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Targeting outdoor-biting malaria vectors using odour-baited mosquito landing boxes (MLB) fitted with low-cost electrocuting grids

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Background:. On-going residual malaria transmission is increasingly due to outdoor-biting vector populations, even in communities where the common indoor insecticidal interventions like indoor residual spraying (IRS) and long-lasting insecticide treated nets (LLINs) are used. Persistent use of these insecticide–based interventions is threatened by development of insecticide resistance as well as behavioural avoidance exhibited by some mosquito species. In many communities, including those where LLINS and IRS are widely used, the proportion of mosquitoes biting outdoors, and during early hours of the night or early hours of the morning.
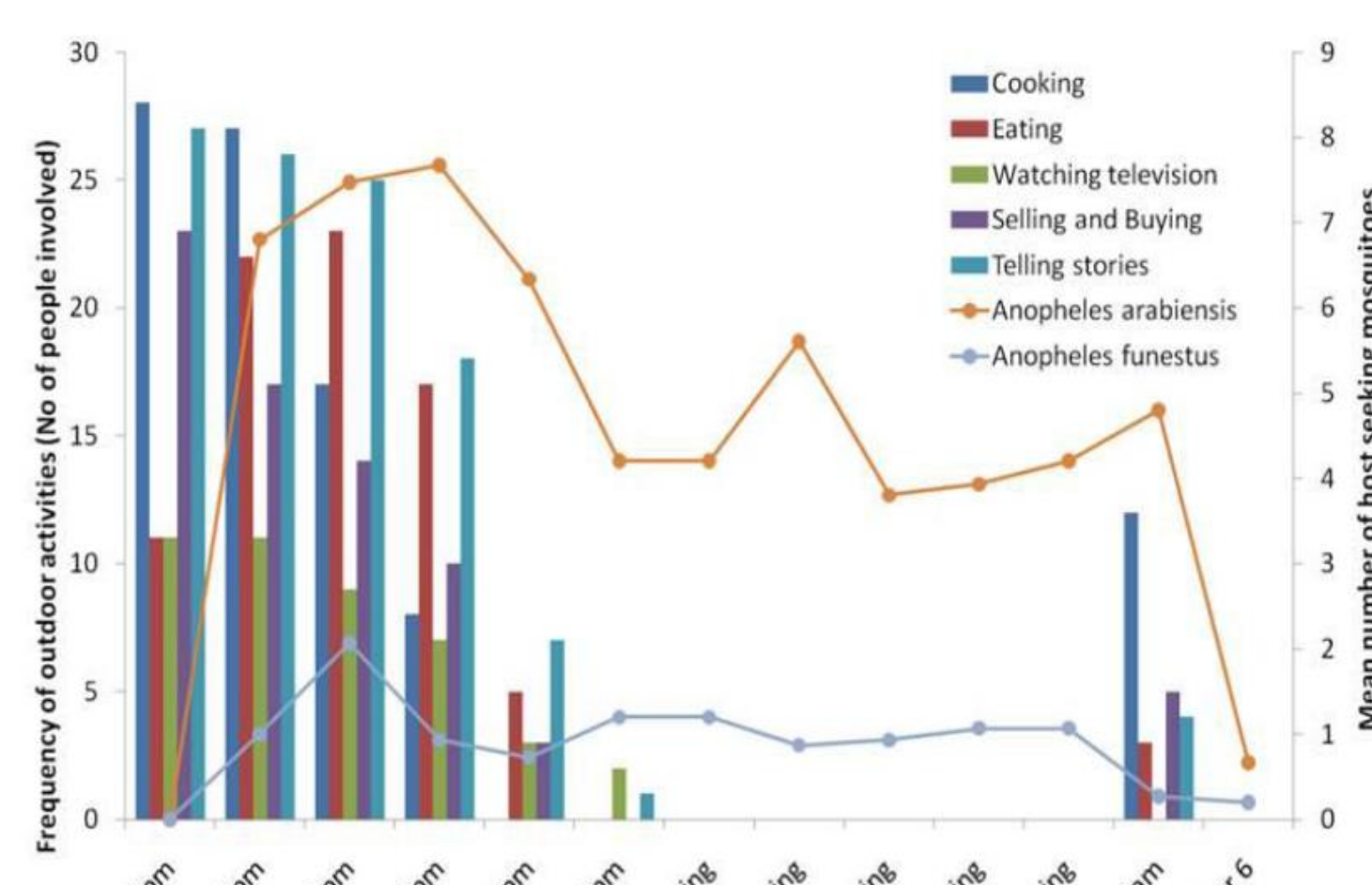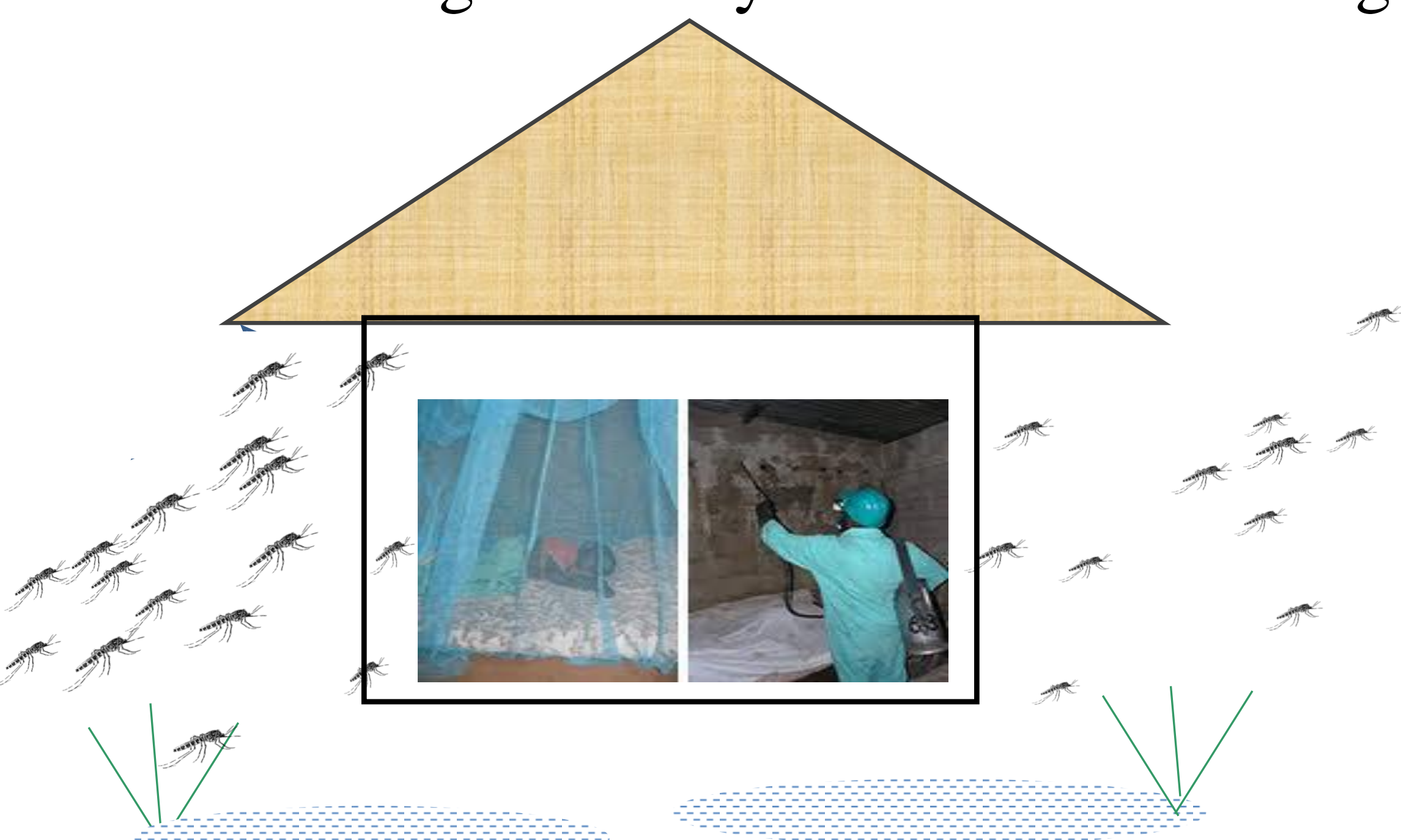
Correlation between the times when people are performing various outdoor tasks and times when host-seeking disease-transmitting mosquitoes are most active outdoors. Outdoor activities occur before 11:30pm, and after 5:00am, matches time periods when host-seeking *Anopheles arabiensis* and *Anopheles funestus* mosquitoes were active.
