

THE EFFECTS OF SCHISTOSOMIASIS

ON THE BEHAVIOUR OF CHILDREN

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U N I V E R S I T Y   O F   N A T A L

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### A B S T R A C T

An ethological study was undertaken in two primary schools in Natal to assess the effect of schistosome infections on the ordinary behaviour of schoolchildren in endemic areas. The following topics are discussed :-

1. The life cycle of the parasite, the possibility of an evolved tolerance of it, the likely limits of such tolerance, the possibility of selective exposure of certain kinds of children to the parasite, and the role of severity of infection in impairment.
2. Appropriate measures for investigating the impairment of the human host centring around the measurement of activity in the context of social interaction.
3. An ethological approach to evaluating human response to disease.

Results indicate that there is selective exposure of more active, sociable children to the disease. In low-level infections of both *Schistosoma haematobium* and *Schistosoma mansoni* there is little evidence of a drop in energetic activity under normal conditions. In subjects with higher egg counts or simultaneous infections with both schistosomes, activity levels drop generally, and especially under hot, humid weather conditions where the drop in activity is greater than that for control subjects.

This work throws doubt on earlier studies indicating that the parasite had no behavioural effect on humans: these studies did not control for selective exposure and may have used methods of low sensitivity and doubtful relevance to everyday life.

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PART 1

LITERATURE REVIEW

## THE AIMS

1. To assess a broad spectrum of possible behavioural differences between children with schistosome infections and uninfected children, and thence to investigate an aspect of the seriousness of the infection in its sub-clinical form. The ultimate aim is to provide guidelines for control and treatment programmes.
2. To discuss the value of the ethological method in human psychological studies; to examine the effects of a schistosome on its human host as an instance of behavioural adaptation to an environmental stress factor.

## CHAPTER 1

### SCHISTOSOMIASIS

---

An estimated 75,000,000 people in Africa have Schistosome infections (Walker 1977). The vast majority of cases are sub-clinical and therefore untreated. Are there detectable signs of behavioural impairment which affect the ability of the individual during the course of the disease and have implications for later life?

The clinical importance of the disease has been the subject of debate since the 1930s according to Bhagwandeem (1968): on the one hand Pijper (1934) suggested that "the harm done by urinary bilharziasis amounts to little more than a periodic loss of blood"; on the other hand Vermooten (1937) was of the opinion that the same disease produced "severe renal pathology". The behavioural damage inflicted by the parasite on its human host has similarly been the source of controversy with researchers holding widely disparate views.

The research areas which are of relevance to the present study are:

1. Those centred around the parasite's life-cycle demonstrating how the parasite can be so enormously successful in survival terms. This, in turn, has relevance to the suggestion that host and parasite have evolved a great deal of mutual tolerance.
2. That dealing with possible impairment of health and work performance due to schistosomiasis.
3. That concerned with the possibility of selective exposure of certain people to the disease.

#### THE LIFE CYCLE OF THE SCHISTOSOME

"A Schistosome is a 'good' parasite. It is 'good' in the sense that the host can tolerate its presence, and is little harmed by it." P.J. Fripp (1972 P 5)

#### The human host

Fripp (1972) describes in hedonistic terms how the adult schistosomes lie in the blood vessels of the host "bathed in nutrient". Waste products are simply carried away by the host's blood stream. The host does not reject this foreign body because it is not only surrounded by an immunologically inert substance, but also incorporates host protein into its body.

The adult worms survive in the host for probably 5 to 10 years. They mate and eggs are released into the blood stream. Warren (1978) states that the eggs have been definitively shown to be the cause of disease syndromes in humans. A large proportion of eggs remain in the host and the immune response to them takes the form of a granuloma around the egg, blocking blood flow and destroying surrounding tissues.

Other eggs pass into the bladder or bowel and finally are excreted into the environment in varying numbers (Bhagwandeem, 1968). Thus, although there is a relationship between egg output and worm load, egg output on any one testing is unreliable as an indicator of worm load. J.E. McMahon (1976) shows a diurnal pattern of egg-excretion in a person harbouring *S. haematobium*, with a peak around the middle of the day. This is possibly an example of an adaptive behavioural pattern with the parasite maximising its chances of being deposited in fresh water by being excreted in the heat of the day.

The eggs hatch in fresh water and the miracidia locate a snail either fortuitously or by some as yet unknown mechanism.

#### The snail host

The miracidia penetrate the snail and migrate to the digestive organs. The miracidium develops into a primary sporocyst which gives rise to secondary sporocysts eventually giving rise to cercariae. At this stage the parasite is often highly damaging to the snail, although with a short life-span and high reproductive rate the snail population probably renews itself rapidly. Shiff, Evans, Yiannakis and Eardley (1975) showed that the rate of shedding of cercariae was increased during the hot months and diminished during cooler weather. The cercariae usually emerge during the day. They penetrate the skin of a human host, and travel to the portal vein, and the cycle is complete.

Warren (1973) mentions 3 distinct clinical syndromes: "swimmer's itch" or the rash caused by the passage of the schistosome through the skin; Katayama Fever, most commonly occurring in *S. japonicum* and coinciding with the onset of production of eggs; and chronic fibro-obstructive disease where eggs lodge in the body-tissue.

### The pattern of the host-parasite relationship

V. de V. Clarke examined the results of the epidemiological surveys in Rhodesia (1966) and concluded that blacks appear to have more natural and acquired resistance to schistosomiasis than whites; resistance may be specific to each species of parasite; strongest resistance develops in communities with moderate schistosomiasis transmission rates as opposed to those with high or low transmission rates.

The exposure to schistosome infections may differ in groups with different water contact patterns. For example, Castle, Clark and Hendrikz (1974) reported that white children with bilharzia or with a previous history of the infection tended to come from the lower socio-economic classes, presumably because they were less likely to have access to swimming pools, and swam in natural waters. In black communities with little or no piped water, a different water contact pattern would operate: active children would play in the rivers, and responsible children would be assigned household duties such as fetching water and washing clothes.

Warren (1973) pointed to stability in the host-parasite relationship, where there is relatively low human morbidity due to the parasite and a large proportion of the human host population carry a light worm load.

In Africa where schistosomiasis is known to have existed in the time of the Pharaohs, it is likely that low-level infections have been widely dispersed throughout the continent in favourable ecological conditions. The parasite probably maintained itself through this characteristic wide dispersion with only occasional severe impairment to its definitive host. The long history of the parasite in Africa suggests that conditions were favourable for the evolution of genetic resistance in those human communities where transmission rates started to rise, impairment became greater, then selection for genetic resistance occurred.



With modern irrigation methods large tracts of land are becoming habitats par excellence for snails, and a concomitant rise in the density of human populations is contributing to the generally accelerated transmission rate. Selection pressure for greater acquired resistance is unable to operate in the short time-scale and population mobility of a migratory labour system. Under these conditions impairment in the human host may be expected to rise.

This account of the life-cycle of the schistosome has several implications for a study of the effects of schistosomiasis on the behaviour of children:-

1. Because contact with contaminated water is the vital link between the snail and man, water contact patterns in the population of an endemic area are important in determining the form of selective exposure that takes place. In areas where there is no piped water, there are 2 groups of people who are likely to be in contact with river water for long periods during the heat of the day: those whose role it is to do the washing of clothes and collection of water for domestic purposes, probably female members of families; and those who use water for recreational purposes - probably active and adventurous children.
2. The unreliability of any one testing of urine or stool specimens for determining the presence and the severity of the infection introduces a significant source of error into the present study. Repeated testing was therefore deemed to be necessary wherever practical.
3. Bhagwandeem (1968), Fripp (1972) and Warren (1973) regard detectable disease to be primarily connected with the passage of eggs through the body tissue. It is possible, however, that other factors such as the loss of nutrients in the human host or the release of waste products into the bloodstream could cause damage as yet undetectable in biochemical terms but nevertheless manifest in behavioural changes in the host.

## RESEARCH INTO THE IMPAIRMENT OF HEALTH AND PERFORMANCE CAUSED BY SCHISTOSOMIASIS

One would expect individuals to change to accommodate a parasite, and this change is likely to have a behavioural component. If behaviour before the change can be assumed to be nearly optimal, most changes would be maladaptive in an uninfected individual. For this reason the research into the change in health and performance is termed "impairment".

It is possible to study disease effects at a number of different levels, all linked, but none able to be reduced entirely to a previous level.

Level 1 Structural and Biochemical Effects: For example, liver damage and low haemoglobin counts.

Level 2 Physiological Effects: These may be measured in terms of oxygen uptake and cardiac frequency during exercise, but are not directly comparable to Level 1 effects because of the intervention of physiological coping strategies mobilised by the immune system of the body.

Level 3 Behavioural Effects: These in turn cannot be reduced to structural and biochemical or physiological effects owing to the intervention of behavioural and cognitive coping strategies. This is an often neglected level of investigation but is nevertheless of interest in its own right. It has implications for assessing the seriousness of a widespread parasitic infection because decrease in activity level or concentration span has enormous social and economic implications regardless of whether or not impairment can be demonstrated at the physiological or structural level.

"The salient features of the mental symptoms found in children suffering from schistosomiasis are forgetfulness, indifference to punishment, apparent laziness and disinclination to mental exertion combined with a sometimes very marked nervous irritability, obstreperousness and mental fatigue." Kieser (1947 P 854).

Most of the research into the effects of bilharzia on health and performance take as their starting point this contention by Kieser in 1947 based on anecdotal evidence from white schoolchildren. In 1977 A.R.P. Walker published a review of the research that had bearing on Keiser's statement and reported that 2 main points had emerged :-

1. An apparent difference between the effects of the disease in white schoolchildren and the effects in black children

Three Rhodesian studies largely confirmed Kieser's impression of the disease in whites (Loveridge, Ross and Blair, 1948; Clarke and Blair, 1966; Castle, Clarke and Hendrikz, 1974). Collectively their results showed that both *S. haematobium* and *S. mansoni* were associated with lower academic performance. Castle et al (1974) found that treated children made progress on tests dealing with spacial relationships and numbers rather than verbal ones which implied that impairment in academic ability might have been the product of intellectual fatigue.

By contrast, Loveridge et al (1948) found that the academic achievement of black children with schistosomiasis was unimpaired and indeed seemed superior to that of their uninfected classmates.

2. The absence of stigmata in blacks with schistosomiasis

Wyndham et al (1958) found no impairment with respect to height, weight and oxygen consumption. Walker's own work from 1962 to 1969 showed no evidence of impairment in black children with schistosomiasis on physical, physiological and performance measures. Similarly Goldin and Barclay (1972) showed no difference in respect of academic performance and Cook, Baker, Warren and Jordan (1974) showed no difference in respect of anthropometric measures and gastro-intestinal symptoms.

A further line of research was conducted on productivity amongst infected sugar cane workers. Foster (1967) says "statements that such infection leads to loss of efficiency are often based only on the premise that 'it must be so', and specific confirmatory data are rare". He quotes Gordon (1953) in the Sudan who said that he and Davey "made strenuous but unavailing efforts to obtain reliable evidence from the local authorities for or against any marked loss of man-power being attributable to infection with one or both of these parasites." Foster's own study found no difference between infected and uninfected workers in terms of actual work output.

Collins et al (1976) in a study using physiological tests of work performance and measurements of field productivity "failed to find any clear evidence that *S. mansoni* affects standard parameters of physiological function or productive output in the normal working situation. These findings...raise the question as to why the discrepancy exists between the widely held view that schistosomiasis seriously prejudices working capacity and the lack of substantive experimental data to support it."

In the light of this substantial evidence can one conclude that schistosomiasis in its sub-clinical form causes little or no impairment in health and performance in black populations in endemic areas. Researchers generally are reluctant to do so and there are a few studies that indicate that an impairment effect is likely, albeit elusive.

#### Evidence for an impairment effect

Experiments with rats show impairment of performance under certain conditions. Kershaw, Leytham and Dickerson (1959) found that maze performance in rats was adversely affected by low-grade infection with schistosomiasis. Stretch, Leytham and Kershaw (1960) investigated the effects of 3 levels of motivation in an underwater swimming task in rats and found that in the lowest level of motivation, rats with schistosomiasis showed a significantly lower rate of learning than uninfected controls. At higher drive levels, however, there was no difference between the groups. They also suggested therefore that the poorer performance of the infected rats in the original experiment was due to 'lethargy' induced by the infection.

Okpala (1961) in the course of a survey of *S. haematobium* in a town in Western Nigeria remarked in his discussion that observation showed that the children manifested undue signs of fatigue during physical exercise and that school absenteeism was often attributed to bilharziasis. Although no egg counts were quoted, the incidence of infection was estimated to be 94.6% so presumably worm loads were high as well. The evidence here corresponds to Keiser's anecdotal evidence for whites.

Jordan and Randall (1962) investigated height and weight, haemoglobin counts, exercise tolerance and scholastic ability in Tanganyikan schoolboys infected with schistosomiasis and compared means with those from uninfected colleagues. Boys with *S. haematobium* were successfully treated and a further set of measures were taken. Their results suggest that boys with *S. mansoni* had lower haemoglobin values, were smaller and weighed less than others. The study of exercise tolerance revealed 2 important variables in the measurement of activity: time of day and seasonal weather conditions. Performance figures for the infected group were lower than for the uninfected group in one comparison, and particularly so for measures taken later in the day. Performance figures were lower too for the infected untreated group when compared with the treated group. The figures did not reach statistical significance. The control of the environmental variables shows an awareness of the problems involved in activity measurement which is not evident in most bilharzia studies. No information is given about the control of any other subject variables such as age or egg count. The measurements were based on pulse rates after a set task. With regard to scholastic ability, the infected group had generally higher marks than the uninfected group. After treatment, however, the treated group had made greater improvements in their class position than either the untreated infected group or the uninfected group.

Abdallah, Badran and Gala (1964) showed that while there was a general tendency for uninfected schoolchildren in Egypt to perform better on tests of mental ability than their infected schoolmates, only the numerical ability test showed a significant difference.

Foster (1967) could find no difference in terms of actual work output among infected and uninfected labourers in Tanganyika. He did, however, report greater absenteeism among infected workers and a consequently lower total production rate. Fenwick and Figenschou (1972) found that workers infected with *S. mansoni* on a sugar estate in Tanzania earned less in bonus pay than their uninfected counterparts, and that treated workers improved their bonus earnings relative to an untreated group.

Bell, Daly, Kanengoni and Jones (1973) found a significantly poorer performance on Ravens Matrices in children with schistosomiasis than in uninfected children. Fifty-eight children were treated with hycanthone. The groups were re-tested and the treated group showed an improvement whereas the untreated group did not. No significant difference was found between groups on body size, growth, biochemistry or school examination results.

Ohmer and Ahmed (1974) found that lung function and a physical condition index in male nurses with *S. mansoni* improved after treatment.

Of major importance is a recent study (El Karim et al, 1980) in the Sudan where maximum aerobic power output ( $\dot{V}O_{2\max}$ ) in an uninfected group was higher than in a group heavily infected with *S. mansoni* and this difference was statistically significant. There was no difference on this measure between uninfected and lightly infected groups. This indicates that severity of infection is an important factor in studies of this nature. The heavily-infected subjects were however all canal-cleaners which causes some difficulty in the interpretation of the results. They differed from the uninfected and lightly infected villagers in several respects : they slept more (2 hours a day), their monthly income was approximately half that of the villagers, they participated less in sporting activities and smoked less. The causal links underlying these differences are not at all clear. The canal cleaners may have taken up this poorly paid occupation because they were unable to compete effectively for other jobs.

## SHORTCOMINGS APPARENT IN THE RESEARCH

The evidence for impairment is generally meagre and contradicted by other studies, but several shortcomings are apparent in the research to date. Probably the most significant is the failure to account for the selective exposure factor.

### The Evidence for a Selective Exposure Factor

1. Sex differences. Several studies have demonstrated sex differences in the prevalence of schistosomiasis in endemic areas. When children are being considered the usual pattern is a high prevalence among boys, whereas in surveys conducted by V. de V. Clarke (1966) among adults on sugar estates, the prevalence was higher among women and this was related to water contact in the course of domestic duties. River water is used for household purposes and in children's play groups for recreational purposes. It is therefore logical to expect higher exposure among the age/sex classes who indulge most in these two types of activity. It is also logical to expect that within the age/sex class certain types of individuals are more playful, or more active and capable in household duties.
2. Socio-economic differences  
Loveridge, Ross and Blair (1948) found that Black Rhodesian children infected with bilharziasis had better school records than those without the disease whereas the opposite effect was found in White schoolchildren. It has been suggested that there are very different exposure patterns operating in these two groups (see page 3). Castle, Clarke and Hendrikz (1974) found that white children with bilharziasis had lower intelligence quotients than uninfected children and concluded that this was not the result of the infection but probably caused by a difference in social background.
3. Superiority of infected individuals.  
Jordan and Randall (1962) found higher scholastic achievement in black infected groups than in uninfected groups.

Foster (1967) reported no significant difference between positive and negative groups on anthropometric measures, but his tables showed that the means were higher rather than lower for positive subjects.

C.T.M. Davies (1973) compared physiological response to exercise in groups of East African children with schistosomiasis, anaemia and malnutrition. He concluded that bilharzia appears to have no measureable effect on performance in children. It would seem from the diagrams presented against a background of the means and standard deviations of the various measures that the bilharzia group actually were better than normals on weight, leg volume and maximum aerobic power.

Collins et al (1976) found in field productivity studies that the infected group without clinical signs had the highest average productivity : it was 10% higher than the uninfected group and 5% higher than the infected group with clinical signs of the disease. A possible explanation was the greater experience with the work in the mild infection group, but it also remained a possibility that there was a selective exposure factor operating. The mild infection group had the highest metabolic rate, significantly higher ( $P < 0,005$ ) than the infected group with clinical signs and the uninfected group ( $P < 0,05$ ). Collins and co-workers explained that these were all migrant workers and selected on the basis of their fitness for work. They maintained "A better index of the human and economic impact of the disease is more likely to be obtained in a static local population where the chronic ill effects of the disease had become more apparent." This type of study demonstrates a possible pattern where the mildly infected group perform better than the uninfected group, and impairment only becomes manifest at a more severe level of infection.

Fine (1975) investigated the economic impact of bilharzia through its effect on working capacity. His subjects were workers in a Kitwe Foundry. From his results he concluded that "Mild symptomless infections were not associated with significant reduction in productivity." (Page 96). He does however present a



table showing the classifications of subjects into "good", "average" and "below average" workers. The bimodal performance distribution of the bilharzia workers is consistent with the selective exposure factor combined with an impairment factor. The control group by contrast contained mainly "average" workers.

There is sufficient reason logically and from the above literature to suggest that a selective exposure factor does operate. If this is indeed the case it would explain why evidence of impairment is so elusive and tends to show up in studies with a before-and-after treatment design where subjects are their own controls.

#### The Adequacy of the Measures

The failure to account for selective exposure factors is one shortcoming in the bilharzia research. A second difficulty is the inadequacy of the measures of performance and mental ability. Most performance measures involve potential performance and use oxygen uptake or pulse rate as the actual measure after a specific work task has been performed. It may be that performance impairment in sub-clinical bilharziasis takes the form of a long-term deficit in available energy rather than fitness, and some of the evidence suggests this with terms like "laziness" and "lethargy" and "mental fatigue". Work tasks such as riding a bicycle ergometer, a step test or running races (Walker, Walker & Richardson, 1972) are probably well within the short term energy capabilities in most subjects. Fenwick and Figenschou's use of bonus pay as a measure is more consistent with the long-term deficit idea, and their study did show production impairment in infected subjects. The animal studies introduced the motivation factor in the learning tasks and found that infected animals performed as well as controls at all except the lowest levels of motivation. The motivation factor has been ignored in the design of measures of human studies.

Jordan and Randall (1962) found that the time of day and seasonal

changes in the weather were important variables in the measurement of performance, yet most studies make no mention of controlling such variables.

The pen and paper tests are notoriously difficult to use in the African context where schooling is started late and proceeds with high absenteeism and breaks of sometimes years. The standardised educational experience of the European and North American context is therefore absent and within-group variations in academic ability tests are great.

#### The Nature of Schistosomiasis

Finally, the nature of schistosomiasis itself makes comparison between research findings difficult. There are two types of schistosomiasis affecting human populations in Africa, *S. mansoni* and *S. haematobium*, and the mix differs from area to area. Some studies treat schistosomiasis as one disease and the positive groups may contain individuals with either or both types. Within each type of bilharzia there is a spectrum of severity ranging from typically very low egg counts of less than 100 eggs per urine sample excreted in a 2-hour period to those of many thousands of eggs per specimen. Most studies, with a notable exception of that by El Karim et al (1980), only quote prevalence figures and do not differentiate between levels of severity, surely a very important variable in a parasite whose effects on humans are proving difficult to detect.

## CHAPTER TWO

### ACTIVITY AND ITS MEASUREMENT

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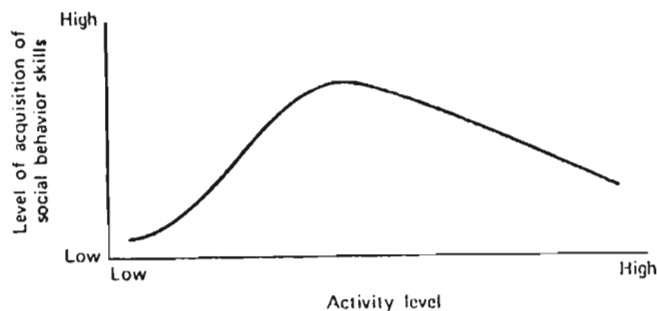
The possibility of behavioural changes with schistosome infections needs further study. The activity dimension is suggested by some of the work. It would be socially and economically important and might be more easily measured in African schoolchildren than cognitive change. The concept of an active - passive dimension in psychology is an old one and moreover, there is evidence of organic damage decreasing activity (as in malnutrition) or increasing it (as in the hyperactive syndrome).

Malnourished or anaemic individuals tend to appear at the lower end of the activity scale. C.T.M. Davies (1973) showed that both undernutrition and anaemia are associated with higher cardiac frequency and diminished maximum aerobic power output, although different mechanisms are at work: in anaemia there is diminished capacity of the blood to transport oxygen, while in undernutrition there is reduced effective muscle mass. At the other end of the scale, hyperactivity is thought to be associated with such diverse organic conditions as lead poisoning, radiation from fluorescent lighting, birth trauma and food additives (Whalen and Henker, 1980).

It would however, appear unwise to consider the activity dimension in isolation. There is evidence from all the above research areas which indicates that social interaction and development is disrupted. In the case of malnutrition in primates (Zimmerman, Geist and Wise; 1974), the low-protein groups were significantly more aggressive than the high-protein groups and spent significantly less time in play behaviour. Graves (1978) showed that undernourished children in Nepal showed significantly less activity than well-nourished children, as well as less attachment behaviour and a heightened need for physical closeness. Routh (1980), in reviewing his series of studies on hyperactivity pointed out that while he "began the present series

of studies with minimal interest in the social behaviour of children", he had "been led by the outcome of one study after another to become more deeply enmeshed in trying to understand the effects of the social ecology" (page 67). He suggested that hyperactive children are immature in their social development as well as in their motor behaviour.

Reproduced from Ross & Ross (1976).



Patterson, Jones, Whittier and Wright (1965) suggested that there was a curvilinear relationship between activity levels and socially acceptable skills. In other words a reasonably high activity level probably exposes a child to a richer environment but an extremely high level is not acceptable to others and problems in social interaction manifest themselves. In the context of less extreme activity, Halverson and Waldrop (1976) found that there was a negative relationship between high cognitive performance and high activity levels at seven and a half years of age. Ross and Ross (1976) defined a hyperactive child as follows : "a child who consistently exhibits a high level of activity in situations in which it is clearly inappropriate, is unable to inhibit his activity on command, often appears capable of only one speed of response and is often characterised by other physiological, learning and behavioural symptoms and problems." (Page 12).

The most immediate task of the present research was to develop measuring techniques to test the hypothesis that schistosomiasis caused lethargy, so an account of the methodologies in the measurement of activity and their inter-relationship is pertinent.

## MEASUREMENT TECHNIQUES

Cromwell, Baumeister and Hawkins (1963) in their review of research on activity levels consider a variety of methods purporting to measure activity, as a first step to formulating a useful construct. They used four categories : direct visual observation, free space traversal, kinetometers attached to the subject, and fidgetometers or devices in the environment activated by the subject when he moves. To this list can be added a related category of techniques used in medical research to measure physical fitness or activity potential.

### Direct Visual Observation

Rating scales such as the Werry-Weiss-Peters Activities Scale (Werry, 1968) can be used to obtain information about subjects in a wide variety of situations and appear to give reliable estimates of high activity levels in a global sense. Routh, Schroeder and O'Tuama (1974) used a questionnaire based on this scale in conjunction with an open-field measure in an investigation into the developmental sequence of activity levels. The parents' ratings confirmed the open field finding of a downward trend with age. Similarly Halverson and Waldrop (1973) found that teachers' ratings of vigour in play correlated highly with mechanically recorded data and the same authors (1976) found a fair degree of stability in subjects rated at 2<sup>1</sup>/<sub>2</sub> years of age and later at 7. But the latter authors caution against using teachers' ratings alone because of a loss of information regarding situational differences in activity level. Another disadvantage of using rating scales is that the rater tends to rate according to a hypothetical norm for that age-sex category, so that comparisons across categories are unreliable.

Ethology has provided the techniques used to good effect by a number of researchers in child behaviour. Typically, activity patterns are described and measured in terms of frequency and duration. Intensity is more difficult to assess. These techniques have the advantage of providing information on a variety of behaviours shown by the subject, and are able to be used across a number of situations. Cromwell et al (1963) mentioned the problem of measuring activity in the child with

the short attention span who shifts from one activity to another, and who may consequently have an inflated activity score. An ethological approach could distinguish between children with low frequency scores on many different patterns and those with high frequency scores on a few patterns. Problems with the ethological method centre around the categorisation of movement : in what way are postural changes to be related to limb movements or locomotion to obtain a general assessment of activity level? Can a functional categorisation reliably distinguish goal-directed from non-goal-directed activity?

