Study of larvivorous fish for malaria vector control in Somalia, 2002

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دراسة الأسماك الآكلة لليرقات في الصومال عام 2002

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الخلاصة: أُجريت دراسة تدخُّلية حول إدخال الأسماك الآكلة لليرقات من نوع الصَّبغاوات المبقَّعة الذيل كأحد طرق مكافحة نواقل الملاريا في قرية كالابييد في شمال الصومال، علماً بأن هذا النوع من الأسماك صامدٌ لتركيز يصل إلى 1.0 مغ/ل من الكلور. وقد أدخلت الأسماك في 25 مستودعاً مائياً، وبعد شهر نقص عدد اليرقات بمقدار يتراوح بين 16.5٪ و78.6٪ (52.8٪ وسطيّاً) وقد كان تقبُّل أفراد المجتمع المحلي ومشاركتهم جيدين ويُعَدُّ إدخال الأسماك الآكلة لليرقات طريقة رخيصة لمكافحة نواقل الملاريا، إلا أن ضمان الاستمرارية يحتاج لاهتمام خاص. ولتثقيف المجتمع أهمية بالغة ولاسيَّما في فصل الجفاف الذي تجف فيه معظم البِرَك.

ABSTRACT An intervention study was conducted on the introduction of the larvivorous fish *Oreochromis spilurus spilurus* as a method of malaria vector control in Kalabeydh village, northern Somalia. This species is resistant to chlorine in water up to a concentration of 1.0 mg/L. Fish were introduced into 25 *berkit* (reservoirs). After 1 month the number of larvae in each *berkit* was reduced by between 16.5% and 78.6% (mean 52.8%). Community acceptance and participation was good. The introduction of larvivorous fish is a cheap method of malaria vector control, but its sustainability needs special consideration and education of the community is important, especially to cover the dry season, when most of the *berkit* dry up.

Etude sur les poissons larvivores pour la lutte contre les vecteurs du paludisme en Somalie, 2002

RESUME Une étude d'intervention a été réalisée sur l'introduction du poisson larvivore *Oreochromus spilurus spilurus* comme moyen de lutter contre les vecteurs du paludisme dans le village de Kalabeydh, au nord de la Somalie. Cette espèce résiste au chlore dans l'eau jusqu'à une concentration de 1,0 mg/L. Des poissons ont été introduits dans 25 *berkits* (réservoirs). Au bout d'un mois, le nombre de larves était réduit de 16,5 % - 78,6 % (moyenne : 52,8 %). L'acceptation et la participation de la communauté étaient bonnes. L'introduction du poisson larvivore est une méthode de lutte contre les vecteurs du paludisme peu coûteuse mais sa viabilité nécessite une attention particulière, et l'éducation de la communauté est importante, en particulier pendant la saison sèche, durant laquelle la plupart des *berkits* s'assèchent.

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Introduction

Malaria is one of the major diseases in Somalia [1], with *Plasmodium falciparum* causing more than 90% of all cases, the remaining 10% being caused by either *P. vivax* or *P. malariae* [2]. Epidemics occur in a cyclic pattern with an interval of several years and mortality and morbidity are high. Otherwise, malaria is limited to certain villages where there are permanent water sources such as small foothill streams and shallow wells.

There were no malaria control activities in place at the time of this study, after a decade of protracted war and conflict. There were no significant vector control activities either, although the World Health Organization (WHO) regularly provides antimalaria drugs and laboratory supplies.

A project on malaria vector control using larvivorous fish, which was jointly implemented by WHO and the then Ministry of Health of Somalia in the early 1980s, had a positive result, with a significant reduction in both mortality and morbidity in the district in which the project was carried out [3].

Larvivorous fish are naturally found in several streams in the foothills of a range of mountains (Gollis range) that runs east–west along the Red Sea coast of Sahil and Awdal regions. Three species of such larvivorous fish were said to be available in these areas. These fish, especially species of tilapia, are present in 4 streams which have permanent water in the Sahil region, namely: Bixin, Biyoley, Hudusa and Lafaruug. The commonest and most efficient species is the tilapia *Oreochromis spilurus spilurus*. The presence of *O. spilurus spilurus* has been documented previously [4], and we discovered that it was still abundant in all 4 streams, though the local residents informed us that numbers are usually reduced by heavy water flows during the rainy season.

