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SWIMMING AND CRAWLING BEHAVIOUR OF *SCHISTOSOMA SPINDALE* (MONTGOMERY, 1906)

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ABSTRACT
Rotary Video microscopic observations were made to study the swimming and crawling behaviour of cercariae of *Schistosoma spindale*. Continuous, forward, backward, spiral, sinusoidal and intermittent movements have been studied and their significance in the water medium was described. Specifications in swimming activity of cercaria are briefly discussed. Forward and backward swimming modes were the common observations and the role of furcal ramii along with wave form of body and tail of cercaria has been described. The crawling behaviour of cercariae was observed on substratum after exhaustive swimming activity for a longer period. During the crawling behaviour the correlation between the suckers, and the contraction and expansion of the body muscles of cercariae are described.

INTRODUCTION

Schistosomes (Blood flukes) have gained world wide significance as they cause pathogenecity to both man and his domesticated animals. In India fortunately human schistosomiasis is not a problem, but animal schistosomiasis has received considerable attention due to its effect which causes morbidity and mortality (Agrawal, 2003; 2005). Swimming of Schistosome cercaria in water is mainly meant for reaching its definitive host. Considerable attention has been paid on the swimming behavior of larval trematodes (Gordon and Griffiths, 1951; Cable, 1956; Smyth, 1966). The advanced and modern methods like Cinematography and Video microscopy techniques paved the way for recording and observing the movement of the cercariae more precisely and such observations were made by Bundy (1981), Samuelson *et al.,* (1984) and Feiler and Haas (1988).Samuelson *et al.,* (1984) observed the swimming behaviour of cercariae of *S.mansoni* by using Video microscope where they recorded the beating motion of body and tail of the cercariae. At present very little information is available on the behavioural aspects of larvae of bovine schistosomes although role of snails has been documented (Agrawal, 2003). In this paper different modes of swimming stages and crawling behaviour of cercariae of *S.spindale* (bovine parasite) have been described.

MATERIALS AND METHODS

Indoplanorbis exustus, after collected locally were separated into batches of three in petridishes and were examined for the release of *Schistosoma spindale* (bovine parasite) cercariae by using an eye piece of microscope. Infected snails were isolated and kept in other Petri dishes and they were exposed to artificial light for quick release of cercariae. The emerged cercariae were used for conducting experiment at the age of three hours. Two or three cercariae were carefully transferred into a Mini Glass Chamber and were observed to study the swimming and crawling behaviour of cercariae.

Apparatus

Rotary Video Microscope is an indigenous instrument designed and fabricated by second author of this paper in his marine research laboratory, Gnanapuram, Visakhapatnam, A. P. India (Fig. 1). On the basis of present requirement, a few modifications were made at the rotating stage of this microscope.

There is an advantage of using this apparatus where the object holding stage rotates circularly both in horizontal and vertical plane upto 3600 and the body of microscope holding the eye piece, objective lens and Video camera also rotates upto 1800 in a vertical plane. This kind of independent rotary movement of stage and body of the microscope enables to observe at any angle without disturbing the object. There is a provision to monitor magnification and processing of the image of the object with the help of computer.

Mini glass chamber

To observe cercarial swimming and crawling behaviour, a Mini Glass Chamber having measurements of 10 mm length, 10 mm height and 2mm width was prepared by using pieces of glass slides which were attached with araldite adhesive to suit rotary video microscope. All three sides of the mini glass chamber were made tight leaving opening on the top for

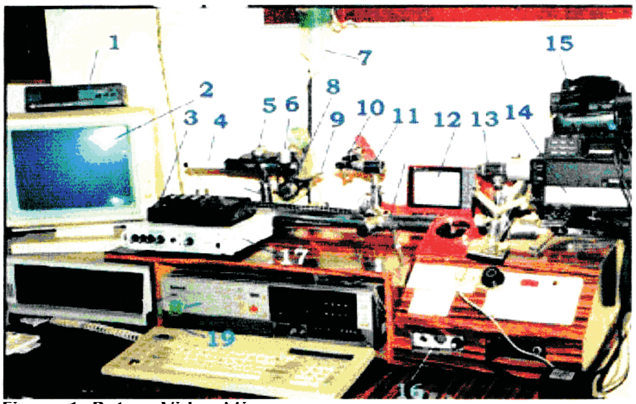

Figure 1: Rotary Video Microscope

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

The observations on cercariae of *Schistosoma spindale* showed different types of swimming activities like continuous, forward, backward, spiral, sinusoidal, intermittent, crawling etc., and are categorised as follows.

