ON THE INFECTIVITY OF AN ORIENTAL LUNG FLUKE, *PARAGONIMUS*
OHIRAI MIYAZAKI, 1939 TO SOME GASTROPOD MOLLUSCS,
WITH REMARKS ON THAT OF OTHER
SPECIES OF THE GENUS IN JAPAN
— A REVIEW —

KENJIRÔ KAWASHIMA

*Department of Parasitology, Faculty of Medicine, Kyushu University,
Fukuoka, Japan*

(Received: August 9th, 1965)

Up to the present, the experimental infection with *Paragonimus ohirai* larvae in the gastropod molluscus belonging to 5 genera including 10 species has been carried out by the author and some other workers. The results showed that this fluke has a high infectivity to amphibious molluscs such as *Assininea parasitologica*, *A. yoshidayukioi*, *Paludinella japonica* and *Oncomelania nosophora* rather than to aquatic molluscs. These results were compared with those of the experimental infection with other species of the genus *Paragonimus* in Japan. The grouping of *Paragonimus* species of Japan according to their infectivity to the molluscs was coincident with that by the morphological characteristics.

INTRODUCTION

Up to the present, the occurrence of 4 species of the genus *Paragonimus* has been reported in Japan. *P. westermani* (KERBERT, 1878) had been recognized for a long time, and another mammalian lung fluke, *P. ohirai* was described as a new species by Miyazaki in 1939. Moreover, *P. iloktsuenensis* which was described by Chen in 1940 in China was added to the genus *Paragonimus* of Japan by Miyazaki in 1944. Subsequently, *P. miyazakii* was described by Kamo, Nishida, Hatsushika and Tomimura in 1961 as the fourth species of this genus in Japan. On the other hand, a species of the genus *Paragonimus* which is closely allied to *P. kellicotti* WARD, 1908 was reported by Miyazaki in Japan. At present, however, Miyazaki is of the opinion that this species is not referred to as *P. kellicotti* but as *P. miyazakii* KAMO et al., 1961.

As regards the molluscan hosts and the intramolluscan development, much information has been accumulated by many earlier workers over the past fifty years. Since Nakagawa first reported in 1915 on the experimental infection of *Melania libertina* GOULD, 1859 [= *Semisulcospira bensoni* (PHILIPPI, 1951)] with *P. westermani*, its infectivity to the molluscs and its intramolluscan stages have been reported by Ando (1915-1921), Nakagawa (1918), Kobayashi (1918-1924), Miyairi (1918, 1934), Yokogawa and Wakeshima (1934), Yamaguti (1943), Komiya and Ito (1950), Komiya, Suzuki and Ito (1961) and Kawashima and Miyazaki (1964b). The molluscan host and the intramolluscan stages of *P. ohirai* were first reported by Ogita (1954). Thereafter, the infectivity of this fluke to the molluscs and its intramolluscan development have been reported by Ikeda (1957), Yokogawa

et al. (1958), Yoshida and Miyamoto (1959, 1960), Yoshida (1960), Kawashima (1961), and Kawashima and Miyazaki (1963a). The larvae of *P. iloktsuenensis* were studied by Chen (1940) in China, and its infectivity to the molluscs and its morphology were also studied by Yoshida (1959), Tomimura, Terauchi and Tarumoto (1960), Komiya, Yoshida and Tomimura (1960) and Kawashima and Miyazaki (1963b). The infectivity of *P. miyazakii* to the molluscs has never been reported except an experimental study by Kawashima and Miyazaki (1964a). Concerning *P. kellicotti* in north America, Ameel (1934) worked out its life history by experimental infections of American *Pomatiopsis* molluscs.

In the following pages, the author wishes to review on the infectivity of *P. ohirai* to some gastropod molluscs, together with that of other species of the genus *Paragonimus* mentioned above.

Experimental Molluscan Infection with P. ohirai Larvae

Data reported on the experimental infection of some gastropod molluscs with *P. ohirai* larvae are summarized in Table 1.

