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Comparative assessment of fish catch using light Emitting diode bulbs and Tilley lamps for light attraction in "Chilimira" fishery in Lake Malawi

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Abstract
Fish catches and fish species composition from two sources of light for light attraction fishery locally known as "kauni", Light Emitting Diode Bulbs (LED) and Tilley Lamps (TL) in *Chilimira* fishery were studied in Salima, Lake Malawi. Fish species were sampled simultaneously upon landing from "*Chilimira"* nets where Tilley Lamps and LED bulbs were used. The study showed that there was a significant association ($p < 0.05$) between light sources and fish species caught. LED light source attracted *Ramphochromis longiceps* and fish species categorised as "other species" which included; *Copadichromis chrysonotus, Copadichromis (Mchenga) eucinostomus, Copadichromis quadrimaculatus, Diplotaxodon macrops, Opsaridium microlepis, Otopharynx argyrosoma, Pseudotropheus livingstoni, Ramphochromis woodi* and *Ramphochromis ferox*. Tilley Lamp attracted *Engraulicypris sardella* and *Rhamphochromis esox*. Multiple regression showed that there was a significant interaction between light sources and fish species ($p<0.05$) on mean weight (g) fish caught. The difference was greater in "other species" and *Rhamphochromis longiceps* than in *Engraulicypris sardella* and *Rhamphochromis esox*. The most abundant species in both sources of light was *Englauricypris sardella*. The study suggests that LED Bulbs and Tilley Lamps have different light properties (luminous intensity, luminous flux, colour, spectrum and spatial radiation) thereby attracting fish differently.

Keywords: LED bulbs, Tilley lamps, Chilimira seine net, Lake Malawi, light fishing

Introduction
Traditionally, fishers in Lake Malawi have been using pressurized kerosene Lamps for a long time [1]. The artisanal fishers use the Lamps to attract fish near the water surface and usually targets fish in schools [2]. The use of light attraction fishing is now popular in Lake Malawi where the lights turn the lake into a city of lights. The light attraction fishery, locally known as "kauni", is done in Lake Malawi exclusively using "Chilimira" net. The "Chilimira" net is an open-water seine net, conical in shape with headline length ranging between 20 meters and 70 meters but of late the gear is being increased in size to almost 100m. The "Chilimira" net continues to dominate the composition of open water seine nets (81%) with 3394 fishing units and has increased in number by 9% from 2016 to 2017 [3]. In the southern and central parts of Lake Malawi, the net is operated from two dugout canoes and one plank boat with an average crew of nine. While in the north, some fishers use one big canoe for a similar operation but the net is relatively smaller. When a shoal of fish is located, light in canoes attracts fish towards the net, it encircles the fish and hauled into the plank boat. Although "Chilimira" fishery can also be used during the day, the fishery usually occurs at night where light is used to attract fish.

The difference between the two light sources is that Light Emitting Diode Bulbs (LED) is a semiconductor device that directly converts electrical energy into visible light and radiant energy [4]. While Tilley Lamp is pressure lantern, which produces a bright white light from vapourising Kerosene. There were several types of LED bulbs that have been introduced on the Malawi market for light fishing. The most common and widely used LED lights are small bulbs of 9 volts each. Recently, there has been a sudden boom of light attraction fishing using bulbs. Unlike the traditional Tilley Lamp, the introduction of LED technology has attracted mixed reaction from fishers and managers of the fishery on Lake Malawi. Some quarters view the technology as environmentally and economically sound, while others consider it as a threat

to the targeted fish stocks and biodiversity as it is too efficient. Unlike Tilley Lamps, LED technology comes in different designs that have different light properties as such attract different fish species because different fish species respond differently to light differently [5,2]. Additionally, LED bulbs reduce cost and increase the take home cash by the fishers after selling the catch [2]. The technology is widely being adopted by fisher to which, in 2017 the number of LED was almost 5 times higher than the Tilley Lamps with 10,413 and 2,137 respectively [3]

The increasing use of this technology sparked mixed reactions from users and managers. The managers do not have information to guide users on capture fisheries in Malawi. There is no information available on the performance of LED light with regard to Tilley Lamps used in Lake Malawi. There is a need for information on fish catches abundance and species composition from "Chilimira" fishing net using LED bulbs and Tilley Lamps. The purpose of this study was to investigate the effects of differences in light properties on efficiency and effectiveness for light emitting diodes (LED) light as a fishing technology and the traditional Tilley Lamps.

