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The role of human activities in the transmission of stomach flukes *Paramphistomum microbothrium* (Fishoeder, 1901) (*Trematoda : Paramphistomatidae)* in Tessaout amont irrigation scheme, Central Morocco

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دور العامل البشري في وبائية ديدان ب. مكروبتريوم في المنطقة السقوية لتساوت العليا

ثم إنجاز بحث أولي حول توزيع رخويات المياه العذبة بقنوات الري بتساوت العليا، فتبين أن هناك تسعة أنواع من القواقع. من بين مضاعفات بناء المحيط السقوي وقنواته ظهور أوبئة. يستلزم انتقالها وجود رخويات المياه العذبة، من بين الأوبئة التي تصيب الإنسان مرض البلهارياس البولية التناسلية الناتج عن Schistosoma haematobium و منها ما يصيب الماشية كما هو الشأن بالنسبة لديدان الكبد الناتج عن Fasciola hepatica كما بين البحث الحالي وجود يرقات ديدان المعدة عند حلزون بيلينوس ترانكتوس في نفس المنطقة، و أن انتقاله يتم نتيجة غسل أحشاء الذبائح في قنوات الري من طرف السكان المجاورون لها. و تمت مناقشة دور العامل البشري في انتقال هذا الوباء و أهميته في الحد من انتشاره.

الكلمات المفتاحية: بيلينوس ترانكتوس - برامفيستموم ميكروبتريوم - البيئة - الصحة الحيوانية - السقي بالمغرب

Rôle des activités humaines dans la transmission de la douve digestive *Paramphistomum microbothrium* (Fishoeder, 1901) (*Trematoda : Paramphistomatidae)* au niveau du système d'irrigation dans la région de Tessaout Amont, Maroc Central

Une prospection menée au niveau des différentes structures du réseau d'irrigation dans la région de Tessaout Amont a montré l'existence de neuf espèces de mollusques d'eau douce appartenant à cinq familles. Les canaux d'irrigation traditionnels sont des sites de transmission de la schistosomose à *Schistosoma haematobium* à l'homme et de la distomatose à *Fasciola hepatica* chez les ovins et les caprins du Haouz. Plus récemment, la transmission de la paramphistomose a été également rapportée pour la première fois dans le Haouz au Maroc. La présente étude montre que l'infestation de *Bulinus truncatus* hôte intermédiaire de *Paramphistomum microbotrium* s'effectue dans des siphons inaccessibles au bétail qui en constitue l'hôte définitif. Il s'est avéré que les œufs du parasite sont mis en contact du mollusque suite au rinçage des viscères de ruminants abattus par les bouchers et par les riverains dans l'eau des canaux et des siphons. Les implications de ce résultat sur les possibilités de lutte contre cette maladie sont discutées.

Mots clés: *Bulinus truncatus - Pharamphistomum microbothurium* - Environnement- Santé animale- Irrigation au Maroc

The role of human activities in the transmission of stomach flukes *Paramphistomum microbothrium* (Fishoeder, 1901) (*Trematoda : Paramphistomatidae)* in Tessaout Amont irrigation scheme, Central Morocco

In a cross section snail survey conducted in Tessaout Amont irrigation system in central Morocco, nine mollusk species belonging to seven families were found. Irrigation earth canals are transmission sites of schistosomiasis to man and fasciolosis to goats and cattle. The present study pointed out the occurrence of Paramphistomiasis in the Haouz and in Morocco. The survey conducted in the area shows that human behavior plays a key role in the contact between the intermediate host and the parasite eggs. Viscera of small ruminants slaughtered nearby the canals are rinsed in the canals and the siphons colonized by *Bulinus truncatus*. The operculated eggs are therefore put into the snail's environment. Implication of this result on control of the stomach flukes in the Houz region is discussed.

Key words: *Bulinus truncatus - Pharamphistomum microbothurium* - Environment- Animal health- Irrigation in Morocco

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INTRODUCTION

Tessaout Amont irrigation system is located in the eastern part of the Haouz plain at 70 Km from Marrakech. The irrigation system was implemented in early 1970 after the construction of Moulay Youssef dam.

A few years later, the first cases of schistosomiasis were reported in 1976 (Moustaid & Touzara, 1983). The epidemiolgy and control of the schistosomiasis in the area were further investigated (Laamrani *et al.,* 2000).

A study conducted in the area by Khallaayoune & El Hari (1991) has pointed out the occurrence of naturally infected *Lymnaea truncatula* by *Fasciola hepatica*. In 1997, Laamrani *et al.* (1997) first mentioned the occurrence of *Paramphistomum microbothrium* infecting *Bulinus truncatus*.

