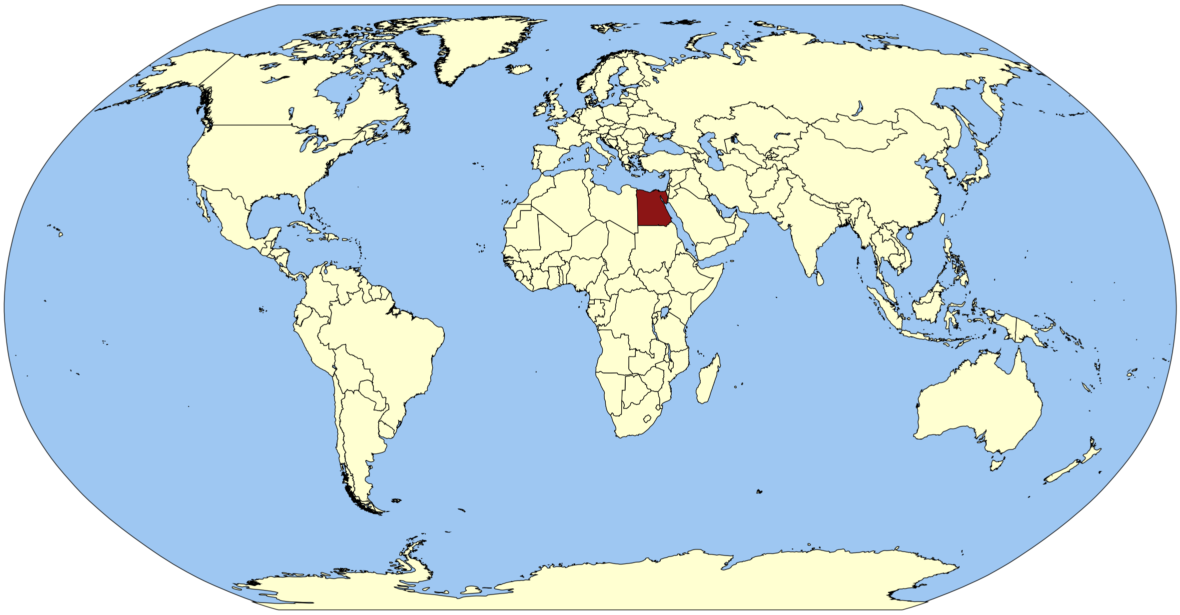
Egypt



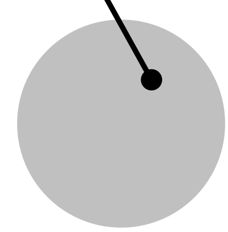
A Long History of Schistosomiasis Control

Schistosomiasis control in Egypt, from small-scale efforts with experimental chemotherapy and molluscicides to large-scale USAID backed projects, has spanned a century. Preliminary control of the disease began in 1915. In 1918, Egypt became the first country to implement the use of antimonial drugs, including pentostam and astiban [5,6]. Chemical snail control efforts using copper sulfate gained more attention following a Lancet editorial in 1919 that praised the potential of molluscicide use, especially in Egypt [5,7]. By 1920, Egypt became an active testing ground for a variety of new drugs and molluscicides [5]. But, significant changes from basin to perennial irrigation due to Aswan Low Dam construction significantly altered snail habitat distribution and set the stage for the high baseline disease prevalence rates as early as the 1930's. Control efforts have made massive strides in reducing country-wide prevalence rates from near 40% in the early half of the 20th century to <0.3% in 2010; yet, endemic foci still exist.

Schistosomiasis in Egypt [16]

3.6 million children require annual treament

<1% of the population requires preventative chemotherapy for schistosomiasis



Control programs in Egypt reach 100% of its infected population.