#### The Kinetometer Approach

Bell (1968) used adaptations of small wrist watches to record activity. Movements of the foot were recorded when the child was seated, and gross motor activity in outdoor situations. The package containing 3 wrist watches was strapped to the foot in a seated position and attached to the back of the child's clothing in the outdoor situation. The watches simultaneously recorded vertical, left-right and front-back movement. The sum of the readings was expressed as a ratio of the recording time, and test-retest reliabilities were estimated at ,55 for the Pearson product-moment correlations giving a reliability of approximately ,7 for the sum of 6 readings over a one month period. Bell re-iterates the views of other workers that his findings indicate "that components and manifestations of activities in different measurement situations should be studied, rather than activity as a unitary invariant function". (Page 305).

Halverson and Waldrop (1973) used Bell's activity-recorder in conjunction with direct observation and teachers' ratings as previously mentioned. The sum of the 3 readings on the recorder was used as the child's activity score on the basis that all 3 were found to be highly inter-correlated. Halverson and Waldrop found that the activity recorder scores correlated highly with observer scores in the categories Gross Motor Activity, Falls, Runs and Shifts in Play, with a negative correlation with Continuity of Play and Stationary. They note a sex difference in activity across situations. Halverson and Waldrop were of the opinion that the activity recorders are a simpler

alternative to observation studies particularly over extended time periods, but they cautioned that there is a need for constant watchfulness to check for mechanical breakdown.

A similar technique was developed by Schulman, Stevens and Kupst (1977) in the field of behaviour modification, and called by them the biomotometer. This instrument was worn on a belt at the waist on the subject's dominant side. Three mercury-wetted switches set at  $120^{\circ}$  to each other record movement parallel to the ground in any direction. When the subject exceeds a set activity score per time unit he is advised by means of an auditory feedback signal. In a validity study the biomotometer shows high correlations with wrist and ankle actometers developed by Shulman and Reisman (1959) in most conditions. The device is small and light and can therefore be used in naturalistic settings. Bell's activity recorder differs from that of Schulman et al (1977) in the direction of movement being recorded and the positioning of the recorder on the body. This suggests that attention should be paid to the type of activity under consideration so that optimal recording of movement may be achieved. Neither recorder is able to distinguish between slow and fast movements or between light and vigorous movements.

#### Free Space Traversal

This usually involves marking off the available space into a grid-system and counting the number of squares traversed by the subject (Ainsworth, Bell and Stayton, 1971). A less versatile measure can be obtained by counting the number of times the subject breaks a photo-electric beam. This would appear to impose very severe limitations on movement, the subject usually being confined to a playroom, and is probably only appropriate for very young children. The count is obviously restricted to locomotory forms of activity.

#### Activity Potential

The estimated maximal aerobic power output or  $\text{VO}_{2\text{max}}$  is widely used as a measure of physical fitness or exercise tolerance. Typically subjects are given work tasks of graded difficulty on a treadmill or bicycle ergometer. They inhale from an air source where air composition is known and exhale into a mixing chamber so that the

oxygen content can be measured and the oxygen uptake calculated ( $\text{VO}_2$ ).  $\text{VO}_{2\text{max}}$  is not usually measured directly but predicted from measures taken during the final minute of exercise at an increasing workload. Regression equations for  $\text{VO}_2$  on cardiac frequency are calculated for each subject. The maximum oxygen uptake ( $\text{VO}_{2\text{max}}$ ) is predicted on a standard cardiac frequency, for example 195 beats/min with no adjustment for age or 210 beats/min with an age adjustment ( $-0,65 \times \text{age}$ ). Other related measures are cardiac frequency at a fixed  $\text{VO}_2$  of 1,5 /lmin or  $\text{VO}_2$  at a fixed workload .

C.T.M. Davies (1973) maintained that while it was clear that  $\text{VO}_{2\text{max}}$  measured the capacity of the body for sustained work, the relationship between  $\text{VO}_{2\text{max}}$  and actual output in "realistic everyday conditions" was in question. Accordingly his study measured the relationship between  $\text{VO}_{2\text{max}}$  and daily work output in cane cutters in Tanzania. He found that there was a significant relationship between  $\text{VO}_{2\text{max}}$  and a daily rate of working. He mentioned the interplay between psychological and physiological factors : in the industrial setting of his study the physiological factor counted for only 25% of the variance in productivity.

Other less costly estimates of physical fitness are in use. Strong, Spencer, Miller and Salebhai (1978) estimated the amount of work on a bicycle ergometer that could produce a heart rate of 170 beats per minute and showed a relationship of this measure to body area.

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In the above discussion of measurement techniques a number of separate dimensions of activity have been mentioned :

1. Categories of actions : locomotory and non-locomotory aspects of activity are part of the larger question of assessing the variety of activity patterns and how they are to be categorised.
2. Frequency.
3. Duration.
4. Intensity.



Most studies of activity have concentrated on pre-school children. The present study dealt with primary school children so what was required initially was a descriptive account of activity patterns in this age group and in this culture in order to work out an appropriate category system. Only when a measure was seen to be appropriate to the age group and sensitive to the difference between infected and non-infected children, could less time-consuming techniques be considered.

### SITUATIONAL DEMANDS AND PHYSIOLOGICAL LIMITATIONS

Situational demands and physiological limitations have been shown to be important determinants of activity level and to function in complex ways. The following account is an attempt to itemise those features of the internal and external environment which are thought to correlate with measures of activity.

#### 1. Sex Differences in Activity Levels.

A number of workers have reported sex differences in activity levels. Halverson and Waldrop (1973) corroborated previous research findings that pre-school boys were more reliably active outdoors than girls; that girls' play was more responsive to situational determinants than boys' play. They also suggest that these differences may be a function of a group situation with boys, and that when boys are playing alone there may be no sex differences in activity level.

Routh, Schroeder and O'Tuama (1974) found no sex differences on open-field measures or parental ratings in 3-9 year olds. The "open-field" was however a 15 x 19 ft room and there was no social interaction with peers so this is not inconsistent with Halverson and Waldrop's suggestion. In the case of the parental rating scale, ratings were probably based on expectations for a child of that sex. Blurton Jones and Konner's (1973) cross-cultural study on sex differences in children's behaviour showed that in both cultures studied boys indulged in more rough-and-tumble play. Higher activity scores for males in the

London sample were absent from the Bushmen sample which suggests that this might be cultural in origin.

## 2. Developmental Activity Patterns.

Routh, Schroeder and O'Tuama (1974) found that the open-field activity of children of 3-9 years of age decreased with age. In a second study Routh, Walton and Padan-Belkin (1978) found an increase in activity between the ages of 3 and 5. They then varied the conditions of the playroom and found that with the mother absent activity decreased in this age range, whereas in the presence of the mother activity increased in 5 year olds. This suggests that the social interaction component of activity changes with age.

In terms of activity potential Strong, Spencer, Miller and Salebhai (1978) found that their measure of physical working capacity showed no significant differences for a given body surface area for boys and girls younger than 10. But in boys of 11 and older the physical working capacity was higher than in girls of the same body surface area and age. In other words, body composition changes at puberty affect the activity levels of boys and girls differentially whereas prior to that, size was of paramount importance in determining activity potential.

A study of the developmental sequence of exploration and play in sub-human primates shows that non social exploration decreases with age in howler monkeys, (Baldwin and Baldwin, 1978), while social play "follows an inverted 'U' pattern, peaking in the early juvenile stage". Relevant therefore to the study of the developmental sequence of activity levels are the concomitant changes in social and cognitive patterns.

In summary therefore one can postulate a general decrease in activity levels with increasing age, with social and cognitive development causing variations in the trend, and structural changes at puberty affecting the sexes differentially.

## 3. The Physical Environment

Smith and Conolly (1977) found that with very low numbers of

children or small amounts of space (25 and less square feet per child) rough and tumble play decreases. When the amount of play equipment was varied, they found that rough-and-tumble play was greatest with a small amount of play equipment. The novelty of the environment was thought to cause a decrease in activity, and this concurs with findings in a novel object study (Kvalsvig, 1976) where locomotory patterns increased in duration and variety with increasing habituation to the novel object.

Humphreys (1974) found that temperature conditions and time of day had a small but significant effect on the activity levels of children in school classrooms. Activity levels dropped at 19,3°C and above in the morning and 21°C and above in the afternoon, but since school clothing and the habitual climate (the study took place in an English School) is obviously a factor here the actual temperatures cannot be generalised to the present sub-tropical study area.

Wyon (1970) found that reading speed and comprehension in 11 year old children deteriorated significantly at 30°C as compared with 20°C, but the greatest detriment in performance on both tasks was at 27°C. Wyon speculated that central nervous system arousal was lowest at 27°C and rose again at higher temperatures, and linked this to a series of industrial studies with similar findings. Two additional results reported by Wyon have implications for the present study :

- a) In a test of language learning on 13 year old children, oral performance deteriorated at a temperature of 27°C and "the effect appeared to be confined to the less able section of the class" (Page 605).
- b) On a test of reading speed and comprehension, the effect of temperature was more marked in the afternoon.

There would appear to be grounds for assuming an additive effect of stress factors such as high temperature, ability and fatigue. This is particularly of importance with the present study where one could postulate severity of schistosomiasis, stressful weather conditions, fatigue and other disease as stress factors having a cumulative effect.

CHAPTER THREE  
HUMAN ETHOLOGY: ISSUES RELEVANT TO THE PRESENT STUDY

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This chapter deals with the particular aspects of human ethology thought to be germane to the present study.

A BIOLOGICALLY-BASED STUDY OF HUMAN BEHAVIOUR

The last five or six years have seen much debate on the biological basis of human behaviour, largely in reaction to E.O. Wilson's book, "Sociobiology: the new synthesis" (1975). Wilson said in his introduction: "The principal goal of a general theory of sociobiology should be an ability to predict features of social organisation from a knowledge of . . . . population parameters combined with information on the behavioural constraints imposed by the genetic constitution of the species." (Page 5).

This is an important statement of belief that a knowledge of behavioural constraints, preprogrammed as envisaged in the "selfish gene" theory (Dawkins, 1976), can ultimately predict features of social organisation. Wilson's book aroused interest and acclaim as well as a storm of protest; the latter directed mainly to the ideas expressed in the final chapter on human sociobiology. Evolutionary theory as applied to human behaviour has provoked strong opposition since Darwin's time, chiefly because of the social and political implications (Charlesworth, 1978). Complete biological determinism is however not simply a distasteful doctrine: it appears to be logically and empirically inadequate.

"The human body is a highly flexible and adaptable system. But it has limits. In some respects it has narrow limits - in its ability to adjust to high temperature and/ or water storage, for example. But in other respects its limits are extremely wide, and this includes the ability to incorporate different social arrangements, accept them as normal and live by them." Reynolds, 1980, page 285.

Social systems may be directly genetically programmed in many species, but in a species apparently programmed for flexibility and capable of symbolic reasoning, genetic determinism loses its explanatory force.

In the study of human behaviour, the theory and methods of classical ethology have been inadequate in many respects. Some of the issues concerning psychology in the '70s have been intersubjectivity, cognition and the distinction between actions and movements. The rigidity of the Fixed Action Pattern is an anachronism in a species in which as Gould (1980) says "the direct programming of behaviour has probably become maladaptive". (page 257) The editors of the recent text, "Human Ethology, its claims and limitations" (1979), cite the failure to come to terms with cultural and cognitive processes in man as a major criticism of human ethology. Dunn, in the same volume, indicates some of the abuses which have arisen from ethologists' views of the biological basis of behaviour.

1. Extrapolation from animal studies to man.

Animal studies on early separation of mother and infant can lead to an understanding of the processes involved in producing later behaviour abnormalities, and alert us to possible parallels for humans. But Dunn made it clear that in human research, specifically human categories - linguistic and intentional - should be employed rather than behavioural ones.

2. Biology versus culture - a sterile dichotomy

The interest in hunter-gatherer societies (e.g. De Vore and Konner, 1974) implied that prolonged early attachment to a mother-figure is a relationship to which we are biologically adapted. Taking this a step further, the implication is that this relationship is the norm, and that mothers in our culture ought to adopt the childrearing patterns of the bushman studies. Dunn opposed this view on two counts. Firstly, present-day hunter-gatherer societies are a product of their particular ecologies and histories and there is no reason to believe that a study on any one group can be generalised to all human beings. Secondly, biology and culture cannot be separated in this way - "in an important sense culture is not a mediator of human nature, it is human nature".

The problem posed in the present investigation is a strongly biological one: the behavioural constraints placed on an organism by a parasitic invasion. The human host is not seen as a passive recipient however, biologically programmed to respond in certain ways. He is seen as an active participant, possibly employing behavioural and cognitive coping strategies.

While inferring mental states from observable behaviour has been avoided, the assumption of cognition is implicit in choice of procedures:

1. The lengthy descriptive phase and the successive arrangements and appraisals of category systems in an ethological study are part of the process of selecting measures appropriate to the species. In the case of human behaviour, the category systems for both activity and social interaction used here are not simple mechanical ones such as limb movements, but are attempts to describe complex patterns of mobility and communication: those behaviours, that is, which represent cognitive processes.
2. Parametric statistical procedures would have implied measurements on at least an equal interval scale. Because such categories as Agonistic Behaviour<sup>1</sup> group a variety of behavioural items as representing one action, this assumption cannot be made. Where the focus of activity was the type of mobility or the type of social interaction and not the observable components, non-parametric statistics are used.

#### NEW APPROACHES TO OLD PROBLEMS

The editors of the book "Human Ethology" (1980) were of the opinion that "the organisation of individual social behaviour" represented the current trend in ethological thinking, and that "the main strength of human ethology is that its approach to old problems is a new one; from the basis of theories, concepts and methods that have proved successful in animal ethology, it has looked at man from a new

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<sup>1</sup> Behaviours of many kinds may represent one action and therefore, the better term for the Agonistic category would be 'Agonistic Actions'. However the term 'Behaviour' has been retained as

viewpoint. The essence of this is the evolutionary perspective .....". The problems to which human ethology has addressed itself are many and varied and only two general areas of particular significance here - developmental psychology and impaired behaviour - will be discussed.

### Developmental Psychology

An evolutionary perspective implies questions about survival and adaptability. There is a current need to understand the effects of trauma on the developmental process as well as what Dunn (1976) called "the human capacity to recover from early trauma". The problem of assessing the effects of a parasitic disease on behaviour in school-age children is ultimately a question of attempting to predict the effects on later development. Thus it lies within the mainstream of the ethological approach to the developmental process.

Dunn (1979) pointed out that ethological studies have provided the impetus for some very fruitful lines of research in developmental psychology: ethology contributed to an interest in the development of perceptual skills through the idea of innate preferences; and to studies on the development of language and cognition through the theory of innate capabilities for social exchange. Comparisons with primate development drew attention to the long period of dependency and its importance in the development of communicatory skills. In these instances ethology has made an important contribution to understanding the social development of the child.

While the lethargic - overactive dimension of activity seems to be the logical starting-point for the present behavioural investigation, in a developing child activity cannot be studied in isolation. Pertinent to a discussion of activity level is the social context of the behaviour. A high level of activity may be wholly appropriate in certain circumstances, but the label of hyperactivity applies where the behaviour is socially inappropriate (see Chapter 2). Similarly, the low activity level of a malnourished child is disturbing because it is part of a syndrome which includes apathy, and implies poor social and cognitive development. It is therefore relevant in this review of the literature to draw on the experience of ethologists for an account of the dimensions of social behaviour in children.

In 1967, Blurton-Jones published an account of some aspects of social behaviour of children in a nursery school which established that the social behaviour of pre-school children "is readily analysable into rather constant motor patterns." McGrew (1968) reported on agonistic behaviour in a free-play setting, extending the range of social behaviour being studied in pre-school children. A surge of interest followed these accounts and a collection of papers was published in book form in 1972 edited by Blurton-Jones. In these research reports and others the following dimensions of social behaviour were indicated:

- a) The extent and consistency of social participation (e.g. Smith, 1978; Roper and Hinde, 1978).
- b) Sex differences in social behaviour (e.g. Hutt, 1972; Blurton-Jones and Konner, 1973)
- c) Agonism and dominance (e.g. Hinde, 1974; Strayer and Strayer, 1976)

Reynolds and Guest (1975) extended the age range of this type of study, as well as the environmental range by observing primary school children in a classroom situation. They showed that social behaviour can be usefully related to educational attainment, high reading ability being associated with a high level of 'friendly' and co-operative interaction with peers.

These aspects of social behaviour in the literature have provided the basis for the investigation of activity levels in their social context in the present study.

#### Impaired behaviour.

In areas where schistosomiasis is endemic there are often a number of other potentially harmful factors such as the presence of other internal parasites, undernutrition, and the breakup of family life under a migratory labour system.

"... the developmental outcome for any particular child is part of a giant equation, with social conditions, the child's temperament, health, the mother's sensitivity and style of caretaking, and the child's social experience with others all of potential importance. The internal relationships between these variables are very complicated, and we are just beginning to tease apart some of these factors, given that others are



The part which ethology can play in 'teasing apart' relationships between factors is illustrated by a sequence of direct observational studies on autistic children. The ground was prepared by Hutt and co-workers in 1966 who described characteristic avoidance of eye-contact in autistic children and the positioning of the child on the periphery of a group. Tinbergen (1977) observed the types of behaviours involved in autism, as well as the circumstances in which these autistic behaviours occurred in normal children, and was able to suggest that autists may be suffering primarily from environmental stress. This would indicate that therapy should be directed to the alleviation of stress. Other workers indicated the implication of flight behaviour in the autistic child and Richer (1976) specifically tested the hypotheses generated. These were that autistic children engage in very few social interactions and try to reduce the probability of encounters with others, that they are seldom aggressive and resort to defensive/flight behaviour when approached. Even if Tinbergen was wrong in assuming environmental stress to be the primary cause of autism, these studies show how the behaviour is self-sustaining and suggest modes of intervention.

Charlesworth (1978) applied ethological techniques to the study of intelligent behaviour, and presented an account of a pilot study comparing Downes syndrome child and a normal child. He emphasized that the individual whose capacity to acquire cognitive skills is impaired is especially vulnerable to adaptational failure as an adult, hence the importance of knowing in detail how he interacts with his environment.

Ethological studies comparing impaired and normal behaviour thus have a two-fold value: through careful study of the behavioural elements they may give insight both into primary factors and possible rehabilitation procedures.

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Human ethology emerges from these accounts as having had a notable influence on a number of problems in psychology, having itself changed in response to specifically human problems, and as offering a set of techniques which are particularly useful in certain stages of research and hardly at all in others. The final test is fruitfulness.

Tinbergen suggested that human ethology has much to offer in applied areas of research. The task undertaken in this thesis is applied, but is in the tradition of developmental psychology. The observational methods used had their roots in the work of Corinne Hutt and co-workers (Hutt, Hutt and Ounsted, 1963 : Hutt and Hutt, 1965). The categories used in collecting data on activity derive with few alterations from the work of McGrew (1972a), and the time -sampling methods are conventional ethological ones as described by Tyler (1979).

PART 11

THE RESEARCH

CHAPTER FOUR  
THE RATIONALE FOR USING AN ETHOLOGICAL STUDY  
TO ASSESS THE BEHAVIOURAL EFFECTS OF SCHISTOSOMIASIS

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THE DESCRIPTIVE PHASE

As discussed in the literature review on schistosomiasis, the evidence for impairment comes from anecdotal material and before-and-after treatment studies. It is clear from the number of studies with negative findings that there are no easy answers to the question of impairment. The point has also been made that results on a single measure could be confusing due to the possibility that the bilharzia group might be initially more active, intelligent, adventurous or responsible. It seemed important then, to look for complex differences between groups; to try to build up a picture of how a child with bilharzia normally behaves. In other words, what was needed was hypothesis-generating research. But the data in this study would have to be more extensive, collected with greater rigour and from larger numbers of children than previous research.

An ethological study with its extended descriptive phase using the complex behavioural patterns currently favoured by the human ethology researchers, seemed to be indicated in these circumstances. At worst, the descriptive data collected would simply indicate large areas of human behaviour where there were no observable differences between the infected and uninfected children, where specific hypothesis-testing was unlikely to yield results. At best, the descriptive data would show several areas where there did seem to be differences and specific hypotheses could be formulated and tested.

The standard procedure in an ethological study is to start with as broad a spectrum of behaviour as practical, and by a process of successive close focussing on initially ill-defined behavioural relationships, to achieve clarity. Anecdotal data are often valuable because as human observers our perceptual apparatus is specially attuned to receiving signals from other humans. Obviously too, our perceptual apparatus frequently leads us to erroneous conclusions because of a tendency to

over generalise, to categorise excessively and to over-emphasise more dramatic signals at the expense of less obvious ones. Human ethnology attempts to capitalise on the observer sensitivity but to formalise safeguards against its short-comings. It does this mainly by defining recurring patterns slowly and patiently from large amounts of data.

#### THE "STRESS-FATIGUE" THEORY

The only real lead from literature and folk-lore was the theory that the burden of the parasites causes fatigue. Yet when physical tests were instituted, the results were often negative. It may be that bilharzia-sufferers perform adequately under test conditions but are relatively inactive when motivation is low. An ethological study with typically low experimenter manipulation attempts to assess how the subject behaves of his own accord in a given set of circumstances. This type of study is particularly suited to investigating the spontaneous activity aspect of the stress-fatigue theory, and if there does appear to be evidence of fatigue in bilharzia-infected subjects, some clarity can be achieved as to its form and circumstances.

#### THE MEASUREMENT OF ACTIVITY

In the section on the measurement of activity a number of ideas emerged from the literature. Firstly, activity level is thought to be multi-dimensional in any one subject. The one hour lunch-break at a school affords a relatively unstructured setting for the observation of the several possible dimensions of behaviour: there is wide freedom of movement, choice of companions and choice of activity, and the child can be observed eating, playing, in conversation or solitary, and his characteristic activity pattern determined in all these circumstances. Identifying and describing recurring behaviour patterns in all these situations provides a broad base for categorisation decisions, so that the concept of activity level can be clarified and linked to the social milieu. The variables of age, sex and temperature conditions can be studied in an environment familiar to the children and spacially unrestricted.

### SOCIAL BEHAVIOUR

The chapter on bilharzia research emphasises the importance of an understanding of social-psychological factors which might mean that certain types of children are more "at risk" with respect to bilharzia, and might mask evidence of impairment when groups of subjects are being considered. It is therefore necessary to study social behaviour. In an ethological study social behaviour patterns can be described and categorized. The difficulty facing research in this area is that it seems likely that the children who are "at risk" might have high initial scores on the very aspects of behaviour which are thought to be impaired by the disease. It was therefore necessary to develop measures which would discriminate between selective exposure and impairment, probably by comparing uninfected groups with infected groups of varying severity. Such measures would have to be based on considerable observation of the relevant social behaviour.

### EVOLUTIONARY THEORY AND ETHOLOGY

Classical ethology attempts to relate behaviour to an evolutionary pattern of adaptation through natural selection. In the case of *S. haematobium* and *S. mansoni*, man is the definitive host: man and these parasites may have evolved together. In attempting to understand the effects of these forms of schistosomiasis on man it is sometimes illuminating to see these effects as one side of the total host-parasite relationship.

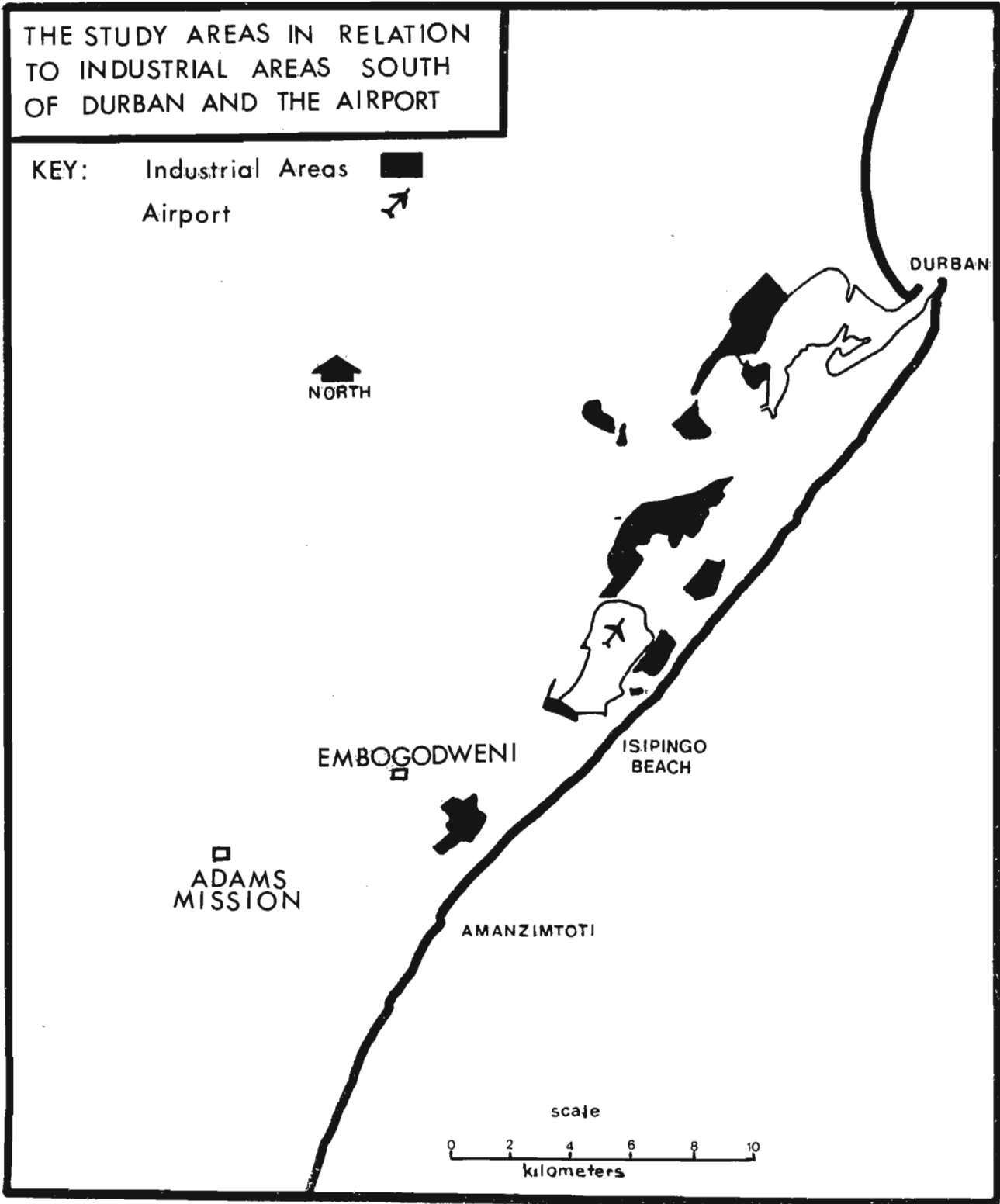
In the section on the life cycle of the schistosome, the thought has been put forward that the parasite maximises its chances of transmission by being released in cercarial form into the water in warm conditions when the human host is most likely to be present. Regarding damage to the snail host, the shorter life span and great reproductive power would mean that a high degree of damage could be inflicted without upsetting the parasite's life-cycle.

