5.0
REPORT APPENDICES:

IPD GRADUATION PROJECT

DESIGN OF AN **ODOUR BAITED MOSQUITO TRAP FOR MALARIA PREVENTION** IN AFRICA

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APPENDIX 2

Product Benchmarking: trap evaluation

BG SENTINEL

Pros

- The spring loaded base makes the trap collapsible.
- The wide circular canopy provides a large surface area, like that of a person, where odour is emitted.
- Odour bait mimicking human scent can be added.
- CO2 can be provided alongside the trap.
- Widely used by researchers.

Standing orientation has shown to be more attractive in the (similar) Suna-Trap.

Cons

- Not suitable for use over long periods.
- Lightweight base situated on the ground is nit suited to rough terrain, strong winds or f(flash) flooding.
- Capture rate unknown but assumed to be similar to a Suna-Trap in standing orientation (<10%).

BG SUNA

Pros

- Design decisions made based on intended use in Africa. Though plastic cone protects the catch and working parts from weather (rain and sand ingress)
- The wide circular canopy provides a large surface area, like that of a person, where odour is emitted.
- Proven to reduce malaria in the field (with collaboration of locals and researchers)

Cons

- Large and bulky parts are detrimental to transport and logistics. Catch bag has many fixing points and can be difficult to fit and remove (especially when full).
- Injection moulded parts (tooling) can be expensive.

MMX

Pros

- Design incorporates CO2 and odour attractants
- Fairly robust and protected from weather conditions including rain and sand.

Cons

- Large and bulky parts are detrimental to transport and logistics.
- Reports explain that the trap is difficult to empty and clean.
- Large plastic body is subject to damage, it is brittle and will smash if dropped.
- Production of this trap has been discontinued.

CDC LIGHT TRAP

Pros

- Small and lightweight making it easy to transport.
- The trap is easy to set up and pack away
- Canopy protects the trap from rain to a degree.
- Widely used by researchers for many years.
- Cheap to produce.

Cons

- Not robust and may not deal well with more extreme weather.
- Small fan and therefore capture area.Design doesnt especially facilitate the addition of CO2 or synthetic odours.
- Working parts are unprotected and subject to danage..

MM PATRIOT

Pros

- Relatively robust.
- Incorporates CO2 and lures.
- Easy to use in terms of cleaning and emptying the catch pot.
- Can be left for long periods of time.

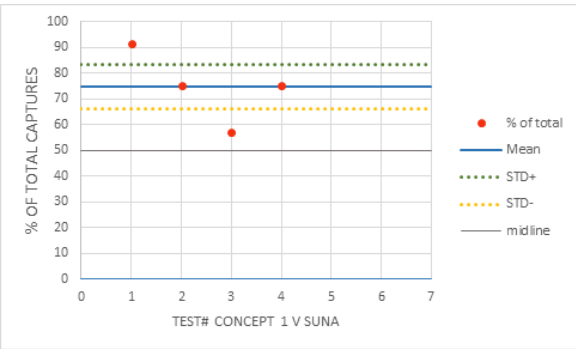
Cons

- Expensive at $330 per unit (not incl. propane tank).
- Requires propane to produce CO2.
- Heavy and difficult to transport in the field.
- Difficult to set up in the field due to large heavy parts.

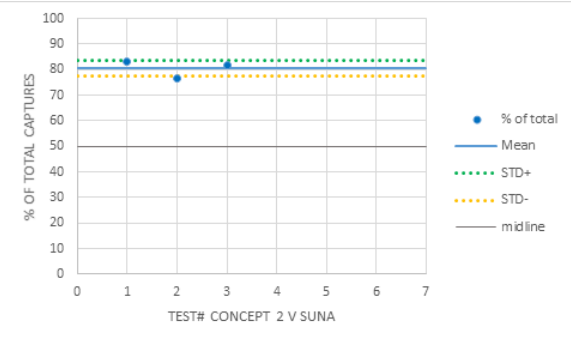
APPENDIX 3
INITIAL CONCEPT TEST RESULTS.

Duel Test Against Control

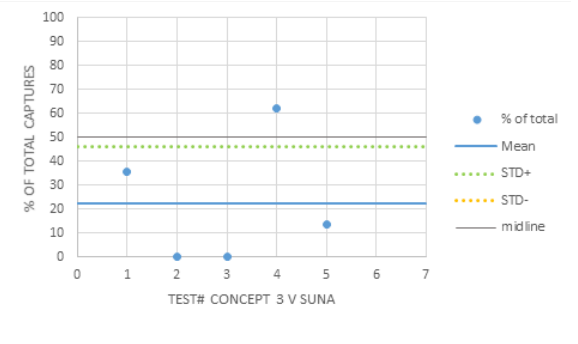
	Concept 1	Heat 1		
		Captures		
	Test #	Suna	Concept	% of total
	Test 1	2	22	91.67
	Test 3	3	9	75.00
	Test 4	9	12	57.14
	Test 5	4	12	75.00
	mean			74.70
	standard dev.			8.42



