Snail Host of Dermatitis-producing Cercaria

POPULATION STUDIES ON *AUSTROPEPLEA OLLULA* (GOULD), THE SNAIL INTERMEDIATE HOST OF DERMATITIS-PRODUCING AVIAN SCHISTOSOMES

1. SEASONAL CHANGES IN SIZE OF THE SNAILS IN RELATION TO THE OCCURRENCE OF PADDY FIELD DERMATITIS

KIYOSHI MAKIYA and TORAO ISHIGURO

Department of Medical Zoology, Nagoya University School of Medicine

ABSTRACT

Population study was made on *Austropeplea ollua* (Gould), the snail intermediate host of avian schistosomes which caused paddy field dermatitis, from the viewpoint of successive changes in the size of the snails in the field in relation to the occurrence of the dermatitis. The growth of the snail host was observed by analyzing the shell-size distributions of summer and overwintering populations. Young snails born in autumn composed the overwintering population in rice stubbles, and appeared on the soil surface in spring season after irrigation water was introduced into the paddy fields. During the first breeding season in early summer, the snail population on the soil surface consisted of two different size-groups, i.e., a few large snails which overwintered in rice stubbles and a majority of samll ones produced by the overwintered snails. During the period from May to October, breeding of the snails was observed twice, first in early summer and again in autumn. The large snails, which were more likely to harbour the cercariae, were found in May-June, August and October, but their density was low in August and October due to draining of the paddy field as a step in rice farming. In consideration of these circumstances, the large snails found in May-June were suggested to be responsible for the occurrence of the dermatitis. Accordingly, snail control measures should focus on the large snails which overwinter in paddy fields.

Keywords: Cercarial dermatitis, Paddy field dermatitis, Snail intermediate host, Overwintering of *Austropeplea ollula*

INTRODUCTION

A dermatitis of unknown etiology occurred frequently in the Yatomi area of Aichi Prefecture around 1968. The dermatitis, named "kayui-kayui byō" or "itching disease" by the people, was characterized by prickly and itchy skin sensations followed by development of papules and pustules. A total of more than 730 patients, most of whom were rice-cultivating farmers, were reported from the endemic area.[1] The epidemic of the dermatitis subsided in a few years but has occurred again since 1973.[2]

At first, the main cause of the dermatitis was assumed to be agricultural insecticide,

真喜屋清・石黒虎男

Received for Publication November 6, 1981

chemical fertilizer or other pollutants which came into contact with the farmers' skin. However, through parasitological investigations carried out by Kumada *et al.*,[3] etiology of the dermatitis was elucidated by the detection of causative schistosome cercaria from the aquatic snail, *Austropeplea ollula* (Gould); the cercaria was experimentally confirmed to cause the dermatitis in man.

According to the results so far reported, the causative cercaria belongs to an avian schistosome, *Trichobilharzia*. The cercariae are shed into the water from the snail intermediate hosts, *A. ollula*, which infest paddy fields of the endemic area. As avian definitive hosts, *Anas poecilorhyncha zonorhyncha* Swinhoe and other waterfowls of the Anatidae family have been suggested.[4]

One of the fundamental measures for preventing the dermatitis is control of the snail intermediate hosts, and they may be controlled by the application of molluscicides if they infest limited areas. The endemic area of the dermatitis, however, includes a wide 870-hectare area heavily infested by the snail hosts. Accordingly, it has been difficult to control the dermatitis epidemic effectively in such an extensive area.

In order to develop effective measures for controlling the snail host, ecological studies of the snail were carried out. The present paper deals with population sutdies on the snail host from the viewpoint of the successive changes in the size of snails in the field in relation to the occurrence of the dermatitis.

MATERIALS AND METHODS

In the endemic rice-farming area, one paddy field was selected for monthly samplings of the snail population. This paddy field had an area of 22 ares and had been heavily infested by the snail hosts in past years.

