P 15.5

THE GLOBE MALARIA PROJECT: A UNIQUE STUDENT/TEACHER/SCIENTIST PARTNERSHIP

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1. ABSTRACT

The GLOBE Madagascar Malaria Project is a new initiative whose objective is to involve students, teachers, and the community in learning more about malaria, collecting environmental data relevant to malaria, and educating the community to assist in combating this mosquito-borne disease. Madagascar schools, scientists, health department officials, government officials including the Minister of Education, and others, have given their support to this project that links GLOBE hydrology and atmospheric data with mosquito larval occurrence and identification. In the context of environmental/Earth science education, the issues related to malaria can be viewed as a unique opportunity for developing scientist/teacher/student partnerships that attack a real-world problem with the resources that only a widely dispersed network of participants, such as GLOBE educators, students and scientists can provide. Local identification of mosquito breeding/hatching sites is critical because mosquitoes tend to stay within a few kilometers of their hatching sites. In developing countries such as Madagascar, it is entirely possible that GLOBE schools in remote locations could provide the only regular source of these kinds of data. Once the Madagascar pilot study is complete, this project can be expanded to the continent of Africa and to other parts of the world.

To date, Madagascar scientists and educators have drafted and field tested science and education materials for teachers and students. The materials are currently under revision based on the initial evaluations gleaned from field testing. The larval collection and identification protocols will be implemented in schools the next school year along with other GLOBE protocols that provide a more complete picture of the environmental conditions controlling mosquito breeding. The data collected will be made available to the scientific and public health community and used to promote student research. Results from this project can be used to increase public awareness of malaria in participants' communities and to provide better information for guiding effective mitigation strategies.

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2. INTRODUCTION

Malaria is a mosquito-borne parasitic disease endemic in many areas of the world, causing more than 3.2 billion people to be at risk. Approximately 80% of the global deaths occur in Africa (World Malaria Report 2005). Although estimates of malaria-related illnesses and deaths have large ranges of error, data indicate more than 200 million illnesses and more than one million deaths annually in Africa (Greenwood 1999). A large portion of malaria morbidity, approximately 116 million, are children under 5 years of age (Carneiro *et al.* 2005).These figures indicate that there is the death of one African, most likely a child, every 30 seconds due to malaria

The epidemiological trends include increases in mortality and the emergence of drug-resistant strains. Locally, approaches to dealing with malaria include spraying existing mosquito populations, application of larvicides, using insecticide treated nets, immunization campaigns, public education to reduce breeding sites, and treatment after the disease has been contracted (World Malaria Report 2005). It is especially important to develop effective strategies for minimizing breeding sites and managing mosquito populations in developing countries where malaria continues to be a major cause of death, and where it is essential to use limited resources in the most efficient and cost-effective way.

GLOBE (Global Learning and Observation to Benefit the Environment, www.globe.gov) is an inquiry-based science and education program targeting primary and secondary schools around the world. Teams of scientists and educators have developed over 50 protocols for taking environmental measurements in hydrology, atmosphere, land cover, soils, and phenology. More than 100 countries, including Madagascar, participate in the program. Within each partner country, one or more County Coordinators oversee the implementation of GLOBE materials in schools. Madagascar joined in 1997 and the Ministry of Education oversees the program. There are 25 schools participating. Throughout Africa, there are 28 GLOBE partner countries involving over 500 schools.

In the context of environmental/Earth science education, the problem of malaria and other vector-borne diseases can be viewed as a unique opportunity for developing scientist, teacher, and student partnerships that attack a real-world problem. Scientists could use data from a dispersed network and schools in rural areas can provide such a network. Involving a network of rural schools is particularly useful since the occurrence of malaria is greater in rural areas than in urban settings (Carneiro *et al.* 2005). The collection of data, in particular rainfall and temperature, in epidemic-prone areas could help with malaria early warning systems (MEWS) (WHO 2001, WHO 2004).

Vector-borne diseases provide a sharp focus for motivating environmental measurements. An awareness of these diseases is embedded in the culture of affected countries, so the need is real and obvious. Students and teachers in many African countries such as Benin, Cameroon, and Gabon, are using GLOBE materials for research and education about this scourge. Recently, a collaborative project began in Madagascar that involves many individuals and organizations working together to develop a cost-effective way to promote community-based malaria research and education. This pilot project has applications not only for Madagascar, but throughout Africa.