The experimental infection of *Oncomelania nosophora* (ROBSON, 1915) was carried out by Kawashima and Miyazaki (1963a) who reported that in all of 66 molluscs examined

Table 1. Comparison of the results of the experimental infections of some gastropod molluscs with *Paragonimus ohirai* MIYAZAKI, 1939

Species	No. of molluscs	No. of infected	Infection rate (%)	Days after exposure	Investigators (year)
<i>O. nosophora</i>	66	66	100	103-134	Kawashima & Miyazaki (1963)
	22	22	100	1- 94	Kawashima (Unpublished)
<i>A. parasitologica</i>	30	10	33.3	113-129	Yokogawa et al. (1958)
= <i>P. devilis</i> of Yokogawa, 1958	69	42	60.8	57-103	Yoshida & Miyamoto (1959)
	14	4	28.5	88	Kawashima (1961)
	48	31	64.6	85- 92	Kawashima (Unpublished)
<i>A. yoshidayukioi</i>	33	19	57.6	87- 94	Yoshida & Miyamoto (1960)
	45	26	57.8	85- 92	Kawashima (Unpublished)
<i>P. japonica</i>	40	12	30.0		Yoshida (1960)
<i>A. japonica</i>			+	63	Ogita (1954)
			+	66-105	Ikeda (1957)
	33	0	0	113-129	Yokogawa et al. (1958)
	50	1	2.0	57- 83	Yoshida & Miyamoto (1959)
	72	4	5.6	100	Kawashima (Unpublished)
<i>A. castanea</i>	97	0	0	94-138	Kawashima (1961)
<i>A. kushimotoensis</i>	37	0	0		Yoshida (1960)
<i>A. latericea</i>	44	0	0	88- 91	Kawashima (1961)
<i>miyazakii</i>	104	0	0	71- 83	Kawashima (Unpublished)
<i>S. bensoni</i>			—		Yoshida (1960)
	55	0	0	80- 95	Kawashima (Unpublished)
<i>C. retropuctus</i>	10	0	0	102	Yoshida & Miyamoto (1959)
	50	0	0	80-100	Kawashima (Unpublished)

during the period of 103-134 days after exposure to the miracidia, a number of rediae and cercariae of this fluke were found. Moreover, the author observed the various stages of the larvae of this fluke in all 22 molluscs examined during the period of 1-94 days after exposure (unpublished). However, this mollusc may play a very minor role as an intermediate host of *P. ohirai* under the natural condition, because *O. nosophora* and *P. ohirai* are different from each other in the geographical distribution. The experimental infection of *Assiminea parasitologica* KURODA, 1958* with this fluke was first carried out by Yokogawa and his co-workers who obtained positives in 10 of 30 molluscs examined during the period of 113-129 days after exposure. In 1959, Yoshida and Miyamoto experimentally found rediae and cercariae of this fluke in 42 of 69 molluscs, the same species as those reported by Yokogawa et al. (1958), examined during the period of 57-103 days after exposure. In 1961 Kawashima also obtained 4 positives in 14 molluscs of *A. parasitologica* examined 88 days after exposure. Thereafter, Kawashima obtained 31 positives in 48 examined during the period of 85-92 days after exposure, using an improved culture box for the maintenance of molluscs (unpublished). Yokogawa et al. (1958), and Yoshida and Miyamoto (1959) proved the natural infection of *P. ohirai* in the same species of mollusc collected from the area where this fluke occurs. Moreover, it was also reported by Yoshida and Kawashima (1961) that *A. parasitologica* was found abundantly at almost all river mouths in the areas where *P. ohirai* occurs. Considering a series of facts mentioned above, it was shown that *A. parasitologica* was one of the most important molluscan hosts of *P. ohirai*.

Yoshida and Miyamoto (1960) studied the role of *A. yoshidayukioi* KURODA, 1959 as the molluscan host of *P. ohirai* and obtained 19 positives of 33 molluscs examined during the period of 87-94 days after exposure, and simultaneously found that some molluscs were naturally infected with *P. ohirai* in the area where this fluke occurs. Kawashima also obtained 26 positives in 45 molluscs, the same species as those reported by Yoshida and Miyamoto (1960), examined during the period of 85-92 days after exposure (unpublished). Even though the distribution of this mollusc is not so well known as that of *A. parasitologica* because it is too small to be easily collected, it is considered important next to *A. parasitologica* as the molluscan host of this fluke. Though *Paludinella japonica* (PILSBRY, 1901) was experimentally proved to be infected with *P. ohirai* (Yoshida, 1960), it seems to play a very minor role as the molluscan host of this fluke.

