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**Short Communication**

# D-allethrin Based Mosquito Coils for Mosquito Control: Knockdown and Mortality Effects on the Malaria Vector *Anopheles gambiae sensu lato*

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## Abstract

Bioefficacy of five commonly used d-allethrin (0.1- 0.3% w/w) based coils was evaluated on non-blood fed female adult *Anopheles gambiae sensu lato* populations. Mortality ranged from 36% - 72% with $KT_{50}$ and $KT_{90}$ of 34.92 - 73.88 min and 143.78 - 447.54 min respectively. On the basis of the longer knockdown durations and mortality effects of the coils tested, the 0.3% d-allethrin coil should only be used as a supplement in minimizing vector-human contact and not as a sole protection measure. 

**Keywords:** *Anopheles gambiae sensu lato*; Malaria; Mortality; Mosquito coil

## Introduction

Mosquitoes are a nuisance and a health threat due to their biting behavior and the several diseases that they transmit. Malaria, a mosquito-vectored disease is hyperendemic in Ghana with the entire population of nearly 25 million people at risk (PMI, 2012). It is the leading cause of adult morbidity and mortality in children under 5 years in the country (NMCP/GHS, 2008). According to the 2008 Demographic and Health Survey (DHS), 43% of all deaths in children from 29 days to 5 years were due to malaria (PMI, 2012). Several measures, either communal or personal, are employed to minimize vector-human contact to reduce the rate of infection. One common personal protection measure by individuals in the country against mosquitoes is the burning of mosquito coils. As compared to other mosquitocidal products, there is universal awareness of mosquito coils in Ghana and their usage is frequent (Baume and Franca-Koh, 2011). The use of mosquito coils and other adulticidals have been incorporated into a national approach aimed at reducing malaria transmission (NMCP/GHS, 2008). The burning of mosquito coils has also been recommended to travelers to malaria risk areas such as Ghana as an effective way of malaria prevention (CDC, 2012; WHO, 2012). The coils are cheaper as compared to other mosquito-protection equipments/measures (Samuelsen *et al.,* 2004; Esse *et al.,* 2008).

The active ingredients in most coils are pyrethrins/pyrethroids and the coils constitute of organic fillers, binder and additives in addition to the insecticide/repellent (Krieger *et al.,* 2003). The non-insecticide parts that smoulder for several hours are base materials such as coconut husks and shells or sawdust based on the source of the coil (Liu *et al.,* 2003).

There have been divergent views in the country on the efficacy of mosquito coils; with opinions divided as to its potency to kill mosquitoes (Atagra, 2008). Notwithstanding the doubt and debate about their efficacy; mosquito coils are still widely used. It is also a common sight to find travelers who spend their nights/part of it outdoors at various transport terminals to burn coils. With the persisting doubt on their effects, the efficacy of five commonly used mosquito coils with different active ingredient concentrations were assessed on populations of *An. gambiae s. l.* to guide and aid in the management of this vector and policy formulation.

## Materials and Methods

### Mosquito Coils

The coils were obtained from retail outlets at the Kwame Nkrumah Circle, a key commercial center in Accra, the capital of Ghana. They were stored in the laboratory at 27±2°C and 70-80% relative humidity (RH).

### Larval Collection and Adult Identification

Larvae were collected weekly from stagnant water at

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Odawna, a community within the commercial center and reared to adults at 27 ± 2°C and 70 - 80% RH in a breeding cage measuring 30 x 30 x 30 $cm^3$. The emerged adults were morphologically identified as *An. gambiae* or *An. funestus* (Gillies and Coetzee, 1987) and fed 10% sugar solution *ad libitum*.

The Odawna community is a blend of residential and commercial activities. It is also a major recipient of traders and travelers in and out of the city due to its proximity to several transport terminals.

### Bioefficacy Test

The test was done in an experimental glass chamber measuring 70 x 70 x 70 $cm^3$ with a small battery operated fan circulating the air within the chamber. The test coil was lighted and extinguished as it begins to smoulder and placed in the glass chamber. Twenty non-blood fed female *An. gambiae s.l.* (2-5 days old) were introduced into the chamber and their knockdown noted at 1 min interval for 10 min and afterwards at 10 min interval for a total observation period of an hr. Afterwards the test mosquitoes were transferred into holding cups provided with a 10% sugar solution soaked cotton wool and held for 24 h. Mortality was noted at the end of the holding period. The test was replicated five times. Controls were done using a blank coil and no coil.

