Conflict between the Need for Income and the Necessity of Controlling Endemic Malaria

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Abstract

Malaria control in Africa mainly explores top-down Government-led initiatives (vertical) rather than horizontal approaches, which normally embrace active participation of communities. African malaria mosquitoes mainly breed in man-made habitats such as brick-making pits, fishponds, irrigation channels etc. This underscores the need to have communities living in affected areas to understand their role in propagating malaria and henceforth, how to contribute in its control. Malaria disproportionately affects poor people whose need for income to support basic survival far exceeds other needs. It is therefore important to integrate income generation activities (IGA) into disease control interventions. A cross-sectional survey was conducted using a questionnaire with open and closed ended questions to determine the potential integration of fish farming and mosquito control on Nyabondo plateau in western Kenya. Some of the questions asked included reasons for fish pond construction, pond condition (whether well maintained in productive state or abandoned), pond ownership (self or group), challenges faced and the respondent’s biodata. A total of 115 fish ponds were visited during the survey. Seventy percent of these were self owned while 30% were owned by local groups. Ponds were either maintained in active productive state or abandoned depending on the education level of the owner. Abandoned fish ponds harbored more Anopheles (malaria) mosquito larvae than active ones. Ninety nine percent of the pond owners practiced fish farming solely for income generation. There were no observable indicators that active fish farming was integrated with mosquito control. There is need to create awareness among the local communities about the importance of deliberately directing fish farming practices for integrated vector management. This will ensure proper maintenance of the ponds, assure nutrition and improve the socio-economic status of malaria burdened rural communities.

Keywords: Anopheles; Fishponds; Income generation; Integrated vector management; Western Kenya

Introduction

Rural African communities hardly participate in mosquito control programs. For their involvement to beneficial residents need to understand the biology and role of mosquito vectors in disease transmission. In western Kenya activities such as brick making and fish farming are mainly practiced for income generation. As community members strive to improve their socioeconomic status they create suitable mosquito breeding habitats inadvertently. This increases the risk of malaria infection [1]. Furthermore, such activities degrade the environment and interfere with local hydrology. Because communities rely on these activities to support their daily needs, vector control must be integrated into livelihood practices. Involvement of communities in vector control is an essential component of Integrated Vector Management (IVM) approaches [2], which advocate for the use of local evidence in designing vector control interventions. Integrated Vector Management is comparable to Integrated Pest Management (IPM), which uses diverse tools, coupled with evidence-based decision-making, to control pests with limited use of pesticides [3].

Malaria vector control in most affected countries such as Kenya has over the years relied on the use of insecticides through Indoor Residual Spraying (IRS) and provision of Treated bed Nets (ITNs). The continued and widespread use of pyrethroid insecticides in these indoor-based interventions threatens the gains made in malaria vector control due to the evolution and spread of insecticide resistance [4-6]. The development of resistant vectors calls for a need to complement indoor measures with outdoor strategies such as the control of immature mosquito stages.

The Nyabondo plateau of western Kenya offers a high potential for fish farming. In 2009 the Kenyan Government set aside funds for community empowerment through a scheme known as the Economic Stimulus Program (ESP). Part of the ESP money was used to construct fish ponds for groups in selected areas. The ponds were constructed and stocked with fish fingerlings through the Ministry of Fisheries in 2009. The intention to help community groups to own up the program and continue with fish farming. However, after the first fish harvests in 2010 the majority of ponds were abandoned and/or left un-attended, so making them suitable mosquito breeding habitats. The Ministry of Fisheries and the Kenya Marine and Fisheries Research Institute (KEMFRI) later identified the need to reclaim and restock the ponds through active participation of pond owners. The owners would in return gain income, have a secure protein source and contribute to improving their health status because the fish cultures would act as biological control agents for malaria vectors. This paper presents findings from Nyabondo plateau, a rural setting in western Kenya, where an IVM program was established with the main goal of involving
community members in mosquito and malaria control activities. We sought to find out from the pond owners the factors underlying their participation in fish farming, whether their ponds were active or abandoned and the challenges they encountered. This information forms a critical knowledge base that is essential for helping to revive fish farming and all its inherent benefits to the local community.

