THE LIFE CYCLE OF THE TREMATODE *ECHINOPARYPHIUM ELLISI*, FROM THE BLACK SWAN

BY T. HARVEY JOHNSTON AND L. MADELINE ANGEL, UNIVERSITY OF ADELAIDE.

Fig. 1–3.

THE larval stage, *Cercaria ellisi* Johnston and Simpson (1944, 125–128), was described from *Lymnaea lessoni* from the Murray River Swamps at Tailem Bend. It was reported to have been identified on twelve occasions between May 1937 and March 1943, the months being those of autumn, spring and summer. On those occasions, the parasite was found in 156 of 2,064 *Lymnaea* examined, i.e. in 7·5 p.c., but these figures do not take into consideration the numbers of that species of pond snail collected from the swamps on other occasions when *C. ellisi* was not recognized. Since those observations were made we have identified the cercaria in 561 of 2463 *L. lessoni*, i.e. in about 23 p.c., but this increase in percentage was due to collections made on three successive occasions, January to April 1947, 32 of 291 being parasitized in January, 210 of 363 in March, and 197 of 507 in April, a total of 439 out of 1,161 snails examined, i.e. about 38 p.c. On other occasions we found only one of 342 and 4 of 365 infected.

The habitat preferred by the black swan, *Chenopis atrata*, which we now know to be the host for the adult stage of the trematode, no doubt affects the distribution of parasitized *Lymnaea*. The bird prefers open, relatively shallow water and feeds on vegetation Second intermediate molluscan hosts living on such vegetation would also be ingested. Chance is thus an important factor in assessing percentage infection of swamp snails.

C. ellisi is a 45 spined echinostome with its body provided with spinules dorsally and ventrally as far back as the level of the acetabulum. The spines are in two rows, those of the aboral series being slightly longer than those of the oral, and are about the same length as those in the groups of corner spines. The cyst stage (118–133 μ, diameter) was obtained experimentally from the mantle cavity of the following molluses: *Amerianna* spp., *Lymnaea lessoni*, *Planorbis isingi*, *Plotiopsis tatei* and *Corbiculina angasi*, as well as in the kidneys of the tadpole of *Crinia signifera*.

It was reported that faecal material deposited by a pelican had been used in midsummer in an endeavour to infect various kinds of pond snails; 92 days later two of the *Lymnaea* were observed giving off *Cercaria ellisi* and numerous cysts of the parasite were found in the tissues of these laboratory-bred snails. Since adult echinostomes possessing 45 spines had not been found in Australian

pelicans, but the water hen, *Gallinula tenebrosa*, had been recorded as the host for a 44 (?45) spined species it was suggested that the faeces might have been contaminated. Contamination of that faecal material with faeces previously deposited on the bank by a black swan would provide the explanation of the finding of *C. ellisi*.

In April 1947 we discovered a number of 45-spined *Echinoparyphium* flukes in the upper portion of the small intestine of a black swan from the Tailem Bend Swamps, and our former colleague, A. C. Beckwith, utilized some of the eggs from the duodenal contents for infection experiments with the following results: of 11 *Lymnaea lessoni*, three gave off *C. ellisi*, four contained many rediae and daughter rediae (with some mature cercariae) at their death, and four were not infected. The snails were isolated for testing for the first time 110 days after they were placed in contact with the *Echinoparyphium eggs*, and on this day one *Lymnaea* was giving off the cercariae; five of the other *Lymnaea* died within four days of this date, and all of these contained large numbers of rediae, while some had mature cercariae. The remaining snails were tested at weekly intervals, and in a fortnight two of them were giving off cercariae (125 days). From this it seems probable that the time taken to reach maturity was not much less than 110 days, although this had not been verified by testing. On 29th October 1947, we repeated the experiment, using eggs from the duodenal contents of a swan in which many specimens of *Apatemon intermedium* but only one egg-bearing *Echinoparyphium* were present in that region. By 1st December (i.e. 33 days later), seven *Lymnaea* were dead and showed no evidence of infection when examined under the dissecting microscope. On this date the four remaining *Lymnaea* were removed to a fresh aquarium, so that they had no further contact with the eggs or possible miracidia. From 6th January 1948, the snails were isolated twice weekly, and on 16th January (i.e. 79 days) one of them was giving off *C. ellisi*. The other three *Lymnaea* did not become infected.

On 1st December eight *Lymnaea*, and on the following day six more, were placed in contact with eggs from the original material, either in small dishes or in the tank from which the four original *Lymnaea* had been removed. None of these became infected. One can conclude from the foregoing that the miracidia had hatched before 1st December, that is, within 32 days of the time that the eggs had been removed from the intestine. The time of hatching of miracidia under natural conditions might be slightly less than this period, since it could be expected that it would take a day or two for the developing eggs to have been passed in the faeces and reach the swamp water.

