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# Geographical Distribution And Seasonal Fluctuation Of Snails And Their Intermediate Hosts In The Blue Nile STATE, SUDAN

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## Abstract:

The present study was carried out at the Blue Nile State to assess the distribution of snails in freshwater canals especially the intermediate hosts of *Schistosoma* and their epidemiology. Snails were collected by the standard scooping method, from small water bodies and canals. The snails' habitats were critically studied. Collected aquatic forms were transferred to the prepared laboratory, where snails were cleaned from the vegetation cover and the attached debris, the snails were then counted and sorted to species and separated in labelled plastic bowls

The study recorded the presence of the Prosobrancha (Melanoides.tuberculata, Lanistus.carinatus and Cleopatra. bulimoides) which are of no medical importance and the Pulmonate (Bulinus.truncatus, Bulinus.forskalii and Biomphalaria pfeifferi) of which Bulinus.for skalii is of no medical importance. The dominated snail was Melanoides.tuberculata. The density of all snails dropped during the flood season, except for Melanoides.tuberculata which is able to protect its soft tissues inside the snails by the operculum. A significant relation ($p < 0.05$) was found between the physical (turbidity and temperature), chemical and biological (decaying matter) characteristics of the water bodies and reproduction of snails. The density of the snails was negatively affected by distance of the site from the point of water entrance into the canal, season, abundance and density of vegetation.

The results showed infectivity of Bulinus.truncatus in water sites frequently visited by the people indicating that schistosomiasis is endemic in the area. The results showed that Bulinus.truncatus is highly susceptible to S. haematobium infection.

## المستخلص:

هذه الدراسة نفذت في ولاية النيل الأزرق لتحديد توزيع الحلزونات في قنوات الماء العذب خصوصاً العائل الوسيط للشستوسوما ووبائيته . أجريت المسوحات الحلزونية لفترة 12 شهر خلال الفترة من مايو 2009 الى أبريل 2010 مستخدمين في ذلك المجرفة. أما بيئة الحلزونات فقد دُرست بشكل بالغ الأهمية فكل الأشكال المائية التي جمعت نقلت الى المعمل المحضر لذلك ، حيث تم نظافة الحلزونات مِنْ غطاءِ النباتاتَ والحطامَ الملحقَ، ثمّ حسابَ وتصنّيفَ الحلزونات إلى النوعِ المحدد وفُصِلَها في طاساتَ بلاستيكيةَ موضح عليها أسماء الحلزونات .وجدت ستة أنواع من الحلزونات في قنوات هذه الولاية هي الحلزونات الرئوية ذات الأهمية الطبية للعائل الوسيط للبلهارسيا التي تصيب الإنسان والتي تنقل بلهارسيا المجاري البولية وبلهارسيا الامعاء على التوالي . *Bulinus truncatus* *(بولاينس* *ترنكاتس)*, *Biomphalaria pfeifferi* *(بيومفالاريا فيفراى)* و *Bulinus forskalii* *(بولاينس فورسكالي)* الذي ليس له أهمية طبية . بينما الحلزونات غير الرئوية مثل *Melanoides tuberculata,* *(ميلانويدز تيوبركيوليتا)* كان له

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السيطرة علي الحلزونات الأخرى و*Cleopatra bulimoides* *(كليوباترا بوليمويدز)* و Lanistus.carinatus *(لانستس كارينيتس)* و هذه ليست ذات أهمية طبية .