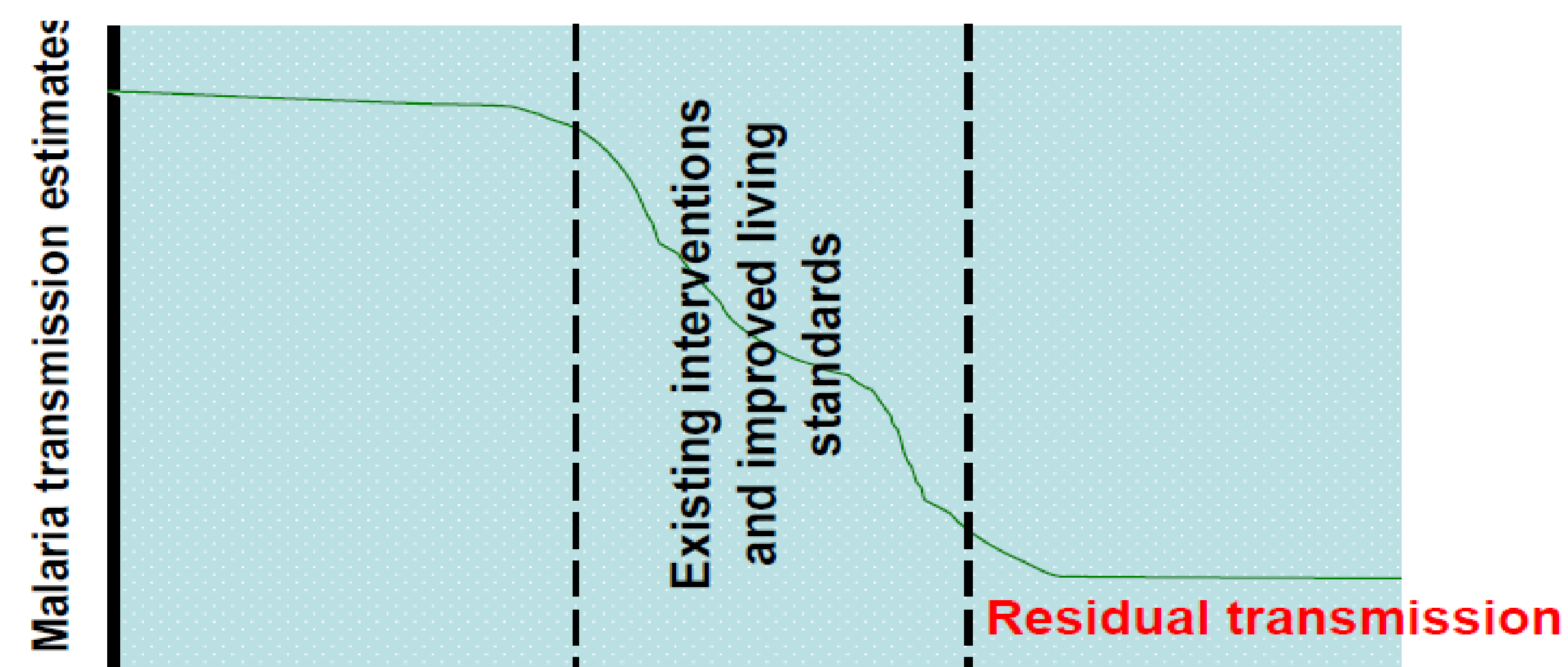
Materials and Methods: The recently developed odour–baited mosquito landing box (MLB) was modified by fitting with low-cost solar driven electrocuting grids and water-proof light sensors that automatically switches the device on at dusk and off at dawn. Three MLBs, one fitted with a single grid on one side, the second fitted with two grids on two sides, and the third one fitted with three grids on three sides were comparatively evaluated in a malaria endemic village in southern Tanzania, where malaria vectors are physiologically and behaviorally resistant to insecticide-based tools. The killing potential of these devices were comparatively evaluated against free frying wild mosquitoes using a 3 by 3 Latin square experiment in dry and wet seasons. The device was baited with synthetic blend of mosquito attractants (Ifakara Blend) and the number of mosquitoes killed by the different MLBs compared.