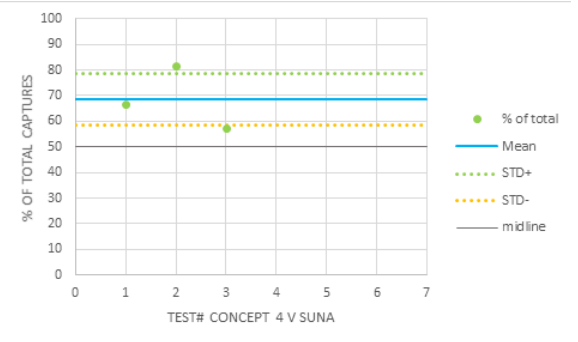
	Concept 2	Heat 2		
		Captures		
	Test #	Suna	Concept	% of total
	Test 1	4	20	83.33
	Test 2	8	26	76.47
	Test 3	2	9	81.82
	mean			80.54
	standard dev.			2.94



	Concept 3	Plug		
		Captures		
	Test #	Suna	Concept	% of total
	Test 1	9	5	35.7143
	Test 2	8	0	0
	Test 3	16	0	0
	Test 4	8	13	61.9048
	Test 5	13	2	13.3333
	mean			22.19
	standard dev.			23.763

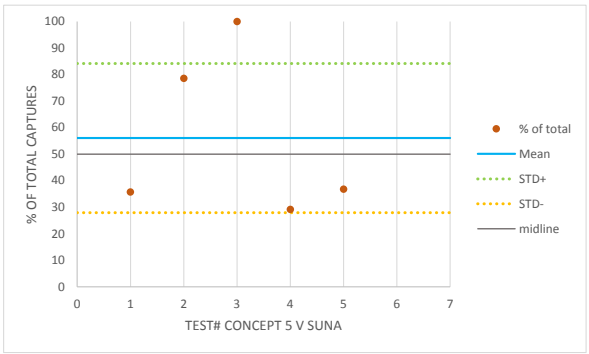


	Concept 4	Water		
		Captures		
	Test #	Suna	Concept	% of tc
	Test 1	8	16	66
	Test 2	5	22	81
	Test 3	9	12	57
	mean			68
	standard dev.			10



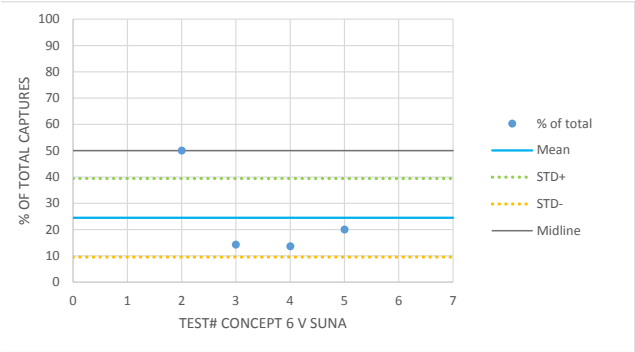
Concept 5 Canopy

	Captures		
Test #	Suna	Concept	% of total
Test 1	9	5	35.71
Test 2	3	11	78.57
Test 3	0	5	100.00
Test 4	17	7	29.17
Test 5	12	7	36.84
Test 6			
mean			56.06
standard dev.			28.09



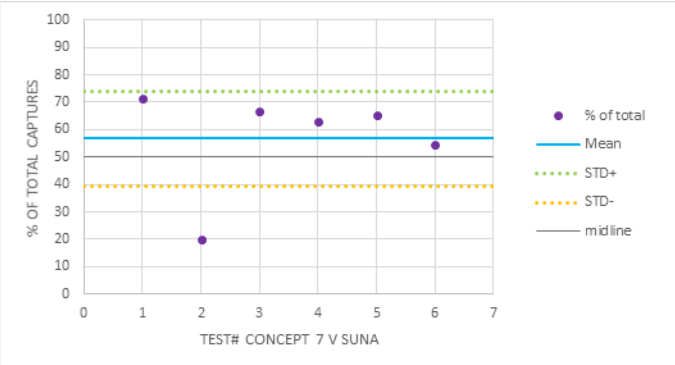
Concept 6 Overhang

	Captures		
Test #	Suna	Concept	% of total
Test 1	0	0	
Test 2	5	5	50.00
Test 3	6	1	14.29
Test 4	19	3	13.64
Test 5	16	4	20.00
Tets 6			
mean			24.48
standard dev.			14.94



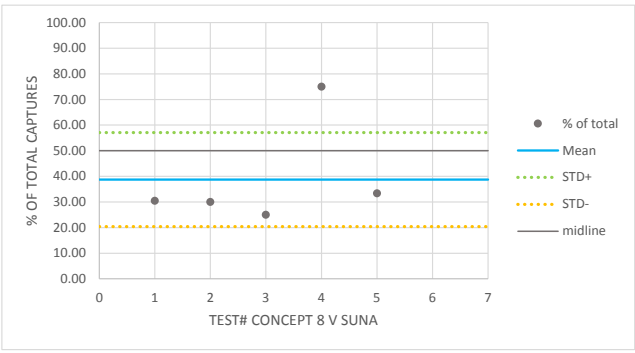
Concept 7 - Donut

	Captures		
Test #	Suna	Concept	% of total
Test 1	6	15	71.43
Test 2	8	2	20.00
Test 3	2	4	66.67
Test 4	10	17	62.96
Test 5	8	15	65.22
Tets 6	15	18	54.55
mean			56.80
standard dev.			17.22



