

**Habitat Favorability and Geographical Links  
Between *Mycobacterium ulcerans* and *Eichhornia  
crassipes* in the Amansie West District, Ghana:  
Social, Economic, and Health Implications**

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## **Introduction**

According to members of the World Health Organization (W.H.O.), the Buruli ulcer is the third most common mycobacteriosis of immunocompetent hosts. The disease was first described by Cook in Uganda, Africa in 1897. However, the disease's etiological agent, *Mycobacterium ulcerans*, was not isolated and characterized until 1948 in Australia, by MacCallum. The first suspected case in Ghana was in 1971, at Korle-Bu Teaching Hospital in Accra (Asiedu, 1998). Outbreaks have occurred following flooding, human migrations, man-made modifications (dams, resorts, etc.), deforestation, and increased agriculture, especially in the Amansie West District (Meyers, 1999). An increase in the number of reported cases in 1999 prompted W.H.O. to fund an on-going medical survey. The survey, initiated by signing of the Yamoussoukro Declaration by President Rawlings, reported one hundred and thirty-three new cases in the first quarter of 1999. The results of the survey are in the process of being analyzed. Already, Ghana's Health Directorate advised the residents of marshy areas to pay attention to the water they drink, as the carrier of the bacteria is unknown (Boateng, 1999). Drawing on recent discoveries and geographical data, Buruli ulcer may be linked to the presence of the water hyacinth, an aquatic invasive plant.

Water hyacinth, *Eichhornia crassipes*, is native to South America and portions of Central America. In the beginning of the century, Alexander von Humbolt collected and

catalogued samples from Jamaica. Since this time, the plant has become a major weed in over fifty-three countries, on the continents North America, Africa, Europe, Asia, and Australia. Due to its ability to reproduce rapidly, the plant is able to thrive under a wide spectrum of nutrient and climatic conditions (Meyers, 1999). In South and Central America, floods and intense water current control the spread of water hyacinth. However, in regions where these conditions do not occur, the plant grows unhindered. A population of water hyacinth can double in twelve days by sending off short runner stems, which develop into new plants. One acre of water hyacinth can deposit 500 tons of decaying plant material on the bottom of a water body every year. This can create problems such as nutrient accumulation and obstruction of the waterway. Other problems associated with the plant include limited boat traffic, flood control issues, and aquatic fauna death (Gopal, 1999). The plant, or its material deposited to the waterway's bottom, may serve as a home to the larvae or aquatic insect that is believed to carry the mycobacteria causing Buruli ulcer. This paper aims to find a correlation to the presence of the disease and of the plant, through similarities in their preferred habitats, analyzing a district in Ghana with both phenomena, and by evaluating environmental factors.

Specifically, this paper will:

- Compare the favorability in habitats for the Buruli ulcer and the water hyacinth.
- Consider environmental factors (sanitation, jobs, lifestyles, and economics).
- Examine case studies from patients at the St. Martin's Hospital in the Amansie West District.

- Make recommendations to reduce the occurrence of the Buruli ulcer and to minimize the spread of water hyacinth along the Offin River in Ghana.

## **Study Area**

The Amansie West District, located in Ghana, Africa, lies within the Ashanti Region. The Amansie West District is one of 18 districts within the Ashanti Region. The Ashanti capital, Kumasi, is approximately 60 km northeast of the district. This district has the highest number of reported incidences of Buruli ulcer. Most cases are from the area alongside the Offin River, with the highest prevalence in Tontokrom (22%).

All social infrastructures are poorly developed and the roads are not well-kept. Therefore, access to health care facilities for the 130,000 citizens of the Amansie West District is quite limited. The district has five health care facilities, a mission hospital, and four government health centers (Asiedu, 1998).

The annual per capita income for a subsistence farmer is about US\$200.00. Most residents are farmers who use nearby waterbodies for bathing and drinking water. This increases the possibility of contracting the Buruli ulcer.

Kumasi is by far the largest city within the Ashanti Region and is the second largest city in Ghana. The vegetation in both Kumasi and the Amansie West District is very similar. Kumasi is a major commercial and transportation center for Ghana. Cocoa is the predominant crop (Columbia Encyclopedia, 1994). Timber has also been an important export. Since 1932, timber has been extracted from the Kakum National Park.

Kakum National Park contains 350 square kilometers of Ghana's rainforest. The rainforest is home to endangered forest elephants, yellow-backed duiker and diana

monkeys, the Mona monkey, the Royal antelope, the Giant Forest hog, the Honey badger, the Forest buffalo, the African Civet cat, about 550 species of butterflies, 250 species of birds, and over 100 species of reptiles, mammals, and amphibian species (<http://library.advanced.org>, 1999). In addition to the abundant wildlife, many different trees and plants dwell in the lush rainforest. Many plants can function as medicine or for traditional household purposes. Some of the vegetation found in the District include rubber trees, the Strangling Fig vine, various ferns, and Mahogany, Ebony, and Palm trees.