1) Just released stage of cercariae from snail: Continuous swimming in all directions was observed in this stage. It indicates the active phase and useful for dispersal of cercariae.

2) Searching stage of cercariae: Forward, backward, spiral and sinusoidal movements were observed in this stage. The forward swimming mode was mainly used for searching, attachment and exerting pressure during penetration into the definitive host. The backward swimming behaviour was used to keep the cercariae in suspension in the water medium and observed mostly during active phase. The clockwise and anti-clock wise spiral type of rotation was observed mostly during backward swimming mode and occassionally during forward progression. This may help cercariae for easy propulsion in the water medium with a less propulsive force. Sinusoidal movement was an erratic behaviour exhibited when cercariae were nearer or on the floor of substratum. This type of irregular locomation appeared to help the cercariae to select a better place over the host body for attachment.

3) Exhaust stage of cercariae: In this stage, cercariae exhibited intermittent swimming behaviour to minimize energy factor. It indicates the passive phase in which the cercariae sink down by spreading the furca. Both forward and backward swimming modes were also observed in this phase.

4) Death stage of cercariae: After prolonged exhaustic stage, cercariae exhibited crawling type of behaviour. This behavior of cercariae appeared to be helpful for searching favourable location on the host body. The non availability of the host led to the death of cercariae.

The foregoing observations show that the cercariae of *Schistosoma spindale* exhibited different modes of swimming behaviour in the water medium soon after their emergence from the intermediate host. Such type of swimming modes was also found in other parasitic species. Forward and backward progressions in cercariae of *S.mansoni* were described by Graefe *et al.,* (1967). Sinusoidal and rotary swimming activities in cercariae of *Himasthla secunda* and *Cryptocotyle lingua* were recorded by Chapman and Wilson (1973). Intermittant, forward and backward swimming modes were observed by Feiler and Haas (1988) in the cercariae of *Trichobilharzia ocellata*. However the detailed descriptions of different stages in swimming activities of cercariae of S.spindale were not recorded previously. Indeginously designed Rotary Video Microscope paved the way to observe such behavioural activity and to predict the possible functional role of each swimming mode of cercariae of *S.spindale*. The continuous swimming activity of cercariae of *S.spindale* meant for dispersal, and the intermittant swimming behaviour exhibited to minimize the energy factor of cercariae are comparable with workdone by Feiler and Hass (1988) in cercariae of *T.ocellata*.

Role of furcal ramii along with wave form of the body and tail

It was observed that the angles of furcal ramii played an important role for the forward and backward swimming modes. In suspension stage, the furcal ramii maintained 900 angles to that of the tail stem. During forward propulsion, both the ramii closely apposed to 1800 angle to that of the tail stem. In this mode of swimming the body and tail of cercariae formed a single wave in which for every 30μ distance from the base of the body, the tail bends between 5-10 upto the furcal ramii (Fig. 2). After this the cercariae formed an "S" shaped structure in which the body formed a trough and the tail became a crest or vice versa. Some times in addition to the bending of the body of cercariae, the tail alone exhibited a trough and a crest (Fig. 3). During the wave formation of the forward progression, the wave height and the wave amplitude of the body was lesser when compared to the tail stem which gave the broader tail stroke for the backward thrust due to which the cercaria moved in forward direction (Fig. 4).