Materials and Methods

Sample collection

Fish sampling was done at Nguo landing site in Salima, Lake Malawi. Three "Chilimira" fishing units using 9 volts LED bulbs (Fig. 1B) and other three using Tilley Lamps (Fig.1T) for light attraction fishery were identified at the landing site. Fish samples of about 30% were collected from all the selected "Chilimira" units upon landing for three consecutive days (15th to 17th October 2014) and three consecutive days (9th to 11th May 2017).

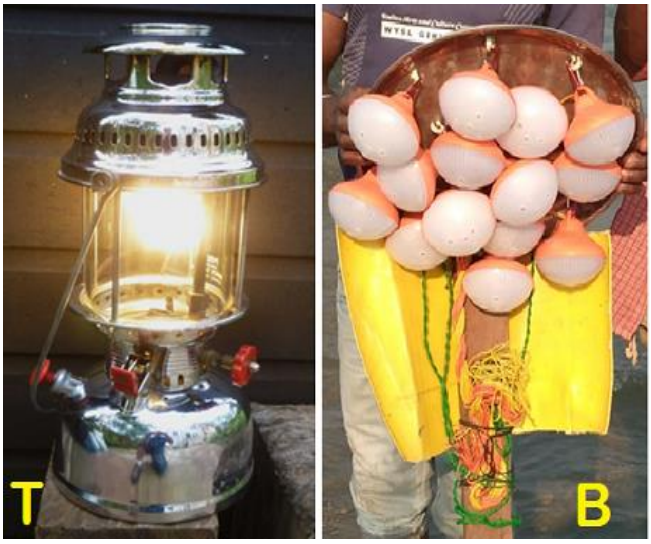

Fig 1: The traditional Tilley Lamps (T) and LED bulbs (B) used in "Chilimira" Fishery during the study.

Sampling was done simultaneously from each selected boat at the beach before fish were sold out. Fish species were sorted out with an aid of pictorial book reference of Ad Konings, 2nd edition [6], the number of individual fish species were counted and recorded. Fish weights were measured and recorded to the nearest 0.01gram (g). Total catch weight for each source of light was a sum of main catch and by-catch weight.

Data analysis

Data were analysed using IBMSPSS Statistics v20 [7]. Multiple regression model was used to determine the interaction between the Light source and fish species.

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 \ldots \beta_i x_i + \varepsilon$$

Where Y=dependent variable, α is the intercept and β_1, β_2, β_3, $\beta_4 \ldots, \beta_i$, are the regression coefficients of X_1, X_2, X_3,$X_4 \ldots$, X_i respectively.

Chi-Square was used to determine the association between light sources and individual counts for fish species caught. The fish species that had less than five individual fish counts were grouped into one named "others".

All individual fish species for the by-catch were weighed while the main catch representative samples were collected and weighed. The average weights for fish species were used to calculate a number of individual counts for the particular species from a specific light source.

$$N = (\sum W) / \frac{W}{n}$$

Where **N** = total number of individuals for the fish species, **W** is the total weight for the fish species, *W* is the fish species sample and *n* is the number of sampled individuals for the fish species count.

Results

There were 12 fish-species from seven genera found in "Chilimira" during the entire sampling period. The most abundant species was *Engraulicypris sardella*, attracted by both LED and Tilley Lamps. The most abundant by catches were *Rhamphochromis esox* and *Rhamphochromis longiceps* found in both sources of lights. Other fish species that were found in both sources of lights included *Copadichromis (Mchenga) eucinostomus, Copadichromis quadrimaculatus, Diplotaxodon macrops, Opsaridium microlepis, Otopharynx argyrosoma, Ramphochromis woodi* and *Ramphochromis ferox,* while *Pseudotropheus livingstoni* was caught in "Chilimira" using LED and *Copadichromis chrysonotus* was specifically found in boats using Tilley Lamp.