The transmission of fasciolasis occurs in traditional canals (earth canals) accessible to cattle as reported by El Hari (1991).

Schistosomiasis transmission occurs in siphons of modern irrigation system called "Puisards" that are suitable "swimming sites for school aged children.

However, the presence of snail infected with *Paramphistomum microbotrium* indicates a particular way of transmission as the cattle cannot access the elevated canals and siphons. The present study aimed at identifying how is the transmission taking place and to estimate the prevalence of natural infection in the snail intermediate host.

Therefore, a first investigation was done to establish the distribution of the snail intermediate host in relation to the habitats factors. A further survey was carried out to determine the seasonal changes in the natural infection of *B. truncatus* with *P. microbothrium*.

Indeed the occurrence of *P. microbothrium* has been mentioned in North Africa. *B. truncatus* is the intermediate host in Egypt (Say, 1976) and in Algeria (Kechmir, 1988).

However, so far, there is no documented evidence of its occurrence in Morocco.

The objective of the present study is to shed some light on a particular setting where the human behavior could contributes to the transmission of *P. microbothrium*.

MATERIALS AND METHODS

1. Area of study

The Tessaout Amont irrigation system lies in eastern part of the Haouz plain, between the eroded hills of Jebilet and the High Atlas Mountains. The plain has a semi-arid to arid climate, characterized by low and irregular rainfall from year to year as well as during the year. Annual precipitation in Attaouia, at the center of Tessaout Amont irrigation system, varies from 170 to 400 mm, with the main rainy season from October to May. In summer, there is drought with the hot Saharan Sirocco wind. Mean annual temperature is 20°C. Annual mean relative humidity is 54% and evaporation is 2300 mm/year (ANAFID, 1990).

2. Irrigation system

The irrigation system serves an area of 53.000 hectares, of which 33.000 are equipped with modern concrete irrigation canals. Another 20.000 ha are provided with water from the modern system through traditional canals, following traditional water rights. The system consists of a large dam with a storage lake and a diversion structure. Downstream after a sand trap, a large distribution structure conveys water to an extensive network of canals. The principal, primary, secondary and tertiary canals are cement lined. The elevated canals necessitate special provisions, siphons, to give access to fields and villages. Generally siphons are constructed to lead water under the road or track. A typical siphon consists to two rectangular boxes, usually 0.8 m by 0.8 (or 1.1) m and 2 m deep, connected by an underground pipe. Being below the canal level, these boxes contain water almost permanently. In the absence of wells or natural watercourses, the numerous siphon boxes represent an important source of water for the local population (Watts *et al.*, 1998).

3. Study sites

A total of 223 sites over the irrigation system were sampled. The snail habitats consisting of canals and siphon boxes as well as drains and traditional canals as shown in the table 1.

Table 1. Number of sites sampled per type of snail habitat

Snail habitat	Primary canals	Secondary canals	Secondary siphons	Tertiary siphons	Quaternarys siphons	Drains	Earth canals	Tessaout River
No. of samples	13	24	23	113	11	12	22	5

Thereafter, a set of 18 sites consisting of siphon boxes was selected in order to follow up the seasonal changes of snail population and natural infection rate.

4. Sampling method

Densities of snails were recorded monthly from July 1995 to June 1997 using a drag-scoop. The scoop was made of a frame 10 cm x 20 cm supporting a wire mesh (0.8 mm) and was mounted on a 2 m long handle. It was used to scrape the walls of the siphon box from the bottom to the surface once on each of the four sides. Thus, scarping an area of 4 x 20 cm x depth in cm. Snail were sorted to species and their number recorded and then returned to the sites within 24 hours.

5. Snail infection

Snails collected were screened for infection by exposing them individually to artificial light for 4 hours, mostly between 12.00 and 16.00 p.m. Only patent infections are considered in the present study. The infected snails were brought to laboratory.

6. Experimental infection of the final host

Parasite identification was first done by Dr. Albaret of the Laboratory of Helminthology at Museum of Natural History in Paris. Metacercariae (Nb=1700) shed by *B. truncatus* naturally infected were used to infect two sheeps by oral ingestion. Adult worm was collected seven months and checked.

RESULTS

1. Snail distribution over the irrigation system (Table 2)

As shown in table 2, the irrigation system has a diverse snail fauna with nine species belonging to seven families. Planordid snails were the most frequent as they were found in 116 out of the 223 sampled sites. This result reiterates the wide distribution of *Bulinus truncatus* over the irrigation system. The ecological factors that underlie the occurence of snails in Tassaout Amont irrigtion system are discussed by Laamrani (1994).

