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SWIMMING AND CRAWLING BEHAVIOUR OF *SCHESTOSOMA SPENDAlE* (MONTGOMERY, 1906)

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ABSTRACT

Rotary The behaviour of Schistosoma spindale cercariae during swimming and crawling was studied using video microscopy. The relevance of continuous, forward, backward, spiral, sinusoidal, and intermittent motions in a water medium has been described and investigated. The details of cercaria's swimming behaviour are quickly reviewed. Common observations included both forward and backward swimming modes, the involvement of furcal ramii, and descriptions of the wave pattern of cercaria's body and tail. Cercariae crawled over the substratum during a prolonged period of vigorous swimming. The cercariae's suckers and the elongation and contraction of their body muscles are shown during their crawling habit.

INTRODUCTION

The pathogenecity that schistosomes (blood flukes) inflict to humans and domesticated animals has given them global relevance. Animal schistosomiasis has garnered a lot of attention because of the morbidity and death it causes (Agrawal, 2003; 2005), but luckily human schistosomiasis is not an issue in India. In order to reach their final host, Schistosome cercaria swim through water. The swimming activities of trematode larvae have been the subject of much research (Gordon and Griffiths, 1951; Cable, 1956; Smyth, 1966). Bundy (1981), Samuelson et al. (1984), and Feiler and Haas (1988) were able to film and see the cercariae's movement more accurately using sophisticated and current technologies including cinematography and video microscopy techniques.The swimming behaviour of S. mansoni cercariae was studied by Samuelson et al. (1984) using a video microscope. The researchers filmed the cercariae's pulsating body and tail movements. Although the involvement of snails has been established, there is still a lack of research about the behavioural features of bovine schistosome larvae (Agrawal, 2003). This research describes the several swimming phases and crawling behaviours of the bovine parasite S. spindale cercariae.

MATERIALS AND METHODS

Using a microscope, we looked for the release of Schistosoma spindale cercariae, a bovine parasite, in Indoplanorbis exustus that had been obtained locally. The insects were divided into three batches and placed in petridishes. Snails with infections were

separated and placed in separate Petri plates, where they were subjected to artificial light in order to facilitate the rapid release of cercariae. When the cercariae had matured for three hours, they were put to use in the experiments. In order to analyse the swimming and crawling activity of cercariae, two or three of them were delicately placed into a Mini Glass Chamber and watched.

Apparatus

The second author of this article created the Rotary Video Microscope at his marine research lab in Gnanapuram, Visakhapatnam. It is an indigenous device.

India, A. P. (Fig. 1). Some adjustments were made to this microscope's rotating stage based on current needs.

One benefit of this device is that it allows the object-holding stage to spin in a circular motion up to 3,600 degrees in both the horizontal and vertical planes. Additionally, the body of the microscope, which contains the eye piece, objective lens, and video camera, may move around 1800 degrees in the vertical plane. The stage and body of the microscope may rotate independently, allowing for observation from any angle without disturbing the object. An option to see the object's picture be magnified and processed by a computer is available.

Compact glass enclosure A Mini Glass Chamber was constructed using glass slides adhered with araldite to fit a rotational video microscope. The chamber's dimensions are 10 mm in length, 10 mm in height, and 2 mm in breadth, allowing for the observation of cercarial swimming and crawling activity. A little glass container with a top aperture and sealed on all three sides