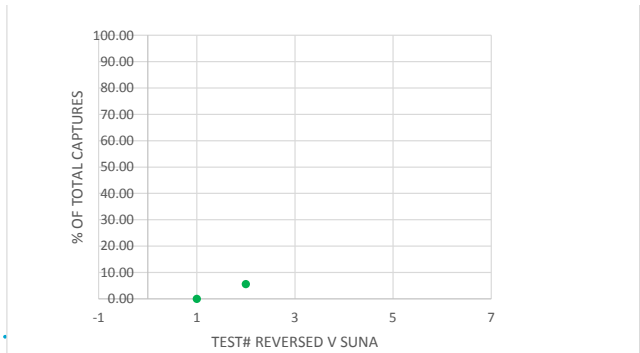
Concept 8 Lower Capture Zone

	Captures		
Test #	Suna	Concept	% of total
Test 1	16	7	30.43
Test 2	7	3	30.00
Test 3	6	2	25.00
Test 4	1	3	75.00
Test 5	16	8	33.33
Tets 6			
mean			38.75
standard dev.			18.32



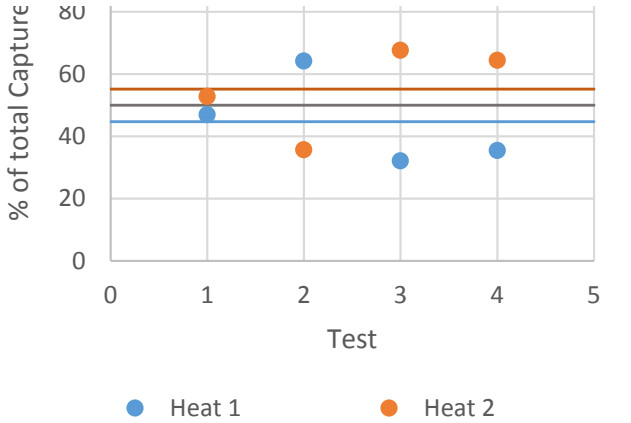
Concept 9 Reversed

	Captures		
Test #	Suna	Concept	% of total
Test 1	5	0	0.00
Test 2	17	1	5.56
Test 3			
Test 4			
Test 5			
Tets 6			
mean			2.78
standard dev.			2.78

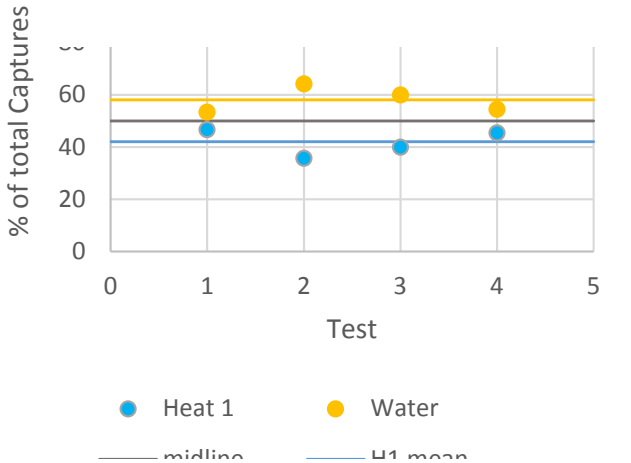


Duel Test of Heat 1, Heat 2 and Hot Water

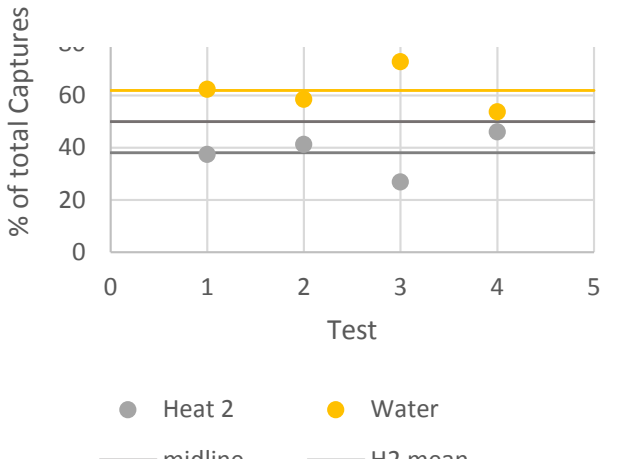
	Heat 1		Heat 2	
Test	Captures	%	Captures	%
0				
1	8.00	47.06	9.00	52.94
2	9.00	64.29	5.00	35.71
3	10.00	32.26	21.00	67.74
4	11	35.48	20	64.52
Mean		44.77		55.23



	Heat 1		Water	
Test	Captures	%	Captures	%
0				
1	7.00	46.67	8.00	53.33
2	5.00	35.71	9.00	64.29
3	14.00	40.00	21	60.00
4	20.00	45.45	24	54.55
Mean		41.96		58.04

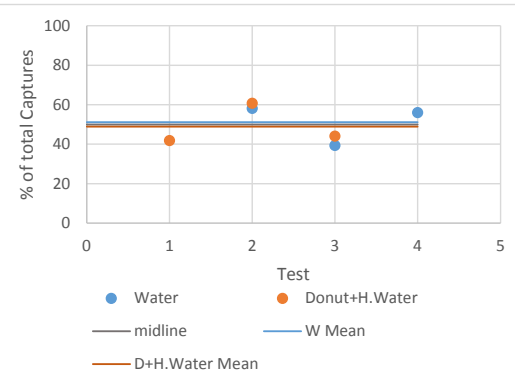


	Heat 2		Water	
Test	Captures	%	Captures	%
0				
1	9.00	37.50	15.00	62.50
2	12.00	41.38	17.00	58.62
3	10	27.03	27	72.97
4	12	46.15	14	53.85
Mean		38.02		61.98

