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A STUDY OF DIPHYLLOBOTHRIIDAE (CESTODA) FROM AUSTRALIAN HOSTS.

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(With Plates II. and III.)

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INTRODUCTION.

Following the recovery of numerous spargana from a local host, an investigation was undertaken to identify the adult of these parasites and determine whether laboratory animals would serve as "reservoir" hosts for the spargana.

The author would like to express appreciation for the co-operation given by Dr. M. J. Mackerras during this work; to Mr. J. Thomson and Dr. M. C. Bleakly who identified the copepods and frogs respectively, and to Mr. A. J. Bearup for many helpful suggestions and Mr. G. Thompson who carried out some of the photographic work.

PREVIOUS RECORDS OF DIPHYLLOBOTHRIIDAE IN AUSTRALIAN HOSTS.

The following records were found in a search of the available literature; those marked with an asterisk were recorded by Young (1939).

ADULTS :—

**Bothridium arcuatum* Baird, 1865, in *Python spilotes* (N. S. Wales).

**Bothridium pythonis* Blainville, 1824, in *Python spilotes* (N. S. Wales).

**Bothridium pythonis* var. *parva* Johnston, 1913, in *Varanus varius* (Queensl.).

Bothridium ornatum Maplestone and Southwell, 1923, in *Python spilotes* var. *variegatus* (Queensl.).

**Bothriocephalus marginatus* Krefft, 1871, in *Macropus* sp. (Queensl.).

**Diphyllobothrium latum* (Linné, 1758) in *Homo sapiens* (Queensl., N. S. Wales, Vict., Tas.). (See Sandars, 1951).

Diphyllobothrium latum (Linné, 1758) in *Canis familiaris* (N. S. Wales) recorded by Gordon (1939). (See Sandars, 1951).

**Diphyllobothrium parvum* (Stephens, 1908) in *Homo sapiens* (Tas.).

**Diphyllobothrium antarcticum* (Baird, 1853) in "Southern Seal" (Antarctic Ocean).

**Diphyllobothrium arctocephalinum* Johnston, 1937, in *Arctocephalus forsteri*. (S. Austr.).

**Diphyllobothrium decipiens* (Diesing, 1850) in *Dasyurus* sp. (Austr.). This record is probably incorrect. It appears as though it was originally recorded from a domestic cat and not from the native cat, *Dasyurus* sp. (See Cobbold 1879, p. 308).

**Diphyllobothrium mansoni* (Cobbold, 1882) in *Felis domestica* (Queensl.).

**Dibothriocephalus felis* (Creplin, 1825) in *Felis domestica* (Queensl., N. S. Wales and Vict.).

Diphyllobothrium erinacei (Rudolphi, 1819) in *Vulpes vulpes* (Vict.) and in *Canis familiaris* (Vict.) recorded by Pullar (1946).

According to Neveu-Lemaire (1936), *Diphyllobothrium decipiens*, *D. mansoni* and *Dibothriocephalus felis* are probably synonyms of *Diphyllobothrium erinacei* (Rudolphi, 1819).

Wardle, McLeod and Stewart (1947) claim that *Diphyllobothrium latum* should be *Dibothriocephalus latus* Linnaeus 1758; *Diphyllobothrium arctocephalinum* Johnston, 1937, should be *Cordiocephalus arctocephalinus* (Johnston, 1937); and that *decipiens*, *erinacei*, *felis* and *mansoni* of *Diphyllobothrium* should be included in the genus *Spirometra* (Mueller, 1937).

SPARGANA :—

Sparganum mansoni (Cobbold, 1883) three records in *Homo sapiens** (N. S. Wales).

Sparganum sp. in *Homo sapiens** (N. S. Wales); *Vulpes vulpes** (S. Austr.); *Dasyurus viverrinus** (N. S. Wales); *Chlamydosaurus kingii** (Queensl.); *Dendrophis punctualatus** (Queensl.); *Demansia textilis** (Queensl.); *Pseudechis australis** (Queensl.); *Pseudechis porphyriacus** (Queensl. and N. S. Wales); *Python spilotes** (N. S. Wales); *Python spilotes* var. *variegatus** (N. S. Wales and Queensl.); *Varanus gouldii** (Queensl.); *Varanus varius** (Queensl.); *Hyla aurea** (N. S. Wales and W. Austr.); *Hyla caerulea** (Queensl. and N. S. Wales); *Thyrsites atun** (N. S. Wales).

