# TRANSMISSION OF SCHISTOSOMA MANSONI IN THREE ECOLOGICAL SETTINGS IN ETHIOPIA.

## I. EPIDEMIOLOGICAL ASPECTS

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ABSl'RACT: The epidemiological indices of Schistosome mansoni for three communities in Ethiopia; Jigga (northwest), Metahara sugar estate (southeast) and Lake Zway (central), each representing the three major transmission ecologies in the country, the stream, irrigation scheme and lake, respectively were studied and compared. A totals of 2897 people (913, 1614 and 370 from the stream, irrigation scheme and lake, respectively) was examined for S. mansoni ova by the Kato's smear method. The highest human prevalence (58% ) and intensity of infection (geometric mean of 450 EPG) were recorded for the lake ecology, whereas the irrigation scheme and stream showed moderate (218 EPG) and light (172 EPG) intensities of infection, despite fairly high disease prevalences of 20% and 41% respectively. Age-specific analysis of prevalence, intensity of infection and relative index of potential contamination (RIPC) indicated that children in their second decade of life to be most responsible. Nevertheless, the decline of all indices with increasing age was less obvious in the lake area than others. The disparity between prevalence and intensity of infection in the stream ecology, inter- ecological differences in the indices of infection and their implication in disease control tactics are discussed. [Ethiop. J. Health Dev. 1993;7(2):63-69]

## INTRODUCTION

Generally speaking, three types of transmission ecosystems are recognized in Ethiopia. These comprise small streams, irrigation schemes, and lakes. The small streams are, by far , the most important because the majority of the endemic areas belong to this category at the moment (1,2). With the increasing need to meet the demands of a growing population, the necessity of developing irrigation schemes has long been recognized.

As a result irrigation schemes have spread at a relatively fast rate. This same economic endeavour results in the creation of new habitats for the snail host of schistosome and increased human water contact. The irrigation ecology gives rise to incidences of schistosomiasis by creating factors which did not exist prior to the introduction of such ventures. Already there are adequate evidence that the disease has spread as a result of irrigation (3,15-18). This makes it axiomatic to make a sound diagnosis of the ecology and pattern of schistosoma transmission to form a basis for the development of a rational control strategy suited to a particular habitat. In realization of this, the Institute of Pathobiology of the Addis Ababa University, started a longitudinal study of schistosome transmission in three endemic localities, representing the three ecological settings. They comprise:

1. the town of Jigga in Gojjam Administrative region, northwestern Ethiopia, a highland stream,
2. Metahara sugar estate, central Ethiopia, an irrigation ecology and,
3. Lake Zway, central Ethiopia, a lake situation (Fig. 1).

In this report comparisons of indices of infection in humans and their implications for control tactics in the three ecological categories are discussed. Jigga Town: a stream ecology. Jigga is a small town in Gojjam Region in northwest Ethiopia, located 375 km from Addis. The town was selected to represent a stream ecological setting because of its proximity to a gently flowing highland stream (Fig. 1). Until a piped water supply was introduced in November 1983, the residents entirely depended on the stream water, including for
small scale irrigation purposes. Intestinal schistosomiasis is long known to be endemic in the town (3).

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Metahara Sugar Estate: an irrigation ecology. The site is situated 190km southeast of Addis Ababa and lies within the Upper Valley of the Awash River Basin of Ethiopia (Fig. 1). Metahara is located at an altitude of
1000m. The water for irrigation is taken from the Awash River (Fig. 1). It is then led into the fields through earthen canals by gravity feed. The network consists of 248.4 km of irrigation canals and 27.08 km of open main drains. The irrigation canals and drains in turn end up in numerous field ditches and smaller drains with velocities of less than 0:12 m/sec, thereby forming semi-stagnant water bodies. In addition to these, there are 18 reservoirs with a total surface area of 4.8 ha. Health service is rendered by a polyclinic located at the headquarter and satellite clinics in the villages. Schistosomiasis mansoni has now emerged as a serious health
problem in this area (1).

Zway: a lake ecology. The lake is located 160 kIn south of Addis Ababa at about 1850 m above sea level. It is the shallowest, with a maximum depth of 4m, among the Rift valley lakes and covers an area of about 14
sq.km. (Fig. 1).