Two kinds of samplers were used for collecting the snails. One was a metal dredge sampler (20 cm long × 10 cm wide × 5 cm high) screened with wire mesh at the bottom, which could collect a soil sample together with the snails on the soil surface. The snails could be sieved out from the soil by washing the soil sample. The other was a metal tube sampler with a diameter of 10 cm. This sampler was used for collecting overwintering snails which were often found in the spaces of the rice stubble. After separating the bundled rice stubble, the snails were sieved out by washing the stubble and soil.

About 10 samples were taken randomly with the dredge samplers during the period from May, 1980 to March, 1981. With the tube samplers, a total of 47 rice stubbles were taken systematically in a grid-wise manner from October, 1980 to March, 1981. In addition to these monthly samplings taken from the paddy field, dredge samplings were made randomly in three drainage canals around the paddy field during the winter months.

After identifying the snail hosts, *A. ollula*, the shell length of all the snails was measured to the closest 0.1 mm with an eyepiece micrometer in a binocular microscope. In order to discriminate different size-groups (cohorts) in the shell-size distribution, the measurement data were analyzed on a probability graph paper. The composition rate, mean shell length and standard deviation of each component size-group were determined by Cassie's method.[5]

RESULTS

1. Relative abundance of the snail intermediate host in the paddy field

The number of aquatic snails collected in the three field surveys are shown in Tables, 1, 2 and 3. A total of 3,168 snails were collected with the dredge samplers during the study period, of which *Austropeplea ollula* (Gould) accounted for 98.1%. The rest were *Physa acuta*

Table 1. Relative abundance of the snail intermediate host, *Austropeplea ollula*, among aquatic snails found in the paddy field (dredge samples)

Date	*Austropeplea ollula*	*Physa acuta*	*Oxyloma hirasei*	*Cipangopaludina chinensis malleata*	Total
May 31, 1980	427	0	0	0	427
Jun. 12	730	0	0	0	730
Jul. 10	887	0	0	0	887
Aug. 11	98	2	0	0	100
Sep. 14	659	36	8	5	708
Oct. 2	205	1	5	0	211
Nov. 13	—	—	—	—	—
Dec. 11	31	0	0	0	31
Jan. 10, 1981	27	1	0	0	28
Feb. 12	38	0	0	0	38
Mar. 12	7	0	1	0	8
Total	3,109	40	14	5	3,168
Percentage	98.1	1.3	0.4	0.2	100.0

Draparnaud, *Oxyloma hirasei* (Pisbry) and *Cipangopaludina chinensis malleata* (Reeve) in decreasing order (Table 1).

Table 2. Relative abundance of the snail intermediate host, *Austropeplea ollula*, among aquatic snails found in the paddy field during winter months (tube samples)

Date	*Austropeplea ollula*	*Physa acuta*	*Oxyloma hirasei*	*Polypylis hemisphaerula*	Total
Oct. 2, 1980	48	0	3	0	51
Nov. 13	130	8	4	1	143
Dec. 11	234	46	2	0	282
Jan. 10, 1981	441	28	0	0	469
Feb. 12	171	94	2	0	267
Mar. 12	205	34	2	0	241
Total	1,229	210	13	1	1,453
Percentage	84.6	14.4	0.9	0.1	100.0

With the tube samplers, 1,453 snails were recovered from the rice stubbles dug out together with the soil. Among these snails, the dominant species was *A. ollula* (84.6%), followed by *P. acuta*, *O. hirasei* and *Polypylis hemisphaerula* (Benson) in number (Table 2).

Out of 307 snails sampled from the nearby drainage canals, however, only a few *A. oulla* (1.3%) were found during winter months. In contrast, most (97.1%) of the aquatic snails in the canals were *O. hirasei* (Table 3).

