

EPIDEMIOLOGY AND CONTROL OF SCHISTOSOMIASIS IN THE PEOPLE'S REPUBLIC OF CHINA

MAO SHOU-PAI

Institute of Parasitic Diseases, Chinese Academy of Preventive Medicine 207 Rui Jin Er Lu, Shanghai 200025,
P. R. China

BIOLOGY

The parasite — The schistosome species involved in human schistosomiasis in the mainland of China is *Schistosoma japonicum*, the Taiwan strain being entirely zoophilic (Hsü et al., 1956). Nevertheless, experiments have shown the susceptibility of *Oncomelania* snail from Taiwan foci to anthropophilic strains of *S. japonicum* (Cross et al., 1980). So far *S. mekongi* has not been identified in China, even in areas adjacent to the existing foci in Southeast Asia in spite of the presence of *Tricula* spp. in Chinese territory.

A rodent species, *Schistosoma sinensium*, laying eggs with lateral spine and with *Tricula humida* as its intermediate host, was discovered in Southwest China and described by Bao in 1959 (Fig. 1). No human cases have been detected except in Thailand (Attawibol et al., 1983; Baidikul et al., 1984). Schistosomes depositing spine eggs were reported independently in 1986 by three authors from Xishuangbanna of Yunnan Province. The first was identified as *S. bovis* from a cattle (Huang et al., 1986). The second report (Chen et al., 1986) was about the presence of furcocercariae in *Indoplanorbis exustus*, giving rise to *S. spindale* like eggs after inoculation to mice. The third was from an elephant suffering from diarrhoea with terminal spine eggs (Fig. 2) and apparently cured by praziquantel (Wu, 1986).

The intermediate host — *Oncomelania hupensis hupensis* is the only vector of human schistosomiasis japonica in the mainland of China, though malacologists are still debating in its taxonomy. Geographic strains of the parasite and/or the snail may exist as suggested by the fact that artificial infection of snails with miracidia from the same area resulted in an infection rate of 78.9% while the infection rates of snails from different areas with the same source of miracidium ranged from 55.4% to 0% and that the snail-parasite incompatibility increased with the geographic distance (Guo & Ni, 1980) (Fig. 3).