كثافة كل الحلزونات إنخفضت خلال موسم الفيضان ما عدا *Melanoides tuberculata* *(ميلانويدز تيوبركيوليتا)* الذي يحمي الأنسجة الداخلية بغطاء ولا يتأثر بتعكير الماء. هنالك علاقة هامة ($p < 0.05$) وجدت بين الخصائص الفيزيائية والكيميائية والإحيائية للأجسام المائية وتكاثر أو توالد الحلزونات . كثافة الحلزوناتِ تتأثر سلبياً بمسافةِ الموقعِ مِنْ نقطةِ مدخلِ الماءِ إلى القناةِ والفصلِ من السنة ووفرةِ وكثافةِ النباتاتِ . أثبتت النَتائِجُ قابليةَ اصابة *Bulinus truncatus* *(بولاينس ترنكاتس)* في مواقعِ الماءِ التي تزارَ بشكل متكرّر مِن قِبل الناس مما يُشيرُ بأنّ مرض البلهارسيا مستوطنُ في المنطقةِ. كما أثبتت النَتائِجُ أيضاً بأن *Bulinus truncatus* *(بولاينس ترنكاتس)* إلى حدٍ كبير معرّض للعدوى ببلهارسيا المجاري البولية .

## Introduction:

For development purposes in Sudan, irrigation schemes have been constructed *e.g*. Gezira, Managil and Rahad Agricultural Schemes as well as El Gunaid, El Girba, Asalaya and Kinana Sugar Cane Schemes. These irrigation schemes and others were constructed and established along the Nile, the Blue and White Nile Rivers and their tributaries. The agricultural sector plays a pivotal role in the Sudanese economy, where its efficiency is central to any programmes of economic recovery (SMFEP, 2000). It remained the largest single contributor to gross domestic product (GDP), 31.6% of national output and the source of virtually 50.23% of the country's labour force (AFED, Arab Forum for Environment and Development, 2012 ).

The establishment of the irrigation schemes has created ideal habitats for the breeding of the snail intermediate-hosts of schistosomiasis. This led to a dramatic increase in both prevalence and intensity of schistosomiasis in these schemes (Kardaman *et al.*, 1982; Hilali, 1992; Taha, 1998, 2002 and 2013). Man-made habitats, such as irrigation canals, pools behind small dams and ponds along roads and railway constructions, may become rapidly inhabited by intermediate-host snails, thus, contributing to disease transmission.

**Physical Factors Affecting Schistosomes' Snails:**

**Temperature:** Temperature directly affects the metabolic activity, and indirectly the distribution and growth of the snails. It also affects photosynthetic pathways and bacterial decomposition rates, thus influencing oxygen availability in the aquatic environment. The snails can tolerate a wide temperature range of 0º C to 40º C, but their optimum temperature ranges is 20º C to 28º C. Malek (1962) related low reproduction in *Biomphalaria* and *Bulinus* snails to high summer temperatures. Dazo *et al*., (1966) reported that the seasonal fluctuation in temperature reduced the number of *Biom.alexandrina* and *Bul. truncatus* or stopped their breeding. In Tanzania, Sturrock (1966) found that temperature of 32º C stopped colonization of the coast by *Biom.pfeifferi*. According to (Demian and Kamil, 1972) under semi-field conditions high temperatures significantly reduce egg production in *Bul. truncatus*. Hilali (1992) related seasonal variation in the density of *Biom.pfeifferi* and *Bul. truncatus* to temperature and not to irrigation cycle, water level, current speed, turbidity and composition and density of aquatic vegetation. In Ghana, (Klumpp *et al*., 1985) observed *Bul. truncatus rohlifsi* burrowing in mud, when the water temperature

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exceeded 38º C. According to (Demian and Kamil, 1972) the daily mortality rate of *Biomphalaria* snails was highest during June to September and lowest during December to April; and the snails breed throughout the year with a peak between November and March.

The snail population is directly affected by physio-chemical factors such as temperature, turbidity, habitat, rainfall, light, water-current velocity, desiccation and fluctuations, geology of the water course and oxygen tension, or indirectly by biological factors such as abundance, feeding pattern, migratory and swimming behaviour. Both factors interact in a complex manner to establish the dynamics of the snail population. Permanent waterbodies, temporary small pools and water projects, create favourable environment for snail breeding. Hence increase their population density and hence increases the disease distribution (WHO, 1979).

