Identification, Habitat, Distribution and Infection of Snails
with effected Cercaria in Arahad Canal, North Kordofan
State, (Sudan 2012)

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August, 2014
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Date: August, 2014
Identification, Habitat, Distribution and Infection of Snails with effected *Cercaria* in *Arahad* Canal, North Kordofan State, (Sudan 2012)

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Date of Examination: 3.08.2014
DEDICATION

I dedicated this work:

.... To my father

...... To my mother

... To my family
Acknowledgements

First and foremost, I thank God almighty for the gift of life, strength, wisdom, relations and all the blessings He has lavished upon me in love.

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Identification, Habitat, Distribution and Infection of Snails with effected Cercaria in Arahad Canal, North Kordofan State, (Sudan 2012)

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Abstract

Populations of freshwater snails are subjected to severe ecological stressors imposed by wide temporal fluctuations in their environment. Their success depends on their physiological capacity to tolerate these fluctuations. Biotic constraints, including parasitism, predation and competition, are added to these ecological stressors. A cross sectional study aimed to study fresh water snails identification, distribution, natural infectivity and study effect of environmental factors in Arahad canal, North Kordofan State, 2013. Three consecutive surveys were done in the period of December 2012-May 2013 in five stations, with interval of one survey per month. Snail density was estimated by using scoop method. The snails collected were identified according to morphological characteristics, while the information on habitats and environmental factors was collected by specific format. The study showed that, a number of 375 snails were collected during the different three surveys. However, the overall prevalence of snail species was 71.2% for Bolinus trancatus, 27.2% for Cleopatra bulimoides and 1.6% for Lanistus natalensis. The highest infectivity rate observed with Lanistus carinuts. 83.3% followed by Bolinus trancatus 56.7% and Cleopatra bulimoides 21.7% respectively. The mean of shedding cerceriae collected from various fresh water sites in Arahad canal was found to be (3.7±1.6). A significance difference found between the three surveys conducted (F=29.352, DF=1, p=.032). Also an association was found between turbidity and type of cerceriae and snail species ($\chi^2= 9.6$, DF=4, P=0.048), thus between type of vegetation and type of cerceriae and snail species ($\chi^2= 9.60$, DF=4, P=0.05). The study concluded that, canalization system, in Alrahad, was found to be a good habitat for the three identified of fresh water snails Bolinus trancatus, 27.2% for Cleopatra bulimoides and Lanistus carinuts. Installation of appropriate sanitary facilities, providing by potable drinking water and educating the people on health risks should be done simultaneously in the study area contributed in prevention of schistomiasis infection.
دراسة التعرف والتوزيع ومعدل الإصابة لقوائق في ترعة الرهد بمحليه الرهد، ولاية شمال كردفان، السودان 2013

المعز ادريس امام عثمان

ملخص الدراسة

يتعرض عشائر من حلزون المياه العذبة إلى الضغوطات البيئية الصارمة التي تفرضها التقلبات الزمنانية الواسعة في بيئتهما. نجاحهم يعتمد على قدرتهم الفيزيولوجية على تحمل هذه التقلبات. تضاف القيود الحيوية، بما في ذلك التكلف، الافتراض والتنافس، لهذه الضغوطات البيئية. دراسة مقطعية تهدف إلى دراسة التعرف، والتوزيع، ومعدل العدوى الطبيعية لقوائق المياه العذبة وتأثير دراسة العوامل البيئية في ترعة الرهد بولاية شمال كردفان في العام 2013. وقد أجريت ثلاثة مسحات متتالية في الفترة من شهر ديسمبر 2012 وحتى مايو 2013 في خمس محطات، بواقع مسح واحدة في الشهر. وقدر كثافة القواقع الحلزونية باستخدام مغرفة بانورامية. تم التعرف على القواقع التي تم جمعها وفقاً لخصائصها المورفولوجية، بينما تم جمع المعلومات عن البيئات والعوامل البيئية من خلال فورمات محددة. وأظهرت الدراسة أن عدد القواقع

Bolinus trancatus

27.2٪ لنوع

bulimoides Cleopatra

و 1.6٪ لنوع

Lanistus carinatus

أعلى معدل للعدوى كان من نصيب ال

Lanistus natalensis

(83.3٪) Bulinus

(56.7٪) Lanistus

من نصيب ال

Cleopatra bulimoides trancatus

التي تم جمعها من مختلف المواقع المياه العذبة في ترعة الرهد ليكون (3.7 ± 1.6٪). وهناكم فرق معنوي احصائي بين المسوحات الثلاثة التي أجريت (29.352، 1، 0.032). كما تمتاألثورة على وجود فروقات احصائية معنوية بين العكارة ونوع القواقع ونوع السركاريا (9.6٪) ؛ وبالتالي بين نوع الغطاء النباتي ونوع القواقع ونوع السركاريا (9.6٪) 

χ² = 4، P = 0.048

وقالون أن تركيب نظام للصرف الصحي وتنظيم الناس بشأن المخاطر الصحية، وتوفير مياه نقاء صالحة للشرب في وقت واحد في منطقة الدراسة يسهم في الوقاية من الإصابة بمرض البلهارسيا.
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CHAPTER ONE
1. INTRODUCTION

Digenetic trematodes are common parasites of wild and domestic animals (Lotfy et al., 2010). These parasites all undergo obligatory larval development in snails that are common in the freshwater habitats of the country. Fluke infections can kill or impair the health of their vertebrate hosts, including people, and some digeneans are either known to infect people, or are suspected of doing so (Yong et al., 2000). Furthermore, several studies suggest that the distribution and prevalence of trematodes of medical and veterinary significance will be altered and in some cases enhanced by global climate change (Mas-Coma et al., 2009). This potentially includes Fasciola spp., Schistosoma spp. and Paramphistomum spp. However, before we can hope to control these trematodes, or to understand the impact of global climate change on their distribution or abundance, we must first have baseline information for what species are present, where and how they are transmitted, and the identity of their snail hosts. Some data are available from other studies of adult digeneans from their definitive hosts and the Cerceriae in freshwater snails (Pandey 2001), but as noted by Devkota (2008), much remains to be learned. Human schistosomiases are water-based diseases because of their strong associations with domestic, occupational and recreational water-contact activities (Jurg et al., 2003). The diseases are caused by three main species of digenetic trematodes, namely Schistosoma haematobium, Schistosoma japonicum and Schistosoma mansoni. All the species of the genus Schistosoma belong to the flatworms in the class trematoda and family Schistosomatidae. They are commonly called blood flukes, because the adult forms inhabit blood vessels of their definitive hosts (Cheesbrough, 1998). Moreover, there are various mammalian and avian schistosomes, such as
Gigantobilharzia and Trichobilharzia of water birds that do not complete their life cycles in the human host but may cause cercarial dermatitis or “swimmers’ itch, an allergic skin reaction caused by the cutaneous migration of schistosomula of these schistosomes in the human skin (Kalyanasundaram et al., 2003).