Ghana has a tropical climate, characterized by moderate temperatures, constant breezes, and sunshine. There are two rainy seasons, from March to July and from September to October. The heaviest rainfall is in the central and southern regions. However, unexpected, high totals for monthly rainfall occasionally appear. This unpredictability makes farming a hazardous occupation in the district. Nonetheless, almost 80% of the population live in rural communities and depend mainly on subsistence or small-scale farming (Consultants for Agricultural and Rural Development Services, 1996). See Figure 1: Ghana's land use patterns.

## **Review of Literature**

Researchers collected information concerning the Buruli ulcer primarily within the last 10 years. In December 1993, a Cuban task force from the Tropical Medicine Institute "Pedro Kouri" (IPK) began research on the disease in the Amansie West District. A total of 105 patients were examined by a clinician and a dermatologist. Blood

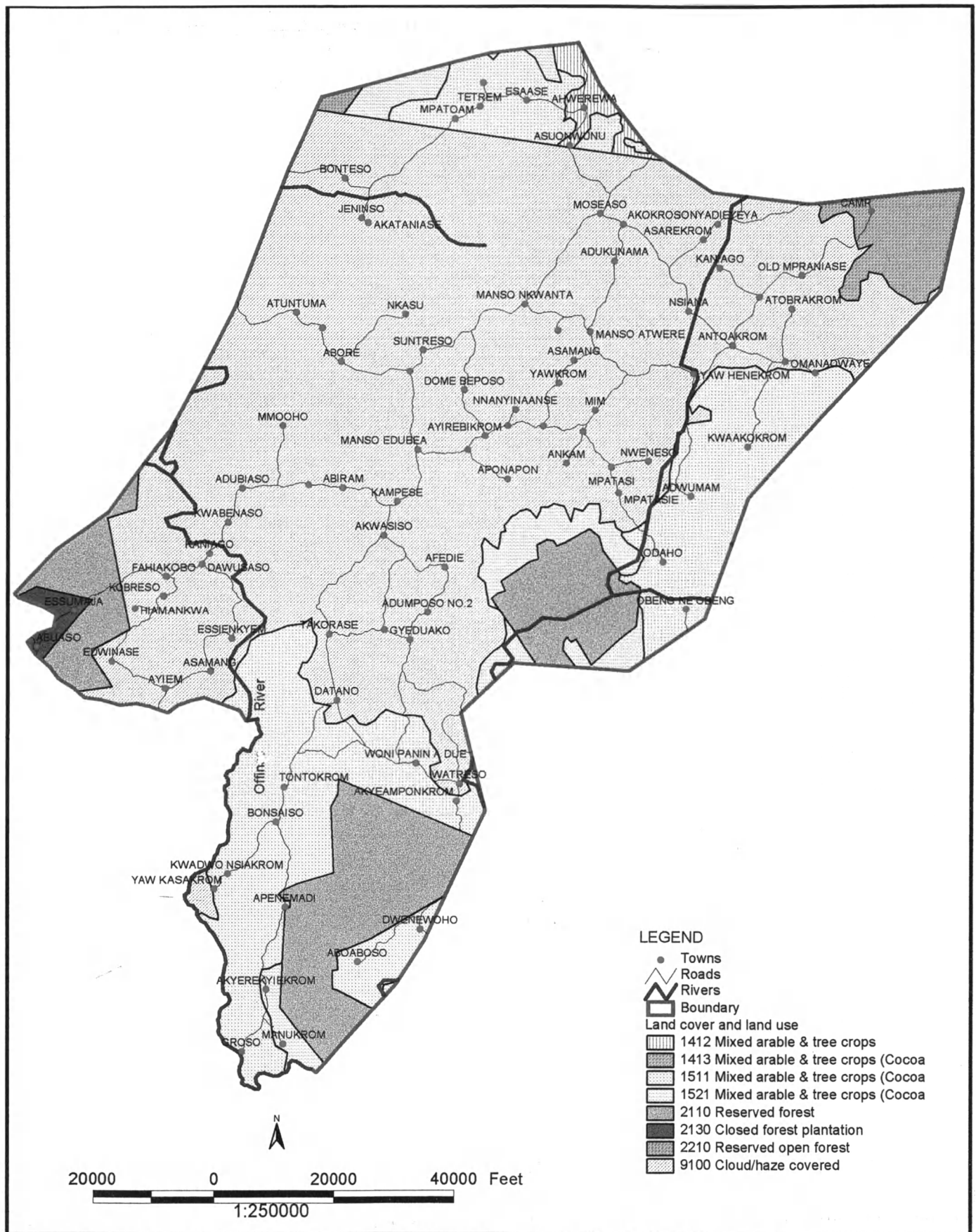


Figure 1: Amansie West District Landuse Patterns

samples were taken from 15 patients with open ulcers. Lab technicians in Cuba were unable to isolate *M. ulcerans*. Instead, all of the cultures grew other organisms (73.33% grew *Enterobacteria* and 26.6% grew *Pseudomonas*). Factors that contribute to the difficulty in culturing *M. ulcerans* include their slow rate of growth and the long clinical evolution of the ulcers (some patients tried to care for the ulcers at home, before seeking treatment). Another possible reason that other bacteria grew is the lapse in time between acquisition of the sample and the time of processing the sample (Memorias do Instituto Oswaldo Cruz, 1999).