The human host however has a much longer life span and a slower rate of reproduction than the bi-sexual snail. Metaphorically speaking, it is not in the parasite's interests to be highly damaging to its human host population. In practical research terms, clear evidence of impairment in the host's behaviour is likely to be found in abnormal circumstances, for instance in extremes: in the few severely infected individuals in the population or in extreme levels of activity in mildly infected individuals.

Physiologically there is evidence of adaptation to the parasite in human hosts - the length of infection in an individual is curtailed by the build-up of resistance. The effects are seen in the age distribution curve: bilharzia declines in a population after a certain age, although the mechanism is unknown. For behaviour research it is important to remember that people may well adapt behaviourally to the presence of the parasite. A subtle shift in behaviour may occur to adapt to a lower energy potential without too much loss of effectiveness.

#### THE REASONS FOR BELIEVING THAT ETHOLOGICAL TECHNIQUES MIGHT PROVIDE MORE APPROPRIATE ASSESSMENT TOOLS THAN STANDARD PSYCHOLOGICAL TESTS

1. Intelligence tests were developed for Western societies where most children of a given age have received a standard education. In the endemic areas studied here school classes often have an age range of 7 years; some children start school late and others have breaks of several years in their schooling. The pen-and-paper tests administered by Moerdyck and Ramsay at Adams Mission in 1975 showed such a high within-group variance that no conclusions could be drawn from the between-group variance.
2. Intelligence tests and other psychological tests have been developed to test very specific aspects of intellectual or interpersonal functions, and aspects that have been specifically anticipated. An ethological study on the other hand gives access to a wide range of simple and complex behaviours of the individual, as well as his social relationships. The ethological method also has the possibility of revealing effects not specifically anticipated.
3. Primate ethological studies have shown that a diseased individual alters his relationship with other individuals quite profoundly. A central concern in human ethological studies has been social behaviour. Ethological studies of children's play groups have developed concepts of affiliation, agonism and dominance which might give access to this type of change in social relationship.

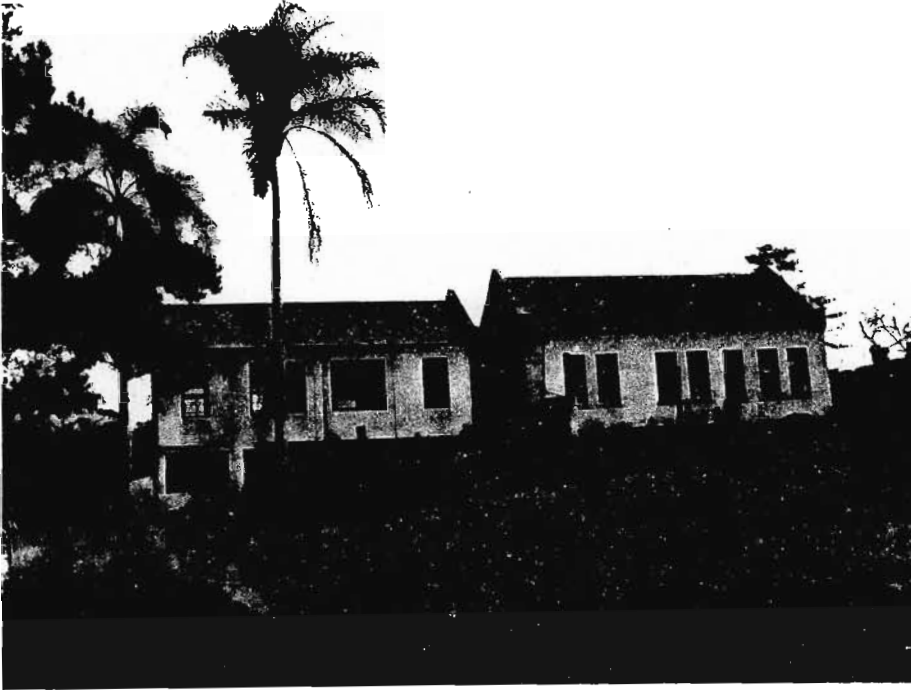




## CHAPTER 5

### THE DESCRIPTIVE PHASE

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Adams Mission Higher Primary School

#### THE STUDY AREA

The area of Adams Mission was chosen for the study because of the extremely low prevalence of *S. mansoni* and the high prevalence of *S. haematobium*, so that the results obtained would relate simply to one form of bilharziasis. The area is a peri-urban one, being about 40 kilometres from the centre of Durban and fairly close to the industrial areas of Prospecton, Jacobs and Mobeni (see map). It is relatively affluent for a black area with many of the adults being employed in these industrial areas. A health survey of the area conducted by Stopforth (1967) showed that malnutrition is not thought to be a major problem in the area, whereas bilharzia is considered by community members to be the most prevalent disease amongst schoolchildren. Stopforth found that there had been an improvement in the amount of vegetables in the diet, and that a substantial number of households were aware of the link between adequate nutrition and good health. Diet sheets obtained from 170 children at the Adams Mission upper primary school during the course of the present study did not reveal any systematic relationship between a protein-deficient home diet and the presence of bilharzia, and all children at the school received a high protein mid-day meal at school.

There is no piped water in the area and water is obtained from a number of streams and pools for household purposes. It is a common sight to see groups of women accompanied by small children in the rock pools of the Amanzimtoti River, washing clothes in the mornings. Older children used to swim in the dam a short distance from the school in the afternoons until this was forbidden by the Agricultural Officer who was concerned about the bilharzia problem. The research staff of the RIDTE plotted the dwellings of children of known bilharzia status on a map of the area in an attempt to find the focus of transmission, and found that those with severe infections tended to be close to the Amanzimtoti River and the dam.

#### THE SUBJECTS

The subjects were children from the upper and lower primary schools. The schools are some 500 metres apart, separated by the Amanzimtoti River valley. The selection of subjects was done by the RIDTE and was based on a survey of the prevalence of schistosomiasis and other parasitic diseases in all the children of both schools (Schutte, van Deventer and Erikson, 1977). The behaviour research workers had no knowledge of the bilharzia status of the children until a late stage in the analysis of the data.

The possibility of attempting to control for other diseases was considered and rejected for the following reasons :-

1. De Witt, Oliver-Gonzalez and Medina (1964) concluded that an enriched diet improved the general health status of malnourished individuals infected with *S. mansoni*, but in the present study of children in the Adams Mission school several factors weighed against instituting a necessarily expensive investigation into malnutrition in the area: nutritional standards in the area were thought to be relatively high: measures of height and weight had shown no difference between bilharzia infected and uninfected groups (Miller et al, 1977); diet sheets similarly had revealed no differences between groups; all children received a high protein soup at lunch time.
2. Schutte et al (1977) found no association between bilharzia and other parasites.

3. No evidence was found in the literature that bilharzia was systematically associated with infectious diseases. Statistically it was unlikely that less prevalent but more serious diseases such as tuberculosis would be significantly over-represented in either the control or the bilharzia-infected groups in the present study when large numbers were being considered.

The possibility remained that bilharzia might be linked to a socio-economic factor. For instance, families who were higher on the socio-economic scale might have rainwater tanks and therefore less exposure to schistosomiasis. An interview schedule was drawn up, but funds were not available for research into this aspect of bias in the result, so the possibility remained.

#### DATA COLLECTION

The descriptive phase took the form of 3 separate studies designed to investigate different environments, to establish criteria for grouping subjects, and to gain insight into the methodological problems.

##### 1. The playroom study (videotaped records)

Four groups of subjects were selected from the lower primary school. Each group consisted of five subjects with high *S. haematobium* infections, matched for sex and age with five control subjects from the available children in the same school class (see Table 1 for subjects' age, sex, and egg count). The age matching was only approximate because some children were unsure of their ages.

The four groups were observed, and their play behaviour recorded in a classroom in which the central area had been cleared of desks. Each child was given a wooden box containing Play Dough, building blocks and a push-along toy. This apparatus was chosen with the object of eliciting difference types of activity: gross body movement such as climbing and jumping using the box and running using the push-along toy; and a variety of fine manipulative skills in modelling the dough or building with the blocks.

Recording took place in 4 half-hour sessions with each group, on the Monday and Friday of two consecutive weeks. On each day there were 2 early and 2 late Sessions. The timetable was arranged in this way to maximise any fatigue effect through the day or through the week.

A video recorder directed diagonally across the room recorded sound and movement; time-lapse photography recorded position and movement along the other diagonal with bursts of shots at two-second intervals; a tape-recorded commentary was made by an observer, particularly noting any movement made out of range of the cameras.

The strength in this type of study lies in the fact that it permits very accurate measurement of both simple and complex behaviour. It is, however, limited spacially and directionally and the use of a playroom group interferes with a child's normal choice of companions and play locations.

TABLE 1  
Videotape Study: infected subjects' sex, age and egg-count

Group	Sex	Age	Mean egg-count
Morning A*	F	8	12 660
	M	8	14 530
	M	7	2 360
	M	9	16 520
Morning B	M	11	610
	F	8	53 440
	F	9	10 425
	M	8	8 410
	M	9	5 920
Afternoon A	F	8	12 660
	F	13	1 560
	M	9	1 627
	M	12	7 744
	M	10	2 922
Afternoon B	F	7	13 670
	M	7	800
	M	9	18 483
	F	12	1 840
	M	9	2 533

$\bar{X} = 9,1$

Mdn = 7 744

M : Male

F : Female

\* One subject pair omitted from this group because of uncertain bilharzia status.

## 2. The Playground Study (Audiotaped Records)

This was designed to overcome some of the limitations in the classroom but, for practical reasons, it lacked accuracy and detail in some respects and can therefore be regarded as complementary rather than as an alternative. It ran concurrently with the playroom study and recording took place during the tea-time and lunch-time breaks. No constraints were put on the child's choice of companions, or on the type and location of activity beyond those imposed by the school situation. The Lower Primary subjects used in the videotape study were included in this study as well as groups from standards 1, 3 and 5. Each of the Upper Primary groups consisted of 10 experimental and 10 control subjects, matched for age and sex (see Table 2 for subjects' age, sex and egg count).

At the start of each day numbered sashes were tied around the waists of 20 subjects. During playtime, 3 observers recorded one-minute commentaries of these subjects' activities, attempting to remain unobtrusive without being furtive. In this way, up to 7 one-minute commentaries were made on each child, with about 540 commentaries in all on the 100 subjects.

Observers were instructed to comment as comprehensively as possible on activity and to include remarks about social interaction where time permitted. This was because activity was the most obvious aspect of behaviour to study in a disease which reputedly causes lethargy. A secondary reason for concentrating efforts on the measurement of activity initially was that it constitutes a confounding variable for most other aspects of behaviour: for instance, a decrease in social interaction could be a reflection of a decrease in either activity or sociability. In accordance with the methodological aspirations of ethology this phase of investigation into activity levels was seen to be mainly descriptive in an attempt to avoid an early crystallisation into measurement categories which might later prove to be inappropriate. Consequently, McGrew's system of reporting movement patterns were suggested for observers (McGrew, 1968).

TABLE 2.

1st Audiotape Study: infected subjects' sex, age and egg-counts  
(excluding lower primary subjects mentioned in Table 1)

Standard	Sex	Age	Mean egg count
I	M	9	5 513
	M	9	7 387
	M	8	22 975
	M	10	3 107
	M	9	17 770
	F	11	8 415
	F	9	3 973
	F	10	15 008
	F	10	4 026
	F	8	3 853
		$\bar{X} = 9,3$	Mdn = 6 450
III	M	13	7 840
	M	11	4 267
	M	12	1 560
	M	14	7 893
	M	11	4 200
	F	10	4 920
	F	11	14 240
	F	14	29 200
	F	13	15 293
	F	12	7 400
		$\bar{X} = 11,1$	Mdn = 7 620
V	M	16	21 267
	M	14	2 573
	M	14	3 240
	M	14	2 147
	M	12	1 720
	F	14	6 293
	F	13	1 907
	F	12	933
	F	13	6 293
	F	14	5 180
		$\bar{X} = 13,6$	Mdn = 2 906.5

M : Male  
F : Female

### 3. Length of infection study (Audiotaped Records)

This was conducted one year later and was designed to investigate the possibility that there were behavioural differences between subjects with a recent infection and those with a long-term infection. The subjects were children from the Upper Primary School between the ages of 9 and 12. Experience with the earlier playground study had shown that adolescents were particularly sensitive to the presence of observers and it was thought advisable to restrict observations to lower age groups (see Table 3 for subjects' age, sex and egg count).

Thirteen subjects who had had negative bilharzia results in October 1975 and who showed positive egg counts in October 1976 were matched for sex and age with 13 subjects who had been negative on both occasions and 13 subjects who had been positive on both occasions. Later testing showed 2 of the negative group members to be of doubtful bilharzia status, and these were subsequently dropped from the study. The scores of their matched subjects were added to those of another member of their age/sex category. The matched groups were thus reduced to 11 units each although some of these units contained scores from 2 subjects.

TABLE 3  
2nd Audiotape Study: matched infected subjects

SEX	AGE	M E A N   E G G   C O U N T	
		NEW POSITIVE	OLD POSITIVE
M	9	1 480	5 040
M	9	2 160	10 520
F	9	1 400	5 560
F	10	800	1 060
M	10	40	1 920
M	10	2 400	4 460
M	10	160	5 120
F	11	40	5 480
M	11	6 480	11 020
M	12	40	4 680
M	12	80	3 840
$\bar{X} = 10,3$		Mdn = 800	Mdn = 5 040

M : Male

F : Female



From the above table it may be seen that the "new positives" differ from the "old positives" both in length of infection (less than one year as opposed to more than one year) and in severity of infection (a median egg count of 900 as opposed to a median egg count of 5040). It is therefore impossible to distinguish between these two factors in the study.

This study differed from the previous audiotape study in that more commentaries were done on fewer children. A total of 377 one-minute commentaries were done on the 37 subjects.

A further difference from the previous audiotaped study was in the recording of social interaction. In the first study comments on social interaction were found to be too haphazard to give sufficient data for reliable analysis. In this study however, observers were instructed to comment on the subjects' involvement or otherwise with other children. This was done initially before recording the one-minute sample, and at the end of the sample a summary of the social interaction content of the sample was given. In this way it was hoped that inaccuracies when action occurred too fast for adequate comment would be clarified immediately.

\*\*\*\*\*

In addition to these 3 observational studies, 2 other data sources were used during the descriptive phase :-

1. A survey of sleeping habits

All children in the lower primary school were asked about the amount of sleep they had had during the previous afternoon and night.

2. School reports

The teacher's ranking of the children on performance in class was obtained from the school reports.

A subject card file was created with all available information on each subject collected in summary forms. This procedure was used with all lower primary subjects taking part in the videotaped study and first audiotape study. It was felt that the data on the upper primary subject in the first audiotaped study was too limited to be of value for these biographical sketches, so they were not included. The data in the length of infection study was more comprehensive for each child, so these subjects were included.



## CHAPTER 6

### ANALYSIS OF THE DESCRIPTIVE PHASE DATA

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During a previous study of play and exploratory behaviour in African, Indian and white pre-schoolchildren (Kvalsvig, 1976), McGrew's Social Behaviour Glossary (McGrew, 1972 A) had been selected as providing a useful breakdown of behaviour into broad categories, and thence into recurring patterns. McGrew's glossary was adapted and amended during the course of this earlier study, and a number of measures were derived from these patterns. The experience gained during the course of this study provided the base for techniques used in the measurement of activity in the present investigations.

In the absence of exact descriptions of the possible behavioural effects of schistosomiasis, relatively wide categories were chosen for measurement, and because measurement of this type is very time-consuming only a limited number of categories were counted. Observers made detailed descriptions of each category before measurement commenced, and during measurement decisions regarding border-line cases were recorded and incorporated into descriptions. Two types of counts were made: duration and frequency, the former being measured with a stop-watch and the latter in terms of the number of incidents of a particular type.

#### CATEGORIES OF BEHAVIOUR USED ON THE VIDEOTAPE STUDY

On the videotapes, a signal marking off time in intervals of 10 seconds was dubbed onto the soundtrack. A systematic sample of 10 one-minute intervals per tape was selected, that is, every third minute. Each subject was watched in turn in these intervals. The following counts were made:

1. The duration of mobile and stationary behaviour was measured for each subject during each sample interval. Mobile simply referred to the locomotary activity, and stationary to a non-locomotory state.
2. Frequency of change from one type of activity to another was counted. This referred to the 4 types of apparatus in the room.

# CATEGORIES OF BEHAVIOUR USED IN THE FIRST AUDIOTAPE STUDY

In the playground, or first audiotape study, the following counts were made:

1. Energetic, mobile and stationary categories of activity were defined. Energetic activity was defined as "gross physical activity involving overt expenditure of effort, for example, climbing, fighting, jumping and running. It also included gross verbal actions such as screaming or shouting".

The mobile category was defined as "locomotory activity such as walking or shuffling sideways in which little overt effort is made. It also includes changes of posture such as sitting down".

The stationary category included all other non-locomotory activity patterns: arm movements, minor shuffling of the feet, talking, smiling or simply remaining immobile.

The transcripts of the tape recorded commentaries were used to categorise all behaviour described. Finally the duration of each category of activity was measured on the tape recorded commentary with a stop-watch.

2. Social interaction was measured in terms of duration by the same process. It was defined as "communication with one or more other children at a verbal or physical level. This included walking with others and talking intermittently, and leaning against another child".
3. Agonistic incidents were counted. These were defined as "any instance of patterns of physical coercion of sufficient force for the effect on the recipient to be perceptible. These patterns are those described by McGrew (1972 a) as Bite, Beat, Pull, Push, Wrestle, Punch, Body Oppose, Repel, Chase. No distinction was made between playful and serious combat, or between aggressor and recipient.
4. Incidents where the subjects' change of activity level were counted, that is, from Energetic to Stationary or Mobile and vice versa.

# CATEGORIES OF BEHAVIOUR USED ON THE SECOND AUDIOTAPE STUDY

On the length of infection study (or second audiotape study) a number of changes and additions were made to these measures (see Appendix 1).

1. Four levels of activity were defined and measured in terms of duration: Energetic, Mobile, Stationary and Immobile. The Energetic category was changed to exclude agonistic activity, so that these measures were independent. The Mobile category remained the same as in the First Audiotape Study. The Stationary category was changed to exclude immobility. The Stationary category in this study then became one of activity which did not involve locomotion, such as talking, playing seated games or standing spinning a yo-yo. A new category was added called Immobile, essentially using McGrew's definition: "gross movement of the trunk, limbs and head ceases for at least 3 seconds". There is no vocalisation, laughing, or any other kind of social interaction, except perhaps leaning against another child. It is essentially a state of passivity, of long duration and not a pause in other activities.

2. Social Interaction. Improved comment on social interaction in this study allowed for more detailed analysis of the data. Social Isolation was defined as "a state of more than ten seconds' duration where the subject is not participating in the activity of any group". This was scored once only for a one-minute commentary on the basis that it described a state of relatively long duration, but the actual duration was difficult to measure.

Games. This was defined as "a social activity governed by rules and social conventions, as in a game of football or hopscotch" and was scored in the same way as Social Isolation for the same reasons. The duration count for social interaction was defined and measured in the same way as in the first audiotape study.

Agonistic Behaviour. Agonistic Behaviour too was defined in the same way, but a distinction was made between short-duration incidents such as Hit or Kick, and longer-duration bouts such as Wrestle or Chase in a fight where individual incidents occurred too fast for commentary.

3. Other Incident Counts. The idea had appeared in some bilharzia studies that lethargy was accompanied by "mental fatigue" or lack of concentration. To investigate this phenomenon, incident counts were made of the changes of focus of activity as well as the changes of level.

A Distress Category included behavioural and physiological signs of distress: Crying, Pouting, Frowning, cut-off-postures such as Hand Cover and Eye Cover, profuse sweating, coughing or very fast breathing.

Incomplete Actions had been used in a previous ethological study (Kvalsvig, 1976). This essentially described what is commonly called fidgeting, and included automanipulative patterns as well as minor movements of the arms and hands where no contact is made with another person or object. The category appeared to be an indicator of underlying muscle tone, and occurred particularly frequently in the early stages of exposure to a novel object. In the present context it was thought that this category might constitute a more subtle indicator of distress than the overt signs mentioned above, and for this reason an incident count was made of these patterns.

Incongruous Activity. For reasons that will be given in the discussion of the descriptive phase results, this category was introduced. It referred to performing an incongruous activity, performing an unusual activity, and initiating a change of group activity. These were interpreted widely at the outset of the analysis, and a list was made of all behaviour that could possibly be classified under these headings. The list was examined and guidelines established: the incongruous pattern was limited to activities usually performed socially, but in that instance being performed in a solitary setting (Talking, Laughing, Dancing and Singing); the unusual pattern was one which had not been observed in any other child during the study. The whole category was then scored on a one-zero basis for each one-minute sample using the more restrictive guidelines.

### Subject Card File

Data from the subject card file for the second audiotape study was condensed, and a brief report was written up for each child based on observers' impressions as well as the subject scores on each measure. This was intended to serve as unbiased background information in the formulation of hypotheses.

## SCORING

### Time Sampling

One-zero sampling was used extensively throughout this investigation in spite of widespread criticism of this method (for example: Altmann, 1974). This method was chosen because many of the patterns or states being described were of long duration and started or stopped gradually. Any other time-sampling procedure would have involved complicated decisions as to when a child had stopped being solitary, for instance, and whether he had started again a few seconds later. The whole one-minute sample was therefore regarded as a scan sample for this type of pattern. A recent article by Tyler (1979) reviews time-sampling procedures. Tyler showed that while one-zero sampling in general is a less accurate estimate of duration than other methods, it is a useful method for comparing groups on patterns that are not easily identified.

### Measures of central tendency

A decision had to be made whether a median or a mean was the most appropriate measure of central tendency of duration counts for each child. A median was favoured during the analysis of the videotape and first playground study on the basis that the median would be measuring the most characteristic score for each child, and only required the assumption that the scales were ordinal. Later during the analysis of the length of infection study the point was considered again. Most children showed a wide variety of activity duration scores and only a few of these were of long duration. The median of course was little influenced by these latter. It was decided that the long-duration scores were important to show up individual differences. The mean was therefore more appropriate because it was influenced by all scores including extreme ones, and the necessary assumption of an equal interval scale seemed reasonable in this case.

Incident counts were of relatively infrequent items and for these it was decided to treat the whole group as the unit, especially in view of the fact that groups were matched for age, sex and educational standards. This treatment however would not distinguish between a group composed of individuals with predominantly middle-range frequency scores, and a group composed of predominantly extreme frequency individual scores. It was decided therefore that this point must be taken into account in interpreting results.

#### PROCEDURES AFTER OBTAINING BILHARZIA STATUS DATA

At this point information concerning the bilharzia status of the subjects was obtained from the RIDTE. Continued testing of the subjects after the initial selection, had revealed previously undetected low-level schistosomiasis in a few of the control subjects and these had to be excluded from the results along with their matched pairs for tables requiring a matched pair format. In the second audiotape study a regrouping took place as previously described so as not to lose too much information.

The results were then tabulated. In all tables the term "positive" refers to subjects with *S. haematobium* eggs in at least one urine sample and usually several urine samples when tested by the RIDTE. The "egg count" refers to the number of eggs excreted in a two-hour midday period.

Because the objectives of this phase of research were to evaluate methodological problems and to generate hypotheses for more stringent testing later, the tables are primarily descriptive with minimal use of inferential statistics.



## CHAPTER 7 RESULTS

### ACTIVITY

The videotape study and the first audiotape study showed that the positives were higher in general than the negatives on activity level. This finding is in the opposite direction to the expectation of lethargy in these subjects. The second audiotape study, though based on a much smaller sample, showed that the group with long-term infection and high egg counts had significantly less energetic activity and more immobility than their negative counterparts.

The Videotape Study (see page 43 for definitions).

Table 4 shows the total amount of time spent in the Mobile as opposed to the Stationary activity state, expressed as a percentage of the total observation time.

TABLE 4  
Time spent Mobile expressed as a  
Percentage of the total observation time.

	All Groups	Morning Groups	Afternoon Groups
Positive subjects	16.18	17.67	14.40
Negative subjects	15.84	12.20	20.25

Note: In all tables "Positive" and "Negative" refer to the presence or absence of bilharzia

This table indicates that although the Positives spent slightly more time in Mobile activity overall, this applied to the morning groups. In the afternoon groups the trend was reversed.

All observations where both members of a matched pair were present in the 60 second observation interval were selected and a comparison was made to determine which member of the pair had spent the greater amount of time mobile in that sample interval (Table 5). This was an attempt to control for the effect of social pressure to conform to the activity level of the group.

TABLE 5

The matched pair member showing greater duration  
of mobile activity in a sample interval

	NO. OF SAMPLE INTERVALS WHERE BOTH PAIR MEMBERS WERE PRESENT		
	All Groups	Morning	Afternoon
Positive member more mobile	153	93*	60
Negative member more mobile	131	65	66

\*The difference between the positive and negative scores is significant  
at the 5% level using the Sign Test.