The somewhat scanty data at our disposal also suggests that an infection takes longer to reach the cercaria-producing stage in autumn than it does in

spring or early summer: of the snails exposed to infection in May, one took not more than 110 days, two not less than 119 days, while two snails exposed at the end of October took not less than 77 days and 79 days respectively; two snails exposed during January 1943 gave off cercariae within 90 days (perhaps 84 days, since testing was done weekly).

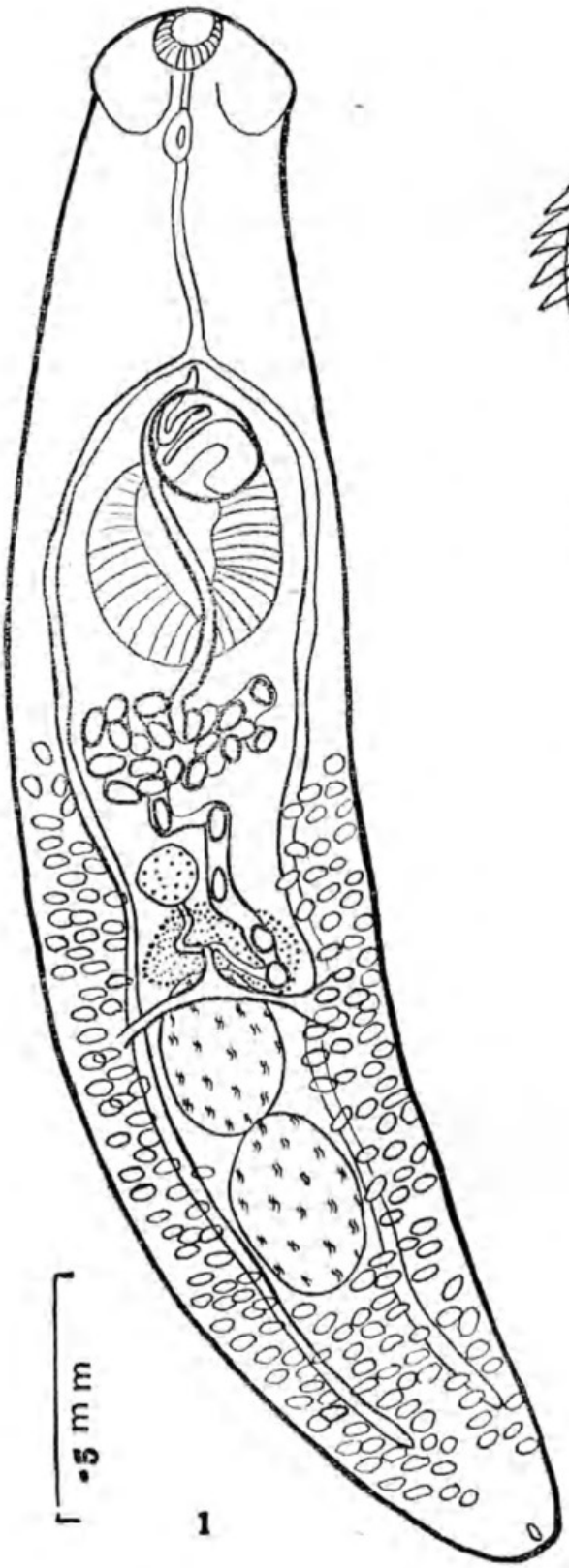
At the same time as eggs from the duodenal contents were used, another experiment was set up, using about 100 eggs which had been dissected out from several adult *Echinoparyphium*, but it would appear that such eggs are not viable or infective since none of the six *Lymnaea* exposed became infected.