Another team of researchers performed a study to estimate the short-term treatment costs of Buruli ulcer in the Amansie West District, in Ghana. The researchers analyzed the socioeconomic cost of treating 102 cases between 1994 and 1996 at St. Martin's Catholic Hospital in Agroyseum. The study is relevant to patients and health and financial planners (Asiedu, 1998).

Yet, not until recently has the disease been given somewhat adequate attention. At a meeting in Yamoussoukro, Cote D'Ivoire, over 100 participants from over 20 countries signed the Yamoussoukro Declaration. Among the signatories were the Presidents and Ministers of Health from Benin, Cote D'Ivoire and Ghana, the Minister of Health from Togo, the Director-General of the W.H.O., and participants from the U.S.A., Australia, Belgium, France, Italy, the Netherlands, Guinea, French Guyana, Papua New Guinea, Switzerland, Uganda, the United Kingdom, and Zimbabwe. Dr. Hiroshi Nakajima, Director-General of the W.H.O., presented an opening address at the convention, emphasizing the urgency of research:



We have all gathered here because of our interest in Buruli ulcer, our concern for the victims of this devastating disease, and our commitment to work as partners in close collaboration with each other. We have an enormous task ahead as we begin the fight against this disease. (World Health Organization press release, 1998)

The declaration pledges intensified action against Buruli ulcer. Two main points are: to provide simple surgical facilities for treatment and to improve and sustain health education programs at all levels. The W.H.O. must assist countries to control the disease by organizing a research agenda and generating the financial resources needed to conduct the Global Buruli Ulcer Initiative (GBUI). The GBUI plans to coordinate and control the research projects (World Health Organization press release, 1998).

Most scientists believe that the disease relates to water bodies. However, the mode of transmission has not been confirmed. Some believe an aquatic insect carries the water-borne bacteria.

The possible link between the bacteria and the water hyacinth was highlighted by Wayne M. Meyers at a W.H.O. conference in June of 1999. He believes that the host of the bacteria could dwell in the water hyacinth's decaying mire on the bottom of a waterway or on live plants.

Water hyacinth has flourished in the United States for over a hundred years. Research on the plant has been performed by several American universities, primarily in tropical states affected by its invasion. Data specifically about water hyacinth's presence in Ghana is scarce. However, the data collected for the United States usually applies to this African country.

As the plant acts as a pest and disturbs plant, animal, and human aquatic activity, an alternative use for the plant is a hot topic for study. Other common topics of research

include: methods for removal, relationships with other aquatic flora, water hyacinth's capability to remove nutrients from water, and water hyacinth as a method for water treatment. A. Basseres experimented with water hyacinths and effluents. He found that the plants eliminate nitrogen, phosphorous, COD, and suspended solids. He also concluded that, "The liberation of oxygen and the root support provided by the rhizosphere allow a nitrifying bacterial flora to develop." (1991). This bacteria that grows at the roots of water hyacinth may be *M. ulcerans*.

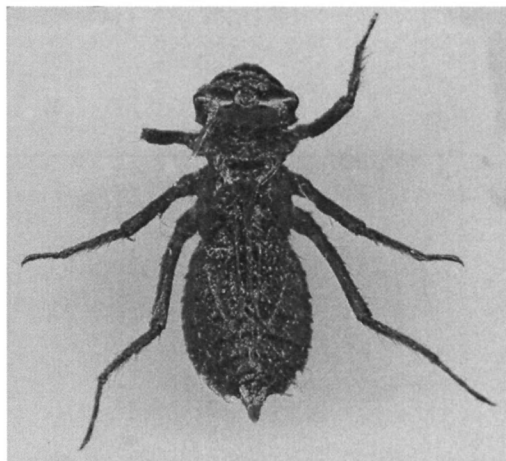
In addition, researchers studied the relationships between the water hyacinth and other floating macrophytes. R, Michael Smart claims that *E. crassipes* yields more biomass when grown with *H. umbellata*. Smart also states that "the combination of these two plant species...should provide year-round performance for optimum wastewater treatment." (1991). A number of additional experiments ended with similar conclusions, like those by Ornes and by Karpiscak. Research linking the water hyacinth and the spread of the Buruli ulcer or water hyacinth's presence in Ghana are two topics that lack information.

## **Epidemiology of the Buruli Ulcer**

In the Greater Accra Region, locals have given the Buruli ulcer names such as *Odontihela*, describing the cotton wool appearance of the lesions, *Aboa gbonyo* (dreadful disease), and *Ashanti Asane*, meaning the disease that might have originated from the Ashanti Region. The Buruli ulcer is defined as an ulcer with undermined borders, necrosis of the underlying subcutaneous tissue and a shiny, hyper pigmented patch of skin surrounding the ulcer (Memorias do Instituto Oswaldo Cruz, 1999). Medical