1.2. Snail Intermediate Hosts of Schistosomiasis

In Nigeria, Biomphalaria and Bulinus species are implicated in the transmission of schistosomiasis (Idris and Ajanusi, 2002). These two genera of snails are aquatic and hermaphroditic. They are found in almost all types of water bodies, ranging from small temporary ponds or streams to large lakes and rivers. Man-made lakes or water bodies, like irrigation canals and dams are in particular excellent habitats (Idris and Ajanusi, 2002). The eggs of Bulinus and Biomphalaria species are deposited en masse on biotic and abiotic substrata in water. Hatching takes place under optimal conditions between 7-10 days. Snails of the two genera may reach sexual maturity in about 4-6 weeks (Idris and Ajanusi, 2002). The reproductive capacity is high and population of these species may undergo marked seasonal fluctuation in density and infection rate with rainfall and temperature being the main determining factors. Although, water is always present in most irrigation canals, which means constancy of water cancels rainfall effect, however, rainfall is presumed to facilitate transmission by washing the eggs of S. mansoni in faeces into water bodies (Idris and Ajanusi, 2002). Furthermore, environmental factors such as the physico-chemical parameters of water bodies are also of concern in the distribution of the snail intermediate hosts of schistosomiasis. These parameters include water current velocity, pH and water temperature (Idowu, 1996). Snail species known to transmit schistosomiasis belong to the two families of aquatic pulmonates, Bulinidae and Planorbidae. The bulinid snails are the intermediate hosts of S. haematobium, thus responsible for urinary schistosomiasis. These
include *Bulinus globosus* (Murelet), *B. rohlfsi* (Clessin) and *B. senegalensis* (Muller) found in most parts of northern Nigerian states, including Kano (*Dunah and Bristone, 2000*). *Schistosoma mansoni*, the cause of intestinal schistosomiasis, is vectored by Biomphalaria pfeifferi (Krauss), a planorbid snail, in Nigeria and in several other countries, such as Egypt, Cameroon, Ghana and the Gambia (*Kalyanasundaram et al., 2003*).

1-5. Justification of the study:
Arahad Canal provide suitable environment for water-borne diseases transmitted by fresh water snails, mainly schistosomiasis which is endemic in Arhad threatening both human and animals. In that area there is no any recent studies for schistosomiasis intermitted host, so establishing base line data behind knowledge of distribution and identification of snails in the area may help in controlling program and design appropriate strategies for control.

1.6. Study Objectives:

1-6.1. General objectives:
To study on identification, distribution and Infection rate of the snails in Arahad locality in North Kurdofan State during December 2012-may-2013.

1-6.2. Specific objectives:

- To identify the common species of snails.
- To determine the habitats of snails.
- To determine the infectivity rate among snails.
CHAPTER TWO
2. LITERATURE REVIEW

2.1 Epidemiology of Human Schistosomiasis:
The epidemiology of human schistosomiasis has been extensively investigated for over 100 years, and its distribution and characteristics are well documented for most endemic areas (Chris and Amadou, 2001). About 200 million people are affected with schistosomiasis world-wide, of whom 85% live on the African continent. Children are especially vulnerable to schistosomiasis, and infected school-age children are often physically and intellectually compromised by concurrent anaemia, attention deficits, learning disabilities and school absenteeism.

The prevalence of the disease is on the increase world-wide. A general pattern of schistosome infection is an increase with age in both intensity and prevalence of infection up to teenage years, followed by a decline in older age groups. The rate of decline can be affected by the species of schistosome present and the degree of endemicity (Jozef et al., 2001). Gryseels and Nkulikyinka (1990) observed that in most endemic schistosomiasis situations the most heavily infected individuals tend to be children, and significantly higher prevalence has been observed in males than in females. Similarly, in 1995, WHO observed that in most areas endemic for Schistosoma mansoni the prevalence of infection is generally greatest in the 10-24 year age group, most of the heavily infected persons being between 10 and 14 years of age, with a low prevalence and intensity of infection in the older group.

Furthermore, Berquist and Ming-gang (1988) reported that prevalence rates and intensity of infection in endemic communities generally increase with age until adolescence, but the decline is earlier in S. haematobium infection than in S. mansoni. In S. mansoni infections, prevalence also tends to abate more slowly than
does intensity, depending usually on the extent of water contact and parasite species. Most factors affecting the distribution and prevalence of schistosomiasis are surface water contact behaviour and environmental or climatic factors which adversely or favourably affect snail populations and the amount of human water contact (Jozef et al., 2001). Such water contact tends to be most frequent around midday which coincides with the peak period of Schistosoma eggs secretion. However, with intestinal schistosomiasis there is strong evidence that a specific sex and certain age groups contaminate transmission sites more than others (Jozef et al., 2001). For example, in Kenya children of 15-19 year age group (particularly males) were found to defaecate disproportionately more frequently near the river bank than were other age groups (Jozef et al., 2001). Contamination of surface waters or other surroundings with faeces and urine containing schistosome eggs is essential for transmission of the parasite. It is likely that all age groups of both sexes urinate while swimming or bathing, despite cultural taboos and religious inclination. However, Chris and Amadou (2001) observed that pre-treatment individuals of 19 years or under contribute more than 75% of the potential contamination. Hence, the basic reason for the transmission of schistosomes is, however, the low level of sanitation in endemic areas with the result that faeces or urine, or both, containing schistosome eggs get into water that contains freshwater snails susceptible to infection (Jozef et al., 2001). Jozef et al. (2001) also reported that variation in hatchability of eggs; the hatching rate of S. mansoni eggs was dependent on the intensity of infection and rose proportionately with it. By contrast, the hatching rate decreased with increasing age of the subject.
2.2. Global Prevalence of Schistosomiasis:

More than 207 million people are infected worldwide, with an estimated 700 million people at risk in 74 endemic countries. Hygiene and play habits make children especially vulnerable to infection, and in many areas a large proportion of school-age children are infected (WHO, 2010).

Human schistosomiasis is an important disease problem in Africa and the Far East and as well as one of the most prevalent parasitic diseases in the world (Ishikawa et al., 2006). For example, in the Philippine archipelago schistosomiasis is endemic in Bohol Island. The disease is caused by S. japonicum transmitted by another snail vector common in the Far East, Oncomelania quadrasi. In 1986, the island was reported to have had a prevalence rate of 15% in the pre-control period, but after a decade of successful control measures the disease prevalence was reduced to a mere 0.2% (Ishikawa et al., 2006).

Li et al. (2000) also reported Oncomelania hupensis hupensis as another snail vector of S. japonicum in China. In Cameroon, the national schistosomiasis survey conducted from 1985 to 1987 indicated that more than 1.7 million people were infected with schistosomes. S. haematobium and S. mansoni were widely distributed, whereas S. intercalatum had a very restricted distribution (Paul et al., 2003). All children of school age were infected in Niger Republic. Moreover, 80% of infected children and over 60% of adults had disease of the urinary system (Adekolu et al., 1993). Up to 71% of school children were infected with S. haematobium in Tanzania (Adekolu et al., 1993).

In the upper region of Ghana between 1951 and 1965, small dams were built with support from USAID. The prevalence of urinary schistosomiasis in the vicinity of this dam was 45.3% that in the area with only traditional water supply was 19.8%
(Hunter, 1981). The rate of urinary schistosomiasis was significantly higher in areas where the small dam reservoir was poorly maintained (Adekolu et al., 1993). All Ghana's water reservoirs have become infested with Bulinus species. Schistosomiasis is highly endemic in all irrigation schemes in Madagascar. The prevalence of urinary schistosomiasis in two schools with an irrigation scheme in Arkilone in western Madagascar was 69%, while outside the scheme was 7% (Adekolu et al., 1993).

