	—	566913	—	—	—	13270	—	—	580183
Clear ditch	—	5560	10029	296821	2580	401902	1210	—	718102
Drained land for rice	—	—	—	59267	73751	305987	—	—	439005
Filled land for rice	—	—	—	240	—	—	—	—	240
Total	6092533	12527289	6943274	6201546	4840192	6904040	1533732	632313	45674919

[a] 3-year period corresponding to the Great Leap Forward.

input amounted to 36438 person-years, mostly contributed by the farmers who benefited from the results when land and irrigation became available for growing rice and other crops. Most importantly, 6 km² of the original 14 km² that harboured *Oncomelania* colonies were made permanently inhospitable to snails.

Water supplies and sanitation

The overall investment in water supplies and faecal control through the control programme was relatively modest (Table 5). Most of the facilities built were communal. The large number of cowsheds and pigsheds that were constructed demonstrates the focus on restricting animal movement to improve animal husbandry, prevent infection and control faecal contamination of the environment. The animal excreta were used for fertilizer or biogas production, thus interrupting enzootic or zoonotic transmission of schistosomiasis.

Detecting schistosomiasis infection

Detection and surveillance of human and animal infection was an important and laborious control programme task. Human surveillance involved sedimentation of stool samples, carrying out egg hatching tests, rectal biopsies, various serological tests, skin tests, and clinical assessments (Table 6). It is noteworthy that the rectal biopsies and skin tests indicated that low-intensity infections were much more widespread than indicated by the less sensitive stool examination. The scale of the task is evident from the number of examinations carried out, including almost 2 million stool tests on humans and nearly 50000 on cattle and buffalo. Although cattle and buffalo were infrequently infected, their contribution to transmission was probably important because of the volume of their faeces that contaminated snail-infested human transmission sites. Although goats had the highest prevalence of infection they were not important hosts because they were few in number.

Table 5: **Water supplies and excreta control improvements, Guangxi, 1953–91**

Type of improvement	Number of units
Public wells	4217
Public water pumps	5784
Household taps	99
Household tanks	54
Sand filter systems	14
Septic tank (3-compartment)	1644
Septic tank (1-compartment)	2192
Pour-flush pit latrines	15780
Biogas for households	4701
Cowsheds	27404
Pigsties	42705

Infection control and treatment

Programme staff treated any person or animal found to be positive in any test, with follow-up examinations to ensure they were cured and not re-infected. Infected persons had to produce nine negative stools before they were considered to have been cured; each stool was sampled three times and each sample processed by sedimentation before three 2-mg direct slide preparations were made for microscopy. Hatching tests were carried out on negative stools. All former schistosomiasis patients therefore had to produce 81 negative 2-mg slides and nine negative hatching tests before release from infection follow-up. For decades the county stations followed up patients with advanced clinical schistosomiasis (1717 persons). These included cases of ascites (560 males, 162 females), splenomegaly (429 males, 77 females), dwarfism (37 males, 12 females), and mixed signs (331 males, 109 females). Male to female ratios ranged from 3.0 to 5.7.

The drug treatment used changed over the years, with the initially long and often cardiotoxic courses of injected antimonials such as antimony potassium tartrate or stibophen (Fouadin) evolving to short-course (3-day) regimens by the end of the 1950s. In the early 1960s a less toxic and less potent oral trivalent antimonial, sodium stibogallate, was developed and found useful for treating acute schistosomiasis. Hexachloroparaxylol was also used in the 1960s, while in the late 1960s and the 1970s nonantimonial cyamines and furapromidium, an oral nitrofuran derivative, became available as did praziquantel in the 1980s. A total of 11354 persons were given a 20-day course of antimonials, 3967 a 10-day course, 540 a 7-day course, 314 a 5-day course, and 51557 a 3-day course. Another 2617 received 7-day courses of sodium stibogallate, 21794 received hexachloroparaxylol, and 381 were given the two drugs together. Also, 331 received nithiocyamine (amoscanate), 2 received pheniocyamine, 1332 phenithionate, and 717 furapromidium. Traditional medicine was given to 1631 patients. Overall, 96537 patients received drug therapy to prevent transmission of and abolish infection with schistosomiasis over the 40-year programme; also, 339 individuals had splenectomies.