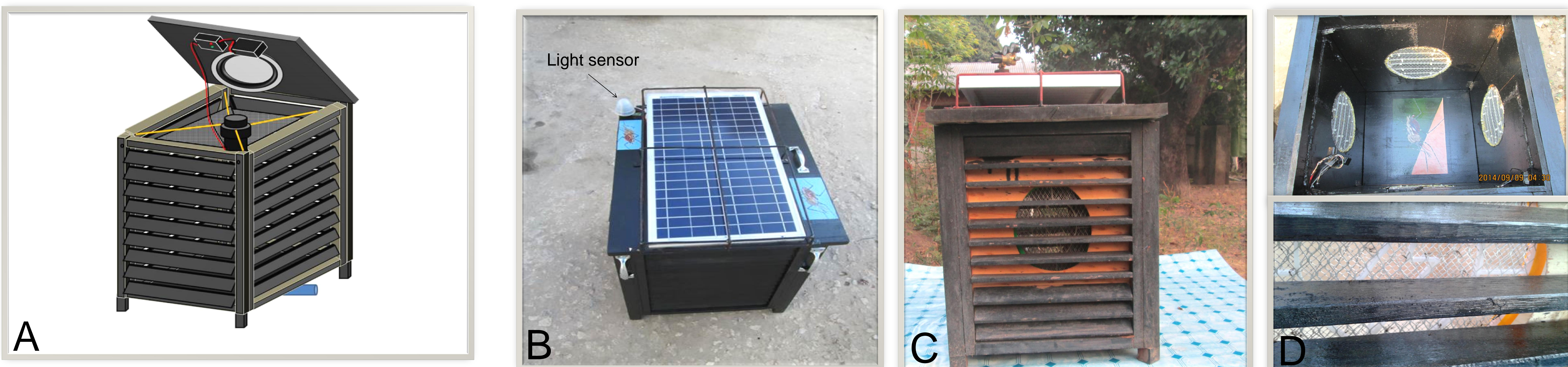
Figure 1: The odor-baited mosquito landing box is designed to mimic humans sitting outside houses, e.g. people cooking in open kitchens in rural communities. Fitted with a water-proof light sensor, and a solar power supply system **(B)**, and electrocuting grids on its sides **(C).** The MLB attracts and instantly kills host-seeking mosquitoes, including major malaria vectors, without destroying the morphological features of the mosquitoes.

Findings 1: Estimated mean number of malaria mosquitoes collected per night from MLBs with grids

Round 1 (Wet season)	Treatments	Anopheles arabiensis			Anopheles funestus		
		Mean [95% CI]	RR [95% CI]	P value	Mean [95% CI]	RR [95% CI]	P value
		13.82 [9.90-19.28]			0.15 [0.05-0.45]		
	Grid 1		REF	REF		REF	REF
	Grid 2	21.97 [18.95-25.47]	1.59 [1.37-1.84]	<0.001	0.14 [0.05-0.36]	0.95 [0.36-2.52]	0.913
	Grid 3	36.04 [9.16-141.76]	2.61 [0.66-10.26]	<0.001	0.23 [0.09-0.55]	1.56 [0.64-3.81]	0.335

Round 2 (Dry season)	Treatments	Anopheles arabiensis			Anopheles funestus		
		Mean [95% CI]	RR [95% CI]	P value	Mean [95% CI]	RR [95% CI]	P value
		17.67 [15.64 -19.96]			0.03 [0.01-0.14]		
	Grid 1		REF	REF		REF	REF
	Grid 2	32.65 [29.07-36.67]	1.85 [1.65-2.08]	<0.001	0.13 [0.06-0.31]	4.79 [2.08-11.02]	<0.001
	Grid 3	28.79 [25.54-32.45]	1.63 [1.45-1.84]	<0.001	0.02 [0.01-0.05]	0.73 [0.29-1.85]	0.515

Findings 2: Estimated mean numbers of *Culicines* and all mosquitoes species killed per night in both dry and wet seasons.

Round 1 (Wet season)	Treatments	Culex species			Mansonia species			Total Mosquitoes		
		Mean [95% CI]	RR [95% CI]	P value	Mean [95% CI]	RR [95% CI]	P value	Mean [95% CI]	RR [95% CI]	P value
		2.61 [1.79-3.81]			14.66 [10.87-19.75]			20.24 [14.72-27.84]		
	Grid 1		REF	REF		REF	REF		REF	REF
	Grid 2	3.39 [2.68-4.28]	1.30 [1.03-1.64]	0.029	12.08 [10.85-13.45]	0.82 [0.74-0.92]	<0.001	99.36 [82.35-119.89]	4.91 [4.07-5.92]	<0.001
	Grid 3	3.26 [2.56-4.15]	1.25 [0.98-1.59]	0.723	10.68 [9.50-12.01]	1.63 [1.41-1.88]	<0.001	41.53 [34.37-50.19]	2.05 [1.69-2.48]	<0.001

Round 2 (Dry season)	Treatments	Culex species			Mansonia species			Total Mosquitoes		
		Mean [95% CI]	RR [95% CI]	P value	Mean [95% CI]	RR [95% CI]	P value	Mean [95% CI]	RR [95% CI]	P value
		1.93 [1.24-2.99]			1.59 [1.01-2.51]			19.07 [13.77-26.41]		
	Grid 1		REF	REF		REF	REF		REF	REF
	Grid 2	2.78 [2.24-3.44]	1.44 [1.16-1.79]	<0.001	2.05 [1.65-2.54]	1.29 [1.04-1.59]	0.02	30.02 [27.77-32.45]	1.57 [1.46-1.70]	<0.001
	Grid 3	3.70 [2.97-4.62]	1.92 [1.54-2.39]	<0.001	4.16 [3.32-5.21]	2.61 [2.08-3.27]	<0.001	33.05 [30.49-35.82]	1.73 [1.59-1.88]	<0.001

Findings 3: Comparison of number of totals of all mosquitoes killed by MLB fitted with 1, 2 or 3 grids.
