

21. *PENTASTOMIDA* OF SNAKES — THEIR PARASITOLOGICAL ROLE IN MAN AND ANIMALS

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PENTASTOMIDA constitute an old and highly aberrant group of parasites. So far the systematic position of this group is not established with certainty. In spite of some affinities with both the arthropods and the annelids the **PENTASTOMIDA** cannot be attached exactly to neither of them nor to any other existing group of animals and it seems therefore preferable to establish for them an independent phylum.

PENTASTOMIDA are typically heteroxenous parasites. In the most evolved species the adults live in the respiratory tract of carnivorous animals, mainly snakes and carnivores, and the larvae develop in the tissues of various mammals.

The development in the intermediate hosts is very long and takes generally several months. It comprises a series of molts, the term of which is the tertiar larva ~~of~~ nymph which remains encysted in the tissues of the host, generally in the peritoneal cavity. It seems that in some cases this nymph is able to leave the cyst in which it is contained and to migrate through the tissues or the organs of the intermediate host. The nymphs may develop in different kinds of hosts. Many of these are accidental hosts that are not normally eaten by the definitive host. This polyxenism leads to an important waste of nymphs but it ensures to the species a very wide dispersal which is finally beneficial for its conservation. Some species of **PENTASTOMIDA**, mainly the most primitive ones, are probably able to undergo their complete life-cycle in the same host. This might be the case for the species that parasitize the insectivorous lizards. So far direct development in the **PENTASTOMIDA** has been established only for one species (*Sambonia lohrmanni*) that lives in the lungs of varans (Fain and Mortelmans, 1960). **PENTASTOMIDA** may produce lesions in man and in animals.

LESIONS PRODUCED IN MAN BY PENTASTOMIDS OF SNAKES

Parasitism of man by adult pentastomids is exceptional and it has been observed only for *Linguatula serrata*, a species that normally lives as an adult in the nasal cavity of dogs. Nymphal pentastomosis, on the contrary, has been reported on many occasions. It is particularly frequent in Central Africa but it is also known in other parts of the world. Man is not a normal host for the nymphs and human parasitism is therefore always accidental. Nymphal pentastomosis in man has been reported in connexion with several species of pentastomids. I am dealing here only with the species that live normally in snakes.

Genus *Armilifer* Sambon — The most important genus for man is *Armilifer*. It contains 3 species which all are able to produce nymphal pentastomosis in man:

1. *Armilifer armillatus* (Wyman): This species has been reported on many occasions in man. It is known only from tropical Africa but in these regions it is very frequent. The life-cycle has been elucidated by Broden and Rodhain (1908, 1909 and 1910) in Leopoldville. The adults live in the lungs of the large snakes such as the pythons and the vipers of the genus *Bitis*. The nymphs develop in all kinds of mammals including man. The degree of parasitism in the natural hosts may be very high. In a small antelope of Congo I found more than 5000 nymphs belonging to *A. armillatus*. All these nymphs were encysted in the peritoneal cavity. Monkeys may also be strongly parasitized. In man the nymphs are generally few in number but some heavy or very heavy infestations have been noted. The first human case has been related by Pruner in 1847. Since then many other authors have reported new cases. In some of the earlier papers the parasite was erroneously reported under the names *Porocephalus moniliformis* or *Armilifer moniliformis*. The nymphs are generally encysted in a thin and transparent cystic membrane. In some circumstances these nymphs escape from their envelope and become free. Some of them migrate through the tissues of the host. This nymphal migration seems to be frequent in animals but is rare in man. Chalmeras (1899) (in Sambon, 1922) reported a case in a negro who died in Accra: "Great number of parasites were observed moving freely in the abdominal cavity over the surface of the various organs, to which some were also observed to be attached." Mouchet (1914) found these non-encapsuled nymphs on different occasions in natives of Congo. He noted that two of these nymphs were attached by means of their hooks to the head of the pancreas, two others were free in the peritoneal cavity and one was free in a lymphatic vessel of the mesentery. So far it is not known with certainty if this escaping of the nymphs from their cystic membrane occurs during the life of the host or only after its death at the moment that, as a rule, the parasites pass from the intermediate to the definitive host. The distinction is very important for the migration through the tissues of the organs of the host may cause important lesions.