Table 1: Number of species caught when using LED or Tilley light sources

Species	Weight of fish in grams	
	LED light source	Tilley light source
Engraulicypris sardella	177 (71.1%)	190 (85.2%)
Rhamphochromis esox	21 (9.6%)	22 (2.2%)
Rhamphochromis longiceps	24 (8.4%)	5 (9.9%)
Others	27 (10.4%)	6 (2.7%)
Total	249	223

$\chi^2 = 24.939$ *p*-value = 0.000

The Chi-square (24.939, p-value=0.000) showed that there was a significant association ($p<0.05$) between light sources and species caught. The LED light source attracted more on *Ramphochromis ferox, Ramphochromis longiceps* and species categorised as "others" which included, *Copadichromis chrysonotus, Copadichromis (Mchenga) eucinostomus, Copadichromis quadrimaculatus, Diplotaxodon macrops, Opsaridium microlepis, Otopharynx argyrosoma, Pseudotropheus livingstoni, Ramphochromis woodi*. While Tilley Lamp attracted more of *Engraulicypris sardella* and *Ramphochromis esox.*

Multiple regression showed that there was a significant interaction between light sources and fish species ($p<0.05$) on

weight (g) of fish caught. Similarly, the difference on interaction was greater in "others" and *Rhamphochromis longiceps* than in *Engraulicypris sardella* and *Rhamphochromis esox* (Fig. 2).

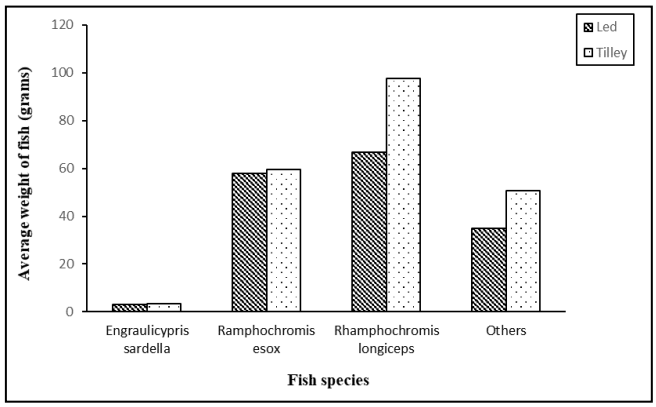

Fig 2: Level of association for the lights sources on species mean weights.

There was no significant difference in the mean weights for the catches from the two sources of light (Fig. 3).

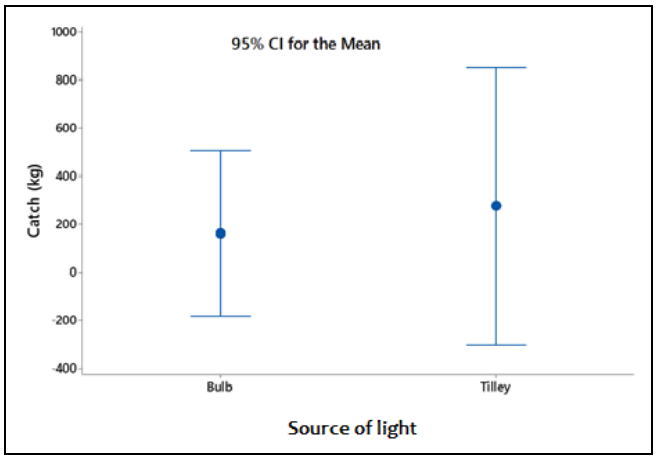

Fig 3: Mean weight difference for LED bulb and Tilley Lamp at 95% confidence interval.

Discussion

Since the mid-1970s, when the decline of capture fisheries was noticed in Malawian natural water resources, fish production from capture fisheries is no longer meeting the annual demand from the ever increasing human population in Malawi. Nevertheless, studies have shown that Lake Malawi has untapped fisheries resources in the offshore pelagic zones estimated to over 30,000 tonnes year^{-1} and this under-exploitation is mainly due to limited technology [8,9]. Notable challenges of sustaining the supply of fish include human population pressure over the resources, technological improvements for efficiency, over-dependence on fishing because of limited or lack of alternative income sources to fishing, and erosion of traditional and customary practices that being experienced after colonialism [10]. The use of LED for Lake Malawi "Kauni" fishery is fairly recent and the effects on the local fishes have not been scientifically explained.