Bearup (1948) records the sparganum of *Diphyllobothrium erinacei* in *Acanthopis antarctica* (Heathcote, near Sydney, N. S. Wales). He reared the adults in experimental kittens and infected the following copepods with procercoids :—*Mesocyclops obsoletus* (Koch), *Cyclops australis* (King) and *Leptocyclops* sp., probably *Leptocyclops agilis* (Koch).

Pullar and McLennan (1949) record *Sparganum* sp. in the pig, *Sus scrofa* (Vict.).

Recently spargana from " wild " domestic pigs from N. S. Wales have been fed to both cats and dogs. Adult *Diphyllobothrium erinacei* were recovered (Personal communication from Dr. H. McL. Gordon).

RECORDS OF NATURALLY INFECTED HOSTS.

Spargana have been recovered from the following hosts, which were taken in the greater Brisbane area :—

(*a*) *Natrix mairii* Gray. Fresh-water Snake.

(*b*) *Pseudechis porphyriacus* Shaw. Red-bellied Black Snake.

(*c*) *Hyla caerulea* White. Green Tree-Frog.

In one specimen of *Natrix mairii*, spargana were found lying close to the muscles on the dorsal side of the body cavity and smaller forms occurred in the fat around the gut. Another specimen of *Natrix mairii* was very heavily infected with spargana which occurred between the skin and body wall, within the muscles of the body and throughout the body cavity; these spargana were most abundant in the middle third of the entire body length (Plate II, figs. 1-3). From one Fresh-water Snake, over 300 spargana, ranging in length from 5-213 mm., were collected.

In *Pseudechis porphyriacus*, spargana with lengths between 5-40 mm· were recovered from the peritoneum of the body cavity.

In *Hyla caerulea*, spargana were most commonly found between the muscles of the inside of the thigh regions of either hind leg. They were also recovered from between the muscles of the shoulder region.

EXPERIMENTAL.

(1) SPARGANA FROM NATRIX MAIRII.

On May 25th, 1950, spargana from the fresh-water snake (*Natrix mairii*) were fed to two young cats, A and B ; each cat was given 6 spargana. One sparganum from the same host was also fed to a laboratory-bred white rat. Twenty-three days later (June 17th), diphyllobothriid eggs, with average measurements 57μ x 35μ, were recovered from the faeces of the cats (Plate III, fig. 1). The faeces were washed thoroughly in tap water, the eggs thus obtained being put into tap water in petri-dishes. One of the developing larvae within an egg measured 32μ x 28μ, and each of the six hooks present were of equal length, 11μ. On July 29th, some of the eggs had hatched, and free swimming coracidia were observed. On the same day, locally obtained copepods, *Cyclops varicans* Sars, were placed in the petri-dish. On September 13th, the copepods were observed to be infected with procercoid larval forms. (Plate III, fig. 2). The males, as is usual, were observed to be infected, often heavily, with *Diphyllobothrium* procercoids, while the females were not infected. Some infected copepods were found dead on September 19th, and on examination they proved to be very heavily parasitized with procercoids ; one examined contained 7 procercoids, 6 of them situated in the tail region.

On September 19th, two tadpoles of *Hyla latopalmata* (Günther) were introduced into a petri-dish of fresh water containing several infected copepods. On November 11th the tadpoles were infected with plerocercoids which were conspicuous, whitish structures lying just under the skin of the host. They were found in various parts of the body and tail on the dorsal and lateral surfaces of the host (Plate III, figs. 3, 4). The growth of these tadpoles was obviously inhibited. In one, the distortion was very evident, especially in the region where the tail joins the body (Plate III, fig. 4).

These spargana were fed, on November 27th, 1950, to various animals :—

(*a*) To a small frog, *Hyla latopalmata* (Günther) bred in the laboratory from a tadpole collected at Camp Mountain, near Brisbane. It was fed one sparganum dissected from the infected tadpole. On May 7th, 1951, a sparganum of increased size was recovered from between the muscles on the inside of the thigh of a hind limb. The frog was killed by chloroform. The sparganum had also been killed and had macerated very quickly.