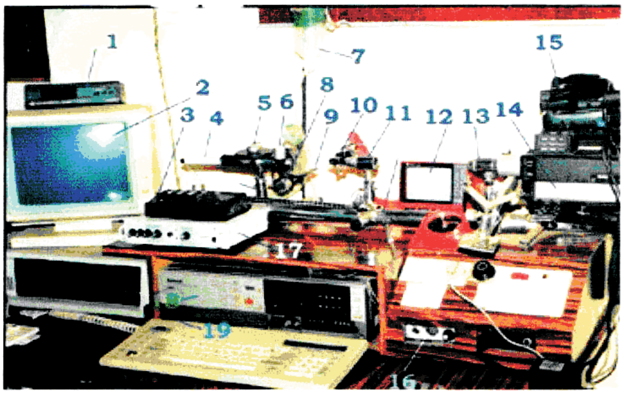

Figure 1: Rotary Video Microscope

1. Video multichannel indicator 2. Computer monitor; 3. Video channel mixer; 4. Back light of the microscope stage; 5. Microscope focus adjusting knob; 6. Knob for horizontal movement; 7. Water dripping bottle; 8. Knob for vertical movement; 9. Stage of the microscope; 10. Lights of the object lens; 11. Object lens holder; 12. Monitor of microscope; 13. Microscope diaphragm; 14. Video camera; 15. Handy Cam Video Camera; 16. Voltage regulator; 17. Channel analyzer; 18. Video Cassette Recorder (VCR); 19. Key board of Computer.

introducing cercariae into the chamber.

RESULTS AND DISCUSSION

Swimming stages of cercaria

1) Various forms of swimming behaviours, such as continuous, forward, backward, spiral, sinusoidal, intermittent, crawling, etc., were observed on Schistosoma spindale cercariae and are classified as follows.
1) During the first stage of cercariae development after snail release, the larvae swim continuously in all directions. When it's in its active phase, it helps the cercariae spread. Stage two of cercariae life cycle: At this point, we saw a variety of motions, including oblique, spiral, and sinusoidal ones. When penetrating a definite host, the forward swimming mode was mostly used for finding, attaching, and applying pressure. The cercariae exhibited backward swimming behaviour mostly during their active phase, which helped to suspend them in the aqueous medium. When swimming backwards, swimmers often displayed a clockwise and anti-clockwise spiral pattern of rotation, although forward movement was also sometimes seen. Cercariae could benefit from this if it makes propelling through water easier and less forceful. When cercariae were close to or on the substratum's floor, they displayed an unpredictable habit known as sinusoidal movement. The cercariae seemed to benefit from this kind of atypical locomotion in choosing an optimal attachment site on the host body.
3) The last stage of cercariae life cycle: while they were trying to save energy, cercariae would swim intermittently. During this inactive phase, cercariae spread their furca and descend to the bottom. During this stage, swimmers could be seen going both forward and backward.

Cercariae entered their death stage when they began to crawl, after a protracted exhaustic stage. It seems that this cercariae behaviour was useful for finding a good spot on the host body. Because the host was unavailable, it resulted

to the death of cercariae.

All of this points to the fact that, not long after emerging from their intermediate host, the Schistosoma spindale cercariae displayed a variety of swimming behaviours in the water. Additional parasite species exhibited similar swimming patterns. Graefe et al. (1967) detailed the forward and backward progressions of cercariae of S. mansoni. According to what Chapman and Wilson (1973) found, cercariae of Himasthla secunda and Cryptocotyle lingua swam in sinusoidal and rotating patterns. Feiler and Haas (1988) noted that the cercariae of Trichobilharzia ocellata exhibited intermittent swimming patterns, including forward and backward motions. Nonetheless, prior records did not provide the specific details of the various phases of swimming activities of S. spindale cercariae. Such behavioural activity could only be seen with the use of an impeccably constructed rotary video microscope, which allowed researchers to speculate on the potential functional relevance of each swimming mode of S. spindale cercariae. Similar to the studies done by Feiler and Hass (1988) in T. ocellata cercariae, the constant swimming activity of S. spindale cercariae intended for dissemination and the intermittant swimming behaviour demonstrated to reduce the energy component of cercariae are similar.

Function of furcal ramii, body and tail wave shape

An essential function for forward and backward swimming modes was found to be the angles of furcal ramii. The furcal ramii remained at a right angle to the tail stem when in the suspension stage. Both ramii are at an angle of about 1800 with respect to the tail stem while the boat is moving forward. Fig. 2 shows that cercariae swim in a manner where their bodies and tails create one continuous wave, with the tail bending 5-10 degrees up to the furcal ramii for every 30µ distance from the body's base. As a result, the cercariae took the shape of a "S"—a trough in the body and a crest in the tail, or vice versa. The cercariae's trough and crest were sometimes visible on the tail alone, in addition to the bending of the body (Fig. 3). In the process of wave generation during forward advancement, the cercaria's tail stem provided a wider tail stroke for the backward push, causing the body waves to be lower in height and amplitude (Fig. 4).