Table 3. Relative abundance of the snail intermediate host, *Austropeplea ollula*, among aquatic snails found in drainage canals during winter months (dredge samples)

Date	*Oxyloma hirasei*	*Austropeplea ollula*	*Cipangopaludina chinensis malleata*	*Physa acuta*	Total
Oct. 2, 1980	40	0	2	0	42
Nov. 13	—	—	—	—	—
Dec. 11	164	4	1	1	170
Jan. 10, 1981	2	0	0	0	2
Feb. 10	70	0	1	0	71
Mar. 12	22	0	0	0	22
Total	298	4	4	1	307
Percentage	97.1	1.3	1.3	0.3	100.0

2. Successive changes in the shell size of the snail host in the field

The monthly changes in the snail size are shown in Fig. 1 for the dredge-sampled (soil-surface) population in terms of shell length. In order to follow the growth of the same size-group (cohort), calculated frequency curves are fitted to the observed size frequencies.

A number of *A. ollula* appeared on the soil surface of the paddy field in spring after irrigation water was introduced for rice planting. After rice planting (May 31), the snail population was composed of two clearly different groups, i.e., a majority (85%) of small snails (group I with the mean shell length of 1.70 mm and group II, 2.55 mm) and a few large ones (group III, 6.40 mm and IV, 7.95 mm). Abundant egg masses found on the soil suggested the first breeding of the snail to have taken place during this period. On June 12, the small (group I, 1.50 mm and II, 2.45 mm) and middle-sized snails (group III, 3.50 mm) made up 95% of the population, but a minority of large snails (group IV, 7.35 mm) still remained.

In the next month (July 10), the large snails were no longer found, and the population was composed of 66% of small snails (group I, 1.45 mm and II, 2.20 mm) and middle-sized ones (group III, 4.20 mm). In mid-August, small (group I, 2.30 mm and II, 3.00 mm) and middle-sized snails (group III, 4.15 mm) accounted for 85% of the population, but some snails had grown into large ones (group IV, 5.65 mm)

These large snails disappeared in mid-September; at the same time, small snails (group I, 1.55 mm and II, 2.45 mm) increased in number together with a majority (72%) of middle-sized snails (group III, 3.55 mm), and the population density became much higher than that of the previous month. This change suggested the start of the second breeding in autumn. After harvest of the rice crop (October 2), small snails were no longer collected from the soil surface and the population consisted of a majority (90%) of middle-sized snails (group I, 3.65 mm and II, 4.80 mm) plus a few large ones (group III, 5.95 mm).

The tube sampling was started from October to examine the overwintering population found in the rice stubbles left in the drained paddy field after the harvest.

Fig 2. shows the successive changes in the shell size distributions together with the fitted frequency curves. Shell-length histograms for the soil-surface population are also shown for comparison.

On October 2, a majority (92%) of small snails (group I, 1.60 mm and II, 2.70 mm) were recovered from the rice stubbles together with many egg masses. The production of the egg