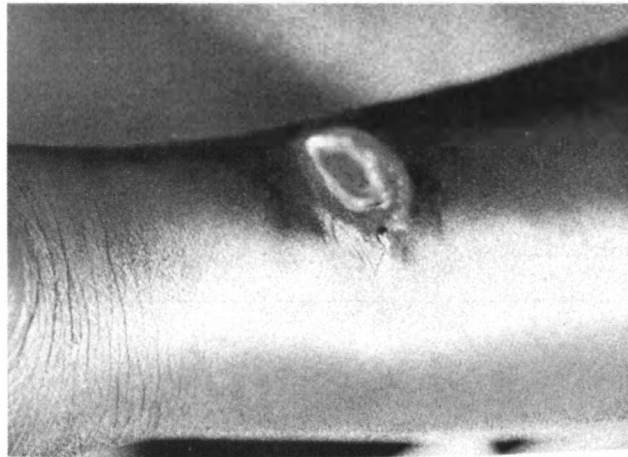
researchers believe the bacteria, *Mycobacterium ulcerans*, causes the ulcer. *M. ulcerans* grows at 32 degrees Celsius. Once in the body, the bacteria elaborates a necrotizing immunosuppressive cytotoxin, mycolactone (a polyketide-derived macrolide). This cytotoxin destroys several layers of the skin and can even damage and deform bones. *M. ulcerans* has been identified in water bugs, such as libellules (dragonfly) larvae, collected from deep in the mire of permanent wetlands (Meyers, 1999).

Dragonflies belong to a group of insects called Odonata, or “toothed”. Their name probably comes from their predatory habits. The larvae of dragonflies, or nymphs, live in water for up to 3 years (“What Exactly is a Dragonfly”, 1999). Nymphs dwell in vegetation, undercut banks, or marshy areas. They have well-developed eyes and a “mouth” on an appendage that reaches out and grabs its food (see Figure 2). Dragonflies are important predators of mosquito larvae (“Dragonfly Larvae”, 1999). Proof of their presence could easily be found by observing their skins, or exuviae, left behind by the nymphs as they leave the water to metamorphose into adult dragonflies. The presence of mosquito larvae is another indication of their distribution.



*Figure 2: Dragonfly Larva*

Buruli ulcer exists in three stages: the necrotic, organizing, and healing stages. In the necrotic stage, the skin tissue has a massive contiguous coagulation necrosis. In the organizing stage, a long-standing lesion appears (see Figure 3). Finally, the ulcer heals, forming granulated tissue and scarring without pigmentation (see Figure 4). The lesions begin as single, painless, firm, moveable subcutaneous nodules (see Figure 5). Sometimes the lesions itch and may ulcerate in one to two months. In active lesions, inflammatory cells are few, as a result of the immunosuppressive activity of the cytotoxin. The ulcers may remain small and heal without formal treatment, or may spread rapidly, undermining skin over large areas (see Figure 6). Important structures such as the eye, breast, or genitalia are sometimes lost or severely damaged from the ulcers. When the bacteria enters the bone, osteomyelitis may lead to crippling disabilities or even amputation. In addition, the ulcer may cause the destruction of nerves, appendages, and blood vessels (Meyers, 1999).



*Figure 3: Early lesion*



*Figure 4: Healed ulcer, lacking pigment*



*Figure 5: Subcutaneous nodule*



*Figure 6: Late ulcer*

Two methods of treatment prevail for eliminating the ulcers. The traditional method consists of a debridement of the ulcer, with soap and a caustic substance, such as wood ashes. Then the sore is washed with warm water and dressed with penicillin. This treatment takes about four months. The negative aspects to this form of treatment are that the healed scar contains no pigment, bones may still be deformed, and skin cancer may develop in the scar tissue that lacks pigment. The second method of treatment involves circulating warm water on the lesion. A temperature of 40 degrees Celsius kills *M. ulcerans*. The skin is then graft. This treatment eliminates the threat of cancer, but does not always prevent deformity. In many villages and regions of Ghana, facilities for this treatment are nonexistent. Also, the cost of this procedure is too high for most Ghanaian residents, especially the rural population, who are at the highest risk of Buruli ulcer. The best treatment is early treatment. In the early stages, simple antibiotics can cure the

lesions, but will recur if left untreated, causing the most severe symptoms of the disease (World Health Organization conference notes, 1999).

Usually, the disease is not fatal. Thus, low priority is given to its treatment and monitoring. Yet, with the growing number of cases, Ghana faces an enormous challenge with its struggling economy. The sufferers of the disease are also challenged by the costs of treatment. The average duration of hospitalization was 102 days in 1996. Some of the costs include surgery, laboratory work, dressing, drugs, miscellaneous and unmeasured costs, and indirect costs like loss of productivity and food. Figure 7 and Table 1 illustrate the baseline costs for the treatment of Buruli ulcer (Asiedu, 1998).