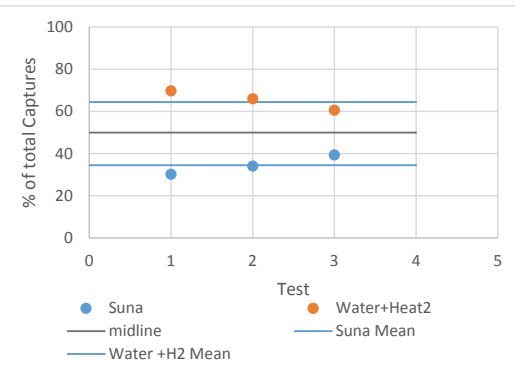


Combining Features

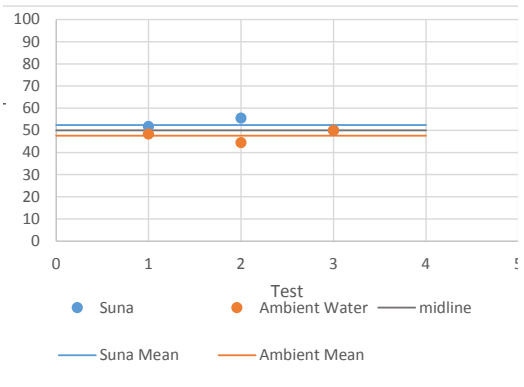
	Water V Water + Donut			
	Hot Water		Donut + H.Water	
Test	Captures	%	Captures	%
0				
1	25.00	58.14	18.00	41.86
2	11.00	39.29	17.00	60.71
3	14.00	56.00	11.00	44.00
4				
Mean		51.14		48.86



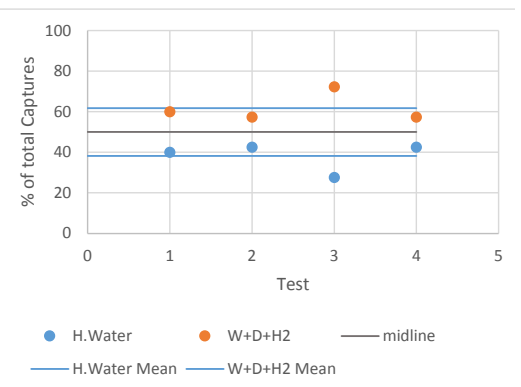
	Suna V Water+Heat2			
	Suna		Water+Heat2	
Test	Captures	%	Captures	%
0				
1	13.00	30.23	30.00	69.77
2	16.00	34.04	31.00	65.96
3	13.00	39.39	20.00	60.61
4				
Mean		34.56		65.44



	Suna V Ambient Water			
	Suna		Ambient Water	
Test	Captures	%	Captures	%
0				
1	15.00	51.72	14.00	48.28
2	20.00	55.56	16.00	44.44
3	20.00	50.00	20.00	50.00
4				
Mean		52.43		47.57



	H.Water V Water+Donut+H2			
	H.water		W+D+H	
Test	Captures	%	Captures	%
0				
1	16.00	40.00	24.00	60.00
2	20.00	42.55	27.00	57.45
3	13.00	27.66	34.00	72.34
4	20	42.55	27	57.45
Mean		38.19		61.81



APPENDIX 4
Hypothesis Evaluation

Hypothesis 1 – Concept one shows that adding heat to the outside of the inlet pipe, just below the rim, produces a higher capture performance than without. This suggests that the heating element produces a close range host cue which provokes close range flights into the capture zone.

Hypothesis 2 – Concept 2 showed the highest average increase in capture rate catching 80% of the total catches across the tests. With a small standard deviation in the results, it can be concluded that adding heat in this way increases performance. Exactly why the capture rate is increased is unknown as flight paths were not recorded but it can be assumed that the warm air re-circulating through the trap draws the targets towards the capture zone.

Hypothesis 3 – Although the concept did provide a wider capture zone with high suction velocity, this variation had a negative influence on performance. It is thought that the wider influence of the strong suction zone resulted in more of the odorous air from the trap being re-circulated and not expelled, reducing the attraction of the trap.

Hypothesis 4 – Concept 4 showed a convincing increase in capture rate and suggests that the combination of host and moisture providing close range host cues makes the trap more attractive to the target vectors. It is probable that the trap causes and increase in approach flights resulting in more captures rather than an increase in the percentage of approaches resulting in capture. It is also probable that the addition of these close range host cues results in closer approach flights which could lead to an increased number of flights resulting in capture.

Hypothesis 5 – It is not possible to make a conclusion to this hypothesis based on the results obtained. Further repetition would be needed and the 3D paths analysed to see how the canopy affects the product performance. Although two tests showed a large increase in performance, the concept was outperformed in the majority of the test. It is assumed that over a number of repetitions it would be found that the performance is approximately equal to that of the Suna-Trap.

Hypothesis 6 – It is not possible to conclude this hypothesis is a true statement. It is believed that the concept has potential and readdressing the prototype could produce more conclusive results. The reduction in performance could have been due to the foam material used for the canopy. Without recordings of the flight paths it is difficult to say if the hypothesis can be truly addressed. However, for all intent and purpose it can be assumed for now that this alteration results in lower capture performance.

Hypothesis 7 – From the results recorded it can be assumed that the intervention in shape of the base did slightly improve the capture rate. It is probably that the odour saturation of the air was increased and the trap became more attractive to the targets. With further testing and accurate simulations it should be possible to optimise this concept to further increase the capture rate.

