Research Note

Laboratory evaluation of three commercial coil products for protection efficacy against Anopheles gambiae from southern Ghana: a preliminary study

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Abstract. Residents in irrigated urban agricultural sites face numerous mosquito problems such as increased mosquito populations and reduced insecticides susceptibility due to the creation of mosquito breeding sites and agricultural use of insecticides and hence require effective protective products against them. In this study, the protection effectiveness of three pyrethroid formulated mosquito coils of Malaysian origin against Anopheles gambiae s.l. from an irrigated urban agricultural site in Ghana were evaluated for their potential use. Sucrose fed An. gambiae s.l. were exposed to insecticide-containing coils in a 70 cm x 70 cm glass chamber to assess the insecticidal effect of the coils. The 0.005% metofluthrin coil caused the most rapid knockdown of 50% of the test mosquitoes. The mean lethal effect of the coils on An. gambiae s.l. were as follows; 0.005% metofluthrin (86%), 0.3% d-allethrin (74.33%), 0.15% d-trans allethrin (72%) and the 0.25% d-allethrin reference coil (69%). The 0.005% metofluthrin coil achieved the highest insecticidal effect on An. gambiae s.l. compared to the other coils and hence performed better than the others as an anti-mosquito product. All the three test coils were effective against An. gambiae s.l. from the irrigated agricultural site compared to the reference coil.

As urban population on the African continent continues to increase, urban agriculture plays an important role in augmenting the food needs of urban communities and serving as a source of livelihood to some urban dwellers (Lee-Smith & Prain, 2006). Urban agriculture involving irrigation alters the natural environment through anthropogenic activities that create breeding habitats for mosquitoes leading to an increase in mosquito population (Afrane et al., 2004, 2012). The increase in breeding sites and abundance creates further mosquito problems such as biting and disease occurrence. Proximity to agricultural sites in the capital city of Ghana, Accra, was associated with higher outdoor biting rates of Anopheles spp and Culex quinquefasciatus (Klinkenberg et al., 2008) and also increased reports of malaria prevalence (Stoler et al., 2009). At the household level, domestic insecticides such as mosquito coils are used for protection against mosquito bites and diseases (Afrane, et al., 2004; Boakye et al., 2009). Most of the mosquito coils marketed and used in the capital city of Ghana were mainly from Asian countries like China, Indonesia and Malaysia (Avicor, S.W. & Owusu, E.O, unpublished data).
Mosquito coils are commonly used in areas of urban irrigated agriculture (Afrane et al., 2004) where unlike in other communities, there is the likelihood of higher mosquito numbers and biting rates (Klinkenberg et al., 2008). However, the efficacy of these coils may be threatened by the decreased susceptibility of insects including mosquitoes in agricultural sites due to intense agricultural use of insecticides (Diabate et al., 2002; Nkya et al., 2014). Hence, households in irrigated urban agricultural sites will need coils that are effective in controlling the mosquito populations to protect their health.

In this study, commercial mosquito coils with different active ingredients originating from Malaysia were assessed on field populations of *An. gambiae sensu lato* from an irrigated urban agricultural site in Ghana to determine their potential use as personal protection products.

Three mosquito coils (FISH M® [0.005% metofluthrin], Shieldtox Red Coil® [0.15% d-trans allethrin] and Tesco Value® [0.3% d-allethrin]) which induced high insecticidal response (50% knockdown time of 3.91–4.72 min and mortality of 84.33–95.33%) in a laboratory strain of *Aedes albopictus* in Malaysia (Avicor et al., 2014a) were used for the study. A 0.25% d-allethrin coil commonly used in Ghana served as a positive reference. Immature *Anopheles* mosquitoes (4th instar larvae and pupae) were collected from residential facilities within the irrigated urban agricultural community of Haatso, an area within the capital city of Ghana. This site is mostly used for vegetable production and has an extensive use of insecticides (Avicor et al., 2011, 2014b). The immature mosquitoes were reared to adults at 26 ± 2°C and 75 ± 5% relative humidity (RH) and identified using morphological keys (Gillies & De Meillon, 1968; Gillies & Coetzee, 1987).

