

**Studies on the Mexican lung flukes, with special reference
to a description of *Paragonimus mexicanus* sp. nov.
(Trematoda: Troglotrematidae)**

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Introduction

Human paragonimiasis in Mexico had been undetermined until 1961, when Martínez Báez and Jiménez Galán found *Paragonimus* eggs in the lung tissue excised from a Mexican male patient of 35 years old. Then, Mazzotti & Miyazaki (1965) reported adult lung flukes for the first time in Mexico, which were obtained by the senior author from one of eleven opossums, *Didelphis marsupialis* L., captured in Colima situated in the mountainous region on the Pacific coast of Mexico. The authors noticed that the Mexican lung fluke was provided with more delicately branched ovary than *P. kellicotti* Ward, 1908, though both species were morphologically very similar to each other, and they emphasized that the metacercariae of both species should be compared in detail. Miyazaki (1964) investigated a lot of living metacercariae of *P. kellicotti* in Michigan, USA, and demonstrated their characteristic features, correcting the thickness of the inner cyst wall reported by Ameel (1934). Unfortunately, however, the metacercaria of the Mexican lung fluke has never been investigated as yet. Ishii (1966) studied many adult worms of *P. kellicotti* in Louisiana, USA, and illustrated the shape of the ovary in detail.

In 1965 Dr. L. Mazzotti in Mexico again

collected many lung flukes from another opossum of the same species at the same locality, Colima, and kindly sent them to the present authors. Recently, Miyazaki and Ishii (unpublished data) compared the specimens from Mexico with *P. kellicotti*, and revealed that the Mexican lung flukes were divided into two species (A and B) and both species were clearly differentiated from *P. kellicotti*. Furthermore, they stated that species B was closest to a new lung fluke found in Colombia by Dr. M. D. Little (1968, personal communication), and species A was probably an undescribed fluke, the specific name of which should be discussed later.

In the present paper the authors wish to describe species A as a new species, proposing a specific name, *Paragonimus mexicanus* sp. nov. In addition, species B and specimens from Guatemala and Panama, as well as eggs deposited in the lung tissue of a Mexican male will be briefly discussed.

Materials and Methods

As mentioned previously, the Mexican lung flukes were collected by Dr. L. Mazzotti from two opossums in Colima and sent to the authors. The flukes amounted to 36 in all, of which 27 were stained with carmine and mounted in balsam, and the remaining nine that were unsuitable for mounting

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were preserved in alcohol and used for observation of the cuticular spines and the eggs collected from the end of the uterus. In some stained specimens the cuticle over and/or under the ovary was removed in order to show the shape of ovary apparently. Forty-seven mature *P. kellicotti* and 23 mature *P. miyazakii* Kamo *et al.*, 1961, which were experimentally obtained in the United States and in Japan, respectively, were used for morphological comparison with *P. mexicanus*. In these materials, the arrangement of the cuticular spines, the shape and size of the ovary and the testes, the size of the oral and the ventral sucker, the shape and size of the uterine eggs, and the thickness of the eggshells were carefully investigated. By the courtesy of Drs. E. Caballero y C., M. D. Little and V. E. Thatcher, one adult specimen from Guatemala labeled as *P. rudis* (Diesing, 1850), two specimens of a new lung fluke from Colombia and ten specimens from Panama labeled as *P. rudis* were respectively made available for comparative study. Dr. M. Martínez Báez kindly sent to the authors many sections of the human lung tissue containing a lot of *Paragonimus* eggs that was excised from the above-mentioned Mexican male. These eggs were carefully compared with those of *P. mexicanus*, *P. kellicotti* and *P. westermani*.

Results

Among 27 specimens of the Mexican lung flukes, two species (A and B) were clearly distinguished from each other: species A was represented by 26 specimens and species B was by only one. Both species were covered with single spines all over and their eggs were also similar in morphology,

but they were easily distinguished from each other by the shape of the ovary and testes. As shown in Figs. 13 and 14, the ovary and the testes were much more simply branched in species B than in species A. The latter was described as *P. mexicanus* sp. nov. in the following chapter. Species B, although only one specimen was available, agreed with two specimens of Dr. Little's new species from Colombia in almost all respects. Among ten specimens from Panama, nine appeared to be the same as species A and the remaining one with species B of the Mexican lung flukes. It was likely that the specimen from Guatemala was identical with species A in Mexico. The eggs deposited in the lung tissue of the Mexican male did not agree with those of either *P. kellicotti* or *P. westermani*. They appeared to belong to *P. mexicanus*.