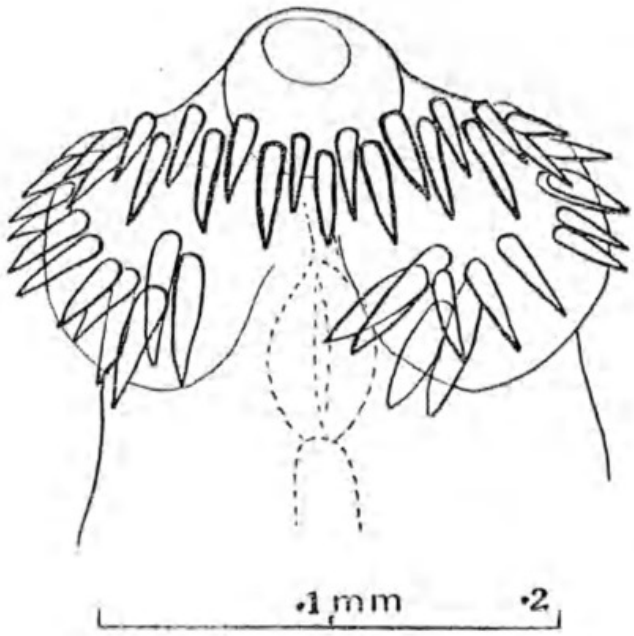
Although we have obtained cercariae experimentally in August and September, we do not collect many *Lymnaea* from the swamps before December, and in the few which have been collected we have not recorded infections of *C. ellisi*. We have found *C. ellisi* in two of a total of 82 snails obtained in October since 1937. On 18th September 1940, 15 *Lymnaea* collected were apparently uninfected; they were retested on 14th November, when one of them was giving off *C. ellisi*.

C. ellisi was recognized from *Simlimnea subaquatilis* from Lake Alexandrina (Johnston and Beckwith, 1946, 125), but has not yet been identified from any snail host other than the two Lymnaeidae mentioned. Though we have attempted to infect *Planorbis isingi* and *Amerianna* spp. our results have been negative and our examination of thousands of these snails collected under natural conditions in the localities where *Lymnaea* infected with *C. ellisi* was found, has failed to reveal the presence of these cercariae in any of them, we can safely conclude that they are not normal hosts for the cercarial stage, though the cercariae readily enter these molluscs and become encysted as metacercariae in them.

Johnston and Simpson (1944) noted the differences between *C. ellisi* and *C. clelandae*, a 45-spined echinostome whose host is *Planorbis isingi*. *C. clelandae* could not be made to encyst in tadpoles, a normal secondary intermediate host of *C. ellisi*, and its cysts were consistently 30μ larger in diameter. The fact that we were unable to infect *Planorbis* with *Echinoparyphium ellisi* at the same time that we infected *Lymnaea*, provides further evidence that the two cercariae are distinct. In our original account (Johnston and Angel, 1939) of *C. clelandae* we stated in error that the oral spines were slightly larger than those of the aboral series whereas the figure (fig. 8) shows the true condition, i.e. that the aboral spines are the longer. *C. clelandae* is the larva of an unrecognized *Echinoparyphium*.

Attempts to obtain the adult of *E. ellisi* experimentally by feeding cysts to a pigeon and a young fowl were unsuccessful.





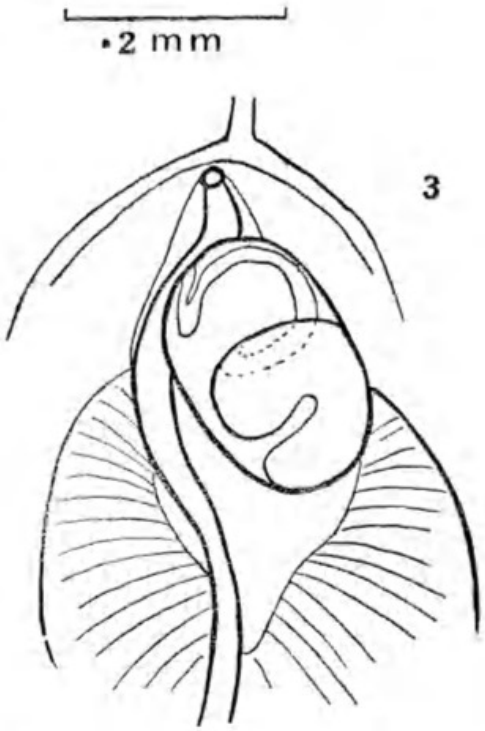


Fig. 1. *Echinoparyphium ellisi*, seen from dorsal surface. 2. Head region. 3. Cirrus sac and metraterm, dorsal.

ADULT STAGE.

The adult worm lives in the duodenum and upper part of the succeeding portion of the small intestine of the black swan, *Chenopis atrata*. Very young forms suggestive of recently liberated metacercariae were collected along with adults in October and April at Tailem Bend, South Australia. Preserved adults vary in form, being short and broad or long and narrow, the former condition probably being the more normal. The following measurements in millimetres (unless otherwise indicated) were made on egg-bearing worms of the former type.

