ON THE LUNG FLUKES CAUSING HUMAN PARAGONIMIASIS*

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In this paper the author wishes to summarize the lung flukes, which cause human paragonimiasis or which are suspected to infect humans not only in Asia but also in America and in Africa. In Asia, more than 20 species were reported in literature, of which 17 species are regarded as valid (Table 1). Since the author found *Paragonimus ohirai* in 1939, 14 species have been recorded in Japan, China and Thailand during past 30 years. Recently four species — *P. siamensis*, *P. bangkokensis*, *P. harinasutai* and *P. sadoensis* — were found by the author and his co-workers chiefly in Thailand. From medical point of view, *P. westermani* is most important widely occurring in Asia; the author reconfirmed this species from South-east Asia to USSR. Another two species were recently proved to be the human parasite; i. e. *P. skrjabini* (syn. *P. szechuanensis* Chung et Ts'ao, 1962) was removed from human body on the mainland of China by Chung et al. (1962), and *P. heterotremus* (syn. *P. tuanshanensis* Chung et al., 1964) was from a boy in Thailand by Miyazaki and Harinasuta (1966). In addition, another species such as *P. miyazakii*, *P. sadoensis*, *P. bangkokensis* and *P. harinasutai* seem to have possibility of human infection, since their crab hosts are not infrequently eaten uncooked or pickled by inhabitants.

In Japan five species are known, of which only *P. westermani* was removed from human body. The main source of human infection with this fluke is a big crab, *Eriocheir japonicus*. The metacercaria is mainly parasitic in the gill vessel and in the muscle of the crab. Another source of infection is a small crab, *Potamon dehaani*, which harbors not only *P. westermani* but also *P. miyazakii* and *P. sadoensis*. Because this crab is sometimes eaten uncooked by people, the latter two species are also suspected to infect humans. *P. miyazakii* parasitizes several kinds of mammals such as the weasel, the martens, the wild boar and the dog. Besides, the fluke was proved by experiment to be able to mature in the albino rat, the Norway rat, the rabbit and the cat. Its first intermediate host is a very small snail, *Bythinella nipponica*, which lives in mountain streams. The second intermediate host of the fluke is the above-mentioned crab, *Potamon dehaani*, which is also distributed in mountainous area. Metacercariae parasitic in this crab are mostly *P. miyazakii* and rarely *P. westermani* at present, but formerly those of the former were long confused with the latter by previous investigators. *P. sadoensis* was most recently found on Sado Island, Niigata Prefecture, and was found to be parasitic in the weasel and the cat. The fluke was experimentally proved to parasitize the dog, the albino rat, the wild mouse, the house rat, the Norway rat, the

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Table 1. *Paragonimus* occurring in Asia

Name	Locality
1. <i>P. compactus</i> (Cobbold, 1859)	India, Ceylon
2. <i>P. westermani</i> (Kerbert, 1878)	India, Ceylon, Thailand, Indonesia, Malaysia, Philippines, China, Taiwan, Ryukyus, Japan, Korea, USSR
3. <i>P. ohirai</i> Miyazaki, 1939	Japan, China
4. <i>P. iloktsuenensis</i> Chen, 1940	China, Japan, Taiwan
5. <i>P. skrjabini</i> Chen, 1959	China
6. <i>P. yunnanensis</i> Ho et al., 1959	China
7. <i>P. miyazakii</i> Kamo et al., 1961	Japan
8. <i>P. macrorchis</i> Chen, 1962	China, Thailand
9. <i>P. fukienensis</i> Tang et Tang, 1962	China
10. <i>Euparagonimus cenocopiosus</i> Chen, 1962	China
11. <i>P. cheni</i> Hu, 1963	China
12. <i>P. heterotremus</i> Chen et Hsia, 1964	China, Thailand
13. <i>P. proliferus</i> Hsia et Chen, 1964	China
14. <i>P. siamensis</i> Miyazaki et Wykoff, 1965	Thailand
15. <i>P. bangkokensis</i> Miyazaki et Vajrasthira, 1967	Thailand
16. <i>P. harinasutai</i> Miyazaki et Vajrasthira, 1968	Thailand
17. <i>P. sadoensis</i> Miyazaki et al., 1968	Japan

Japanese vole, *Microtus montebelli* and the woods mouse, *Apodemus speciosus*. The snail host of the fluke is *Tricula minima* living in mountain streams, and the crab host is *Potamon dehaani*.

Generally speaking, it is not easy to diagnose the species of *Paragonimus* by its eggs in sputum or in feces. But, typical eggs of *P. westermani* have the gradually thickened eggshell at non-operculated end, and those of *P. miyazakii* are the smallest of the five species and the eggshell is thinner than other species in Japan.

Over 50 years ago, the life cycle of *P. westermani* was clarified by a Japanese doctor, K. Nakagawa in Taiwan by finding its metacercaria in a crab, *Potamon rathbuni* for the first time. Since then, many kinds of crustacean hosts had been recorded in different parts of Asia. In recent years, six species of fresh-water crabs were decided as the host of *P. westermani* by the author and his co-workers; i. e. *Potamiscus johorensis*, *P. cognatus* (unpublished) and *Parathelphusa maculata* in Malaysia, *Potamon smithianus* in Thailand, *Parathelphusa rugosa* in Ceylon (unpublished), and *Potamon miyazakii* in Taiwan.