Description of

Paragonimus mexicanus sp. nov.

Holotype (Figs. 1 and 13)

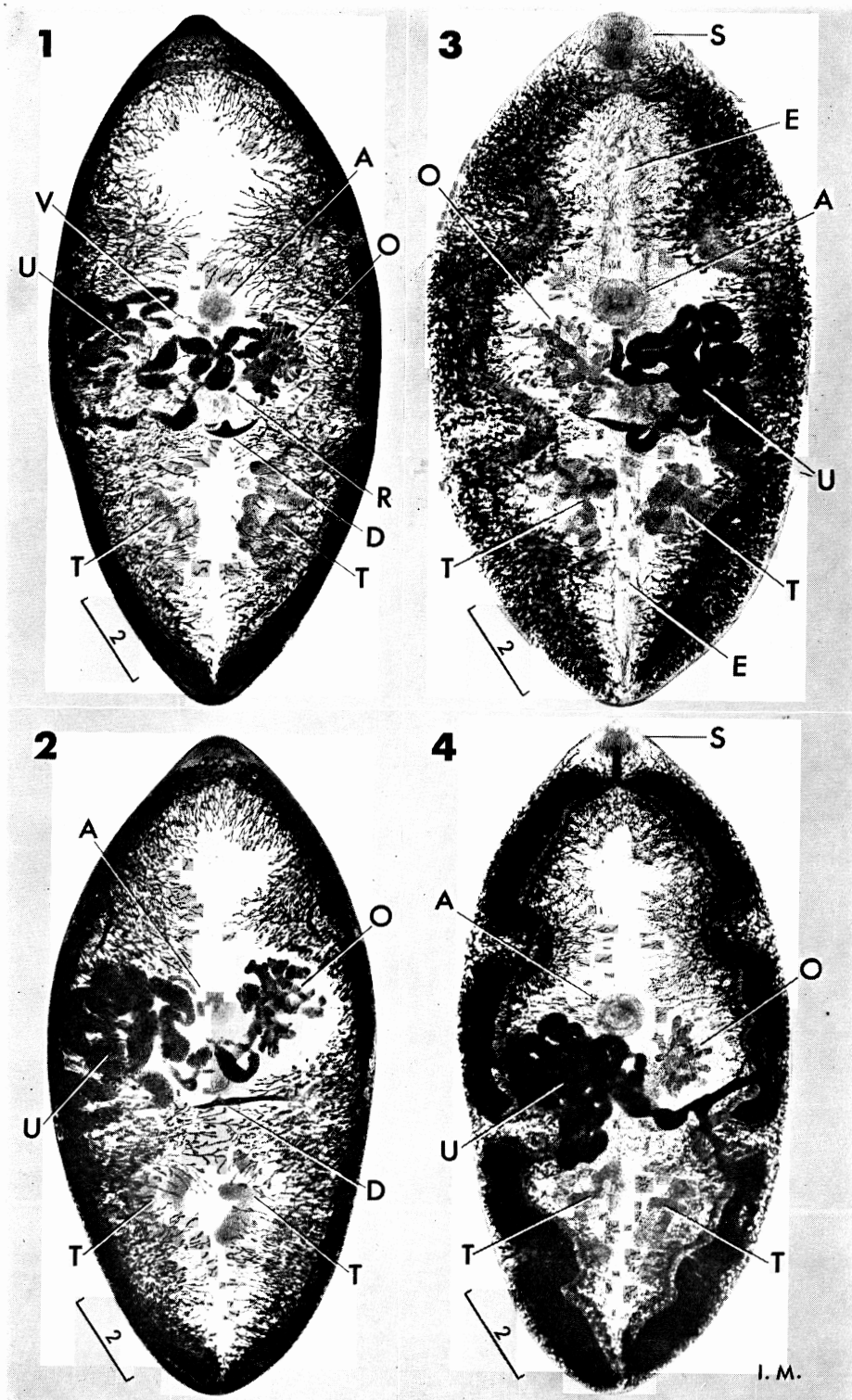
Body spindle-shaped, 14.6 mm long by 7.0 mm wide. Whole body covered with singly spaced cuticular spines, the tip of which is pointed or serrated (Fig. 11). Some spines split into two or more. Oral sucker 1.12 by 0.56 mm, followed by a small pharynx (0.48 by 0.34 mm) and a short esophagus (0.51 mm). Ventral sucker 0.83 by 0.78 mm, situated slightly anterior to the center of the body. Ovary delicately branched and located on the right side of the body, measuring 1.90 by 1.70 mm in outline. Seminal receptacle recognized, which measured 0.24 by 0.17 mm. Uterus coils on opposite side to the ovary, containing numerous eggs. Vitelline gland widely distributed on both

(All scales in mm)

Fig. 1. Holotype of *P. mexicanus* sp. nov. from an opossum. Dorsal view.