Chris and Amadou (2001) highlighted the significant role of young people in S. mansoni contamination and transmission. They also reported the prevalence of the infection of 16% and 32% in two endemic areas in Burundi. Kimberly et al. (2001) obtained prevalence rates of 13.8% and 59.7% for S. mansoni and S. haematobium respectively from school children in the East Central Zimbabwe. Their result was similar to the one of the previous surveys in the area which indicated high prevalence of S. haematobium and low prevalence of S. mansoni. They attributed the widespread occurrence of schistosomiasis in the area to the presence of dense river drainage system. In Mali, a prevalence study carried out by Elias et al. (1994) showed the prevalence of S. haematobium of 30% with maximum age prevalence and age intensity found among the younger age groups. Within these age groups it was realised that the males showed higher rates of infection of 31.7% than females (i.e. 28.7%). Chris and Amadou (2001) and Gryseels and Nkulikyinka (1990) observed a significantly higher prevalence in males than in females. For example, in three areas of Zaire the sex-related prevalence of infection was 50%, 21% and 7% for males, and 24%, 12% and 3% for females, respectively (Chris and Amadou, 2001).

In Uganda, the national schistosomiasis control programme successfully used geographic information system (GIS) and remote sensing techniques for mapping
purposes and spatial targeting of mass drug administration (MDA). For example, it was found that communities living in close proximity to lakes, at altitudes <1,400m and in areas where annual precipitation was more than 900mm were at high risk of intestinal schistosomiasis (Patrick et al., 2006).

2.3. Endemicity of schistomiasis in Sudan:

Schistosomiasis has affected the people of Sudan for many centuries. Its spread could have been associated with the traders who frequented the Nile Valley in ancient times. In the eighth and seventh centuries B.C., southern Egypt and northern Sudan formed a single political entity. In 1918, Christopherson suggested that Schistosomiasis is endemic in all provinces, with the exception of the desert fringing the Red Sea (Ayad, 1956). Schistosomiasis is endemic in Sudan and cases can be detected in all states except the Red Sea State. It a behavioral disease which always occurs where sanitary standards are low and man is the final sole host. Schoolchildren who live in such endemic areas are at risk of Schistosomiasis as they tend to swim and bath in water channels and get exposed to the infective cercariae (Mustafa, 2012).

1.5. Prevention and Control of Schistosomiasis

Schistosomiasis, among other helminth diseases, has been described as the disease of the poorest of the poor (Alan et al., 2003). The disease epidemiology is attributable to water contact pattern, biology and distribution of the potential snail vectors and the local geographical, geological and climatic conditions (Ugbomoiko, 2000).

The basic reason for the transmission of schistosomiasis is, however, the low level of sanitation in endemic areas with the result that faeces or urine or both containing
schistosome eggs get into water that contains freshwater snails susceptible to infection (Jozef et al., 2001).

Contamination of surface waters or their surrounding with faeces and urine containing schistosome eggs is essential for transmission of the parasite. Contamination can be direct, affected by such factors as location and patterns of defecation according to age, sex and cultural practices, and indirect, which can be affected by rain overflowing latrines (Jozef et al., 2001). Several important environmental management strategies for vector control by alteration of the natural habitat of molluscs, include flushing of streams, stream channelisation, canal relocation with deep burial of snails, liming of irrigation canal systems, straightening and clearing riverbanks of vegetation, removal of shade/vegetation, concreting irrigation canals and banks of dams, and the use of intermittent irrigation (Madsen et al., 2007).

Furthermore, the establishment and reproduction of snails can to a large extent be controlled by effective water management, such as regular draining of canals and for high water velocities. An effective drainage system can have economic benefit, as well as reduce the irrigation-related health-risks (Slootweg and Keyzer, 1993). Since infection with schistosomes occurs when cercariae penetrate intact skin of the definitive host, blocking entry of cercariae into the skin could therefore potentially control the infection. Recent studies (Kalyanasundaram et al., 2003) show that topical application of anti-penetration agents with cercaricidal effect, such as lipoDEET, a lipid formulation of N, N-diethyl-m-toluamide, is highly effective in killing schistosome cercariae in the skin. However, under field conditions, DEET by itself might not be sufficient to control schistosomiasis in an endemic area; rather it could be applied synergistically along with other control measures such as restricted water contact, snail control and prophylactic
chemotherapy (Kalyanasundaram et al., 2003). Thus, given its broad insect repellence and anti-schistosomal activity, lipoDEET could be of benefit for travellers visiting endemic areas where schistosomiasis and insect-borne infections are highly prevalent, especially if minimal water contact is expected. Given the cercaricidal effect, a topical application of lipoDEET could also be used against cercarial dermatitis (Kalyanasundaram et al., 2003).

Abu-Elyazeed et al. (1993) carried out a field trial using 1% Niclosamide as a topical antipenetrant to S. mansoni cercariae. The lotion was applied daily to the upper and lower limbs of the farmers occupationally exposed to S. mansoni cercariae-infested water, resulting in lower schistosomal reinfection rate (53.3%) compared with individuals that did not apply the anti-penetrant (71.3%). However, they recommended for total body application of the lotion and less water contact for increased protection. Early attempts to control schistosomiasis during 1930-1985 were based on chemical molluscicides for snail control, and relatively ineffective and less well-tolerated drugs such as antimony-based compounds and Niridazole for treatment (Alan et al., 2003). Most chemical molluscicides are expensive, require skilled people to use them in water and are not environmentally friendly. Because snails are able to bury themselves and consequently escape the chemicals, they may have to be applied several times (WHO, 1995). A number of molluscicides have been used against the snail vectors of schistosomiasis in endemic areas worldwide, the most common being Niclosamide, copper sulphate, Frescon, sodium pentachlorophenate, Yurimin and B-2 (Madsen et al., 2007). However, this approach to snail control is limited because of the recurring expense and the environmental damage, especially the killing of fish (Li et al., 2000). The current control strategy used in most endemic areas involves health education, environmental modification, large scale periodic treatment of humans and
domestic animals (especially cattle) with non toxic drug praziquantel, and focused snail control (Li et al., 2000). The WHO has developed a strategy, which was adopted in the world Health Assembly resolution of May, 2001, aimed at control of morbidity due to schistosomiasis in sub-Saharan Africa. The resolution urged member states to ensure access to essential drugs against schistosomiasis in all health services in endemic areas for the treatment of clinical cases and groups at high risk of morbidity, such as women and children. The goal of this resolution is to attain a minimum target of regular administration of chemotherapy to over 75% of all school-age children at risk of morbidity by 2010 (Alan et al., 2003).

Praziquantel, a pyrazinoisoquinoline, is currently the drug of choice for the treatment of schistosomiasis (Alan et al., 2003).

However, praziquantel is not the perfect antischistosomal drug because it does not affect young stages of the parasite (Anthony and Sake, 2002), i.e. the immature worms are less sensitive to praziquantel, and therefore many would have escaped drug action and developed into egg-laying adults shortly after treatment. Fortunately, Artemether, a drug used to control malaria, was found to be effective against immature schistosomes, but is less effective against adult worms (Alan et al., 2003). The morbidity caused by schistosomiasis has been controlled in China, Egypt and the Philippines mainly by the widespread use of the safe and efficacious drug Praziquantel, and by Oxamniquine and Praziquantel in Brazil (Alan et al., 2003). In several other countries, socio-economic development combined with treatment have been most effective in preventing new cases and curing existing infections; hence, in Mauritius, Morocco, Venezuela, much of the Caribbean and Puerto Rico, elimination of the parasite is a realistic goal which is close to being reached (Alan et al., 2003). In spite of this development there is a need to revisit
transmission containment, especially now that there are reported cases of emerging drug resistance with Praziquantel (Patrick et al., 2006).