Length 2·1–3·4, usually about 3 mm.; maximum breadth at acetabulum ·4–·6, at collar ·33–·39, breadth nearly uniform from level of acetabulum to that of posterior testis; posterior end tapering to become bluntly rounded; body minutely spiny dorsally and ventrally as far back as region of acetabulum; preacetabular portion commonly with ventrally infolded margins and bent ventrally so that both suckers tend to approximate. Collar with 45 sharp-pointed spines, including four stouter spines in each ventral corner and arranged more or less in two pairs; corner spines ·063–·069mm. by 13·4μ; remainder in two rows; ventral (oral) spine next each corner group ·052mm. by 9·6μ, succeeding spines ·053 mm. by 11·5μ (aboral), ·055 mm. by 13·4μ (oral) and ·052 mm. by 9·6μ, so that the marginal spines of the oral series tend to be rather larger and wider than the aboral spines which alternate with them; dorsal spines of oral series ·048 mm. by 9·6–11·5μ, those of aboral series larger, stouter, ·053 mm. by 11·5μ. Oral sucker spherical, ·11–·16 mm., or slightly longer than broad. Acetabulum in second quarter or fifth of body length, ·33–·462 long by ·30–·38 wide with rather deep concavity. Ratio of length of oral and ventral suckers 1 : 2·5–3·5; ratio of width 1 : 2–3. Postacetabular region about three-fifths body length. Prepharynx short, ·06 mm. long; pharynx ·088–·11 long, ·033–·06 broad; oesophagus long, ·33–·65, narrow; crura long, narrow, slightly sinuous, terminating some distance in front of end of body.

Testes in tandem, contiguous, elliptical with broad ends, in posterior half of body; anterior ·165–·35 long, ·13–·22 wide; posterior ·165–·44 long, ·13–·22 wide; posterior ·165–·44 long, ·13–·2 wide; both almost touching crura; post-testicular region about one fifth body length. Cirrus sac relatively short, rounded, ·22 by ·143–·165, obliquely placed, with posterior portion overlying front of acetabulum, with large twisted tubular inner seminal vesicle in posterior half of sac, succeeded by narrow cirrus lying bent in anterior part of sac. Genital pore almost median, just behind intestinal bifurcation; atrium with rather thick muscular walls.

Ovary near midlength of body, to one side of midline, spherical, ·09–·13; oviduct curving backwards and inwards to enter shell-gland complex where it receives narrow, very short, common yolk duct; uterus soon widening and thrown into one or two loops behind ovary and below shell gland, then passing forward beside or below ovary before becoming arranged in a few coils in region between ovary and acetabulum; metraterm muscular, passing above acetabulum near midline or to one side of it, eventually travelling beside or below front part of cirrus sac to enter atrium. Eggs broadly elliptical, ·0875–·1 mm. long, ·065–·075 wide, usually 12–30 (occasionally nearly 50) in uterus. Yolk glands not reaching level of acetabulum but extending nearly to posterior end of worm, i.e. a short distance beyond crura; follicles numerous, small, irregularly rounded, occupying zone dorsally and ventrally from body margins inwards to cover crura; vitelline fields joining in portion of post-testicular region; transverse yolk duct relatively wide, irregular, lying just in front of or dorsally to anterior testis and above shell gland. Latter compact, extending almost from one crus to the other and from anterior testis to ovary.

The youngest stage obtained from the duodenum of the host was ·47 mm. long, ·12 mm. wide at collar, ·112 at acetabulum; oral sucker ·05, acetabulum ·075 diameter, sucker ratio 2:3; posterior end acetabulum at ·3 mm. from head end of worm, postacetabular region ·15 mm., i.e. nearly one-third body length: pharynx ·03 long, ·02 wide. Another very young worm was ·66 long, ·154 wide at collar, ·165 at acetabulum; oral sucker ·062, acetabulum ·11 diameter, ratio nearly 1:2; postacetabular region ·26, thus more than one-third body length. Another specimen was ·815 long, ·143 wide at collar, ·154 at acetabulum; oral sucker ·055, acetabulum ·112, sucker ratio 1:2; postacetabular region ·32, about 2:5 of body length. A worm, 1·1 mm. long, was ·264 wide at acetabulum; oral sucker ·077 long by ·066 wide, acetabulum ·154 diameter, ratio of widths 3:7; preacetabular region ·6, postacetabular about ·35. In a specimen 1·32 mm. long the postacetabular length was ·66, just half the total length. Another worm, 1·54 mm. long, ·33 wide at acetabulum, had oral sucker ·088 long by ·066, acetabulum ·22 diameter, sucker ratio (width) 3:10, postacetabular length just half that of body. In a specimen 1·87 long by ·385 wide the oral sucker was ·088 and acetabulum ·275 long by ·264, and postacetabular region ·964, i.e. just over half body length.