In man the encysted nymphs of *Armilifer armillatus* are commonly located in the peritoneal cavity. Most of them are encysted beneath the capsule of the liver or embedded in the superficial layers of this organ. They may also be found along the intestine, the mesentery or on other abdominal organs or tissues. More rarely they are encountered in other organs such as the lungs, the brain and under the ocular conjunctiva. In almost all the cases these nymphs were perfectly tolerated and pathological complications were very rare. In two cases they had produced important lesions that had finally produced the death of the patient. In the case described by Cannon (1942), the nymphs were extremely numerous and they had almost completely obstructed the large intestine. Bouckaert and Fain (1959) have observed a similar case in Congo but the nymphs were located along the hepatic angle of the large intestine and in addition there was a distinct inflammation of the peritoneum at the site of the nymphal masses.

2. *Armilifer moniliformis* (Diesing): The adults of that species are very common in the lung of Asiatic pythons. Nymphal parasitism in man has seldom been reported. This species has also been found once in the common *Python* (*P. sebae*) in Congo, but nymphs have never been found in that country.

3. *Armillifer grandis* Hett.: Nymphs of that species have been reported from the Water-Hen (*Porphyrio*).

Recently I have observed several cases of human pentastomosis produced by nymphs that I attribute to *Armillifer grandis*. So far it is the first-time that the nymphs of that species have been found in man. The nymphs were removed on the occasion of surgical operations from mesentery and the omentum of several natives in the Republic of Congo, province of Equateur (region of Flandria). They were encysted in these organs and apparently had produced no pathological lesions. These nymphs are distinctly smaller than those of *A. armillatus* and have more circular thickenings. In the female nymphs the anus is closer to the vulva than in *A. armillatus*, but however the two apertures do not open in the same depression as it is the case in the adults and probably also in the nymphs of the genus *Cubirea* (see Fain and Salvo, 1966).

Genus *Porocephalus* Humboldt — This genus is known only from America and Africa. Up to now human parasitism by either adults or nymphs of this genus has not observed with certainty. The cases reported by Sambon (1922) are doubtful and probably they were misidentifications.

LESIONS PRODUCED IN ANIMALS BY PENTASTOMIDS OF SNAKES

Little is known about the pathology caused by the pentastomids of snakes developing as larvae in the natural intermediate hosts other than man. I have never seen any inflammatory reactions in the animals parasitized by even very numerous nymphs of *Armillifer armillatus*. For instance I did not find any lesion in the antelope from Congo that was infested by more than 5000 nymphs. Pathological features have apparently not ~~more~~ been observed in intermediate hosts in relation with the other genera of pentastomids at least in natural conditions.

It seems that in some abnormal intermediate hosts, such as experimental hosts, pentastomids may produce inflammatory reactions. Esslinger (1962), studying the lesions produced in rats experimentally infected with *Porocephalus crotali*, found that the host reactions to the immature pentastomids follow patterns similar to those occurring with other agents of "visceral larva migrans". These lesions could be observed in the liver of the rats and they were strikingly similar to those which have been reported in human larval toxocarasis.

LESIONS PRODUCED BY PENTASTOMIDS IN SNAKES

The lesions caused in snakes by the adult or the larval stages of pentastomids are not well known. The adult pentastomids are generally located in the lungs of the snakes but in some species (e.g. *Kiricephalus pattoni*) sexually mature specimens are regularly found in the dermis just under the scales. Studies of the tissues surrounding the parasites have shown no inflammatory reaction or tissue proliferation on the part of the host (Self and Kuntz, 1966). Some species of pentastomids are able to produce important lesions in the lungs of their hosts. In the genus *Cubirea* at least in the females the anterior part of the body, also called head, is distinctly separate from the rest of body by a thin neck. In all the specimens of *C. pomeroy* that I have collected this head was completely

enclosed in a fibrous pouch developed on the external wall of the lung. The opening of this pouch was very narrow and just large enough to give passage for the neck of the parasite. The rest of the body hunged freely in the lung cavity. The removal of the parasite was very difficult and needed a careful dissection of the fibrous pouch containing the head. It is well known that the infective nymphs arrive to the lung of the snake by direct penetration of the gut wall and lung tissue and not by migration up the oesophagus and passage into the lungs via the glottis and the trachea. This direct migration through the internal organs may cause perforation of blood vessels which may lead to the death of the animal.