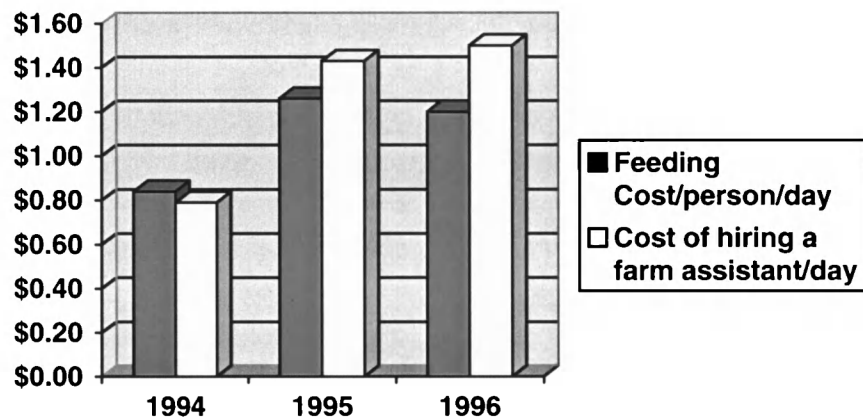


Figure 7

<b>Treatment Costs for Buruli Ulcer</b>				
	<b>1994</b>	<b>1995</b>		
				<b>Total</b>
Number of patients	36	34	32	102
<b>Total Costs</b>				<b>Total</b>
Direct	\$13,377.18	\$6,000.23	\$4,468.15	\$23,845.56
Indirect	\$21,429.59	\$18,006.53	\$16,611.43	\$56,047.55
Total	\$34,806.77	\$24,006.76	\$21,079.58	\$79,893.11
<b>Average Costs</b>				<b>Average</b>
Direct	\$371.59	\$176.48	\$139.63	\$229.23
Indirect	\$595.27	\$529.60	\$488.57	\$537.81
Total	\$966.86	\$706.08	\$628.20	\$767.05
<b>District Health Budget</b>				<b>Total</b>
Total	\$16,115.00	\$15,271.00	\$27,271.00	\$58,657.00
% as a direct cost	83.0%	39.3%	16.4%	40.7%

*Table 1: Treatment Costs*

## **Botanical Treatise of the Water Hyacinth**

Water hyacinth thrives in a warm, marshy, stagnant water body. The plant is a floating macrophyte which "...outclasses all other aquatic weeds in its rate of growth, multiplication and dry matter production, and its ability in respect to energy and pollution control. (Gopal, 1999)." Since the leaves of the plant lie on the surface of the water, other aquatic plants are often shaded and crowded out. The plant consumes a large quantity of oxygen, especially at its roots. Even as vegetation falls to the bottom of the water body and decays, it consumes oxygen. The nutrients previously absorbed by the water hyacinth are then released back into the water. Some species of fish cannot tolerate the raised levels of nutrients (Gopal, 1999).

The roots and the root hairs of the water hyacinth may be the area where *M. ulcerans* can survive. At the roots, nitrifying bacteria (converting ammonia to nitrate)

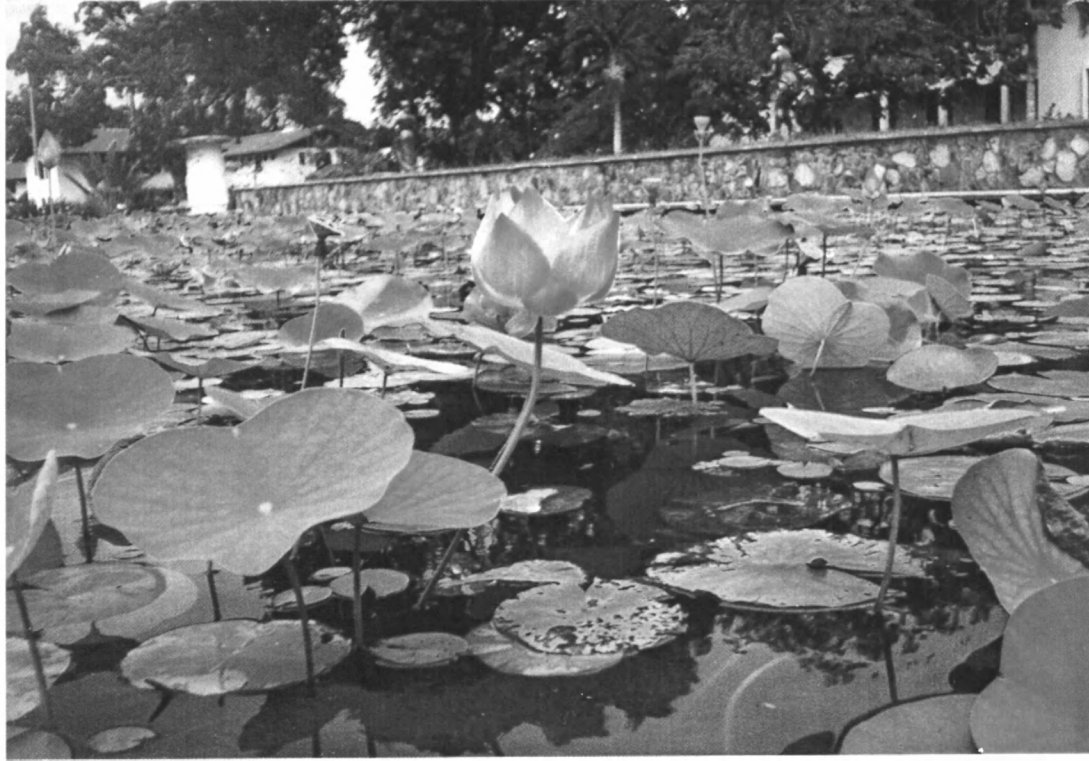


fixate, due to the presence of oxygen. Oxygen fuels microbial biomass activities, such as nitrification and biochemical oxygen demand (BOD) degradation (Basseres, 1991).

