INTRODUCTION

Schistosomes (Blood flukes) have gained world wide significance as they cause pathogenicity 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

Indoplanorb is 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.

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.
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 occasionally 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 locomotion 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 exhaustive 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). Intermittent, 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. Indigenously 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 intermittent 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 angle 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 1: Rotary Video Microscope](image)

![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](image)

The diagrams represent the angles and wave patterns observed during swimming activities of cercariae of *S.spindale*.
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 90°, when the bigger wave formed behind the sub-terminal region the angle of right ramus of furcae came to 25° towards the trough of the wave whereas the left ramus came to the angle of 155° 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.oceifata. 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
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 whereas 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
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).

REFERENCES