The second human lung fluke, *P. skrjabini*, was found in China, and its natural host is *Paguma larvata* and the cat. It was also found in subcutaneous nodules of the patients. The body is slender, the ovary is delicately branched, the cuticular spines are single and the testes are very small as compared with the body-size. The source of infection with this parasite is a stone crab, *Potamon denticulatus* and *P. yaanensis*.

In Thailand, the author has been carrying on joint works with staffs of the Bangkok School of Tropical Medicine in the endemic area in Nakornnayok situated

about 90 km from Bangkok. In the area they recognized four known species — *P. westermani*, *P. siamensis*, *P. heterotremus* and *P. macrorchis*, as well as two new species, — *P. bangkokensis* and *P. harinasutai*. Of these six species, *P. heterotremus* and *P. macrorchis* were originally found in the mainland of China. From medical point of view, *P. heterotremus* is most significant in that endemic area, because the eggs in sputum of patients are different from those of *P. westermani* on the one hand, and two immature worms identified as *P. heterotremus* were demonstrated from the skin of a boy residing in the same area on the other hand. The most important morphological feature of this parasite is the far bigger oral sucker than the ventral one ; i. e. the diameter of the former is twice as long as the latter in mature worms. Cuticular spines are single, the ovary is delicately branched and the testes are also branched and larger than the ovary. As the source of infection a big crab, *Potamon smithianus* is very important, since this crab frequently harbors the metacercaria of *P. heterotremus* and is eaten uncooked by inhabitants. Another lung flukes such as *P. bangkokensis* and *P. harinasutai* have some possibility of human infection, because their metacercariae are also parasitic in the same crab. Particularly, medical attention must be paid to the egg of *P. harinasutai*, the shell of which is not rarely thickened at non-operculated pole just like that of *P. westermani*. Incidentally, the author was surprised to know that the important crab host, *Potamon smithianus* was infected with six species of *Paragonimus* metacercariae in one endemic area of Nakorn-nayok. Of these species the metacercaria of *P. heterotremus* is the smallest and that of *P. harinasutai* is the largest, averaging 0.29 by 0.24 mm and 0.6 by 0.6 mm, respectively.

In recent years, human paragonimiasis has begun to attract medical attention in some countries of Central and South America such as Mexico, Costa Rica, Panama, Colombia, Ecuador, Peru, etc., although some cases of the disease were already reported in former times. But, the causative agent of the disease has not definitely been decided as yet. In the Western Hemisphere only two species — *P. rudis* (Diesing, 1850) and *P. kellicotti* Ward, 1908 — had been recorded during past over 100 years, and in this year another two species — *P. caliensis* Little, 1968 and *P. mexicanus* Miyazaki et Ishii, 1968 — were reported in Colombia and in Mexico, respectively. Of the four species *P. rudis* is regarded as a *nomen nudum* at present, and the remainder three are as valid species. According to Miyazaki and Ishii (1968 a, b), *P. mexicanus* was found in the opossum, *Didelphis marsupialis* captured in Colima and is similar to *P. kellicotti* in morphology, but they are most easily differentiated from each other by the size of eggs and the thickness of eggshells. After examining some specimens from Guatemala and Panama, the same authors noted that *P. mexicanus* might be occurring also in these countries. Recently, the author received a specimen from Costa Rica, and he identified it as *P. mexicanus* (unpublished). The eggs deposited in the lung tissue of a Mexican male reported by Martínez Báez and Jiménez Galán (1961) did not agree with those of either *P. westermani* or *P. kellicotti*, but they appeared to be those of *P. mexicanus*. This new lung fluke seems to be important in the medical field of Central America.

P. caliensis was also found from opossums in Colombia by Little (1968), and characterized by simple branching of the ovary and testes as well as by irregularity of the eggshell. This fluke seems to occur also in Panama and Mexico, but its

infectivity to humans is unknown as yet.

Ibáñez and Miranda (1967) found the lung flukes for the first time in Peru, which were collected from a domestic cat in an area of human infections. At their request the author is carrying on taxonomical studies on their materials, and it is likely that this Peruvian fluke is different from known species of *Paragonimus*, as stated by the authors. On the other hand, the author investigated the eggs in sputum of a Peruvian patient, and clarified that they showed the same character with uterine eggs of the lung fluke from the cat mentioned above. Anyway, human paragonimiasis in Central and South America is suspected to be caused by two or more different species of *Paragonimus*. However, *P. westermani*, one of important human parasites in Asia, is most probably not distributed in the Western Hemisphere.

In Africa two species are known; i. e. *P. africanus* Voelker et Vogel, 1965 in Cameroons and *P. uterobilateralis* Voelker et Vogel, 1965 in Cameroons and Liberia. The former is suspected to infect humans, since its crab hosts, *Sudanautes africanus* and *S. pelii*, are frequently eaten by inhabitants and the eggs from patients and from experimental animals are similar to each other. Adults of *P. africanus* are provided with a delicately branched ovary and remarkably large, branched testes just like *P. macrorchis* in Asia, but they are easily distinguished by the fact that *P. africanus* has far bigger oral sucker than ventral one.

In conclusion, the causative agent of human paragonimiasis is not a single species, as thought formerly, but it amounts to several species, which are different not only in morphology but also in ecology and biology.

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