(*b*) One sparganum was fed to a laboratory-bred mouse (*Mus musculus albus*). On March 15th a sparganum of increased size was recovered from between the muscles of the back, in the region behind the right fore-limb. This was fed to an experimental cat. Soon afterwards this animal broke its back and had to be destroyed. No tapeworm was recovered.

(*c*) To experimental Cats (*Felis domestica*) :—

(i) One cat was fed 1 sparganum dissected from the tadpole. Sixteen days later, on December 13th, a young specimen of *Diphyllobothrium erinacei* was recovered.

(ii) One cat was fed a dead tadpole containing live spargana. On December 24th, *Diphyllobothrium* eggs (average size 56μ x 33μ) were moderately abundant in the faeces of the cat.

The white rat which was also fed a sparganum from *Natrix mairii* on 25th May, 1950, was killed and examined on December 14th, and a sparganum 120 mm. long was recovered from between the muscles of the left thigh. This sparganum had increased considerably in length, having been only 20-30 mm. long when taken from the fresh-water snake and fed to the rat. It was then fed on December 14th to a cat, and on January 11th, 1951, *Diphyllobothrium* eggs (average size 63μ x 30μ) were seen in the cat's faeces. On May 21st, one adult *Diphyllobothrium erinacei* was recovered from the intestine of the cat.

(2) SPARGANA FROM PSEUDECHIS PORPHYRIACUS.

Two host specimens were examined and in both, spargana were very abundant. Spargana from one host were placed in a corked tube and kept in a refrigerator until the following day. They were then removed and shortly afterwards placed in 0·85% saline and were observed to be alive and very active. Three of these spargana were fed to an experimental cat on October 15th, 1951 ; twelve days later (October 27th) the cat died and no diphyllobothriids were recovered.

(3) SPARGANA FROM HYLA CAERULEA.

One of the most common frogs in the greater Brisbane area is *Hyla caerulea* White, approximately one quarter of the population of which appears to be infected with sparganа. Two spargana recovered from locally obtained *Hyla caerulea* were fed to an experimental cat on December 5th, 1950. A few diphyllobothriid eggs (average size 60μ x 30μ) were observed in the faeces on January 6th, 1951 ; on January 18th eggs, of average size 62μ x 31μ, were abundant. The minimum time between the feeding of spargana and the appearance of diphyllobothriid eggs in the faeces of the host was 23 days.

Longevity of Diphyllobothrium erinacei.

Of the 2 cats, A and B, fed with spargana from *Natrix mairii* on May 25th, 1950 :—

(*a*) From cat A, 4 adult *Diphyllobothrium erinacei* were recovered from the small intestine on November 3rd, 1950. They were all about 30 cm. in length with a maximum width of 0·5 cm. The scolices were buried fairly deeply in the intestinal mucosa.

(*b*) In the faeces of cat B, *Diphyllobothrium* eggs (average size, 62μ x 31μ) were still abundant on November 22nd, 1951. (In the same faeces some eggs measured 52μ x 31μ). On November 28th, only a few *Diphyllobothrium* eggs were present in the cat's faeces and no eggs were recovered on December 12th.

Variance in Egg Size of Diphyllobothrium erinacei.

Neveu-Lemaire (1936, p. 398) states that the size of the eggs of *Diphyllobothrium erinacei* is very variable, measuring 52μ to 76μ long, by 31μ to 44μ wide.

Eggs recovered from the several specimens of *Diphyllobothrium erinacei* during the present work, varied considerably in size, the most usual egg size being 62μ long, by 31μ wide.

DISCUSSION.

Bearup (1948) showed experimentally that spargana from *Acanthopi antarctica* (Death Adder) were those of *Diphyllobothrium erinacei*. Since spargana from *Natrix mairii* and *Hyla caerulea* have now also been shown

experimentally to be of *Diphyllobothrium erinacei* it seems that this tapeworm is established, at least in eastern Australia, and that a wide range of animals may serve as " reservoir " hosts for the sparganum stage in its life history. According to Galliard and Ngu (1946) and Gan (1949) the tadpole is an important host in which the plerocercoid stage develops from the procercoid. Under natural conditions they must serve as effective transmitters of spargana to other intermediate hosts, such as frogs, lizards, snakes etc.