Following the national schistosomiasis survey in Nigeria in 1990-1992, Praziquantel has been on the essential drug list in all the states of the Federation since 1994. However, the percentage coverage of the population is less than 10% (Paul et al., 2003). Akinwale et al. (2004) observed that such intervention programmes in health care delivery might have been faced with certain drawbacks such as poverty, ignorance and sub-standard hygienic practices. So also are knowledge, attitude, belief and practices of the recipient populations to the disease.

There is as yet no vaccine for prophylactic measures against schistosomiasis, but recent developments in schistosomes’ genome analysis, offer hope for the development of new tools for control (Paul et al., 2003).

2.4. Distribution of Schistosomiasis intermediate hosts in Sudan:

Several surveys were conducted in different part of the Sudan studying snail distribution in all endemic areas. In Barber region in North Sudan Biomphalaria species were recorded (Archibald, 1933). In Gezira state both species Bulinus and Biomphalaria were reported by (Stephenson, 1947). And then Greany (1952) described Bulinus truncatus, B.forskalii and B.looses, and Biomphalaria africanus, B.alexandria in different canals of Gezira scheme. Manjing, (1978) reported B. pfeirfferi in all Gezira canals since the irrigation system in Gezira-Managil scheme provide favorable conditions for snail breeding and schistosomiasis transmission (Madsen et al, 1988). Hilali, (1992) described Biomphalaria pfeirfferi in Managil agricultural scheme, and he found the same speicies with Bulinus forskalii in Khartoum state (Hilali, 1995).
2.5. Animal Schistosomiasis:

Animal schistosomes can be found in mammals, birds and reptiles mainly crocodiles; the life cycle is identical to human schistosome (Horák and Kolárková, 2001). Water snails infected by the first larvae (miracidia) serve as obligatory intermediate hosts in which asexual multiplication occurs, and then they release the infective stage (cercariae) which then penetrate the skin of vertebrates and develop into adults. Sometimes, a non-specific host might be infected, although it might be light infection but the repeated infections can cause significant losses due to long-term effects on animal growth and productivity, as well as increasing their susceptibility to other parasitic or bacterial diseases (De Bont and Vercruysse, 1998). Epizootiological surveys conducted in the White Nile State of the Sudan showed that 70-90% of cattle in irrigated areas were infected with S. bovis (De Bont and Vercruysse, 1998).

Schistosomiasis is posing a real threat on ruminants, mainly cattles in Africa and Asia, where it is estimated that at least 165 million animals are infected (De Bont, and Vercruysse, 1997). Out of the 10 species reported to naturally infect cattle only Schistosoma mattheei and Schistosoma bovis have received particular attention, mainly because of their recognized veterinary significance (Taylor, 1987). Another species of importance in animals is Schistosoma japonicum because of its zoonotic aspect of transmission.

2.6. Biology of fresh water snails:

Some 350 snail species are estimated to be of possible medical or veterinary importance. Most intermediate hosts of human Schistosoma parasites belong to
three genera, *Biomphalaria*, *Bulinus* and *Oncomelania*. The species involved can be identified by the shape of the outer shell. Simple regional keys are available for the determination of most species. The snails can be divided into two main groups: Aquatic snails that live under water and cannot usually survive elsewhere (*Biomphalaria, Bulinus*), and amphibious snails adapted for living in and out of Water (*Oncomelania*). In Africa and the Americas, snails of the genus *Biomphalaria* serve as intermediate hosts of *S. mansoni*. Snails of the genus *Bulinus* serve as the intermediate hosts of *S. haematobium* in Africa and the Eastern Mediterranean, as well as of *S. intercalatum* in Africa (WHO, 1995).

In south-east Asia, *Oncomelania* serves as the intermediate host of *S. japonicum*, and *Tricula* as the intermediate host of *S. mekongi*. Among the snail intermediate hosts of trematodes, the species belonging to the genus *Lymnaea* are of importance in the transmission of liver flukes. *Lymnaea* species may be either aquatic or amphibious (WHO, 1995).

2.7. Ecology of fresh water snails:

Snail habitats include almost all types of freshwater bodies ranging from small Temporary ponds and streams to large lakes and rivers. Within each habitat, snail Distribution may be patchy and detection requires examination of different sites.

Moreover, snail densities vary significantly with the season. In general, the aquatic snail hosts of schistosomes occur in shallow water near the shores of lakes, ponds, marshes, streams and irrigation channels. They live on water plants and mud that is rich in decaying organic matter (WHO, 1995).
They can also be found on rocks, stones or concrete covered with algae or on various types of debris. They are most common in waters where water plants are abundant and in water moderately polluted with organic matter, such as faeces and urine, as is often the case near human habitations. Plants serve as substrates for feeding and oviposition as well as providing protection from high water velocities and predators such as fish and birds. Most aquatic snail species die when stranded on dry land in the dry season (WHO, 1995). However, a proportion of some snail species are able to withstand desiccation for months while buried in the mud bottom by sealing their shell opening with a layer of mucus. Most species can survive outside water for short periods. For reproduction, temperatures between 22 °C and 26 °C are usually optimal, but *Bulinus* snails in Ghana and other hot places have a wider temperature range. The snails can easily survive between 10 °C and 35 °C. They are not found in salty or acidic water. In most areas, seasonal changes in rainfall, water level and temperature cause marked fluctuations in snail population densities and transmission rates. Reservoirs that contain water for several months of the year in Sahelian Africa can be intensive transmission sites of urinary schistosomiasis during a very limited period, because surviving *Bulinus* species rapidly recolonize the reservoirs after the rains start (WHO, 1995).

*Oncomelania* snails can survive periods of drought because they possess an Operculum capable of closing the shell opening. In the temperate zone they can survive for 2–4 months, in the tropics much less. They live both in and out of water. In humid areas such as poorly tilled rice fields, sluggish streams, secondary and Tertiary canals of irrigation systems, swamps and roadside ditches. The vegetation in these sites is important in maintaining a suitable temperature and humidity.
Their food is similar to that of aquatic snails but they also feed on plant surfaces above water (WHO, 1995).