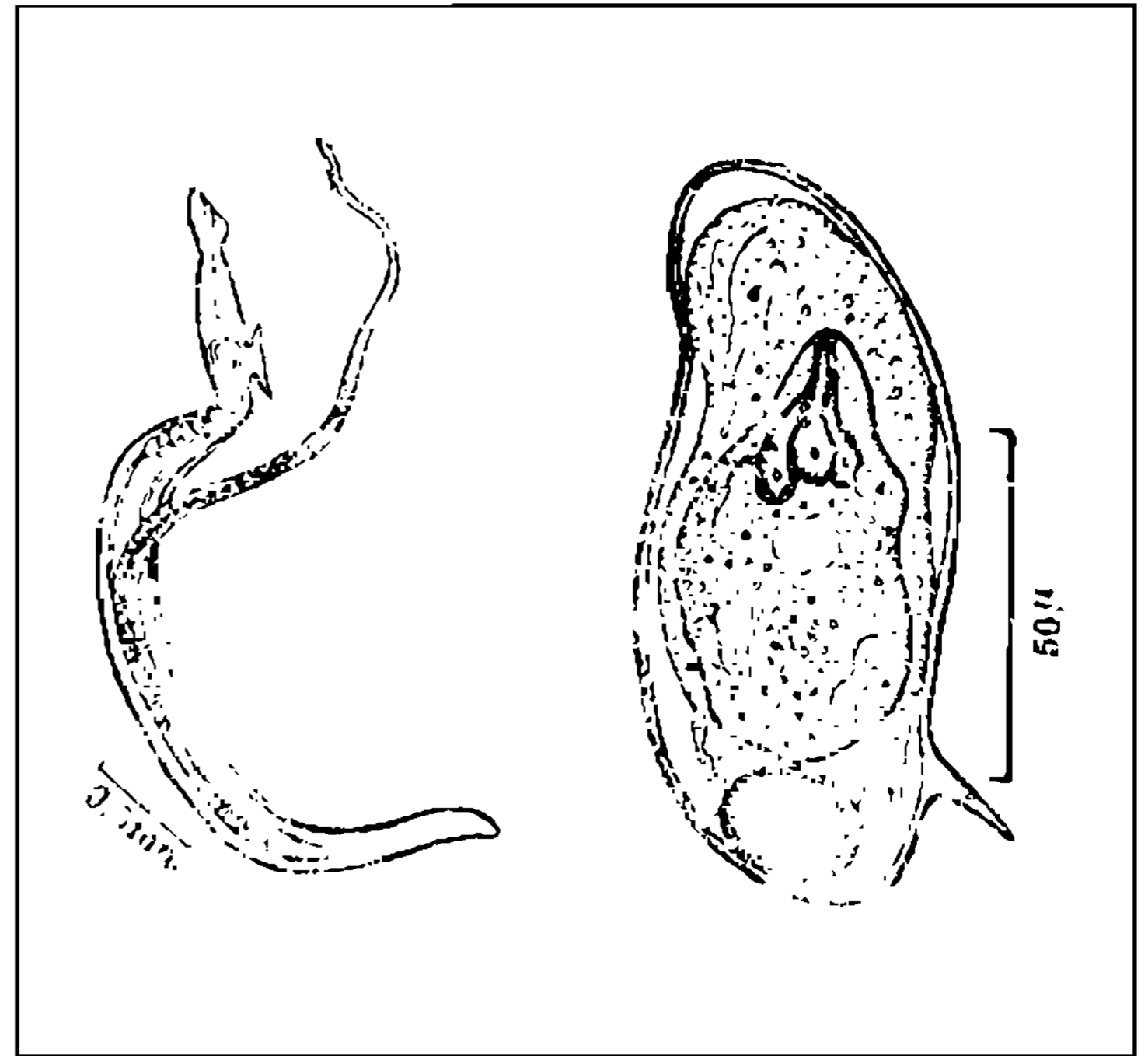


Fig. 1: *Schistosoma sinensium* — A. Male and female adults; B. Ovum (after Bao, 1959).



Fig. 2: Ovum of *Schistosoma bovis* (?) from an Indian elephant (after Wu, 1986).

The reservoir host — Thirty one species of wild animals belonging to five orders (Table I) and nearly all the domestic mammal species have been found naturally infected with *W. japonicum*, though their importance in the maintenance of schistosomiasis varies greatly from one endemic area to another (Mao & Shao, 1982).