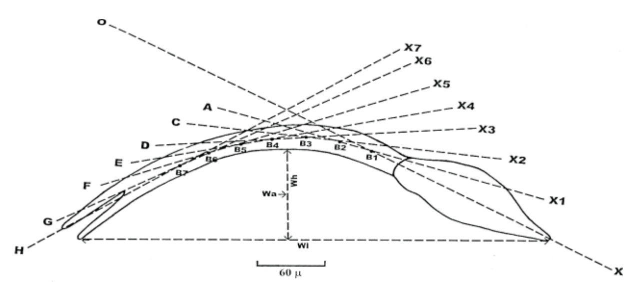

Figure 2: Cercaria of *S.spindale* exhibiting wave patterns of body and tail showing the changed angles for very 30µ distance of tail stem during forward swimming mode

Wl	=	Wave length of Cercaria	= 400µ
Wh	=	Wave height of Cercaria	= 90µ
Wa	=	Wave amplitude of Cercaria	= 45µ
∠AB 0-DB C	=	10^0 at every 30 µ	
∠EB D-HB 0	=	8^0 at every 30 µ	

1 3
4 7

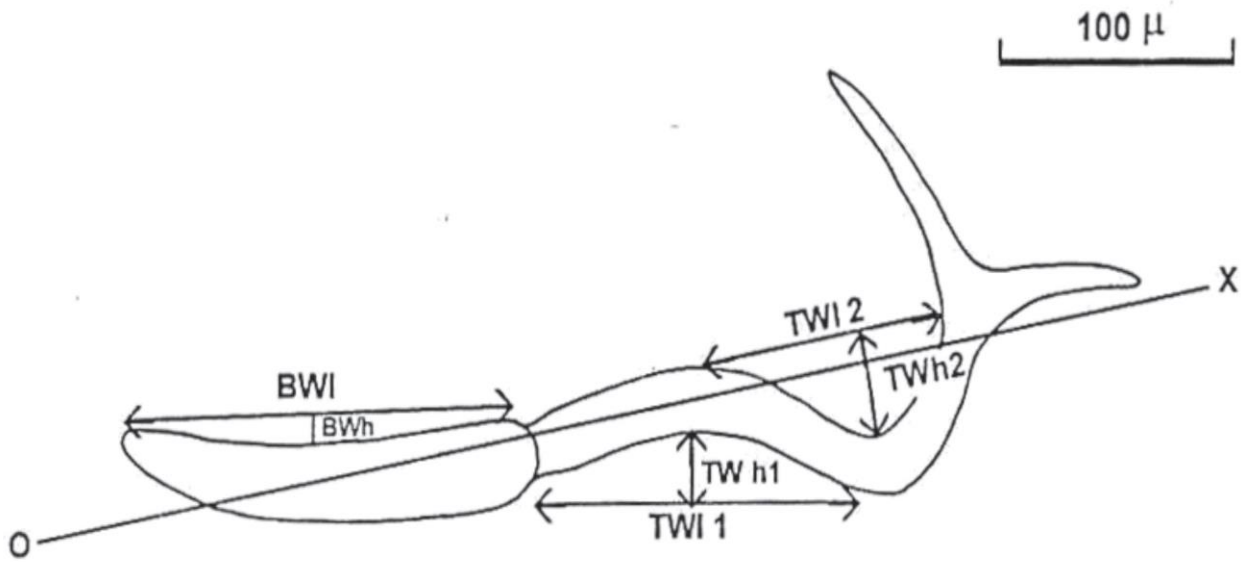

Figure 3: Cercaria of *S.spindale* exhibiting the wave pattern of body and tail stem during forward swimming activity

		Body	
BWl	=	Wave length of the body	= 160μ
BWh	=	Wave height of the body	= 3 μ
		Tail Stem	
TWl_1	=	Wave length of tail stem	= 140μ
TWl_2	=	Wave length of tail stem	= 100μ
TWh_1	=	Wave height of tail stem	= 20μ
TWh_2	=	Wave height of tail stem	= 44μ