**Material and Methods:**

**Study Area:**

The Blue Nile State is one of the 18 States of the Sudan, where Ad-Damazin is the capital of the State. The State is located in the South-Eastern part of the country and bordered by Sinnar State in the North-Eastern, Ethiopia in the south-eastern and the Upper Nile State in the west. There are six Localities in the State: Ad-Damazin, Baw, Geissan, Kurmuk, Roseires, and Tadamon. El Roseires Dam is one of the main sources of hydroelectric power-generation capacity in the country, established in 1966 with a nominal volume of 36.3 km. Much of the water impounded at El Rosaries is used to expand and intensify agriculture on the Gezira Scheme, for a full-supply level of 480 m with intention that it could be raised later to a full supply level of 490 m. The existing embankment Dam was also designed to allow for the heightening to be realized without interruption in using the reservoir, which was recently realized. The estimated area of the State is 45,844 km² and the approximate population is 850,000 individuals, with three-quarters of them resident in rural areas (Ministry of Irrigation and Water Resources, 1992).

The State had a relatively long rainy season, May - October, where the precipitation averaged 1000 - 1200 mm annually, which might influence the breeding of insects of medical importance (Blue Nile State, Ministry of Health, Development and Planning Management, 2011). Summer temperatures exceed (40˚ C) and are usually coupled with high humidity, winters are cooler (30˚ C) with lower humidity. Night time temperatures vary from 30˚ C in summer to as low as 10˚ C in winter.

**Malacological Surveys:**

For malacological surveys, two waterbodies were selected to monitor the snails' population dynamics and their relative infection rates, for manipulation of transmission pressure of Bilharzia. The waterbodies were selected based on initial observation of intensive water-contracts of different categories by inhabitants as well as been sites for excreta disposal by the villagers. On monthly basis, for 12-monthes, malacological surveys were conducted for the two waterbodies. The essential water-contacts were identified, mapped and monthly monitored *via* a standardized scoop, as described by Amin (1972).

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The deep scoop was made of a metal square frame 30 cm X 30 cm. on which steel gauze was soldered and finally covered on one side by lighter gauze of one-millimetre mesh. The frame was soldered to a long metal bar to act as a handle. The technique for using the scoop was to start at the edge of the water-body, push away, scraping the canal bed and the vegetation to a distance of about one-meter towards the middle of the canal, and then firmly lift the scoop upwards vertically. With practice, this action, with a slight shake through the water on the vertical lift, collected both vegetation and snails without picking up too much bottom mud which would make finding snails impossible.

All collected vegetation and snails from a searched contact-site were transferred to a labelled plastic bowl. Ten scoops were taken from each searched contact-site of the two surveyed waterbodies. The collected snails were transported to prepared laboratory in University of Blue Nile. During each monthly survey, the physical characteristics of each transmission site were recorded. These include: measurement of water depth using a scaled ruler, water temperature using a graduated glass thermometer, the level of water turbidity, speed, the type of aquatic vegetation and the density of vegetation was estimated as a degree of coverage as described by Hilali *et al* (1985).

Collected aquatic forms were transferred to the prepared laboratory, where snails cleaned from the vegetation cover and the attached debris, the snails were then counted and sorted to species was separated in labelled plastic bowls

**Data Handling and Statistical Analysis:**

Data analysis was carried out using a micro-computer and the SPSS (Statistical Packages of Social Sciences). One-way-ANOVA was used to calculate the means of snail density. Tabular and pictorial forms were produced.

**Results:**

**The Molluscan Fauna:**

Six species of snails were collected from El Sheikh Farah stream and Ganees east pool during the period from May 2009 to April 2010. Snails of medical importance are Bulinus.truncatus and Biomphalaria.pfeifferi (intermediate-hosts of human schistosomiasis), while Bulinus.forskalii, Melanoides.tuberculata, Lanistus.carinatus and Cleopatra.bulimoides snails are not of medical importance.