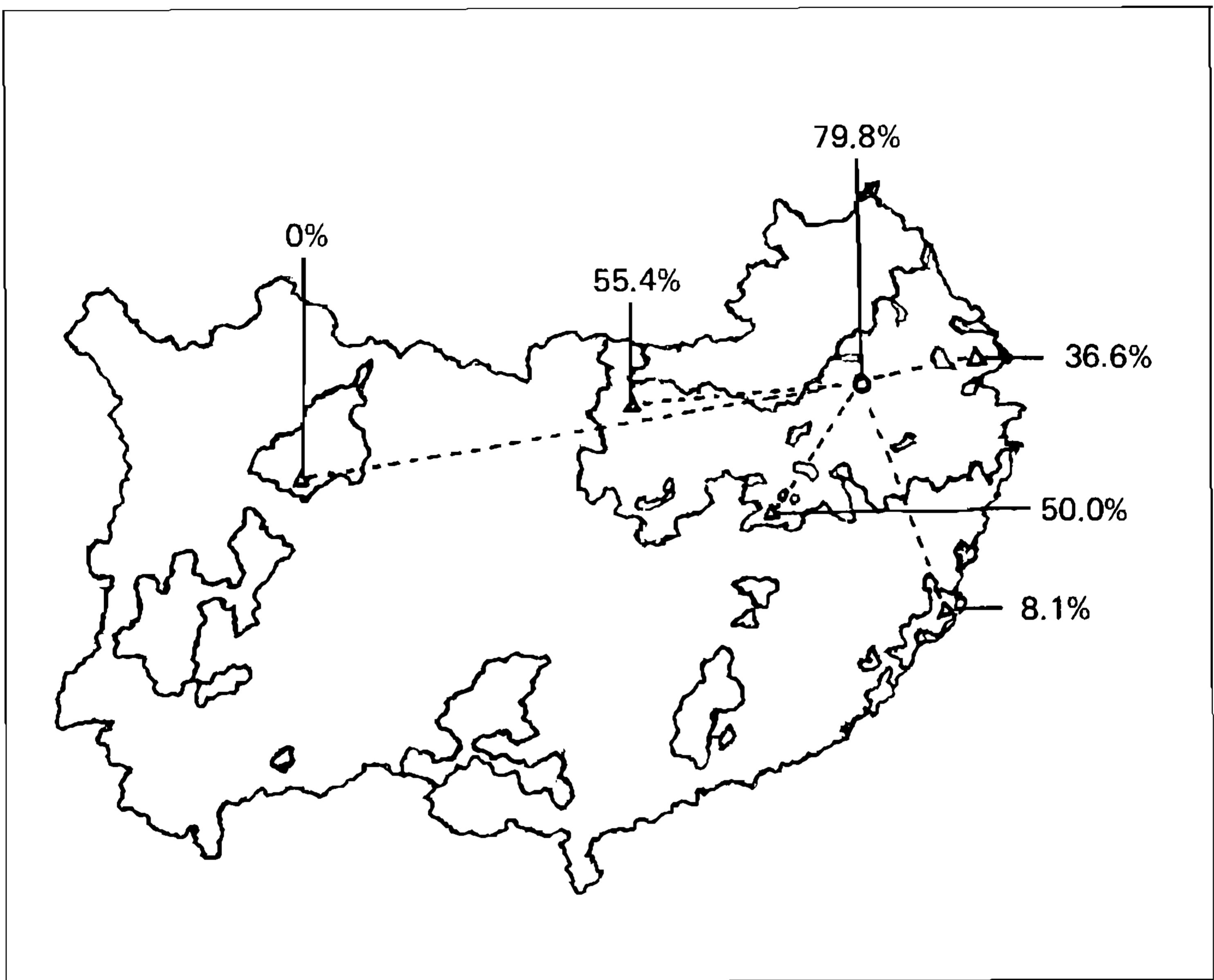


Fig. 3: Results of artificial infection of *Oncomelania* (Δ) with *S. japonicum* miracidia from Anhui (\circ). Guo & Ni, 1980.

EPIDEMIOLOGY

Distribution — Schistosomiasis has been endemic in the provinces of Jiangsu, Zhejiang, Anhui, Jiangxi, Fujian, Hubei, Hunan, Guangdong, Sichuan and Yunnan, Shanghai Municipality and Guangxi Autonomous Region, all situated in the southern part of China between $22^{\circ}50'$ and $33^{\circ}25'$ N.L. (Fig. 4) (Qian et al., 1985).

Stratification — Three types of endemic regions are classified according to topography, snail habitats, infection sources and water-contact pattern (Mao, 1984). The plain region is mainly confined to the Yangzi Delta, including suburbs of Shanghai Municipality and a great part of Jiangsu and Zhejiang Provinces. It is a rice-producing area with dense population. Both the prevalence and intensity of infection

were high. About one third of schistosomiasis patients were from that area covering only 7.8% of the total snail-ridden area.

The lake region consists of areas surrounding big lakes and along the shore of Yangzi River and its principal tributaries. Its snail-ridden area amounted to 82.8% of the total infested area with 43.7% of the total patients.

The mountain and hill regions comprise rather two different types. The mountain type is confined to Sichuan and Yunnan Provinces while the hill type occurs in Guangxi Autonomous Region and Fujian Province, and also in small areas intercalating with lake and plain regions. Less than 10% of snail-infested area belonged to mountain and hill region with 22.7% of the total number of patients.

TABLE I

List of wild animals naturally infected with *Schistosoma japonicum* in the mainland of China