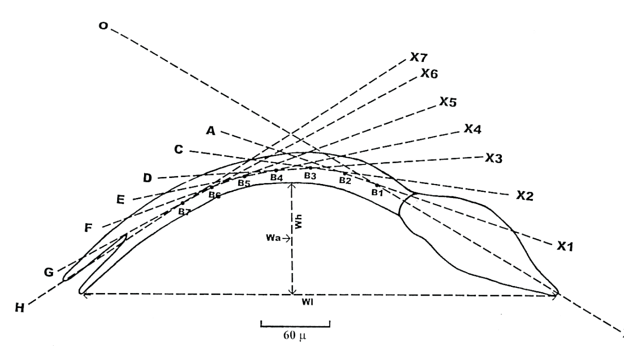

Figure 2: Cercaria of *S.spindale* exhibiting wave patterns of body and tail showing the changed angles for very 30μ distance of tail stem during forward swimming mode

Wl	=	Wave length of Cercaria	= 400μ
Wh	=	Wave height of Cercaria	= 90μ
Wa	=	Wave amplitude of Cercaria	= 45μ
$\angle AB_1O\text{-}DB_3C$	=	10^0 at every 30 μ	
$\angle EB_4D\text{-}HB_7O$	=	8^0 at every 30 μ	

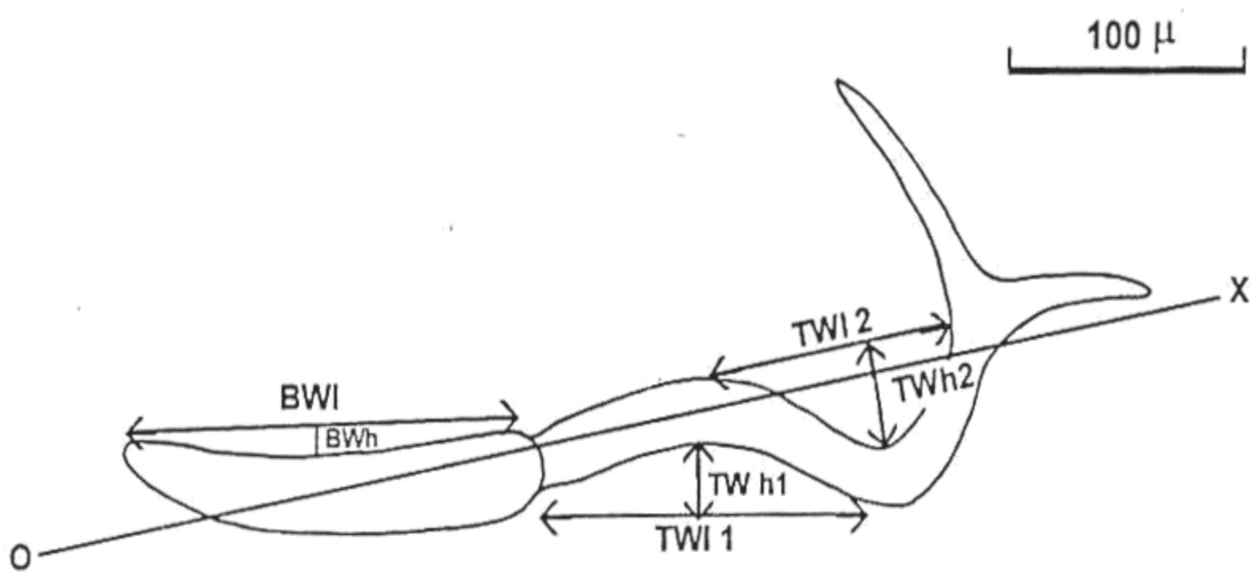

Figure 3: Cercaria of *S.spindale* exhibiting the wave pattern of body and tail stem during forward swimming activity