In the case of the morning samples, the difference between positive and  
negative scores is significant at the 5% level. This suggests that the  
subjects with *S. haematobium* were more active than the control subjects  
in the morning but that this effect disappeared later in the day.

Table 6 shows which member of a matched pair was mobile for longer when  
all instances where they were recorded together were taken into account.

TABLE 6

The matched pair member showing greater duration  
of mobile activity in all sample intervals

	Total	Morning	Afternoon
Positive member more mobile	10	6	4
Negative member more mobile	8	3	5

Difference between positives and negatives not significant using the sign  
test.

#### The First Audiotape Study (see page 44 for definitions)

Because age is thought to be a variable in activity level and these  
subjects had a wide age range, it was thought advisable to adhere to a  
strict matched pair format in the treatment of scores. Using the median  
score per 1-minute sample for each activity level, the scores for both  
members of each matched pair were compared (Table 7). The positives  
scored significantly higher on energetic activity.



TABLE 7  
Comparison of Matched Subjects on the median duration  
score for 3 levels of activity

	Energetic	Mobile	Stationary
Positive member higher	29*	28	21
Negative member higher	15	19	27

\* The difference between the positive and negative scores on energetic activity is statistically significant at the 5% level (Sign Test).

In an attempt to identify extremely energetic individuals, the activity level with the highest median score for each individual was used as the predominating activity level for each child. Table 8 shows the distribution of the predominately energetic, mobile and stationery individuals within the positive and negative groups.

TABLE 8  
The distribution of predominantly Energetic,  
Mobile, and Stationary subjects within each group.

	Energetic	Mobile	Stationary
Postives	8	13	28
Negatives	3	9	37

The differences between groups for each activity level are not statistically significant at the 5% level using a Sign Test.

The inference from these tables is then that despite a larger sample than the videotape study, a wider age range and different measuring techniques, the general finding of a higher activity level in the positives was maintained.

#### The Second Audiotape Study (see page 45 for definitions).

Because there were three matched groups, negative subjects were compared separately to the new positive group and the old positive group. Using the mean duration score for each subject the differences between the groups were compared (Table 9) on each level of activity.

TABLE 9  
Comparison of Old Positive and New Positive  
subjects with the negative control group on  
mean scores for 4 levels of activity

	Energetic	Mobile	Stationery	Immobile
Old Positive higher	2*	7	4	9 **
Negative higher	9	3	6	2
New positive higher	5	5	2*	9 *
Negative higher	6	6	9	2

\* p<.05 Willcoxon Matched Pairs signed ranks test

\*\*p<.02 Willcoxon Matched Pairs signed ranks test

Other comparisons between groups on each activity level were not statistically significant using the Willcoxon Matched Pairs Signed Ranks Test.

The pattern of activity for the groups was different. The negatives generally spent a large proportion of the sample Stationary They contrasted directly with the old positives on the Energetic and Immobile categories; the negatives were high Energetic activity scores and low Immobile scores relative to the old positives. The new positives had high scores on both the Energetic and Mobile categories, and quite high scores on immobility as well, which suggests extremes of activity.

In other words the newly infected subjects showed bursts of energetic activity interspersed with complete immobility. Those with long term infections showed depressed activity levels generally.

\*\*\*\*\*

Regarding the question of the apparent inconsistency between the results of the first and second audiotape studies, there was a major difference between the weather conditions prevailing at the times of the studies. The second audiotape study by chance took place during a heat wave, and the research notes for the two hottest days mentioned that most of the schoolchildren were sitting or lying in the shade in the playground (see Table 10 for a comparison of midday temperatures).

TABLE 10  
Mid-day temperatures at Adams Mission in Degrees Celcius

First Audiotape Study	Second Audiotape Study
20,6	23,9
22,2	24,1
25,7	30,7
23,7	24,6
23,2	29,7
24,2	
26,5	
23,1	
20,2	
23,0	

Note: 20% of the observations in the second audiotape study took place at temperatures of over 29 C, and none at under 23,9 C. In the first audiotape study there were no midday temperatures over 26,5 C, and 70% of the observations took place at under 23,9 C.

This relates to the possibility that stress factors such as fatigue and heat affect performance in bilharzia sufferers more strongly than in uninfected persons. There is a suggestion in the literature that bilharzia sufferers are adversely affected by fatigue (Fenwick & Figenschou, 1972). The afternoon observations on the videotape study suggest that after 2 p.m. the bilharzia groups were less mobile than in the morning. It is possible that the bilharzia subjects in the second audiotape study were the most affected by the excessive heat on these two days. The median scores for the negatives and old positives were the same for the more moderate days, but on the two hottest days the negatives had a median energetic activity score of 3,7 seconds and the old positives had a median score of 0.

#### SOCIAL INTERACTION

In the first audiotape study recording of social interaction patterns were judged to be insufficiently detailed, and this measure has therefore not been tabulated.

Table 11 summarises the results on the social interaction measures for the second audiotape study.

TABLE 11  
2nd Audiotape Study  
Summary of Social Interaction Scores

	<u>Negative</u>	<u>New Positive</u>	<u>Old Positive</u>
Social interaction (median frequency in seconds)	28.0	22,1	21.6
Social Isolation (frequency)	20	31	52*
Game (frequency)	42	43	20*

---

\* Difference between Negatives and Old Positives  $p < .01$  (Binomial Test)

---

There were no statistically significant differences on the duration scores when a Willcoxon Matched Pairs Signed Ranks Test was used. The incident counts suggest a difference between the negatives and the old positives on measures of social interaction with the old positives being more socially isolated.

In the second audiotape study the number of bouts of agonistic behaviour in the new positive group is 22. 13 of these however were scored by the same subject, and thus the apparent difference between the groups on this measure is doubtful.

Table 12 summarises the results for the agonistic behaviour category.

TABLE 12  
Agonistic Behaviour

1st Audiotape Study	Negative	Positive
No. of samples	208	205
Incidents	106	158*

2nd Audiotape Study	Negative	New Positive	Old Positive
No. of samples	99	103	101
Incidents	49	27	20*
Bouts	4	22	5
Duration (median in secs/1 minute sample)	1.4	1.0	0.3

\* Difference between Positive and Negative Groups  $p<.01$  (Binomial Test).

The duration score of social interaction followed the pattern of the activity scores, with the positives being higher than the negatives in the first audiotape study and lower in the second. Agonistic behaviour and Games followed the same trend. It seems likely then that the general activity component was a confounding factor here.

#### OTHER INCIDENT COUNTS

##### Change of Activity

Frequency of change of activity can refer to either the level of activity (i.e. stationary, mobile, etc.) or to the focus of the activity (i.e. the type of game being played) depending on the measurement criteria stated in the procedure section. In the videotape study, two pieces of apparatus elicited a stationary state and the other two pieces elicited mobility, so the change of activity score more properly reflects a change of focus, although it is measured in terms of level.

Generally speaking regarding focus, there is some tentative evidence from the videotape study that a short attention span might be present in positive subjects, although in the second audiotape study the numbers of subjects are too low and the situation too unstructured to confirm this (See Table 13). In the case of change of level, a high score seems to be closely related to a generally high activity level : for instance, in a game of football there are frequent changes of level without any implications of a short attention span.

TABLE 13  
Change of Activity

<u>Videotape Study</u>	Negative	Positive	
Samples (10 secs)	758	620	
Incidents (focus)	410	419*	
<u>1st Audiotape Study</u>			
Samples (1 minute)	146	144	
Incidents (level)	618	592	
<u>2nd Audiotape Study</u>	Negative	New Positive	Old Positive
Samples (1 minute)	99	103	101
Incidents (level)	622	622	434
Incidents (focus)	45	48	50

\* Differences between Positives and Negatives:  $p < .01$  (Binomial Test).

#### Innovations

In the videotape study, note was taken of innovations where one member of a group initiated an activity. There were 11 such incidents, 8 of which were initiated by bilharzia positive subjects. This result together with the scrutiny of the videotapes after the bilharzia status of the subjects was known, led to an impression that the positive subjects were unusual in ways that were difficult to define. In vague terms this was expressed as "trying too hard" and "more tense". In an attempt to clarify this the categories of Distress, Incomplete Actions and Incongruous Activity were introduced into the 2nd audiotape study. The results are tabulated below (Table 14), and the indications are that the positives show more incongruous or unusual activity than the other groups, but the results are not statistically significant using the Sign Test.

TABLE 14  
Unusual Activities: incident count

	Negative	New Positive	Old Positive
Samples (1 minute)	99	103	101
Distress	3	9	3
Incomplete Actions	67	62	46
Incongruous Activity	9	22	12

### SURVEY OF SLEEPING HABITS

Of the 137 children who were interviewed, 28 reported sleeping in the afternoon. 5 of these were positives and 23 negatives.

79 respondents were able to estimate the number of hours slept on the previous evening. Of these, 15 reported sleeping in the afternoon, and were therefore excluded from the comparison of the length of evening sleep. The mean for the positive group was 10,21 hours, and for the negative group was 10,16 hours.

The probe question asking how the respondents knew what the time was, indicated that the information given was probably unreliable possibly because the respondents were very young and there were very few clocks in the homes. Nevertheless, there is no indication from the responses that the positives slept more than the negatives.

### SCHOOL REPORTS

During the 1st audiotape study the position in class for the subjects, where available, were scored according to whether they fell in the first or second half of the class (Table 15).

TABLE 15  
Position in Class

	Negative	Positive
First half	18	26
Second half	23	19

Although the difference between the two groups did not reach significance, it can be inferred from these figures that there is no indication that positives fare worse in school work than negatives.

### SUBJECT CARD FILES

Examining the card files, no particular impairment was evident when the positive group was viewed as a whole. However, when the positive group was divided into 3 levels of severity on the basis of egg counts, the impression of lethargy was more common in the severely infected groups.



TABLE 16  
Card file data on lethargy

	Negative	Positive (Severity of schistosomiasis)		
		<1 000 Eggs	1 000 - 5 000	>5 000 eggs
No. of cases	25	7	14	10
Lethargic	3	2 (28%)	4 (28%)	7 (70%)
Medium	12	2	5	2
Active	10	3	5	1

When the condensed reports of the subjects in the length of infection study were examined, impressions of impairment were strongest in the most severe cases. The following are the reports for the 5 subjects with egg counts of over 10 000. 4 are old positives and 1 is a new positive.

M.S. Egg Counts 1975 : 17 770      1976 : 19 240

Quite good marks and position in class. Teachers remark : "He works very well but was disturbed by illness at the end." Seemed to be popular - everyone seemed to address him, but very inactive. Was totally inactive on 2 occasions.

W.N. Egg Counts 1975 : 22 975      1976 : 7 120

Bad marks and class position. Teacher's remark : "Absent a lot. He still needs to work hard." Only seen once because of absenteeism. Was engaged mainly in solitary pursuits and not very energetic.

W.M. Egg Counts 1975 : 18 483      1976 : 10 520 ; 9 324 ; 13 778

Very low marks - failed. Teacher says he must be more confident (sic). Extremely unsociable and inactive. When questioned, he said that his grandmother, who was also his guardian, had recently died.

G.M. Egg Counts 1975 : 613      1976 : 5 120 1977 : 6 780; 10 800

Low marks and position in class. Teacher's report says he will be tried in the next standard although really he failed. She also said that he was not diligent enough in his work. Unsociable and inactive. He looked dull, tired and uncared-for. He was breathing very fast. Left school early in 1977.



P.M. Egg Counts 1975 : 0      1976 : 6 480 ; 3 696 ; 4 636 ; 10 412 ; 5 122 ; 11 664

Average mark and position in class. Plump, well-looking, very neat and clean. Alternates between bursts of social activity and immobility. Also varied in sociability. High change of level scores.

The following three reports belong to subjects with low egg counts. The first had the lowest egg count in the old positive group, and the other 2 had the lowest egg counts in the new positive group.

I.N. Egg Counts 1975 : 1 027      1976 : 560

Below average mark and position in class. Teacher's remark : "He is trying to learn Zulu. He enjoys his work." Reasonably active and affiliative.

F.N. Egg Counts 1975 : 0      1976 : 40

Average school work. Teacher remarks that he was trying, but that he was absent a lot. Looked stiff and awkward when walking. Seemed to want to join in games, but sometimes didn't although on other occasions he was very active. An impression that he was sick was checked, and he said that he was not.

P.B. Egg Counts 1975 : 0      1976 : 40

Has a good class mark and position in class although the teacher remarked that she could do better. Usually engaged in group activities, energetically and sociably. Very variable in activity level, and quite high on Incomplete Actions.

#### DEPTH INTERVIEWS WITH TREATED SUBJECTS

At the end of the descriptive phase 8 severely infected subjects were admitted to King Edward Hospital for treatment. Depth interviews were conducted with 5 of these to establish their attitudes towards, and information about, the disease.

All were aware that they had the disease and had been aware of this before their selection for treatment. All were aware of the connection with water, but most believed that only stagnant water (such as the dam near the Local Affairs Commissioner's Office) was the source of bilharzia.

All reported using river water for household washing and for bathing. 4 of the 5 respondents reported swimming in the river or dam. All subjects claimed that their general health was good, and only one complained of a feeling of fatigue which he attributed to evil spirits. Two of the subjects reported sleeping during the day.

## CHAPTER 8

## DISCUSSION OF THE DESCRIPTIVE PHASE RESULTS

## HYPOTHESES EMERGING FROM THE DESCRIPTIVE PHASE

In the descriptive phase of the project the following general hypothesis was investigated : "Children with schistosomiasis are more lethargic and unsociable than their uninfected colleagues, and poor performers at work and play." The results show that this general hypothesis is either too simple or wrong in many respects. Certain negative results can be stated with a fair degree of confidence at this stage. The positive subjects in the study when regarded as an undifferentiated group gave no evidence of being less active, sleeping more or performing badly on school work. However certain qualifications are necessary and can be stated in the form of hypotheses emerging from the descriptive stage :

1. There is selective exposure of active children to Schistosomiasis.

The major question arising out of the results on activity levels is that of the apparently increased activity in the bilharzia groups on both the videotape and 1st audiotape studies. It would appear unlikely that bilharzia actually confers greater energy on its sufferers. Those children who have haematuria would know that they have bilharzia. It is possible that the increased activity would be some form of compensation, but in my opinion this is unlikely: there does not appear to be any stigma attached to bilharzia, probably because it is so prevalent in this area (75% of children at this school); moreover it is simply one of a number of internal and external parasites prevalent in this area and I would not expect the children to react emotionally to it. There is a possibility that the higher activity scores were indicative of impaired control of behaviour in the same way as so-called hyperkinesis represents impaired behaviour. Alternatively, there could be a selective exposure factor in favour of the more active children. Although there were no control interviews for comparison, the depth interviews on the treated subjects indicated that all respondents used river water for household washing and for bathing, and that 4 of the 5 reported swimming in the river or the dam. The selective exposure hypothesis seems more likely than the impairment one in terms of the bilharzia group's better performance on school work.

2. Impairment in performance becomes evident when environmental conditions are stressful.

There is a suggestion in the literature that infected subjects are adversely affected by fatigue (Fenwick & Figenschou, 1972). In the videotape study there was little difference between infected and uninfected subjects on mobility in the afternoon in contrast to the higher mobility of the infected subjects in the morning. This suggests that the infected subjects were more susceptible to fatigue. Similarly the apparent inconsistency between the results of the 1st and 2nd audiotape studies could be due to the bilharzia group in the 2nd audiotape study being more affected by the excessive heat.

3. Severity of infection as a factor affecting activity levels.

Severity of infection was thought to be a factor for the following reasons :

- (a) In the second audiotape study, the old positives were less active than the new positives, which could be due either to the duration or to the severity of the infection.
- (b) When the impressionistic data from the card file was examined, and the positive group divided into 3 levels of severity, a greater proportion of those in the high severity category were lethargic.

The obvious difficulty with testing these hypotheses is that one is postulating selective exposure of active children as well as impairment in the form of lower activity levels in severe cases : in other words, that some of the infected children are more active and others less active than control.

The first choice of research design under these circumstances would be to have each child as his own control under different conditions. However, the difficulties of testing enough negatives to gain a substantial sample of newly infected cases later were prohibitive, and the expected

developmental sequence is in any event a gradual decline in energetic activity. Similarly, a before-and-after treatment design was considered and rejected at this stage. Firstly one cannot ethically defend exposing large numbers of children to the risks of treatment when they are not showing any obvious signs of impairment, and then re-introducing them to the endemic area which is their home. One could only be reasonably certain of health benefits if a control programme were introduced at the same time to that area. Cost becomes a significant factor when one considers that other health priorities exist, for example tuberculosis and malnutrition. Secondly, to consider such a programme, one would need co-operation from medical authorities, and at this stage of the research it was not forthcoming.

The best course of action was therefore considered to be an extended study with a large group of children. Energetic activity would be monitored over a period of 4 months from August to November when one could expect a wide range of weather conditions on the Natal Coast. The low transmission rate of bilharzia at this time of the year was an added advantage because the bilharzia status of the subjects would be relatively stable. Social interaction would be studied concurrently, and in much greater detail than previously. The subjects would be drawn from an existing group (i.e., a school class which had been established at the beginning of the school year in January) where social structures such as friendship groups and leadership were fairly stable. The positive group would be considered as a whole in some measures, and broken down into levels of severity in others.

## THE MEASURES

To what extent have the measures used in the descriptive phase been successful in discriminating between groups?

### Activity

Activity has been categorised in different ways :

A 2 level system using the categories Mobile and Stationary.

A 3 level system using the categories Energetic, Mobile and Stationary.

A 4 level system using the categories Energetic, Mobile, Stationary and Immobile.

The 4 level system seemed to be the most informative with significant differences between groups on the extreme categories, i.e., Energetic and Immobile. The difference between groups was not a simple greater-than or less-than relationship, and varied according to change in circumstances. The indications were therefore that either Energetic or Immobile states should be monitored over a long period of time and a variety of conditions. The audio-taped commentary system proved very time-consuming with the analysis of each 1-minute sample taking approximately 20 minutes to complete and check. Other disadvantages with this system are the errors introduced by the time-lapse between action and comment, and the difficulty of adequate commentary during very fast-changing sequences of activity. For these reasons it was decided to develop a more efficient method of measuring activity, and this will be described in the next chapter.

### Social Interaction

It seems likely that the general activity component was a major confounding factor in the duration score of social interaction and in the scoring of agonistic behaviour. Social isolation appeared to be a more informative measure, but was only used on the 2nd audiotape study where the subject numbers were low, and the egg counts unusually high in the



old positive group. The Game measure also seemed to be an informative one. The old positives differed significantly from the negatives on these two counts, being more isolated and less involved with group activity. The new positives on the other hand were involved with group activities, but showed a somewhat higher social isolation score than the negatives.

#### Other Incident Counts

The frequency of change of activity level did not add anything to the information gained from activity measures per se, being higher in subjects whose general activity level was high. The change of focus measure was more promising in the videotape situation, where positive subjects showed a significantly higher incidence of change of focus. This measure would seem to be more suited to a structured situation such as a school classroom and merits special attention in this kind of setting, to investigate the hypothesis that children with bilharzia have a shorter attention span.

The question of innovative or incongruous behaviour is a complex one but the indications are that positives show more unusual behaviour. It was not however clear whether this constituted leadership behaviour in accordance with the selective exposure hypothesis, or whether it was part of a syndrome of irritable hyperactive behaviour.

The measurement of social behaviour in the descriptive phase of the study was not sufficiently comprehensive to answer the question of whether selective exposure operates to any great extent as a factor in observed differences between groups.

#### A SPECULATIVE PICTURE OF CHILDREN WITH SCHISTOSOME INFECTIONS

Is a general picture emerging of a child suffering from bilharzia? Only a highly speculative general picture can be suggested on the basis of the descriptive phase results. The most likely pattern would appear to be thus :

Active, responsible, intelligent and gregarious children spend more time in river water, either performing household chores or playing with friends, and therefore become infected with schistosomiasis. In the first year of the infection or while it is at a low level, impairment or behavioural changes in the course of adaptation are very difficult to detect: the children are still very active but there are signs of distress and irritability; they are distractable in class and susceptible to fatigue later in the day and under conditions of extreme heat. Most bilharzia sufferers fall into this category. The few with very high egg-counts are lethargic and become socially isolated. Their school performance decreases due to absenteeism.



## CHAPTER NINE

DEVELOPING A METER TO MONITOR ENERGETIC ACTIVITY

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Bell (1968) had used a meter consisting of 3 wrist watches modified to record movement in 3 planes. This was the type of instrument required, but it took no account of levels of activity. Any movement in any of the 3 planes was recorded. It was in the extreme levels of activity that the differences between negative and positive subjects lay in the descriptive phase of the bilharzia study. There were however a number of lessons to be learned from Bell's method. Bell reported that a careful check was kept on the reliability of a meter so that the effects of defective watches could be eliminated from the data. He reported a high test-retest stability (in the region of ,7 for the sum of 6 readings). Halverson and Waldrop (1973) reported on the reliability of the same meter showing that there was a high odd-even stability.

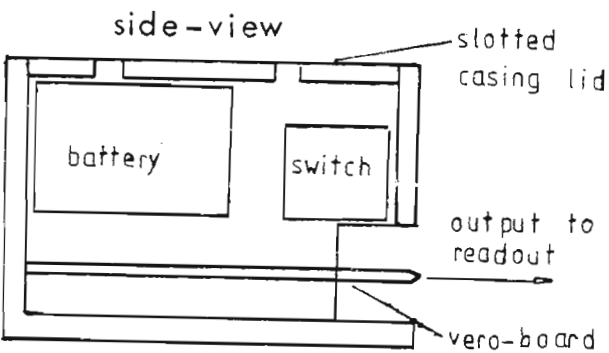
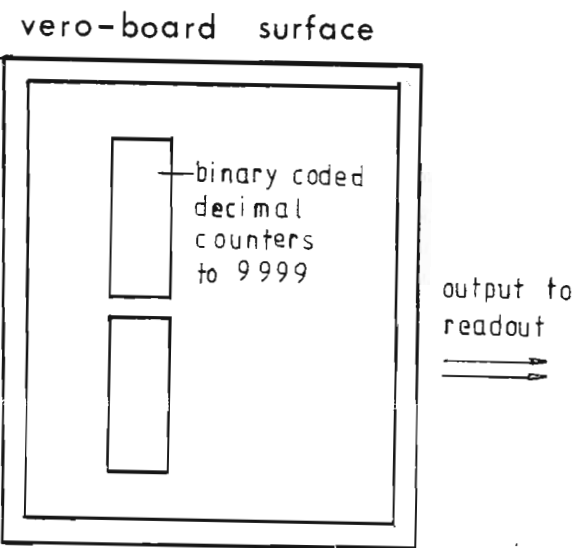
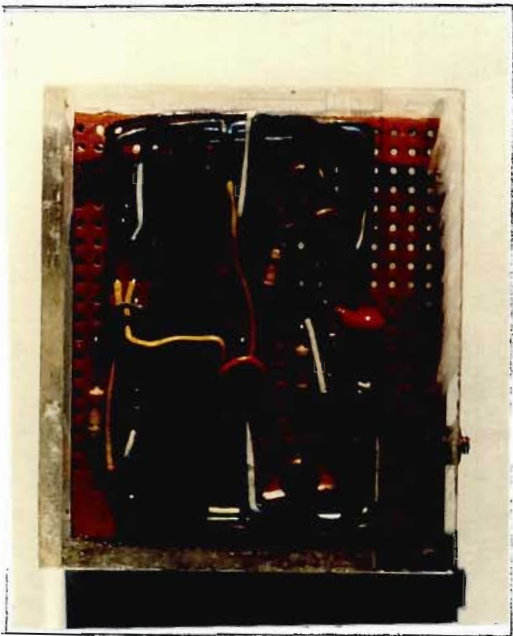
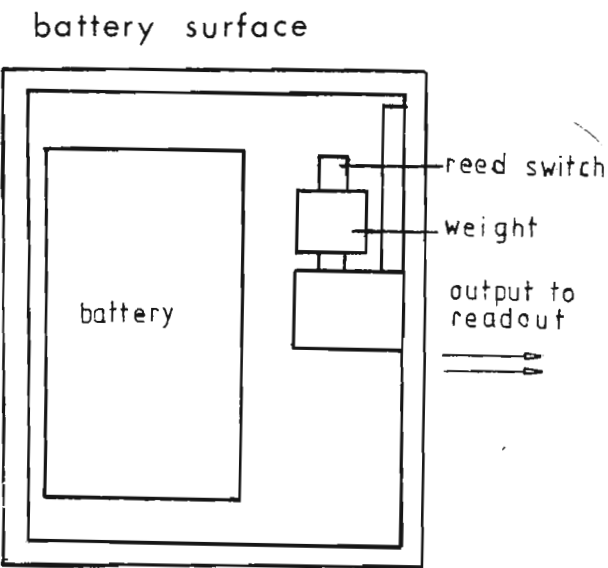
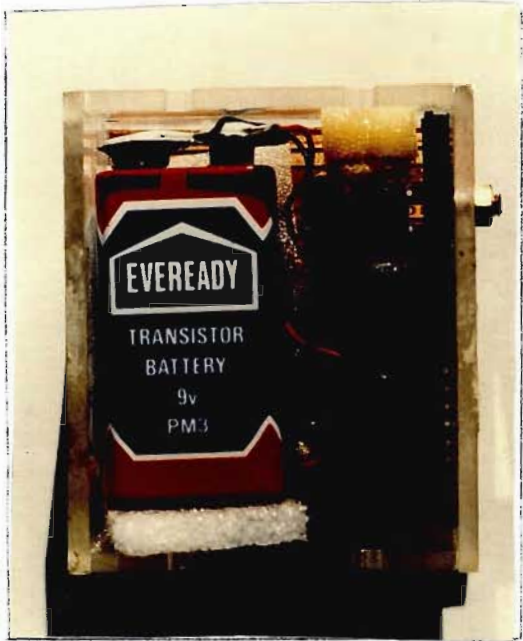
In order to meet the demands of the bilharzia study, the following guidelines were proposed for the development of a meter :

1. A large number of meters were required for simultaneous use so that the cost of the study should be kept as low as possible.
2. The meter should record energetic activity only. If possible, the sensitivity of the meter should be adjustable.
3. It should not interfere with normal play activity, i.e., it should be small and comfortable to wear, probably on a belt.
4. The casing should be sufficiently robust to withstand playground activity.
5. The meter should not be affected by changes in weather conditions.
6. The subjects should not be able to see or hear the recording of the activity score.

