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Research Note

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

Avicor, S.W.[1*], Wajidi, M.F.F.[1] and Jaal, Z.[2]
[1]Molecular Entomology Research Group, School of Distance Education, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia
[2]Vector Control Research Unit, School of Biological Sciences, Universiti Sains Malaysia, 11800 Minden, Penang, Malaysia
[*]Corresponding author email: wintuma@live.com
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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 sensu lato* 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 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. gambaie 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 (4^{th} 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 ± 2ºC 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 ± 2ºC and 75 ± 10% RH.

Qcal (http://sourceforge.net/projects/irmaproj /) was used to calculate the knock down time for 50% (KT_{50}) and 90% (KT_{90}) 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 KT_{50} of the *An. gambiae* mosquito than the reference coil (Table 1). The KT_{50} 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 KT_{50} (5.20 min), nearly twice as fast as that achieved by the positive reference coil. With reference to their KT_{90}, 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 KT_{50} 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.*

Table 1. Knockdown effect of pyrethroid coils on *Anopheles gambiae* population

Active ingredient (w/w)	KT_{50} (min)	95% CI	KT_{90} (min)	95% CI	Slope ±SE
0.25% d-allethrin (reference coil)	9.96	9.38-10.57^{a}	23.19	21.26-25.29^{a}	2.60±0.11
0.3% d-allethrin	5.86	5.56-6.19^{b}	11.18	10.28-12.15^{b}	3.41±0.19
0.15% d-trans allethrin	8.02	7.55-8.51^{c}	18.09	16.57-19.76^{c}	2.69±0.12
0.005% metofluthrin	5.20	4.89-5.53^{d}	11.49	10.48-12.60^{b}	2.77±0.14

Means with different superscripts have a significant difference at p<0.05.

Table 2. Induced mortality in *Anopheles gambiae* exposed to smoke from pyrethroid coils

Active ingredient (w/w)	Mortality (%) ± SE
0.25% d-allethrin (reference coil)	69.00 ± 4.16^{a}
0.3% d-allethrin	74.33 ± 2.73^{a}
0.15% d-trans allethrin	72.00 ± 4.04^{a}
0.005% metofluthrin	86.00 ± 2.65^{b}

Means with different superscripts have a significant difference at p<0.05.

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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REFERENCES

Abbott, W.S. (1987). A method of computing the effectiveness of an insecticide. 1925. *Journal of the American Mosquito Control Association* **3**: 302-303.

Afrane, Y.A., Klinkenberg, E., Drechsel, P., Owusu-Daaku, K., Garms, R. & Kruppa, T. (2004). Does irrigated urban agriculture influence the transmission of malaria in

the city of Kumasi, Ghana? *Acta Tropica* **89**: 125-134.
Afrane, Y.A., Lawson, B.W., Brenya, R., Kruppa, T. & Yan, G. (2012). The ecology of mosquitoes in an irrigated vegetable farm in Kumasi, Ghana: abundance, productivity and survivorship. *Parasites & Vectors* **5**: 233.
Avicor, S.W., Owusu, E.O. & Eziah, V.Y. (2011). Farmers' perception on insect pests control and insecticide usage pattern in selected areas of Ghana. *New York Science Journal* **4**: 23-29.
Avicor, S.W., Owusu, E.O. & Wajidi, M.F.F. (2013). D-allethrin based mosquito coils for mosquito control: knockdown and mortality effects on the malaria vector *Anopheles gambiae sensu lato*. *International Journal of Agriculture and Biology* **15**: 1035-1038.
Avicor, S.W., Wajidi, M.F.F., El-garj, F.M.A., Jaal, Z., Yahaya, Z.S. (2014a). Insecticidal activity and expression of cytochrome P450 family 4 genes in *Aedes albopictus* after exposure to pyrethroid mosquito coils. *Protein Journal* **33**: 457-464.
Avicor, S.W., Eziah, V.Y., Owusu, E.O. & Wajidi, M.F.F. (2014b). Insecticide susceptibility of *Bemisia tabaci* to Karate® and Cydim Super® and its associated carboxylesterase activity. *Sains Malaysiana* **43**: 31-36.
Boakye, D.A., Adasi, K., Appawu, M., Brown, C.A. & Wilson, M.D. (2009). Patterns of household insecticide use and pyrethroid resistance in *Anopheles gambiae sensu stricto* (Diptera: Culicidae) within the Accra metropolis of Ghana. *African Entomology* **17**: 125-130.
Diabate, A., Baldet, T., Chandre, F., Akogbeto, M., Guiguemde, T.R., Darriet, F., Brengues, C., Guillet, P., Hemingway, J., Small, G.J. & Hougard, J.M. (2002). The role of agricultural use of insecticides in resistance to pyrethroids in *Anopheles gambiae s.l.* in Burkina Faso. *American Journal of Tropical Medicine and Hygiene* **67**: 617-622.
Gillies, M.T. & Coetzee, M. (1987). *A supplement to the Anophelinae of Africa south of the Sahara (Afrotropical Region)*, Publication No. 55. Johannesburg: Publications of the South African Institute for Medical Research.
Gillies, M.T. & De Meillon, B. (1968). *The Anophelinae of Africa south of the Sahara*, Publication No. 54. Johannesburg: Publications of the South African Institute for Medical Research.
Klinkenberg, E., McCall, P.J., Wilson, M.D., Amerasinghe, F.P. & Donnelly, M.J. (2008). Impact of urban agriculture on malaria vectors in Accra, Ghana. *Malaria Journal* **7**: 151.
Lee-Smith, D. & Prain, G. (2006). Urban agriculture and health. Brief 13. In: *Understanding the links between agriculture and health*, 2020 Vision Focus Brief Series Number 13, Hawkes, C. & Ruel, M.T. (editors). Washington, DC: IFPRI.
Lukwa, N. & Chiwade, T. (2008). Lack of insecticidal effect of mosquito coils containing either metofluthrin or esbiothrin on *Anopheles gambiae sensu lato* mosquitoes. *Tropical Biomedicine* **25**: 191-195.
Nkya, T.E., Akhouayri, I., Poupardin, R., Batengana, B., Mosha, F., Magesa, S., Kisinza, W. & David, J.P. (2014). Insecticide resistance mechanisms associated with different environments in the malaria vector *Anopheles gambiae*: a case study in Tanzania. *Malaria Journal* **13**: 28.
Payne, R.W., Murray, D.A., Harding, S.A., Baird, D.B. & Soutar, D.M. (2006). *GenStat for Windows*. 9th Edition. Introduction. Hemel Hempstead: VSN International.
Stoler, J., Weeks, J.R., Getis, A. & Hill, A.G. (2009). Distance threshold for the effect of urban agriculture on elevated self-reported malaria prevalence in Accra, Ghana. *American Journal of Tropical Medicine and Hyg*iene **80**: 547-554.
Ujihara, K., Mori, T., Iwasaki, T., Sugano, M., Shono, Y. & Matsuo, N. (2004). Metofluthrin: a potent new synthetic pyrethroid with high vapor activity against mosquitoes. *Bioscience Biotechnology and Biochemistry* **68**: 170-174.