Fig. 2. Paratype No. 1. Dorsal view. Cuticle and vitelline glands were removed over and under the ovary.

Figs. 3 and 4. Paratypes No. 2 and No. 3. Ventral view. The oral sucker is a little larger than the ventral one in both specimens. (A: ventral sucker, D: vitelline duct, E: excretory bladder, O: ovary, R: seminal receptacle, S: oral sucker, T: testis, U: uterus, V: seminal vesicle)



other is *P. kellicotti* Ward, 1908 found from the cat in the United States. Thereafter, the latter species had frequently been studied by many investigators and its validity was definitely verified. But, *P. rudis* was so briefly described that its morphological features were quite unknown, and the re-description of this species has never

appeared in literature, though it has passed over 100 years since the original description. Ultimately, *P. rudis* must be regarded as *nomen nudum*.

Caballero (1946, 1956) reported *P. rudis* from the opossum, *Didelphis mesamericana mesamericana* and the skunk, *Mephitis macroura macroura* in Guatemala, and from

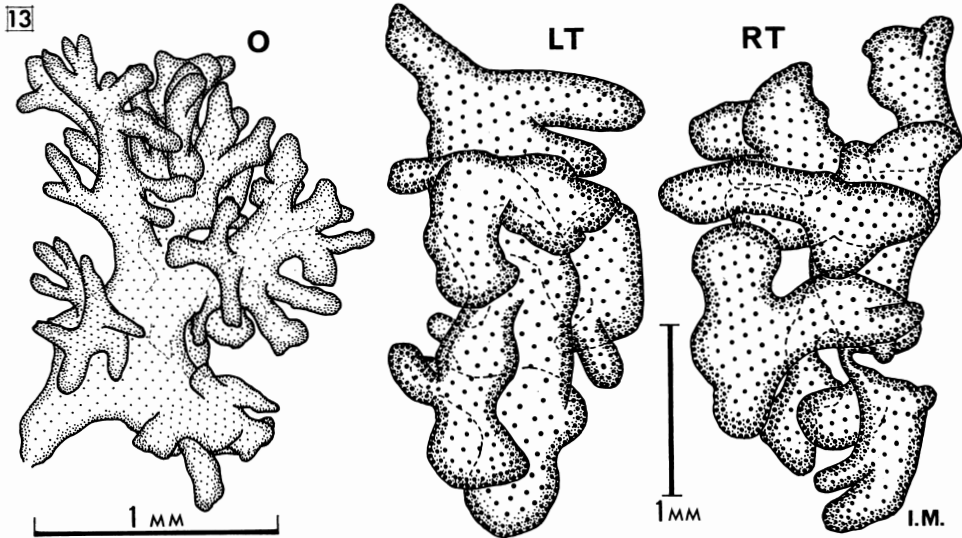


Fig. 13. Ovary and testes of the holotype of *P. mexicanus* under different magnification. Dorsal view. (O: ovary, LT: left testis, RT: right testis)

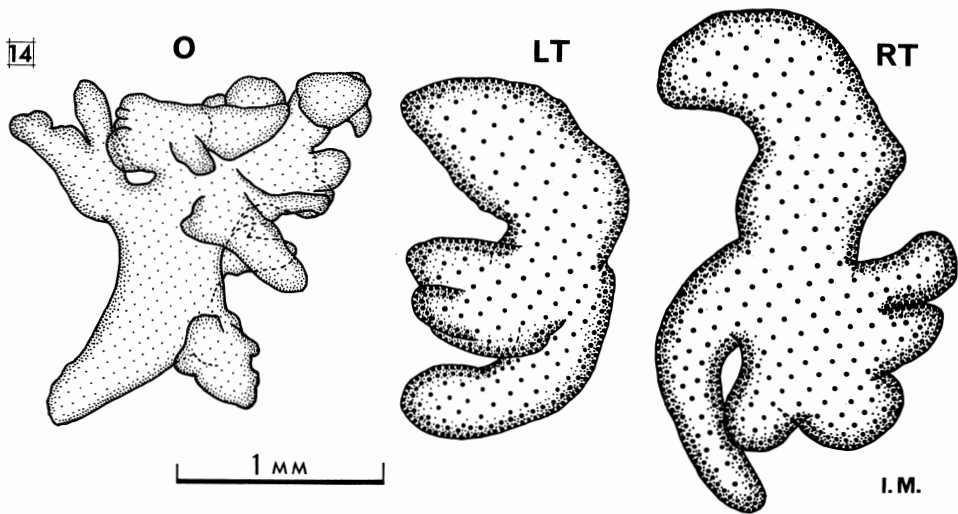


Fig. 14. Ovary and testes of species B of the Mexican lung fluke under the same magnification. Dorsal view. (O: ovary, LT: left testis, RT: right testis)