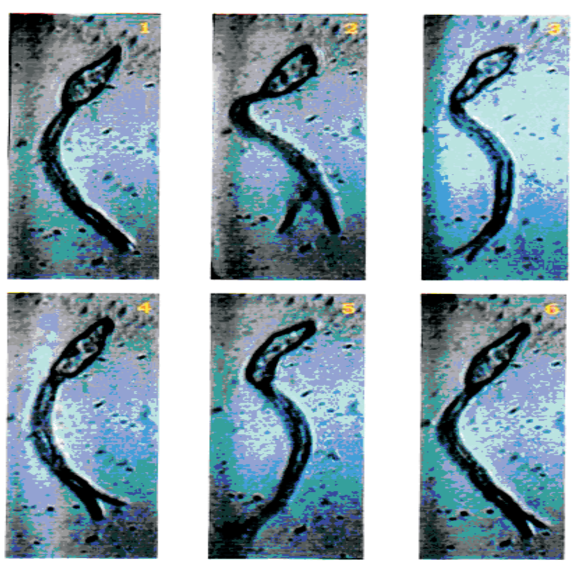

Figure 4: Photo micrograph of live cercaria of *S.spindale* showing forward swinmming activity

When swimming quickly, it was usual to see the cercaria swimming backwards as a smaller wave began at the sub-terminal portion of the tail stem and worked its way towards the body. As a lesser wave developed, the angle of the furcal ramii remained at 900 degrees. However, as a larger wave developed behind the sub-terminal zone, the angle of the right ramus of the furcae increased to 250 degrees at the wave's trough, while the left ramus increased to 1550 degrees near the wave's crest.

Figure 5 shows the wave. It continued following the same sequence as it went from trough to crest and back again. The cercaria retreated as a result of the forward push produced by the left and right furcal ramii's alternating strokes (Fig. 6).

Research on the function of furcal ramii in connection to cercariae's wave-like bodies and tails is scant. The cercariae of S. mansoni were studied by Graefe et al. (1967), who found that wave contraction along the tail stem caused the furcal ramii to be tightly opposed during forward passage. The tail stem might oscillate between two fixed positions to cause it to go backwards. In cercariae of T.ocellata, Feiler and Haas (1988) described a similar process. The cercariae of H.secunda and C.lingua were characterised by Chapman and Wilson (1973) as having tail motions that resemble waves. According to Bundy (1981), cercariae of the species Transversotrema patialense exhibit alternating effective and recovery strokes of furcae.

Findings from our studies on S. spindale cercariae are in agreement with those from Graefe et al. (1967) and Feiler and Haas (1988). Still, researchers have tried to figure out how the furcal ramii relate to each other in both forward and backward swimming. In the cercariae of T.patialense, the symmetrical power for forward push in the aqueous medium was provided by the alternating identical strokes of the left and right furcal ramii during backward swimming, lending credence to the notion of Bundy (1981).

Role of suckers in crawling behavior of cercariae

The crawling behavior appeared to be helpful for searching favorable location on the host body. In the beginning, cercaria holds the substratum with the help of oral sucker and brings the ventral sucker nearer to the oral sucker by contracting the