Table 2. Frequency of occurrence of mollusk species collected in Tessaout Amont irrigation system

GASTEROPODA	No. of Habitats colonized out of 223 sampled sites
Pulmonata	
Planorbidae	
Bulinus truncatus	103
Planorbarius metidjensis	13
Lymnaeidae	
Lymnaea peregra	93
Lymnaea truncatula	11
Physidae	
Physa acuta	87
Ancylidae	
Ancylus fluviatilis	32
Prosobranchia	
Melanopsidae	
Melanopsis praemorsa	56
Hydrobiidae	
Mercuria confusa	22
LAMELLIBRANCHIA	
Sphaeriidae	
Pisidium casertanum	20

2. Density of the snail intermediate host

Table 3 shows the highest densities of *B. truncatus* were normally found in tertiary and quaternary siphon boxes with respectively 36 and 11 snails/m^2. This is in line secondary with results previously reported from the area (Khallaayoune *et al.*, 1998). One way analysis of variance after Logarithmic transformation (Log $_{\text{snail count}}$ +1) showed a significant difference in density of *Bulinus truncatus* between habitats (p<0.01). The high density recorded in the drains is erratic as the sampled sites in drains where drying up and the snails were concentrated in small "breeding pockets". The high standard deviation clearly demonstrates that the high density in drains is due to particularly high densities in a few sampling sites.

Table 3. Density of *Bulinus truncatus* (individuals/m^2) in different habitat in the Tessaout Amont irrigation system

Snail habitat	Primary canals	Secondary canals	Secondary siphons	Tertiary siphons	Quaternarys siphons	Drains	Earth canals	Tessaout River
No. of Samples	13	24	23	113	11	12	22	5
Density of *Bulinus truncatus*	0	3	19	36	11	61	14	0
Standard deviation	-	5.7	75.2	96.8	32.9	137.2	33.4	-

3. Seasonal changes in snail density

Figure 1 shows that the population of *B. truncatus* was present throughout the year, but snail abundance varied markedly over the period of the study. Highest density was recorded during the dry season. Thus, density of *B. truncatus* was high in July 1995, thereafter the density gradually decreased to August 1995 and remained low until April 1996. Then, density started to increase towards the late April 1996. Peaks of density were therefore recorded from May to September 1996 and at April 1997. This peak was then followed by a decline in density. This pattern was parallel to the temperature profile that increased gradually from March to August and decreased thereafter. The lowest densities were recorded during the cold season (November to February) because water temperature in the study area goes below 10°C.

4. Seasonal changes in natural infection

As shown in figure 1, over the period of observation, infected *B. truncatus* were collected near Lakhaoucha, Smoun and Sidi Meslem villages.

Infection rate was maximal in July 1995 when 0.73% snails were infected by *P. microbothrium*. The lowest rate was 0.12% recorded in October 1996 at Sidi Meslem. The occurrence of infected snails is sporadic and the pattern of infection is erratic. Infected snails were found in siphon boxes close to human habitation. Eggs of *P. micrbothrium* are thrown in the siphon boxes when the viscera washed in the stagnant water. Therefore, eggs are put into the snail environment through a human activity and not by the final host as it occurs naturally.