7. The meter should be able to run without adjustment for a period of at least 1 hour.

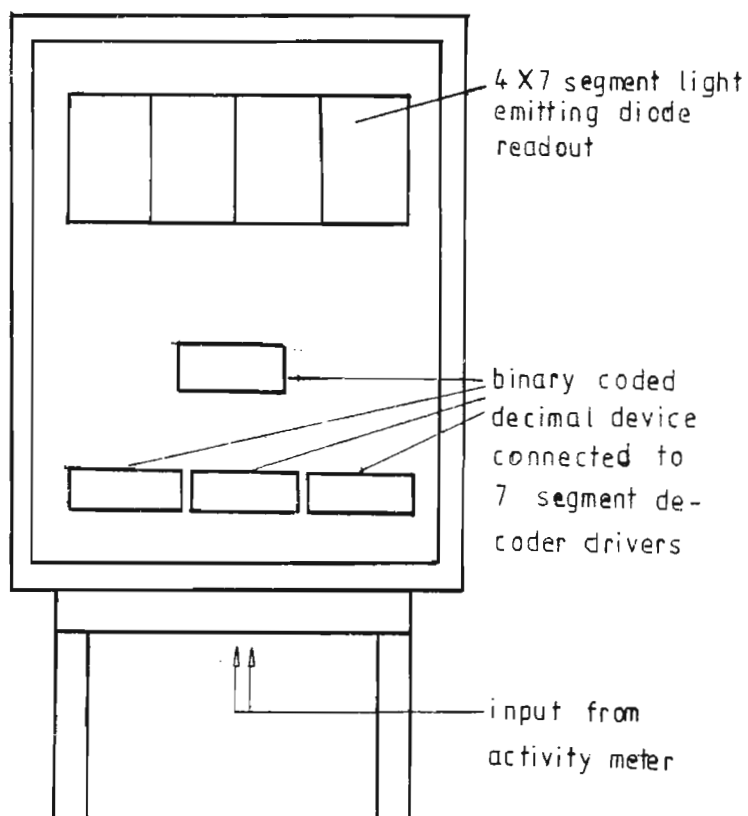
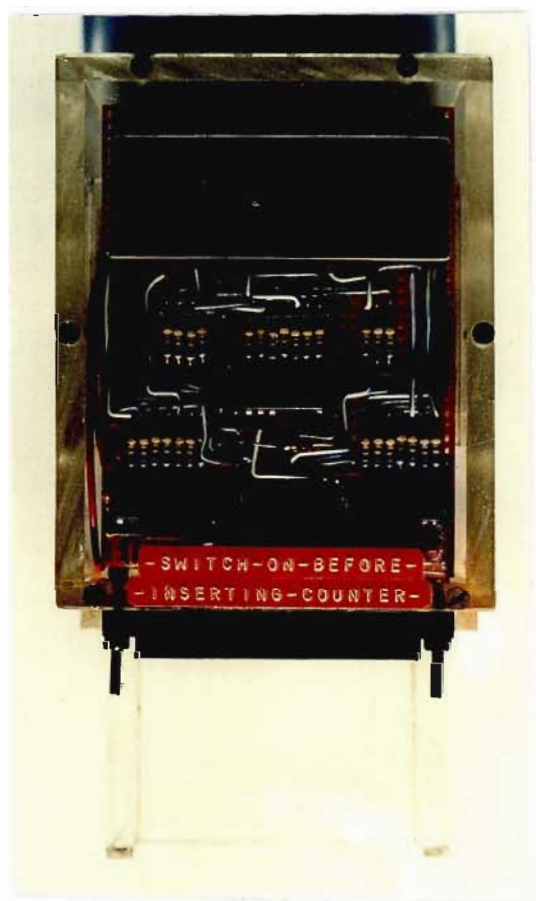
A meter was developed in accordance with these guidelines. It consisted of a pulse counter with a digital readout. Movements in the vertical plane only are recorded, because these include almost all actions such as Jump, Run and Skip which made up the Energetic Activity category in the descriptive phase. Walking, for instance, is not recorded, but a bouncing gait would be. On the counter a small weight which moved vertically activated a reed switch. Pages 69, 70, and 71 show photographs and diagrams of the counter and readout unit. Two prototypes were built and certain technical problems such as a bounce effect in the reed switches were eliminated. These were then tested on children at play and the optimal weight to record energetic activity was established. It was also established that the meter met with the other criteria set out in the guidelines, and a further 58 meters were built. The meters were encased in small shatterproof perspex boxes, numbered, and packed with newspaper for the comfort of the subjects into the correspondingly numbered belts.

PHOTOGRAPHS AND DIAGRAMS OF THE ACTIVITY  
METER INDICATING THE COMPONENTS

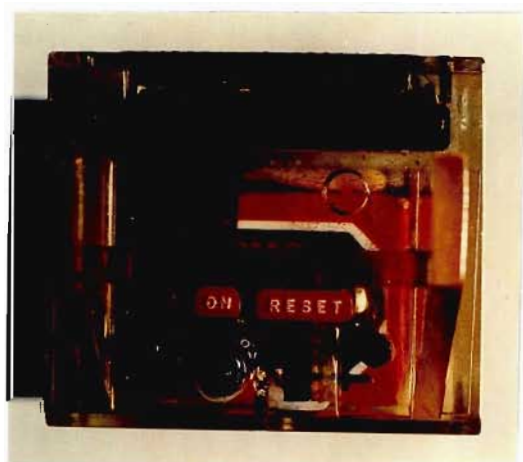


# PHOTOGRAPHS AND DIAGRAM OF THE READ-OUT METER

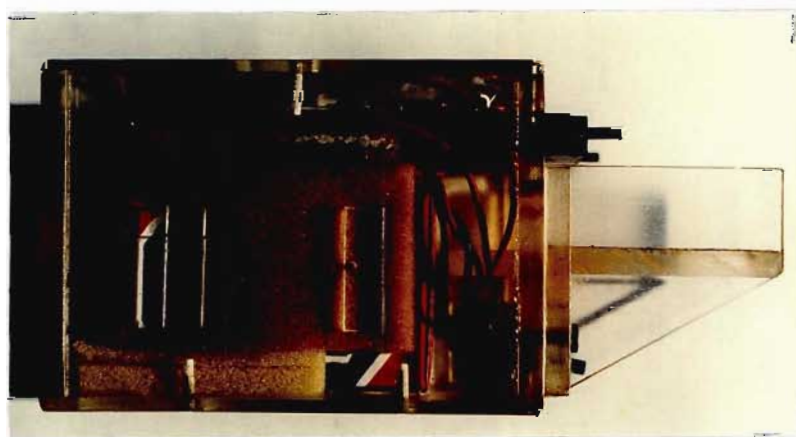
upper surface of the read-out meter



input surface

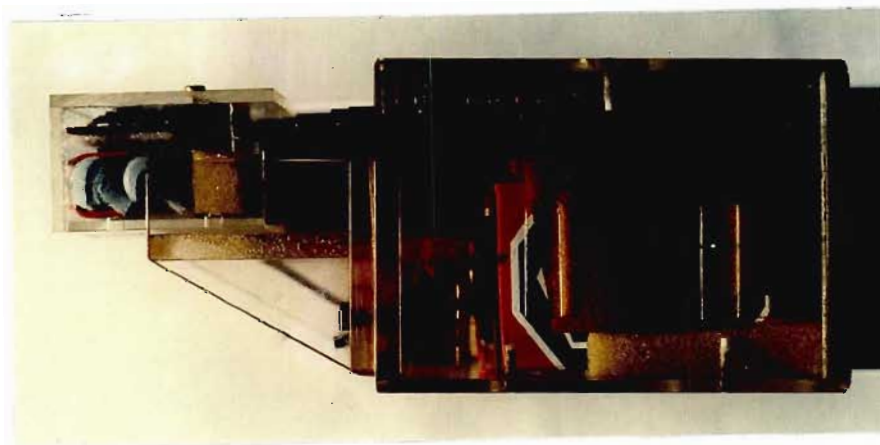
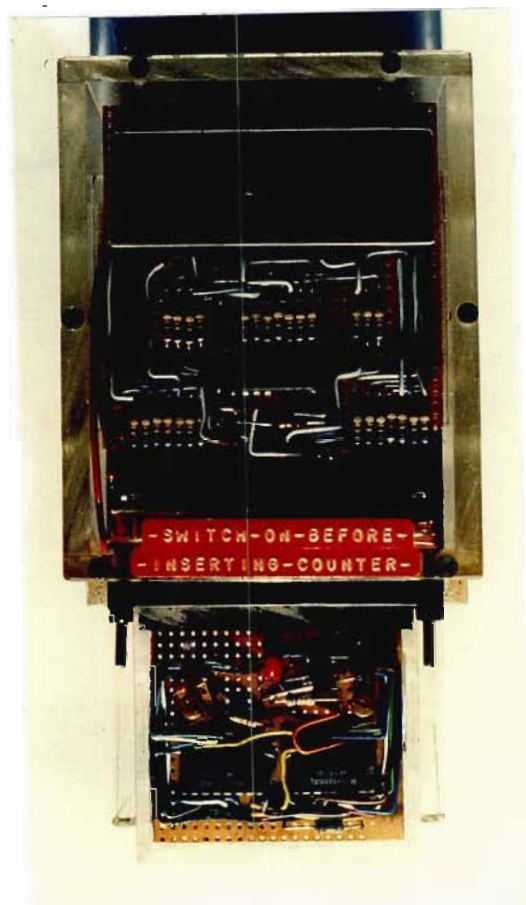


side view



PHOTOGRAPHS SHOWING AN ACTIVITY METER  
CONNECTED TO THE READ-OUT METER

upper surface



side view



The meters were then tested in the school playground situation. School boys were asked to wear the meter during school playtime and comment on what it felt like. The general consensus was that they soon forgot they were wearing it and were able to play in the normal way. Children in a ballet class wore meters through a very varied programme of exercises and dance steps. The only exercise they were unable to do was a back-strengthening one which involved lying on the stomach.

#### VALIDITY

There was a high correlation between the teacher's ratings for energetic activity and the meter scores in the children's ballet class. It was interesting to note that even in a structured situation such as this one the meter scores ranged from 70 to 900.

#### RELIABILITY

A preliminary indication of reliability was gained in the local school by placing 2 meters one above the other on each of 25 children for a playtime of approximately 20 minutes. The 25 pairs of meters gave a correlation of ,92. Subsequently similar checks were used during the main study at Adams Mission from time to time. A problem developed during the first 2 weeks of the Adams Mission study which was traced to the contact edge of the meters becoming coated with a film from air pollutants and causing malfunction of the readout unit. This was noticed during a reliability check while the children were being habituated to the wearing of the meters, and there was a very poor correlation between meters.

A number of cleaning and checking procedures were adopted at this point :

1. The contact points of the meters and readout unit were cleaned daily and the meters were kept in plastic bags to minimise the effects of air pollution.
2. Every 2 to 3 weeks meters were checked for mechanical defects by subjecting them to a mechanically controlled vertical movement designed to activate the meter at its threshold.
3. Records were kept of the performance of each meter and scrutinised daily. Any meter which showed consistently low or consistently high readings was tested, and if faulty, the readings were omitted from the study. There were however, only a few such incidents.

From repeated reliability checks during the main study it became clear the the reliability of the meters fluctuated from time to time and the correlation coefficients ranged from ,7 to ,92 using the Spearman Rank Order Correlation. It was however obviously impossible to place 2 meters in the same position on the children for checking reliability, and with smaller children particularly, the upper and lower meters were at different angles during normal play movement.

The odd-even stability of the activity scores per child was assessed during the main study after 4, 6 and 20 readings. For 4 and 6 readings the odd-even correlations were approximately ,4. This rose to ,61 for boys and ,67 for girls after 20 readings. On the face of it this does not compare very favourably with Halverson and Waldrop's figure of between ,8 and ,9 for 6 readings. Energetic activity may fluctuate more than the type of total activity score generated by the meter used by Halverson and Waldrop; the subjects in the Adams Mission study were older and possibly more variable in their behaviour. For the purposes of this study activity stability that was too high would have meant that the

expected variation corresponding to changes in environmental conditions was not present. Over 50 visits were made to the school in the 4 months of the main study in very varied weather conditions, only excluding heavy rain. From force of circumstances the school procedure varied from time to time making different activity demands on the children.



CHAPTER 10  
THE MAIN STUDY: PROCEDURE

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The Standard I Classroom at Adams Mission

This study was intended as an in-depth analysis of energetic activity and social interaction in a group of schoolchildren to examine the hypotheses of selective exposure to schistosomiasis, severity of infection as a factor in causing impairment, and weather conditions as a stress factor in infected subjects.

THE SUBJECTS

The standard I class at Adams Mission was chosen for this in-depth study for a number of reasons:

1. It was known from the prevalence study that approximately 50% of the children would have *S. haematobium* and that relatively few would have any other health problem.
2. The majority of children in Standard I at this school were below 14 years of age and therefore more suitable for study by direct observational methods than older children who are more sensitive to the presence of observers.

3. The standard I classroom was situated at some distance from the main school and the children spent most of their lunchbreak in the immediate environment of the classroom which was in fact the Community Centre Hall. Observation was thus simplified by the fact that these children were generally physically separated from the rest of the primary school for a large portion of the lunchbreak: identification of subjects was easier and social groupings took place within a single class. It had been noted in the descriptive phase of the study that social groups were on age lines as well as education standard lines in the main school playground.
4. The standard I children had to go to the main playground at the start of the lunchbreak to get their meals. They were then free to return to their classroom area, a distance of some 100 metres, in their own time and at their own speed. This gave a structure to the time available such that a considerable distance had to be traversed by each child. The category of Energetic Activity as defined during the descriptive phase was in essence "a degree of activity in excess of the demands of the situation and relatively unrelated to the geographical distance traversed by each child". The qualification "relatively unrelated to geographical distance" is used because Energetic Activity is seen as having the available space as a constraining factor on the amount of Energetic Activity feasible. In this situation, the children had a large amount of space at their disposal. There was thus greater scope for energetic activity with these children than for the remainder of the primary school who were confined by custom if not by actual school rules to the areas immediately adjacent to their classrooms.

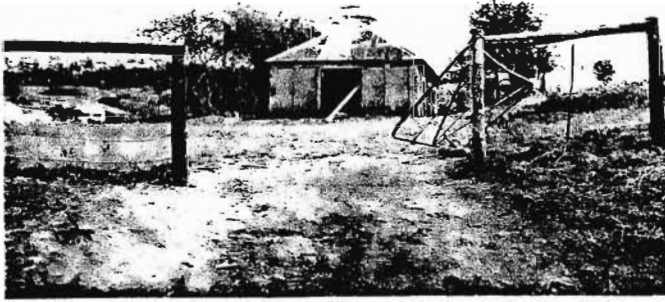
The children were tested by the staff of the RIDTE for bilharzia and other parasites, and an independent researcher selected 33 pairs of subjects from the available 84 children, 1 pair member being infected with *S. haematobium* and the other not. These were matched on the basis of sex and age to within 1 year. The latter criterion was judged to be fairly unreliable. Certain pairs were rejected where there were big differences in the build and apparent physical maturity of the subjects,

and reconstituted from the available unmatched children. The final pair groupings were thus on the basis of the same educational level and sex, and similar age, build and physical maturity. This design was not strictly a matched pair one in the sense that each subject could only be paired with one other, rather it was an attempt to ensure homogeneity of the control and experimental groups on as many of the relevant variables as possible.

#### THE DATA SOURCES

1. Scores from the activity meters.
2. A sequential set of photographic records of the children running or walking to the main school for lunch, and a further set of photographs taken while lunch was being eaten depicting the social groupings.
3. Audiotaped commentaries of one-minute's duration each aimed at descriptions of each subject's social interaction patterns.
4. Daily records of the major events taking place in the playground and a subjective account of weather conditions.
5. Subject card files.
6. School reports.

## THE LUNCH-TIME ROUTINE FOR STANDARD 1



1. Std. 1 Classroom  
showing football ground



2. Progress to Main  
School for lunch.



3. Lining up for lunch



4. Hopscotch game  
at the Main School



5. Walking back



6. The leaders in the football  
game



## DAILY OBSERVATION PROCEDURE

The process of data collection lasted from August until November with breaks on days where there was actual rain and the children were not allowed out, on days when school closed early and during the November tests when the lunch-hour routine changed. Not all measures were taken every day. The study started at the end of July, but the first 2 weeks using the activity meters were regarded as habituation time, and problems with meter reliability were dealt with during that time. Thereafter the meters were checked for reliability on the children on 3 occasions during the recording period. When the procedure with the meters was running smoothly, the tape recorders and cameras were introduced and the children were allowed to examine them and play with the tape recorder, until they were judged to be sufficiently habituated - after about 2 weeks. At this stage the photographic records and social interaction recording commenced. Photographic records of the rank order of running down to lunch were terminated after approximately 20 satisfactory sets had been obtained. The metering of activity and social interaction commentaries continued until school closed towards the end of November.

Between 50 and 60 meters were available for use each day. The belts containing the meters were tied on the children in the sample each day a few minutes before the completion of the morning classes. The children returned to the classroom for assembly during which a short grace was said, and they were then dismissed by the teacher for the lunch hour. The children then ran or walked down the road to the main school playground. Photographs were taken from a point on the way, of the sequence in which the children passed that point. These photographs also gave information on the social clustering of the children. On reaching the main playground most of the children lined up while the monitors, who were the older ones, kept order and fetched and distributed the food. The children then sat singly or in groups on the ground eating their lunch and talking. Photographs were taken again at this time and an attempt was made to scan the area photographically twice during this period in

order to gain information about those who were obscured or unrecognisable or in the process of changing groups during one or other of the photographic scans. As soon as the eating was complete, the children's activity diversified: a few immediately started games, others walked back to the standard I classroom and games were started there, others went to the neighbourhood shops and houses, and on some occasions went into orchards to gather peaches or into the sugarcane fields to obtain cane to suck. The girls were generally divided between the 2 school playgrounds and played ball games in groups. Each day a few girls had the duty of going down to the river to wash mugs used during lunch. The boys usually made for the flat piece of ground outside the Standard I classroom and played football informally in 1 large group. On occasions a smaller group formed usually consisting of younger boys who were perhaps outclassed in the main football game.

From the time that the food arrived, to the end of the lunchbreak, the children were unsupervised by teachers. Observers attempted not to interfere, show disapproval, or indeed obvious interest which was especially difficult during aggressive incidents. On a few occasions observers were present and apparently tolerated during aggressive incidents, whereas the children would warn each other of the approach of the teachers at the end of the lunchbreak and any aggression in progress broke up. It would seem then that the strategy adopted at least placed fewer constraints on the behaviour of the children than the presence of their teachers. It is interesting to note that the only injury that was witnessed during the 4 months occurred when 2 close friends were playing with stones and the one hit the other apparently accidentally.

Social interaction commentaries were recorded from the time that the children finished eating and started moving towards the Standard I classrooms. It was decided that social interaction was so uniform during the meal that more information was to be gained from photographic records of social grouping. As behaviour changed after the meal the commentaries become more informative data sources.



An Observer recording a commentary

Commentaries were made by 2 observers, both of whom had worked on the audiotaped commentaries of the descriptive phase. To check on the reliability of the commentaries observers independently recorded commentaries on the same subjects at the same time for one lunch period (see Appendix 2). On normal observation days each observer had a list of 5 names of same-sexed subjects: this procedure was found to be the most practical for obtaining as many commentaries as possible during the remaining time - approximately 30 minutes - available for free play after lunch had been eaten. Since the boys and girls generally played separately in different areas, too much time would have been wasted moving about the play area if each observer had been commenting on both boys and girls on a single day. Five subjects per day was the optimal number of subjects who could be identified and located during the time.

While lunch was being eaten each observer positively identified each subject on her list. This became easier as the study progressed and the children and their customary associates and play habits became familiar. Commentaries commenced when the first children started moving away from the lunch area and observers took the names in sequence from the top of the list. This ensured a time-lag between commentaries on a particular subject and prevented a bias from developing in favour of the subjects who were engaged in more striking activities. It sometimes happened however that the subjects from one list were playing both at the top and lower playgrounds. In this event, subjects from the lower playground

were observed twice before the observer moved to the top playground, but in no case were 2 consecutive commentaries made of the same subject. Another procedural difficulty which occurred less frequently was introduced when the subject disappeared from all the usual play haunts. This subject was questioned as to his movements when school resumed and a note made on his personal file so that some records were built up of children who engaged in atypical and solitary pursuits. Each child on the observer's list was observed 2 or 3 times during a lunchbreak according to circumstances.

Observers also noted any unusual or aggressive incident occurring during this time and these were noted on the subject cards of the individuals concerned. In this way less frequently occurring behaviour patterns could be described, albeit in a less reliable manner.

Commentaries were timed with a stop watch and were devoted to communicatory patterns with activity patterns being considered as secondary. This procedure arose from experience during the descriptive phase where it was found to be impossible to comment adequately on both aspects of behaviour simultaneously. At the end of each commentary a brief summary of the circumstances of the observations was given.

At the end of the lunchbreak the meters were collected at the classroom door and each child was given a sweet. The meters were then connected to the display unit and the scores recorded for each child.

#### DAILY RECORDS AND PREPARATION OF THE METERS

After each day's observations, records were written up to minimise errors and omissions which might result from too great a time-lag between observations and permanent records. Meters were prepared for the following day. This procedure was as follows :

##### 1. Daily reports

These contained a subjective view of the weather conditions, an account of any circumstances peculiar to that day, such as change in school routine or a disciplinary incident: a summary of the major playground activities: and a list of all records taken during the day and subjects observed. This was considered as a co-ordinating record for all other records.



2. Subject activity records

The meter records for the day were transferred to the record sheets and a running total was kept of the number of readings per child. Children who had been absent and therefore had fewer readings were noted for priority on the next day's lists. This was felt to be important because of the influence of seasonal changes in weather conditions on activity: the number of activity recordings per subject were thus kept level through the 4 months of the study.

3. Meter reliability records

The successive readings of each meter were recorded and scanned each day for suspected anomalies. Any meter showing an unusual pattern of readings, either high or low, was referred to a technician for checking. Generally this procedure was shown to be over-cautious, but in 2 or 3 cases of malfunctioning it allowed for an early detection of the problem and the unreliable readings were omitted from the record.

4. Social Interaction Data

Commentaries were scored according to the social interaction checklist by the observer who had made the commentary. (See Appendix 3). In this way ambiguities in the commentary could be rectified while the incidents were fresh in the observer's mind. Scoring was then checked by the researcher and any instances not covered by the definitions were discussed and a decision made, which was then incorporated into the working definitions. Interobserver reliability was therefore not an issue. Conversations were scored, not according to content which was usually inaudible, but according to the behavioural accompaniments. These were interpreted conservatively: the neutral category thus referred to a lack of clear indications as to the nature of the interaction. The tapes were then labelled and filed and the recorders prepared with fresh tapes and new subject lists.

5. Subject Cards

Any additional information from any source during the day was added to the individual subject's card. These could be teachers' comments, an account of illness, observers' notes of aggressive incidents, or observers' impressions.

6. Photographic Records

Negatives for the day were developed, labelled and filed, and film was wound for the next day. Whenever there was a break in recording days, such as rainy weather, school outings or weekends, slides were printed from the negatives, mounted, labelled and stored. Good identification photographs were selected for each child for reference purposes later.

7. Preparation of the meters

The meters were randomised and the contacts were cleaned. They were set at zero and re-packed for the next day.

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## CHAPTER ELEVEN

### ANALYSIS PRIOR TO OBTAINING BILHARZIA STATUS DATA

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Because a certain amount of subjective judgment was necessary for part of the analysis, the preliminary stages were completed without the researcher being aware of the bilharzia status of the subjects.

#### ACTIVITY METER SCORES

The mean activity score was calculated for each subject. Three scores of above 5 000 were eliminated from the data on the grounds that they were so far above the remainder of the activity scores that they were more likely to be due to a malfunctioning meter than a reflection of very high activity levels.

#### PHOTOGRAPHIC RECORDS

When all the photographs had been printed as slides and labelled, the observers identified the children in each slide. This procedure started before the end of the data collection phase and was completed soon after the end of this phase while the name and appearance of each subject was still fresh in the observers' minds. All identifications were then checked by both observers. In cases of doubt the subject's clothing on that day was checked from other photographs, and the subject identification photographs were consulted for other distinguishing features. In all, some 1100 slides were printed providing information on activity rankings and social groupings. This was a highly satisfactory data source:

1. It enabled a large amount of data to be gathered in a short time by one observer (a research assistant was only available intermittently).
2. Because of the large number of children in the Standard I class (84) fast, reliable identification of subjects constituted a problem. Identification of subjects in photographs could be checked at leisure.
3. Children adjusted more easily to photographs which were momentary, and of a group, than to audiotaped commentaries which were of an individual and lasted one minute. This was important in view of the general policy that observations should be made openly but with as little intrusion as possible in the ongoing activities of the children.

## ACTIVITY RANKINGS

On the slide sets dealing with the sequence of children on their way to the main school, all children in Standard I whether in the sample or not, were ranked in order of passing the camera on each day. On 10 of the 20 days more than 50 pupils could be identified with a reasonable degree of certainty, and these days were selected for an overall ranking of the subjects.