### Data Analysis

Median knockdown time ($KT_{50}$) and 90% knockdown time ($KT_{90}$) of the mosquitoes, their 95% confidence interval and probit slopes of regression were computed using IRMA Qcal (http://sourceforge.net/projects/irmaproj/).

## Results

The various knockdown times ($KT_{50}$ and $KT_{90}$) were high for all the test coils though knockdown times to higher concentrations (0.25-0.30%) were relatively lower (Table 1). At $KT_{50}$, there was no significant difference among coils with the same active ingredient concentrations whilst at $KT_{90}$, the differences among all the coils were insignificant with the exception of New Victory® and Paradise®.

Mortality responses of the mosquitoes to the insecticidal coils varied (Table 2). The mortality of the control populations (I and II) were less than 5% and hence were not corrected for (Abbott, 1925).

## Discussion

The use of mosquito coil is common in neighbouring West African countries such as Burkina Faso (Samuelsen *et al.,* 2004; Yamamoto *et al.,* 2009), Cote D'Ivoire (Doannio *et al.,* 2006; Esse *et al.,* 2008; Koudou *et al.,* 2010) and Nigeria (Efunshile *et al.,* 2011). In Ghana, about 43% of mosquito coil users use them on a daily basis (Baume and Franca-Koh, 2011). Though it is a prescribed malaria prevention tool for travelers (CDC, 2012; WHO, 2012), direct evidence that burning it prevents clinical malaria is lacking (Lawrance and Croft, 2004).

The sampled *An. gambiae s.l.* populations were not readily knockdown as compared to Malaysian populations of *Aedes aegypti* and *Culex quinquefasciatus* subjected to d-allethrin coils (0.2% w/w) (Yap *et al.,* 1996) and mats (36 mg/mat) (Adanan *et al.,* 2005). The *Ae. aegypti* and *Cx. quinquefasciatus* populations had a $KT_{50}$ of less than 3 min and 9 min respectively (Yap *et al.,* 1996; Adanan *et al.,* 2005), which were very low as compared to this study. Knockdown times of *Cx. pipens pallens* and *An. dirus* subjected to dl, d-T80 allethrin (0.27% - 0.50% w/w) mosquito coils under a 25 $m^3$ room experimental setup were also fairly low, ranging between 20.8 -28.3 min and 8 min respectively (Katsuda *et al.,* 2008). However the knockdown times for the *An. gambiae* populations were lower in comparison with that of *Cx. p. quinquefasciatus* (72 - 196 min) and *Ae. aegypti* (170 - 361 min) (Katsuda *et al.,* 2008).

The range of mortality responses of the Anopheles mosquitoes is similar to mortality studies for *Ae. aegypti*, *Cx. quinquefasciatus* and *Cx. p. pallens* and *Cx. p. quinquefasciatus* (Yap *et al.,* 1996; Adanan *et al.,* 2005; Katsuda *et al.,* 2008) though there were also some very low mortality values for *Cx. p. quinquefasciatus* (4%), *Cx. quinquefasciatus* (6%) and *Ae. aegypti* (11.67%) (Yap *et al.,* 1996; Katsuda *et al.,* 2008). However, *An. dirus* was totally susceptible to dl, d-T80 allethrin mosquito coil (Katsuda *et al.,* 2008).

It took a longer time for the *An. gambiae s.l.* populations to be knocked down, and hence, it is likely they might have now been less susceptible to the toxic fumes of the coils due to the frequent burning of coils by residents and travelers. Hence, burning these coils must not be a sole anti-mosquito measure but rather an addition to other anti-vector devices and alternatives.