2.8. Snail Vector Population and Infection Studies

A combination of both abiotic and biotic factors exerts its influence on the fecundity and hence population density of a snail in a given habitat (Betterton et al., 1988). According to Slootweg and Keyzer (1993), the principal reproduction period for snail vectors of human schistosomiasis in the Benue valley of Northern Cameroon is the cooler dry season (December – March) when the water temperatures are optimal for reproduction (between 20°C and 25°C). The second half of the rainy season (July – September) is a minor reproduction period for the snail vectors. Similar observation was made in Nigeria by Etim et al. (1998) who reported that the snail population was highest in April just after the onset of the rains but dropped at the peak of the rainy season. Appleton (1978) found that snail growth requires between approximately 18°C and 32°C, as with the optimal conditions between 22°C and 26°C. Moreover, Idris and Ajanusi (2002) reported that in order for planorbide snails to maintain their number they need a warm season (26.6°C to 31.4°C) of a few months. They also reported a high reproductive capacity of these species and that population may undergo marked seasonal fluctuation in density and infection rate with rainfall and temperature being the main determining factors. Ndifon and Ukoli (1989) reported an increased snail density immediately after the rainy season and beginning of the dry season and peak densities of eggs and juveniles during hottest months of March, April and May and their low density during the rainy period. This may be due to the fact that snails require high temperature for eggs to be laid. In a similar vein, Ezeugwu and Mafe (1998) reported that snail intermediate hosts were more abundant during the
hot dry season (March/ April) probably due to the fact that this coincided with the period when the aquatic habitats become stable in terms of water level and velocity. In a research conducted by Etim et al. (1998), the snail intermediate host populations were found to be widespread in the area of the prevalence study even though the snail densities were low and fluctuated with the seasons. They further observed that both densities and dynamics of snail populations and water contact pattern showed focal patterns in time and space. Consequently, the dynamics of transmission of schistosomiasis depend on a complex set of local and temporary conditions. Rainfall cycles are amongst the most important climatic factors that affect life history of snail intermediate hosts, but reproduction and population also depend on the temperature and various other factors. In areas where rainfall, water level and temperature are relatively constant, reproduction may take place throughout the year (Webbe, 1988). Temperature emerges as the abiotic factor of greatest importance in determining the distribution of host snails in lentic environments (i.e. standing water bodies). Water current velocity is the most important factor in lotic environment (Webbe, 1988). Snail vectors have been reported by Appleton (1978) to have a remarkably narrow tolerance to current velocity. For example, Bulinus and Biomphalaria species occur only in standing water habitats and in waters flowing at velocities of up to 0.3m/sec. This narrow tolerance range of 0.0 to 0.3m/sec restricts the longitudinal distribution of these snails in river systems and renders large parts of the water courses inhabitable despite water quality and temperature that is suitable. In addition, Luka et al. (2005) reported a low density of snail vectors in fast flowing streams. However, these snails have been found in slow-flowing canals and in the back waters of main canals where the weirs provide suitable protection from the fast flowing water (Logan, 1983). Freshwater snails constantly face desiccation, occasioned by drying up of surface water from small water bodies either regularly in a seasonal
manner or occasionally due to unusual rainfall, among other factors. However, most of the freshwater snails have the ability to withstand considerable periods of desiccation (Webbe, 1982). During the periods of droughts, these snails have been found to burrow into the mud as a means of aestivation, around the periphery of these habitats (Oyeyi et al., 1988). The distribution of aestivating snails depend on the type of vegetation cover, relative humidity, temperature, size, genetic endowment and substratum where these snails aestivate, thus escaping drought periods hence prolonging their survival into the next favorable season. Other stimuli besides desiccation have been implicated in the commencement of aestivation. These include water level, aquatic flora and fauna, electric conductivity, and temperature. However, aestivation in bulinids is an active process which does not entirely depend on mere drying of a habitat (Oyeyi and Ndifon, 1988). Betterton et al. (1989) observed that B. rohlfsi did not aestivate during the early dry season, when the habitat was contracting through evaporation. When aestivation commenced, there was no abrupt change in any of the physical parameters monitored. However, there was a coincident decline in the population of unicellular algae with the onset of the process. In the case of B. Senegalensis aestivation occurs before the pools have severely contracted and that the species aestivates in response to a sudden fall in water temperature as reported by Betterton et al. (1988). Goll et al. (1984) found that only immature B. Senegalensis survived aestivation. In similar findings, Oyeyi (2000) reported that all the surviving snail intermediate hosts were about 3.0mm in shell length. Brown (1980) noted that the capacity for explosive population increase of bulinid and planorbid snails means that the few survivors will rapidly repopulate the habitat. Furthermore, the success of bulinid snails at colonizing water bodies was linked to its ability to aestivate (Appleton, 1978). It was also reported by Oyeyi and Ndifon (1988) that post-aestivators consumed food at a higher rate than the non-aestivators.
and that *B. rohlfsi* in particular, appear to maximize breeding and rapidly repopulate its seasonal habitat through large appetite after aestivation, implying that aestivation may involve the use of reserved foods by the snails in an economic manner, over a period of time covering the aestivation period when the reserves become depleted. Snail intermediate host populations have been reported to be controlled by ecological factors such as physico-chemical factors of water habitat, vegetation, substratum and water current velocity which may act either singly or in combination thereby exerting their effects (Webbe, 1982). For example, salinity and turbidity influence the characteristics of the water. Salinity and oxygen tension decrease the survival of the snail vectors of schistosomiasis. Additionally, pollution decreases oxygen concentration in water. These factors also influence the development of the snail vectors. *B. globosus* was shown by Brown (1980) to be intolerant of high turbidities. It has been indicated that a turbidity of 360mg/l due to suspended minerals from granite erosion prevented development and hatching of *B. pfeifferi* eggs (Webbe, 1982). On a general note, the water of most snail habitats is usually eutrophic, containing some dissolved organic materials and is not normally turbid (Webbe, 1982). Ezeugwu and Mafe (1998) found that total water hardness appeared to enhance snail abundance. Moreover, Meier-Brook et al. (1987) observed experimentally that *B. truncatus* is adapted to hard water, in contrast to * Biomphalaria* species. However, increase in chloride concentration was found to be apparently deleterious (Ezeugwu and Mafe, 1998). Generally, both low and high pH appeared harmful to snail vectors due to the possibility of denaturation of the mucus on the exposed skin surface (Webbe, 1982). On a general note, *planorbid* snails have been shown to adapt to a wide range of environmental conditions such as water bodies with moderate organic content, little turbidity and a substratum rich in organic matter and moderate light. Although these factors might vary from one species to another, optimum habitat
conditions are usually similar for all of them (Webbe, 1982). Moreover, Luka et al. (2005) found an association of snail population with human activities such as organic pollution which all determine abundance and distribution of the snail vectors. Betterton et al. (1988) investigated 165 freshwater habitats throughout Kano State and revealed the presence of a number of potential snail intermediate host species, namely Bulinus senegalensis, B. forskalii, B. globosus, B. rohlfsi and Biomphalaria pfeifferi. They also found that the most widespread species was B. senegalensis which inhabited shallow pools and excavations on a variety of substrata. Yahaya (1988) conducted a research in the same state with a view to identifying larval trematodes naturally infecting snail vectors of Schistosoma recovered earlier by Betterton (in the same year), Save B. forskalii. He reported an overall field infection rate of 16.6%, a lower rate compared to the known prevalence of the trematode diseases in the area. However, Wright (1966) suggested that in Africa a higher infection rate for human schistosomes was preponderant in snails collected from ponds and pools than in those collected from open habitats such as streams and irrigation systems. Furthermore, Etim et al. (1998) recovered in Biase area of Cross River State B. globosus, B. truncatus, B. forskalii and Biomphalaria pfeifferi with cercarial infection rates of 39.9% in the dry season and 35.9% in the rainy season. Similarly, Idris and Ajanusi (2002) observed that in Katsina State, a proportion of infected Bulinus species was highest in the months of May and June, during which infection rates were 21.05% and 58.33%, respectively. However, they recorded no infection in these snails between the months of July and December. In the case of Biomphalaria species, the highest rates of infection were seen in the months of February, March and April (25.0%, 55.56% and 61.11%) respectively. The least infection rates were observed between July and January (Idris and Ajanusi, 2002). Gerard and Theron (1997) reported an alteration of the physiology and metabolism of freshwater snail hosts by larval
trematodes (Cercariae) which, in turn, may have life history consequences such as effects on growth, fecundity and survival. Moreover, they observed an age-specific effect characterized by limitation of growth rate when the snails were infected as juveniles and reduction of reproductive effort when snails were infected as adults. Also there was a time-specific effect with early enhancement of growth rate and reproductive effort for infected juvenile and adult snails respectively during prepatency, before reduction and cessation during patency. It was however reported by Jozef et al. (2001) that the percentage of infected snails and the cercariometry at a given time point reflect both the level of transmission from the definitive host to snails and the vectorial capacity of the snails resulting from an accumulation of contacts with miracidia during the previous months.
CHAPTER THREE
3-METHODOLOGY

3.1. Study design:

A Cross-sectional study design was conducted in Arhad to collect random samples of snails from the breeding sites in Toraat Arhad.