Order RODENTIA
<i>Apodemus agrarius ningpoensis</i>
<i>Callosciurus erythraeus ningpoensis</i>
<i>Eothenomys melanogaster colurnus</i>
<i>Hystrix subcristata subcristata</i>
<i>Lepus europaeus</i>
<i>Lepus sinensis</i>
<i>Microtus mandarinus</i>
<i>Mus musculus</i>
<i>Rattus confucianus socer</i>
<i>Rattus flavipectus flavipectus</i>
<i>Rattus fulvescens</i>
<i>Rattus losea exugnus</i>
<i>Rattus nitidus</i>
<i>Rattus norvegicus</i>
<i>Rattus rattus</i>
<i>Rattus murinus</i>
Order CARNIVORA
<i>Felis bengalensis chinensis</i>
<i>Felis pardus fusca</i>
<i>Helictis moschata ferreo-grisea</i>
<i>Herpetes urva</i>
<i>Meles meles leptorhynchus</i>
<i>Mustela sibirica davidiana</i>
<i>Nyctereutes procyanoides procyanoides</i>
<i>Viverricula indica pallida</i>
<i>Vulpes vulpes hoole</i>
Order ARTIODACTYLA
<i>Mydropotes inermis inermis</i>
<i>Muntiacus reevesi</i>
<i>Sus scrofa chridonta</i>
Order INSECTIVORA
<i>Crocidura attenuata</i>
<i>Erinaceus europaeus</i>
Order PRIMATE
<i>Macaca mulatta</i>
(from Mao and Shao, 1982)

As indicated in Table II, the snail habitats differ with the type of endemic regions. Besides, the outer morphology of *Oncomelania* is also different from one region to another, though not without exceptions.

In plain and hill regions, human patients are the main infection source while rodents, sewage rat in plain region and wild rabbit in hill region, are of some importance. In lake region, bovines, especially buffaloes, are believed to play a more important role than patients. It is interesting to note that *Microtus fortis*, the predominant rodent species in lake region, has never been found naturally infected and experimental infection with schistosome cercariae yielded negative results.

TABLE II

General characteristics of *Oncomelania h. hupensis* in different types of endemic regions

Region type	Distribution	Shell
Plain	spotty or linear along banks of water courses	medium size moderately ribbed
Lake and marshland	surface distribution on flatlands flooded yearly for 3-8 months	big size coarsely ribbed
Mountain and hill	surface distribution on mountain slopes; spotty or linear along stream banks	small size smooth or finely ribbed

The water contact pattern also differs with the region types, resulting in differences in age and sex distribution of schistosomiasis patients (Fig. 5).

CONTROL AND PROBLEMS

Direction – National Schistosomiasis Control Programme was inaugurated in late 1955, under the guidance of Central Directing Board for Schistosomiasis Control, which was replaced in 1986 by the newly formed Bureau of Endemic Diseases under the Ministry of Public Health. The policies formulated in early days consisted of four items: to prevent and treat actively while putting prevention first; to use comprehensive measures while considering local and seasonal conditions; to integrate scientific techniques with mass movement; to fight repeatedly.

Achievement (Fig. 4) – As of 1986, Shanghai Municipality, Guangdong and Fujian Provinces were free from schistosomiasis. Of 372 counties historically endemic for schistosomiasis, the infection is still prevailing (i. e. in attack phase) in 94, practically eliminated in 154 (i. e. in consolidation phase) and eliminated in 124 (i. e. in surveillance phase). There still remained about one million cases to treat and more than 3.2 billion m² of snail-infested area to deal with.

