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**THE DISTRIBUTION AND PREVENTIVE MEASURES OF
*SCHISTOSOMA JAPONICUM***

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Schistosoma japonicum is distributed in the Far East, such as in Japan, China, the Philippines, Formosa, Celebes, Thailand, Laos and Cambodia. In China the whole of the Yantze Basin is studded with endemic foci from western Szechuan to the Sea and it was said that 10 millions patients were estimated. In the Philippines 300 thousands patients were estimated in 1953, but in 1969 it increased up to 500 thousands. According to WHO, the estimated figures are shown in the Table 1.

Table 1. Estimated number of persons exposed and infected with
Schistosoma japonicum in the Orient (WHO)

County	Total Population	Population exposed	Population infected
China	700,000,000	100,000,000	32,777,630
Japan	89,000,000	3,500,000	116,300
Philippines	27,000,000	1,500,000	421,500
Celebes	5,000,000	10,000	1,000
Thailand	26,000,000	?	?
Total	847,000,000	105,010,000	33,316,430

In Japan five endemic foci are involved, namely Kofu Basin, Tone River Valley, Numazu District, Katayama District and Chikugo River Valley extending into both Fukuoka and Saga Prefecture. The area and estimated patients are shown in Table 2.

Since 1957 Japanese Government has carried out 10 year control program of replacing the earthen ditches with those lined with concrete, spraying molluscicides and treatment of patients. *Oncomelania nosophora*, the intermediate host of *Schistosoma japonicum* disappeared rapidly, and in Katayama District no *Oncomelania* is found. In Kurume patient is difficult to be found. In Southern Asia, Celebes, Thailand, Laos and Cambodia the intermediate host is not yet found.

Table 2. The infested area of schistosomiasis japonica in Japan (in 1959)

Infested area	Space	Population	Percentage of infection	The estimated number of patient
Kofu Basin, Yamanashi Pref.	90.99km ²	217,000	30%	65,000
The area along the River Tone				
Ibaragi Pref.		—	5.2%	—
Chiba Pref.		—	3.8%	—
Saitama Pref.		—	2.7%	—
Numazu district, Shizuoka Pref.	5.75	—	5.0%	—
Katayama district				
Hiroshima Pref.	9.09	38,000	30.0%	11,000
Okayama Pref.	1.26	2,500	0	—
The area along the River Chikugo				
Fukuoka Pref.	39.00	51,600	30%	15,000
Saga Pref.	29.00	30,000	30%	9,000
Total	175.09	339,100		100,000

Since the Department of Parasitology was established in Kurume University 20 years has passed. I would like to show the present status of control in Japan with special reference to our studies.

A Ecology of *Oncomelania nosophora*

1. Distribution and habitat of *Oncomelania* in Fukuoka and Saga Prefectures.

The distribution of *Oncomelania* snails along the Chikugo River covers an area of 8,300 hectares, extending into both Fukuoka and Saga Prefecture. Population in those area is 74,000. The snail is amphibious, living in irrigation ditches, in a moist grass land on the bank of large rivers or rarely in rice fields.

2. The influence of relative humidity on the activity of *Oncomelania nosophora*

It appears from its habitat that activity of the snail depends more or less on the relative humidity of its environment. However, an experiment showed that the snails were not invariably active when the relative humidity was high (97-100 %), and that they were active, irrespective of a change in the relative humidity to some extent, so long as the touched surface of the shell was wet. It may be assumed that in nature the activity of the snail is arrested for need of moisture and is resumed as the touched surface of its shell becomes wet with rain or dew.

3. The movement of the snail in a breeding box

The rate at which the snails move under different environmental condition was studied by keeping them separately in a breeding box divided in three sections, watery, grassy and bare. It was observed that the snails kept in the water moved faster than those kept in the grassy or bare sections.

4. Daily rhythmic activity of *Oncomelania nosophora*

Under the seasons of favorable conditions *Oncomelania* snail shows daily

rhythmic activity that belongs to a type of dependent rhythmicity having two peaks at night. During daytime it almost rests, but resumes its normal activity after sunset when light intensity reduces to about 0 lux, and after few hours the activity reaches the maximum. Then after the activity declines slightly, but when light intensity increases over about 0 lux, the snails begin to resume their activity. Then after sunrise it gradually declines and scarcely moves. The first peak of activity corresponds to their feeding behavior and the second represents their returning behavior to the rest place during daytime.

5. Hibernation of *Oncomelania nosophora*

In natural habitat of grassy riverbed of the Chikugo at Mamezu, Saga Prefecture, a great number of snails passed the winter on the surface of the ground, but some of them (about 30 %) were found to be within one cm in depth from the surface of the ground. In this area, the principle hibernant places on the surface of the ground are grass-stub and under piles of dead grasses. Difference of temperatures were studied on these places. The inside of grass-stub was highest on the ground and the next higher place was under the part of accumulation of dead grass. These facts apparently indicate that the snail moved to the warm place during early winter and hibernated in that place. The field investigation revealed that the hibernant snails became active after rainfall in the mid-March where the mean temperature of the day exceeded 10°C.