3-2. Study area

North Kordofan is one of the (17) State in Sudan. The State located North Kurdofan between longitude '21.20-32 East, '26-56.30 West and latitude 16-36.16 North, 12-14 South. The total population is about 2,920,992 inhabitants. The surface area of the State is (244,700) km.

3.2.1. Arhad locality:

The study was carried out in Arhad locality it is one of (12) localities in the state, it is distributed into (4) administrative units and it is contain about 305 villages. The temperature range from (27°C-35°C).

The monthly rain fall range from (45) mm (June–October), humidity range 60%. However, the total population density is about (157,838), most of them are farmers. There are (111) primary schools and. Arahad the locality involve Khor Abu-habil which is Seasonal runoff. The prevalence of schistosomiasis in Arahad locality is 85%.
Figure 1 map of North Kordofan State
3.3. Study population:

The study population is adult of snail.

3.4. Sampling:

3.4.1. Sample size:

All accessible breeding sites of snails were targeted for snail's collection.

3.4.2. Sample techniques:

Three surveys were conducted during December 2012-May 2013 in four stations, with interval of one survey per month. Snail density was estimated by using scoop method. The snails collected were identified according to morphological characteristics, while the information on habitats and environmental factors were collected by special designed format.

3.4.2.1. Collection method:

Snails were collected by scooping method which is a flat wire-mesh of metal frame (40×30cm) supported a mesh of 1.5 micro-size attached to an iron handle of 1.5meter long as described by (Amin, 1972), by taking 10-15 dips/site, start with the edge then scraped the bottom and vegetation. The collected sample were put in jars containing water of the canal and transported to alobeid laboratory for sorting out and identification.

3.4.2.2. Identification method:

The collected snails were washed and identified morphologically to different genus and species according to the specified guidelines. By Mandle-Barth (1962) key to the identification of East and Central African Fresh water snail of medical and veterinary
3.4.2.3. Snail screening for Cerceriae:

Each five snails were put in 5ml of water in glass bottle then they exposed to artificial light at least for 60 minutes (Webbe and Sturrock, 1964). The presence of Cercaria was confirmed under dissecting microscope. Iodine addition was stopped cercaria movement and stained it for identification following Frandsen and Christensen 1984 key.

3.5. Data analysis

The data collected was analyzed using SPSS Program version 19.0. ANOVA test Suitable statistical tests then were conducted to test the study variables.
CHAPTER FOUR
4-RESULTS

4.1. Identification of snails:

Table 4.1 and Fig.4.1 shows there were different snail collected from Arahad canal. Number of (375) snails were collected during the different three surveys.

The overall prevalence of snail species was (71.2%) for Bulins trancatus, (27.2%) for Cleopatra bulimoides and (1.6%) for Lanistus carinatus: However, high density of snail species collection was observed during survey no. 2 with Bulinus trancatus (37.5%) followed by survey no. 3 (36.3%) and (26.2%) at the survey no. 1. While for Cleopatra bulimoides the high density of collection observed during the survey no.2 (58.8%), (29.4%) during survey no. 2 and only (11.8%) during the survey no.1.

For Lanistus carinatus: the survey no.1 witnessed absence of Lanistus. carinatus: while highest density of Lanistus found during the survey no.3 (83.3%) followed by survey no.2 (16.7%).
**Table 4.1. Prevalence of various fresh water snail species collected from Arahad Canal during different three planned, North Kordofan State, 2013**

<table>
<thead>
<tr>
<th>Survey no.</th>
<th>Snail species collected</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Bulinus truncatus</em></td>
<td><em>Cleopatra bulimoides</em></td>
</tr>
<tr>
<td></td>
<td>No. collected</td>
<td>%</td>
</tr>
<tr>
<td>Survey.1</td>
<td>70</td>
<td>26.2</td>
</tr>
<tr>
<td>Survey.2</td>
<td>100</td>
<td>37.5</td>
</tr>
<tr>
<td>Survey .3</td>
<td>97</td>
<td>36.3</td>
</tr>
<tr>
<td>Total</td>
<td>267</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 4.2. Infectivity rate of various fresh water snail species collected from Arahad Canal during different three planned, North Kordofan State, 2013

<table>
<thead>
<tr>
<th>Survey no.</th>
<th>Snail species collected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Bulinus truncatus</em></td>
</tr>
<tr>
<td></td>
<td>No. examined</td>
</tr>
<tr>
<td>Survey.1</td>
<td>70</td>
</tr>
<tr>
<td>Survey.2</td>
<td>100</td>
</tr>
<tr>
<td>Survey.3</td>
<td>97</td>
</tr>
<tr>
<td>Total/average</td>
<td>267</td>
</tr>
</tbody>
</table>
4.2. Snails and their natural infection rates:

Table 4.2 and Fig.4.2 demonstrates the infectivity rate of snail species at laboratory condition. The overall infection of snail species was (171) out of (375) examined. The infectivity rate was found (45.6%).

The highest infectivity rate observed with *Lanistus carinatus*: (83.3%) followed by *Bulinus truncatus* (56.7%) and *Cleopatra bulimoides* (21.7%) respectively. The highest infection rate observed during survey no.2 with *Bulinus truncatus* (84%), (50%) during survey no.1 and (36.1%) during survey 3. *Cleopatra bulimoides* showed highest infection rate (41.7%) during survey no.1 (23.3%) during survey no.2, while no infected snails during survey no.3. *Lanistus carinatus*: snail was found infected only during survey no.3 (100%).
Fig. 4.1. Number of various fresh water snail species collected from Arahad Canal during different three planned, North Kordofan State, 2013
Fig. 4.2. Infectivity rate of various fresh water snail species collected from Arahad Canal during different three planned, North Kordofan State, 2013
Table 4.3. Shedding of cercariae from snails collected from the study sites during different three surveys in Arahad Canal, North Kordofan State, 2013.

<table>
<thead>
<tr>
<th>Survey no.</th>
<th>Mean± Std. Error of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey. 1</td>
<td>3.7±3.2</td>
</tr>
<tr>
<td>Survey. 2</td>
<td>3.3±3.3</td>
</tr>
<tr>
<td>Survey. 3</td>
<td>4.0±3.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3.7±1.6</strong></td>
</tr>
</tbody>
</table>

Table 4.3 shows that the mean of shedding cercariae collected from various fresh water sites in Arahad canal was found to be (3.7±1.6) during the different surveys conducted. Survey no.3 showed highest mean of shedding cercariae4.0±3.0 followed by survey (1 3.7±3.2) and survey 2. (3.3±3.3).
Fig. 4.3. Types of Cercariae present in Arahad Canal during different three planned surveys, North Kordofan State, 2013

4.4.1. Fresh water types of Cercariae:

Fig.4.4 indicate that, Longifurcate-Pharyngeat Monostome cercariae (LPM) was the most Cercariae found during the three conductive surveys in Arahad canal (55.6%) followed by un-described Xiphidiocercariae type -1 (22.2%) and Virgulate Xiphidiocerceria 22.2% showed absence of Cerceriae in Arahad canal.
4. 4.2. Environmental factors affecting snails' population:

![Bar chart showing water velocity in Arahad Canal during three surveys.]