3. MALARIA IN MADAGASCAR

Madagascar has a diversity of habitats ranging from low coastal areas to mountainous areas reaching 2,876 meters. The total land area is 587,040 km^2. There are two seasons: a hot, rainy season from November to April and a cooler, dry season from May to October. Rainfall and temperature patterns vary from consistent rain and temperature along the coastal areas to low temperatures and low humidity areas in the central highlands and semi-desert south. Malaria transmissions vary from year to year within the geographic regions depending on the meteorological conditions and elevation. The peak outbreaks of malaria are associated with the rainy season from December to April. Along the coast where transmission is more consistent from year to year, adults have semi-immunity to malaria. In areas with more interannual variability, immunity is less common and epidemics with high mortality are more common (Madagascar Ministry of Health & Family Planning 2004).

In Madagascar, malaria is a primary cause of ill health. The disease has tremendous economic costs: $52,487,516 US, 4,076,934 productivity days, and 2,266,265 days of school absenteeism each year (Madagascar Ministry of Health & Family Planning 2004).

Mosquitoes of the genus *Anopheles* are the primary malaria vector worldwide. In Madagascar the most common species are *A. funestus*, *A. Gambiae*, and *A. Arabiensis*. These species carry the parasite *Plasmodium falciparum*, which causes 98% of the malaria infections there (Madagascar Ministry of Health & Family Planning 2004). The *Anopheles* genus has a number of distinguishing characteristics in all life stages from eggs through adult. See Figure 1. Many of these features can be seen with the naked eye or with a low-power microscope or hand lens, and can be easily differentiated from another common genus in Madagascar, *Culex*. For instance, *Anopheles* eggs are laid singly and each egg has ribbed lateral floats. Their larvae have no breathing siphon and lie parallel to the water surface rather than hanging down from it. The adult mosquito stands in an oblique position with palps (structures located on both sides of the proboscis next to the antennae) that are as long or longer than the proboscis for both males and females.

4. PROJECT DESCRIPTION

<u>Planning Stage:</u>
In 2003, GLOBE science PI Dr. David Brooks suggested that GLOBE undertake a malaria-related project to address this critical environmental issue in a way that would help GLOBE countries develop stronger national and regional programs. In 2004, based on the strong

Figure 1. Mosquito identification chart developed for students and teachers.

GLOBE program developing in Madagascar, GPO and Dr. Brooks initiated discussions with the Madagascar Country Coordinator, Mr. Albert Rafalimanana. In early 2005, a Boulder middle school teacher, Mr. Jason Albert, and science curriculum specialist, Mrs. Anitta Frant, approached GPO. Mr. Albert and Mrs. Frant were planning to be in Madagascar between August 2005 and June 2006 and offered to work with GLOBE schools in Madagascar as volunteers. GPO, Mr. Rafalimanana, and Dr. David Brooks, discussed options for taking advantage of Mr. Albert and Mrs. Frant's offer. It was decided that a pilot project involving five schools would be implemented. Mr. Rafalimanana would arrange to hold workshops for teachers to learn the GLOBE materials and how to promote student research exploring relationships between environmental factors and the occurrence of malaria. Schools would be selected so that Mr. Albert and Mrs. Frant would be able to visit and work with the teachers and students periodically. Low-cost GLOBE protocols that had direct relevance to mosquito habitat and breeding were selected, and included air temperature, precipitation, relative humidity, cloud cover and type, water temperature, water pH, and water transparency. The Madagascar Ministry of Education and GPO provided the equipment for the schools. The collection of other data, such as soil pH, soil moisture, and dissolved oxygen in water were encouraged but not included in the basic equipment provided. It was decided to keep the number of environmental measurements small to start and as the comfort level of teachers increased, more could be added later.

Mr. Rafalimanana shared this project idea with scientists and ministry officials in Madagascar. The idea quickly engaged many individuals from different organizations – the University of Antananarivo, Ministry of Health, Centre National d'Applications et des Rescherches Pharmeceuticques (CNARP), in addition to the Ministry of Education. With the support of GPO and Dr. Brooks, the Madagascar malaria scientists and Ministry officials took ownership of the project and expanded the initial idea of developing a protocol for collecting and identifying mosquito eggs, larvae, and pupae that could be used by students and teachers with inexpensive equipment. As well, more schools were added to the original five selected. Early life stages of the mosquito were chosen for the collection and identification by students. This would minimize the risk of children being bitten by mosquitoes. Adult biting *Anopheles* mosquitoes are active at dusk, dawn, or at night (CDC Web site).