Overview of Egypt [17]

- Population in 2015: 88,487,396
- Official Language: Arabic
- Capital: Cairo
- Republic
- Percentage of Population with Access to Improved Drinking Water in 2012: 99.3%
- Percentage of Population with Access to Improved Sanitation in 2012: 95.9% [9]

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UPSTREAM ALLIANCE

An Ancient Problem

Schistosomiasis has ancient roots in Egypt. Retroactive ELISA testing has confirmed evidence of *S. haematobium* in an Egyptian adolescent mummy more than 5000 years old [1]. In 1851, Theodor Bilharz, a German physician stationed in Egypt, formally discovered the causative agent of hematuria and linked the parasite to urinary schistosomiasis, identifying it as *Distomum haematobium* [2]. In 1902, Sir Patrick Manson discovered a case of schistosomiasis with notably different lateral-spined eggs [2]. At that time, Manson declared the existence of two separate species of *Schistosoma* in humans, and, in 1907, the second species identified as *S. mansoni* took his name [2]. In 1915 Robert Lieper was sent to Egypt to investigate the life cycle of the schistosomes in order to provide advice on preventive measures [2]. Lieper's research confirmed the existence of two separate snail intermediate hosts, *Bulinus truncatus* and *Biomphalaria alexandrina*, implicated in the life cycles of *S. haematobium* and *S. mansoni*, respectively [3,4].

Schistosomiasis and Irrigation

In 1937, the first schistosomiasis epidemiological surveys were conducted across Egypt. *S. haematobium* was found only in Upper Egypt, which corresponds geographically to the southern part of Egypt. Cases were limited to regions with perennial irrigation agricultural systems in place [8]. In areas employing perennial irrigation, both in the Nile Delta and Nile Valley south of Cairo, an average 60% prevalence rate of S. haematobium infection was estimated. In contrast, those districts that employed basin irrigation had an estimated 6% prevalence [1]. The distribution of *S. haematobium* thus showed a clear correlation to the development of irrigation schemes that allowed for year round standing water, increased human-water contact, and improved snail habitat. Prevalence of *S. mansoni* was estimated at 60% prevalence in the Northern and Eastern parts of the Nile Delta and only 6% prevalence in the Nile Valley region surveyed [1].

Foiled by the Dam

During the early stages of control in the 1930's, efforts emphasized national health education campaigns to reduce contact with contaminated water [5]. These campaigns were likely an attempt to offset the growing number of infections correlated to increased water contact following the construction and expansion of the Aswan Low Dam. The Aswan Low Dam was opened in 1902, but alterations to increase dam height continued until 1933 when the dam reached its peak height [2]. This was followed by an increase of *Schistosoma haematobium* infections between 1934 and 1937 in four investigated areas. Studies showed that baseline levels of prevalence varying from 2-11% rose to 44-75% following dam expansion [9]. By the 1930's, over two-thirds of Egyptian agricultural practices utilized perennial irrigation [2]. Despite the fact that concurrent health education campaigns were implemented to promote schistosomiasis awareness, the disease continued to spread [5].

The Nile River, below the Aswan Low Dam. An increase of schistosomiasis cases followed increased damming along the Nile

Disease Prevalence in the '50s

In 1955, a randomized survey conducted by the Egyptian Ministry of Health was performed in the same villages first surveyed in 1937. Results proved overall *S. haematobium* prevalence was 38%, while 9% were infected with *S. mansoni* in the Delta. *Schistosoma mansoni* was not found to be locally endemic in Upper Egypt at that time [2].

Disease Spreads

In 1967, the countrywide prevalence of *S. haematobium* and *S. mansoni* cases, combined to make 40% [5]. In the same year, the Aswan High Dam in Upper Egypt completed construction. Snail species distribution patterns were greatly affected by the subsequent changes in irrigation patterns of the Nile Delta. By the 1970s the changes proved to allow for the expansion of *Biomphalaria alexandrina* snails but limited distribution of *Bulinus truncatus* populations, leading to an increase of *S. mansoni* transmission and a decrease of *S. haematobium* transmission in Lower Egypt [10]. *Biomphalaria alexandrina* populations began to expand upstream at that time and the snail was found at increasingly further distances from its source, as far as Aswan City [2].