The water hyacinth could also serve as a host to the insect carrying *M. ulcerans*. Such bugs could survive in the mire, created by decaying water hyacinth plants, or on the live plant.

Manual and mechanical removal tactics temporarily control water hyacinth populations. Pesticides have also proven effective in eliminating water hyacinth. Other control methods that have been attempted include biological control, herbivorous fish, phytopathogens, and integrated measures (Gopal, 1999).

Although the water hyacinth is primarily considered a pest, the plant has been proved to be effective as a compost, animal feed, paper, energy source, and in wastewater treatment (Gopal, 1999). In 1989, Pima County Wastewater Management Department conducted a pilot study, concluding that water hyacinth successfully treated secondary effluent to Arizona's BOD and total suspended solids (TSS) permitted levels (Karpiscak, 1994). Moreover, pollutants, such as nitrogen, phosphorous, and suspended solids (Basseres, 1991). Perhaps the water hyacinth in the Amansie West District could use the plant in a beneficial, rather than attempting to remove or chemically eliminate its presence. Financially, the region could benefit from a venture to transform the plant to a composted fertilizer, serving the region's farming population.



*Figure 8: Water hyacinth, University of Ghana*

## **Environmental Factors**

Environmental factors, like land use patterns, employment, sanitation, health care, and water supply, play a role in the abundance of Buruli ulcer in the Amansie West District.

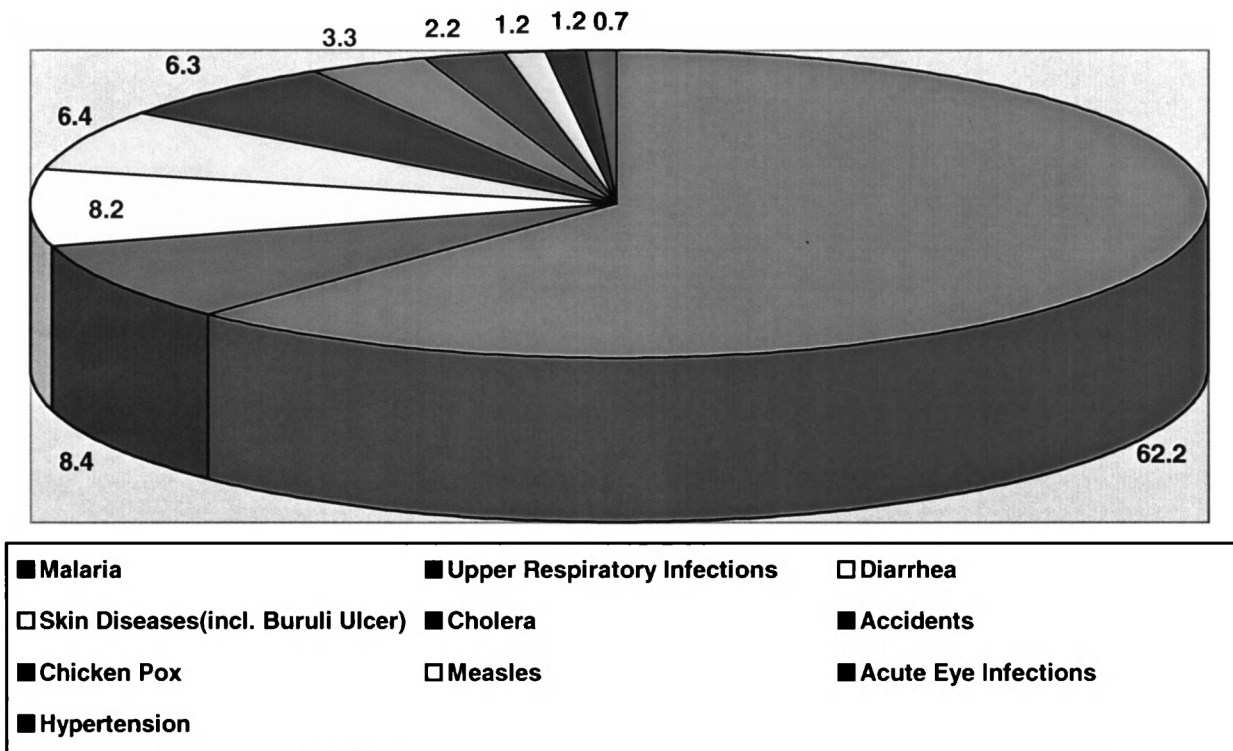
The primary land uses in the region include agriculture, fishing, and water storage. In 1984, about 49% of the labor force were farmers. Those in wholesale and retail trade totaled 19%. Those employed by transport, storage, and communications companies equal 12% and the rest of the population works in construction. Just less than 80% of the population live in rural areas and depend on subsistence or small-scale farming. The income is generally low in the region, due to the weather conditions,

marginal soils, the high cost of agricultural resources, and the lack of post-harvest handling facilities (Consultants for Agricultural and Rural Development Services, 1996).