COMMENTED LIST OF **PENTASTOMIDA** PARASITIC ^N SNAKES

PENTASTOMIDA are very common in snakes. This parasitism has been observed in all the continents but is particularly frequent in tropical regions. Not less than 26 species of **PENTASTOMIDA** grouped in 9 genera, have been found as adults in the lungs of snakes. They represent 5 families which belong to the two orders existing in the phylum (**CEPHALOAENIDA** and **POROCEPHALIDA**).

Order **CEPHALOAENIDA**: This order is the most primitive one. It comprises only one family (**CEPHALOAENIDAE**), with two genera:

1. Genus *Cephalobaena* Heymons: This genus is represented by only one species *C. tetrapoda* Heymons, which parasitizes the lung of South-American CROTALIDAE (*Bothrops* and *Lachesis*) and COLUBRIDAE (*Leptophis*). The life-cycle is unknown.

2. Genus *Raillietiella* Sambon: This cosmopolitan genus is represented by about 20 species, half of them being parasitic in snakes, the other species living in lizards or varans.

In Africa 3 species have been described in snakes. The most common is *R. boulengeri* Vaney and Sambon. This species has been found as an adult in the lung of many kinds of snakes: BOIDAE, VIPERIDAE, ELAPIDAE and COLUBRIDAE. Completely developed nymphs have been found free in the lung of various snakes. They represent probably "migrating" nymphs coming from a prey swallowed some time before. Encysted nymphs, some of them being still in the moulting stage, have also been found but only in lizards. These hosts are probably the intermediate hosts for *R. boulengeri* (reported by Fain, 1964). The 2 other African species have been encountered only in one snake each. The first is *R. congolensis* Fain known from the lung of an undetermined snake in Congo, the other is *R. tetrapoda* (Gretillat, Brygoo and Domergue), described from a single male, apparently in the moulting stage, found in the lung of *Acrantophis dumerili* in Madagascar. In Southern Europe and in Asia there are 4 species of *Raillietiella* that parasitize snakes. The most common is *R. orientalis* (Hett). That species is closely related to *R. boulengeri* and it has also been found in different families of snakes: CROTALIDAE (genus *Ancistrodon*), ELAPIDAE (genus *Naja*) and COLUBRIDAE (genera *Coluber* and *Elaphe*). A nymph probably belonging to that species has been found free in the lung of an asiatic snake (*Tropidonotus maculatus*) (reported by Fain,

1964). The 3 other European or Asiatic species have been very seldom related they are: *R. mediterranea* (Hett) living as an adult in *Coluber*, *R. spiralis* Hett whose host is also a COLUBRIDAE (genus *Coelopeltis*) and *R. agoi* Tub. and *Masil*, which parasitizes an ELAPIDAE of the genus *Naja*. In South America there is only one species *R. jurococerca* Diesing. It has been reported from BOIDAE (genus *Boa*), from CROTALIDAE (genus *Lachesis*) and from numerous COLUBRIDAE (genera *Coluber*, *Elaphe*, *Phrynonax*, *Spilotes*, *Drymobius*, *Rhadinaea*). The life-cycle of *R. jurococerca* is still unknown. In North-America the only reported species is *R. bicaudata* Heymons and Vitzhum. It lives as an adult, in COLUBRIDAE of the genera *Elaphe* and *Ophibolus*.

Order POROCEPHALIDA:

1. Genus *Sebekia* Sambon: All the species of that genus (seven, in total) live as adults in the lungs of crocodiles. The nymphs of one species (*S. oxycephala* Diesing) have been encountered frequently in fishes and in various snakes (genera *Bothrops*, *Dimades*, *Heterodon*, *Eunectes*) and occasionally in lizards.