With the lack of current malaria vector control activities in the county, the introduction of larvivorous fish could be an appropriate method of vector control. It was deemed necessary to first conduct a baseline study to verify the efficiency of the fish and the willingness of the community to participate in this approach.

The objectives of the study were to determine the chlorine resistance of the fish *O. spilurus spilurus*, to evaluate the larva-eating capacity of the fish in the laboratory and in the *berkit* (man-made cement reservoirs used for water storage) and to test the feasibility, acceptability and applicability of controlling malaria vectors using larvivorous fish with the involvement of the local community.

Methods

This intervention study was conducted over a 1-year period starting February 2002 at the study centre in Hargeisa and at the field site in Kalabeydh village, Gabiley district, northern Somalia.

Fish collection for rearing

In February 2002 we collected larva-eating fish from the following villages in Sahil region: Hudusa 24 fish, Lafaruug 32 fish, Bixin 28 fish. We introduced these into 2 fishponds in Hargeisa and used them to determine chlorine-sensitivity and to study their larva-eating capacity.

By early September 2002 we had rehabilitated the fish-breeding pond located at the district hospital in Gabiley. The pond is a cement tank of length 3.0 m, width 2.5 m and depth 2.0 m. In the middle of the pond there is a dividing wall 1.0 m high with a communicating hole in the centre. There were a high number of larvae in the pond. We collected fish from Lafaruug village (around 130 km east of Gabiley) and on 5 September 2002 we introduced 12 fish into the pond (3 days later there were no larvae in the pond except some 1st and 2nd instars)

Chlorine sensitivity of tilapia

With the support of a water and sanitation expert, we prepared chlorine solutions and carried out sensitivity tests.

A 1% stock solution of calcium hypochlorite (HTH 70, 70% free chlorine) was prepared and used to make up the test solutions. Five buckets of 20 L capacity were prepared. Four of them contained 10 L treated water each in concentrations 0.5 mg/L, 1.0 mg/L, 1.5 mg/L and 2.0 mg/L chlorine; the fifth contained 10 litres of untreated water for control purposes.

We selected 10 fish of similar size from the breeding pond and introduced 2 fish into each bucket. The buckets were then covered with a piece of mosquito net to prevent the fish jumping out. All the fish were introduced at the same time. The condition of the fish was followed up at 30 minutes and 1 hour, then hourly to 24 hours.

Larva-eating capacity of the fish

This activity was conducted at the central study site in Hargeisa between 20 and 30 July 2002.

We collected larvae from *berkit* in Garabis village, 18 km south of Hargeisa. To collect the larvae we used a large dipper and transferred them into jerrycans of capacity 20 L, one-third full of water. The jerrycans were transported to the study centre in Hargeisa the same day. A satisfactory number of larvae (250–300) were counted out into each of 10 large basins of water. Most of the larvae were 2nd, 3rd and 4th instars.

We selected 10 medium-sized fish from the breeding pond, recorded their weight and length and introduced 1 into each basin. We selected fish of similar size and length and provided them with more or less the same number of larvae. The basins were then covered with mosquito net to prevent the fish jumping from the basin and to avoid external contamination.

After 24 hours we counted the number of larvae remaining in the basins.

Community awareness and orientation

On 12 March 2002, we organized a meeting with the elders of the community in Kalabeydh village. Around 14 men and 4 women participated. The objectives of the meeting were to inform the community about the study, explain the main components and details of the study, get acquainted with the community leaders, learn the views and comments of the elders regarding the study and ask for their collaboration and support.

In early April 2002 we again met with the community leaders. We displayed some of the larva-eating fish and explained the various benefits of the fish such as: mosquito control, malaria control, nutritional value and cleaning of the *berkit*. We also met the owners of the *berkit* and discussed the benefits of larvivorous fish with them. In addition, we visited the local school and explained the uses of the fish.