The fact that *A. japonica* VON MARTENS, 1877, living in great numbers in the area where *P. ohirai* occurs, can serve as the molluscan hosts of this fluke, was experimentally proved by Ogita in 1954. This fact was experimentally reconfirmed by Ikeda in 1957. No infection rate, however, was shown by either of the workers. In 1958, Yokogawa and his co-workers reported that 33 molluscs of *A. japonica* examined during the period of 113-129 days after exposure were found all negative for the larvae. On the contrary, Yoshida and Miyamoto (1959) found an infected mollusc of 50 *A. japonica* experimentally exposed and examined during the period of 57-83 days after exposure. In the author's experiment, using the improved culture box for the maintenance of molluscs a number of rediae and cercariae were found in 4 molluscs out of 72 *A. japonica* examined 100 days after exposure (unpublished). The infection rate was 5.6 % which was 2.8 times as high as that in Yoshida's experiment. Introduction of a new method for culture of

* This mollusc was reported as *Paludinella devilis* (GOULD, 1861) by Yokogawa et al. In 1958, Kuroda did not agree with Yokogawa's identification of this mollusc and he considered it to be a new species of the genus *Assiminea* to which he gave the name *A. parasitologica*.

molluscs to the experiment may increase not only the survival time but also the infection rate. However, this mollusc has never been found to be naturally infected with this fluke, in spite of the investigation of a great number of the molluscs. This seems to be due to the fact that habitats of *A. parasitologica* and *A. japonica* are so different as to be called "habitat segregation"* and that the larvae of *P. ohirai* have more close relations to *A. parasitologica* than *A. japonica* in the ecological characteristics (Kawashima, Tada and Miyazaki, 1961a & b). It seems that the difference in their habitat gives no opportunity for the miracidia of *P. ohirai* to encounter with *A. japonica* under the natural condition. However, if such an opportunity had been provided under the natural condition, some of the larvae might have grown into the cercariae, though the infection rate was very low.

Meanwhile, the host specificity of *P. ohirai* larvae was experimentally investigated, using *A. castanea* WESTERLUND, 1883 by Kawashima (1961) and using *A. kushimotoensis* KURODA, 1958 by Yoshida (1960), but no larvae were recovered in any species of the molluscs. The infectivity of *P. ohirai* to *A. latericea miyazakii* HABE, 1943 was also observed by the author. But neither rediae nor cercariae were found in 44 molluscs examined during the period of 88-91 days after exposure (Kawashima, 1961). Though the infection experiment using the improved culture box for this mollusc was also carried out by the author, the larvae of this fluke were never recovered in this mollusc (unpublished). The infectivity of *P. ohirai* to *Semisulcospira bensoni* (PHILIPPI, 1851) and to *Clithon retropictus* (VON MARTENS, 1879) was also investigated experimentally, but no larvae were recovered in either species of the molluscs (Yoshida, 1960; Yoshida and Miyamoto, 1959; Kawashima, unpublished).

Grouping of the Molluscs by Their Susceptibility to P. ohirai

Considering a series of the results of the experimental infection of some gastropod molluscs with *P. ohirai* from the stand point of the host-parasite relationship, these molluscs may be grouped into three. The first group consisting of *A. parasitologica*, *A. yoshidayukioi*, *O. nosophora* and *P. japonica*, the former two species of which were found to be naturally infected with this fluke, is referred to the group of the molluscs which have a high infectivity to this fluke. The second group including *A. japonica* is referred to the group which has a slight infectivity to the same fluke. The third group consisting of *A. castanea*, *A. kushimotoensis*, *A. latericea miyazakii*, *S. bensoni* and *C. retropictus* is referred to the group in which the larvae of the fluke were never recovered. From the above-mentioned results, it seems that the difference in the susceptibility to *P. ohirai*, between the first two and the others in the first group may be mainly due to the difference in the habitat between them. If *O. nosophora* or *P. japonica* be found in the area where *P. ohirai* occurs, they would serve as a natural molluscan host of the fluke. The difference in the susceptibility between the first and the second two groups of the molluscs may be also due to the difference in their habitat. It seems that the difference in their habitat results in the reduction of the chance of encounters with *A. japonica* and secondarily in the decrease of the suitability to the mollusc. Then, it is likely that the difference in the susceptibility between the first and the second groups is quantitative. However, as the third group has never been found to be experimentally or naturally infected with this fluke, the differences between the first or the second group