Hypothesis 8 – It is not possible to conclude on this hypothesis. The trap performed poorly against the Suna-Trap. The canopy used in this concept featured a pattern of larger holes than that of the Suna-Trap and it was later found that this is detrimental to performance. It is therefore not possible to conclude on whether the absence of an inlet pipe inhibits performance or not.

Hypothesis 9 – Based on the initial failures in testing and the uncertainty of the effectiveness of the prototype in can be assumed that this concept does not prove this hypothesis to be true.

APPENDIX 5
Interviews

Dr A. Hiscox

:andra Hiscox

Constructed Skype Interview (informal)

mary of Discussion

duction of Intent

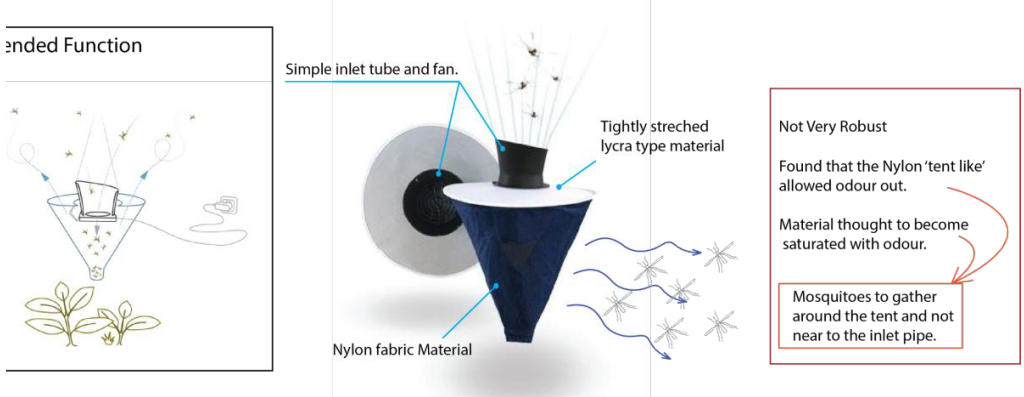
ıy thesis project I am developing a new Odour baited SMoT with an improved capture rate which could be suitable for ı Africa. The project is split into two sections: the first focusing on technological aspects which could be implemented to ɛ a trap with a higher capture rate than the benchmark Suna-trap, and the second is to investigate the context factors lesign a trap which is suitable and available (to BoP consumers) in Africa.

gn Decisions

nterested to understand the design intent behind the development of the Suna-trap and the decisions which lead to the ı of the final product.

did you approach the design of the Suna-Trap?

- The SolarMal project intended to use the Mosquito-Magnet MMX trap however the product was discontinued and no longer produced by mosquito magnet. The need for a replacement trap was required within 12 months.
- We approached Biogents for a replacement trap which could perform as well as the MMX trap in the expected Environment on Rusinga.
- One product, the Mosquitito, seemed it might be suitable however further investigation showed some potential issues which could be improved with further development.



initial evaluation concluded the Mosquitito:

- Was not robust enough for field work in Africa as the traps were going to be in permanent locations rather than moved around.
- Odour was expelled through the conical catch bag which was made of a 'sort of nylon fabric' which was thought to become saturated with odour over time (however GSMS or other analytical methods were performed to determine whether/how much odour is absorbed). This resulted in elevated levels of mosquito activity around the base of the trap rather than the inlet pipe.
- It was feared that the intended orientation and elevation the trap could be subject to flooding during the periods of heavy rainfall experienced in Rusinga.]]

Why is the back of the product a cone?

- The cone was found to become saturated and emit odour causing mosquitoes to accumulate around the base rather than around the top where they can be captured.
- The nylon material was first replaced with an aluminium cone but that was found to be too heavy. It was also too expensive and there was an anticipated risk of theft due to the value of the metal.
- In the end plastic was chosen as it was thought to be robust enough to last up to three years on Rusinga. Also, the base was not water resistant so the product could be turned upside down and the cone also served at a water cover. UV resistant plastic was used to protect against degradation over the course of three years in the field.
- Changing the cone shape was not considered due time constraints and no reason to doubt that the form, taken from the Mosquitito, needed to be changed.

- The Lycra type material that served as the canopy was also replaced by plastic as it was thought to be more robust. It was also possible to use UV resistant plastics and a white/black colour contrast between the canopy and inlet tube.
- A number of hole-patterns were trialled in dual choice tests and it was found that patterns consisting of more, smaller holes was more attractive to the target mosquitoes than options with hole-patterns of larger holes.
- The length of the CO2 outlet tube was also determined from results of dual choice test where multiple lengths of tube were tested.

- After initial development the new 'suna-trap' was tested against competitor products. (Reported in paper 'Development and optimisation of the Suna-trap as a tool for mosquito monitoring and control' by A. Hiscox et al) These being the CDC light trap, BG sentinel and MMX trap.

- The traps were tested in the lab environment as well as outside a hut in semi-field experiment set up in Africa.
- The Suna-trap was found to perform as well as, if not better than the other traps as well as found to be better suited to the intended scenario.

Rusinga

The set up for the Rusinga experiment had a trap suspended outside the home. Why was the trap placed outside the home as opposed to inside and why so close to the house?