the fox, *Urocyon cinereoargenteus costaricensis* in Costa Rica. But, the present authors are very skeptical of his identification, because he was of opinion that *P. rudis* was the only species of the genus and others such as *P. westermanni*, *P. compactus* (Cobbold, 1859), *P. ringeri* (Cobbold, 1880), *P. kellicotti*, *P. edwardsi* Gulati, 1926, *P. ohirai* Miyazaki, 1939, *P. iloktsuenensis* Chen, 1940, and *P. macacae* Sandosham, 1953 were all synonymous with *P. rudis*. Later, Caballero and Montero (1961) obtained *Paragonimus* from an opossum, *Philander opossum fusco-griseus* in Costa Rica which they called *P. rudis*, and in the catalogue of trematodes they considered that the lung flukes other than *P. rudis* were all synonyms of this oldest species. Thatcher (1967), on the other hand, found *P. rudis* in some wild and domestic animals of Panama such as the common opossum, *Didelphis marsupialis* (in 2 of 17 examined), the four-eyed opossum, *Philander opossum* (8 of 15), the coati, *Nasua narica* (1 of 1), the jaguar, *Felis onca* (2 of 2), the cat, *Felis catus* (1 of 1), and the dog, *Canis familiaris* (1 of 3, by eggs in feces). Besides, the author described "*P. rudis* (= *P. kellicotti*)". Thus, the lung fluke called "*P. rudis*" seems to occur widely in Central America, but the present authors cannot agree with their opinion about the taxonomy of *Paragonimus* for the reasons mentioned previously.

P. mexicanus sp. nov. is similar to *P. kellicotti* in morphology, but they are distinguished by the shape of the ovary, the size of the oral and the ventral sucker, the size of uterine eggs, and the thickness of eggshells. Of these criteria for differentiation, eggs are most reliable for separating the two species, although it is generally difficult to identify lung fluke by the character of the egg. As shown in Table 2 and Fig. 12, the eggs of *P. mexicanus* are significantly smaller than those of *P. kellicotti* and the eggshells are thinner in the former than in the latter. The ovary is usually more delicately branched in *P.*

mexicanus than in the other, as already indicated by Mazzotti & Miyazaki (1965). In *P. mexicanus* the oral sucker was larger than the ventral one in 17 of 23 specimens examined, while in *P. kellicotti* only eight of 28 specimens examined had a larger oral than ventral sucker. The longest diameter of the oral and the ventral sucker was compared in each specimen, and the ratio of the former to the latter was 1.078 ± 0.101 (mean standard deviation) in *P. mexicanus*, ranging from 0.93 to 1.35, while that of *P. kellicotti* was 0.978 ± 0.092 , ranging from 0.84 to 1.25. The difference of the ratio between the two species was statistically significant ($P < 0.001$). On the other hand, *P. mexicanus* is more similar to *P. miyazakii* than to *P. kellicotti*, and either ovary or uterine eggs cannot be used for differentiation of the two species, as shown in Table 2. But, they are distinguished by the size of two suckers. For this purpose the longest diameter of the oral and the ventral sucker was compared in each of 23 mature *P. miyazakii*, and it was revealed that only one specimen had a larger oral than ventral sucker. Besides, the ratio of the oral to the ventral sucker in this species averaged 0.840 ± 0.076 , ranging from 0.70 to 1.06, and was significantly smaller than that of *P. mexicanus* ($P < 0.001$). Furthermore, the dissimilarity of geographical distribution between the two species can support the authors' opinion that *P. mexicanus* is quite different from *P. miyazakii*, which has not yet been found outside Japan. Incidentally, *P. mexicanus* seems to be separated from an unidentified lung fluke in Colombia by the distribution of the uterus, which was reported by Dr. Little (1968, pers. comm.) to be close to *P. uterobilateralis* Voelker et Vogel, 1965.