Benefits of eradication

When eradication was officially certified in 1989 by national and provincial governments, the population

Table 6: **Results of human stool and animal examinations for schistosome infections, Guangxi, 1953–91**[a]

1. Human stool examinations

No. targeted	No. tested	No. positive: Male	No. positive: Female	No. positive: Total	No. newly positive	No. re-infected
2139425	1909689 (89.2)[b]	51908	36493	98516 (5.2)	77830	20594

2. Skin tests

No. children (aged 5–14 years): Tested	No. children (aged 5–14 years): Positive	No. immigrants: Tested	No. immigrants: Positive
149102	12201 (8.2)	3972	327 (8.2)

3. Clinical and immunological examinations by stool status

	Stool-positive at least once: No. tested	Stool-positive at least once: No. positive	Always stool-negative before: No. tested	Always stool-negative before: No. positive
Abdomen examination	52943	2532 (4.8)	202108	3216 (1.6)
Rectal biopsy	—	—	56320	12292 (21.9)
Skin test	—	—	271761	41063 (15.1)
COPT[c]	24607	2009 (8.1)	31687	2372 (7.5)
IHA[d]	4981	410 (8.2)	6961	365 (5.3)
ELISA[e]	344	5 (1.5)	113	0 (0)

4. Animal examinations

	No. stool tests	No. positive	Dissection: *n*	Dissection: No. positive
Cattle	247601	1905 (0.8)	—	—
Buffalos	237587	1410 (0.6)	—	—
Wild rats	—	—	32645	98 (0.3)
Domestic dogs	—	—	384	13 (3.3)
Goats	—	—	118	32 (27.1)

[a] Numbers derived directly from records and not adjusted for small inconsistencies.
[b] Figures in parentheses are percentages.
[c] Circum-oval precipitin test.
[d] Indirect haemagglutination test.
[e] Enzyme-linked immunosorbent assay.

of formerly endemic counties in Guangxi was 11408383. By 1997 the population was approximately 14 million, 7.3% of whom live in the former human infection zone and 0.7% in areas that had snails but no human disease. Combining these at-risk groups indicates that in 1997 the number of people living in formerly snail-positive areas exceeded 1.1 million. These people, their cattle and buffalo (172636 in 1989), and their farmland (1142428 *mu* (76542 hectares in 1989)) have all been freed of schistosomiasis (Table 7).

Discussion

Guangxi used a multi-pronged scientific programme to eradicate schistosomiasis. The achievement is not to be dismissed as a product of Maoist China from which other countries have little to learn. Nor can Guangxi be dismissed as a minor focus within China not representative of the problems confronted elsewhere in the country. Moreover, the programme had major successes without using the improved and simplified Kato–Katz stool method, before single-dose praziquantel chemotherapy had been adopted, and without using modern tools for serodiagnosis or rapid community assessment.

Guangxi is very poor, mountainous, and remote even by Chinese standards. The relatively few patients was more a result of the rapid success of the control programme in preventing infection compared with other areas than due to the relatively small area actually colonized by snails. In fact, this small snail-positive area was as much a problem for eradication as it was a benefit in keeping the number of patients low. Finding snails that infested 0.2% of

Table 7: **Agricultural profiles of previously schistosomiasis-endemic counties, Guangxi, when eradication was declared in 1989**

Characteristic	Total	Subtotal
Population in 1989		
19 Endemic counties	11 408 383	(100.0)[a]
Human infection zone		833 447 (7.3)
Snail-positive, human-negative zone		75 658 (0.7)
Farmland		
Irrigated rice	6 132 538	
Human infection zone		573 961 (9.3)
Snail-positive, human-negative zone		42 660 (0.7)
Dry farmed	4 487 251	
Human infection zone		464 719 (10.4)
Snail-positive, human-negative zone		61 189 (1.4)
Bovines		
Cattle	997 858	
Human infection zone		61 801 (6.2)
Snail-positive, human-negative zone		9 747 (1.0)
Buffalos	912 859	
Human infection zone		81 892 (9.0)
Snail-positive, human-negative zone		6 916 (0.8)

[a] Figures in parentheses are percentages for each characteristic.

25% of the huge area of the 19 counties, which themselves represented a quarter of Guangxi and had a population of 1 million people, was a challenge that called for snail detection with quality control, skilful human resource management, and persistence.