There are 5 islands in the lake whose inhabitants depend mainly on fishing or subsistence farming. The estimated total population of the islands is close to 1500. Zway town, with 7 ,000 inhabitants, is situated
on the western shore of the lake. There are a number of other villages located on the shores of the lake with population sizes ranging from 500 to 2000. There are intense and varying human water contact activities including recreational activities, fishing, irrigation, laundry , water fetching etc. Intestinal schistosomiasis is long known to be endemic in the area (1,3,15,18).

**METHODS**

1.Site Selection: After a reconnaissance tour by a group of experts in 1983, three sites were selected for the purpose of studying the transmission characteristics of Schistosoma mansoni in streams, irrigation schemes and lake ecological settings in Ethiopia. Selection of snail monitoring stations and parasitological examination were conducted in each area at about the same time. Results of snail studies and other concurrent studies such as socio economy, water contact behaviour and morbidity will be presented elsewhere.

2.Population Census and Parasitological Examination: In each study site all houses were mapped and numbered. The inhabitants were registered by household, age, sex, occupation, religion, education, place of birth and duration of stay in the area. Systematic random samples of households were then taken and, wherever possible, all the

FIGURE 1 AND FIGURE 2

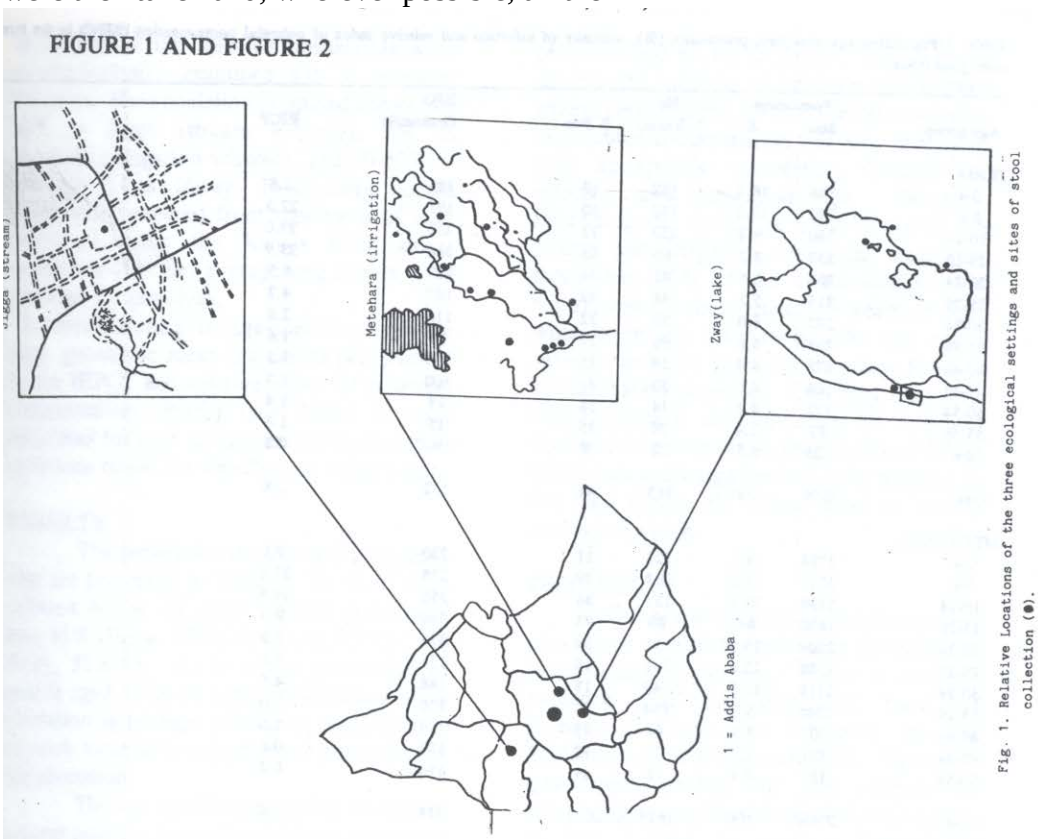


Fig. 1. Relative Locations of the three ecological settings and sites of stool collection (●).