Knowledge, attitude, behaviour and practices surveys

In May and June we regularly contacted the community for the knowledge, attitudes, behaviour and practices study and other community interaction activities. Interviews were carried out based on a household survey. A qualitative questionnaire was prepared and trained interviewers conducted the interviews. Almost all the households of the village were included since the population was so small that a cluster survey was not applicable. We interviedwed 162 heads of households, 120 (74.1%) woman and 42 (25.9%) men

Situation of the *berkit* in the village

There are 32 *berkit* in and around Gabiley village. Six were broken and could not retain water. In 20 of the *berkit* larvae were found and fish were introduced; in 5 of them no larvae were found, but we nevertheless introduced fish. This decision was made because we had promised the community that we would introduce fish into all the *berkit* to reduce the number of mosquitoes and clean the water. In addition, we wanted to see whether mosquitoes would breed in those *berkit* despite the presence of the fish. One owner refused to introduce the fish despite the presence of some larvae; he claimed that he would use oil in his *berkit* instead of fish.

Larva density assessment

Owing to undetermined factors, there were no larvae in the *berkit* before August; the first batches of larvae had appeared by the end of the month.

Berkit are usually large and contain a large volume of water, so long-tailed dippers of 2 L capacity and opening of 30 cm diameter were introduced into the 4 corners of each *berkit*, i.e. 4 dippers per *berkit*. The collected larvae were transferred into a bucket containing around 4 L of water.

The first step was to check the larvae in the bucket. Pupae and 3rd and 4th instar larvae are easily visible and identifiable. From observation of the water surface, the presence of both *Anopheles* and *Culex* spp. larvae could be established. The former lie in a horizontal position on the surface of the water while the latter lie head-down, perpendicular to the surface. Besides this, the long siphons of the *Culex* spp. larvae are readily visible.

Larvae were then taken from the main bucket using a plastic dipper of 30 mL capacity or by filtering through a piece of mosquito net into an empty bucket. Using magnifiers and/or a microscope to see clearly the siphon of the *Culex* larvae and the palmate hairs of the *Anopheles* larvae, the number of larvae was counted and classified as *Anopheles* or *Culex* spp. and the stage determined.

Introduction of fish into the *berkit*

The nearest location where fish are naturally available is in the stream at Lafaruug village in Sahil region, which is around 148 km east of Kalabeydh (study village). On 8 September 2002, we started to collect fish from this stream using locally made fishnets. The density of the fish in the stream was very high. We transported the fish in jerrycans one-third filled with water, normally 8 fish in each jerrycan.

Usually, we arrived at Hargeisa or Gabiley the evening of the same day. On arrival, we transferred the fish from the jerrycans to the larger basins. About 2%–6% of the small fish died during transportation, possibly due to stress or hypo-oxygenation due to the small container. The fish were kept overnight without food and early the following morning we transported them to Kalabeydh.

We took fish from Hargeisa fish breeding pond on 1 occasion, but the number of fish in this pond had been dramatically reduced since they were being used for a development programme going on in the area.

We decided to first introduce fish into those *berkit* in which larvae were found and afterwards introduce them into the remaining *berkit*, even though there were still no larvae in them. On each introduction day we had a short discussions with the owners or their representatives about such issues as acceptance of the introduction of fish into his/her *berkit*, benefits, care of the fish, what can be harmful for the fish and the plan for sustainability.

We registered the owner's name and measured the dimensions of the *berkit*. The depth was usually 3 m, although a few were deeper or very exceptionally shallower.

After the determination of larva density, we transferred the fish from the containers into buckets, counted the number of fish needed to introduce into that particular *berkit* and slowly put the fish into the water. This was done in the presence of the owner (except for 2 *berkit* where we could find neither the owners nor their representatives). On average 1 fish was introduced for every 3–4 m^2 surface area. We ensured that we introduced both female and male fish into each *berkit* so they could continue to reproduce.

For the sustainability of this project we agreed with the village community, as well as the district commissioner of Gabiley district, that they would keep fish in at least 2 *berkit* over the winter season, during which most of the *berkit* dry up and fish consequently die. The alternative would be to collect fish from the fishbreeding pond in Gabiley 18 km away and reintroduce them into their *berkit* when the rainy season resumed the following year.