Materials and Methods

Study area

This study was carried out on Nyabondo Plateau, which is located in Kisumu County, Western Kenya. Nyabondo lies at an altitude of 1658 m above sea level, is located at latitude -0.38 (0° -23’ 0 S) and longitude 34.98 (34° 58’ 60 E). It is a rural setup with a population of about 332,313 persons. The community largely depends on brick making as the main economic activity with small scale mixed farming activities such as crop/fish farming and livestock keeping. Agricultural activities are dominated by crops such as maize, cassava, sorghum and sweet potatoes. Land is owned by individuals and decisions concerning water extraction are made solely by the land owners. Project staff of the International Centre of Insect Physiology and Ecology (icipe) has routinely carried out weekly mosquito larval habitat surveys in Nyabondo from 2006 to date. During the weekly field surveys, potential breeding habitats were noted and checked for the presence or absence of mosquito larvae. A sample of Anopheles mosquito larvae were collected from positive habitats using 350ml standard dippers [7]. Anopheles mosquito larvae were then counted and recorded as either early or late instars and the larval habitat type noted. Results of preliminary surveys on suitable mosquito breeding habitats found brick pits, artificial ponds and abandoned fish ponds to be the most preferred breeding habitats among which seven were closed and eight were open-ended was monitored [4].

Results

Pond owner’s characteristics

A total of 115 pond owners, 73 males and 42 females were interviewed during the survey (Table 1). Majority of fish pond owners

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency (N=115)</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>73</td>
<td>63.5</td>
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<tr>
<td>Female</td>
<td>42</td>
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<td>3.5</td>
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<tr>
<td>Location</td>
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<td></td>
</tr>
<tr>
<td>Kajimbo</td>
<td>55</td>
<td>47.8</td>
</tr>
<tr>
<td>Kamgan</td>
<td>40</td>
<td>34.8</td>
</tr>
<tr>
<td>Sigoti</td>
<td>20</td>
<td>17.4</td>
</tr>
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<td></td>
</tr>
<tr>
<td>Married</td>
<td>91</td>
<td>79.1</td>
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<tr>
<td>Widower</td>
<td>16</td>
<td>13.9</td>
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<tr>
<td>Single</td>
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<tr>
<td>Active</td>
<td>56</td>
<td>48.7</td>
</tr>
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</table>

Table 1: Characteristics of ponds and pond owners on Nyabondo plateau.
were in Kajimbo (47.8%) followed by Kamgam (34.8%) and Sigoti (17.4%) location. Respondents ages varied from 20 to 80 years old with majority being married (79.1%). Almost half (46.1%) of the pond owners had attained secondary level of education with only a small fraction being non educated (6.1%).

Pond condition

A total of 115 fish ponds were visited during the survey. Among them 51.3% were abandoned while 48.7% were actively maintained. Among the active fish ponds 45.5% were stocked by the Ministry of Fisheries, 36.4% by icipe's Nyabondo IVM project and 18.2% by the pond owners (Table 1). Whether a pond was active or abandoned varied depending on the owner's level of education ($\chi^2=13.503$, df=3, p=0.004). Owners educated to College level were 2.5 times more likely to own ponds when compared to those with Secondary level education (OR = 2.551, CI 0.924 – 7.044, p = 0.007). Further analysis revealed that pond owners with Primary school level of education were 17.676, p=0.144) times more likely to own ponds when compared to adults aged between 31 to 40 and 51 to 60 years, respectively. Although education level was not a significant ($\chi^2=6.643$, df=3, p=0.084) determinant of pond ownership, respondents with College level of education were 4.5 times (OR=4.547, CI 1.349–15.333, p=0.015) more likely to own ponds when compared to those with Secondary level education.