* This phenomenon will be included in "the second type of habitat segregation" that was defined by Miyadi and Mori (1953): Animal ecology, pp. 221, Iwanami-shoten, Tokyo.

and the third one are qualitative and may be influenced not only by ecological but also by their physiological characteristics.

As mentioned previously, it seems that *P. ohirai* has a higher infectivity to amphibious molluscs such as *A. parasitologica*, *A. yoshidayukioi*, *P. japonica* and *O. nosophora* than to aquatic molluscs.

*Experimental Molluscan Infection with Paragonimus
Larvae Except P. ohirai*

It is a very interesting fact that *P. iloktsuenensis* is very similar to *P. ohirai* not only in the crustacean host or the mammalian host but also in the molluscan host. Namely, it was experimentally proved by Yoshida in 1960 that *P. iloktsuenensis* developed into the cercariae in the following 4 species of the Japanese gastropod molluscs: *A. parasitologica* (infection rate: 56.6%), *A. yoshidayukioi* (65.3%), *A. japonica* (8.3%) and *P. japonica* (2.6%), of which the first species was found to be naturally infected with this fluke by Yoshida in 1959 and by Tomimura, Terauchi and Tarumoto in 1960. In Formosa, the larvae of *P. iloktsuenensis* were found by Chiu (1965) in the mollusc, *Tricula chiui* HABE et MIYAZAKI, 1962 which is allied to *Oncomelania formosana* (PILSBRY et HIRASE, 1906). Tang (1940) found a rodent type of *Paragonimus*, in Fukien, China, and also found the cercariae of the same type in the mollusc, *Katayama* (= *Oncomelania*) *tangi*. In 1963 (b), it was reported by Kawashima and Miyazaki that a number of rediae and cercariae of *P. iloktsuenensis* were found in almost all of *O. nosophora*, in the infection experiment. The above-mentioned molluscs except *A. japonica* have the character to live in the water front and are amphibious. Then, it seems that *P. iloktsuenensis* has a high infectivity to amphibious molluscs as *P. ohirai*. According to Chen (1940), in Canton, China, *Assiminea lutea* A. ADAMS, 1861 was found naturally infected with *P. iloktsuenensis*. However, there was no information concerning whether or not this mollusc was amphibious.

As to *P. miyazakii*, the author treated it by the same infection method as that used in *P. ohirai* or *P. iloktsuenensis* and also experimentally proved that it developed into the cercaria in *O. nosophora*, though the mollusc showed a slight susceptibility (infection rate: 4.5%; Kawashima and Miyazaki, 1964a). Though there is an opinion that American *Pomatiopsis* and Japanese *Oncomelania* should be placed under the same genus, it is interesting that *O. nosophora* collected in Japan was proved by Basch (1959) to be experimentally infected with an American lung fluke, *P. kellicotti*, and that American *Pomatiopsis* molluscs were proved by Getz (1962) to be also experimentally infected with *Schistosoma japonicum* (KATSURADA, 1904) from Japan. It is also interesting that hybrids were obtained from experimental crossings of male *Pomatiopsis lapidaria* and female *Oncomelania quadrasi* (van der Schalie, Getz and Dazo, 1962).