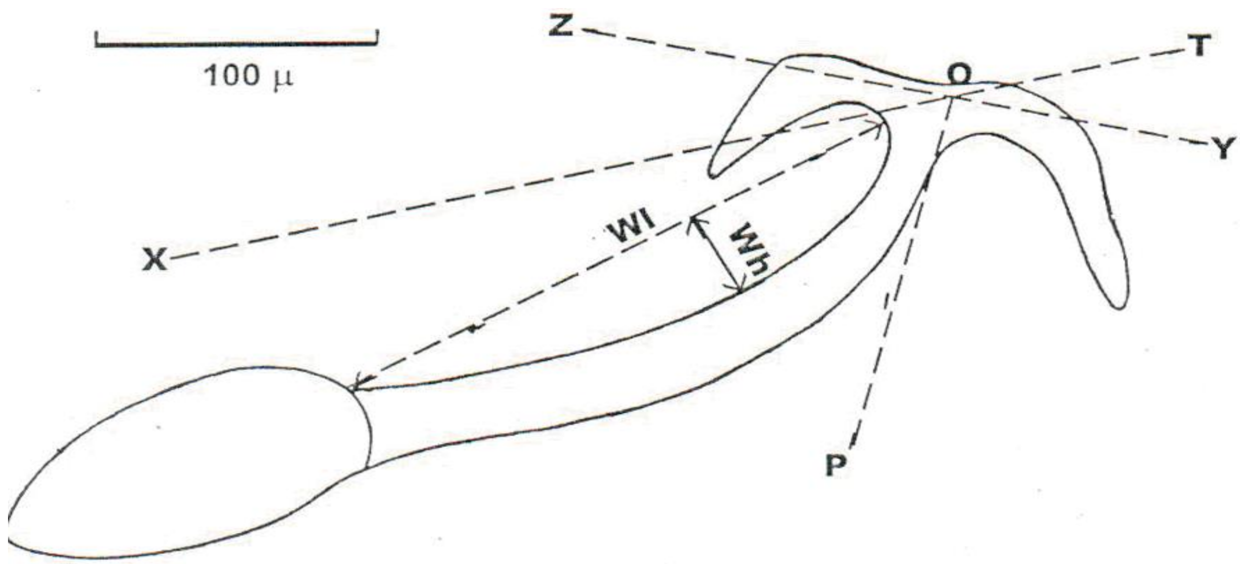

Figure 5: Cercaria of *S.spindale* exhibiting the angles of furcal ramii during the backward swimming activity
ZY =Axis of furcal ramiil; OP = Perpendicular line to the ZY line; WI = Wave length of tail stem = 205µ; Wh = Wave height of tail stem = 40µ; <XOZ = 25º; <XOY = 155º

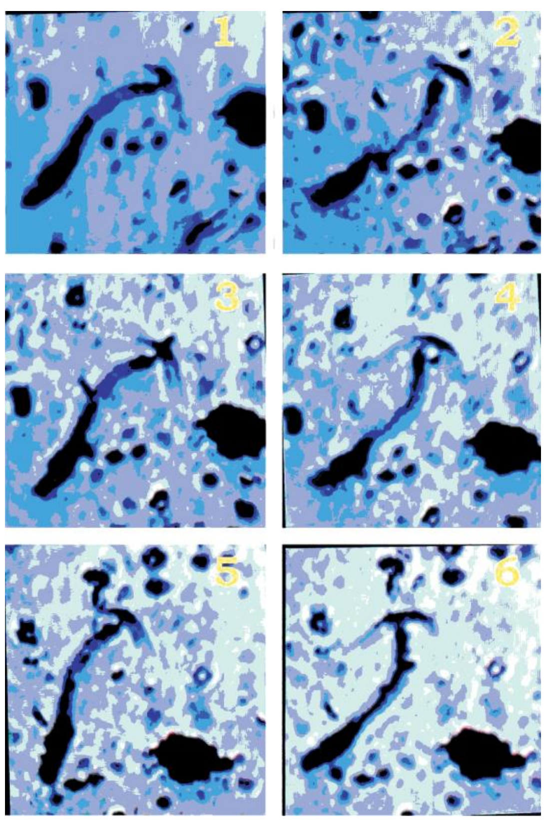

Figure 6: Photo micrograph of live cercaria of *S.spindale* showing backward swimming activity

muscular tissue in the body. It releases the oral sucker after grasping the substratum with the ventral sucker, and then stretches the muscles in the body. After releasing the ventral sucker, it re-uses the oral sucker to grasp the substratum. In this manner, the body's muscles contract and expand.

As seen in Figure 7, the cercaria of S. spindale attach themselves to the substratum via both oral and ventral suckers, like a leech. When cercaria were untethered from their tails, researchers found that their bodies could move independently.

While the cercaria's body isn't involved in locomotion, Chapman and Wilson (1973) found that the shed tail of C. lingua demonstrated autonomous swimming activity. Beyond the tail's lashing motions, the current research found that the body of S. spindale cercaria plays a significant part in locomotion. When I was crawling, this was very obvious. After detaching from the tail stem, the cercarial body continued to travel in a crawling motion. This shift was made easier by both suckers. Neither monocercous nor furcocercous cercariae were found to exhibit this crawling activity.