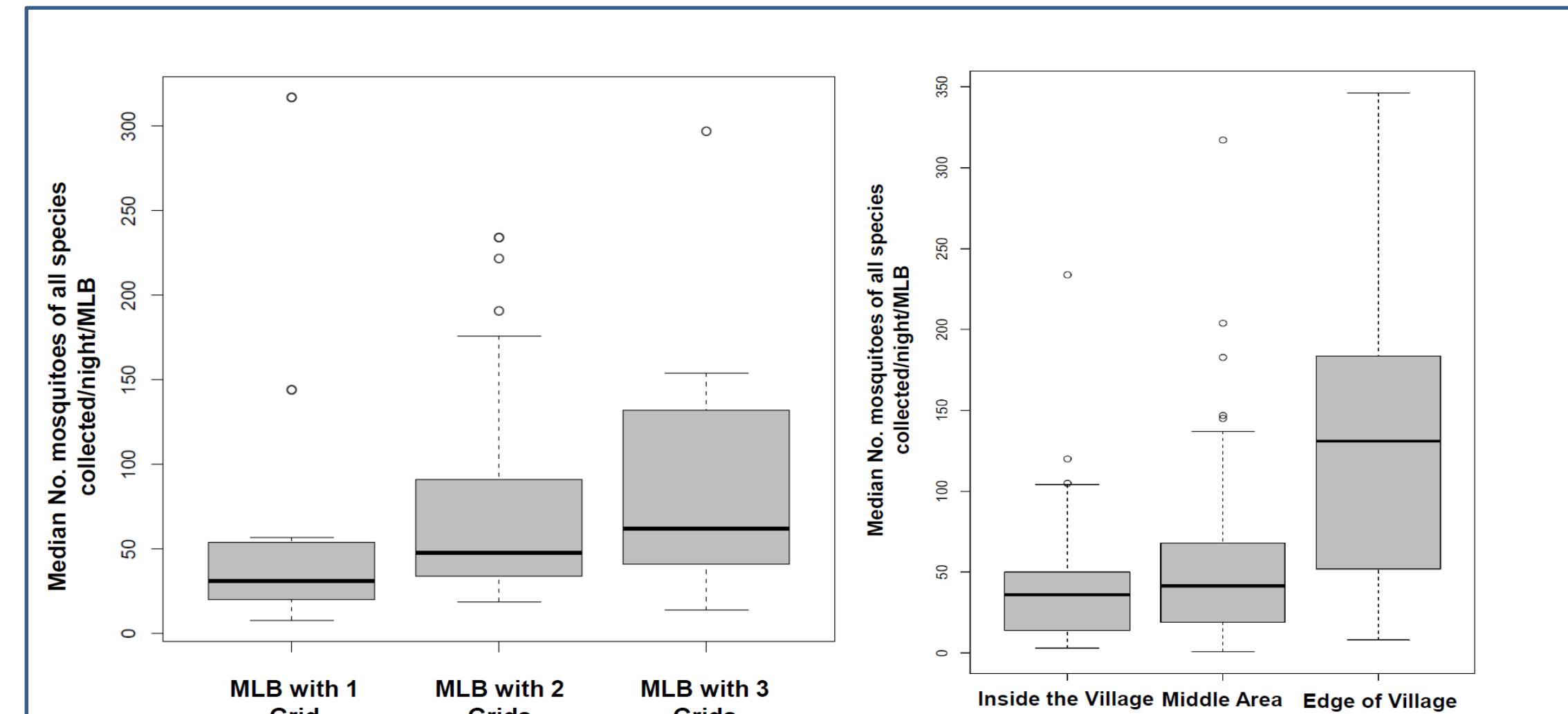
Conclusion: These findings demonstrate that the MLBs fitted with low-cost electrocuting grids and automated on/off switches, can efficiently attract and instantly kill disease-transmitting mosquitoes even if the mosquitoes are physiologically and behaviorally resistant to insecticide-based interventions. The devices could reduce outdoor-biting mosquito densities and transmission of pathogens, thereby potentially complementing existing indoor malaria prevention methods, and accelerating efforts towards elimination. They could also be used for surveillance rather than control. Further studies are underway to compare efficacy of these MLBs to other existing outdoor sampling and monitoring tools.