		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

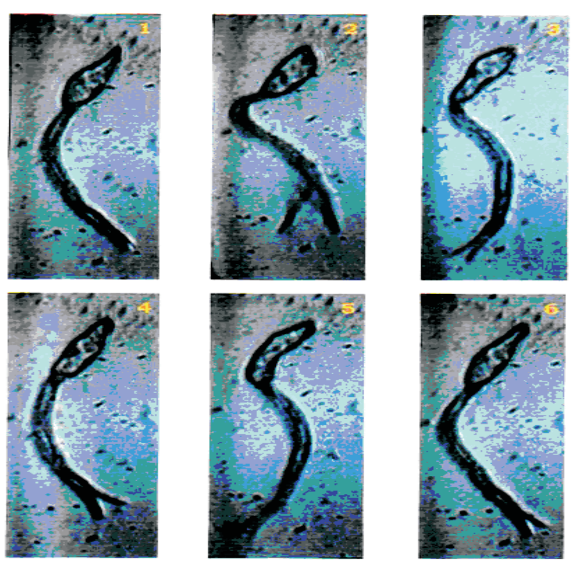

Figure 4: Photo micrograph of live cercaria of *S.spindale* showing forward swinmming activity

The backward swimming was commonly observed during fast progression where a smaller wave started at the sub-terminal part of the tail stem and proceeded towards the body of cercaria. During the formation of smaller wave, the angle of furcal ramii maintained 900, when the bigger wave formed behind the sub-terminal region the angle of right ramus of furcae came to 250 towards the trough of the wave where as the left ramus came to the angle of 1550 towards the crest of the wave (Fig. 5). When the trough became crest, it maintained the same procedure and vice-versa. The alternate strokes of the left and right furcal ramii exert forward thrust due to which the cercaria moved in backward direction (Fig. 6).

There are few investigations who reported the role of furcal ramii in relation with the wave forms of the body and tail of cercariae. Graefe *et al.,* (1967) worked on the cercariae of *S.mansoni* and stated that the furcal ramii were closely opposed during forward progression due to wave contraction passing down the tail stem. Backward progression was effected by oscillation of tail stem by two fixed points. Similar mechanism was reported by Feiler and Haas (1988) in cercariae of *T.ocellata*. Chapman and Wilson (1973) described the wave form of tail movements in the cercariae of *H.secunda* and *C.lingua*. The alternate effective and recovery strokes of furcae in cercariae of *Transversotrema patialense* were described by Bundy (1981).

Our observations made in the cercariae of *S.spindale* conform the results of Graefe *et al.,* (1967) and Feiler and Haas (1988). However an attempt has been made to calculate the angular relationship of the furcal ramii during forward and backward swimming modes. The alternate similar strokes of left and right furcal ramii during backward swimming gave the symmetrical force for forward thrust in the water medium which supports the view of Bundy (1981) in the cercariae of *T.patialense*.