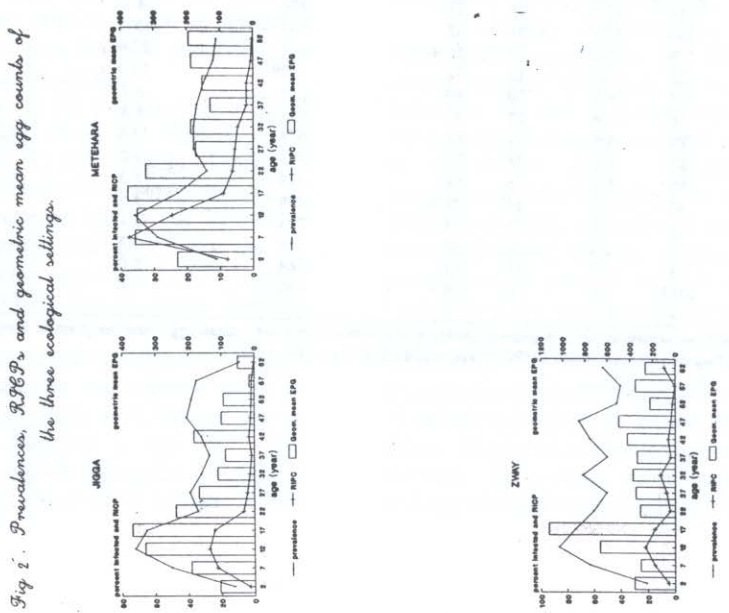


Fig 2. Prevalences, RIPCs and geometric mean egg counts of the three ecological settings.

Table 1: Population age structure, prevalence (%), intensity of infection and relative index of potential contamination (RIPC) in the three ecological types.

| Age group | Population size | & | No. Exam. % pos | % pos | EPG Geometric |
|---|---|---|---|---|---|
| JIGGA | | | | | |
| 0-4 | 746 | 18.4 | 162 | 12 | 105 |
| 5-9 | 780 | 18.2 | 183 | 50 | 191 |
| 10-14 | 380 | 9.4 | 153 | 72 | 330 |
| 15-19 | 333 | 8.2 | 60 | 65 | 368 |
| 20-24 | 268 | 6.6 | 41 | 34 | 237 |
| 25-29 | 215 | 5.3 | 44 | 39 | 167 |
| 30-34 | 243 | 6.0 | 56 | 32 | 110 |
| 35-39 | 234 | 5.8 | 66 | 27 | 87 |
| 40-44 | 178 | 4.4 | 34 | 32 | 183 |
| 45-49 | 188 | 4.6 | 32 | 41 | 100 |
| 50-54 | 172 | 4.2 | 34 | 38 | 93 |
| 55-59 | 97 | 2.4 | 26 | 35 | 15 |
| 60+ | 225 | 5..5 | 22 | 9 | 50 |
| Total | 4059 | 100 | 913 | 41 | 172 |
| METAHARA | | | | | |
| 0-4 | 3784 | 18.5 | 328 | 11 | 230 |
| 5-9 | 3515 | 19.2 | 353 | 29 | 358 |
| 10-14 | 2139 | 10.5 | 157 | 36 | 352 |
| 15-19 | 1630 | 8.0 | 80 | 23 | 380 |
| 20-24 | 2204 | 10.8 | 121 | 14 | 326 |
| 25-29 | 2588 | 12.6 | 202 | 18 | 174 |
| 30-34 | 2118 | 10.3 | 149 | 18 | 188 |
| 35-39 | 1246 | 6.0 | 134 | 17 | 130 |
| 40-44 | 707 | 3.5 | 46 | 15 | 154 |
| 45-49 | 351 | 1.7 | 25 | 12 | 187 |
| 50-54 | 187 | 0.9 | 18 | 11 | 194 |
| Total | 20469 | 100 | 1614 | 20.0 | 218 |
| ZEWAY | | | | | |
| 0.4 | 289 | 22.2 | 21 | 21 | 360 |
| 5.9 | 183 | 17.7 | 81 | 63 | 304 |
| 10-14 | 108 | 10.5 | 66 | 86.4 | 667 |
| 15-19 | 75 | 7.3 | 19 | 74 | 1129 |
| 20-24 | 67 | 6.5 | 20 | 60 | 311 |
| 25-29 | 58 | 5.6 | 22 | 50 | 347 |
| 30-34 | 70 | 6.9 | 19 | 68.4 | 573 |
| 35-39 | 52 | 5.0 | 24 | 50 | 337 |
| 40-44 | 55 | 5.3 | 16 | 63 | 424 |
| 45-49 | 36 | 3.5 | 14 | 71.4 | 498 |
| 50-54 | 36 | 3.5 | 7 | 43 | 223 |
| 55-59 | 10 | 1.0 | 5 | 40 | 350 |
| 60+ | 53 | 5.0 | 19 | 53 | 264 |
| Total | 1032 | 100 | 370 | 58.6 | 450 |