The efficacy test was done in a glass chamber measuring 70 cm x 70 cm x 70 cm (Avicor et al., 2013). Twenty-five female *An. gambiae s.l.* (10% sucrose fed, aged 2-5 days) were introduced into the glass chamber and exposed to the vapor from a single test coil for an hour. During the exposure period, mosquitoes that were knocked down (unable to stand, walk or fly) were counted at 10 min intervals. Mosquitoes were placed in paper cups containing 10% sucrose solution and mortality noted after 24 h. This was replicated four times for each treatment including the control. Non-mosquito coil exposed mosquitoes were used as a control. The testing and post testing holding conditions were 27 ± 2°C and 75 ± 10% RH.

Qcal (http://sourceforge.net/projects/irmaproj/) was used to calculate the knock down time for 50% (KT50) and 90% (KT90) of the test populations, the confidence intervals (CI), slopes and standard errors (SE). Mortality in the control group was corrected (Abbott, 1987), before the values were arc sine transformed and analyzed using Genstat Release 9.2 (Payne et al., 2006) with a one way analysis of variance. Mortality values were considered as significantly different if p<0.05 and the means were separated with the least significant difference.

The risks of urban agriculture in creating mosquito breeding sites (Afrane et al., 2004) and possibly selecting for insecticide resistant mosquitoes (Diabate et al., 2002) require that products used against mosquitoes in these communities should provide a high degree of protection. During the efficacy test, all the three test coils achieved significantly shorter KT50 of the *An. gambiae* mosquito than the reference coil (Table 1). The KT50 of all the coils were significantly different (p<0.05) from each other although that of 0.005% metofluthrin and 0.3% d-allethrin were relatively close to each other compared to the others (Table 1). The 0.005% metofluthrin had the shortest KT50 (5.20 min), nearly twice as fast as that achieved by the positive reference coil. With reference to their KT90, the 0.005% metofluthrin and 0.3% d-allethrin coils were not significantly different from each other but were significantly different from the 0.15% d-trans allethrin and the 0.25% d-allethrin (Table 1). The test coils knocked down the *An. gambiae* population faster compared to a study in which *An. gambiae* exposed to 0.3% d-allethrin had a KT50 of over 30 min (Avicor et al., 2013). However, the knockdown times in this study were longer compared to the Malaysian study involving a susceptible *Ae.*
albopictus strain (Avicor et al., 2014a). High knockdown activity of metofluthrin in mosquitoes compared to d-allethrin has been reported (Ujihara et al., 2004) and in an experimental hut assay in Zimbabwe, An. gambiae s.l. exposed to metofluthrin mosquito coil had a higher knockdown rate compared to when exposed to an esbiothrin-based coil (Lukwa & Chiwade, 2008).

Upon fumigation with the test coils, there was a significant difference (p<0.05) in An. gambiae mortality (Table 2). The 0.005% metofluthrin coil achieved a significantly (p<0.05) high mortality compared with the reference coil and the other two coils but there was no significant difference among the mortality effects of the other coils (p<0.05, Table 2). The widespread agricultural use of pesticides in the study area (Avicor et al., 2011, 2014b) could account for the low susceptibility levels of the mosquito species as seen in other studies (Diabate et al., 2002, Nkya et al., 2014). However, the test coils were able to cause high mortalities in the mosquito compared to the commonly used reference coil hence achieving a better control of An. gambiae. The An. gambiae mortality in this study is relatively high compared to a previous study (Avicor et al., 2013), though the mortality caused by the 0.3% d-allethrin in this study (74.33%) was only marginally higher than in the previous study (72%). The mortality effect of metofluthrin on An. gambiae in this study is agreeable with the mortality range in a Zimbabwean population of An. gambiae exposed to metofluthrin coil (Lukwa & Chiwade, 2008).

The test coils produced better insecticidal effects on An. gambiae than the commonly used reference coil with the metofluthrin based coil producing significantly faster knockdown and mortality rates. It is the best suited coil product among the test coils to address the household mosquito problems of users in this agricultural site.

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