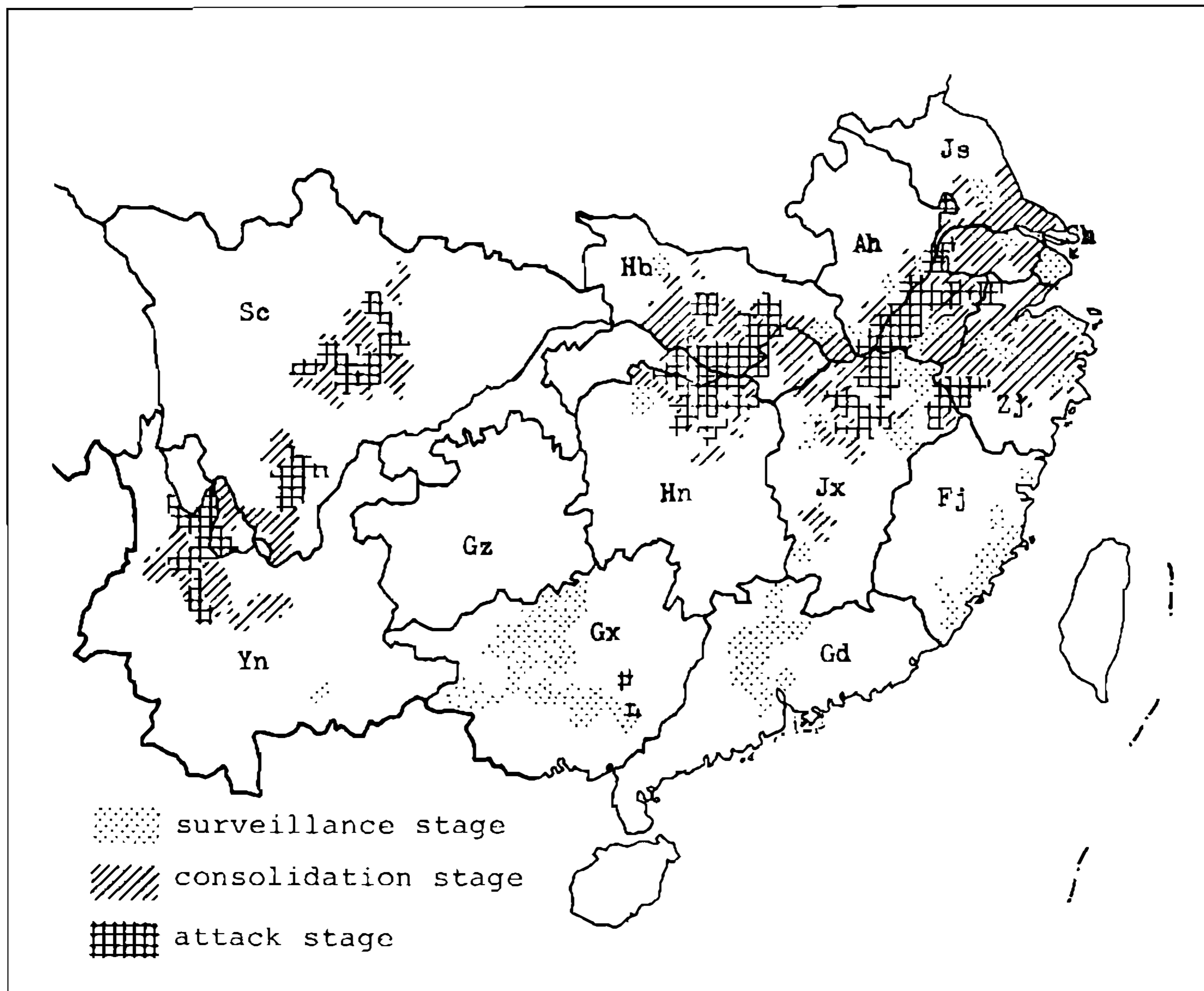


Fig. 4: Southern part of China showing distribution of schistosomiasis japonica. Abbr. Ah: Anhui Province; Fj: Fujian Province; Gd: Guangdong Province; Gx: Guangxi Autonomous Region; Gz: Guizhou Province; Hb: Hubei Province; Hn: Hunan Province; Js: Jiangsu Province; Jx: Jiangxi Province; Sh: Shanghai Municipality; Sc: Sichuan Province; Yn: Yunnan Province; Zj: Zhejiang Province.