Fig. 4.4. Water velocity observed in Arahad Canal during different three planned surveys North Kordofan State, 2013.

4.4.2.1. Water velocity:

Fig.4.3 illustrates that (88.9%) of water velocity observed in Arahad Canal was low flowing (stagnant) while (11.1%) was medium flowing and (0%) was high flowing.
Fig. 4.5. Fresh water types of vegetation observed in Arahad Canal during different three planned surveys, North Kordofan State, 2013

.4.2.2. Type of vegetation: Fig. 4.5. shows that all fresh water vegetation types were growing at the edge of the canal.
4.4.2.3. Vegetation density:

Fig. 4.6 indicates that all the vegetation density at fresh water canal was thick.
4.4.2.4. Presence of animals:

Fig. 4.7. shows that, about (77.8%) of animals found were goats and (22.2%) was cows and about (0%) of animal were sheep and was Dogs about (0%)
Fig. 4.8. Presence of birds in Arahad Canal during different three planned surveys, North Kordofan State, 2013

4.4.2.5. **Presence of birds:** Fig.4.8. Shows that presence of birds had same percent (33.3%) which includes; doves and ducks, Bulbuls and eagles.
Fig. 4.9. Presence of predators in Arahad Canal during different three planned surveys, North Kordofan State, 2013

4.4.2.6. Presence of fresh water predators:

Fig. 4.9. indicates that, bug fish is the dominant predators present in fresh water canal (55.6%) followed by beetles bug (33.3%) and nymphs (11.1%).
Fig. 4.10. Human contact to fresh water in Arahad Canal during different three planned surveys, North Kordofan State, 2013

4.4.2.7. Human contact to fresh water:

Fig. 4.10 Shows that Similar percent of human contact was observed in fresh water canal (33.3%) among farmers, children swimming and fishermen.
Table 4.4. Turbidity, snail species during the surveys in Arahad Canal during the study period 4.4.2.8. Water turbidity: Table 4.4. Shows that the water was almost clear (low) during the three surveys conducted in fresh water canal. However, the snail's species present during the different period of the surveys.

<table>
<thead>
<tr>
<th>Snail species</th>
<th>Turbidity</th>
<th></th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lanistus carinatus</strong></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Survey 1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Round 2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Round 3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Bulinus truncatus</strong></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Survey 1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Round 2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Round 3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Cleopatra bulimoides</strong></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Survey 1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Round 1</td>
<td>Round 2</td>
<td>Round 3</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>Survey</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9(100%)</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.5. Vegetation species found in Arahad Canal during the study period:

Table 4.4 illustrates that the majority of the vegetation found at the edge of fresh water canal which includes different species such as *Lawsonia inermis*, *Prosopischilensis*, *Ricinus communis*, *Acacia nilotica*, *Chlorocy Peru's rotundus*, *Mangnifera indica*, and *Azadrachta indica*. While the emerged one was *Cynodon dactylon* and the other floating was *Ipomea*.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific name</th>
<th>Growth status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hina</td>
<td><em>Lawsonia inermis</em></td>
<td>At the edge</td>
</tr>
<tr>
<td>Awir</td>
<td><em>Ipomea</em></td>
<td>Floating</td>
</tr>
<tr>
<td>Meskeet</td>
<td><em>Prosopischilensis</em></td>
<td>At the edge</td>
</tr>
<tr>
<td>Nagila</td>
<td><em>Cynodon dactylon</em></td>
<td>Emerged</td>
</tr>
<tr>
<td>Khirwea</td>
<td><em>Ricinus communis</em></td>
<td>At the edge</td>
</tr>
<tr>
<td>Sunot</td>
<td><em>Acacia nilotica</em></td>
<td>At the edge</td>
</tr>
<tr>
<td>Sieed</td>
<td><em>Chlorocy perus rotundus</em></td>
<td>At the edge</td>
</tr>
<tr>
<td>Manga</td>
<td><em>Mangnifera indica</em></td>
<td>At the edge</td>
</tr>
<tr>
<td>Neem</td>
<td><em>Azadrachta indica</em></td>
<td>At the edge</td>
</tr>
</tbody>
</table>
4.5. Statistical analysis:

Univariate Analysis of Variance showed that there was significance difference between the three surveys conducted (F=29.352, DF=1, p=.032).

Chi-square test showed there was association between types of Cerceriae and water turbidity ($\chi^2= 9.6$, DF=4, P=0.048). Other association found between types of Cerceriae, snail species and types of vegetation ($\chi^2= 9.60$, DF=4, P=0.05). Also an association was observed between snail species, types of Cerceriae and water velocity ($\chi^2=11.556$, DF=4, P=.021).

Independent sample t-test showed there was significance difference between snail species and snails infection (F=12.768, DF=4, p=.023). However lanistus was more infected.

ANOVA test showed that, there was no significance difference between number of shed Cerceriae during the different surveys (F=0.011, P=DF=8, 0.989). Also, there was no significance difference between animal types and snails infection (F=0.006, P=DF=8, 0.939), predators and snails infection (F=0.152, P=DF=8, 0.862) and types of birds (F=0.263, P=DF=8, 0.777)
CHAPTER FIVE
5. DISCUSSION

Populations of freshwater snails are subjected to severe ecological stressors imposed by wide temporal fluctuations in their environment. Their success depends on their physiological capacity to tolerate these fluctuations (Russell-Hunter, 1961). Biotic constraints, including parasitism, predation and competition, are added to these ecological stressors.

The present study proved that the canalization system, in Alrahad, was found to be a good habitat for some of freshwater snails. However, the study found that, there were three different snails species collected from Arahad canal. Number of (375) snails were collected during the different three surveys. The overall prevalence of snail species was (71.2%) for Bulinus truncatus, (27.2%) for Cleopatra bulimoides and (1.6%) for Lanistus carinatus. Similar study conducted by Madsen et al. 1988 which aimed to investigate the distribution of aquatic macrophytes and molluscan intermediate hosts of schistosomes in the following irrigation systems in the Sudan: the Gezira-Managil Agricultural Scheme (GMAS), the Rahad Agricultural Scheme (RAS) and the New Halfa Agricultural Scheme (NHAS).