Though perceived to be least efficient in controlling mosquitoes, mosquito coils were the most commonly used in a Burkinabe community due to their low cost (Samuelsen *et al.,* 2004). With the transmission of malaria still high in Ghana (WHO, 2011), the use of cheaper antimosquito products such as coils (Samuelsen *et al.,* 2004; Esse *et al.,* 2008) is likely to continue. Paradoxically, in a bid to ward away mosquitoes so as to avoid their bite and disease transmission, users are exposed to the smoke of mosquito coils and this could have adverse effects on their health (Krieger *et al.,* 2003; Liu *et al.,* 2003). Though the smoke from a burning coil could reduce the number of mosquito bites received (Lawrance and Croft, 2004), it could also be a health risk potentially for lung cancer (Krieger *et al.,* 2003; Liu *et al.,* 2003; Chen *et al.,* 2008). However, Zhang *et al*. (2010) noted that replacing the base materials of coils with charcoal powder drastically

**Table 1:** Knockdown times of *An. gambiae s.l.* to d-allethrin mosquito coils

| Coils | % d-allethrin | $KT_{50}$(min) 95% CI | $KT_{90}$(min) 95% CI | Slope ± SE |
|---|---|---|---|---|
| New Victory® | 0.10 | 73.88 | 447.54 | 1.22 ± 0.19 |
| | | 56.56 - 96.52[a] | 202.45 - 989.40[a] | |
| Safenight® | 0.10 | 59.46 | 347.29 | 1.25 ± 0.18 |
| | | 48.40 - 73.05[a,b] | 178.15 - 677.09[a,b] | |
| Areigne® | 0.25 | 45.67 | 217.56 | 1.41 ± 0.18 |
| | | 39.65 - 52.62[b,c] | 136.01 - 348.03[a,b] | |
| Perfume® | 0.25 | 40.28 | 163.37 | 1.57 ± 0.18 |
| | | 35.82 - 45.30[c,d] | 113.23 - 235.73[a,b] | |
| Paradise® | 0.30 | 34.92 | 143.78 | 1.55 ± 0.17 |
| | | 31.18 - 39.10[d] | 102.51 - 201.68[b] | |

CI = confidence interval; SE = standard error
Means followed by the same letters in the same columns are not significantly different

**Table 2:** Mortality responses of *An. gambiae s.l.* to the various mosquito coils

| Coils | Control (blank coil) | | | Control (no coil) | | | Mosquitocidals | | |
|---|---|---|---|---|---|---|---|---|---|
| | N tested | N dead | Mortality (%) | N tested | N dead | Mortality (%) | N tested | N dead | Mortality (%) |
| Areigne® | 100 | 0 | 0 | 100 | 0 | 0 | 100 | 61 | 61 |
| New Victory® | 100 | 1 | 1 | 100 | 0 | 0 | 100 | 36 | 36 |
| Paradise® | 100 | 2 | 0 | 100 | 0 | 0 | 100 | 72 | 72 |
| Perfume® | 100 | 4 | 4 | 100 | 0 | 0 | 100 | 67 | 67 |
| Safenight® | 100 | 2 | 2 | 100 | 0 | 0 | 100 | 59 | 59 |

N = number

reduced emissions and hence a relatively safer option from exposure to toxic emissions.

In conclusion, the knockdown times and mortality of the *An. gambiae s.l.* populations suggest that the mosquito coils tested cannot offer an overwhelming degree of protection when used as the only anti-mosquito method against this malaria vector. Their continuous use by both residents and travelers could compromise their protection from this vector. However, it could be used a supplement to other personal protection measures.

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## References

Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide. *J. Econ. Entomol.*, 18: 265–267

Adanan, C.R., J. Zairi and K.H. Ng, 2005. Efficacy and sublethal effects of mosquito mats on *Aedes aegypti* and *Culex quinquefasciatus* (Diptera: Culicidae). *In*: *Proceedings of the Fifth International Conference on Urban Pests,* pp 265–269. C.Y. Lee and W.H. Robinson (eds.). Malaysia

Atagra, C., 2008. *2 Agencies Disagree Over Efficacy Of Mosquito Coils*. Available at: http://www.modernghana.com/news/164776/1/2-agencies-disagree-over-efficacy-of-mosquito-coil.html (Accessed: 13 Dec 2011)

Baume, C.A. and A.C. Franca-Koh, 2011. Predictors of mosquito net use in Ghana. *Mal. J.,* 10: 265

CDC, 2012. *CDC Health Information for International Travel 2012*. Oxford University Press, New York, USA

Chen, S.C., R.H. Wong, L.J. Shiu, M.C. Chiou and H. Lee, 2008. Exposure to mosquito coil smoke may be a risk factor for lung cancer in Taiwan. *J. Epidemiol.*, 18: 19–25

Doannio, J.M., D.T. Doudou, L.Y. Konan, R. Djouaka, L.P. Toe, T. Baldet, M. Akogbeto and L. Monjour, 2006. Influence of social perceptions and practices on the use of bednets in the malaria control programme in Ivory Coast (West Africa). *Med. Trop.*, 66: 45–52