Semisulcospira bensoni and some other related species have been known as a molluscan host of *P. westermani* which is considered to be one of the most important causative agents of human paragonimiasis. Recently, the infectivity of *P. westermani* to *A. parasitologica*, *A. yoshidayukioi*, *P. japonica*, *A. kushimotoensis* and *O. nosophora* was experimentally investigated. All of them, however, showed negative results for the larvae of this fluke (Yoshida, 1960; Kawashima and Miyazaki, 1964b). The work by Kawashima and Miyazaki (1964b) suggested that it would be doubtful that the cercariae of *P. westermani* were found in *O. nosophora* in China (Chen, 1941: Nat. Med. Jour. China, 27, 550-552, quoted from Abbott, 1948).

Grouping of Paragonimus Species by Their Infectivity to the Molluscs

From the results of studies on the infectivity of *Paragonimus* to the above-mentioned gastropod molluscs, especially to *O. nosophora*, *Paragonimus* of Japan, are divided into the following three groups by their infectivity. The first group—*P. ohirai* and *P. iloktsuenensis*—has a high infectivity to amphibious molluscs, especially to *O. nosophora*, though it has never been found naturally infected. The second group—*P. miyazakii*—has a slight infectivity to *O. nosophora* but shows no natural infection. The third group—*P. westermani*—has no infectivity to amphibious molluscs including *O. nosophora* but to aquatic molluscs such as *S. bensoni* and some other related species. On the other hand, Miyazaki (1964) reported that *Paragonimus* can be divided into four groups, according to the shape of the ovary and arrangement of cuticular spines of the adult worm, as follow: (1) *P. ohirai*—*P. iloktsuenensis* group, ovary profusely branched, cuticular spines in groups; (2) *P. kellicotti*—*P. miyazakii* group, ovary profusely branched, cuticular spines singly spaced; (3) *P. westermani* group, ovary simply branched off into 6 lobes, cuticular spines singly spaced; (4) *P. compactus** group, ovary simply branched off into 6 lobes, cuticular spines in groups. It is a very interesting fact that the grouping of *Paragonimus* species of Japan by the characteristics of infectivity to the gastropod molluscs was coincident with that by the morphological characteristics mentioned above.

REFERENCES

- ABBOTT, R. T. (1948): Handbook of medically important mollusks of the Orient and the western Pacific. Bull. of the Mus. of Com. Zool., 100, 245-328.
- AMEEL, D. J. (1934): *Paragonimus*, its life history and distribution in north America and its taxonomy (Trematoda: Troglotrematidae). Am. J. Hyg., 19, 279-317.
- BASCH, P. F. (1959): Two new molluscan intermediate hosts for *Paragonimus kellicotti*. J. Parasitol., 45, 273.
- CHEN, H. T. (1940): Morphological and developmental studies of *Paragonimus iloktsuenensis* with some remarks on other species of the genus (Trematoda: Troglotrematidae). Ling. Sci. J., 19, 429-530.
- CHIU, J. K. (1965): *Tricula chiui* Habe et Miyazaki, 1962: A snail host for *Paragonimus iloktsuenensis* Chen, 1940 in Taiwan. Japan. J. Parasitol., 14, 269-280 (with Japanese summary).
- GETZ, L. L. (1962): *Pomatiopsis cincinnatiensis* and *P. lapidaria* as potential intermediate hosts of *Schistosoma japonicum*. J. Parasitol., 48, 498-499.
- HABE, T. (1942): Classification of Japanese Assimineidae. Venus, 12, 32-56 (text in Japanese).
- HABE, T. (1943): Supplemental notes with corrections on the Japanese Assimineidae. Venus, 13, 96-106 (text in Japanese).
- HABE, T. AND MIYAZAKI, I. (1962): *Tricula chiui* sp. nov., a new snail host of the lung fluke *Paragonimus iloktsuenensis* Chen in Formosa. Kyushu J. Med. Sci., 13, 47-49.
- IKEDA, A. (1957): The experimental study on the larval development of *Paragonimus ohirai* Miyazaki, 1939 in the first intermediate host, *Assiminea japonica*. Japan. J. Parasitol., 6, 312-313 (abstract in Japanese).
- KAMO, H., NISHIDA, H., HATSUSHIKA, R. AND TOMIMURA, T. (1961): On the occurrence of a new lung fluke, *Paragonimus miyazakii* n. sp. in Japan (Trematoda: Troglotrematidae). Yonago Acta Medica, 5, 43-52.
- KAWASHIMA, K. (1961): An experiment on the host specificity of *Paragonimus ohirai* Miyazaki, 1939 to several snails of the genus *Assiminea*. Japan. J. Parasitol., 10, 161-164 (text in

* *P. compactus* has not been found in Japan.