Poor sanitation and water quality problems are common throughout Ghana. In the Ga District, approximately 40% of settlements depend on dams and dugouts as the water supply. Another 40% depend on boreholes and piped systems. Some villages along the rivers still depend on river water. Even Amsaman, the district capital, does not have potable water (Consultants for Agricultural and Rural Development Services, 1996). In 1988 in Ghana, 44.5% of the population was without a safe water supply, by W.H.O. standards. Almost 70% of Ghana's population did not have appropriate sanitation. In urban areas, 64% of the people had access to appropriate sanitation. Yet, in rural areas, only 15% had access. Safe water was accessible to 93% of the urban population and only 39% of the rural population. In rural areas, most people defecate indiscriminately. Pit latrines abound in urban and rural areas. Floods cause latrines to overflow and bring about biological contamination (Aryeetey-Attoh, 1997). Refuse disposal is mainly open dumping and many unapproved dumps exist throughout the region (Consultants for Agricultural and Rural Development Services, 1996).

Health centers are under-staffed and crowded. Immunization of children is minimal, but is increasing. Schistosomiasis, Yaws, Buruli ulcer, and Tuberculosis are endemic in the Ga and Amansie West Districts (see Figure 9)(Consultants for Agricultural and Rural Development Services, 1996).

**Top Ten Illnesses in the Ga District's Out-Patient Department**



*Figure 9*

Each of these environmental factors plays a part in the abundance of the Buruli ulcer. Without a doubt, the bacteria is related to water bodies and many rural citizens depend on water, no matter how unsanitary, for their livelihood.

### **Case Studies**

St. Martin's Catholic Hospital in Agroyesum is a 100-bed hospital that serves as the referral district hospital for the four Amansie West health centers. Since 1993, St. Martin's has focused on the treatment of Buruli ulcer cases for the district and Ghana (Asiedu, 1998).

I interviewed a number of patients at the clinic. Unfortunately, most of the patients are under the age of fifteen, therefore, their knowledge of English was minimal (see Figure 10). Also, many of the Buruli ulcer patients are citizens of rural villages and lack adequate education. The following is information about the Buruli ulcer patients, as translated by Dr. Joseph Oppong (University of North Texas, Department of Geography).

- A taxi driver from *Kwanchabo* noticed a “bug bite” wound that soon became an ulcer. He has been in the clinic for about two months. His hometown is near the Ofin River. However, he never swims in the river.
- Kojo Fordjour is a farmer from *Aduaben*. He has suffered from the disease for over a year. First, he noticed swelling and then the wound “exploded”. He also lives near the Ofin River.
- John K. Enseng is a farmer from *Asaman*. He has had the disease for over one year and complains that his wound is very painful. His farm is about three miles from the Ofin River. He uses river water for drinking.
- This man is from the Central Region, near the Ofin River. He noticed a blister that was swollen. The blister had a clear discharge when it painfully burst. He often wades or paddles across the river.
- Mr. Oppong, from *Tepa Ashanti*, near the *Brong-ahafo Region*, discovered a small, swollen spot with pain. At the clinic, he underwent surgery. Unfortunately, the surgery did not help alleviate the ulcer.



*Figure 10: Children with Buruli ulcer, St. Martin's Hospital*

Dr. Edward Antwi presides over the Buruli ulcer division of the St. Martin's Hospital. His interview provides a personal perspective on the disease. Most of his patients are rural citizens, whose ulcers are primarily on the lips, limbs, or head. He believes that the bacteria can enter pre-existing cuts. Dr. Antwi claims that many victims do not seek treatment because, initially, there is no pain. In addition, many villagers have no transportation or money for treatment. Many of his patients are children who also suffer from malnutrition. Dr. Antwi is convinced that the contraction of Buruli ulcer is directly related to water bodies: "Perhaps in the soil, water, or plants..." (Antwi, 1999).

## **Analysis**

Accounting for environmental factors such as man-made modifications, sanitation levels, water quality levels, and employment of the Amansie West District allow scientists to better understand the relationships between the occurrence of water hyacinth and the Buruli ulcer. Since most citizens of the Amansie West District are rural farmers, they depend on local waterbodies to wash their clothes, their bodies, and for drinking water. Some citizens even use rivers for sanitation facilities. This could possibly accentuate the problem. Buruli ulcer sufferers and health care providers would benefit from additional research in this area.

In poor, remote areas of Ghana, hospitals are unlikely to recover from the high cost of treatment for the Buruli ulcer patients because of their inability to pay. The budget simply cannot allot more money for these patients. Immunizations, education, and other medical allotments would diminish, if financial officials secured more money for Buruli sufferers, affecting a large portion of the population. However, if victims sought early treatment, the costs drastically decrease. The majority of costs are due to the price of drugs and dressing. Factors contributing to late treatment include geographical access, lack of funding, superstitions, and stigmatization (Asiedu, 1998).

Children, making up the majority of Buruli ulcer sufferers, must tolerate extremely negative consequences if their ailments cause deformity or amputation. Prolonged hospitalization can disrupt their schoolwork. Also, if children are unable to work on the family farm, they become a burden for the remainder of their life. The chances of their financial and social success is low. All of these factors play roles in the

presence of the Buruli ulcer. Water hyacinth and dragonfly larvae are two other possible contributors.