**Distribution of Snails:**

**Seasonal and Relative Abundance of Snails:**

About 59% of the snails collected during the study were from El Sheikh Farah water-bodies (Table 1). The snail species found throughout the year were Bul. truncatus and M. tuberculata while Bul. forskalii were not collected during January; Biom.pfeifferi disappeared from January to April and L. carinatus and C. bulimoides were not detected in the aforementioned waterbodies. The density of each species was relatively low with no clear consistent pattern; where the relative abundances of Bul. truncatus and M. tuberculata significantly exceeded that of other snails ($P < 0.001$), Table (1). Like above, the survey

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ensured significant seasonal variations in the collected snails from El Sheikh Farah waterbodies, ($P < 0.05$).

**Table (1): Seasonal fluctuation of snails collected from El Sheikh Farah waterbodies in the Blue Nile State (May 2009 - April 2010).**

| Months | Bul.truncatus | Biom.pfeifferi | Bul.forskalii | Melanoides | Lanistes | Cleopatra | Total |
|---|---|---|---|---|---|---|---|
| May 2009 | 41 (7.7) | 31 (23.8) | 10 (11.1) | 30 (6.6) | 0 | 0 | 112 |
| June | 50 (9.4) | 39 (30) | 23 (25.6) | 125 (27.6) | 0 | 0 | 237 |
| July | 41 (7.7) | 7 (5.4) | 3 (3.3) | 116 (25.6) | 0 | 0 | 166 |
| August | 28 (5.3) | 4 (3.1) | 4 (4.4) | 28 (6.2) | 0 | 0 | 64 |
| September | 3 (0.6) | 3 (2.3) | 3 (3.3) | 18 (4.0) | 0 | 0 | 27 |
| October | 20 (3.8) | 3 (2.3) | 2 (2.2) | 10 (2.2) | 0 | 0 | 35 |
| November | 100 (18.8) | 3 (2.3) | 20 (22.2) | 110 (24.3) | 0 | 0 | 133 |
| December | 77 (14.5) | 10 (7.7) | 25 (27.8) | 30 (6.6) | 0 | 0 | 142 |
| Jan 2010 | 32 (6.0) | 0 | 0 | 20 (4.4) | 0 | 0 | 52 |
| February | 36 (6.8) | 5 (3.8) | 0 | 28 (6.2) | 0 | 0 | 69 |
| March | 28 (5.3) | 15 (11.5) | 0 | 18 (4.0) | 0 | 0 | 61 |
| April | 75 (14.1) | 10 (7.7) | 0 | 20 (4.4) | 0 | 0 | 105 |
| Total | 531 (44.1) | 130 (10.8) | 90 (7.5) | 453 (37.7) | 0 | 0 | 1203 |
| Relative abundance of snails Statistically significant (P-vale < 0.001)<br>Monthly fluctuation of snails Statistically significant (P-vale < 0.05) | | | | | | | |

( ) = monthly percentage of relative abundance.

In Ganees Sharig pool Bul. truncatus, M. tuberculata and L. carinatus were found throughout the year. Biom.pfeifferi was not monitored from July to November, Bul. forskalii and C. bulimoides almost disappeared from December to April, (Table 2). Again the numbers of Bul. truncatus significantly exceeded that of Biom.pfeifferi. Generally Bul. truncatus snails were found during the rainy season, the season of high turbidity, ($P < 0.05$). Like El Sheikh Farah waterbodies, the survey ensured significant seasonal variations in the collected snails as well as their relative abundance, ($P < 0.05$).

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**Table (2): Seasonal fluctuation of snails collected from Ganees Sharig pool in the Blue Nile State (May 2009 - April 2010)**