THE RANK ORDER OF CHILDREN  
ON THEIR WAY TO THE MAIN SCHOOL.  
(ONE PHOTOGRAPH FROM EACH QUARTILE)



Q1



Q2



Q3



Q4

From the general observation of this particular aspect of playground activity, the rankings would seem to be the product of both social and activity considerations. Those appearing on the pathway down to the

mainschool first were running hard and appeared singly. As time went on the pace of those passing the camera was slower; there were pairs of children and larger groups who talked and teased. Among the younger children these were usually single-sex groups, but the teenage boys and girls tended to come down in a big group late in the rank order. The last few children coming down were usually the same few younger girls who accompanied the teacher when they left the classroom last.

Activity rankings from photographic data were obtained by taking the median rank for each child on the 10 largest sets of ranks. These were then arranged in an overall rank order. A comparison was made between the ranks derived from the photographic data, and those derived from the meter scores, using a Spearman Rank Order Correlation. There was a low positive correlation of ,23 which was statistically significant ( $p < .025$ ).

On the basis of the general observations, it was decided to group the ranks into quartiles on the assumption that those in the first quartile were motivated mainly by the expenditure of energy, running hard and paying little attention to each other (see photograph from Q1). Those in the 4th quartile were motivated by social considerations, i.e. meeting and conversing with friends (see photograph from Q4).. It was hoped that the two major areas of concern, activity and social interaction, would be served with a single data source.

#### SOCIAL GROUPS

The major data source for the identification of social groups were the sets of photographs taken during lunch. Two criteria were used in scoring associates : that they should not only be in close proximity to each other, but also oriented towards each other. A second data source was the set of photographs taken on the path and here the same criteria held. The final source was taken from the audiotaped commentaries and was less reliable. Here, any communication between the subject under observation and any other standard one pupil was scored as an association. The efficacy of this data source depended on the ready identification of the second child and this of course improved as the study progressed. This category of associate score was kept separate from the rest for the initial part of the analysis because of obvious biases in favour of easily identified subjects. Finally however a



decision was made to count these scores with the rest because they added so considerably to the picture of the total associates for each child during the entire lunch break.

A card file was set up for all subjects. Each group of associates was cross-referenced on the subject associate cards, and all associates scored whether members of the sample group or not. Thus when a photograph showed a group of five children eating together, the card for Subject 1 would show a score of one association against each member of the group, and similarly for the cards of the other group members. If the group remained unchanged in a later photograph in the sequence for that lunch hour, no further associate scores were made. If however members left or joined the group, it was defined as a new group and a second set of associate scores were made. The final associate card for Subject 1 contained a list of all other children he had associated with and a score next to each one of the separate occasions on which they were recorded in association. There was an additional category for the number of times Subject 1 was recorded as being solitary.

Because the majority of associations were single-sex, separate sociograms were constructed for boys and for girls. From the general observations on playtime associations it was known that the girls formed smaller playtime groups whereas the boys tended to congregate for eating or play in a large group. Different procedures were therefore adopted in constructing the sociograms.



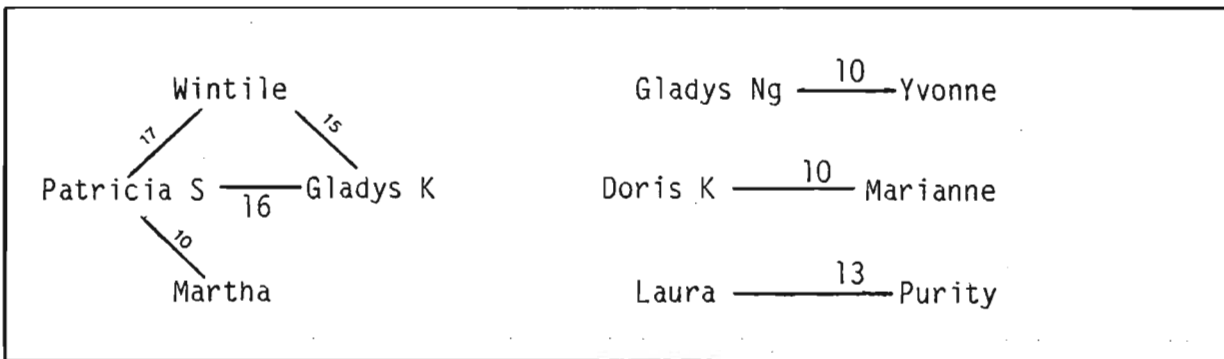
Girls: a number of small groups



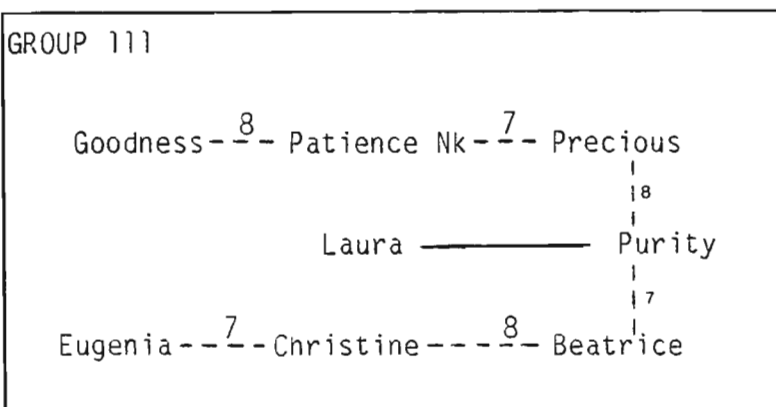
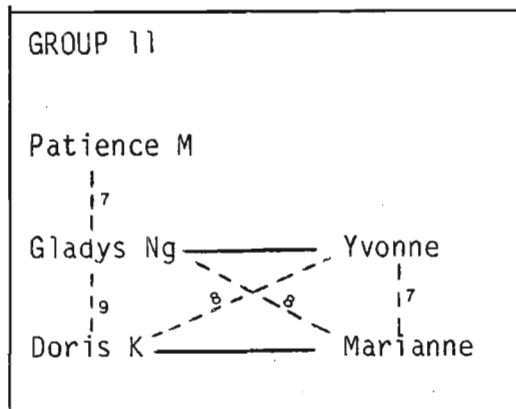
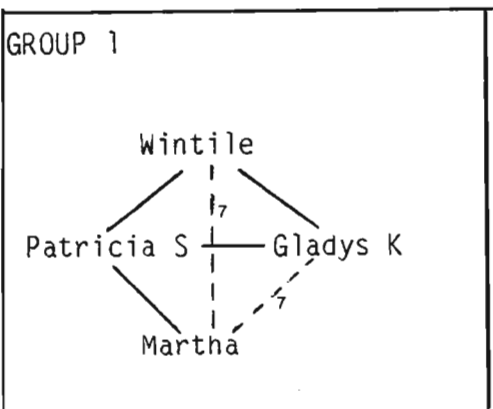
Boys: one large group

### Girls

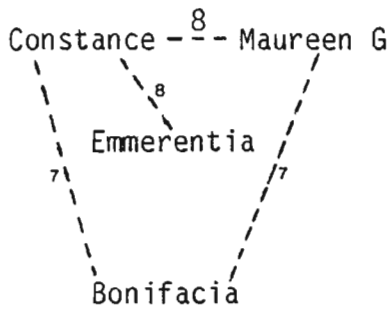
The associate scores between any pair of individuals was regarded as a bond of greater or lesser strength according to the score attached to it. The largest score was 17, and scores of less than 5 were disregarded. Starting with the strongest bonds a diagram was constructed showing the names of the girls and the strength of the bond between them. Thus for bonds of between 10 and 17 the sociogram was as follows :



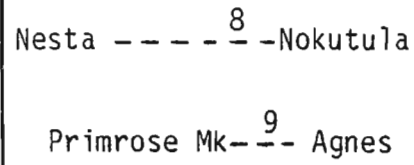
Then adding in bonds of 7, 8 and 9, the diagram had the following form :



## GROUP IV

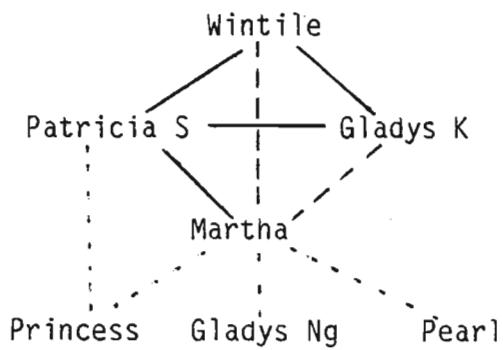


## PAIRS



Disregarding for the present the two pairs, these four groups are seen as the nucleus of the stable groups. Extending them each in turn to include bonds of 5 and 6, the following picture emerges :

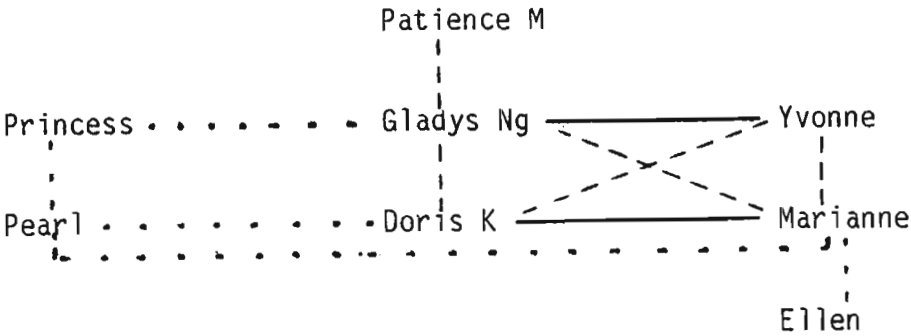
## GROUP 1



This group is characterised by very strong bonds, and, with the exception of Martha, its members have very few contacts outside the group.

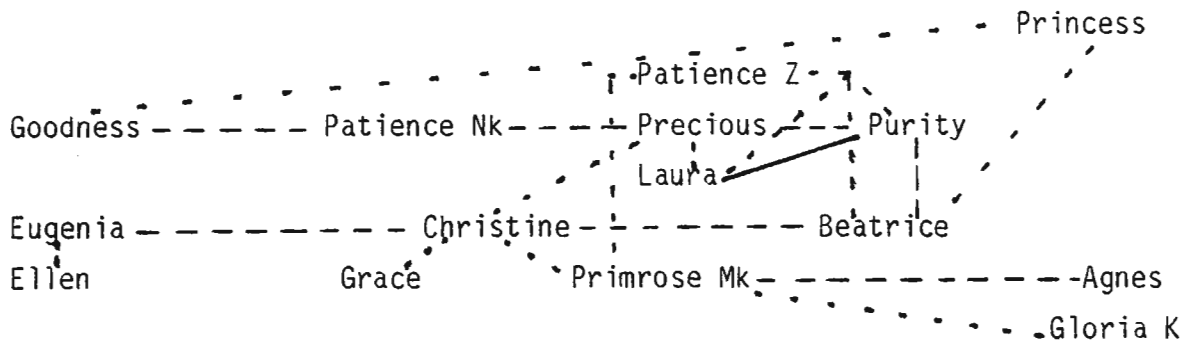


GROUP 11



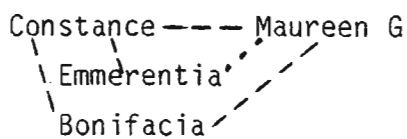
This group consists of the older girls who associate by reason of their status as monitors as well as on grounds of friendship. Pearl was younger than the rest and not a monitor.

## GROUP 111



This is a much more loosely constructed group consisting of most of the younger girls. It can now be seen to contain Primrose Mk so that this pair is really part of the larger group.

## GROUP 1V

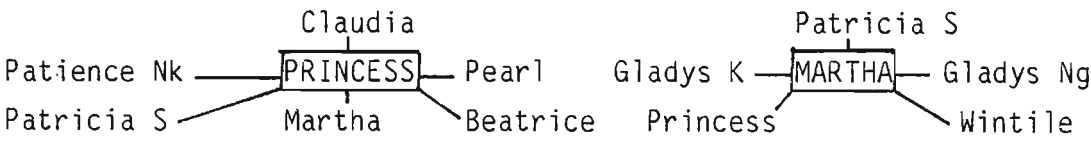


This group consists of younger children and is well-defined. Two group members, Constance and Maureen, are sisters, and possibly the group formed around this bond. The sisters were often absent which would account for the comparatively low associate scores.



Ellen

In addition to the four main groups there remain one unassimilated pair group and five children who are classified as solitary on the basis of the high solitary score. Ellen was under-represented in the associate score because she was the most helpful of the monitors and was engaged in fetching, carrying and distributing the food at the time when most of the associate scores were gathered. With this exception, the associate scores seemed to correspond with the observers' impressions. Besides Ellen, the other two multiple group members' associates are as follows :





### Classification of Subjects according to groups

Girls were defined as members of one of the four main groups when they had bonds of 5 and over with more than one other member. The subject cards of girls with bonds with only one group member were examined for other cues to enable decisions to be made about their inclusion :

1. Patience M in Group 11 had a strong bond with Gladys and bonds of 3 or 4 with all other group members. She was known to have been ill (boils) which may have accounted for the generally lower associate score. It was decided to include her as a Group 11 member.
2. In Group 111, Goodness and Agnes have strong bonds with one group member only each, but neither have 3 or 4 strength bonds with other group members. In the case of Goodness, it is possible that this reflects an identification problem for the observers because her subject cards show her as being consistently involved in games. Agnes on the other hand was easily identified and seems truly peripheral, being probably of subnormal intelligence, and willing to attach herself to anyone who would tolerate her company. Both of these cases were however classified as peripheral because of insufficient evidence of stable group involvement.

In the same group Grace and Gloria K had bonds of 5 with one group member each and insufficient ties with other group members to warrant a classification as stable group members. They were classified as peripheral.

In addition to the four stable groups, Ellen, Princess and Martha were classified as multiple group members on the basis of numerous bonds with members of various groups.

All other girls were classified as peripheral or solitary. This included the pair bond, because the essence of group membership was seen to be stable bonds with a number of other children.

Boys. The classification criteria here were the same as those for the girls except that bonds of 4 were accepted as evidence of group membership. In all cases those with only a single bond of 4 were excluded from the category of group members. An identification problem developed between Ephraim and Michael G. so both were excluded from the sample.

#### SOCIAL INTERACTION DATA FROM THE AUDIOTAPES

The scores for each subject on each category of social interaction on the check list were totalled and checked.

#### SUBJECT CARDS

A 1-sentence description of each 1-minute audiotape commentary was recorded on the subject's card. Where another child was mentioned during the commentary, his or her card was marked with the date and the observation. The subjects' report cards were examined where available and the marks, position in class, and teacher's comments were also added to the subject's card.

The Subject Card Index thus contained a summary of all available comments on the subjects during the 4-month study period, including impressions of the teachers and observers, and provided a background to the more rigorous measures of the activity and social interaction data.

#### WEATHER DATA

At the outset of the study it had been decided that there was no advantage in taking daily measurements of weather conditions when the meteorological office was situated only a few kilometres away (see map) and we were not equipped to match the quality of their observations. An official from the meteorological office confirmed that the Louis Botha

Airport readings would be essentially the same as those at Adams Mission with the possibility of a slightly higher humidity at Louis Botha Airport. Accordingly temperature data and wind direction and velocity were taken from the Louis Botha Airport records for the study periods. These were tabulated with the observers' subjective reports on weather conditions to provide some basis for a classification of weather conditions into categories that are relevant for human behaviour. A summary was made of weather conditions during the study period :

#### Temperature

The range was from  $15,6^{\circ}$  to  $29,9^{\circ}$  Celsius. Comments generally indicated that below  $20^{\circ}$  the observers regarded the weather as cold, and above  $25^{\circ}$  the weather was regarded as hot. Of the 43 days of activity measurement :

7 were below  $20^{\circ}$  - low  
 28 were from  $20^{\circ}$  -  $24,9^{\circ}$  - moderate  
 8 were above  $24,9^{\circ}$  - high.

Towards the upper and lower limits of the "moderate" category wind velocity was critical in determining the subjective judgment of the observers.

#### Wind direction

The direction of the wind fell into 2 main categories : around the South and around the North East. Low velocities were associated with easterly winds and high velocities with winds at the extremes of the two groups: the South-South West and the North East. Wind direction was not commented on by observers, but seemed to be associated with velocity in a fairly regular way.

#### Wind velocity

The range was from 1.3 - 14.8 metres/second. Below 3.6 metres/second observers recorded comments such as "muggy" on hot days, and "damp" on cold days. Above 10 metres/second observers recorded comments of "windy". There are intermediate stages : 3.6 - 5 metres/second where "overcast" is the frequent comment; and 8 - 10 metres/second where the wind is mentioned on cold days.

8 days were below 3.6metres/second - low

26 days were between 3.6and 10 metres/second - moderate

8 days were above 10 metres/second - high

From the above account it would seem logical to categorise the weather conditions prevailing at the time of the study according to 3 levels of both wind velocity and temperature, with moderate conditions of both wind and temperature accounting for the majority of the readings.

### PREDICTIONS

Immediately prior to obtaining the information regarding the bilharzia status of the subjects, an attempt was made to predict the bilharzia status of the subjects. At this stage the researcher had no information as to the general levels of infection in Standard 1 at Adams Mission because this was known to fluctuate from year to year. Neither was information available on diseases other than bilharzia in the sample. Predictions were made on the basis that a child with bilharzia ought to "look ill", i.e. he ought to have a dry skin texture, listless or irritable appearance, and be less sociable than his healthy peers. The subjects were ranged according to their matched pairs, and one of each pair was selected as the subject most likely to have bilharzia.

These predictions had additional value as a check for possibility of observer bias and the effectiveness of the blind procedures in general.



## CHAPTER TWELVE

## INFORMATION ON THE BILHARZIA STATUS OF THE SUBJECTS

All analysis to this point had been made in ignorance of the bilharzia status of the subjects. All records of tests on the subjects were then made available by RIDTE. In addition to the bilharzia results, other medical history was given, and certain subjects were shown to have other diseases likely to affect their activity levels. The following is a list of the original matched pairs with the bilharzia status and other medical information.

TABLE 17  
MATCHED PAIRS

NEGATIVE			POSITIVE		
Name	Age	Medical Data	Name	Age	Medical Data
<u>GIRLS</u>					Mean Egg Count
Claudia	7	Burn scars on leg	Patience Z	8	503
Maureen M	9		Precious	9	1 256
Christine	9		Laura	9	346
Nokutula	9		Rose	9	56 New Positive
Grace	9		Gladys K	9	237
Purity	9		Patricia S	9	5 780
Adelaide	10		Wintile	10	1 718
Emmerentia	10		Constance	10	673
Princess	10		Primrose My	10	144
Goodness	10		Patience Nk	9	27
Maureen G	10	Positive, treated	Eugenia	9	195
Gloria K	10		Gloria Mn	10	188
Nesta	10		Primrose Mk	9	4.5 New positive
Agnes	11		Patience My	11	111
Bonifacia	11		Martha	11	41
Beatrice	11		Ellen	11	181

## NEGATIVE

## POSITIVE

Name	Age	Medical Data	Name	Age	Medical Data
<u>BOYS</u>					Mean Egg Count
Bongani	9	Positive in 1976	Trevor	9	27 396
Victor	9		Saikor	9	2 294
Kelvin	10		Patrick Nt	10	1 566
Derrick	9	Cardiac murmur	Errol	10	664
Francis	9		Cyril	10	3 732
Matias	9		Protus	10	511
Lincoln	11		Gift	11	1 990
Pennuel	11		Vincent	11	6 574
Bonginkosi	11		Edward	11	866
Gordon	12		Stanley	11	66
Carel	12	Blind in one eye	Sunshine	13	5 310
Michael Mb	12		Michael G	12	231
Desmond	12		Nkululeko	12	1 462
Thamsanqa	12		Wiseman	13	401
David	12	Egg count of 5 on 2nd Testing	Ephraim	11	5 312
Ashwell	11		Clifford	10	61

David had to be dropped from the sample because of his uncertain bilharzia status. Stanley was chosen to be dropped from the bilharzia group to preserve the matched pair design. He was chosen instead of Ephraim, David's original counterpart, because he fitted the age criterion and had a low egg count, whereas Ephraim's higher egg count made him an essential member of the infected group for comparisons between levels of infection.

The egg counts as a whole were much lower than on previous years, which implied that there would be little evidence of impairment in this sample.

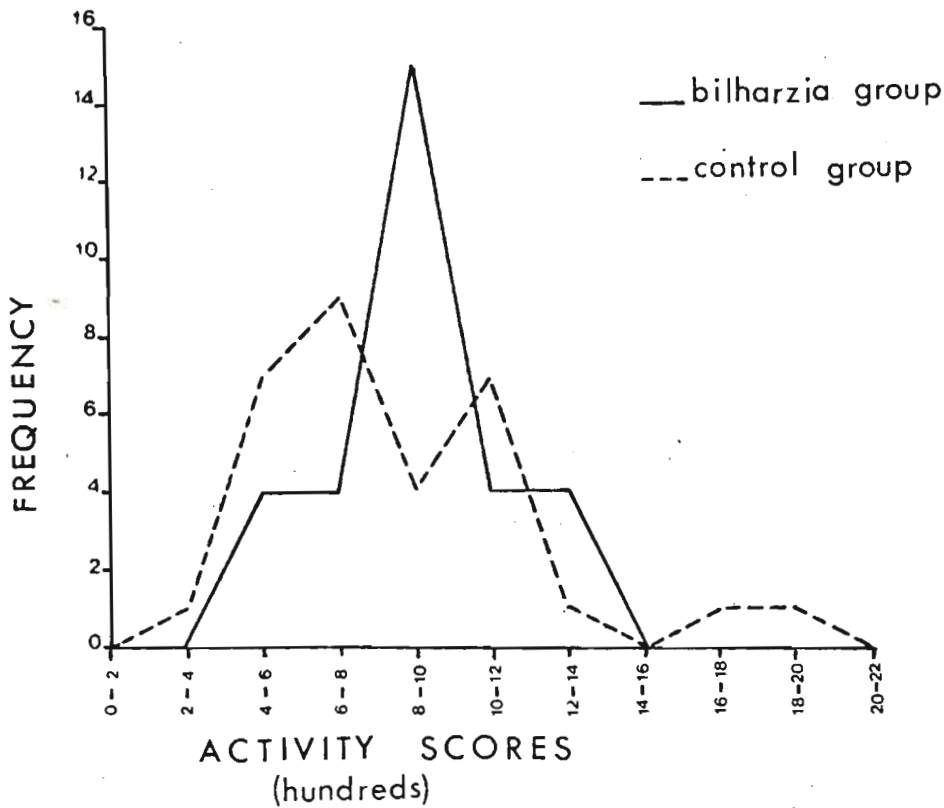
Three members of the control group, Maureen, Derrick and Carel, had physical defects likely to affect activity potential. It was decided to retain these three in the sample for all measures aimed at demonstrating selective exposure, but to drop them where hypotheses centred around the impairment factor.

## CHAPTER THIRTEEN

## RESULTS: ACTIVITY

## THE ACTIVITY METER SCORES

FIGURE 1  
The distribution of the activity scores



The above graph shows the distribution of activity scores as a reference point for the tables that follow. The activity scores as measured by the meter are designed to correspond as nearly as possible to the Energetic Activity category of the descriptive phase, and all mention of activity scores derived from the meter should be taken to refer to energetic activity only.

In both boys and girls the mean activity score for the bilharzia group was slightly higher than for the control group but the standard deviation was lower in both cases. Using the coefficient of relative variation as described by Peatman (1947), these differences in variation between the bilharzia and control groups were tested for significance.

TABLE 18  
Summary of Activity Scores  
Mean and Variation

	n	$\bar{X}$	$\sigma_n$	Coefficient of Relative Variation
Positive Girls	16	790,74	162,46	20,25 *
Negative Girls	16	694,15	234,32	34,41 p = ,03
Positive Boys	15	1 006,17	228,77	23,22 *
Negative Boys	15	994,37	362,91	33,81 p = ,08
Positive Total	31	894,98	224,80	25,13 *
Negative Total	31	839,42	338,49	40,32 p = ,0129

\* Probability using Peatmen's test for the significance of differences in the Coefficient of Relative Variation.

The most telling point emerging from the activity data was that the bilharzia group was more homogeneous with respect to activity scores. In spite of the higher mean score in the infected group the highest scoring members of the bilharzia group did not achieve scores as high as some of the control group; neither were the lowest activity scores in the bilharzia group as low as some in the control group. This would seem to indicate that there is evidence for both selective exposure and impairment. Those with the lowest initial activity scores were perhaps not often exposed to contaminated waters either through recreational activities or household duties. In this context it can be noted that the three members of the sample with physical defects likely to affect activity potential were all uninfected, and their activity scores were well below average (575,65; 606,65; and 662,80) (See photographs on Contrasts, page 117). On the other hand those with the highest scores in the infected group may nevertheless have been unable to reach their full potential as reflected in the lower ceiling to their scores.

The measurement of Energetic Activity was far more comprehensive than in the previous data collection, having been monitored for 23 separate 1-hour sessions on most subjects, as opposed to approximately 8 minutes during the descriptive phase. Measurement took place over 4 months instead of over the 2-week spans of the descriptive phase, which meant that the influence of temporary environmental and health fluctuations would have been minimised. It was therefore disappointing to be without a clearcut difference between groups on overall mean Energetic Activity. As in the first audiotape study the mean for the bilharzia group was higher, and thus the negative finding of the descriptive phase was upheld : there is no evidence that the bilharzia group as a whole is less active than the control group.

The individual mean scores for the boys were generally higher than those for the girls (Tables 19 and 20).