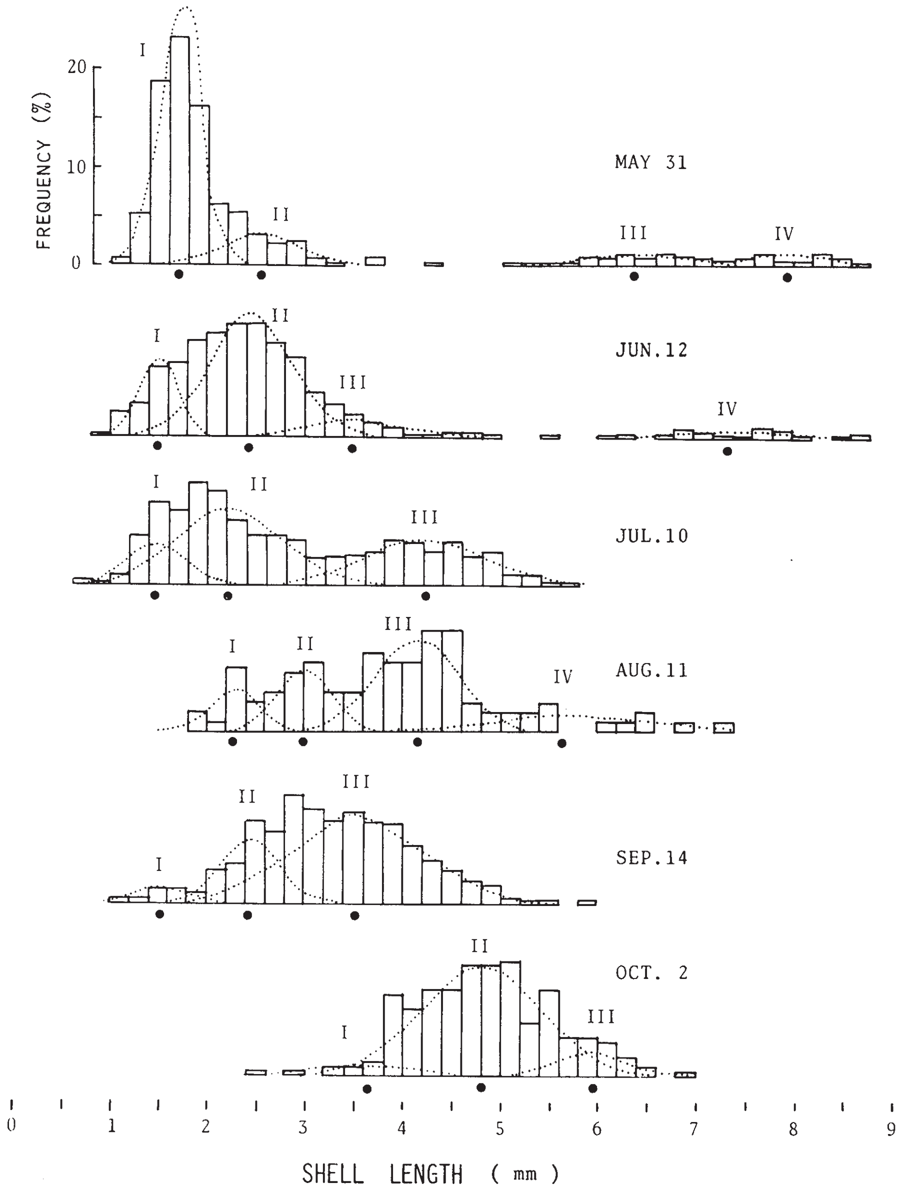

Fig. 1 Monthly change of shell length distribution of the snail intermediate host, *Austropeplea ollula* (dredge-sampled soil-surface population)
Observed frequency distributions are shown by the histograms along with the calculated frequency curves. Component size-groups are indicated by the Roman numerals and mean shell length (solid circle).