Pond ownership

Majority of the ponds were owned by self 69.6% while groups owned 30.4% of the total ponds surveyed. Majority of ponds were located in Kajimbo location (47.8%), followed by Kamgam (34.8%) and finally Sigoti (17.4%). Pond ownership varied among the respondents depending on their location ($\chi^2=7.751$, df=2, p=0.021) and age group of the respondent ($\chi^2=12.744$, df=5, p=0.026). Further analysis revealed that Sigoti location had a 91% chance of having self owned ponds when compared to Kajimbo location (OR = 0.085, CI 0.331 – 1.836, p = 0.021). The age group of the respondent showed no relationship with pond ownership, however, youth aged between 20-30 years old were 2 (OR=2.00, CI 0.304–13.173, p=0.471) and 3.4 (OR=3.407, CI 0.657–17.676, p=0.144) times more likely to own ponds when compared to adults aged between 31 to 40 and 51 to 60 years, respectively. Although education level was not a significant ($\chi^2=6.643$, df=3, p=0.084) determinant of pond ownership, respondents with College level of education were 4.5 times (OR=4.547, CI 1.349–15.333, p=0.015) more likely to own ponds when compared to those with Secondary level education.

Reasons for pond construction

Of all the respondents 99.1% (114/115) mentioned income as the main reason for practicing fish farming. Among these 16.7% (19/114) mentioned income and food security while 39.5% (45/114) mentioned income and mosquito control. Fish farming for income generation as well as mosquito control activity was influenced by the respondents marital status ($\chi^2=9.894$, df=3, p=0.019) and education level ($\chi^2=12.585$, df=3, p=0.006). Further analysis revealed that married (those with families) pond owners were five times more likely to mention both income and mosquito control when compared to widowers (OR 5.323, CI 1.566 – 18.096, df=1, p=0.007). Further analysis of the respondent's education level was found to be insignificant.

Fish species preference

A majority (52.2% (60/115)) of the respondents preferred Tilapia, 13.9% (16/115) preferred Cat fish while 33.9% (39/115) liked both species. Age group was the only characteristic found to significantly affect one's preference for a certain fish species ($\chi^2=18.722$, df=10, p=0.044). Further analysis by regression did not show any relationship between the different age groups and the species preferred.

Challenges associated with fish farming

When asked what they perceived as the challenges associated with fish farming, the respondents mentioned pond construction and maintenance, expensive fish feeds, and poor/unpredictable weather conditions. The responses varied affected by gender ($\chi^2=7.975$, df=3, p=0.047), fish pond ownership ($\chi^2=21.595$, df=3, p=0.000), age group ($\chi^2=33.738$, df=15, p=0.004) and the location ($\chi^2=18.301$, df=6, p=0.006) of the respondent. Further analysis found fish pond ownership to be the only factor influencing the challenges mentioned. Self owned ponds were almost three times likely to have challenges with pond construction and maintenance when compared to group owned ponds (OR = 2.90, CI 1.075 – 7.795, p=0.035). On the other hand, group owned ponds were six times (OR = 6.196, CI 2.573 – 14.919, p=0.000) more likely to have challenges with the weather conditions when compared to self owned ponds. Group owned ponds had 80% (OR=0.195, CI 0.043-0.887, p=0.034) chance of facing challenges with fish feeds when compared to individually owned ponds.

Ponds reclamation program

In With the assistance of icipe's Nyabondo IVM project ten and twenty one fish ponds were stocked in 2011 and 2012, respectively. In 2011 the first phase of stocking was done in the month of May and the second phase in August. In 2012 stocking of fish ponds with fingerlings was done between the months of June and November. Three among the 21 stocked ponds in 2012 were newly constructed, nine were active whereas the remaining ten were reclaimed ponds. Ponds that were stocked are being followed closely to determine how much income each one of them will generate and to ensure that no fish pond is abandoned thereafter.

Estimated earnings from fish farming

Earnings from fish farming is dependent on many factors among which the number of fingerlings stocked, water quality, pond management and type of feed etc. The weight of harvested fish size is critical as it determines the market value. On average one Kilogram, of fish cost about USD 4.00 (300 Kenyan shillings (KShs)). Therefore, assuming an ideal scenario where a fish pond is stocked with 1000 fingerlings and managed optimally to yield 100% with each fish weighing a minimum of one kilogram, the gross total income generated would be about 4000 USD (340,000 Kshs). The pond owner might incur approximately USD 353 (30,000 Kshs) costs related to construction and USD 176 (15,000 Kshs) costs related to feeds then the total earning per year would be USD 3,471 (i.e. USD 4000 minus USD 529).