Details on the swimming behaviour of S. spindale cercariae

Several intriguing findings emerged from the aforementioned research. A unique structure for propulsion in the life cycle of trematodes is the cercaria tail. Monocercous and Furcocercous cercaria have quite different tail movements compared to body movements.

1) The tail goes ahead of the body during movement in monocercous cercaria, such as monostomes, echinostomes, xiphidiocercaria, and Himasthla secunda (Chapman and Wilson, 1973). The cercaria's body is the origin of motile force. It was noted that in furcocercous cercaria, similar to S. spindale, the body came before the tail while moving forward, and the tail came before the body when moving backward. Nonetheless, the tail was the site of origin for the bidirectional motile force.

2) The body does not play a role in locomotion in monocercous cercaria of Cryptocotyle lingua; however, the tail does (Chapman and Wilson, 1973). In contrast, the current work demonstrated that the body of S. spindale cercaria may move independently, in addition to the tail stem.

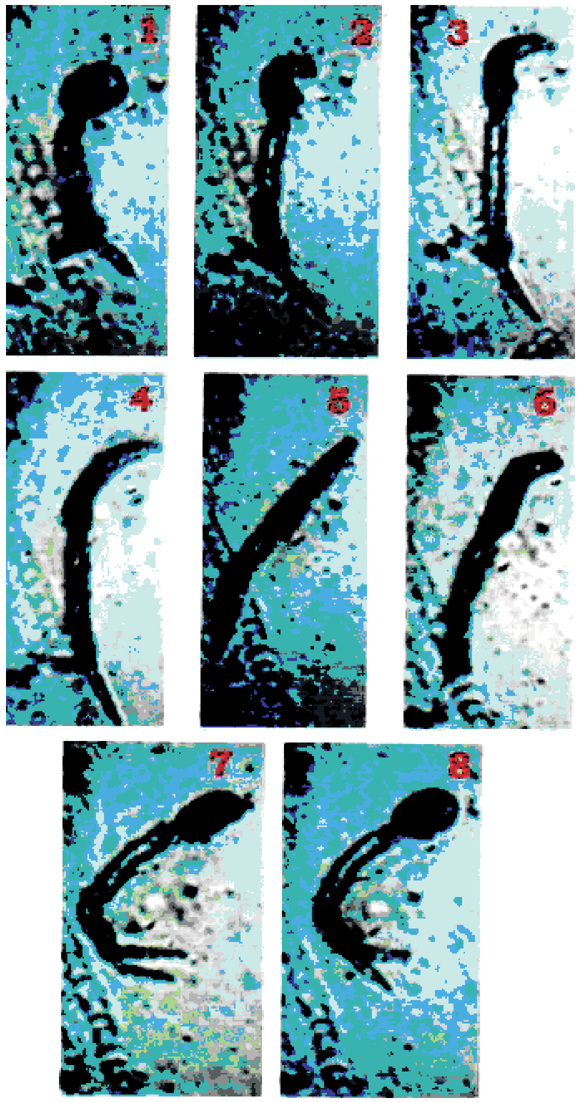

Figure 7: Photo micrograph of live cercaria of *S.spindale* exhibiting crawling movement on the substratum

observed during crawling movement of cercaria.

1) The movement of Monocercous cercaria is asymmetrical, in contrast to that of S. spindale (furcocercous) cercaria.

seldom displayed sinusoidal or spiral-type motions, instead often moving in a straight line while moving forward or backward.

2) The cercaria of S. spindale were found to move in a variety of ways, including vertically, horizontally, diving, and crawling. Except for continuous and uneven motions, no similar findings were reported in monocercous cercaria (Chapman and Wilson, 1973).

3) The furcal ramii were crucial in the forward and backward propelling processes of S. spindale cercaria. However, the furcal ramii are not present in monocercous cercaria. Consequently, there is a lack of directionality. According to Chapman and Wilson (1973), the tail's asymmetry allowed it to change its orientation.

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