TABLE 19  
Mean Activity Scores for Girls

POSITIVE		NEGATIVE	
Name	Score	Name	Score
Patience Z	946,22	Claudia	407,17
Precious	898,04	Maureen M	606,65
Primrose Mk	1 011,21	Nesta	678,09
Laura	904,87	Christine	577,17
Rose	872,68	Nokutula	401,09
Gladys K	744,30	Grace	937,04
Patricia S	889,43	Purity	516,00
Patience Nk	987,87	Goodness	1 002,61
Eugenia	820,78	Maureen G	516,77
Wintile	691,30	Adelaide	773,78
Constance	896,74	Emmerentia	861,83
Primrose My	474,23	Princess	1 036,58
Gloria Mn	561,78	Gloria K	1 048,52
Patience My	593,13	Agnes	259,08
Martha	558,95	Bonifacia	734,91
Ellen	800,32	Beatrice	749,14
$\bar{X}$ = 790,74		$\bar{X}$ = 694,15	
$\sigma_n$ = 162,46		$\sigma_n$ = 234,32	

TABLE 20  
Mean Activity Scores For Boys

POSITIVE		NEGATIVE	
Name	Score	Name	Score
Errol	1325,68	Derrick	662,8
Trevor	907,17	Bongani	990,14
Saiccor	1269,09	Victor	1070,77
Cyril	950,57	Francis	681,29
Protus	619,96	Matias	1216,25
Patrick	991,68	Kelvin	1869,22
Clifford	1011,81	Ashwell	593,33
Gift	1348,95	Lincoln	1104,82
Vincent	655,39	Pennuel	887,96
Edward	1362,14	Bonginkosi	1002,00
Ephraim	802,91	Gordon	736,86
Michael G	800,74	Michael B	769,77
Nkululeko	999,99	Desmond	1079,55
Wiseman	1029,59	Thamsanqa	1675,14
Sunshine	1017,69	Carel	575,65
$\bar{X} = 1006,17$		$\bar{X} = 994,37$	
$\sigma_n = 228,77$		$\sigma_n = 362,91$	

#### ACTIVITY SCORES AND WEATHER CONDITIONS

An analysis of of variance programme was run on the University of Natal UNIVAC computer using the following variables :

- A. Severity of disease : 3 levels.
  - (i) No bilharzia
  - (ii) Egg counts of less than 1 000
  - (iii) Egg counts greater than 1 000.
- B. Male/Female
- C. Temperature : 2 Levels.
  - (i) Moderate (20-25°C)
  - (ii) High (25°C).
- D. Wind velocity : 2 levels.
  - (i) Moderate (3.6-10 m/sec).
  - (ii) High (>10 m/sec).

Subjects with diseases other than bilharzia were excluded. Only 2 levels of temperature and wind velocity could be analysed in this way because there was too little information in the low temperature and wind velocity categories to permit an ANOVA.

The F ratios were as follows :

TABLE 21  
F Ratios for 4-factor ANOVA on activity scores

VARIABLE(p105)	DF	F Ratio	PROBABILITY
A	2	0,599	
B	1	0,251	
C	1	37,819	$p < 0,001$
D	1	9,453	$p < 0,01$
AB	2	3,484	$p < 0,05$
AC	2	0,148	
AD	2	2,311	
BC	1	0,567	
BD	1	3,022	
CD	1	0,012	
ABC	2	967,486	$p < 0,001$
ABD	2	3,373	$p < 0,05$
BCD	1	5,554	$p < 0,05$
BCD	1	3,783	
ABCD	2	793,343	$p < 0,001$

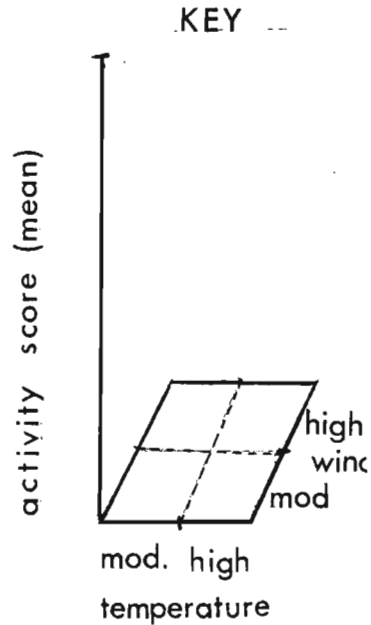
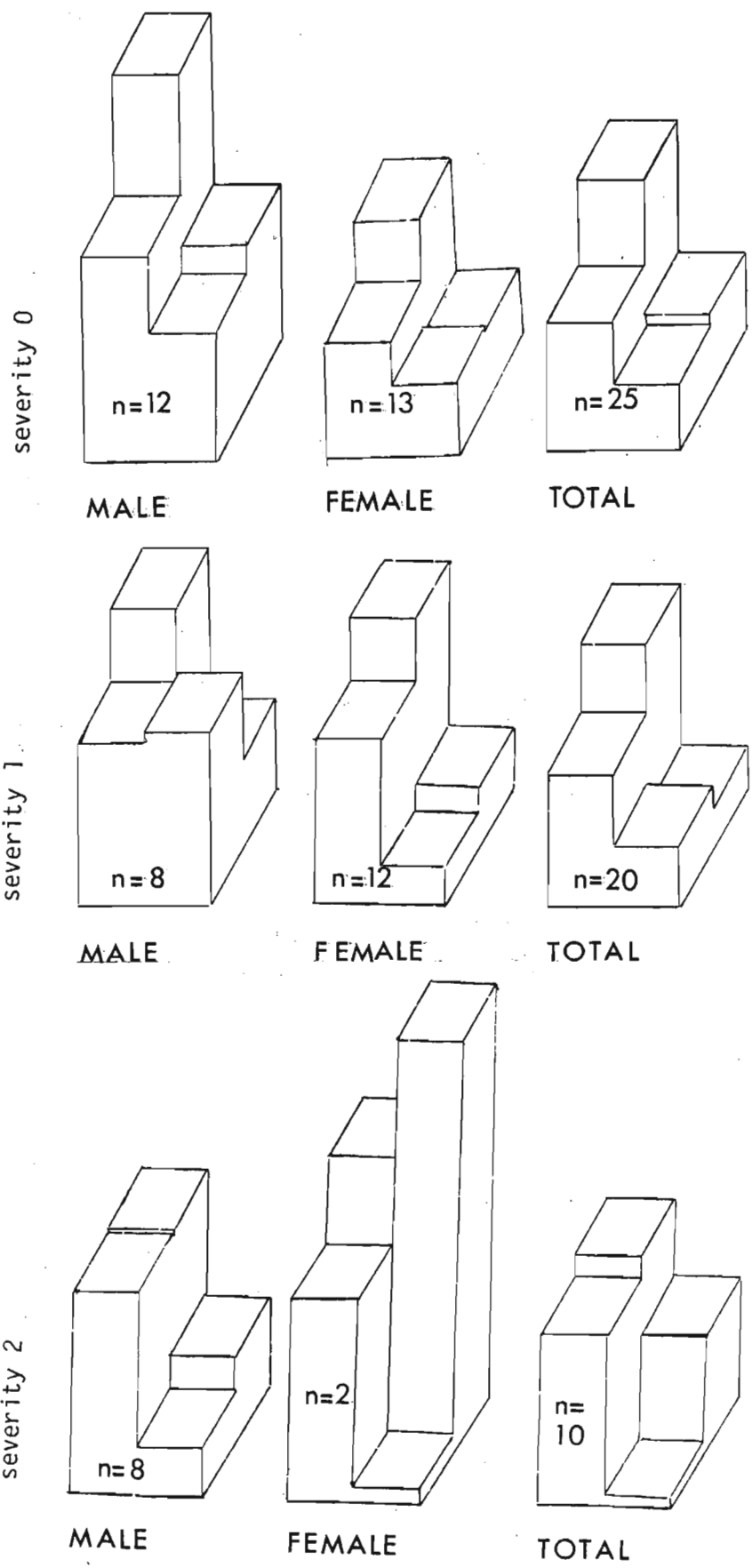
To clarify these results, 3-dimensional graphs were drawn showing activity as a function of the interaction of wind velocity and temperature in each sex/severity category. The interpretation of the highly significant four-factor interaction is based on inspection of the trend evident in the graphs.

Clearly other factors were operating as well as the four shown on the graphs. This particularly applies to the social pressure to conform to group activities on a particular day regardless of weather conditions, so whatever interpretation is put on the results of the ANOVA, it will be deficient in this regard. This applies most strongly to the sex factor interaction because on any particular day of data collection predominantly males or predominantly females were selected for measurement.



Figure 2.

GRAPHS SHOWING ACTIVITY AS A FUNCTION OF  
MODERATE AND HIGH TEMPERATURE AND WIND  
VELOCITY CONDITIONS



Moreover the girls and the boys usually played separately so different social pressures to conform applied. In other words, whatever is presented on the graphs as a function of sex differences in activity, will probably be confounded with social pressure differences.

### Severity

The general impression from the graphs is that the surfaces for severity 0 and 1 did not differ markedly. Severity 2 however shows a different pattern of activity : the mean score for the high temperature/moderate wind velocity weather condition was much lower and the mean score for the moderate temperature/moderate wind condition was much higher.

### Weather Conditions

Scanning the graphs there are several interesting points in connection with the 4 weather conditions represented :

#### 1. Moderate temperature/moderate wind velocity.

This condition is the most reliable in terms of the amount of data which the mean activity score represents. It occurred on 17 days. Activity levels here actually increased with an increase in disease severity to the point where they are almost as high as the moderate temperature/high wind velocity condition. A possible interpretation of this is that the severely infected group maximise their activity on the days when the least constraints operate.

#### 2. Moderate temperature/high wind velocity.

This is the weather type which shows the highest activity levels. The graph shows that mean activity under this condition decreases as the infection level rises. This could imply a low ceiling to energetic activity where bilharzia is worst.

### 3. High temperature/moderate wind velocity

This condition generally placed the greatest constraint on the amount of energetic activity shown, and this appears to be most depressed at severity level 2.

High temperature can generally be seen as a constraint on energetic activity. The exception here is in the severity 1 males in the hot/moderate wind velocity condition. This could possibly be the result of the combination of a low number of observations on only 8 subjects and some uncontrolled factors affecting activity on those days.

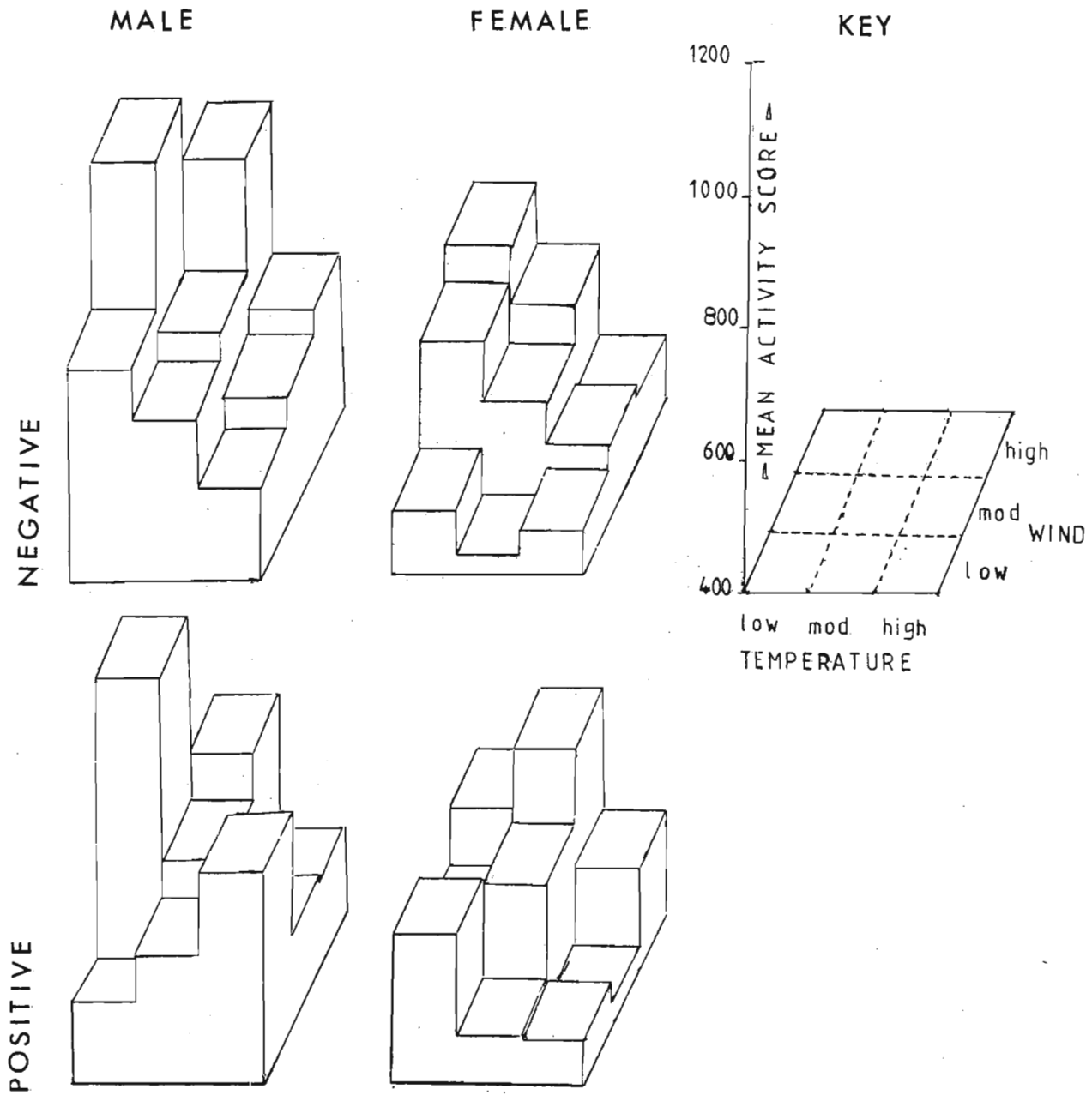
High wind has the effect of increasing energetic activity. There are 2 possible ways in which this could happen : wind-buffeting and higher noise-level in the surroundings could make shouting and energetic behaviour necessary, or alternatively the better body cooling by moving air or lower humidity could allow for greater freedom to be energetic. Probably both these factors operate, but the impression gained during these observations was that subjects felt constrained to be more energetic and noisy under high wind conditions.

Following this line of thought it was felt that moderate wind and temperature conditions represent a freedom from constraint as far as activity was concerned. In the high wind/high temperature condition there are opposing constraints which probably contributed to the generally unstable picture in this aspect of the graphs.

\*\*\*\*\*

Figure 3.

GRAPHS SHOWING ACTIVITY AS A FUNCTION OF  
LOW, MODERATE AND HIGH TEMPERATURE AND  
WIND VELOCITY CONDITIONS



A second tabulation was made using all 3 levels of wind and temperature and 3-dimensional graphs were drawn depicting all 9 weather conditions. The corners of the 3-dimensional blocks are the least reliable results because those weather conditions were infrequent. Subjects with other diseases were excluded here too, and in this case the matched pairs were also excluded. Severity of bilharzia was not taken into account and the subjects were simply grouped into positive and negative. No observations had been made for males in the cold/windy condition.

The surfaces generally show a continuation of the slope demonstrated in the more restricted ANOVA graphs, with females showing lower mean scores than males in almost all conditions, and especially the high humidity conditions, i.e. moderate temperature/low wind, high temperature/low wind, and high temperature/moderate wind. The surfaces of the positive group graphs were generally more uneven than the control group surfaces, but it is impossible to say whether this represents a difference between groups or whether it reflects the unreliability of the data under the relatively infrequent corner conditions.



A wild game on  
a windy day



A quiet game in the shade  
on a hot day

## CHAPTER FOURTEEN

## RESULTS: SOCIAL INTERACTION AND OTHER MEASURES

Three different data sources consistently show that social interaction is stronger in the positive group :

1. The social group categorisation.
2. The social interaction categorisation derived from the audiotape check lists.
3. The activity ranking derived from the sequence of subjects travelling to the lunch area.

## SOCIAL GROUPS

The bilharzia and control subjects were tabulated according to their involvement with the main Standard 1 playtime groups (Table 22).

TABLE 22

## Involvement in Main Play Groups

	Multiple	Main Groups	Peripheral	Solitary
Positive girls	2	11	2	1
Negative girls	1	6	6	3
Positive boys	-	8	4	1
Negative boys	-	6	8	1
Positive total	2	19	6	2
Negative total	1	12	14	4

Then classifying multiple group members and main group members together as Main Group Members, and all others as peripheral, the following 2-level classification was tested using 2-tailed  $2 \times 2 \chi^2$  squared tests (Table 23).

TABLE 23  
2-level classification of involvement in Main Play Groups

	Main Groups	Peripheral	
Positive girls	13	3	
Negative girls	7	9	
Positive boys	8	5	
Negative boys	6	9	
Positive total	21	8	
Negative total	13	18	
			Significant difference at the 5% level using a $2 \times 2 \chi^2$ test.

The table shows that the positives were significantly more often members of the main playtime groups.

## SOCIAL INTERACTION

The check list for social interaction had been designed to distinguish between interpretations of various ambiguous findings in the descriptive phase. Were children with bilharzia more active because this type of child has greater contact with water, or was the high level of activity due to his or her heightened irritability after becoming infected with the parasite? Was the ill-defined category of unusual behaviour in the descriptive phase an indicator of more independent, self-confident subjects or was it a reflection of deteriorating social relationships?

Main Social Character of each 1-minute observation sample

TABLE 24

Main social character of each time sample

	No. of samples	Alone	In company	In conversation
Positive girls	120	20	44	56
Negative girls	139	39	45	55
Positive boys	129	24	53	52
Negative boys	132	23	63	46
Positive total	249	44	97	108
Negative total	271	62	108	101

Note: All differences between positive and negative scores on social interaction items were tested for significance using a Binomial Test (two-tailed). Unless otherwise stated the differences were not significant at the 5% level of confidence.

There are no significant differences between groups on this measure. The higher "in conversation" score for positives (43,4% of the total numbers of samples as against 37,3% for the negatives) is however consistent with the higher main group classification on the associate data, and is found in both boys and girls.



### Nature of Interactions

In interactions between the subjects and others there was sometimes sufficient behavioural information to classify the interaction as friendly, teasing or hostile. A further distinction was made in the teasing category to denote whether the subject was the actor or the recipient.

TABLE 25  
Nature of the interactions scores on a one-zero  
basis in each time sample

	No. of Samples	Friendly	Teasing	Teased	Hostile
Positive girls	120	19	7	6	4
Negative girls	139	19	9	10	6
Positive boys	129	14	16	11	13
Negative boys	132	16	23	9	10
Positive total	249	33	23	17	17
Negative total	271	35	32	19	16

No consistent differences between groups manifested themselves on these measures. The slightly higher teasing score in the negative group was the reflection of high teasing scores in only 2 subjects.

### Contact patterns

TABLE 26  
Contact Patterns scored on a one-zero basis  
in each time sample

	No. of samples	Initiated	Recipient
Positive girls	120	22	24
Negative girls	139	15	19
Positive boys	129	21	21
Negative boys	132	24	19
Positive total	249	43	45
Negative total	271	39	38

There were no significant differences between groups on the active or passive nature of social contact as measured in this way.

Relationship to Group

TABLE 27  
Relationship to Group scored on a one-zero  
basis in each time-sample.

	No.of Samples	Co-operative	Disruptive	Leadership
Positive girls	120	39	23	27
Negative girls	139	61	16	22
Positive boys	129	61	35	31
Negative boys	132	58	36	23
Positive total	249	100	58	58
Negative total	271	119	52	45

Both male and female positives scored higher on leadership patterns. In the female positives this was coupled with higher aggressive patterns. Neither of these differences reached the 5% level of significance.

Behaviour Patterns

TABLE 28  
Behaviour patterns  
scored on a one-zero basis in each time sample

	Samples	Laughs	Smiles	Cries	Pouts	Frowns	Talks	Non-verbal Communication
+ve Girls	120	16	40	0	2	6	98	57
-ve girls	139	22	58	0	2	8	98	64
+ve boys	129	12	39	0	2	7	99	64
-ve boys	132	27	45	1	0	3	91	53
+ve total	249	28	79	0	4	13	197	121
-ve total	271	49	107	1	2	11	189	117

The difference between groups on the Laugh pattern is significant at the 5% level using a 2-tailed Binomial Test.

The difference between groups on the Laugh pattern is significant at the 5% level. It is consistent with the finding on the Smile pattern, although the latter does not reach significance.

\*\*\*\*\*

Taken together these results support the Selective Exposure Hypothesis. The only support for the irritability theory comes from the higher scores on the Laugh and Smile patterns in the negative group. Alternatively these could be explained as placatory patterns from the less forceful negative groups.

#### ACTIVITY RANKS

Using the final rankings and comparing the numbers of bilharzia and control subjects in each quartile no statistically significant differences were found (Table 29).

TABLE 29  
Activity Ranks

Quartile	Positive Subjects	Negative Subjects
1	8	7
2	5	10
3	6	8
4	11	5

There were however more positive subjects in the last quartile which represents the children who moved from the classroom to the playground the slowest, probably because they were waiting for friends or teachers and talking on the way.

#### BACKGROUND INFORMATION AND PREDICTIONS

##### Subject card data

This information was used mainly as background for other measures, and in the prediction attempts. The positions in class as shown on the school reports were grouped for the positives and negatives and ranked for those children in the sample. A median test was not significant, but positives generally had done better (median position in class : 31) compared with negatives (median position in class : 41,5).

Predictions

The hypothesis that children with bilharzia "looked ill", regardless of the seriousness of the infection, was tested using the matched pair format and attempting to predict the schistosome-infected member of the pair from a general impression of appearance, social behaviour and playground activity.

Data regarding unrelated illness were not available when predictions were made. The predictions using these criteria were more often wrong than right, more spectacularly so in the case of boys. The blind procedures in this study are vindicated. Any observer bias would tend to predict that uninfected subjects were showing behaviour impairment.

TABLE 30  
Prediction of subject's bilharzia status  
on the basis of appearance and behaviour

	Incorrect	Correct
Male pairs	11	5
Female Pairs	9	7
Total	20	12

Four of the five boys correctly predicted had an average egg count of higher than 1 000. Only three of the total sample of girls had an egg count of more than 1 000, and two of these were correctly predicted. It would appear then that the impaired appearance and behaviour hypothesis (see page 117, Contrasts) does not apply to low-level infections, but might hold for high-level infections.

\*\*\*\*\*

## CONTRASTS

All photographs on this page were taken in ignorance of the bilharzia status of the subjects



The above photograph was taken of the leaders in the informal football game. It transpired that every boy in photograph had bilharzia. Their general appearance can be contrasted with that of the 3 uninfected subjects who had other physical impairment. Their identification photographs appear below and they are shown characteristically solitary and inactive



cardiac murmur



Bad burning of  
the legs



Blind in one  
eye

## SUMMARY OF MAIN STUDY RESULTS

Improved measuring techniques in the Main Study showed that a number of differences between the infected and uninfected groups were consistent for both boys and girls:

1. The infected groups showed slightly higher mean activity scores than the control groups.
2. The standard deviations were smaller in the infected groups
3. Social interaction was stronger in the infected groups: they were significantly more often members of the main playground groups; they were more often observed in conversation, and had higher leadership scores.
4. Schoolwork as judged by position in class was slightly better in the infected groups.

No consistent differences were observed in the nature of social interactions or in contact patterns, but the negatives did smile and laugh consistently more often.

When severity of infection was taken into account, only those children with egg counts of over 1000 showed differences from the control group that could be construed as impairment:

1. On the three-dimensional graphs there was not much difference between the activity surfaces of the Severity 1 (negative) and the Severity 2 (under 1000 eggs) graphs. The Severity 3 group (over 1000 eggs) had a lower score in the hot, moderate wind condition.
2. The predictions of bilharzia infection on the basis of an impression of poorer health in one member of each matched pair were mainly wrong in the case of the children with low egg counts. Predictions were better in the higher egg count group.

\* \* \* \* \*

An opportunity arose to attempt to replicate the findings with respect to activity, and to extend them by using the meters on schoolchildren in a different school with a different infection pattern.



## CHAPTER FIFTEEN

## THE EMOGODWENI STUDY



Malakazi Squatter Settlement

## THE STUDY AREA

The school is situated above the Isipingo River and serves an area of Kwa Zulu which includes the Malakazi squatter settlement. Water and sanitation are particular problems for this community where there is a large population (estimated at 30 000) living close to the bus services to industrial areas, but with only 1 source of piped water. There is a constant queue at the tap during the day time, and in the evening when workers are at home, fights often break out over position in the queue.

The disease pattern at Embogodweni was different from that at Adams Mission:

1. Both *S. haematobium* and *S. mansoni* were present.
2. Egg counts for *S. haematobium* cases were generally higher.

## HYPOTHESES

The specific hypotheses investigated here were :-

1. The group with *S. haematobium* only would show the same activity pattern with respect to a control group as was found in the main study at Adams Mission, namely a higher mean energetic activity score, and a smaller variation in scores.
2. The group with *S. mansoni* only would show the same pattern as the group with *S. haematobium* on the grounds that selective exposure to the disease operated in the same way, i.e. through prolonged water contact.
3. Subjects with both types of schistosome infection would show a lower mean energetic activity score than those with 1 type only on the grounds that impairment in activity level would manifest itself in this group.

#### THE SUBJECTS

Four groups of subjects were selected : a negative group; a group which had *S. haematobium* only; a group which had *S. mansoni* only; and a group which had both *S. haematobium* and *S. mansoni*. The subjects were selected by the RIDTE on the following basis (Table 31).

TABLE 31  
Proposed grouping of subjects

	Control	<i>S. Haematobium</i>	<i>S. mansoni</i>	Both types
Male Age 7 - 10	10	10	10	10
Age 11 - 13	10	10	10	10
Female Age 7 - 10	10	10	10	10
Age 11 - 13	10	10	10	10

Where there was a choice of subjects in the Schistosomiasis categories, those with higher egg counts were chosen in order to maximise the severity of the disease within each category.

#### THE PROCEDURE

Fifteen minutes before the end of the morning session at the school, lists of subjects' names were called out in the various classrooms. Belts with meters were tied on the subjects who then returned to the classrooms for the remaining few minutes before the bell rang. They were requested to play as usual during the lunch break of 45 minutes, and to return the belts to the researcher when the bell rang again for the start of the afternoon session.



Approximately 50 activity meters were used each day, and the meters were read immediately after the lunch break. They were cleaned, checked and reset prior to each recording session using the identical procedure adopted during the Adams Mission Study.

The study took place during the months of October and early November on all school days that rain and school procedure permitted. The intention was to obtain 6 readings for each child, but owing to a number of factors - absenteeism, early closing days at the school, and the end-of-year tests - this criterion was reached in only  $\frac{1}{3}$ rd of the subjects. It was decided that those subjects who had only 1 activity reading should be excluded from the sample because of the highly variable nature of activity measurements.