- An objective of the SolarMal project was to determine if the implementation of mosquito traps could reduce mosquito house entry and reduce populations of outdoor biting mosquitoes. A number of trials were conducted in the semi field experiment environment to determine at which height the trap was most effective. During the trial mosquito home entry was reduced.
- There is a delay between the infective mosquito bite and the malaria infection which causes the symptoms experienced – 10-14 days on average. This makes it harder for people to appreciate the traps as an immediate benefit. Mosquito bites are still seen as an annoyance and unless people can notice a reduction in mosquito bites they may fail to see benefit of the traps in the short term. In many areas of the Island the traps caught very few mosquitoes sometimes only a couple in a night.

From what I understand, the sustainability of the trapping systems throughout the project relied on the SolarMal team and local technicians who received training and were employed by the team to help maintain the systems. However, when the experiment ended and the team withdrew, the product service system that was left didn't work for a number of reasons and in many cases traps were discarded and only the lights provided remained working,

- Yes, the systems remained with the houses in which they were installed. There was a plan for a community-based organisation to lead the maintenance of systems once the research project had ended. A 'community advisory board (CAB) were established and they in turn set up a sustainability board but were unable to source the

replacement parts and set up a business. Other problems surrounding a sustainable product service system included people's ability to save, willingness to save and overheads involved before parts can be purchased.
- It is easy for people to see the immediate benefits of the indoor lighting and there are many really good reasons for maintaining them. It is, and it is often the case, that the feeling of 'having' is better than the 'not having' something. In the way that it is easy to see the benefits of having lights at night or phone charging. When you remove a negative thing such as, stopping the mosquito bites, it is less attractive as that is how it should be. It is like providing affordable healthcare…. It's is appreciated but in a different way because that's how it should be: healthcare should be available.

What context related difficulties did you face when implementing traps in Rusinga?

- The traps are pretty big and bulky. Many of the SolarMal systems were provided to homeowners in more remote locations and each day we had to load the car (Toyota Hilux) up with cones, canopies, fans and nets and head out across country. Although the traps seem quite simple there is still a number of components and set ups often took a while. For the people receiving traps, it could take a little while to get to grips with the set up and the kind of fiddly bits. Although after a few uses it becomes easier.
- Essential smaller, more lightweight traps which are easier to distribute and install would have been great. It would also improve logistics on a greater scale especially with shipping costs etc.

It is a question which pops up regularly and the answer is still unclear – does the addition of attractants increase the number of mosquitoes drawn to the home?

- There is nothing to suggest it does. Studies have shown that the current synthetic odours are not more attractive than a human being but they are as attractive as a human odour placed in a trap. The odours given off from the home are far more attractive to mosquitoes than the odour in the trap. Mosquitoes can pick up on the elevated CO2 levels combined with odours from houses or villages from long ranges. Of course it all depends on conditions such as wind etc. but mosquitoes can pick up on plumes from 75m, 150m… 200m.
- Essentially the attractiveness of the trap is competing against humans. Placing the traps too far from the home wouldn't work as mosquitoes would be more attracted to the house or village rather than the trap.
- The current, push-pull project I am working on utilises the human odour from the eaves of the home. By implementing repellents impregnated on to fabric and positioned in the eaves the mosquitoes are repelled from the home. The trap positioned outside the home lures the mosquitoes which have been repelled, as well as those mosquitoes which are yet to encounter the home.

I investigated possible scenarios of mosquito home entry and hypothesis of behaviour which leads me to wonder if it is the overlap of odour from the home with the synthetic odour from the trap which forms a concentrated area which is very attractive to the mosquitoes and it is this that causes them to enter the trap. (Shows quick sketch home entry diagram with trap set-up).

- Yes this is quite possible and is what we imagine might be the case. However the traps do not fully prevent home entry, and bed-nets should always be used. In many cases it is thought that mosquitoes caught in the traps have been unable to find a blood host and approach the trap after exiting the home.

Looking back at the Rusinga experiment, knowing what you now know? What would you do differently in a repeat experiment?

- Probably developing the traps to be easier to transport, install and maintain. Especially so they can be left on site and continue being used successfully.
- And better development of a sustainability programme to enable the systems to keep running once the research project ended.

M. Murindahi

Interview

A PhD researcher conducting a research on malaria

Semi Constructed Interview (informal)

Summary of Discussion

Introduction of Intent

For my thesis project I am developing a new Odour baited SMoT which could be suitable for use in Africa. The project is split into two sections: the first focusing on technological aspects which could be implemented to create a trap with a higher capture rate than the benchmark Suna-trap, and the second is to investigate the context factors and design a trap which is suitable and available (to BoP consumers) in rural Africa. From this interview I hope to understand more about the social environment in which the product is intended.

Involvement with malaria prevention

Can you tell me more about what you do and your experience with Malaria and Malaria prevention in your case or Research?

The research I am working on is aims to investigate whether a Citizen Science approach can work in lower income countries to help in malaria prevention.

Despites the success that has made in the past decades in malaria control in my case, malaria is brought again on the table since its increase since 2012. There are interrelated factors that have contributed to this upsurge. These include: the variability of rainfall that increase breeding sites, temperature that influence the development of the vector and the parasite, the increase of insecticide resistance, the increase of feeding and biting behaviour change of the vectors, the drop/ low coverage of preventive measures.