A noteworthy epidemiological feature was the much higher infection and disease rates among males because their farming and fishing activities caused them to have greater exposure. This signals the close relationship between rural activities and schistosomiasis in China. Studies of infected persons have shown that chronic schistosomiasis substantially impairs work capacity (*20*) and causes malnutrition (*21*). The links between schistosomiasis and farming, fishing, water use and the rural economy were appreciated from the outset of the programme in China and drove the pioneering multisectoral strategy to control the disease.

The control programme was neither vertical nor horizontal. It is best described as both — with a horizontal cross-sectoral multibureau structure at the top for policy, planning, and another horizontal structure at the bottom for implementing and reporting in collaboration with local people. In between, government workers in each sectoral element communicated vertically along monosectoral lines that did not cross and did not need to. The whole process involved quality control, cyclical training, and community motivation and education, all facilitated by detailed information feedback and annual epidemiological review. Supervision involved a large team of trained and re-trained professionals from the Institute of Parasitic Diseases, advised by its own research and policy committee and also by national experts; the political economy and management of the Guangxi programme have been described by Sleigh et al. (*9*) and can be adapted for use elsewhere.

The data presented here show that the control work was laborious, well planned, and carefully monitored. The overall aim was to eradicate the snails, the only certain way to abolish zoonotic schistosomiasis. Progress was steady, and the successful 40-year outcome is real and not the result of biased or filtered reporting. It should encourage comparable regions in China to continue efforts with schistosomiasis control, and other poor countries to create integrated control programmes that match their socioeconomic, cultural, geographical and transmission circumstances. Guangxi's success depended on clear and measurable control objectives and skilful management of all resources mobilized. Everybody knew the objectives, which were periodically reviewed and implemented persistently for a very long time. The strategy was soundly based on the known relationship between snail density and transmission intensity, the observed ecological dependence of the snails on local human and physical geography, the desire to abolish infection to relieve suffering and boost production, and recognition that the task was impossible without grass roots knowledge and constant local cooperation.

The control programme downsized after eradication in 1989. Patient follow-up stopped in the early 1990s and many antischistosomiasis stations are now used as general township health clinics. The county schistosomiasis staff have been re-trained and deployed in general health work or special programmes, especially mental health and care of chronically ill psychiatric patients. Provincial staff in Nanning moved on to work on the prevention of liver and lung flukes or other parasitic diseases. A small core of the most skilled workers continue with the schistosomiasis surveillance programme.

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Résumé

Eradication de la schistosomiase dans le Guangxi (Chine). Partie 1: cadre, stratégies, opérations et résultats, 1953–1992

L'article analyse les résultats d'un programme qui a duré 40 ans et a conduit à l'éradication de la schistosomiase dans la province de Guangxi en Chine, une région vaste et pauvre dans laquelle la charge de cette maladie est la plus élevée du monde. La corrélation entre la présence du mollusque *Oncomelania* et la survenue de l'infection chez l'homme est basée sur les donnée historiques du comté, des cartes de répartition et de densité initiales du mollusque et de prévalence initiale de la schistosomiase. La totalité des déclarations annuelles de schistosomiase observée dans le comté ont été recueillies et analysées, y compris les données relatives à l'abondance et à l'infestation du mollusque, la lutte contre l'infestation humaine et animale, l'examen des selles et le traitement des patients, les examens cliniques et sérologiques, la surveillance au moyen de tests cutanés, le suivi et le traitement des patients, l'examen des animaux, la fourniture en eau et l'assainissement, les modifications de l'environnement.

Les résultats attestent des efforts du programme de lutte, de l'ampleur de son travail scientifique et systématique et de son évolution au cours des 40 années. Il faut notamment remarquer l'importance du dépistage et du traitement non interrompus des cas, de la destruction des mollusques et de la modification continue de leur habitat grâce à la participation massive des communautés et à l'emploi de méthodes adaptées aux conditions locales. L'action du programme a permis d'écarter plus de 10 millions de personnes du risque de schistosomiase et favorisé le développement économique rural et la santé. La ténacité, la bonne qualité des enregistrements, l'adoption de stratégies évolutives et souples localement, ainsi que des objectifs clairs ont contribué au succès final du programme.

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