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

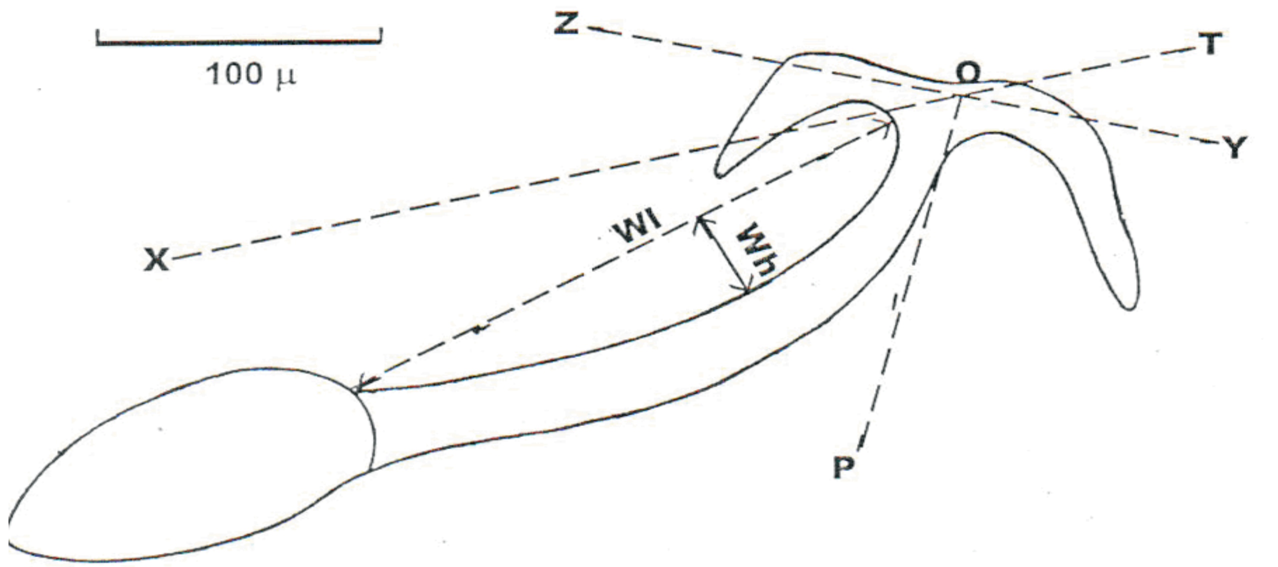

Figure 5: Cercaria of *S.spindale* exhibiting the angles of furcal ramii during the backward swimming activity
ZY = Axis of furcal ramiil; OP = Perpendicular line to the ZY line; Wl = Wave length of tail stem = 205μ; Wh = Wave height of tail stem = 40μ; <XOZ = 25°; <XOY = 155°

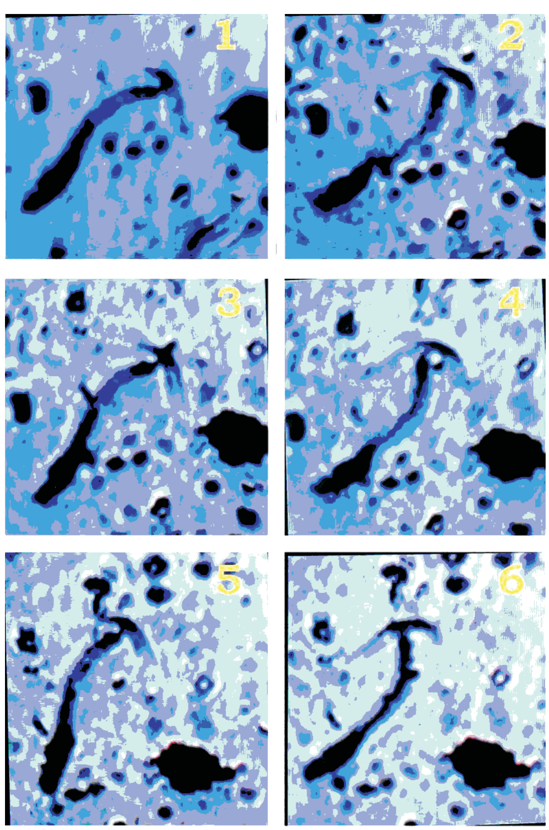

Figure 6: Photo micrograph of live cercaria of *S.spindale* showing backward swimming activity

body muscles. After holding the substratum with the help of ventral sucker, it releases the oral sucker, then stretches the body muscles. Now it holds the substratum again with the help of oral sucker by releasing the ventral sucker. Thus, by the way of contraction and expansion of the body muscles and with the help of oral and ventral sucker the cercaria of *S.spindale* crawls on the substratum like a leech (Fig. 7). It was also observed that the body of cercaria separated from the tail had independent movement.

Chapman and Wilson (1973) stated that the shed tail of cercaria of *C.lingua* exhibited independent swimming activity where as the body of cercaria has no role in the locomotion. The results of the present study indicate that the body of cercaria of *S.spindale* has an important role during locomotion besides the lashing movements of the tail. This was quite evident during crawling movement. The cercarial body exhibited individual crawling movement even after separating from the tail stem. Both the suckers helped in this movement. This type of crawling behaviour was not reported either in monocercous cercariae or in furcocercous cercariae.