- Index of potential Contamination (IPC) = population size x prevalence x arithmetic mean egg count per gram of faeces Relative Index of potential Contamination (RIPC)= age specific IPC/total IPCx100.

inhabitants of the selected households were parasitologically examined for S. mansoni infection. The population examined comprised 20% in Jigga (stream ecology), 8% in Metahara (irrigation scheme), and 20-50% in and around Lake Zway. In all cases, double slides were prepared from specimens of each individual using the Kato's thick smear techniques (19) and average egg counts were recorded for positives.

3 .Statistical analysis: Age-specific prevalence rates, geometric mean egg counts per gram of faeces (EPG) and relative index of potential contamination (RIPC) (see Table I) were calculated for each ecological setting and their variations tested for significance using z-test.

The population structures for the study sites are presented in Table 1. In all of them children below 15 years of age constituted over 45% (Jigga, 45%; Metahara, 45.7%; and Zway, 51.0%). An increased percentage of
people aged 15 to 34 years in Metahara sugar plantation is perhaps related to concentration of work force in search of job opportunities in the plantation.

The age specific population examined, percent positive, intensity of infection in terms of geometric mean egg count per gram of faeces and the relative index of potential contamination versus the base population are
shown in Table 1 and Fig.2. Comparing the three ecological types, the lake ecology shows the highest human
prevalence (58.1% ) and intensity of infection (450 EPG). The stream ecology was second in human prevalence (41 %) but lightest in terms of intensity (172 EPG) whereas the irrigation scheme showed lowest human prevalence (20.0% ) but moderate intensity (218 EPG).

In all localities the prevalence, intensity of infection and relative index of potential contamination were highest among subjects aged between 5 and 19. The prevalence was highest among the 10-14 years of age in all age groups (72% in Jiga, 36% in Metahara and 86.4% in Zway). However, in all sites the intensity of infection was highest among persons aged 15-19. The relative index of potential contamination was also consistent with age-specific prevalence, intensity of infection and Population size. What is interesting and should be noted is that in the stream and irrigation ecological categories more than 75% of the contamination was contributed by those under 19 years of ,age, whereas in the lake setting the age range extends up to 34 years for the same level of contamination potential. One may also note that prevalence and intensities of infection decline fairly after the second decade of life in the stream and irrigation ecologies whereas in the lake region all indices tend to remain consistently high.

**DISCUSSION**

Our knowledge of the distribution and prevalence of schistosomiasis in Ethiopia has been steadily expanding. There is adequate evidence that the ecological basis of transmission have an influence on the epidemiology of the disease (20). However, quantitative studies for the Purpose of comparing the epidemiological characteristics of the disease in varying transmission ecosystems are seriously lacking. Among Schistosoma mansoni transmission ecosystems in Ethiopia, the stream ecology continues to be the most important at the moment considering its relative contribution to an overall transmission of the disease (1,2). Nevertheless, the
irrigation and lake ecologies pose considerable threats regarding transmission intensity and ecological health impacts. Although precise comparison of data is difficult due to the inequality of the sample populations studied in the three ecologies, it seems that infected individuals in the stream and irrigation transmission ecosystems have lower intensities of infections in terms of geometric mean egg output, despite relatively high infection rates in humans. In contrast, those from the lake ecology exhibited exceedingly high prevalence and intensity of infection. It was noted that geometric mean egg counts exceeded a thousand in the 15-19 age group among the inhabitants of the lake region, compared to about 400 eggs/g for the same age group among the inhabitants of the stream and irrigation settings. Ongom and Bradley (21), in their study of a fishing

community of Panyagoro, West Nile (Uganda) observed extremely high human prevalence and intensity of infection which persisted throughout adult life similar to our Lake Zway community .