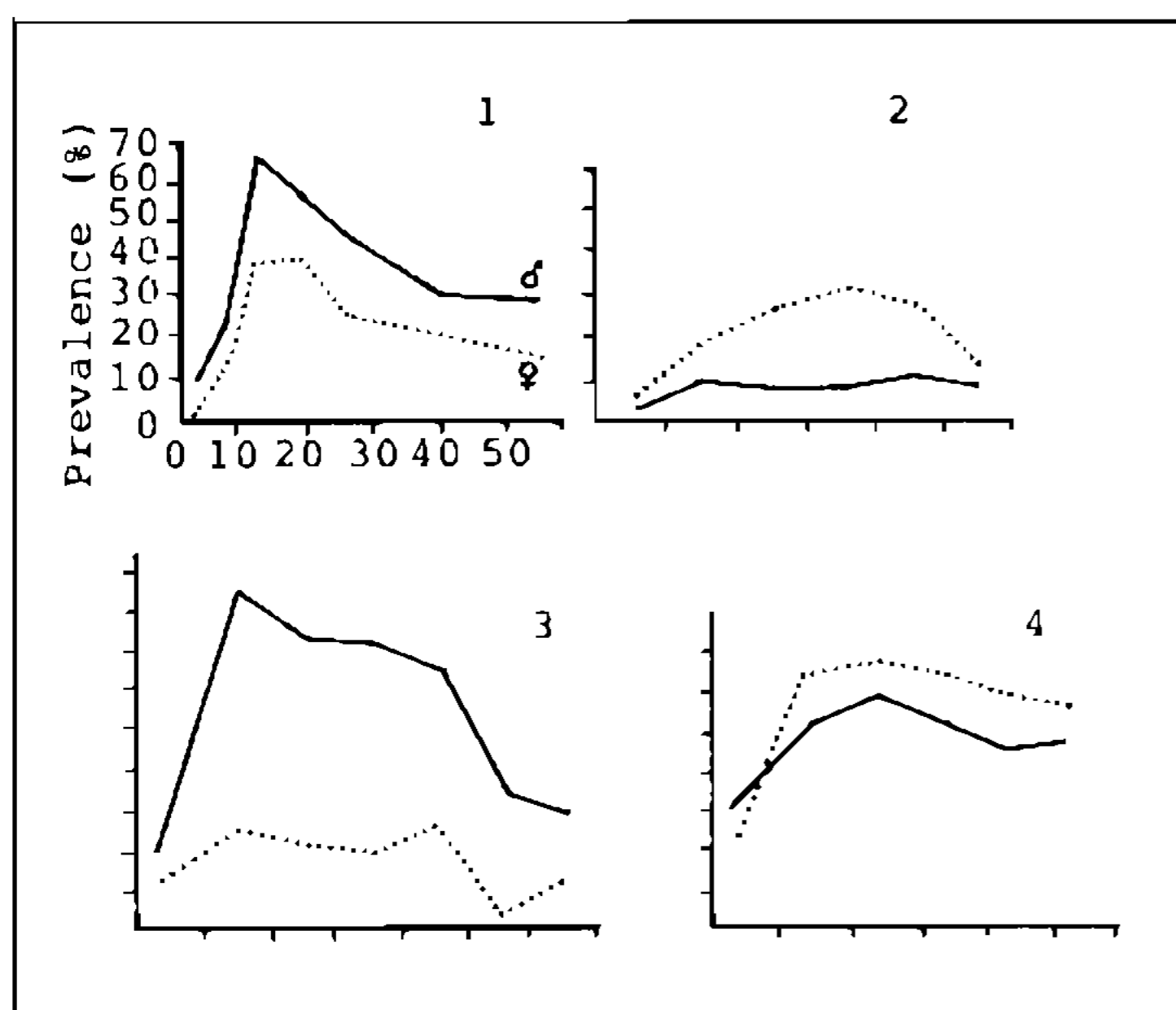


Fig. 5: Age and sex distribution of schistosomiasis in different types of endemic areas: 1. Wuxi, a plain region. 2. Weishan, a mountain region. 3. Yyeyang, a lake region. 4. Fuqing, an urban area. (Based on data of early 50s except 2).

Problem – Lake region and mountain region are problem areas in the national control programme. High mountain region is characterized by thin-population, difficult accessibility, retarded socio-economic development and different ethnic behaviours. Less than 10% of schistosomiasis patients and 1% of snail-ridden area are found in this type of endemic region.

Lake regions are hard nuts for following reasons:

a) It is a vast area covering five provinces along the Yangzi River, involving long river shores and numerous lakes of different capacities, most of them serving as reservoirs for flooding water and silt too, from upper reaches of Yangzi River. An early report by the Bureau of Hydraulics of Hunan Province stated that the silt brought down yearly to the Dongting Lake amounted to 132 million m^2 , adding 1,120

hectares of land in the Lake, which would be potential snail habitat. The same is true for long shores along the Yangzi River from Hubei to Jiangsu Provinces. According to a survey in Huarong County, Hunan Province, 584 hectares were newly formed from 1971 to 1983, or an annual increase of 40.4%. Weeds and reeds would grow on the land 2 to 3 years after its formation, to be followed by settlement of *Oncomelania* snails in another 2 to 3 years (Zhu & Zeng, 1986). It seems that in recent years the increase of snail breeding places might overbalance their elimination through routine snail control efforts.

b) Lake regions are densely populated and very important for rice-production and fisheries. Agricultural activities result in frequent exposure to schistosome infection and acute cases recorded yearly by thousands. Should newly infected cases outnumber those treated in the same period, one must consider the chemotherapy programme a failure.

c) Bovines are important reservoirs, if not more important than humans as source of infection. Their relative potential contamination index may be as high as 70-90%, in contrast to less than 20% in plain region.

d) The migration of boatmen and fishermen hinders the implementation of chemotherapy project.