- Japanese with English summary).
- KAWASHIMA, K., TADA, I. AND MIYAZAKI, I. (1961a): Host preference of miracidia of *Paragonimus ohirai* Miyazaki, 1939 among three species of snails of the genus *Assimineae*. Kyushu J. Med. Sci., 12, 99-106.
- KAWASHIMA, K., TADA, I. AND MIYAZAKI, I. (1961b): Ecological analysis on the mechanism of the host preference of miracidia of *Paragonimus ohirai* Miyazaki, 1939 in natural condition. Kyushu J. Med. Sci., 12, 143-151.
- KAWASHIMA, K. AND MIYAZAKI, I. (1963a): The experimental infection of larval lung-fluke to Japanese *Oncomelania* snails I. Experimental infection of *Paragonimus ohirai* Miyazaki, 1939 to *Oncomelania nosophora* (Robson, 1915). Japan. J. Parasitol., 12, 94-97 (text in Japanese with English summary).
- KAWASHIMA, K. AND MIYAZAKI, I. (1963b): The experimental infection of larval lung-fluke to Japanese *Oncomelania* snails II. Experimental infection of *Paragonimus iloktsuenensis* Chen, 1940 to *Oncomelania nosophora* (Robson, 1915). Japan. J. Parasitol., 12, 159-161 (text in Japanese with English summary).
- KAWASHIMA, K. AND MIYAZAKI, I. (1964a). The experimental infection of larval lung-fluke to Japanese *Oncomelania* snails. III. Experimental infection of *Paragonimus miyazakii* Kamo, Nishida, Hatsushika and Tomimura, 1961 to *Oncomelania nosophora* (Robson, 1915). Japan. J. Parasitol., 13, 421-426 (text in Japanese with English summary).
- KAWASHIMA, K. AND MIYAZAKI, I. (1964b): The experimental infection of larval lung-fluke to Japanese *Oncomelania* snails. IV. Experimental infection of *Paragonimus westermani* (Kerbert, 1878) to *Oncomelania nosophora* (Robson, 1915). Japan. J. Parasitol., 13, 459-463 (text in Japanese with English summary).
- KOMIYA, Y., SUZUKI, R. AND ITO, Y. (1961): The experimental infection of *Paragonimus westermani* to the first intermediate host, *Semisulcospira libertina*. I. Experimental infection through the skin penetration of the snail body. Japan. J. Parasitol., 10, 65-70 (text in Japanese with English summary).
- KURODA, T. (1958): On the more species of *Assimineae* from Japan (A fresh water gastropodous genus). Venus, 20, 16-22.
- KURODA, T. (1959): Another new species of *Assimineae*, a trematode's intermediate host snail from Japan. Venus, 20, 335-338.
- MIYAZAKI, I. (1939): Ein neues Lungendistom *Paragonimus ohirai* n. sp. Fukuoka Acta Medica, 32, 1247-1252 (text in Japanese with German summary).
- MIYAZAKI, I. (1944): On the third species of lung fluke from Japan, "small type of *Paragonimus ohirai*". Report of Kagoshima Medical School, No. 1. 19-25 (text in Japanese).
- MIYAZAKI, I. (1955): *Paragonimus kellicotti* Ward, 1908 found in the Japanese weasel, *Mustela sibirica* in Kyushu. Medicine and Biology, 37, 71-74 (text in Japanese).
- MIYAZAKI, I., KAWASHIMA, K. AND YOSHIDA, Y. (1960): Studies on the snail hosts of *Paragonimus ohirai* Miyazaki, 1939 and *P. iloktsuenensis* Chen, 1940. Kyushu J. Med. Sci., 11, 261-275.
- MIYAZAKI, I. (1964): Further studies on *Paragonimus* in Japan. Progress of Medical Parasitology in Japan, 4, 457-467 (text in Japanese).
- OGITA, K. (1954): A study on the first intermediate host of the lung-fluke, *Paragonimus ohirai* Miyazaki, 1939. Acta Medica, 24, 148-159 (text in Japanese with English summary).
- TANG, C. C. (1940): A comparative study of two types of *Paragonimus* occurring in Fukien, South China. Chinese Med. J., Supplement 3, 267-291.
- TOMIMURA, T., TERAUCHI, J. AND TARUMOTO, I. (1960): Studies on the first intermediate host of lung fluke, *Paragonimus iloktsuenensis* Chen, 1940 in the mouth of the River Shinyodo, Osaka Prefecture. Medicine and Biology, 54, 45-51 (text in Japanese).
- VAN DER SCHALIE, H., GETZ, LOWELL L. AND DAZO, BONIFACIO C. (1962): Hybrids between American *Pomatiopsis* and Oriental *Oncomelania* snails. Am. J. Trop. Med. Hyg., 11, 418-420.