Post-intervention larva density assessment

One month after the introduction of the fish into the *berkit*, the second assessment of larva density was carried out. Because of the short period between the 2 assessments, other factors that may affect the development of larvae, e.g. temperature, humidity, development of larva eaters such as tadpoles and consumption of the water by humans and livestock, were considered insignificant. The procedure was carried out using the same method as in the pre-intervention stage, i.e. taking 4 dips from the 4 corners of the *berkit* and then counting the number of larvae in each dip.

The assessment began with the first *berkit* in which the fish were introduced and continued in accordance with the date of introduction.

Results

Chlorine sensitivity

After 30 minutes, the fish introduced in the water that contained 2.0 mg/L and 1.5 mg/L chlorine became very active and appeared to be irritated and after 2 hours those in the 2.0 mg/L basin all died.

Those in the chlorine concentration of 1.5 mg/L first became weak and after 3 hours they also died.

All the other fish (1.0 mg/L, 0.5 mg/L and 0 mg/L chlorine) remained alive and were very calm, active and swimming normally 24 hours after introduction.

Larva-eating capacity of fish in the laboratory

Most of the 10 fish tested during the study ate more than 90% (minimum 83%, maximum 99%) of the total number of larvae that had been given within 24 hours.

The fish used in the experiment were not the largest of their species. Those we tested weighed between 24.0 g and 34.1 g. We have encountered fish weighing as much as 72 g.

Knowledge, attitude, behaviour and practices survey

Only 56.2% of the 162 interviewees knew about malaria in the pre-intervention study. This rose to 66.0% in the post-intervention interview. At the same time, 22.8% (pre-intervention) and 30.5% (post-intervention) reported that they had had an episode of malaria, but most of these occurred several years before. Only 7 persons (4.3%) reported having had malaria in the previous year.

Of the people interviewed, 19.1% (pre-intervention) and 23.0% (post-intervention) reported knowing another person in their family who had had malaria episodes, with 4.9% and 8.0% respectively claiming that they knew of 1 person who had died from malaria in a period ranging from 1 month to 10 years previous to the study.

The 2 main traditional treatments reported by the interviewees were inducing diarrhoea using local laxatives and camel milk. About 16% of those interviewed claimed they knew of at least 1 form of malaria control activity, rising to about 44% in the post-intervention survey. There was a significant increase also in knowledge about malaria, its mode of transmission, protective measures and the importance of larvivorous fish.

In the pre-intervention survey, 58.6% of people judged the introduction of the fish acceptable. In the post-intervention survey, 83.0% said they would accept the introduction of the fish into their *berkit* if they owned one.

Impact of fish on larva density in the *berkit*

Fish were introduced into 25 out of 26 *berkit* in the village. Of these, 21 had larvae in various numbers, no larvae were found in 4 of the *berkit*, while the owner of 1 *berkit* refused to introduce fish.

During the post-intervention assessment of the larvae it was noticed that the number of larvae had been dramatically reduced (Table 1). The maximum reduction was 78.6%, which was for a small cement *berkit* built above the ground (instead of dug into the ground in the usual way). The minimum reduction was 16.5% and the mean was 52.8%.

Discussion

Tilapia fish, which are naturally available in several streams in northern Somalia, have a very high larva-eating capacity. The species of larvivorous fish used in our study, identified as tilapia *O. spilurus spilurus*, can resist living in chlorinated water up to a concentration of 1 mg/L. This means it can be used in the normally chlorinated piped water, which usually has a concentration of less than 1 mg/L, and in urban water tanks as an alternative method of mosquito control.

Clearly, the knowledge of the community regarding malaria and malaria control was limited. Larvivorous fish were not known to the people in Kalabeydh but when the advantages were explained, acceptance of introducing the fish into their reservoirs was very high. Most of the people interviewed mentioned one or other traditional form treatment of malaria, but it seems that outbreaks are not perennial but cyclic, with significant intervals between outbreaks.