Discussion

The findings on larval sampling evidently show the importance of abandoned fish ponds as suitable habitats for mosquito breeding in Nyabondo. When the ponds are abandoned and unmaintained, they propagate mosquito populations and hence increased malaria burden but when active, they act as an important income generation activity and a biological control system for malaria vectors. Anopheles arabiensis i.e. the most abundant malaria vector in this area is an opportunistic feeder and mainly prefers to bite and rest outdoors. Its control will therefore need more innovative approaches, rather than relying on measures that target indoor environments only such as the IRS and ITNs. Majority of the sampled ponds (84.3%) were constructed under the ESP program.
with a few (15.7%) being self owned. Ninety nine percent of the respondents owned ponds solely for income generation with slightly more than half preferring Tilapia species. Like any other development activity, fish farming has challenges ranging from pond management, feeds and unpredictable weather conditions.

Examining health in an agricultural context presents opportunities for improving health as well as health risks by creating conditions suitable for insect vector propagation [9]. Findings from this study indicate that for as long as ponds are holding water, if left abandoned (un-attended), they provide good mosquito breeding habitats and thereby enhance malaria transmission. Howard and Omlin [7], warned on the dangers of abandoning ponds in the nearby area of Kisii with similar reasons. Active ponds with fish on the other hand did not record the presence of anophele larvae. Different fish species have however, been shown to have the potential for mosquito vector control mainly in the East Mediterranean region [10] and other parts of the world [11-15], providing a good opportunity for community involvement in mosquito vector control. Since reclamation of ponds began, increased interest in fish farming has been observed among the pond owners and three among those stocked in 2012 were newly constructed ponds with the trend likely to go up in 2013. Rural areas such as Nyabondo, present a challenge in disease control and their active involvement and participation is significant for success [16]. It is envisaged that with initial support by the project in obtaining fingerlings and fish feeds, the pond owners will be empowered to carry on when the project withdraws its support.

There is more evidence on the impact of human activities on environmental quality and the importance of manmade mosquito breeding habitats in mosquito proliferation and consequently to malaria transmission [13,17-20]. Majority of these human activities are mainly geared towards creation of farmland for agriculture to ensure food security and earn some income for the family. Similarly, the respondent's main goal to engage in fish farming was solely for income generation. Oreochromis niloticus (Perciformes: Cichlidae) a delicacy in the area was the most preferred fish species and therefore its market is readily available. Cat fish ranked second in terms of customers preference however many respondents liked the idea of having both species in one pond so that they double their income. Nonetheless, to the local person, the ability to generate income ranks first, followed by food security for the family and probably disease control would most likely be ranked last if not towards the end. This bi-directionality of agriculture and health offers an incentive for the two sectors to work together — to orient agricultural systems to benefit health, and health systems to benefit agriculture [9]. Poor environmental quality provides conditions for insect vector breeding and ultimately infectious disease transmission such as mosquitoes and malaria [1]. Encouragingly, almost 40% mainly respondents with families mentioned income as well as mosquito control. This finding might have been influenced by the fact that the team has been creating awareness on dangers of abandoning fish ponds within primary schools in the area. Hence the findings provide evidence that school going pupils can used as reliable agents of change to their parents and community at large. Malaria is commonly considered a disease of poverty [21,22], it therefore requires control measures be implemented simultaneously with complementary social intervention in order to be effective [1]. Improving the social environment can lead to changes in the coping and caring options of individuals, communities, and institutions as well as changes in malaria incidence [23]. Each setting (location) will have its own combination of control measures as there is no uniform control strategy that suits all locations [24].