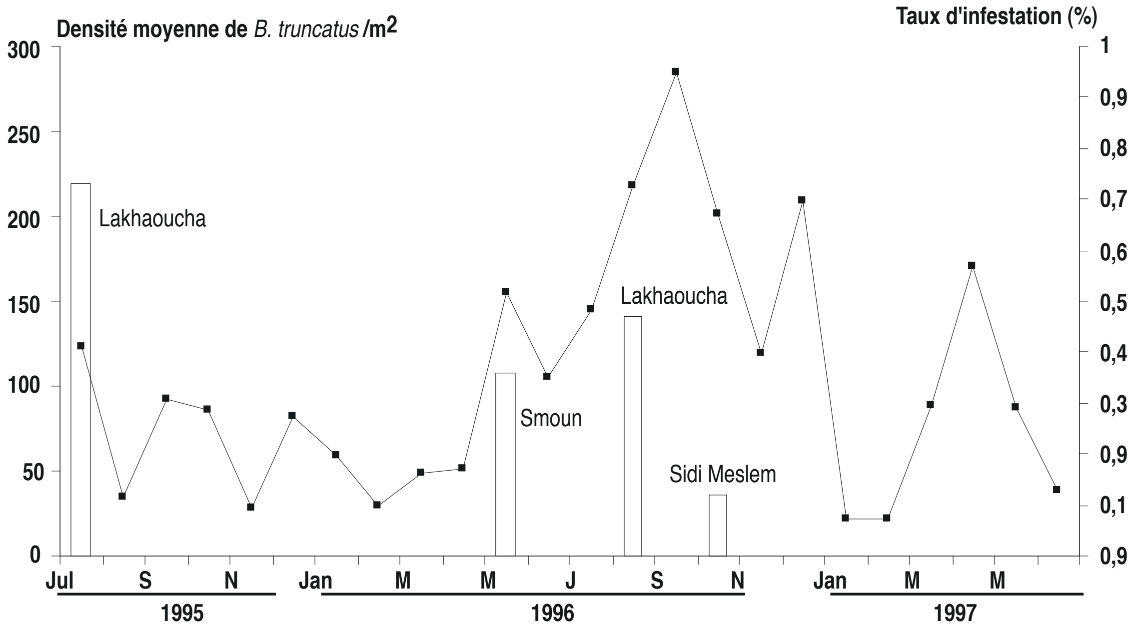

Fig 1. Seasonal changes in *Bulinus truncatus* density and natural infection by *Paramphistomum microbothrium*

DISCUSSION

The study shows another aspect of irrigation and water resource development on human and animal health as this was evidenced in several areas in developing countries (Hunter *et al.,* 1980).

The results presented pointed out that Tessaout Amont irrigation system has a rich and dense malacofauna. Three mollusks of medical and veterinary importance were collected namely *Bulinus truncatus, Planorbarius metidjensis* and *Lymnaea truncatula*. *B. truncatus* is the intermediate host of *Schisotosoma haematobium* and *Paramphistomum microbothrium*.

However, no double infection was noticed. *Planorbarius metidjensis* from Tessaout Amont is susceptible to the sympatric strain of *Schisosoma haematobium* under laboratory conditions (Khallaayoune & Laamrani, 1995). However, no natural infection of this snail in the area is found so far.

The monthly monitoring of natural infection showed that snail infection of *Bulinus truncatus* with *Paramphistomum microbothrium* is low and erratic. Considering the presence of *B. truncatus* over the year, the low infection rate is probably due to the occasional occurrence of eggs of *Paramphistomum microbothrium* in the siphon boxes.

Though the number of infected snails was low, their percentage was relatively high in comparison of infection rates reported for other helminthiasis in the area such as schistosomiasis (Laamrani, 1994) and fasciolasis (Khallaayoune & El Hari, 1991).

The natural infection of *B. truncatus* by *P. microbothrium* raised the question of how the transmission cycle could be accomplished in elevated canals and structures.

The present study showed that contact between final hosts (small ruminants) and the intermediate host that colonize the irrigation system is facilitated by slaughtering of cattle done by the riparian.

The sporadic occurrence of natural infection in snails is related to the slaughtering of sheep and goats and their viscera washed or rinsed in the siphon boxes at occasions. Slaughtering takes place nearby the canal occasionally during seasonal activities such as olives harvesting or at celebrations of religious or social events. The final hosts is probably infected by direct ingestion of metacercariae encysted at the surface of floating material or the surface of the irrigated plants mainly Lucerne.

However, more investigation is needed to identify ways of infection of the final hosts.

The present study reiterated the occurrence of paramphistosomiasis in Morocco and the particular way of transmission occurring in a modern irrigation system in Morocco. Indeed, Laamrani *et al.* (1997) first mentioned the presence of the parasite in the area.

In fact the parasite is known to occur in different parts of the African continent. The disease is reported from Egypt by Say & Abdel-Rahman (1975). Kechmir (1988) in Algeria noticed infection rate of *B. truncatus* as low as those reported in the present study. Paramphistosomiasis was also reported in Sub-Saharien Africa by Dinnik & Dinnik (1954) and Sey (1982) and in Europe by Sey (1980).

However, the parasite and snail species are varying between geographical areas as reported by Brown (1994). *Paramphistomum sukari* is transmitted by *Biomphalaria pfeifferi* in Kenya (Dinnink, 1965) and in Ethiopia (Graber & Daynes, 1974). In Mauritius, *Paramphistomum phillerouxi* is transmitted by *Bulinus forskalii* (Dinnink, 1965).

In conclusion, in the study area, the intermediate host of *P. microbothrium* is *B. truncatus*. The infection is low sporadic. The control of *P. microbothrium* should first be oriented to the change of human behavior through information, education of the population.

The disease control and prevention requires the interruption of the cycle at the weakest link thar seems to be in the curent situation the miracidium. Any control program should aim at raising awareness of the villagers that viscera can wash at the same place just by taking out water from the siphon instead of washing them in the siphons.

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