The substantial reduction in numbers of larvae in the *berkit* was probably due to the tremendous larva-eating capacity of the fish. The only other factor that could have affected larva numbers would be the average temperature, which was slightly lower in October (20 °C) than in September (22 °C). In fact, the fish may have eaten even more larvae if they had not been fed prior to their introduction. Since in many areas where malaria is endemic the only available breeding sites are man-made reservoirs, there is no doubt that introduction of this larvivorous fish in these water sources will dramatically reduce the mosquito population in these villages and hence malaria infection. Our findings are a practical demonstration that using larvivorous

Table1 **Reduction in the number of larva in the *berkit* of Kalabeydh village after the introduction of larvivorous fish**

***Berkit* no.**	**No. larvae**		**Reduction %**
	Pre-intervention	**Post-intervention**	
1	102	39	61.8
2	151	60	60.3
3	89	45	49.4
4	52	32	38.5
5	64	23	64.1
6	111	40	64.0
7[a]	87	39	55.2
8	14	3	78.6
9	95	39	59.0
10	73	28	61.6
11	54	22	59.3
12	58	25	56.9
13	73	21	71.2
14	85	71	16.5
15	64	28	56.3
16	74	59	20.3
17[b]	0	0	–
18	59	35	40.7
19	98	49	50.0
20	64	26	59.4
21	54	34	37.0
22	0	0	–
23	59	28	52.5
24	0	0	–
25	0	0	–
26	0	0	–
Total	1580	746	52.8

[a]*Berkit constructed above ground.*
[b]*Owner refused to introduce fish.*

fish for vector control can be a very efficient method of tackling malaria.

The results of this study are in agreement with several reports documenting the success of using larvivorous fish as a vector control method. Larvivorous fish were part of an integrated control programme that succeeded in eradicating malaria from the Southwest Pacific [*5*]. Based on the results of similar studies on the indigenous larvivorous fish *Aphanius dispar* in Ethiopia and Djibouti, fish have been introduced on an operational scale for the control of malaria transmission on those countries [*6,7*].

Other such activities were being carried out in northern Somalia around the same time as our study. There were outbreaks of malaria in 2 regions and to tackle the epidemic, WHO officers decided to distribute larvivorous fish into the areas affected. They introduced the fish into 20 villages in Sahil and Togdher regions. They collected the fish from their natural sources and introduced them into the *berkit*. There is also a special programme known as basic development needs and under this programme larvivorous fish have been distributed in 8 villages.

We visited some of these villages and noted that community acceptance was very high; in fact, owners whose *berkit* had no fish were eager to join the scheme. To be sustainable, however, the programme requires continuous observation and care of the fish, otherwise the whole effort would be wasted.

According to the findings of the study, the tilapia fish has a strong resilience in many aspects, especially in adapting to the environment, but it seems to be very sensitive to extreme pollution of the water and to substances such as lime and diesel oil. We noticed an increase in mortality of the fish, particularly the smaller ones, in *berkit* where people had introduces these substances.

Conclusions

We hope that this baseline study of larvivorous fish will be supportive to the malaria control activities in Somalia.

Chlorine resistance of the fish is important; they must be able to survive in the normal chlorine concentration of drinking water. Our results demonstrate that this is the case, and therefore the locally available tilapia species would be suitable for vector control in chlorinated water.

The efficacy of the fish was outstanding in the laboratory tests on larva-eating capacity. Having seen the lack of larvae in the water sources in which the fish naturally live, along with the considerable reduction in the number of larvae in the *berkit* into which fish were introduced in Kalabeydh village, it is evident that this species, *O. spilurus spilurus*, could be used as a very efficient method of controlling mosquitoes in areas where the water resources, and thus breeding sites for mosquitoes, are limited to man-made reservoirs (*berkit*).

Larvivorous fish could be used as the primary malaria vector control activity in this region as well as in other regions of Somalia which have similar geographical features. The fish could be distributed to all suitable villages supported by activities to encourage people to use the fish as a nutritious food and to inform and educate them on keeping the fish and how to sustain them through the dry season. Because the *berkit* normally dry up in winter, efforts should be made to obtain species of fish (e.g. annual fish, *Nothobranchius* spp.) that lay their eggs in the mud to hatch when the rain resumes. Sustainability of this fish would be easier than the currently used species of tilapia.

Further studies should be conducted on the breeding season of mosquitoes in *berkit* and other types of man-made reservoir and to investigate whether it is usual for them to have no significant numbers of larvae in the first half of the year.

Community acceptance and participation was much better than we expected. It seems that almost all the owners were ready to accept the introduction of the fish into their *berkit* and also to participate in the whole sustainable activity in the future.

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