By October 2005, scientists had developed a draft protocol for the collection and identification of the mosquito larvae and teachers from selected schools had received training in the GLOBE protocols. The protocol was created in time for field testing during the mosquito breeding season and in time for utilizing the volunteer educators from Boulder.

<u>Implementation Stage:</u>
The mosquito collection and identification protocol was tested on teachers and students from Beza Mahafaly and Besaha Tanosy schools (Photos 1 and 2, Figure 2). In October 2005, 63 students, aged 8-18, and teachers attended workshops in which they learned how to collect, identify and calculate larval density, in addition to measuring water quality parameters. The teachers provided feedback as to the ease of usage for capturing and using the identification charts. Teachers found some difficulty in collecting samples. When using

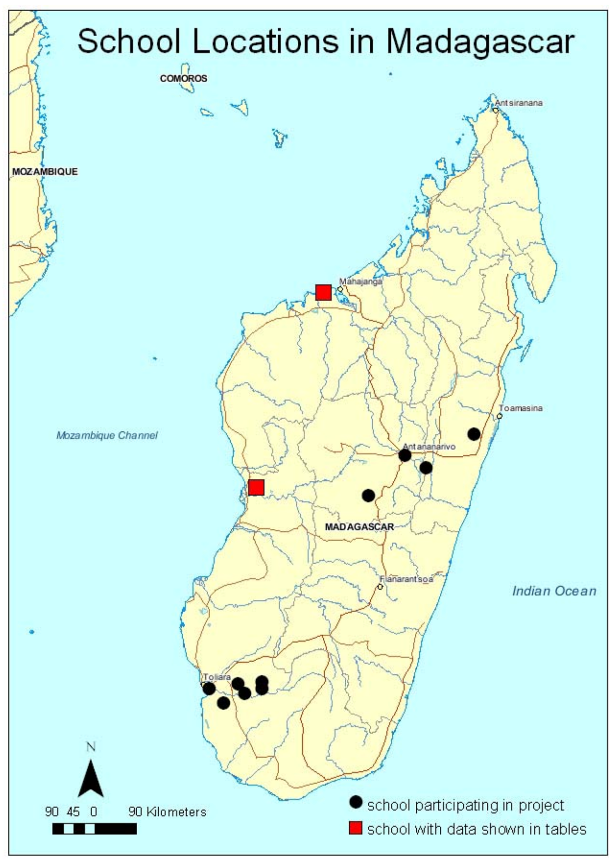

Figure 2. Map showing locations of schools and study sites.

identification charts, participants correctly recognized the *Anopheles* genus 100% of the time. Based on the results of the field testing of the draft protocol, revisions were made. Teachers were better prepared to implement activities in their classroom.

Photo 1. Teacher and students learning the GLOBE and mosquito protocols at Bezaha.

Photo 2. Teacher and students learning the GLOBE and mosquito protocols at Betioky.

Through this workshop and classroom implementation, scientists and educators determined that students are able to learn:

- about the consequences of malarial infections on their local communities;
- about the development cycle of the *Plasmodium* parasite and female *Anopheles* mosquito's role in the transmission of the disease;
- how to tell the differences between male and female adult mosquitoes;
- mosquito's life cycle;
- how to recognize adult breeding sites and times of increased infection risk;
- how to recognize main larval lodgings;
- how to differentiate eggs;
- how to differentiate between *Anopheles* and *Culicinae* larvae and adults involved or not in the local malaria disease transmission;
- how to evaluate larval density;
- the importance of water temperature, pH , transparency in larval development;
- the importance of air temperature, pH, vapor density in mosquito development; and
- methods in the integrated fight against larvae.

5. PRELIMINARY DATA

Data reported from some sites in Madagascar are presented in Table 1-4, as summarized by Dr. Brooks from the original data reports. In all cases, larvae numbers are the total from five independent dip samples conducted at each site and date.

Even though this project is in its early stages, there are some clear and interesting trends that support the basic concept of this project – that environmental conditions exert major influences on *Anopheles* and non-*Anopheles* mosquito breeding patterns, and that students and their teachers can contribute to a better understanding of these patterns. In Site 1, the influence of predators is clear, and the effect of Laccophilus (water beetles) is striking. The preference of *Anopheles* for clear water is also striking, as there are no *Anopheles* larvae found at Site 3 in the stagnant water in irrigation ditches. The dramatic reversal of the ratio of *Anopheles* to non-*Anopheles* larvae within one week in the pond at Site 4, between 18 and 25 March, may be accurate, but these are kinds of data that require additional verification.

