be significantly higher than the unit cost for yeast. The research community, in turn, must provide integrated, realistic proposals that will provide value-for-money approaches to the agreed priority areas of development.

Acknowledgements
The Malaria Genome Project Consortium is funded by the US Department of Defence, Burroughs-Wellcome Fund, The Wellcome Trust and NIAID/NIH and is based at three sequencing centres: The Institute of Genome Research (http://www.tigr.org/); The Sanger Centre (http://www.sanger.ac.uk/); and Stanford University (http://sequence-www.stanford.edu/).

The meeting, funded by WHO/TDR and European Union (INCO-DC), was held at The Novartis Foundation, London 24–25 January, 1999. The organizers would like to thank the staff of The Novartis Foundation for their help in facilitating the meeting. Our thanks also go to everyone who participated in this workshop, especially David Roos and Chris Newbold for detailed comments on this manuscript.

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The Epidemiology and Host–Parasite Relationships of *Schistosoma japonicum* in Definitive Hosts

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Wuxi, Jiangsu, China
September 1998

Schistosoma japonicum infection remains a public health problem in specific ecological zones of the People's Republic of China and the Philippines, with 69–75 million individuals at risk of infection and approximately 2.4 million individuals infected at any time. It is unique among the major schistosomes infecting humans, as zoonotic transmission is important, with domesticated animals serving as reservoir hosts of the parasite, and an amphibious snail as intermediate. Although human infection and disease caused by *S. japonicum* have been reduced in China and the Philippines, further reductions may be difficult because of the continual transmission from infected animals.

The meeting aimed to discuss: the current epidemiologic situation of *S. japonicum* infection in humans and animals; the role of *S. japonicum* transmission to humans via domestic animal reservoirs; interventions using animal vaccines against *S. japonicum*; and the development of better methods of infection and disease control in endemic human communities. Emphasis was placed on promoting an intersectoral approach to research, surveillance and control, and facilitating interregional cooperation and collaboration.

Patterns of *S. japonicum* Infection

Feng Zheng (Institute of Parasitic Diseases, Shanghai, China) and Remigio Olveda (Research Institute for Tropical Medicine, Manila, the Philippines) reported that in both China and the Philippines, national levels of prevalence and intensity of *S. japonicum* infection in humans have decreased over the past 10–15 years. The proportion of those infected who suffer severe and advanced disease has also decreased dramatically. Despite this general success, the pattern of *S. japonicum* infection has become more localized in specific ecological zones: the marshland/lake and mountainous regions of China and the high-rainfall areas of the southern Philippine islands. Longitudinal community studies in moderate to high transmission areas of China and the Philippines indicated that annual case-finding and treatment with praziquantel lowers prevalence, intensity and schistosomosis-associated morbidity, especially in children and adolescents (S.T. McGarvey, Brown University, Providence, USA). However, there appears to be a stable minimum level of prevalence (of 15–25%) attainable by annual case finding and treatment. Furthermore, findings from the long-term Philippine study showed a rebound increase of morbidity when annual treatment is missed.

The World Bank loan to the Philippines for *S. japonicum* infection control ended in 1995, and that to China ends in 1999. General concern was expressed that, without these funds, there will be fewer resources for surveillance and control, and that prevalence, intensity and morbidity might increase, especially in the poorer and more isolated communities within the endemic regions. Zhou Xiaonong (Jiangsu Institute of Parasitic Disease, Wuxi, China) used remote sensing and geographic information system (GIS) data from China and demonstrated increases in snail habitat in the 1980s, and the consequent increases in human prevalence rates. The 1998 summer floods in China might lead to the expansion of snail habitats and increases in *S. japonicum* prevalence.

In China, national survey data indicate an *S. japonicum* prevalence of 7% among cattle and 9.6% in water buffalo. There appears to be no difference in animal infection rates between the marshland/lake and mountainous regions in China. Specific community studies in endemic provinces of China showed higher prevalence rates in cattle (Shi Fuhui, Shanghai Institute of Animal Parasitology, China). There are no current survey data on animal infection rates in the Philippines, although endemic area infection rates of 10–15% are found in pigs and in water buffalo (Tomas Fernandez, Visayas State College of Agriculture, Baybay, Leyte, the Philippines). Studies of the spatial distribution of animal feces in lake and marsh regions, and the mountainous regions of China suggested that cattle dung contributes substantially to potential transmission of *S. japonicum* infection (Shi Fuhui and Zheng Jiang, Shanghai Institute of Parasitic Diseases, China; Yang Xianxiang, Hubei Institute of Schistosomiasis Control, China; Ge Jihua, Anhui Institute of Schistosomiasis Control, China; Zhou Yibiao, Hunan Institute of Parasitic Disease, China; Sun Leping, Jiangsu Institute of Parasitic Diseases, China; Wang Dewu, Dali Livestock & Veterinary Station, Yunnan, China).