In order to understand this increase and to provide with malaria mosquito data that have been missing in our country, citizen science approach is foreseen as key in mosquito control and monitoring. In addition, traditional method (HLC) do not work on the required scale due to lack of resources and funding. There is inadequate technical capacity for mosquito surveillance. With the lack of professional personal available, the approach turns to citizens to transmit their observations of their homes to scientists to help to understand the current malaria increase. Agriculture is the main sources of income in Rwanda. In the recent years, the development of agriculture has led to an important transformation of the ecological landscape, creating suitable habitats for malaria vectors. Evidence shows that the introduction of intensive irrigation agriculture increases the malaria transmission. It is very important to gather data on mosquito populations and prevalence and continue to monitor as agricultural industries continue to expand. The survey was conducted aiming to gauge the perception of nuisance in 2 settings in rural areas. The results demonstrate that research can rely on population experience and knowledge in the determination of mosquito spots. Mosquito traps were well accepted because residents saw a way to reduce mosquitoes in their home.

Participation in the research empowered the participants since they could provide their homes to collect some mosquitoes hence reduce the risk malaria transmission but also to gauge the outcome with their practices in malaria control.

Level of Knowledge

1. To what extent are people aware of the dangers of malaria?

   - People are well informed on malaria (the disease) however the knowledge on mosquitoes (breeding sites) is still low.

      a. What are the main reasons for lack of knowledge of malaria?

   - There is no Lack of knowledge on malaria (the disease) but the knowledge on the mosquitoes (breeding sites) need to be improved especially what are the practices they can do to reduce mosquitoes or to avoid mosquito biting in their environments or homes.

2. How are people educated about the dangers of malaria?

      a. Are people aware of the various malaria prevention methods (bed net, insecticides, residual spraying and traps)

   - Yes, methods currently provided or in place.

      b. Are people concerned with protecting themselves from malaria?

- People are concerned with protecting themselves but don't for a number of reasons Such as bedbug infestation as people perceive bedbug biting as a threat than mosquito bites. Bed nets are a good environment for bedbug since it become easy and direct to feed on the host during the night. Weather is another factor such as hotness, itching discomfort were among the cause for not using bed nets as found in a study conducted in the area (Ingabire et al., 2015). In the same study it was found that Men tend not to use bed net more than women do. There is not enough bed nets per house due to low coverage of bed nets. Hence lacking funds or delay in the availability of the funds can hinder the execution of activities planned for malaria control. Due to poverty, not all the people can afford a bed net because of lack of resources.

      c. How about protecting their children?

   - At a household level, the head of the household prioritize children and pregnant women. However due to unavailability of bed nets (a net per 2 persons per house), then sometime children are not protected as well especially when the number of people per house increases.

3. Are people aware of the cost of malaria treatment?

Yes they are, almost the all population have access to malaria treatment through an health Insurance programme in place however there are a few who do not have the health insurance hence cost becomes a factor to not get treatment because they can't afford it without an health insurance it costs in this case.

   a. How about the cost of prevention?

   Due to the programme which is in place that provide with bed nets.

   b. Do people not recognise that prevention costs are usually much cheaper than treatment and they could save a lot of money over a year?

- It could be possible through education to show people the potential of purchasing nets themselves by instalment hence it will help to save life and prevent them from getting sick which further will cost more for the treatment.

4. How valuable are bed nets within rural communities?
- I prefer to leave a blank since this is not a conclusion from a research it is just speculation. Leave a blank= no answer

Finance

1. What are the main financial management systems available to people in Rural Rwanda (conventional banking, mobile banking, table banking or individual savings?)
   I prefer to leave a blank since this is not a conclusion from a research it is just speculation. Leave a blank= no answer

2. Do you have any knowledge on the unofficial 'table banking' approach to community saving/lending in Rwanda? (Table banking is a group funding strategy where members (usually women) of a particular group meet once every month, place their savings, loan repayments and other contributions on the table then borrow immediately either as long term or short term loans to one or a number of interested members)
   - I do not know. However, I understand the concept and can see it can be profitable to the people in their communities.

3. In table banking groups, what are people most likely to borrow money for?
   - Probably bed nets will be the last on the list. Mainly health insurance school fees, food or other costs such as providing to birth delivery expenses for example or to invest in business development.

APPENDIX 5
SWOT ANALYSIS

Internal
attributes of the System

S
Strengths

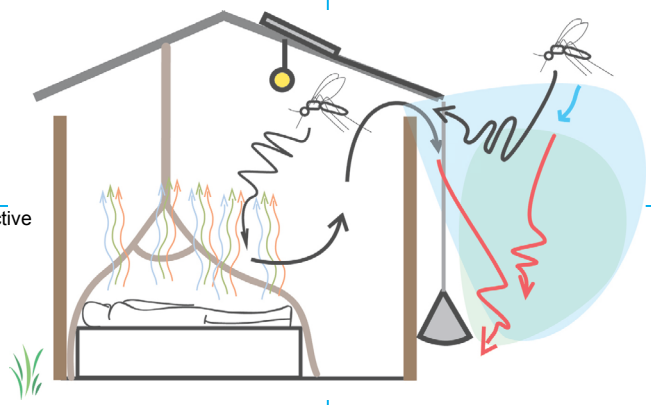
- Proven to aid Malaria prevention in field test when used alongside LLINs
- Reduces vector home entry in semi-field and field testing reducing annoyance.
- Useful research tool for entomological projects in Africa.
- Delivers perceived user benefit from reduced home entry and fewer bites.
- Users have expressed a willingness to pay monthly for maintenance of system.
- Low Power requirement from the trap

W
Weaknesses

- Low capture rate of only 4% from all paths recorded (estimated resultant capture rate 10%)
- Systems are bulky and difficult to transport/ distribute
- Current traps don't make use of close range host cues.
- Traps and parts are not available to consumers in Africa.
- Product and maintenance potentially too expensive for consumers.
- Requires community participation to sustain effective trapping over time.