Efunshile, M., A. O. Amoo, G.B. Akintunde, O.D. Ojelekan, W. König and B. König, 2011. Use and effects of malaria control measures in pregnancy in Lagos, Nigeria. *Kor. J. Parasitol.*, 49: 365–371

Esse, C., J. Utzinger, A.B. Tschannen, G. Raso, C. Pfeiffer, S. Granado, B.G. Koudou, E.K. N'Goran, G. Cisse, O. Girardin, M. Tanner and B. Obrist, 2008. Social and cultural aspects of 'malaria' and its control in central Cote D'Ivoire. *Malar. J.*, 7: 224

Gillies, T.M. and M. Coetzee, 1987. *Supplement of the Anopheles of Africa South of Sahara (Afrotropical Region)*, Vol. 55. Publication of the South Africa Institute of Medical Research, Johannesburg, Republic of South Africa

IRMA-QCal (Insecticide Resistance Monitoring Application - Qcal). Available: http://sourceforge.net/projects/irmaproj/(Accessed: 10 July 2012)

Katsuda, Y., S. Leemingsawat, S. Thongrungkiat, N. Komalamisara, T. Kanzaki, T. Watanabe and T. Kahara, 2008. Control of mosquito vectors of tropical infectious diseases: (1) bioefficacy of mosquito coils containing several pyrethroids and a synergist. *Southeast Asian J. Trop. Med. Public Health*, 39: 48–54

Koudou, B.G., H. Ghattas, C. Essé, C. Nsanzabana, F. Rohner, J. Utzinger, B.E. Faragher and B.A. Tschannen, 2010. The use of insecticide-treated nets for reducing malaria morbidity among children aged 6-59 months, in an area of high malaria transmission in central Côte d'Ivoire. *Parasite Vectors,* 3: 91

Krieger, R.I., T.M. Dinoff and X. Zhang, 2003. Octachlorodipropyl ether (s-2) mosquito coils are inadequately studied for residential use in Asia and illegal in the United States. *Environ. Health Perspect.*, 111: 1439–1442

Lawrance, C.E. and A.M. Croft, 2004. Do mosquito coils prevent malaria? A systemic review of trials. *J. Travel Med.*, 11: 92–96

Liu, W., J. Zhang, J.H. Hashim, J. Jalaludin, Z. Hashim and B.D. Goldstein, 2003. Mosquito coil emissions and health implications. *Environ. Health Perspect.* 111: 1454–1460

NMCP/GHS, 2008. *Strategic Plan for Malaria Control in Ghana (2008-2015)*. Available at: http://www.ghanahealthservice.org/includes/upload/publications/STRATEGIC%20PLAN.pdf (Accessed: 27 April 2012)

PMI, 2012. *Malaria Operational Plan – FY 2012 (Year 5): Ghana.* Available at: http://www.fightingmalaria.gov/countries/mops/fy12/ghana_mop_fy12.pdf (Accessed: 14 Sept 2012)

Samuelsen, H., L.P. Toe, T. Baldet and O. Skovmand, 2004. Prevention of mosquito nuisance among urban populations in Burkina Faso. *Soc. Sci. Med*., 59: 2361–2371

WHO, 2011. *World Malaria Report: 2011*. World Health Organisation, Geneva, Switzerland

WHO, 2012. *International Travel and Health*. World Health Organisation, Geneva, Switzerland

Yamamoto, S.S., V.R. Louis, A. Sié and R. Sauerborn, 2009. The effects of zooprophylaxis and other mosquito control measures against malaria in Nouna, Burkina Faso. *Malar. J.,* 8: 283

Yap, H.H., M.P. Lim, N.L. Chong and C.Y. Lee, 1996. Efficacy and sublethal effects of mosquito coils on Aedes aegypti and Culex quinquefasciatus (Diptera: Culicidae). In: Proceeding of the 2nd International Conference on Urban Pest, pp: 177–184. Wildey, K.B. (ed.). Heriot-Watt University, Edinburgh, Scotland, UK

Zhang, L., Z. Jiang, J. Tong, Z. Wang, Z. Han and J. Zhang, 2010. Using charcoal as base material reduces mosquito coil emissions of toxins. *Indoor Air,* 20: 176–184

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