  PII: S0169-4758(99)01409-X

For both human and animal studies, there is an urgent need for standardized urine and blood diagnostic tests for *S. japonicum* infections. Accurate and affordable infection surveillance and evaluation of the efficacy of potential interventions will require such rapid and reliable detection of infection and its intensity.

Simulation modeling of the dynamics of animal–human transmission will help understand the variables fundamental to such transmission, and indicate how potential interventions might affect the desired outcomes (Sake De Vlas, Erasmus University, Rotterdam, The Netherlands). Such modeling first requires detailed community studies of *S. japonicum* infection in the three specific ecozones because of the different animal populations in each, variation in seasonality of transmission and human exposure patterns. Erik Sørensen and Henrik Bøgh (Danish Centre for Experimental Parasitology, Denmark) presented developments in molecular genetics of *S. japonicum* that permit identification of worm strains and may enable tracking of how specific isolates in animals may contribute to human transmission, and vice versa.

Animal Husbandry and Anti-schistosomal Treatment

The management of domestic animals and its role in infection control was considered through presentations on the spread of infection through livestock trading, animal manure management and animal penning (Zhang Jiang; Chen Yan, Hunan Institute of Parasitic Disease, China). Yang Xianxiang (Hubei Institute of Schistosomiasis Control, China) described a comprehensive agricultural program to reduce *S. japonicum* infection through reduction of snail populations. Increased crop rotation, construction of fish ponds, tree planting, deep ploughing, hardening of irrigation canals, focal molluscicide and human and animal chemotherapy led to reductions in snail density and infection rate, and in *S. japonicum* infection prevalence.

Several studies on infected animals demonstrated a reduced infection prevalence in animals, along with substantial variation among species in response to praziquantel treatment. It was difficult to eliminate *S. japonicum* egg contamination by animals based only on chemotherapy (Chen Yan and Zhou Yibiao, Hunan Institute of Parasitic Disease, China; Wang Dewu).

Animal Vaccination and Immunology

Three reports considered potential *S. japonicum* vaccine candidates for possible large-scale vaccination trials. Lin Jiaojiao (Shanghai Institute of Animal Parasitology, China) reported relative reductions in worms for sheep, cattle and buffaloes vaccinated with each of three recombinant antigens, Sj28, Sj23 or paramyosin. Takeshi Nara (Juntendo University, Tokyo, Japan) showed that recombinant paramyosin protected against challenge infection in domestic pigs. Donald McManus (Queensland Institute of Medical Research, Australia) showed reductions in *S. japonicum* worm burdens and eggs in the liver among water buffaloes vaccinated with recombinant paramyosin. There was vigorous discussion on the need to know the magnitude of reductions in egg output, after animal vaccination, which would be sufficient to reduce transmission to humans. Zhang Shaoji (Jiangxi Institute of Parasitic Diseases, China) reported on the self-cure phenomenon in water buffaloes and pigs experimentally infected with *S. japonicum*. All agreed that the immunologic mechanisms of self-cure must be studied for their potential value for animal interventions.

Discussion and Conclusions

No systematic estimates exist of the contribution of domestic animals to *S. japonicum* transmission among humans. Veterinary epidemiological studies are urgently needed to improve understanding of the zoonotic implications of the disease and to create a basis for suitable control measures in domestic animals.

The scope of future *S. japonicum* infection control programs needs to be broadened. The control of schistosomiasis japonica must be included under the umbrella of integrated parasite control, particularly zoonotic parasitic diseases, to improve food security and human health in the context of agricultural development. This could increase the incentive for livestock owners to treat their animals with praziquantel and hence participate in the control of human schistosomosis.

At the end of the symposium a *Regional Network for Research, Surveillance and Control of Schistosomiasis japonica* was formed and is to be co-chaired by Feng Zheng and Remigio Olveda. The network will establish and encourage informal and formal collaborations and linkages between China and the Philippines and among the many institutions conducting *S. japonicum* work in both countries.

Acknowledgements
The symposium was held at the Jiangsu Provincial Institute of Parasitic Disease in Wuxi, China, 8–10 September 1998, and was organized by the Jiangsu Institute of Parasitic Disease, the Shanghai Institute of Parasitic Diseases, The Danish Centre for Experimental Parasitology, The Research Institute for Tropical Medicine in Manila and the Sina Academy of Preventive Medicine. Financial support was provided by the Ministry of Health of the People's Republic of China, The Danish Centre for Experimental Parasitology, the Swedish International Development Cooperation Agency and the World Health Organization's Special Programme for Research and Training in Tropical Diseases (TDR). There were 38 scientific presentations and a round table discussion with over 70 participants from 10 countries representing government health officials, several human and animal parasitic and tropical disease institutes, universities and key international organizations. The Proceedings of the symposium have recently been published by the Jiangsu Institute of Parasitic Diseases, Wuxi, Jiangsu, P.R. China.

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