Many respondents expressed their concerns over pond management with the main challenge being unpredictable weather conditions which varied depending on whether the pond was owned individually or by a group. This was evident early in the year 2012 as a results of a long dry spell (data not shown) some of the respondents lost their fish as a result of ponds drying up. There is a need for communities living on Nyabondo plateau to be enlightened on water harvesting and conservation to be able to adapt to weather changes and on a larger scale to climate change. Self owned ponds were more likely to face challenges with construction and maintenance compared to group owned ponds. This may be explained by the fact that almost all group owned ponds were constructed through ESP and to some extent fish feed and fingerlings were provided, while for individually owned, it was the owner's responsibility to construct the pond, stock it and provide fish feeds. Perhaps to solve the problem of access to fish feeds and fingerlings, establishment of a local fish feed industry and fingerling production unit would be beneficial to the community.

Education plays a major role in empowerment at whatever level or position one may hold within the society and vice versa [25-27]. This is demonstrated in the current study by the fact that the pond owners with a higher level of education were more likely to have their ponds active when compared to a level below. For example, pond owners with college level of education were likely to have their ponds active when compared to those with secondary school and primary school levels of education. To bridge the gap in education among community members, awareness creation and capacity building at community level should be mandatory as advocated by IVM. Explanations need to be provided to local communities on the causal connections between malaria transmission and abandoning of fish ponds. The main malaria vector control strategies in the region mainly target indoor resting vectors whereas according to mosquito species analysis results (unpublished data) the main vector species in Nyabondo, An. arabiensis prefers to rest and bite outdoors. Consequently, targeting the immature stages of mosquitoes would be the best complementary tool for managing both outdoor and indoor vectors. Putting additional financial investment into further lowering the number of mosquito bites would have a greater positive effect on malaria incidence [28]. Adoptions of locally available strategies for mosquito vector control are more preferred and the applicability will depend on the dynamic human component of vector ecology, social and economic factors that influence land and water use within the affected communities [29]. Because ITNs, IRS are implemented through Ministry of Health in Nyabondo, combining with larval source management strategies such as the use of predators like fish and environmental management present opportunities for community participation.

The study faced limitations and among them the inclusion of pond owners only and exclusion of other community members from participating in the survey might have caused a bias in results obtained and consequently in their interpretation. The study worked on assumptions that might have affected the manner in which the results presented were interpreted. We assumed that all ponds owned by groups received support from the ESP upon giving consent that they were interested in fish farming and would continue after the initial support provided. Realistically, this may not have been the case as the ESP might have simply focused on achieving their goal of having ponds constructed but not necessarily ensuring sustainability of fish farming. As a consequence, most groups later lost interest in fish farming and left their ponds un-attended. Whereas an ideal scenario is assumed while estimating the earning from fish farming, the results should be interpreted cautiously as this may not be realistic in the long run. Last
but not least, we assume that by reclaiming abandoned ponds, interest in fish farming will be aroused and that part of the income generated will be used for restocking to ensure sustainability. With additional income we expect family members to afford protective and preventive tools for controlling malaria.

Previous studies have concentrated on proving the relationship between house income or socioeconomic status and disease burden. This is probably one of the few studies that link mosquito vector control with income generation as way of sustainably involving communities in disease control and efforts are underway to explore if indeed income from fish farming reduced malaria incidence in the families concerned before scaling up to communities with similar challenges.

Conclusion

Abandoned fish ponds provide suitable conditions for mosquito vector breeding and thus posing a health hazard. Pond owners need to be enlightened on the advantages of maintaining the ponds active and how they can contribute towards malaria vector control. By utilizing the ecologically sound strategies of mosquito vector control through IVM, communities can easily be mobilized to participate in malaria control. The use of fish as a biological control agent for mosquito larvae as well as an IGA activity ensures the human health component and socio-economic aspects are addressed concurrently. At the heart of this strategy lies social change in the form of poverty alleviation and education. The community needs to understand the problem and feel empowered to make changes to their lives. Further research is required to show if indeed by empowering communities through income generation, disease incidence is reduced/eliminated.

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Conflict of interest

Authors declare no conflict of interest. The funding organization did not have any role in the collection of data, analysis and interpretation of the results.

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