Pilot studies — With the advent of praziquantel for mass chemotherapy, several field studies in Lake region were supported in early 80s by the National Schistosomiasis Research Committee to investigate the usefulness of selected population chemotherapy with focal mollusciciding or integrated with other control measure. Prevalence reduction of 18% in villagers and 5% in bovines was recorded when only infected humans were treated while prevalence reduction of 83% in humans and 82% in bovines was noted when integrated measures were used (Table III). It is too early to draw conclusions as follow-up studies are still going on.

As to the cost estimates listed in Table IV they are barely comparable, because though the expenditure for case treatment is the same, that for case detection varied with the prevalence while the snail-infested area to be covered by molluscicides varied greatly from one pilot site to another.

TABLE III

Results of 5 years' pilot studies in lake regions by selected population chemotherapy of humans(H), bovines(B), focal (F) or comprehensive(C) mollusciciding and other(O) measures

Locality Prov.	Author	Population	H	Measures used				Change in preval. (%)		
				B	F	C	O	Whole	3-9 yrs	Bovines
Jianli Hubei	Yang	1.453	+		+			44.9– 37.2		23.1– 21.9
Tongling Anhui	Wu	2.433	+	+	+			43.0– 1.5	13.6– 0	25.5– 17.7
Xinzi Jiangxi	Zhang	1.630	++	+	+			20.8– 1.9	20.4– 4.3	
Yingchen Hubei	Wan	956	+	+	+		+	60.4– 9.1	37.7– 1.0	50.0– 5.4
Guichi Anhui	Su	3.301	+	+		+	+	13.4– 2.3	3.4– 1.1	5.6– 0.9

TABLE IV

Cost estimates (RMB/c/y in 5 years)

Locality	Author	Measures used				% reduction prevalence	Cost
		H	B	F	O		
Tongling	Wu	H	B	F		96.5	4.80
Guichi	Su	H	B	C	O	82.8	7.08
Cunshan	Li	H	B	C		74.2	11.54
Wuhan	Dai	H	F			69.6	6.53
Songzi	Xu	H	B	F		46.0	3.43