The first larval stage, the procercoid, was bred successfully by Bearup (1948) in several species of fresh-water copepods from N. S. Wales, viz. *Mesocyclops obsoletus* (Koch), *Cyclops australis* (King) and *Leptocyclops* sp., probably *Leptocyclops agilis* (Koch). Galliard and Ngu (1946) note that previous workers had infected successfully a number of different species of *Cyclops* in other parts of the world ; they themselves infected 2 species, viz. *Cyclops leuckarti* Claus syn. *Mesocyclops obsoletus* (Koch), and another unidentified species. It has been shown experimentally that *Cyclops varicans* Sars from Queensland also serves as a host for the procercoid larval stage of *Diphyllobothrium erinacei*.

Bearup (1948) recorded the appearance of eggs of *Diphyllobothrium erinacei* in the faeces of the kitten 45 days after the sparganа had been fed to it. In the present experiments eggs were recovered in abundance as early as 23 days after sparganа had been fed to a cat. This indicates that the worms reach their adult stage in the final host in a period of just over three weeks.

SUMMARY.

(i) A new host record is made for the sparganum of *Diphyllobothrium erinacei* (Rudolphi), viz. *Natrix mairii* Gray (Brisbane, Queensl.).

(ii) Spargana from *Natrix mairii* and *Hyla caerulea* from the Brisbane area were shown experimentally to be of *Diphyllobothrium erinacei*.

(iii) The copepod, *Cyclops varicans* Sars, was shown to act as a host for the procercoid stage in the life history of *Diphyllobothrium erinacei*.

(iv) Both poikilothermic and homoiothermic hosts, viz. tadpoles and adults of *Hyla latopalmata* (Günther) and laboratory-bred mice and rats, were shown experimentally to serve as reservoir hosts for spargana of *Diphyllobothrium erinacei*.

(v) It is postulated that the spargana recorded from Queensland hosts, as in the list already given, are all of *Diphyllobothrium erinacei*.

(vi) The adult of *Diphyllobothrium erinacei* has been shown experimentally to live almost nineteen months within the intestine of a cat (*Felis domestica*).

ADDENDUM.

In April, 1952, spargana were recovered from the muscles under the right arm of a Tasmanian Tiger Cat, *Dasyurops maculatus*. This host, from near Launceston, Tasmania, had been flown to Brisbane on dry ice. The spargana were fed to a cat, and the adult tapeworm, *Diphyllobothrium erinacei*, was recovered.

The body of the Tiger Cat was made available for examination through the kindness of Mr. G. Mack, Director of the Queensland Museum.

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EXPLANATION OF PLATES.

Plate II.

Spargana of *Diphyllobothrium erinacei* (Rudolphi) in situ in the host *Natrix mairii* (Water Snake).

Fig. 1. Spargana between the skin and muscles of the body wall, X5·6. Fig. 2. Spargana in the body cavity between the body walls and gut, X5·6. Fig. 3. Body of a Water Snake pinned out to show a very heavy infection of spargana, X2·8.

Plate III.

Stages in the Life History of *Diphyllobothrium erinacei* (Rudolphi).

Fig. 1. Eggs in faeces of an infected cat, X90. Fig. 2. *Cyclops varicans* Sars with procercoid larval forms in the thorax and abdomen, X90. Figs. 3 and 4. Tadpoles of *Hyla latopalmata* (Günther) with plerocercoid larval forms (spargana) distorting both the body and tail regions of the host, X5.