For taxonomy of the genus *Paragonimus* it is very important to investigate larval forms, particularly the metacercaria. Unfortunately, however, any larvae have not yet been found in Mexico; while in Costa Rica a kind of *Paragonimus* metacercaria

was reported by Sogandares & Smalley (1965, 1967) from two fresh-water crabs, *Ptychophallus tristani* and *Potamocarcinus magnus*. But the metacercaria was not identified because of a failure in getting adults by experimental infection to a domestic cat. The present authors suppose that the metacercaria of *P. mexicanus* will show more clear features than its adult worms, by which it is easily distinguished from *P. kellicotti* and *P. miyazakii*.

From geographical point of view, it seems that *P. mexicanus* is occurring not only in Mexico but also in other countries of Central America such as Guatemala, Costa Rica and Panama. In addition, by the character of eggs found in the human lungs in Mexico, it is probable that *P. mexicanus* causes human paragonimiasis in Mexico and in other parts of Central America. The second species in Mexico, which is less prevalent in this country, seems to be occurring also in Panama and Colombia. Further studies are quite necessary to clarify this lung fluke.

Summary

Paragonimus mexicanus sp. nov. was described from the opossum, *Didelphis marsupialis* L., captured in Colima situated on the Pacific coast of Mexico. The new species was similar to *P. kellicotti* Ward, 1908 and *P. miyazakii* Kamo et al., 1961 in morphology, but it was separated from the former by the size of the oral and the ventral sucker, the shape of the ovary and the character of uterine eggs, and from the latter by the size of two suckers and the geographical distribution. It is probable that *P. mexicanus* occurs also in Guatemala, Costa Rica and Panama. The patient of paragonimiasis in Mexico seems to have been caused by the new species. Another lung fluke was found in Mexico, which was easily distinguished from *P. mexicanus* by much more simple branching of the ovary and testes. This species closely resembles the new species found by Little in Colombia.

Acknowledgement

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メキシコ産肺吸虫の研究, とくに新種 *Paragonimus mexicanus* sp. nov.

(メキシコハイキュウチュウ, 新称) の記載 [特別掲載]

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アメリカ大陸には, これまでに *P. rudis* (Diesing, 1850) と *P. kellicotti* Ward, 1908 の2種が知られている。ところが, 最古の肺吸虫である前者は, 記載が簡単で, その特長がわからない。その後100年以上もたっているのに, まだ1度も再記載がなく, いまだに, ナゾである。ただし, 中米で Caballero (1946, 1956), Caballero & Montero (1961), および Thatcher (1967) が, グアテマラ, コスタリカ, ならびにパナマから *P. rudis* を報告したが, 彼らは最古の種名を用いたにすぎない。Caballero らは, *P. rudis* 以外のものは全部これのシノニムと考えており, Thatcher も *P. rudis* (= *P. kellicotti*) とかいている。したがって, 彼らの同定をそのまま認めるわけにはいかない。Mazzotti & Miyazaki (1965) は初めてメキシコから肺吸虫成虫を報告し, Miyazaki & Ishii (未発表) はこれと *P. kellicotti* との間では, 卵の大きさと卵殻の厚さが, 最もよい区別点になるとのべた。材料は Dr. Luis Mazzotti がメキシコの Colima で, 2頭のフクロネズミ *Didelphis marsupialis* からえたものである。これを米国産

の *P. kellicotti*, 日本産の *P. miyazakii*, グアテマラとパナマ産の *P. rudis*, ならびにメキシコ人の肺切片標本中の卵と比較して, つぎの成績をえた。1) メキシコ産の肺吸虫に2種を区別した(AとB)。Bは27中わずか1個体であったが, 南米コロンビアで Little (未発表) がみつけた新種に一致するようである。Aは27中26をかぞえ, 他の新種として上記の学名と和名を提唱した。2) この新種は *P. kellicotti* に似てはいるが, 口吸盤が腹吸盤より大きい個体の多いこと, 卵巣の分枝がより複雑なことの他に, 最良の区別点として, 卵が明らかに小さく, 卵殻のうすいことを重視した。3) *P. miyazakii* とは, 一層似ているが, 両吸盤のちがいと地理的分布の差から, 別種と考えた。4) グアテマラからの1個体とパナマ産10中9個体は *P. mexicanus*, のこりの1個体は Little による新種と思われた。5) メキシコ人(♂)の肺切片中の卵は *P. westermanni* にも *P. kellicotti* にも一致せず, *P. mexicanus* に属するようである。人体寄生の可能性が考えられるので, 中米では注目すべき肺吸虫になりそうである。

Addendum (October 28, 1968)

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