Based on Kloetzel's (22) assumption, they estimated a parasite load of 2000-4000 worm pairs per person for a mean output of 1000 eggs/g, for lOO-200g of faeces daily. They concluded that certain types of subsistence
activities such as fishing may lead to heavy schistosomal transmission. In the lake regions of Ethiopia, including lake Zway, fishing is predominantly carried out by young male adults using locally made wooden or papyrus boats and nets. This may subject them to long hours of exposure to water. Hence, the high intensity of infection observed among the infected residents of the lake ecology should primarily be attributed to the intensity of human exposure to infective water. However , since S. mansoni transmission is effected by B. sudanica in the lake ecology and by B. pfeifferi in the others, possible occurrence of different parasite strains could be an additional factor resulting in different host-parasite relationships.

Furthermore, in the stream and irrigation ecologies less than 40% of the population, aged 5-19, is responsible for about 75% of the potential contamination whereas in the lake ecology 60% of the population, aged 5-39, is responsible for the same level of potential contamination. Although this index of infection is affected by the population structure of the community the results suggest that adults in the lake ecology contribute to the
contamination of the environment more significantly than their counterparts in the other ecologies, owing to the reports of persistently high prevalence and intensity of infection among this age group in the area. This has significant implications in designing control measures. For instance, selected group chemotherapy of those below 20 years of age may be sufficient to significantly reduce morbidity and transmission in the stream and irrigation ecologies while, for similar purposes, mass chemotherapy may be warranted in the lake ecology . Limited quantitative studies by Polderman (23), Hiatt (24), Hiatt and Gebre-Medhin (25) and Birrie (26) have shown low intensities of infection among subjects, including school children, living in stream environments despite high prevalence rates. In Chewahit (a northwestern Ethiopian community with prevalence of 42% ) Polderman (23) could neither observe high egg output, even among the school age children, nor relate tile presence/absence of eggs to human exposure to infective water. The absence of major illness among subjects living in stream ecologies have been shown by Jordan and Webbe (20). With the higher rates of prevalence in Chewahit (42%) (23) and Jigga (41% ) (in this study) higher levels of egg excretion would be expected. Therefore, the apparently light infections and absence of major illness characterizing stream-based mansoni transmission in this country remain unclear at the moment. However, our findings regarding the indices of infection in the irrigation ecology should be interpreted with caution. From being only a rare disease in the 1960 on (5-7), schistosomiasis mansoni has now surfaced as a serious health threat in the Metahara Sugar Estate. In the relatively older Wonji Sugar estate, alarming levels of prevalence and possible intensities of infection (24) have been registered. This means that it may be a matter of time for the situation in Metahara irrigation scheme to show a similar upswing. In general, whether these findings are representative of others in their respective ecologies or not should be resolved in the future through rigorous studies on the ecological basis of transmission, human water contact patterns, immunological status of infected subjects and the possible occurrence of different parasite strains in varying
ecological and cultural settings.