REFERENCES

- ATTAWIBOL, S.; BUNNAG, T.; THIRACHANDRA, S.; SINTUPRAMA, K. & SORNMANI, S., 1983. *Schistosoma mansoni*-like infection in Phayee Province, Northern Thailand. *Southeast Asian J. Trop. Med. Pub. Hlth.*, 14: 463-466.
- BAIDIKUL, V.; UPATHAM, E. S.; MALEEYA KRISTRACHUE; VIYANANT, V.; VICHASIRI, S. & LEE P. et al., 1984. Study of *Schistosoma sinensium* in Fang District, Chiangmai Province, Thailand. *Ibid.*, 15: 141-147.
- BAO, D. C., 1959. Report of the discovery of a new species of *Schistosoma* in China (*Schistosoma sinensium*, sp. nov., Schistosomatidae). In Chinese Medical Association ed. 1958 All-China Conference of Parasitic Diseases, Beijing, People's Health Publishing House: 667-675 (in Chinese).
- CHEN, D. J.; FANG, C. Z.; YANG, Z. & YANG, H. M., 1986. First report of *Schistosoma spindale* in Yunnan. *J. Parasitol. Parasitic Dis.*, 4: 296 (in Chinese).
- CROSS J. H., LO, C. T., 1980. Susceptibility of new Taiwan foci of *Oncomelania hupensis* to geographic strains of *Schistosoma japonicum*. *Southeast Asian J. Trop. Med. Pub. Hlth.*, 11: 347-377.
- DAI, Y. H.; LI, J. S.; WU, M. Y. & ZOU, J. Z., 1986. Study on the control strategy of schistosomiasis in Hongxin marshland. In Zheng G. ed. *Advances of Epidemiology of schistosomiasis in China*, Nanjing, Jiangsu Publisher of Medical Journals: 63-65 (in Chinese).
- GUO, Y. H. & NI, Q. H., 1980. Preliminary studies on hybridization of *Oncomelania* snails. *Ann. Rpt. Inst. Parasitic Dis, CAMS*: 1-3 (in Chinese with English abstract).
- HSU, H. F. & HSU, S. Y. LI., 1956. On the infectivity of the Formosan strain of *Schistosoma japonicum* in *Homo sapiens*. *Am. J. Trop. Med. Hyg.*, 5: 521-528.
- HUANG, D. S.; XIE, T. Z.; LI, S. P.; ZHU, J. X. & LEI, Z. X., 1986. Discovery of *Schistosoma bovis* in Yunnan. *Chin. J. Veter. Sci. Technol.*, 7: 62-63 (in Chinese).
- LI, S. K.; LIU, G. C.; LI, Y. S.; HU, C. F.; YANG, R. Q. & SHE, Q. Z., et al., 1986. Study of the control strategy of schistosomiasis in Junshan Island. In Zheng G. ed. *Adv Epidemiol Schistosomiasis in China*, Nanjing, Jiangsu Publisher Medical Journals: 89-93 (in Chinese).
- MAO, S. P. & SHAO, B. R., 1982. Schistosomiasis control in the People's Republic of China. *Am. J. Trop. Med. Hyg.*, 31: 92-99.
- MAO, S. P., 1984. No secret weapon. *Wld. Hlth.*: 12-13.
- QIAN, X. Z.; LU, G.; MAO, S. P. & ZHENG, G., 1985. Schistosomiasis Atlas in the People's Republic of China. Shanghai, Chinese Map Society (in Chinese).
- SU, D. L.; XU, S. Y.; YUAN, H. C.; HE, C. Y.; SHEN, J. J.; YANG, Q. J. et al., 1986. Comparative field observation on the control of schistosomiasis in a lake region of Guichi County. In Zheng G. ed. *Adv Epidemiol Schistosomiasis in China*, Nanjing, Jiangsu Publisher of Med Journals: 23-29 (in Chinese).
- WAN, Z. G.; GAO, W. C.; TAO, G. X.; ZHOU, R. H.; XU, D. B.; HUANG, Y. L. et al., 1986. Study of control strategy of schistosomiasis in a heavily endemic area of lake region type in Yingcheng County. In *Ibid*: 60-63 (in Chinese).
- WU, J., 1986. Schistosomiasis in an Indian elephant and its treatment. *Sci. Technol. Clin. Veter. Med.*, 4: 58-59 (in Chinese).
- WU, W. D.; WANG, P. Y.; GUAN, J. Z.; XU, L. F.; MEI, J. D.; TAO, S. G. et al., 1986. Schistosomiasis control in a lake region with treatment of infection source and focal mollusciciding. In Zheng G. ed. *Adv Epidemiol Schistosomiasis in China*, Nanjing, Jiangsu Publisher of Medical Journals: 56-59 (in Chinese).
- XU, Y. C.; DONG, Y. G. & HUANG, D. M., 1986. Schistosomiasis control in an embanked lake region in Dshen Village of Songzi County. In *Ibid*: 82-85 (in Chinese).
- YANG, Z. C.; XIONG, Y. Z.; ZHANG, S. Y. & YANG, D. H., 1986. Study on control strategy of schistosomiasis in a marshland along river shore in Jianli County. In *Ibid*: 66-68 (in Chinese).
- ZHANG, R.; TAN, H. Q.; HUA, X. J.; WU, J.; ZHAO, J.; LIU, Y. M. et al., 1985. Continuous study on schistosomiasis control effect by treatment of infection sources and focal mollusciciding in a limnetic area in Xingzi County, Jiangxi Province. *Ann. Rpt. Inst. Parasitic Dis., CAPM*: 1-3 (in Chinese with English Abstract).
- ZHU, N. P. & ZENG, F. Y., 1986. Developmental process of schistosomiasis endemic area on the river shore in Hongshan of Huarong County. In Zheng G. ed. *Adv Epidemiol Schistosomiasis in China*, Nanjing, Jiangsu Publisher Medical Journals: 113-117 (in Chinese).