In a worm 1·48 long, a small cirrus sac was already differentiated, while in one, 1·59 long by ·3 wide, testes, ovary, uterus and cirrus sac were recognizable. A specimen 1·8 long by ·33 had comparatively few yolk glands, but they were conspicuous and were arranged in a single linear series along each crus. With increasing length of parasites, these glands became much more

numerous and the vitelline fields more extensive. The smallest, and apparently youngest, egg-bearing worms were 2·0–2·2 mm. long and these contained only two or three eggs. One worm, 2·1 mm. long by ·35 wide was not yet ovigerous, but another of the same length but of greater breadth (·374) contained a few eggs. Sexual maturity thus becomes established when the worms reach about 2 mm. in length. Many eggs were present in some specimens 2–3 mm. long.

In a young worm 1·6 mm. long the corner spines were ·065–·069 mm. long by ·011; the marginal ·038–·046 by 7·6μ, those of the two series being subequal; and the aboral dorsal spines ·057 mm. by 9·6μ and the oral dorsals ·04–·042 mm. by 7·7μ.

Verma (1936, 155) published a brief unfigured account of *Echinoparyphium gizzardai* from the gizzard of the black swan, his specimens being obtained from the Calcutta School of Tropical Medicine, where Dr. P. A. Maplestone was a member of the staff. This latter officer collected parasitic material whilst he was on the staff of the Australian Tropical Institute, Townsville; hence it is likely that the parasites came originally from North Queensland. As we have occasionally found in the gizzard of the black swan small cestodes which occur normally in the duodenum it is possible that trematodes from the latter situation may have wandered into the gizzard after the death of the host.

The reported dimensions of the worm and of its organs agree fairly well with those given by us for *E. ellisi*, but the acetabulum was stated to lie in the first fourth of the body length and there were only 22 collar spines, those at the angles (corner spines) being ·05 by ·015 mm., and others of two sizes ·042 by ·01 and ·0252 by ·09 mm. The small number of the spines was specially noted. Our form has 45 spines whose dimensions are different from those of *E. gizzardai*.

Verma also gave a very brief unfigured account of *Echinoparyphium* sp. from the intestine of the same bird host. Under this generic name he recorded some specimens as having 44 spines, those of the end groups measuring ·067 by ·0168 and ·042 by ·01, while the lateral and dorsal spines, ·0588 by ·122 mm., appeared to be arranged in couples; the ventral sucker was at one-fourth to one-fifth the body length; and eggs ·256 by ·588 (obviously an error for ·0256 and ·0588) to ·084 by ·05. Another specimen was stated to possess only 33 spines.

Our material agrees with Verma's *Echinoparyphium* sp. with 44 spines (probably an error for 45). The number of spines reported for *E. gizzardai* is probably also an error, since the genus has an uneven number. As there is so much agreement between *E. ellisi* and *E. gizzardai*, except in regard to the number and sizes of the spines, we consider it likely that a re-examination of

the Calcutta material would reveal synonymy. However, until that should occur we prefer to retain the specific name given originally to the cercarial stage and place *Echinoparyphium* sp. Verma (1936, 155–6) as a synonymy.

Typical adults of *E. ellisi* have been deposited in the South Australian Museum. We wish to acknowledge our indebtedness to the Commonwealth Research Grant to the University of Adelaide; and to Messrs. G. G., Fred, and Bryce Jaensch of Tailem Bend, and Mr. L. Ellis, also of Tailem Bend, for their generous assistance in regard to material.

SUMMARY.

Cercaria ellisi Johnston and Simpson 1944 from *Lymnaea lessoni* and *Simlimnea subaquatilis* from the Lower Murray region is the larval stage of *Echinoparyphium ellisi*. The second intermediate hosts are various species of freshwater molluses; and tadpoles can also act as such under experimental conditions. Adult and growth stages from the upper intestine of the black swan, *Chenopis atrata*, are described, and the relation of *E. ellisi* to *E. gizzardai* Verma is discussed.

LITERATURE.

Johnston, T. H. and Angel, L. M. (1939): "Larval Trematodes from Australian freshwater Molluscs. Part VI." *Trans. Roy. Soc.*, S. Austr., lxiii, 1939, 200–203.

Johnston, T. H. and Beckwith, A. C. (1946): "Life cycle of the sheep liver fluke in South Australia." *Trans. Roy. Soc.*, S. Austr., lxx, 1946, 121–126.

Johnston, T. H. and Simpson, E. R. (1944): "Larval trematodes from Australian freshwater Molluscs. Part IX." *Trans. Roy. Soc.*, S. Austr., lxviii, 1944, 125–132.

Verma, S. C. (1936): "Notes on trematode parasites of Indian birds. Part I." *Allahabad Univ. Studies,* xii (12), 147–188.