Specifications in swimming activity of cercariae of *S. spindale*

Several interesting observations were made from the foregoing studies. The tail of cercaria is a novel structure for propulsion in trematode life cycle. The movement of tail differs considerably from that of body both in Monocercous and Furcocercous cercaria.

1) In monocercous cercaria like monostomes, echinostomes, xiphidiocercaria and in *Himasthla secunda* (Chapman and Wilson, 1973) the tail precedes (moves in advance) the body during locomotion. Motile force starts from the body of this cercaria. In furcocercous cercaria like in *S.spindale* it was observed that the body preceded the tail during forward propulsion and the tail preceded the body during backward propulsion. However the motile force in both directions was initiated in the tail itself.

2) In monocercous cercaria of *Cryptocotyle lingua*, the tail has independent movement but body has no role in locomotion (Chapman and Wilson, 1973). Whereas in the present study, the body of cercaria of *S.spindale* showed independent locomotion along with tail stem. This was

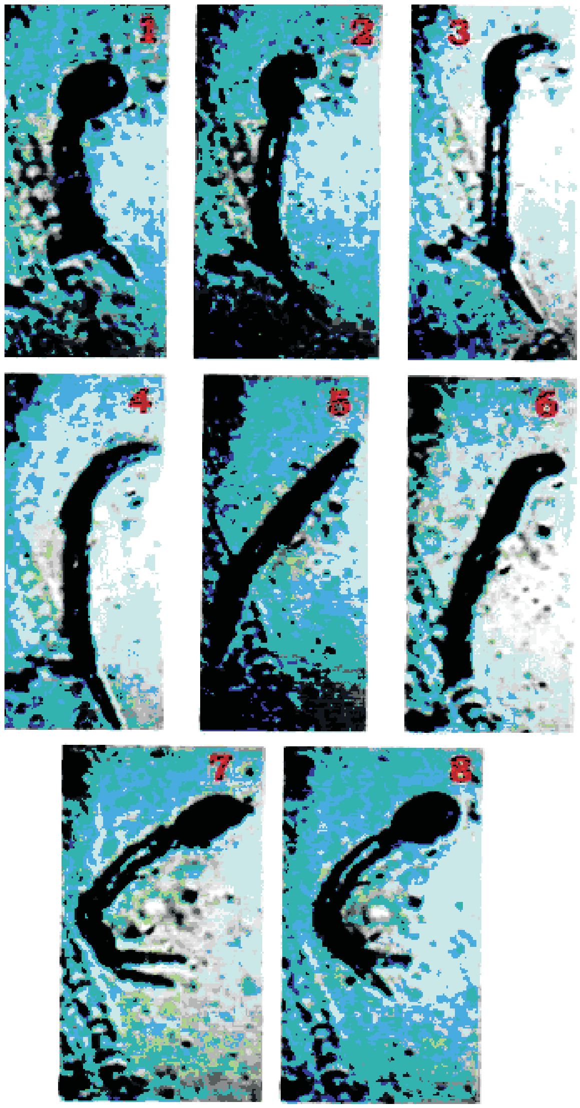

Figure 7: Photo micrograph of live cercaria of *S.spindale* exhibiting crawling movement on the substratum

observed during crawling movement of cercaria.

3) Monocercous cercaria exhibits asymmetrical path during locomotion while the cercaria of *S.spindale* (furcocercous) mostly exhibited straight line during forward and backward progressions, rarely it showed sinusoidal and spiral type of movements.

4) Vertical, horizontal, diving and crawling movements were observed in cercaria of *S.spindale*. No such observations were made in monocercous cercaria except continuous and asymmetrical movements (Chapman and Wilson, 1973).

5) Furcal ramii played an important role during forward and backward propulsious in cercaria of *S.spindale*. But in monocercous cercaria furcal ramii are absent. Thus there is no forward and backward movements. Change of direction was accomplished by asymmetrical beat of the tail (Chapman and Wilson, 1973).

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