2. Genus *Leiperia* Sambon: The adults live in crocodiles; the nymphs of the South American species of the genus (*L. gracilis* Diesing) have been found mainly in fishes, and once in a snake.

3. Genus *Sambonia* Noc and Giglioli: The adults of the only known species (*S. lohrmanni* Sambon) live in the lungs of varans in Africa, Asia and Australia. I have shown that species may perform its complete life-cycle in the same host (Fain and Mortelmans, 1960). Self and Kuntz (1957) have reported this species from the lung of a snake in Solomon Is., but this record seems doubtful and needs confirmation.

4. Genus *Waddycephalus* Sambon: The only one good species described in that genus is *W. teretiusculus* Baird. It has been found as an adult in the lung of several Australian elapid snakes. It has also been reported from a COLUBRIDAE (of the genus *Elaphe*) in Hong-Kong. Encysted nymphs attributed to that species have been reported from an Australian elapid snake (genus *Pseudechis*). The life-cycle of that species is unknown.

5. Genus *Porocephalus* Humboldt: This genus is represented by species all living, as adults, in the lung of snakes. The nymphs are encountered in mammals, in snakes and in amphibians. Three species are parasitic in American Snakes. The first is *P. crotali* (Humboldt) which as an adult, is very common in the CROTALIDAE but only in the genus *Crotalus*. Encysted nymphs have been reported from numerous mammals especially in Brazil but it is not sure if all nymphs belonged really to that species. Another American species is *P. clavatus* (Wyman). The adults are met only in the lungs of BOIDAE of different genera *Boa*, *Eunectes* and *Epicrates*. Nymphs attributed to that species have been reported from marsupials. The third species is *P. stilesi* Sambon, living as an adult in CROTALIDAE (genera *Lachesis* and *Bothrops*) and in a COLUBRIDAE (genus *Helicops*). Encysted nymphs are reported

from snakes and lizards. These three South-American species are morphologically very close to each other and some authors consider that there is probably only one species *P. crotali*, and that the two other species are synonymous.

Stiles (1891) has worked out the life-cycle of *Pentastomum proboscideum* Rud., (which corresponds probably to *Porocephalus crotali*) from a *Boa constrictor*. He described 4 larval stages which were recovered from laboratory infected mice. The life-cycle of *P. crotali* has been studied again by Penn (1942) and Esslinger (1962). In Africa two species have been reported. The most frequent is *P. subulifer* (Leyckart). It has been encountered as an adult in several genera of snakes of the Viperidae (*Causus*, *Bitis*), ELAPIDAE (*Naja*) and COLUBRIDAE (*Mehelya*). Curiously enough that species seems to be able to become completely adult only in snakes of the *Mehelya*. Encysted nymphs are common in snakes (*Causus*, *Neusterophis*, *Elapsoidea*, *Psammophis*) and rare in mammals (monkeys and galagos). Another African species (*P. benoiti* Fain) is known from an undeterminate snake probably a *Naja*.

6. Genus *Kiricephalus* Sambon: This genus is represented by 3 species living, as adults, in the lung of snakes. The life-cycle of that genus is still unknown. Two species are known only from America. The first is *K. coarctatus* (Diesing). The adults are encountered in several genera of COLUBRIDAE (*Columber*, *Elaphe*, *Drymobius*, *Thamnophis*, *Tropidonotus*, *Ophibolus*, *Herpetodryas*). Nymphs and young adults have been found encysted in the subcutaneous muscles of *Elaps fulvius* from Guatemala and of the North-American *Elaphe melanoleucus*. A young male has also been found in a mammal *Mephitis mephitis* (CARNIVORA, MUSTELIDAE). The second American species is *Kiricephalus tortus* (Shiple) described from a COLUBRIDAE (*Dipsadomorphus irregularis*) in North-America. The third species of that genus is *Kiricephalus pattoni* (Stephens) which is only known from Asia, Australia and Madagascar. The adults are found in the lung of COLUBRIDAE (in Asia and Madagascar) and of BOIDAE (in Madagascar and Australia). Nymphs and young adults have been found in the subcutaneous tissues or in the walls of the stomach of snakes. Encysted nymphs have also been reported from frogs in Java. Self and Kuntz (1966) have found that *K. pattoni* may inhabit tissues even in sexually mature stages.