| Months | Bul.truncatus | Biom.pfeifferi | Bul.forskalii | Melanoides | Lanistes | Cleopatra | Total |
|---|---|---|---|---|---|---|---|
| May 2009 | 11 (5.8) | 7 (15.6) | 4 (7.7) | 30 (8.5) | 6 (4.9) | 8 (10.8) | 66 |
| June | 20 (10.6) | 8 (17.8) | 7 (13.5) | 45 (12.7) | 14 (11.5) | 9 (12.2) | 103 |
| July | 9 (4.8) | 0 | 5 (9.6) | 25 (7.0) | 17 (13.9) | 10 (13.5) | 66 |
| August | 16 (8.5) | 0 | 3 (5.8) | 35 (9.9) | 7 (5.7) | 25 (33.8) | 86 |
| September | 25 (13.2) | 0 | 13 (25) | 120(33.8) | 10 (8.2) | 11 (14.9) | 179 |
| October | 24 (12.7) | 0 | 20(38.5) | 18 (5.1) | 15 (12.3) | 7 (9.5) | 84 |
| November | 10 (0.5) | 0 | 0 | 20 (5.6) | 5 (4.1) | 0 | 35 |
| December | 19 (10.1) | 6 (13.3) | 0 | 10 (2.8) | 13 (10.7) | 0 | 48 |
| Jan 2010 | 10 (0.5) | 9 (20) | 0 | 17 (4.8) | 8 (6.6) | 0 | 44 |
| February | 18 (9.5) | 6 (13.3) | 0 | 10 (2.8) | 9 (7.4) | 2 (2.7) | 45 |
| March | 17 (9.0) | 4 (8.9) | 0 | 12 (3.4) | 8 (6.6) | 0 | 42 |
| April | 10 (0.5) | 5 (11.1) | 0 | 13 (3.7) | 10 (8.2) | 2() | 40 |
| Total | 189 (22.6) | 45 (5.4) | 52 (6.2) | 355 (42.4) | 122 (14.6) | 74 (8.8) | 838 |
| Relative abundance of snails Statistically significant (P-vale < 0.05)<br>Monthly fluctuation of snails Statistically significant (P-vale < 0.05) | | | | | | | |

( ) = monthly percentage of relative abundance.

**Distribution by Season**

The distribution of the snails in El Sheikh Farah waterbodies and Ganees Sharig pool by season is given in Table (3). All species were encountered at the three seasons except for C. bulimoides which disappeared during winter. The highest record was scored by M. tuberculata during autumn and Bul. truncates during winter and summer. Bul. truncatus significantly exceeded that of Biom.pfeifferi and significant variations were reported for the abundances of collected snails, ($P < 0.05$).

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**Table (3): Distribution of snails by season in Ganees Sharig pool and El Sheikh Farah waterbodies in Blue Nile State (May 2009 - April 2010)**

| Season | Bul. truncatus | Biom. pfeifferi | Bul.forskalii | Melanoides | Lanistes | Cleopatra | Total |
|---|---|---|---|---|---|---|---|
| Autumn (20-30ºC) | 236 (32.8) | 64 (36.6) | 83 (58.5) | 540 (66.8) | 63 (51.6) | 62 (83.8) | 1048 |
| Winter (19-29ºC) | 248 (34.4) | 83 (47.4) | 45 (31.7) | 107 (13.2) | 26 (21.3) | 0 (0.0) | 454 |
| Summer (30-40ºC) | 236 (32.8) | 28 (16.0) | 14 (9.9) | 161 (19.9) | 33 (27.0) | 12 (16.2) | 539 |
| Total | 720 (35.3) | 175 (8.8) | 142 (7.0) | 808 (39.6) | 122 (6.0) | 74 (3.6) | 2041 |
| Relative abundance of snails Statistically significant (P-vale < 0.05)<br>Seasonal fluctuation of snails Statistically significant (P-vale < 0.05) | | | | | | | |

**Discussion and Recommendation:**

In countries which implement the canalization system in irrigation schemes particularly tropical and subtropical, schistosomiasis may become a public health problem. This is mainly due to creation of suitable habitats for the spread and multiplication of intermediate-host snail of schistosomiasis. The increase in agricultural activity and the conversion of arid and semi-arid areas into irrigated schemes increased water-associated diseases mainly malaria and schistosomiasis (El Gaddal, 1985). This ranked schistosomiasis as the second most important public health problem of the tropical and sub-tropical regions and among the 10 tropical diseases of most concern to the World Health Organization (WHO, 2003).