A potential way to alleviate the spread of this disease is to monitor the presence of water hyacinth and dragonfly larvae. The nature of the dragonfly larvae, their eating habits, the structure of their mouths, and their habitats supports the theory that they help transmit the bacteria from the water hyacinth to humans. The larvae are likely to thrive at the roots of the plant, where the decaying mire accumulates. The bacteria is likely to thrive at this point, where oxygen abounds.

## **Recommendations**

Health concerns in Ghana are deeper than they first appear. The problems stem from physical, educational, and economic difficulties. Conflicts of interest between Ghana, as a developing nation hoping to conserve its own resources, and industrialized countries only exacerbates existing problems. The solutions are multi-faceted and long-term. However, some steps can immediately be put into action in order to alleviate some of the symptoms.

Promoting public and private toilets in areas with reliable pipe-borne water or rain-harvesting systems would lessen inadequate sanitation facilities. Constructing proper waste disposal systems to dump wastes would minimize unauthorized dumping. Choosing a location on infertile land away from homes would also improve health issues. Guidelines for toilet facilities must be established. Also, strict enforcement of national health and sanitation inspection and standards must be put into place, in order to ensure cooperation.



Water quality represents another area of inadequacy. Buruli ulcer is likely to persist in Ghana, if the level of water quality does not rise. In rural areas, water obtained from streams, rivers, or ponds is often polluted by agricultural chemicals, soaps from vehicle, clothes, and personal washing, fallen leaves, and other plant and animal residues. Even if literature is posted outlining the dangers, illiteracy rates mean that rural residents will continue to drink such water. Providing cheap, safe water to all Ghanians would entail restructuring the Ghana Water and Sewage Corp. (GWSC). The GWSC must operate more like a corporation, establishing a set price for water equal to the marginal cost of providing the water. Inhabitants in remote areas could harvest and use rainwater the as the main resource or as a standby system in case of water shortages. They could also incorporate simple water treatment methods such as boiling, chlorination, filtration, or sedimentation.

In order to lessen the occurrence of the Buruli ulcer, health educators must educate the children. School is an accessible place to reach a great number of this age bracket. However, many of those who suffer from this disease are rural citizens, who often do not attend school. Therefore, health caretakers could employ a mobile medical unit, similar to those that sell “blood tonics” and other bogus remedies, to not only spread information about how to identify the lesions, but also to treat some people who would not be able to travel to a health care facility for help. This mobile medical unit could also help to lessen the cost of treatment by reaching victims before the lesions reach late phases. If the costs still were not low enough, an international health organization, a research team, or a missionary effort could provide funding for the mobile unit. As

Buruli ulcer often attacks children with unhealthy immune systems, school nurses could ensure adequate nutrition and other factors contributing to a robust immune system.

Furthermore, researchers must monitor and record any progress or any change in status of the health of a community. Researchers must not only log this information, but must also do so in a standard format that could be reproduced and verified. This is an enormous challenge when one considers performing the research, the mapping, the logging, the reporting, and the monitoring without a computer, a typewriter, a copier, or even a camera. The absence of these facilities and funding create intimidating obstacles to most researchers. The W.H.O. could distribute and then assimilate a standard form for health care facilities to monitor the number of admitted patients, biannually, due to Buruli ulcer, their location of contraction, and their background information. Maps created from current satellite images could provide a window into the location of sizeable populations of water hyacinth. These populations could then be verified in field studies and then mapped for the Ghanian E.P.A. to monitor and/or eliminate. Methods for elimination or alternative uses for the plant are debatable. Data collectors could assimilate any changes made to the population must also be reported and the results, in conjunction with those from health care facilities in order to assess their relationship, in full.

## **Summary**

The creation of the Yamoussoukro Declaration brought attention to the rapid spread of Buruli ulcer. This declaration encouraged citizens to watch their drinking water and promoted education about the disease. Unfortunately, the disease's catalyst, *M. ulcerans*, a mycobacterium, has not been successfully isolated and its carrier is unknown.

Further, research concerning the Buruli ulcer in Ghana, or its link to the presence of water hyacinth is inadequate. However, many links can be drawn between the presence of these two phenomena.

The larvae which likely carry the bacteria and the water hyacinth both need water to survive. Also, both thrive in about the same temperature (32 degrees Celsius), and prosper in stagnant or slow moving water. The water hyacinth may act as a breeding ground for dragonflies since the plant provides some stability and reduces the current to some degree. The decaying plant material provides a wonderful nesting ground for the dragonflies and a suitable home for the larvae. In previous studies, scientists collected bacteria from the root zone of the water hyacinth. All of these similarities promote the possibility of a link between the water hyacinth and the Buruli ulcer.

Of the patients that Dr. Joseph Oppong and I interviewed, all of them lived near a waterbody, namely the Offin River. All of the patients were rural citizens and farmers. An overwhelming number of Buruli ulcer sufferers at St. Martin's Hospital are under fifteen years of age, which means that education about warning signs and prevention methods must reach this age group.

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