The LED source is designed to face downwards, concentrating light down the water column aiming at fish attraction, limiting the spread of light. In general, the "kauni" fishery targets pelagic species which include all species in the genera *Rhamphochromis, Diplotaxodon, E. sardella, C. quadrimaculatus* and among other species. The common characteristic of these species is that they migrate in school and attracted to light. When the fish gather in schools around the source of light, the fishers seine (net) around them. The light properties including luminous flux, intensity, spectrum, colour and spatial radiation influence fish attraction differently. Gengnagel (2013) [2], emphasised that the quantity of energy of light emitted per second in all direction (luminous flux) is the primary determinant of catch volume. However, there was no significant difference for the mean total catch of the two sources of light (Fig. 3) as it was overshadowed by the main catch, *E. sardella* that was dominant in both sources of light comprised of over 98% of all species.

Despite the fact that there was no significant difference in mean catches for the sources of lights, it is interesting to note that fishers are interested in adopting LED technology. Fishers are shifting from using Tilley Lamps (Fig. 1T) to LED bulbs and in 2017 alone four districts of Mangochi, Likoma, Nkhata Bay and Salima (Fig. 4) were still using Tilley Lamps. There are enough indications that fishers are highly interested in LED technology (Fig.1B) for "kauni" fishery in Lake Malawi on various reasons.

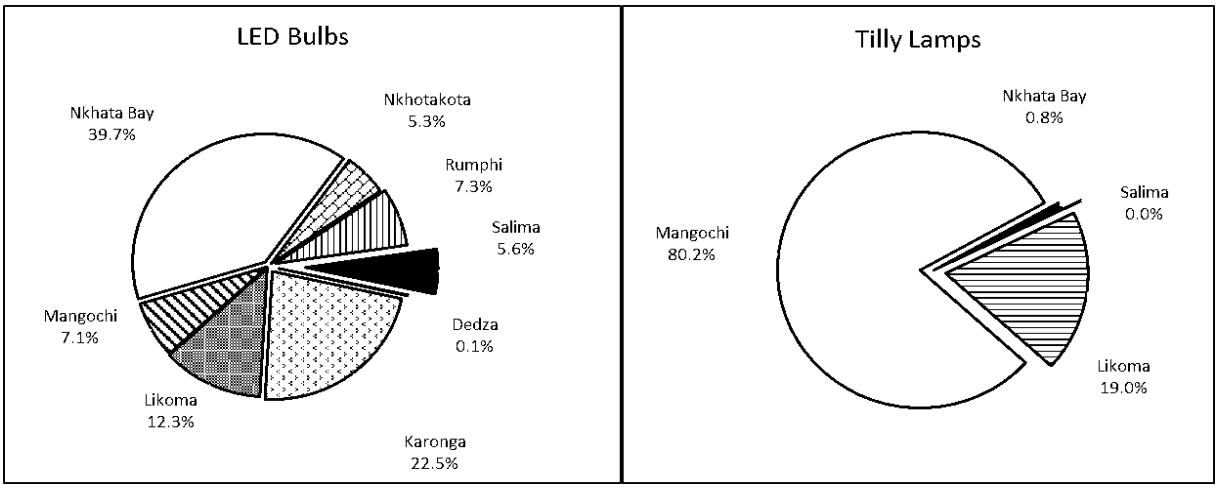

Fig 4: Level of usage of LED bulbs and Tilley Lamps in "Chilimira" fishery in Lake Malawi (SOURCE: Fisheries Annual Frame Survey Report 2017 [3]).

Amongst other reasons include the scarcity and rising costs of Kerosene. The LED is safe for use, kerosene is highly inflammable and Tilley Lamp tank is pressurised to vapourise the fuel making it more lethal. The LED is more tolerant to low voltages where it is easy for fishers to carry along portable rechargeable batteries. The LED is tolerant to use in water conditions without causing damage. The use of LED is considered to be economical as fishers save a remarkable amount of Kerosene used for light fishing. Fishers are not discouraged to use the LED technology although the technology is not yet approved.

The significant association ($p<0.05$) between light sources and species caught explains that fish species had different responses to the two sources of lights used. There are different explanations for fish behaviour in response to light sources [11]. The responses are species related, ontogenic development, characteristics of the light sources and enhancement of feeding efficiency where fish move towards the light to feed on zooplanktons that also get attracted to lights [12]. It was expected that all species in genus *Rhamphochromis* could be attracted to a specific source of light but LED bulbs attracted more *R. longiceps* where other species in the genus were too few to be considered for Chi-square analysis. The fishing area could also play a role in the availability of other species.

