

## Heads or Tails: Where Does the Head of a Miracidium Lie in the Schistosome Egg?

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A schistosome egg is formed of three components: the embryo from the ovary, the food supply for the developing embryo from the vitelline or yolk glands, and the egg envelope or shell, the material for which is produced by the shell gland.

In the female schistosome worm a great deal of the body, if not the greater part, is occupied by the ovary and the yolk glands. The yolk glands are situated at the posterior extremity of the worm and from these the vitelline duct runs forward to join the oviduct. The ovary also lies in the posterior part of the worm just anterior to the intestinal caeca. The oviduct arises from the posterior part of the ovary and passes forward to join the vitelline duct. Presumably somewhere in the oviduct the egg is fertilised by the male partner. This must happen before the egg shell material is applied, though it must be assumed that the sperm are able to ascend through the uterus, which may contain a number of eggs. The oviduct and vitelline duct join together at the end of the uterus and the embryo with its supply of nourishment from the yolk gland is passed into the posterior end of the uterus, which is a long tube extending forward to the anterior end of the worm where the vagina opens to the exterior just behind the ventral sucker. It is on account of this anatomical arrangement that the female worm can extend her anterior extremity into a fine capillary vessel and then proceed to lay her eggs, during which time she withdraws herself back into the gynaecophoric canal of her mate who, because of his greater bulk, is unable to enter small-bore blood vessels as can his female partner.

At the stage of shelling of the embryo the immature miracidium has the anterior end, the papillary beak, which might be loosely termed the head, pointing forward down the uterus. The miracidium is covered with fine ciliary hairs except at the papillary beak, and it is these hairs which provide the mature hatched miracidium with its means of locomotion.

The shell is made of material excreted by the shell gland at the posterior end of the uterus. It seems that the immature miracidium is coated

with its shell material as it enters the end of the uterus. Female *Schistosoma haematobium* and other species of schistosomes which lay terminal spined eggs have the shell gland opening into the end of the uterus, while *S. mansoni* females have the shell gland duct opening into the side of the fundus of the uterus. It would seem that the miracidium is pushed by muscular movements of the fundus of the uterus into the shell gland substance and so becomes completely coated by the shell. When this is complete the sphincter of the shell gland "nips off" the shell gland material and the last remnant is drawn out as the now shelled miracidium moves down the uterus. The shape of the spike of a terminal spined egg is probably determined by the efficiency of the shell gland sphincter and the musculature of the uterus. In some cases the eggs have a shell that merely encloses the miracidium with the merest rudiments of a spine, while in other cases the egg is elongate and the spine sturdy and well defined. In the case of *S. mansoni* the shell gland is on the side of the fundus of the uterus, and so in the case of eggs of this species the spine is set obliquely on the side of the egg towards the posterior end. Here also there are variations in egg shell shape which are probably conditioned by the uterus and the shell gland sphincter. In some cases the spine is thick and strong and sticks out of the shell at an angle of about  $75^\circ$ , while in others the spine is very thin and short and the angle between the spine and the shell may be as small as  $30^\circ$ .

In the case of *S. haematobium* mature female worms, the uterus usually contains a string of eggs awaiting deposition, but in the case of *S. mansoni* there are usually only one or two eggs in the uterus at any one time.

It seems certain, therefore, that the schistosome egg, when first formed in the fundus of the uterus, has the contained miracidium with its papillary beak (head) or anterior end facing away from the spiked (posterior) end of the shell.

#### THE POSITION OF THE MIRACIDIUM IN ITS SHELL WHEN OBSERVED IN STOOL OR URINE

The time which elapses between the shelling of the miracidium and the passage of the mature egg into stool or urine may be days or even as long as three weeks. During this period does and can the miracidium turn itself around in its shell in the uterus of the worm, or in the tissues of the host, or in the stool or urine when the egg is finally extruded from the host?

A study of a number of textbooks on helminthology and tropical medicine indicates that there are drawings and micro-photographs showing eggs with the miracidium pointing forwards and backwards. A number of texts illustrate the eggs of *S. haematobium* and *S. mansoni* with the papillary beak or head of the miracidium pointing forwards—that is, to the non-spiked end of the shell. These include Hackett (1954), Mackie, Hunter and Worth (1945), Blacklock and Southwell (1931), Belding (1958), Piekarski (1962), Manson-Bahr (1960) and Maegraith and Leithead (1962). Manson-Bahr (1960) also shows a drawing of a *S. haematobium* egg pointing backwards and a micro-photograph of nine *S. haematobium* eggs—six pointing forwards and three backwards. Dubois and van den Berghe (1948) illustrate micro-photographs of eggs of both species with the miracidia pointing backwards. Girges (1934) and Spencer and Monroe (1961) show drawings of a *S. haematobium* pointing forwards and *S. mansoni* pointing backwards.

It was decided to examine carefully a number of mature eggs of *S. haematobium* from urine and *S. mansoni* from stools in order to assess the proportion pointing forward and backwards. Urine specimens were preserved and fixed as soon as possible after they had been passed by the addition of 1 ml. of a merthiolate-citrate solution and stool specimens were preserved by asking the subject to place a quantity of freshly evacuated stool into a screw-capped jar in which had been placed about 25 ml. of a 10 per cent. formalin solution containing "Teepol," a detergent.

One thousand mature eggs of *S. haematobium* were examined to ascertain the position of the miracidium in the egg; 492 had the miracidium pointing forward and 508 pointing backwards—that is, to the spiked end of the shell. Similarly, 500 *S. mansoni* eggs were examined and the counts were 266 pointing forward and 234 pointing backwards.

#### DISCUSSION

If it is accepted that eggs of *S. haematobium* and *S. mansoni* are sealed into their shell envelopes with the head of the miracidium pointing forward to the rounded end of the shell, it seems that by the time the mature egg is passed into stool or urine the miracidium can be facing either way with equal frequency.

In urine of low specific gravity, active movements of the miracidium within the shell can often be observed even before dilution of the

centrifuged deposit with water has been done. Observation of the hatching process under the microscope generally shows that active ciliary movement, probing movements by the head of the miracidium and twisting movements of the body may occur. It is unusual, however, to see a miracidium turning right round in its shell until the egg shell is swollen up and on the point of rupture.

In the case of eggs of *S. mansoni*, the shell is a very close fit to the body of the mature miracidium and osmotic pressure is very much slower in having its effect, and movements of the miracidium within the shell are limited to rather feeble ciliary action.

It is therefore of some interest to consider at what stage in the maturation of the egg does the miracidium have the opportunity or incentive to turn itself around in its shell. During the intra-uterine stage the developing miracidia may well be so loose within their shells that they can turn about freely. On the other hand, however, at this stage of the development of the miracidium, the ciliary apparatus is not effective. Once the egg has been laid by the worm into the tissues it is in an isotonic state with the body fluids and unlikely to be subjected to any stimulus to turn around in its shell. As the egg is passing through the tissues, maybe as long as three weeks, the miracidium is presumably developing at the expense of the contained vitelline material and comes to fit its shell even more snugly. Schistosome eggs which do not find their way into stool or urine within three weeks are trapped in the tissues and die. When such eggs are examined in *post-mortem* digestion studies they are generally black and solid in appearance and no definition of miracidial anatomy can be observed. Examination of the eggs found in 10 per cent. potassium hydroxide digestion of tissue fragments would be of no use, as the miracidial structure is completely destroyed.

Rectal biopsy material may provide some indication of the stage of turning round of the miracidium in its shell and throw some light on the question as to the stage in the development and progression of the schistosome egg at which this occurs.

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