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**REFERENCES**
1.Teklemariom Ayele, Hailu Birrie, Lo, C.T and Fekadu Abebe. The epidemiology of schistosomiasis in Ethiopia. Uz Unpublished data. 1988.
2.Lo, C. T , Hailu Birrie, and Teklemariom Ayele. Localities of Biomphalaria pfeifferi and Bulinus trancatus/tropicus -complex new for Ethiopia with epidemiological notes on new transmission foci of Schistosoma mansoni, S.haematobium and S.bovis. Unpublished data 1988.
3.TekLemariom Ayele. Distribution of schistosomiasis in Ethiopia. Results of 1978-82 survey. In proc. Schisto. Symp. Addis Ababa 1982; Nov. 1-4.
4. Teklemariam Yiman. Schistosomiasis at Wonji. Ethiop. Med. J., 1964; 2: 259.
5.Aklilu Lemma "Preliminary report on schistosomiasis survey at the HVA estate in Wonji". Institute of pathobiology. Unpublished data 1966.
6.Aklilu Lemma. 19 (b). "A report on schistosomiasis survey in Metahera " .Inst. of pathobiology, Int. report 1966.
7.Aklilu Lemma. "Studies on Bilharziasis in Wonji, Shos and Metahera sugar plantations, with recommendations for possible control measures to be taken by HVA company". Inst. of psthobiology. Int. report. 1968.
8.Aklilu Lemma. Bilharziasis in the Awash Valley: an epidemiological study with special emphssis on ita possible future economic and public health importsnce. Ethiop. Med. J., 1969; 7: 147-176.
9.Duncon, I., Aklilu Lemma. Investigation into the control of schistosomiasis at the HVA Wonji-Shoa Sugar Estates in Ethiopia. I. Initiation of the project. Ethiop. Med. J., 1976; 14: 3-15.
10.Kloos, H., Aklilu Lemma. Bilharziasis in the Awash valley. n. Molluscan fauna in irrigation farms and agriculture development. Ethiop. Med. J., 1974; 12: 157-173.
11.Kloos, H., Aklilu Lemma. Bilherzies in the Awash valley, ill. Epidemiological studies in Nura Era, Abedir Melka Sedi, and Amibera irrigation schemes. Ethiopi. Med. J., 19770; 15:
161-168.
12.Kloos, H. and Aklilu Lemma. Schistosomiasis in irrigation schemes in the Awash valley, Ethiopia. Amer. J. Trop. Med. Hyg., 1977b; 2: 899-908.
13.ReddaTeklehaimanotand Goll, P.H. Investigationation the control of achil10aomiaail at the HV A Wonji-Shoa eltAtea in Ethiopil. 2. Interirn evaluation of the project. E/hip. Med. J., 1978; 16: 115-121.
14.BNijing, C.F.A. Bilharziasia in irrigation achemcs in Ethiopia. Trop. Geogr. Med., 1969; 21: 28().292.
15.Fekade Tsegaye, Getahun Abebe. preliminary shcistosome survey in Zway, Arossi, report 10 the Ministry of Health (mimeographed document) 1968.
16.Zaphiropoulol, D.M. Preliminary observations on bilharziasil in Lake Tana, Ethiopil and on the treatment of Schistosome mansonl infectiona with Miracle. Gonder Hlth. Ser. Tech. Rep., 1963; 7: 27-33.

17.Polderrnan, A.M. Intc8Iinal achil10aomiasil north and west of Lake Tana, Elbiopil. Trop. Geogr. Med., 1974; 26: 170-177.
18.Tcklemariam Ayele and Tesfamichael Tesfa Yobannes. Epidemiology of Schistosoma mansonl around Lake Zway and its islands, Ethiopia. Ethiop. Med. J., 1982; 25: 133-139. 19.Petera, PS, EJ-A1amy, M. and Warren K.S. Quick Kalo smear for field quntitation of Schilloaomc manaoni eggs. Am. J. Trop. Med. Hya., 1980; 29, 217-219.
20.Jordan, P. and Webbe, G. Schistosomiasis; Epidemiology, Treatment and control. Williham Heincma Medical Books Lld., wndon 1982. (361 Pp).
21.Ongom, V.L, and Bradley, D.J. The epidemiology and consequence. of Bchlstosoma mansoni infectiona in West Nile, Uganda. I. Field studies of a community at Panyagora. Trans. Roy. Soc. Trop. Med. Hyg., 1972; 66: 835-851.
22.Kloctzcl, K. Spleno~..lyin achil10aomiasilmanaoni. Am. J. Trop. Med. Hya., 1962; 11: 472-47
23.Polderrnan, A.M. The tranamission of inteltinal achil10aomiasil in Bcgemnder Province, Ethiopil. Final report- Lab. of parasilology, Lcidcn, Netherlands 1975. (159 Pp)
24.Hiatt,RA. Morbidity from Schil10aoma manaoni infectiona: and epidemiologioal study based on quantitative analysis of egg excretion in two highland Ethiopiln villages. AM. J. Trop. Med. Hyg., 1976; 25: 808-817.
25.Hiltt, R.A, 8nd Mehari Gebremedhin. Morbidity from Schistoaoma manaoni infectiona: an epidemiological study based on quantitative elg excretion in Ethiopil. Am. J. Trop. Med. Hyg., 1977; 2: 473-481.
26.Hailu Birrie. Survey of SChislosomlasls mansoni in the Borkena river basin, Ethiopia. Elhlop. Med. J., 1986; 24: 159- 167.
27.Daniel Fedade, Feksdu Abebe, Hailu Birrie, Shibru Tedla, and Teklemariam Ayele. A community based morbidity study of achilloaomias; naoni in relation 10 intenaity of infection in Jigga, Ethiopil. Institute of Pathobiology. Unpublished data 1988.