6. Influence of floods on the distribution of *Oncomelania nosophora*

In July 1953 the endemic area of schistosomiasis along the Chikugo River was flooded, and many people were affected by schistosomiasis japonica acuta. Before the flood, we could find many *Oncomelania* snails in the grass plots on the Chikugo River bed. One month later we could not find any more there. Three years later *Oncomelania* snails have increased to their former numbers. In April 1956 we found the snails in the middle of a small community outside of the endemic area, where a pile of rubbish was built at the flood time. The author thought that the flood carried the snails with the rubbish and that the snails increased in numbers during three years.

B Eradication of *Oncomelania nosophora*

I. Physical methods

1) Burning

a) Burning snails with straw

Burning *Oncomelania* snails with sheaves of wheat straw was studied in small dry irrigation ditches. 5.65 kg of wheat straw were burned in an 8 meter long ditch with width of 60 cms. After the burning, snails were examined, and 91.4 % of them were dead.

b) Eradication of *Oncomelania* snails with a soil-burning flame thrower.

Of 127 snails collected immediately after burning, 98 (77.2 %) were found dead.

2) Burying experiments of *Oncomelania nosophora* in the soil in winter

Oncomelania snails were buried in the soil in the depths of 2, 4, 8 and 10 cm from the surface in two cylinder bottles and one wooden box. These glass bottles

were buried under the eaves. One bottle was moistened sometimes by a sprayer to keep it wet and the other was kept dry. The wooden box, 60 cm long, 28 cm wide and 32 cm high, was buried in the garden in the natural condition. In the wet condition 8 snails climbed up to the surface in the next spring, but no snail climbed up in the dry condition. After a half year all snails were dug up and examined for dead or living. In the dry condition the deeper snails were more alive than the superficial snails. All snails in the wet condition were dead. From the above experiments the author concluded that it is necessary to bury the snails at least 6 cm deep in the soil.

II. Chemical methods

1) Ca cyanamide

Ca cyanamide is an effective chemical for *Oncomelania* eradication, but it never satisfactorily controlled the snail host and is more effective when *Oncomelania* snails are put in Ca cyanamide solution with soil than Ca cyanamide alone in vitro. It seems that decomposed substances of Ca cyanide kill the snails.

2) Sodium pentachlorophenate

Sodium pentachlorophenate is cheaper than Ca cyanamide and can be used in sandy irrigation ditches and inclined ditches. It is convenient to eliminate the snails in grass plots of the Chikugo River.

3) Sevin

Since 1954 sodium pentachlorophenate has been used with success as a molluscicide for *Oncomelania nosophora*. But this chemical is toxic to fish in a low concentration, and there were some troubles with fisherman. Molluscicides not toxic to fish are desirable. Sevin is insoluble in water and less toxic for mammals. According to Ruppel this chemical is effective for the control of slugs. Experiments with this drug were studied in vitro and in the field. Sevin was non-toxic to some fishes as *Cyprinus carpio*, *Carassius auratus*, *Ophicephalus argus* and *Zacco* sp. LD₅₀ of Sevin for *Oncomelania* snails was estimated to be about 0.41 mg per 100 cm². In the field Sevin was sprayed at a rate of 2 g per square meter, and its molluscicidal rate was 71 %. This chemical may be applicable to *Oncomelania* snails in swamps or creeks where sprayed chemicals are apt to flow into stream. Sevin has been recommended for *Oncomelania* snails in the riverbed of the Chikugo after burning the weeds in winter. Sevin undergoes chemical changes in an alkaline solution and weedash contains K₂CO₃. It is feared that the effectiveness of Sevin may decrease of decomposition. Experiments were conducted to find out how Sevin changes in ash extracts and how long the ash extract is capable of reducing Sevin. Sevin was dissolved in water with ash (20 g in 1000 ml of water) and reduction percentage of naphthyl-methyl-carbamate (NAC) in Sevin was observed on the 4th, 11th and 18th days. Reduction percentages were 88.7 % on the 4th, 94.9 % on the 11th and 98.1 % on the 18th day. When Sevin was dissolved in 100 g ash extract (100 g in 1000 ml of water), the reductions were 89.3 % on the 4th, 94.9 % on the 11th and 100 % on the 18th day. These results suggest that spraying of Sevin should be tried 3 weeks after burning of weeds.