Repeated bilharzia testing by the RIDTE brought about changes in the estimated bilharzia status of a number of subjects. False negatives are frequent when the criterion is the presence of eggs in the urine or stool sample. The egg-counting techniques are described by Schutte et al (1980). Most of the changes in groups consisted of moving subjects from any of the negative groups for each type of bilharzia to a positive group. In a few of the subjects there were large and inexplicable differences between earlier and later bilharzia test results, and these subjects had to be dropped from the sample. It was thought that there was a possibility in these cases that urine or stool samples had been incorrectly identified.

During the course of the year a medical team had examined a large proportion of the subjects for disease both related and unrelated to bilharzia. Heart disease and malnutrition were judged to be unrelated to bilharzia status but likely to have a considerable effect on activity level, so these subjects were excluded, as was one subject who was possibly microcephalic. Subjects with anaemia and chest problems were also excluded from the sample because these symptoms were judged to be more probably related to disease other than bilharzia. Enlargement of the liver was however thought to be very probably related to *S. mansoni* and abnormalities in the rectum to *S. haematobium*, so these subjects were retained in the sample.

Because of all these changes, the matched group design no longer applied, and the final composition of the groups was as follows :

TABLE 32  
Final grouping of subjects

	Control	S. haematobium	S. mansoni	Both
Boys	14	14	9	19
Girls	14	13	15	20

Fluctuations in weather conditions were ignored because there was not much variation during the month of testing, and because the school playground contained more trees and was less exposed to prevailing winds than the Adams Mission playground had been.

The results were not directly comparable to the Adams Mission results because the duration of the lunch break was different :  $\frac{3}{4}$  of an hour as against 1 hour. The structuring of playtime was also different : no meal was served and some subjects obtained food from a local shop during the course of the midday break.

## RESULTS

The mean activity score for each subject was used as the best estimate of his activity level regardless of the number of days which it represented. Boys' and girls' scores were tabulated separately.

The results for the Embogodweni study were grouped in two ways : firstly according to the types of Schistosomiasis present, and secondly according to severity within each type.

In all tables the differences in activity scores between groups have been tested for significance using the Mann-Whitney U Test, and are not significant at the 5% level unless otherwise stated. Differences between coefficients of variation have been tested using Peatman's test and are not significant at the 5% level. Ferguson's Non-Parametric Trend Test for non-monotonic trends has been used to test for an inverted U trend across the activity score tables, and the trends are not statistically significant unless otherwise stated.

TABLE 33  
Mean Activity scores for groups with each type of  
schistosome infection

	Uninfected control	S. haematobium only	S. mansoni only	Double infections
Boys	561,6	643,2	738,1	569,6
Girls	560,7	575,3	586,4	544,0

The mean activity score for the *S. haematobium* only group was higher than the control group mean in both boys and girls as in the Adams Mission study (Table 33). The *S. mansoni* only group showed a similar pattern. Activity levels dropped however in subjects infected with both *Schistosomes*. Once again the control groups had higher relative variation coefficients than the *S. haematobium* only groups and the other infected groups as well (Table 34).

TABLE 34  
Coefficient of Relative Variation

	Control	S. haematobium	S. mansoni	Both
Boys	62,16	50,20	35,70	53,27
Girls	65,51	37,84	60,76	40,55

These findings are consistent with the selective exposure hypothesis (See discussion, page 61) for both *S. haematobium* and *S. mansoni* and suggest impairment of performance in subjects with double infections.

#### Levels of *S. haematobium*

3 levels of *S. haematobium* were used :

Level 1 - less than 1 000 eggs excreted in a 2 hour midday period

Level 2 - 1 000 to 5 000 eggs

Level 3 - Over 5 000 eggs.

Only 3 subjects had mean egg counts of over 5 000, but the remaining subjects were tabulated according to their level of *S. haematobium*, regardless of whether they had *S. mansoni* as well.

TABLE 35  
Mean activity scores for different levels of *S. haematobium*  
infections

	Uninfected Control	1 000 eggs	1 000-5 000 eggs
Boys	561,6 (n=14)	599,1 (n=22)	577,1 (n=10)
Girls	560,7 (n=14)	616,9 (n=23)	542,3 (n=8)

There is an inverted U trend, those with light infections being most active. It is significant ( $p < .05$ ) in the case of the girls (Ferguson's Non-Parametric Trend Test for non-monotonic trends). The drop in scores for girls with over 1 000 eggs is significant ( $p = .0192$ ) when tested with the Mann-Whitney U Test).

TABLE 36  
Coefficient of Relative Variation

	Control	Level 1	Level 2
Boys	62,16	57,26	46,21
Girls	65,51	33,05	43,62

The coefficients of relative variation are larger for the control groups than for the infected groups as in the Adams Mission study although these differences do not reach the 5% level of significance.

#### Levels of *S. mansoni*

In a similar manner levels of *S. mansoni* were identified :

Level 1 - less than 500 eggs/gram dry weight of stool

Level 2 - 500 to 1 000 eggs

Level 3 - more than 1 000 eggs.

In the case of boys only 2 subjects had greater than level 1 infection severity, so no comparison could be made. The girls however had the following mean scores and coefficients of relative variation.

TABLE 37  
Levels of *S. Mansoni* for girls :  
Mean scores and coefficients of Relative Variation

	Control	Level 1	Level 2	Level 3
Mean Activity scores	560,7	589	609	434,9
Coefficient of relative variation	65,51	50,61	49,85	42,35

Again there is a trend towards greater activity with moderate infection, but a fall in activity when infection is heavy.

#### SUMMARY AND COMPARISON WITH THE ADAMS MISSION MAIN STUDY ACTIVITY SCORES

1. In both areas there were higher mean activity scores for subjects with low level infections of *S. haematobium* than for uninfected subjects. In addition to this, subjects at Embogodweni with low and moderate level *S. mansoni* infections showed a similar pattern of high mean activity levels when compared with the uninfected group, and lower activity with heavy infection.
2. The relative variation coefficients were higher in the control groups than in the infected groups.
3. At Embogodweni the extreme disease categories, i.e. those with both schistosomes and those with high levels of *S. haematobium* and *S. mansoni*, had lower activity scores than the single infection groups and the low disease level groups.

PART 111

THE DISCUSSION

## CHAPTER SIXTEEN

## ACTIVITY RESEARCH

## DISCUSSION OF TECHNIQUES OF MEASURING ACTIVITY

The Four-Level System

The 4-level system for activity used in the descriptive phase seemed more sensitive to differences between groups than either the 2-level or 3-level systems. Chapter 3 referred to the four measurable dimensions of activity : category (i.e. locomotary and non-locomotary), duration, frequency and intensity. The system used in the descriptive phase organised information on all four dimensions and was therefore versatile. The levels were arranged in a hierarchy which referred to intensity of activity. Immobile and Stationary were non-locomotary categories and the other two, locomotary ones. Duration could be measured for each level. Frequency of change of level was not found to be of particular use for measure in the open field situation, but in the structured playroom situation a high score was thought to be an indicator of distractibility.

The main disadvantage of this direct-observational technique was that it was time-consuming. The initial work in this study was exploratory because there were no real guidelines from the bilharzia literature as to the particular aspects of spontaneous activity that should be measured : neither was there much detail in the developmental literature or the literature on hyperactivity as to the particular patterns of activity which were relevant for this age group. It seemed important therefore to collect information in a relatively unstructured way initially. Having settled however on a 4-level system, it would have been possible to monitor activity at all levels using a modified electronic events-recorder had the situation demanded this information. A programme for data-processing could have operated directly on the electronically-coded information.

### The Activity Meter

In this study however the results showed significant differences between infected and uninfected groups on the energetic activity level. The energetic category seemed to be appropriate too for use with the pre-adolescent child who is usually physically capable of maintaining a high level of activity, and not yet socially inhibited from displaying it. For adolescents and adults the category loses its usefulness because in those age groups energetic activity is rarely seen outside a sporting or work context.

The activity meters seemed to be a reasonably reliable means of measuring this level of activity although design improvements to the contact edge could reduce the need for frequent checking and cleaning. The meter would have been less conspicuous for use in naturalistic settings if the casing had been specially moulded and the belt made of elasticised material.

It is my impression that an activity meter designed to measure activity patterns of established relevance represents an improvement over the global activity measured by Bell's meter and that the meter used in this study has a potential for adjusting sensitivity by increasing or decreasing the weight activating the switch.

## SITUATIONAL DEMANDS AND PHYSIOLOGICAL LIMITATIONS

### Sex and Age as Variables in Activity

The interpretation of the results of this research was complicated by the lack of background information on activity for the pre-adolescent child. Striking differences were apparent between sexes on both activity and social interaction in the main study, even without specific analysis. The activity level of the boys was higher and the girls were more involved in social interaction.



As stated in Chapter 2 there is evidence for a downward trend in activity level with increasing age, but social and cognitive developments cause variations in the trend. The impression gained from results in this study was that social development had a very direct bearing on activity levels. In the younger children (7 to 10 years) energetic activity was frequently solitary (running down to lunch, bobbing about while watching a game) whereas in the 11 to 13 year group energetic activity was not seen as often outside a social context (a football or netball game, teasing and mock-fighting). The energetic activity patterns changed too from a wide variety of quick light movements to less varied and more powerful movements. This is not surprising in view of the growth spurt at around 11 years and increasing gravitational pull with increased height, as well as considerable increase in strength (Gould, 1980).

A descriptive study investigating the development of activity patterns in relation to growth and social development could very well give insight into features of the developmental process with this neglected age group which would be of use in research, clinically and in educational psychology. Cognitive development must undoubtedly be affected by the need to find ways of using increased strength effectively and to control it during aggressive and potentially damaging incidents. The increase in teasing might be an example of the latter. It is interesting to note that the increase in height and strength to nearly adult proportions takes place before sexual maturity and is not a steady increase as in 7 to 9 year olds but a rapid one accompanied by an increase in nutritional needs.

### Weather Conditions

While research in industrial psychology is presently concerned with stress factors in factory and mining conditions (fatigue, temperature and noise) very little work appears to have been done on the weather conditions in an external environment : wind and humidity and their interaction with temperature. The 3-dimensional graphs in this study show that the combination of wind and temperature factors has significant effect on spontaneous energetic activity. A more searching investigation of these factors and humidity would have implications for such industries as agriculture, forestry, construction and stevedoring where the major portion of physical labour takes place outside. Features of the individual's response such as central nervous system arousal, shivering, the onset of sweating, and the drying rate of perspiration could be related to work output, accuracy and industrial safety.

## CHAPTER SEVENTEEN

THE EFFECTS OF SCHISTOSOMIASIS ON BEHAVIOUR

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Although the aim of this investigation was to identify and measure the effects of schistosomiasis, the descriptive phase revealed such complexity of relevant factors that the main findings of this study deal with antecedent conditions as well as effects.

## SELECTIVE EXPOSURE

Higher mean scores on a measure of energetic activity have been found in most infected groups studied in both phases of the investigation. It appears likely, then, that there is a selective exposure factor operating whereby active, gregarious children had a higher probability of being infected through play activities or household duties involving contact with water. If this assumption is correct, and if the pattern is widespread in areas where there is no piped water, then this might explain why in the past the infected subjects in some studies score higher than controls (for example, Jordan and Randall, 1962, reported higher scholastic achievement in infected groups). The failure to control for selective exposure casts doubt on many of the studies with negative impairment findings. The implication from this study is that children who are most valuable to a community in terms of work and organising ability are at risk.

The possibility still exists that schistosomiasis actually produces higher activity levels as in the hyperactive syndrome, but this interpretation is not supported by the social interaction data on the in-depth study at Adams Mission : the infected children appeared capable and socially well-integrated. The only indication of possibly irritable behaviour was in the lower Smile and Laugh patterns in infected subjects. The social interaction measures may have been insufficiently extensive and sensitive to explore this effect in mild and moderately infected children.

For research purposes a selective exposure factor implies that the impairment effect of schistosome infections is probably being masked when the uninfected groups are used as controls, and the proper research design should be a before-and-after treatment design where subjects are their own controls. Two studies with this type of design have indicated an impairment effect (Jordan and Randall, 1962 ; Bell, Daly, Kanengoni, and Jones, 1973). Furthermore a study of water contact patterns as recommended by the Scientific Working Group of the World Health Organisation (1979) for studies on transmission and control of bilharzia would be decisive in determining the role of the selective exposure factor.

#### APPROPRIATE MEASURES

The findings from this study support the view that the effects of the parasite on the human host are not likely to be highly damaging in general. In the case of spontaneous activity, significant effects were found in the average duration of energetic activity as opposed to simple mobility. The activity meter has proved to be an efficient measurement technique in this instance. In productivity studies in working adults, work in excess of the demand of the situation would seem to be an appropriate measure, as in the bonus pay measure used by Fenwick and Figenschou (1972). Similarly in the case of social interaction, impairment effects were seen only under high temperature conditions in a group with high egg counts.

The consideration of the cumulative effects of stress factors such as heat, fatigue, severe schistosomiasis, other parasites and malnutrition, is important in rural African populations. Resilience in the face of detrimental conditions is often considerable in child development (Kagan et al, 1970). This relates to current complex models of child development mentioned by Dunn (1979) where there is no single predictor of psychological and behavioural impairment. It seems to me that the effect of schistosomiasis on work output in children at school and adults at work manifests itself in a lack of stress tolerance which is proving difficult to quantify, but may nevertheless be having considerable social and economic impact. An unpublished report by Diana Haycock on the Adams Mission children

showed that progress through school was slower in the case of the infected subjects; they were generally older than the uninfected children in the same class. In the case of sugar cane workers the findings of higher absenteeism and less bonus pay were mentioned previously. It may be necessary to explore many different conditions before the ultimate uncompensated behavioural change is found.

Perhaps the most important methodological inference from this study is the need for an extended descriptive phase in investigating the effects of the disease on human subjects, who may well adapt behaviourally to the presence of the parasite.

#### THE DIFFERENTIAL EFFECTS OF TYPE AND SEVERITY OF SCHISTOSOMIASIS

*S. haematobium* has been extensively investigated in this study. In mild level infections (less than 1 000 eggs), there is little evidence of impairment of group mean activity level, but there is a suggestion of a lowered ceiling to the amount of energetic activity displayed. This derives from the significantly smaller relative variation co-efficient in the generally mildly infected children in the Adams Mission sample and the same pattern at the Embogodweni School. In medium range infections (1 000 to 5 000 eggs) the evidence points to a drop in energetic activity generally and particularly under the hot, humid conditions which prevail on the Natal Coast in summertime. Under these climatic conditions subjects with medium range infections are affected to a greater degree than uninfected or mildly infected subjects. For subjects with heavy infections (over 5 000 eggs), the numbers were too small in the sample study in the more detailed second phase of the research to yield anything but anecdotal evidence. Records kept on these individuals, however, indicate that appearance and behaviour are usually affected : they look tired, irritable and unsociable.

In a case of *S. mansoni*, the evidence is less extensive but the pattern appears to be similar to that of *S. haematobium*, with a lower ceiling to activity among mildly infected subjects, and a drop in mean activity level in cases with over 1 000 eggs/gram stool dry weight.

Subjects with both *S. haematobium* and *S. mansoni* have a lower mean activity level than those with one type only.

These findings have considerable implications in determining public health priorities. The evidence suggests that control measures such as the introduction of piped water becomes a public health priority when both types of parasite are present in an area or when egg counts of over 1 000 are prevalent because the development of the most active children in the community is likely to be affected. The question of medical treatment of the individual is more complex, but it seems probable that *S. haematobium* becomes seriously behaviourally damaging to the individual when egg counts of over 5 000 are being recorded.

This study has not explored every possible category of behaviour for change under any conditions, but it may be the most wide-ranging study to date. Moreover it has attempted to explore a socially and economically important segment of the children's lives.



## CHAPTER EIGHTEEN

HUMAN ETHOLOGY AND HUMAN RESPONSE TO DISEASE

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"I think ethology is one of the many areas of thought in which a philosophical understanding of the nature of scientific progress is salutary: in real life science does not prance from one mountaintop to the next."

Medawar, 1976, p 448

The strongest justification for calling this an ethological study is its reliance on descriptive data and the cognisance it takes of the human response to schistosomiasis as an evolved one.

## A DEFENSE OF DESCRIPTIVE DATA

The view of science expounded by Popper is that there are successive levels of theory: at each level certain aspects can be refuted, giving rise to a further theory which may in turn be refuted in certain aspects, or held as long as it is found to be satisfying. Based on this Principle of Falsifiability, confidence limits in statistical procedures are designed to minimise the possibility of accepting as true a false hypothesis. The problem with this view for the behavioural sciences is that the Principle of Falsifiability is no more absolute than induction would be. In practice so many conditions surround a negative result that one is seldom justified in completely rejecting a theory, as Popper himself has recognised:

"At the same time, I also realised the opposite: the value of a dogmatic attitude: somebody had to defend a theory against criticism, or it would succumb too easily, and before it had been able to make its contributions to the growth of science."(1972).

Research into the effects of schistosomiasis has as its hypothesis that this parasitic infestation causes damage to its human host. Most investigations in the past have yielded negative results, but because researchers are aware that their techniques might be inappropriate, investigations continue. The traditional Popperian approach is reversed because there is greater danger in accepting the alternate hypothesis of no damage.

Research rigour in the behavioural sciences surely does not rest emphatically in the Principle of Falsifiability. An important concern is to guard against the spurious simplification of a complex phenomenon. An extended descriptive phase is necessary in order to avoid premature hypothesis-testing and resultant trivial theory.

I would like to suggest that the main value of the ethological approach in the present context has been in the descriptive data that it has presented. Wide-ranging description has given insight where tests have failed: selective exposure and the influence of environmental stress cannot be ignored, just as it is no longer possible to lump together all levels of severity when discussing the effects of infection. The descriptive data have suggested several hypotheses, some specifically investigated here and others (such as the hypothesis of increased distractibility) not yet tested.

#### STRATEGIES FOR COPING WITH DISEASE

The idea of coping strategies comes from the over-arching theory of evolution. An evolved host-parasite relationship implies that a satisfactory *modus vivendi* between host and parasite is maintained. But the suggestion in this thesis is that there are debilitating changes in the host's behaviour in the form of a lowered stress tolerance. Does this contradict the notion of a coping strategy? I think not because we are dealing with a situation where new demands are being made on the host. He cannot easily avoid a structured six-hour school day or an eight-hour working day; the perceived injunction against absenteeism in a school term or a cane-cutter's six-month contract preclude escape from a fatiguing situation. Strategies are restricted in the host in the same way that caged animals are unable to use a flight strategy in a threat situation.

In considering a human response to disease there is the question of whether a single symptom is an indication of a more general process, and a behavioural response may similarly be part of a more fundamental change. It is clearly unprofitable to think of specific actions as being genetically determined. Baerends (1976) thinks of behaviour in terms of systems which are functionally organised: "The systems and sub-systems postulated after analysis of complex behaviour sequences



can best be defined as control systems of different orders fulfilling special tasks in the context of hierarchical organisation." He said: "A change in one part of the functional organisation may lead through the interaction of sub-systems to a variety of behavioural differences."

Vulnerability to internal parasites and other forms of disease is a universal human condition. I would like to speculate on the possibility of a genetically-determined control system which shifts the motivational balance of sub-systems to cope with stress in the form of a parasitic attack. In the light of certain observations in the course of this study I propose two strategies, one for mildly debilitating and another for severely debilitating conditions.

In mildly debilitating conditions an individual could maintain social participation by interspersing bursts of energetic activity with periods of complete rest (as the New Positive group appeared to do in the second audiotape study). Where hot, humid weather conditions imposed additional constraints, activity levels would be depressed below those of uninfected children, but active social participation could be maximised in temperate conditions (see graphs on weather conditions and activity). Similarly, in the early mornings, before the exigencies of fatigue had taken their toll, activity levels could be higher than in uninfected children (as in the Videotape Study).

In a severely debilitating condition this strategy must fail through a lack of energy to carry it out. For survival, these individuals are compelled to rely on others to supply the necessary resources for the period of reduced efficacy. The best strategy to adopt under these conditions would be to communicate distress and cease all effective participation in social activities to underscore the need for assistance. In the present investigation, a few severely infected individuals showed behaviour patterns consistent with this strategy, as did three uninfected individuals with known physical impairment other than bilharzia. They had very low mean activity levels and were frequently solitary.

It would be of value to investigate the hypothesis that one or other of these two strategies operate in response to physical debility. In matched group studies individual differences would blur a change to a different strategy, but descriptive case studies of individuals with progressive diseases could indicate whether there are in fact two distinct strategies as in a catastrophe theory model, or whether there is a gradual change in the components of behavioural response to disease. Conversely, convalescent studies might provide the same information in reverse order.

It seems likely that the dependency strategy persists after a severe illness and a thorough investigation into the effects of disease on behaviour could be invaluable in planning rehabilitation procedures in such disciplines as physiotherapy and clinical psychology.

I am only too well aware that strategies for coping with disease, if they exist, pose large questions unlikely to be answered in a single study at a stroke. But this thesis has attempted to go beyond a tight test of one hypothesis. Too sharp a focus on a small fragment of a flexible system leaves one with an unintelligible blur when the system shifts. This has been the case with much past work on the effects of the schistosome on human behaviour. I should like to end this thesis with a further quotation from Peter Medawar (1976) as an eloquent statement of the beliefs motivating this endeavour:

"It is indeed, not a grand ethological revelation that the scientist should seek from his awareness of the evolutionary process, but rather an enlargement of the understanding made possible by a new and wider angle of vision, a clue here and an apt analogy there, and a general sense of evolutionary depth in contexts in which it might otherwise be lacking."

Medawar (1976)

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SAMPLE CHECKLIST FOR  
SECOND AUDIOTAPE STUDY

(All duration and incident scores for each subject  
were collected and totalled on these checklists)

NAME	DATE	TIME					
<u>SUBJECT :</u>							
BASE							
ENERGETIC							
MOBILE							
STATIONARY							
IMMOBILE							
SOCIAL INTERACTION							
AGRESSION							
CHANGE (FOCUS)							
CHANGE (LEVEL)							
INNOVATION							
DISTRESS							
SOCIAL ISOLATION							
GAME							
INCOMPLETE ACTION							

# COMPARISON OF COMMENTARIES BY TWO OBSERVERS

Two observers independently recorded eight one-minute time samples. There was more concurrence in commentaries where the subject was relatively inactive, but concurrence for both active and inactive subjects was deemed to be reasonable with respect to the behaviour categories in Appendix 3. To illustrate this, one active and one inactive subject have been randomly chosen from the available commentaries. These are presented side by side for comparison. Note: It is only on the facial expression **categories that the commentaries differ.**

Secs.	Observer 1	Observer 2
<u>Patience Z (inactive)</u>		
0 - 5	Standing, talking to herself,	She is standing, leaning against the Dom. Sc. building
6 -10	against the wall, calls out,	talking, stopped talking, just looking, talks,
11 -15	talking, leans up against the wall,	talks to the girls that are playing, leaning
16 -20	talking,	against the Dom. Sc. building, talking, stops, talks
21 -25	pouting, I think, pouting,	to Beatrice B, she seems
26 -30	talking, in conversation all the time,	to have been complaining about something,
31 -35	talking,	now standing, talks, talks,
36 -40	somebody has pointed something	fumbling with the belt of her dress, stares at something,
41 -45	out, they all go to have a look, she following	turns, she walks, she walks next to Maria, walking,
	along with the rest	
46 -50	.....	somebody saw something
51 -55	walking along. . .	and they decided to go to that thing that they saw, walking
56 -60	.....	next to Maria, keeps looking back, standing looking back.
	End comment: She was just standing at the	End comment: I don't know what she's looking at, but she's
	end waiting for someone to catch up. I think	standing looking back.
	the teachers have gone back to the classroom	
	and they're all going.	

Clifford M (Active)

0 - 5	He's backstepping in the middle of a football game	He's walking because he's playing with a group of boys
6 - 10	standing, getting into position, stands, calls out	They're playing soccer, runs, accidentally knocks against one boy
11 - 15	walking and talking, but not to anyone in particular	shouts as somebody, talking, walking,
16 - 20	stopped talking, standing,	holding himself now, just standing staring, he runs for the ball, turns round, kicks, runs,
21 - 25	runs now as the ball comes close to him, runs kicks it	
26 - 30	right in the forefront now, kicking the ball, dribbling it, dribbling the ball	kicks, kicks, actively running, he kicks, kicks,
31 - 35	right in the forefront, I had to get out of the way as he came past	accidentally kicks someone, bounces against him, kicks, kicks
36 - 40	he's been in control of the ball for quite some time, someone's taken it away from him	nearly falls, trips, kicks, kicks
41 - 45	he's lost control of the ball now,	they're playing rather roughly, kicks, running, shouting, smiling, scratching his head, running, walks now,
46 - 50	he calls out as a goal is	
51 - 55	scored, he's running across the field now, not talking	
56 - 60	standing	walks towards opposite end, standing, looks.
	End comment: In the middle he was in control of the ball. Otherwise he was playing. When he talked it wasn't to anyone special, he was just calling out.	End comment: He's been playing very actively, he had most of the ball while I was recording him, and he was very fast in his movements.

## SAMPLE CHECKLIST FOR SOCIAL INTERACTION IN THE MAIN STUDY

NAME

DATE  
TIME

ALONE  
IN COMPANY  
IN CONVERSATION

## FRIENDLY CONVERSATION

NEUTRAL "

TEASING " "

TEASED IN "

HOSTILE "

INITIATES CONTACT  
APPROACHED BY ONE  
APPROACHED BY SOME

HELPED  
HELPS OR CO-OPERATES  
ATTACKED  
FIGHTS  
ORGANIZES  
LEADS

LAUGHS

# SMILES

CRIES

## POUTS

# FROWNS

# TALKS

## NON-VERBAL COMM.

## UNUSUAL ACTIVITY

DISTRESS:  
HEAVY BREATHING  
SWEATING  
OTHER