7. Genus *Armillifer* Sambon: This genus is known from Asia, Africa and Australia. It comprises 3 species, living all as adults in the lungs of large snakes mainly BOIDAE but also in some VIPERIDAE: *Armillifer armillatus* (Wyman) is the most common species of the genus. It lives as an adult in African pythons and in the large VIPERIDAE mainly *Bitis*. *A. armillatus* may also develop in smaller snakes (*Boaedon*, *Bothrophthalmus*) but it seems that in these hosts the parasite is not able to reach its complete maturity. Nymphs, encysted or free, are very common in many kinds of mammals including man. They have also been found, but very rarely, in prey birds (*Bubo africanus* and *Pernis apivorus*). Another African and less common species is *Armillifer grandis* (Hett). It has been found only in large VIPERIDAE, particularly in the genus *Bitis*. The snake that is the most frequently parasitized, at least in Congo, is *Bitis nasicornis*. Other hosts less frequent are *Bitis gabonica* and *Cerastes cornutus*. Encysted nymphs have been found in a Water-Hen of a Zoological Garden (Fain, 1961). Similar nymphs have been found recently in man in Congo (Fain and Salvo, in press). The third species of the genus

is *Armillifer moniliformis* (Diesing). The adults are frequently found in Asiatic and Australian pythons. It has also been reported, but very rarely, from Central African pythons.

Encysted and free nymphs have been found in many kinds of mammals.

8. Genus *Cubirea* Kishida: The two species, known in that genus are found only in Africa. Self and Kuntz (1957) have reported the presence of immature specimens of *Cubirea pomeroy* from a snake in Solomon Is. This record cannot be accepted without confirmation for the young specimens of that genus are not well known and they are very difficult to identify with certainty. *Cubirea annulata* (Baird) lives, as an adult, in the lung of different species of *Naja*. It has also been recovered from *Bitis gabonica* and *Bitis nasicornis*. Nymphs or (?) adults of *C. annulata* have been found in a Demoiselle Crane (*Anthropoides virgo*) and encysted nymphs attributed to that species have been reported from a Water-Hen (*Phorphyrio*). The other species is *Cubirea pomeroyi* (Woodland). It is very close to the former. The hosts belong to the genus *Naja*. Nymphs are unknown.

9. Genus *Gigliolella* Chabaud and Choquet: This genus is very close to *Armillifer*. There is only one species, *G. brumpti* (Giglioli). It is parasitic in the lung of BOIDAE in Madagascar.

Nymphs have been found in lemur apes and in TENRECIDAE.

10. Genus *Ligamifer* Heymons: There is one species (*L. mazzai*) which lives in Asiatic snakes.

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DISCUSSION

L. D. Brongersma: "Is *Armillifer moniliformis* also present in Central Africa?"

A. Fain: "Yes, I found it in an African python in Leopoldville, but it is possible that that species has been introduced in Africa by means of Asiatic pythons of Zoological Gardens."

E R R A T A

Pages :

- 167, line 16 : Instead of ... "larva of", read ... "larva or".
- 169, line 33 : Instead of ... "these", read ... "those".
- 170, line 3 : Instead of ... "hanged", read ... "hung".
- line 10 : Instead of ... "dead", read ... "death".
- line 11 : Instead of ... "COMMENTED", read ... "ANNOTATED".
- line 11 : Instead of ... "PARASITIC SNAKES", read ...
"PARASITIC IN SNAKES".
- 172, line 2 : Instead of ... "close each", read ...
"close to each".
- line 7 : Instead of ... "PEN", read ... " PENN ".
- line 10 : Instead of ... "snakes: VIPERIDAE", read ...
"snakes of the families VIPERIDAE".
- line 12 : Instead of ... "the Mehelya", read ...
"the genus Mehelya".
- line 13-14 : Instead of ... "Psammophis) rare", read ...
"Psammophis) and rare".
- line 16 : Instead of ... " 5 ", read ... " 6 ".