In Sudan, many agricultural schemes had been constructed, with their canalization system providing suitable microhabitats for the snails' breeding, and hence dramatic propagation of schistosomiasis (Ahmed et al, 2012).

Schistosoma intermediate-host snail populations fluctuate seasonally in many parts of the tropics due to abiotic factors such as rainfall (Marti, 1986), temperature (El-Emam and Madsen, 1982; Taha, 1998; 2002 and 2013). However, freshwater snails, in the field, are subjected to different physical, chemical and biological factors and they can tolerate a wide range within each factor. When an optimum of all these factors exists in nature, the snails breed and establish colonies in the habitat. The most pronounced effects on the establishment of snail populations are temperature and rainfall which are closely related to

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each other. The impact of temperature on snail populations were reported from studies carried out in Ghana (Klumpp *et al*., 1985); Egypt (Dazo *et al*., 1966); Sudan (Malek, 1962); Tanzania (Sturrock, 1966) and South Africa (Appleton, 1977). While that of rainfall was reported from in the Tanzanian coast by (Webbe and Msangi, 1958), in Rhodesia by Shiff (1964) and in Sudan by (Babiker, 1987; Hilali, 1992 and Taha, 1998; 2002 and 2013).

The malacological surveys of this investigation suggested significant variation in the distribution of all snails by season except for *C. bulimoides*. The highest total number of snails was monitored during winter, November - January, while this was monitored during summer, March - June in Gezira, (Karoum, 1988; Hilali, 1992; Ahmed, 1999 and Taha, 2002); Al Rahad (Elias, 1992) and White Nile irrigation schemes (Ahmed, 1994). The association between snail density and aquatic vegetation in the Blue Nile State was confirmed earlier by (Ferguson 1977) this is agreement with the results obtained from (Thomas and Tait, 1984; Thomas *et al*. 1983; Hilali *et al*. 1985 and Taha, 1998; 2002 and 2013). *Bul. truncatus* snails were more abundant than *Biom.pfeifferi* snails throughout the study period in the waterbodies. This is agreement with the results obtained from the Gunaid Scheme by (Gasm El-Seed, 1998).

The monthly malacological surveys ensured that 10.4% of the collected *Bul. truncatus* were infected with *S. haematobium* and all collected *Biom.pfeifferi* snails were found free from *S. mansoni* infection. The micro-ecological sites of *Bul. truncatus* and *Biom.pfeifferi* snails are characterized by dense vegetation cover, which provide high content of organic food for snails' survival. Furthermore, the banks of the pool and stream at these sites are eroded and the water is almost stagnant. In addition, during the surveys of these sites, a lot of faecal mater was noted on the banks and there is the possibility that it reaches water. All aforementioned conditions, might effectively contribute in providing protection and food source for the snails, hence abundantly collected from these sites. Similar findings were reported by (Babiker *et al*. 985 a and b; Hilali *et al*., 1995; and Taha, 2002). Jordan and Webbe (1982) stated that faecal matter attract the snails because of the organic matter it contains.

One of the techniques methods adopted to control the schistosomes' intermediate-hosts is the destruction of the snail habitats through engineering methods. These are not economically feasible in many of the endemic countries due to the depressed economics of many of the afflicted nations. Snail control strategies have relied almost exclusively on chemical control, molluscicides, which are applied through various techniques to the watercourses (Ahmed, *et al*., 2002).

**Conclusion:**

**The present integrated investigation in the Blue Nile State concluded that:**

1- The pools and streams, in the Blue Nile State, provided favorable habitat for breeding of freshwater snails, especially optimum temperature as well as the abundance of aquatic vegetation cover.

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2- *Bulinus.truncatus* and *Biom.pfeifferi* snails are abundant in large numbers at the terminal sites of the pool and stream.

3- The dense vegetation provided food and substrata for snails to lay eggs as well as protection.

**Recommendations:**

1. Snail control or elimination by molluscicides.
2. Biocontrol agents or by accessible environmental approach.

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