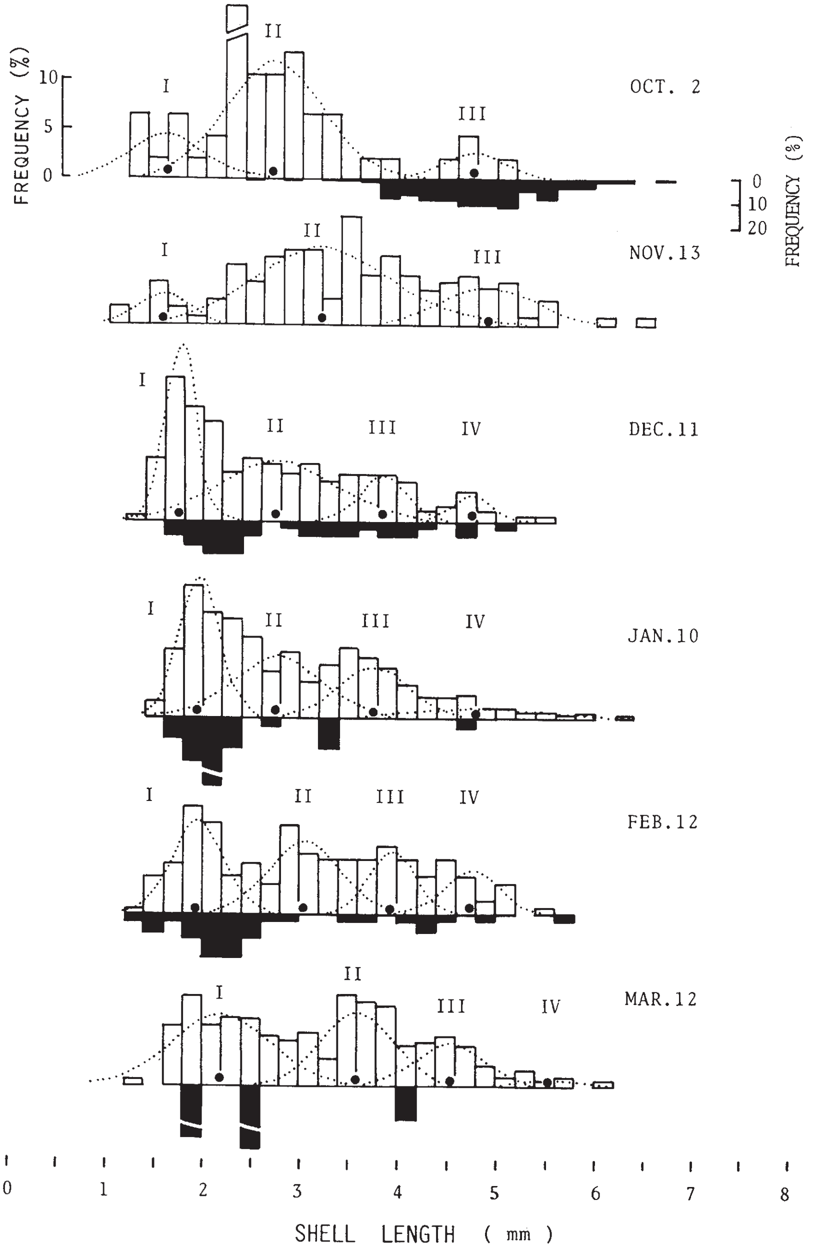

Fig. 2 Monthly change of shell length distribution of the snail intermediate host, *Austropeplea ollula* (overwintering population in rice stubbles and populations on the soil)
The transparent histograms indicate the distributions of the tube-sampled population in the rice stubbles and the solid histograms show those of the dredge-sampled population on the soil.

masses indicated the second breeding which was suggested by the change in shell size distribution and density in mid-September.

It should be noticed that the shell size distribution of the rice-stubble population was quite different from that of the soil-surface population. This difference suggested that the small newborn snails gathered in and around the rice stubbles, while the large snails remained on the soil surface. In mid-November, the size distribution did not differ from that of the previous month except that the percentage of middle-sized snails increased.

From mid-December to mid-January when snails were very scarce on the dry soil surface, the smallest snails (group I, in Dec. 1.75 mm and group I in Jan., 1.95 mm) became abundant and accounted for most (68–70%) of the rice-stubble population together with the second smallest snails (group II in Dec., 2.75 mm and group II in Jan., 2.75 mm).

In the next month (February 12), small snails (group I, 1.95 mm and II, 3.05 mm) still made up the larger proportion (66%) of the snail population. On March 12, however, middle-sized snails (group II, 3.60 mm and III, 4.55 mm) accounted for more than half (53%) the number and some large snails (group IV, 5.55 mm) were also found in the rice-stubble population.

From December to March, the size distribution between the rice-stubble and soil-surface populations differed little, but the population density was very low on the soil surface of the paddy field.

DISCUSSION

In the present study, it was clearly shown that (1) *Austropeplea ollula*, the snail host of the dermatitis-causing cercaria, predominated on the soil of paddy field during rice-farming seasons and in the rice stubbles during the winter season (Tables 1 and 2), and (2) drainage canals were not important as overwintering sites of this snail, in view of the scarcity of the snail observed there during the winter months (Table 3). Similar results were obtained in preliminary surveys carried out in 14 other paddy fields in the same area over an entire year (unpublished). It can be concluded from these field surveys that the paddy fields are most important as the natural habitat during rice-farming seasons and also as the overwintering sites of the snail host.