The most snail species were recorded from GMAS, where Biomphalaria pfeifferi (Krauss) and Bulinus truncatus (Audouin) were very abundant and equally frequent. In RAS, B. pfeifferi was less common than B. truncatus; the opposite was found in NHAS. Density of the intermediate hosts and of submerged plants was high, particularly in the terminal section of minor canals. Chemical and physical characteristics of the water showed remarkable variation among sites, which was related to the composition and density of the aquatic vegetation. In GMAS, positive and negative associations between snail and plant species were found. Contingency tests revealed no significant negative correlations between pairs of
snail species. On the contrary, a number of positive correlations were found. In GMAS, *B. pfeifferi* was positively correlated with *B. truncatus*, *Lymnaea natalensis* Krauss, *Cleopatra bulimoides* (Olivier) and *Lanistes carinatus* (Olivier). In RAS, *Melanoides tuberculata* (Muller) was positively correlated with *B. pfeifferi*. The highest infectivity rate observed with *Lanistus* (83.3%) followed by *Bolinus truncatus* (56.7%) and *Cleopatra bulimoides* (21.7%) respectively during the study period. However the mean of shedding was found (3.7±1.6). Moreover, the study indicated that Longifurcate-Pharyngeat Monostome cercariae (LPM) was the most Cercariae found during the three conductive surveys in Arahad canal (55.6%) followed by un-described Xiphidiocercariae type -1 (22.2%). A study conducted by Abdel aziz e.tal.2006 in Khartoum State contradicted to our study; the Snails were collected from Dawar El Mahadi Agricultural Scheme to determine the natural infection rate of *Bulinus truncatus* and *Biomphalaria pfeifferi* snails with trematodes’ cercariae. The study found that Out of (1,257) screened *Bulinus truncatus*, 187 (14.9%) shed four types of cercariae. The highest prevalence of natural infection (9.5%) was by schistosome cercariae followed by *Amphistome* (2.5%), *Xiphidiocercariae* (2.4%) and lastly by avian cercariae (0.5%).

The study not agreed with Nagla and Babikir, 2008, she seems that the environmental factors; such as water flow, water level and density of vegetation; have no effect in the distribution of the fresh water snails in the canalization system. While the study consistent to the conclusions of Madsen et al. (1988) to some extent who stated that the density of *B. pfeifferi*; *B. truncatus*; *Cleopatra bulimondes* and *Lanestis carinatus* were positively correlated with the densities of submerged plants in Gezira irrigated scheme. The effectiveness of exposure by a shedding snail depends upon numbers of factors, such as the amount of time spent in a given area, number of cercariae shed,
water current, vegetation, and the number and distribution of suitable intermediate hosts (Campell, 1973 and Hyman, 1967).

On the other hand the probability of a snail becoming infected increases with age and is dependent upon the time spent in the aquatic environment and the ability to inoculate by miracidia, even though, snail populations grant higher trematode diversity, prevalence and intensity of infection are the major determinant factors of the rate of transmission of digenetic trematodes from the snail-intermediate host to the next host in their life cycle (Margolis et al., 1982; Anderson and May, 199).

Univariate Analysis of Variance showed that there was significance difference between the three surveys conducted (F=29.352, DF=1, p=.032).

An association was found between types of Cerceriae and water turbidity ($\chi^2= 9.6$, DF=4, P=0.048). Other association found between types of Cerceriae, snail species and types of vegetation ($\chi^2= 9.60$, DF=4, P=0.05). Also an association was found between snail species, types of Cerceriae and water velocity ($\chi^2= 11.556$, DF=4, P=.021). Since, independent sample t-test showed there was significance difference between snail species and snails infection (F=12.768, DF=4, p=.023). However lanistus was more infected. Also, there was no significance difference found between number of shed Cerceriae during the different surveys (F=0.011, P=DF=8, 0.989). Thus, there was no significance difference between animal types and snails infection (F=0.006, P=DF=8, 0.939), predators and snails infection (F=0.152, P=DF=8, 0.862) and types of birds (F=0.263, P=DF=8, 0.777).

This study reported that, the water was almost clear (low) during the three surveys conducted in fresh water canal. Madsen et al. 1988, observed that in the main canal, fairly high densities of both B. pfeifferi and B. truncatus may occur upstream of sluice gates, where water is relatively calm close to the banks. Minor
canals (up to 10 meters wide) are used for water storage within the scheme, thus making them suitable as snail habitats and for human activities.

The study reported that most of the vegetation found at the edge of fresh water canal which includes different species such as *Lawsonia inermis*, *Prosopishilensis*, *Ricinus communis*, *Acacia nilotica*, *Chlorocy perus rotundus*, *Mangnifera indica*, and *Azadrachta indica*. While the emerged one was *Cynodon dactylon* and the other floating was *Ipomea*. However, snail-plants association has been reported in many places of the world (*Thomas and Tait, 1984*). Aquatic plants are among the ecological factors affecting snail populations (*Appleton, 1978; Hilali et al., 1985*).

In the Sudan some of these aquatic plants are reported by Osman *et al.* agree to some extent with our study, who reported *Acacia nilotica*, *Tephrosia sp.*, *Sesabania sesaban*, *Ricinus commuis*, *Cassia eldus*, *Ipomoea aquatica*, *Balanites aegyptiaca*, *Ziziphus spina christi*, *Cyperus rodundus*, *Mimosa pigra* and *Jussiaea repens*. For water velocity about (88.9%) of water velocity observed in Arahad Canal was low flowing (stagnant) while (11.1%) was medium flowing. This findings corresponding to Anna, 2009. Thus, the vegetation density at fresh water canal was thick. Also stated that Animal activity (livestock) did show a significant effect on the distribution of *L. natalensis* which found habitats without animals more suitable. Both *B. pfeifferi* and *L. natalensis* were significantly affected by vegetation in the surrounding and found habitats with grass, shrubs and trees more favourable before cultivated areas and forests. Statements in WHO, 1995, under the title fresh water snails confirmed that the aquatic snail hosts of schistosomes were more abundant in water moderately polluted with organic matter, such as faeces and urine, as is often the case near human habitations. Also plants serve as substrates for feeding and oviposition as well as providing protection from high
water velocities and predators such as fish and birds. This finding supported presence of human contact from farmers, children swimming and fishermen.
5.1. CONCLUSION

In conclusion, the study proved that the canalization system, in Alrahad, was found to be a good habitat for the three identified fresh water snails. Number of (375) snails were collected during the different three surveys. The overall prevalence of snail species was (71.2%) for Bulinus trancatus, (27.2%) for Cleopatra bulimoides and. (1.6%) Lanistus carinatus: ?. Also the knowledge of the importance and distribution of the snail host populations is essential and must be taken into account for developing future control strategies. Highly infection of snail's species was observed in Alrahad canal therefore, alert for Contact people in Alrahad area is very crucial.
5.2. RECOMMENDATIONS

The study recommended the following:

- Further studies needs to be established to understand the environmental factors have to provide a base line data to maintain a rational, cost effectiveness and applicable snail control measures, in addition to expansion of study period to cover all seasons of the year.
- Chemical factors of water such as temperature, pH, conductivity and BOD$_5$ should be studied in the further study to give a clear view of the effect of environmental factors on fresh water snails.
- Well-designed and maintenance of irrigation canals and structures to prevent snail-breeding sites should take place.
- Installation of appropriate sanitary facilities and educating the people on health risks should be done simultaneously in the study area.
- Routine canal maintenance to facilitate the improvement of irrigation performance should normally consist of periodic removal of silt deposits and vegetation.
- New research initiatives on controlling intermediate hosts could focus on methods of aquatic plant removal, structural changes of irrigation canals or Reservoirs for snail control, better strategies of water management and control, and whether changed agricultural practices could have an impact on snail populations.
REFERENCES


Mas-Coma S, MA Valero and MD Bargues. (2009). Climate change effects on trematodiases, with emphasis on zoonotic *fascioliasis* and *schistosomiasis*. *Veterinary Parasitology* **163**: 264–280.


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APPENDEXES

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