Control Measures Increase

In response to these grave reports, National Schistosomiasis Control Program (NSCP) that began in 1976 and initially focused on control in Middle Egypt, expanded southwards to prevent the spread of *S. mansoni* into Upper Egypt [8,1]. Additional control measures in this intervention included active case detection and treatment with bilarcil/metrifonate, and focal mollusciciding with niclosamide [11].

An Unforeseen Complication

In 1981, *B. glabrata* was accidentally introduced into Egypt, perhaps as a result of careless release from neighboring research institutions in Africa [12]. In the following years, the species rapidly invaded the irrigation and drainage systems of the Nile Delta area and began to hybridize with local *B. alexandrina* populations [13]. The hybrid snails were found to be naturally competent for *S. mansoni* infections, perpetuating transmission [13].

An Unforeseen Solution

Of most significance during the early 1980s is the introduction of the crayfish, *Procambarus clarkii*, to the Nile Delta for aquaculture. The crayfish rapidly spread, became invasive, and colonized many areas. By 1996, it was estimated that 4.6 metric tons/year of *P. clarkii* could be harvested from the Nile, [16]. It is now clear that *P. clarkii* preferentially preys upon *B. truncatus* and *B. alexandrina* snails in the wild, and was therefore likely a source of inadvertent biological control of schistosomiasis transmission [14]. Thus, it is plausible these crayfish played a role in reducing transmission and enabling praziquantel, the drug of choice to treat schistosomiasis from the mid 1980's onwards distributed and funded by USAID, to make a dent in the prevalence rates by reducing transmission and re-infection at the same time.

More Motions for Control

Whether it was the NSCP's control efforts, fortuitous biocontrol with *P. clarkii*, the prior existence of varied experimental control measures since the 1920s, or a combination of all three, large strides have been made in reducing transmission. *S. haematobium* dropped from 48% to 11.9% from 1935 to 1988 while *S. mansoni* fell from 32% to 16.4% in the same period [8]. Over the course of this time period control measures primarily focused on transmission control of the snail intermediate host occasionally supplemented by anitbilharzial treatment [1]. In 1988, the Egyptian Schistosomiasis Research Project (SRP) commenced a 10-year cooperative project funded by USAID implemented through the Ministry of Health and Population [10]. The project aimed to reduce the countrywide prevalence estimated at 20%, combined for both schistosome species, through provision of praziquantel to those infected [11]. By 1989, free praziquantel doses were available to infected individuals through the Ministry of Health network of Rural Health Units [2]. Increased funding from the World Bank in 1997 further propelled control efforts to include focal mollusciciding alongside preventative chemotherapy [10,11].

Successful Outcomes

By the time the World Bank-backed NSCP program closed in 2002, it was estimated that 10 million school children at risk in rural Egypt had received praziquantel, and all residents of more than 500 high-risk villages were offered treatment [10]. It was declared that schistosomiasis was no longer the number one public health problem in Egypt, and by 2003 the prevalence was estimated to have dropped to <3% [6,11]. The role of *P. clarkii* crayfish on reducing snail populations is not quantified, and it is unclear how important a role this overlooked aspect of schistosomiasis bio-control played in significantly reducing disease prevalence.

Current Control Efforts

In 2007, the Ministry of Health and Population drafted a proposal for Schistosomiasis eradication [5]. In 2010, with an estimated countrywide prevalence of <0.3%, another elimination effort was launched integrating sanitation, environmental interventions and health education into preventive chemotherapy campaigns [11]. Despite the low prevalence in 2010 and the launch of this control effort, noted foci of endemicity still exist for *S. haematobium* in Upper Egypt and *S. mansoni* in lower Egypt, possibly due to a lack of improvement in rural sanitary conditions [15]. Continued vigilance is needed to control snail populations and interrupt schistosomiasis transmission entirely from Egypt.

The role of crayfish on controlling snail populations is an overlooked facet of schistosomiasis control in Egypt. Continued vigilance is needed to control snail populations and interrupt schistosomiasis transmission entirely from Egypt.

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