III. Biological methods

1) Fire fly larva

Three groups of larvae (9-10 mm, 6-7 mm and less than 2 mm in length) were fed on *Oncomelania* snails (large over 5 mm long, and small under 5 mm) for a period of 37 days. Predatory activity of them were as follows.

i) large larva (9-10 mm long)

Mean number of large *Oncomelania* snails (over 5 mm long) fed per larva, per day was 0.049 and small snails 0.055.

ii) median-sized larva (6-7 mm long)

Mean number of large *Oncomelania* snails fed per larva, per day was 0.149 and small snails 0.041.

iii) small larva (under 2 mm long)

Mean number of small *Oncomelania* snails fed per larva, per day was 0.006.

2) *Rhabditis oncomelaniae* Yokoo et Okabe

In the course of rearing the *Oncomelania* snails in laboratory, many of them died without any demonstrable reason. Upon careful examination of the dead snails and the rearing boxes, a kind of nematodes was found in abundance, and this was felt to be the cause of death of the snails. This nematode was named as *Rhabditis oncomelaniae* Yokoo et Okabe, 1968.

Some infection experiments of *O. nosophora* with *R. oncomelaniae* were carried out in laboratory and in field. The first problem to be solved was to culture artificially this *Rhabditis*. The culture was easily produced by using the following procedures. One gram of agar and ten grams of strained spinach were put into 100 ml of water in a flask. This mixture was sterilized and dissolved. Thirty ml of this mixture was poured into a petri dish which was 9 cm in diameter, and left to coagulate. About 100 *Rhabditis* were dropped into each petri dish mentioned above. Each dish was kept in a room at about 27°C. Within a few days numerous *Rhabditis* were obtained. In laboratory, *Oncomelania* snails died within a few days when they were put into the medium containing *Rhabditis*. However, the snails were not killed by this method when 20 to 1,100 *Rhabditis* per a snail were put into a petri dish with the snail, though some snails were infected with 1 to 44 nematodes. In field, 15,000 and 450,000 nematodes were scattered in 2 areas separately by a watering can. According the results of 3 times weekly surveys, infection rates of the snails decreased week by week. Whether the snails die or not seems to depend on the number of the *Rhabditis*. After the microscopic observation of many serial sections of snails infected with *Rhabditis*, many nematodes were found penetrating into the snail bodies.

IV. Environmental changes

1) Cementing of ditches

In 1938 Okabe recognized no snail in cemented ditches built for other purposes in an endemic area of the tributary of the Chikugo River and recommended the cementing of irrigation ditches for the control of snails.

In 1956 a ten year project of cementing all irrigation ditches in the endemic areas was planned with the financial aid of Government. At the end of the fiscal year of 1967 the ratio of cemented ditches amounted to 80.4 %. 687,774 meters

of ditches remained uncontrolled.

The law was prolonged up to 1973.

2) Artificial alteration of the vegetation on the riverbed of the Chikugo River

The construction of a golf course was performed from 1960 to 1965. Before the construction of the golf course near Mamezu a great number of *Oncomelania* snails were found on the riverbed of the Chikugo. Only one snail was found after extensive searches for *Oncomelania* snails by four persons several times in July 1966. In July 1958, 394.5 *Oncomelania* snails per 1 square meter were found by Dr. Nakao at the same place.

The reason for complete disappearance of *Oncomelania* population on the Chikugo riverbed near Mamezu was seemed to be ground-levelling and artificial alteration of the vegetation on the riverbed. As a result of comparison of the past and present vegetation there, it was prominent that the most dominant species altered from *Miscanthus floridulus* to *Cynodon dactylon* which was the second dominant species in the past. This *Cynodon* was left alive to participate as an element species in forming the lawn. Some horticultural races of *Zoysia japonica* were also introduced to fill the incompleteness of the lawn covered by *Cynodon*. An exhaustive burning of the subterranean roots of *Miscanthus* dug up after reaping made the extinction of the plant possible in the area, and the lawn kept there in a good condition to prevent the re-population of the snails.

Recent survey for schistosomiasis japonica in Japan shows the decrease of incidence of schistosomiasis and disappearance of *Oncomelania* snails from Katayama, the Chikugo River basin, Shizuoka Prefecture and the Tone River Basin except Kofu Basin. The reason why *Oncomelania* snails are remained in Kofu Basin is not understood.

DISEASES OBSERVED IN KENYA

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The Japanese medical team, six doctors in total number, from Nagasaki University School of Medicine has been engaged in medical work at the Rift Valley Provincial General Hospital, Nakuru in Kenya for about four years. The diseases of the 3756 medical inpatients hospitalized during the period from Jan. 1966 to Dec. 1968 were clinically and statistically investigated and comparative studies to the pattern seen in Japan were discussed.

2) Geography of Kenya and tribe distribution.

Topographic circumstances, especially its altitude, river and lake were the most important factors of the distribution of the diseases in the country. Precipitation was closely related to the incidence of malaria, amoebiasis, schistoso-