- YOKOGAWA, M., YOSHIMURA, H., KOYAMA, C., SANO, M., TSUDA, M., SUZUKI, J. AND TSUJI, M. (1958): On a new intermediate host, *Paludinella devilis* (Gould, 1861) Habe 1942, of *Paragonimus ohirai* Miyazaki, 1939. Tokyo Ijishinshi, 75, 67-72 (text in Japanese).
- YOSHIDA, Y. AND MIYAMOTO, M. (1959): Studies on a first intermediate host, *Assimineia parasitologica* Kuroda, 1958 ("*Paludinella devilis*", of Yokogawa and Koyama et al. non Gould), of *Paragonimus ohirai* Miyazaki, 1939. Japan. J. Parasitol., 8, 122-129 (text in Japanese with English summary).
- YOSHIDA, Y. (1959): Studies on the first intermediate host of *Paragonimus iloktsuenensis* Chen, 1940 in Japan (1) Experimental infection with the larva of *P. iloktsuenensis* to *Assimineia parasitologica* Kuroda, 1958 and *Assimineia japonica* von Martens, 1877. Japan. J. Parasitol., 8, 822-828 (text in Japanese with English summary).
- YOSHIDA, Y. AND MIYAMOTO, M. (1960): Another new first intermediate host, *Assimineia yoshidayukioi* Kuroda, 1959 of *Paragonimus ohirai* Miyazaki, 1939. Japan. J. Parasitol., 9, 211-216 (text in Japanese with English summary).
- YOSHIDA, Y. (1960): Experimental studies on the first intermediate hosts of *Paragonimus westermanii*, *P. ohirai* and *P. iloktsuenensis*. Japan. J. Parasitol., 9, 377-378 (abstract in Japanese).
- YOSHIDA, Y. AND KAWASHIMA, K. (1961): On the distribution of the snail hosts of *Paragonimus ohirai* Miyazaki, 1939 and *Paragonimus iloktsuenensis* Chen, 1940 in Japan. Japan. J. Parasitol., 10, 152-160 (text in Japanese with English summary).

Fig. 1. *Assiminea japonica* VON MARTENS, 1877 (Scale 1 mm)
Fig. 2. *Assiminea parasitologica* KURODA, 1958 (Scale 1 mm)
Fig. 3. *Assiminea yoshidayukioi* KURODA, 1959 (Scale 1 mm)
Fig. 4. *Assiminea castanea* WESTERLUND, 1883 (Scale 1 mm)
Fig. 5. *Assiminea kushimotoensis* KURODA, 1958 (Scale 1 mm)

- Fig. 6. *Assiminea latericea miyazakii* HABE, 1943 (Scale 1 mm)
 Fig. 7. *Paludinella japonica* (PILSBRY, 1901) (Scale 1 mm)
 Fig. 8. *Oncomelania nosophora* (ROBSON, 1915) (Scale 1 mm)
 Fig. 9. *Semisulcospira bensoni* (PHILIPPI, 1851) (Scale 1 mm)
 Fig. 10. *Clithon retropictus* (VON MARTENS, 1879) (Scale 1 mm)