Until the detection of a large number of overwintering snails in rice stubbles, there was thought to be a possibility that the overwintered snails might be introduced by irrigation water from the pipe network originating at the upper part of the nearby river. However, this possibility was denied conclusively by the repeated tests of sieving the water with a wire-screened dipper.

The results obtained from the analysis of the snail size distribution (Figs. 1 and 2) can be summarized as follows: (1) large snails in early summer were regarded as overwintered snails, which survived until mid-June, (2) a lot of young snails were produced by this overwintered generation in the first breeding period (May–July), (3) the second breeding in autumn was observed during September and October, (4) large snails which produced young in autumn died in winter, (5) in their place, young snails composed the overwintering population in rice stubbles, and (6) some young snails were found on the soil surface during winter months, but their density was very low compared with that of the rice-stubble popultaion (Cf. Tables 1 and 2).

Some ecological aspects of this snail were reported from a veterinary point of view,[6–8] because this snail is also an important intermediate host of liver fluke, *Fasciola hepatica*, which mainly infects domestic animals and occasionally man. The results of these studies on the natural habitats, seasonal abundance and breeding periods of this snail were almost same as those of the present field observations.

According to the findings of the above studies, the smallest snails that harboured *F. hapatica* cercariae measured 4.8 to 5.5 mm in shell length and the smallest snail depositing egg masses was 5.5 mm. This minimum size of the snail host for cercarial infection seems to be almost same as that of *Trichobilharzia* schistosomes which cause the dermatitis.[9,10] Based on these results, older snails larger than this minimum size are regarded to be important in shedding the cercariae.

Many snails longer than 5 mm were found in the May-June period and also in August and October (Fig. 1). However, the population density was considerably lower in August and October than in May-June. The percentage of dead snails increased remarkably in this area in the August-October period due to the draining of the paddy fields as a step in rice farming.[11] Judging from these circumstances, the large snails in the May-June period seem to be responsible for the occurrence of the dermatitis in these months. Moreover, the occasion for farmers to enter the paddy fields is more frequent during rice-planting season (April-May). This fact may be a factor which intensifies the occurrence of the dermatitis in this period.

Infection of *Trichobilharzia* cercariae among the snails was found positive during early summer[10] and the number of dermatitis patients reported has been highest during this period in the past.[1,2] The positive infection rate of the snail hosts and prevalence peak of the dermatitis cases jointly coincided with the abundance of large snails found in the field in May-June.

In consideration of these circumstances, control measures of the intermediate host should focus on the large snails in early summer which overwinter in the paddy fields.

The growth rate of this snail host was calculated by rearing captive snails in outdoor conditions.[7] However, an accurate estimation of the rate in the field has been difficult [12] because many size-groups were included in a population, consequently frequency curves of the component size-groups overlapped in the snail size distribution.

In the present study, an attempt was made to analyze the polymodal size distributions by assuming that the snail-size measurement of one size-group (cohort) was expected to fit a normal distribution. As was seen in Figs. 1 and 2, this assumption seemed to be adequately satisfied for the purpose of estimating the growth rate in the field.

In Fig. 1, for example, many snails of one size-group were regarded to grow as follows: Group I (mean shell length = 1.70 mm) on May 31 → group II (2.45 mm) on Jun. 12 → group III (4.20 mm) on Jul. 10 → group IV (5.65 mm) on Aug. 11. A large number of another size-group were estimated to grow as follows: Group I (1.50 mm) on Jun. 12 → group II (2.20 mm) on Jul. 10 → group III (4.15 mm) on Aug. 11. During the next months, a great number of group III (3.55 mm) on Sept. 14 were thought to grow into group II (4.80 mm) on Oct. 2.

Using these estimations, the average growth rate of the shell length was calculated to be 0.053 mm per day during the period from May to October. Based on this growth rate, more than two months are needed for snails in the field to grow from small (1.50 mm) to large snails longer than 5.0 mm.