Some sites collected more water quality data than others. It is not clear whether a lack of information about potential predators means that the data were not collected or that no predators were observed. However, these inconsistencies are to be expected at the start of any such project, when protocols are being developed, when important factors are still being considered, and before even preliminary assessments of the data have been undertaken.

Considering the considerable transportation and communication challenges that exist in Madagascar, these reports are actually very well coordinated; this speaks well for the effort devoted to this project in Madagascar and for the GLOBE

Program's general insistence on developing written protocols and training program implementers to a uniformly high standard.

Table 1. Site 1. Lycée Philbert Tsiranana, lake near maize and cassava fields, surrounded by mango trees, 10 April 2006.

Water Condition	*A. funestus*	*Culex*	pH	T °C	Predators
Clear, no aquatic plants	15	11	9	27	None
Disturbed by women washing and kids playing	4	1	10	27	--
Surrounded by aquatic vegetation	66	3	8	29	--
Thick vegetation	2	1	8	27	Laccophilus (water beetles), dragon fly larvae
Vegetation, no pellicules	19	2	7	27	Frogs

Table 2. Site 2. Lycée Philbert Tsiranana, small former salt marsh, 13 April 2006.

Water Condition	*A. funestus*	*Culex*	pH	T °C	Predators
Clear, no pellicules, sparse vegetation, small mangroves	23	6	7	29	--
Clear, visible bottom, no pellicules, mangroves, water lilies	3	1	10	30	Laccophilus
Clear, visible bottom, no pellicules, mangroves	69	25	8	29	--
Clear, visible bottom, no pellicules, mangroves	38	13	6	35	--
Pellicules	2	1	8	30	Laccophilus, Frogs

Table 3. Site 3. Lycée Miandrivazo, Tolaria, irrigation ditches, March 2006.

Water Condition	*A. funestus*	*Culex*	pH	T °C	Predators
04 March, Irrigation ditches, stagnant water, proximate houses, sunny, silt and mud, *Graminaeas*, *E. crassipes*, herbaceous, ~18cm deep	0	29	--	34	Unidentified?
11 March	0	70	--		--

Table 4. Site 4. Lycée Miandrivazo, Tolaria, pond, March 2006.

Water Condition	*A. funestus*	*Culex*	pH	T °C	Predators
18 March	1	11	--	33	--
25 March	13	1	--	34	--

6. NEXT STEPS

A Madagascar Planning Committee with representatives from the numerous organizations involved has been formed. The next steps are being discussed based on the outcomes of the preliminary workshops, classroom implementation, and data collection efforts. Responsibilities for the project are being distributed among the organizations. However, it is to be determined how much money from the Ministries will be allocated to the project.

For the mosquito collection and identification protocol refinement, the GLOBE scientists and scientists from the University of Antananarivo (Entomology Department, Chemistry Department), CNARP, and the Ministry of Health will be working with the schools to improve the consistency and quality of data being collected. This will require working with students and teachers in the field and based on observations, make changes to improve the protocol.

In addition to the protocol, Madagascar scientists and educators are developing supplemental educational materials to accompany the field techniques. This will help with classroom implementation and to help incorporate science concepts, as well as field and laboratory skills in the curriculum. Eventually, these materials will be made available to GLOBE programs in other countries where malaria is an important environmental issue.

Based on the results of both the science research using the data and the environmental awareness promoted by involvement of the community in the research process, applications to malaria prevention methods will be explored.

7. CONCLUDING REMARKS

In less than one year, a protocol was developed, tested and evaluated, equipment was acquired, and workshops were held for teachers and students in rural schools. Given the communication and transportation challenges in a developing country, this is quite an accomplishment.

This project is still in its beginning phase, and it will be seen how the draft science and educational materials will be used in the classroom, the types of student research conducted, how the data will be used for malaria research and mitigation, and how easily this work can be applied in other countries. The accomplishments to date are great and the potential to make substantive and sustainable contributions to science, community-based monitoring, and malaria mitigation is even greater. The broad-based participation by students, teachers and scientists in communities, ministries, and organizations demonstrates interest in the project and should help to ensure successful outcomes.

8. REFERENCES

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