Helpful
to achieving objective

Harmful
to achieving goal



External
attributes of the Context

Opportunities
O

- Improve the performance of the trap to make a more effective tool for prevention of Malaria and increasing perceived product benefit.
- Introduce heat and moisture as close range host cues to improve capture performance.
- Improve the feasibility of distribution and installation by reducing the time taken to install/ set up the trap.
- A more robust product could reduce maintenance burden making the system more affordable.
- Improve user experience by simplifying the catch bag reducing time taken to empty and replace.
- Create a demand and make the product available to consumers

Threats
T

- Trap function cannot be maintained by users in Africa.
- Low prioritisation of preventative healthcare
- Energy requirement.
- Synthetic odour strips and CO2 need to be maintained for the trap to be effective.
- System and maintenance costs may be unaffordable to many individuals in rural Africa.

SWOT Analysis

	Opportunities					Threats				
	Improve the performance of the trap to make a more effective tool for prevention of Malaria and increasing perceived product benefit.	Introduce heat and moisture as close range host cues to improve capture performance.	Improve the feasibility of distribution and installation by reducing the time taken to install/set up the trap.	A more robust product could reduce maintenance burden making the system more affordable.	Improve user experience by simplifying the catch bag removing the need to empty and replace.	Trap function cannot be maintained by users in Africa without support.	Low prioritisation of preventative healthcare	Requires electrical and human energy and additional energy requirements could be detrimental.	Synthetic odour strips and CO2 need to be maintained for the trap to be effective.	System and maintenance costs may be unaffordable to many individuals in rural Africa.
Proven to aid Malaria prevention in field test when used alongside LLINs	+	0			-	–	-		-	–
Reduces vector home entry in semi-field and field testing reducing annoyance.	+	+	+			-	+		-	-
Useful research tool for entomological projects in Africa.				+		+	+	-		-
Delivers perceived user benefit from reduced home entry and fewer bites.				+	+	-	+	-		-/+
Users have expressed a willingness to pay monthly for maintenance of system.	++						+			+
Low Power requirement from the trap		-					+	-		
Suna= Low capture rate of only 4% from all paths recorded (estimated resultant capture rate 10%)	++	++		+		-	-			
Systems are bulky and difficult to transport/distribute		-	++		+	-	-	-	-	
Current traps don't make use of close range host cues.	+	++			-	-	-		0	
Traps and parts are not available to consumers in Africa.	+			-		-	-			
Product and maintenance potentially too expensive for consumers.	–			++		–	–		-	–
Requires community participation to sustain effective trapping over time.	-			-	-	-	-		-	-

Negative Issues (Potential Problems)

- Increasing performance makes the traps more effective *versus* Users unable to maintain the system.
- The trap (system) cannot be maintained without support *versus* Use of traps alongside LLINs can reduce Malaria.
- The trap (system) cannot be maintained without support *versus* Maintenance of the trap could be too expensive for the user.
- Low prioritisation of preventative healthcare *versus* Maintenance of the trap could be to expensive to the user

Positive Issues (Potential Solutions)

- Improving performance for a more effective product *versus* Users expressed a willingness to pay
- Improving performance for a more effective product *versus* Current Traps have a low capture rate.
- Introducing heat and moisture more a more effective trap *versus* Current Traps have a low capture rate.
- Introducing heat / moisture more a more effective trap *versus* Current Traps don't have close range host cues.
- Improve distribution and installation *versus* traps are bulky and difficult to transport.
- A more robust system would require less maintenance *versus* Maintenance costs are unaffordable to users.

Key Issues

- Increasing performance makes the traps more effective *versus* Users unable to maintain the system.
- The trap (system) cannot be maintained without support *versus* Use of traps alongside LLINs can reduce Malaria.
- The trap (system) cannot be maintained without support *versus* Maintenance of the trap could be too expensive for the user.
- Low prioritisation of preventative healthcare *versus* Maintenance of the trap could be to expensive to the user

CAUSE
Low capture rates found in current products is detrimental to the potential use of odour baited mosquito traps used alongside LLINs, as tools for prevention of malaria in the field. Increasing the performance by adding a source of hot water as well as an external heating element makes the traps more effective. Although agreeing weekly upkeep was possible and showing a willingness to pay for monthly maintenance, users have shown to be unable to maintain the system without the support of a product service system. Combined with the low prioritisation of preventative healthcare and the expense associated with purchase and maintenance contributes to the low demand for the product.

EFFECT
Without improving the capture rate, as well as appropriateness in context, mass trapping of mosquitoes using SMoTs may not be effective enough to deliver the user benefit required for community wide sustenance of the system. As well as technical design challenges related to improving performance, the design most consider the use in context and address the challenges highlighted in order to be effective.

CENTRAL PROBLEM DEFINITION

With community participation and the support of an affordable and sustainable product service system, the use of odour baited mosquito traps alongside LLINs have potential to contribute to the eradication across Africa. In order to be more effective as a tool for prevention of transmission and control of vector populations, the performance of the trap must be improved. Although many insights have been gathered which can be considered during the design phase, it is not possible to design a market ready product without semi-field and field testing with users in context.