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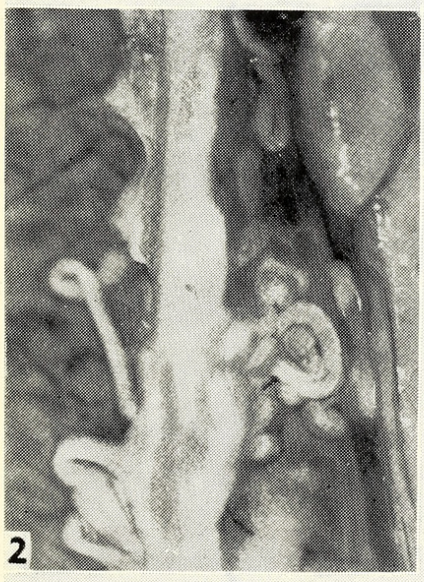

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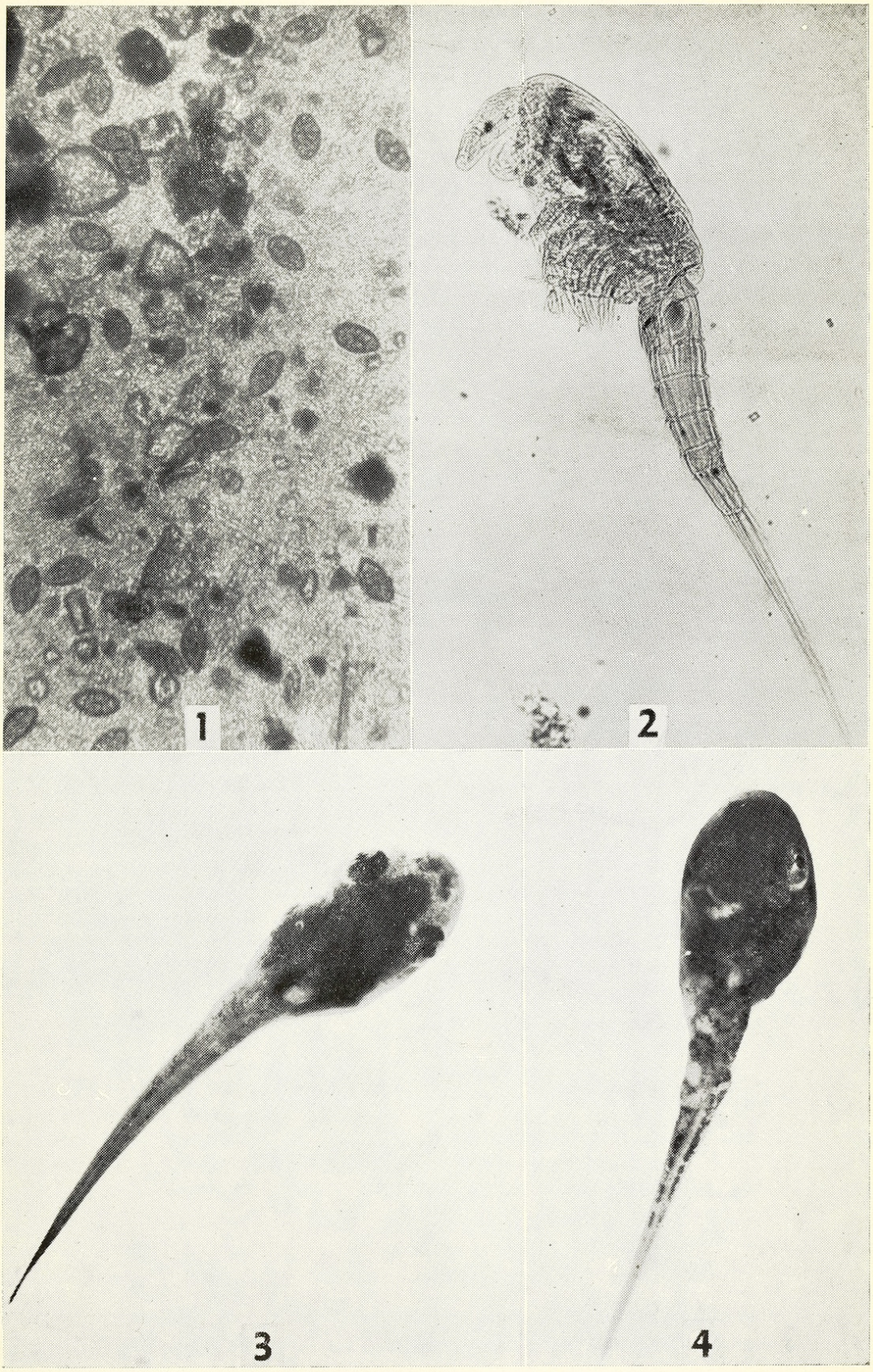
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