For the overwintering snails in the rice stubbles (group I, II, III and IV in Fig. 2), the growth rate was estimated to be very low (0.0024 mm per day) between December and February. Each size-group, however, started to grow more rapidly in early spring from February to March, the rate being estimated to be 0.018 mm per day. These growth rates during winter and early spring corresponded to 4.5% and 34.0% of the rate during rice farming seasons.

ACKNOWLEDGEMENTS

The authors wish to express their thanks to Professor N. Kumada, Department of Medical Zoology, Nagoya University School of Medicine, for reading of the manuscript, and all the members in the Pharmacology Department of Kainan Hospital and Mrs. Sakaki for their technical assistance. The authors are also obliged to Mr. Y. Watanabe, owner of the paddy field, for his permission to carry out snail sampling in his paddy field.

REFERENCES

1) Ōta, H., Matui, H., Takashima, K. *et al.*, Paddy field dermatitis in Aichi Prefecture I. Occurrence of the cases in the western region. *Rep. Aichi Inst. Pub. Hlth.*, **20**, 59—63, 1970 (in Japanese).
2) Ishiguro, T., Kato, H., Yamada, Y. *et al.*, Paddy field dermatitis among inhabitants near the mouth of the Kiso River. (I) A survey of the incidense of the disease. *J. Japan Assoc. Rural Med.*, **29**, 867—872, 1981 (in Japanese).
3) Kumada, N., Ohya, S., Makiya, K. *et al.*, Paddy field dermatitis in Aichi Prefecture II. Results of the survey of fresh-water snails and parasitic cercariae in the western region of the prefecture. *Rep. Aichi Inst. Pub. Hlth.*, **20**, 65—73, 1970 (in Japanese).
4) Kumada, N., Ohya, S., Makiya, K. *et al.*, Paddy field dermatitis in Aichi Prefecture V. Eggs and adults of the genus *Trichobilharzia* recovered from resident waterfowls in the endemic area. *Rep. Aichi Inst. Pub. Hlth.*, **21**, 39—46, 1971 (in Japanese).
5) Cassie, R. M., Some uses of probability paper in the analysis of size frequency distributions. *Aust. J. Mar. Freshwater Res.*, **5**, 513—522, 1954.
6) Ono, U. and Kimura, S., Study on *Lymnea ollula* as the intermediate host of *Fasciola hepatica* in Hyogo Prefecture. *J. Jap. Soc. Vet. Sci.*, **10**, 227—230, 1957 (in Japanese).
7) Esaki, Y., Studies on ecology of *Fossaria ollula* I. Development and life of the snail. *J. Jap. Soc. Vet. Sci.*, **10**, 375—378, 1957 (in Japanese).
8) Nomura, M., Study on *Lymnea ollula* infected by *Fasciola hepatica* in Tsurugiya area, Ishikawa Prefecture. *Study of livestock*, **8**, 87—88, 1962, (in Japanese)
9) Suzuki, N., Paddy field dermatitis in Saitama Prefecture 6) The number of cercariae of *Trichobilharzia brevis* from the snail host, *Austropeplea ollula* and the duration of the cercarial shedding period. *J. Japan Assoc. Rural Med.*, **30**, 197—201, 1981 (in Japanese)
10) Kumada, N., Ohya, S., Makiya, K. *et al.*, Paddy field dermatitis in Aichi Prefecture III. Further studies on fresh-water snails and parasitic cercaria. *Rep. Aichi Inst. Pub. Hlth.*, **21**, 25—31, 1971 (in Japanese).
11) Makiya, K., Kumada, N., Ohya, S. *et al.*, Paddy field dermatitis in Aichi Prefecture IV. Population dynamics of *Austropeplea viridis*, the host snail of dermatitis-producing cercariae in the endemic paddy fields. *Rep. Aichi Inst. Pub. Hlth.*, **21**, 33—38, 1971 (in Japanese)
12) Yazaki, T., Studies on distribution of fresh-water snails in mountainous streams of eastern Suwako area, Nagano Prefecture, from the viewpoint of rural medicine (VI). *Ochanomizu Med. J.*, **6**, 1975—1802, 1958 (in Japanese).