Although the species categorised as "others" and *R. longiceps* were considered by catches the study showed that the marginal mean weights were different in the two sources of light. The marginal mean weight for "others" and *R. longiceps* was high in Tilley Lamp than LED bulb (Fig. 2). The significant interaction between light sources and fish species ($p<0.05$) on mean weight (g) of fish caught can be attributed to fishing grounds. Regardless the fact that the marginal means were high in Tilley Lamps, the species were in uniformly high in "Chilimira" net using Tilley Lamp and the species were also found in "Chilimira" net using LED bulbs. A study by Weyl (2004) [13] identified 62 species from 28 cichlid genera and 13 species from nine non-cichlid genera from Chilimira using Tilley Lamp only in southeast arm of Lake Malawi. This suggests that species composition from light attraction can be influenced by fishing locality.

Conclusion

The study showed that there was a significant interaction between light sources and fish species ($p<0.05$) on mean weight (g) fish caught. It was revealed that there was a significant association ($p< 0.05$) between light sources and fish species caught. However, there was no significant difference in mean weight for the two sources of light because the catches were dominated by *E. sardella*. The difference in the interaction of light sources and fish species suggests that LED Bulbs and Tilley Lamps have different light properties (luminous intensity, luminous flux, colour, spectrum and spatial radiation) thereby attracting fish differently.

A number of factors need to be studied thoroughly and compared, like the economics of the two sources of light as to what percentage are fishers saving for using LED over Tilley Lamp. Assess the level of social acceptance of LED by communities and other stakeholders, considering that the technology is very new in the country. There is a need for a detailed trial on the light properties of LED i.e. luminous intensity, luminous flux, colour, spectrum and spatial radiation.

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References

1. Weyl OLF, Banda MC. Notes on the Chilimira net catch composition from catch and effort in Mangochi District. NARMAP Technical Report No. 2001; 5:8.
2. Gengnagel T, Wollburg P, Mills E. Alternatives to Fuel based Lighting for Night Fishing Field Tests of Lake and Ocean Applications in East Africa. The Lumina Project. Technical Report, 2013, 11
3. The government of Malawi (GoM), Fisheries Annual Frame Survey Bulletin No. 84. Ministry of Agriculture Irrigation and Water Development, Department of Fisheries, Lilongwe, Malawi, 2017.
4. Hua L, Xing X. Research on LED Fishing Light. Research Journal of Applied Sciences, Engineering and Technology. 2013; 5(16):4138-4141,
5. Arimoto T, Glass CW, Zhang X. Fishing Vision and Role in Fish Capture. In: Marine Fisheries Policy Brief 4. Fishing Using Lights: How should India handle this new Development. 2011, 4
6. Konings A. Konings's Book of Cichlids and all the Other Fishes of Lake Malawi. Second Edition. T.F.H Publications Inc. United States of America, 1990
7. IBM SPSS Statistics 22.0. Statistical Software for Social Scientist. IBM Corporation. Software version: 22.0. Reference #: 7038407, 2016
8. Menz A. The Fishery Potential and Productivity of the Pelagic Zone of Lake Malawi/Niassa. Chatham, UK: Natural Resources Institute, 1995, 386.
9. The Government of Malawi (GoM), National Fisheries Policy. Department of Fisheries, Lilongwe, Malawi, 2016.
10. Donda S, Njaya F. Food security and poverty alleviation through improved valuation and governance of river fisheries in Africa fisheries co-management in Malawi: An analysis of the underlying policy process. Report submitted to World Fish Centre.
11. Yami Ben M. Fishing with light. FAO Fishing Manuals. Farnham, Surrey, England: Fishing news book Ltd. 1976.
12. Mohamed, K.S. Fishing Using Lights: How should India handle this new development? Marine Fisheries Policy Brief-4. ICAR-Central Marine Fisheries Research Institute, Kochi. India, 2016.
13. Weyl OLF, Kazembe J, Booth AJ, Mandere DS. An assessment of a light-attraction fishery in southern Lake Malawi. African Journal of Aquatic Science. 2004; 29(1):1-11