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ORIGINAL ARTICLE

Mosquito repellent activity of essential oil of Ethiopian ethnomedicinal plant against Afro-tropical malarial vector *Anopheles arabiensis*

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Juniperus procera;
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Abstract In Ethiopia, malaria remains to be one of the major public health issues that causes significant impediment to socio-economic development too. A laboratory-based study has been conducted to evaluate the repellency of Ethiopian ethnomedicinal plant Tedh [vernacular name (local native language, Amharic); *Juniperus procera* (Cupressaceae)], against Afro-tropical malarial vector, *Anopheles arabiensis* Patton at four different concentrations viz., 1.0, 1.5, 2.5, and 5.0 mg/cm^2. Experimentation on the percentage of protection in relation to the dosage has been performed. The tested concentrations of the essential oil of *J. procera* exhibited various degrees of repellency in terms of percentage of repellency and complete protection time against female *An. arabiensis* viz., 1.0, 1.5, 2.5 and 5.0 mg/cm^2 [64.10% (92 min)], [68.10% (125 min)], [72.20% (190 min)], and [80.60% (311 min)], respectively. Student's *t*-test results show statistically significant ($P < 0.001$) [0.1 mg/cm^2 ($t = 82.7$; $df = 4$); 0.15 mg/cm^2 ($t = 124.8$; $df = 4$); 2.5 mg/cm^2 ($t = 25.3$; $df = 4$); 5.0 mg/cm^2 ($t = 175.3$; $df = 4$)] difference between treated and control groups. The examined essential oil exhibited significant repellent properties and it has been identified that it could serve as a potent repellent against insect vectors of disease. In Africa, Tedh is well-known as a therapeutic agent to treat various illness and insects' repellent plant to drive-away insect vector of diseases. As the essential oil of Tedh is exceptionally safe and economical it could serve as a potent personal protective tool to minimize the burden of insect-transmitted diseases particularly malaria in the future.

1. Introduction

Over the centuries, the vector-borne diseases are imposing a serious public health threat to humankind in terms of illness and deaths worldwide. Besides their negative public health impact, these diseases are also posing serious obstacle to socio-economic development in *countries* wherever they are

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endemic in nature (Karunamoorthi and Sabesan, 2010). Malaria continues to be a major global public health problem with 3.3 billion people at risk in 106 endemic countries (Karunamoorthi et al., 2013). It imposes not only severe public health impact but also negative socio-economic development in the resource-poor settings of Africa, Asia, Latin America and beyond (Karunamoorthi and Bekele, 2009). It remains as one of the important causes of maternal and childhood morbidity and mortality in sub-Saharan Africa (SSA) particularly in Ethiopia (Karunamoorthi et al., 2010a). It also contributes to stillbirths, low birth weight, and early infant mortality (Menendez, 1995).

WHO Malaria Report (2012) estimates that the malaria related illness and mortality have been dramatically declined by the combined efforts of distribution of long lasting insecticide treated mosquito nets (LLINs), effective case management with potent antimalarials, source reduction and selective intradomicillary spraying. However, the heavy reliance on pyrethroids has led to the emergence of resistance in a wide variety of malaria-endemic settings of Africa and the rest of the world. It is considered to be a potential threat to the global public (Karunamoorthi and Sabesan, 2013). Generally, plant-based insecticides are target-specific and relatively non-toxic. Consequently, there is a revived interest observed by several researchers to develop green pesticides/reduced-risk of pesticides. As a result, over thousands of plant species were evaluated as potential insecticidal agents in terms of larvicidal, antifeedant, repellent, oviposition deterrent, growth regulatory and anti-vector activities (Karunamoorthi, 2012a).

An. arabiensis is one of the important malarial vectors in sub-Saharan Africa (Onyabe and Conn, 2001; Mutero et al., 2004) particularly in Ethiopia, while *An. funestus* Giles, *An. pharoensis Theobald*, and *An. nili Theobald* are secondary vectors (Karunamoorthi and Yirgalem, 2013). It adapts to endophagic and endophilic patterns, where hosts are domestic and indoor, but are of exophagic and exophilic nature, where the hosts are mainly outdoors (Coluzzi et al., 1979; Ameneshewa and Service, 1996; Mendis et al., 2000). It has the ability to adapt to all types of climatic features, and it can avoid insecticide sprayed surfaces and can adjust into exophagic. In this context, repellents could play a pivotal role whenever and wherever other vector control interventions are impossible and impracticable (Karunamoorthi and Sabesan, 2010).

The repellent plant usage an integral part of Ethiopian tradition and culture (Karunamoorthi and Husen, 2012) is a common practice to drive-away insects/mosquitoes. Interestingly, the East African plant called Golden flower/pyrethrum (*Chrysanthemum cinerariaefolium*) is a precursor to all the existing commercial insect repellents (Karunamoorthi, 2012b). Essential oils are the best-known sources tested against insects (Pitasawat et al., 2007). Even today, in the rural parts of SSA countries, people do still use numerous plants as repellents blindly or hardly knowing their efficiency, safety and mode of action through trial-and-error or word-of-mouth communications from elders (Karunamoorthi, 2012b). In this perspective, this study is a spinoff research work aimed to determine the indigenous Ethiopian ethnomedicinal plant *Juniperus procera* essential oil as a repellent against the Afrotropical vector *An. arabiensis*.

2. Materials and methods

2.1. Selection of the plant

The Tedh was selected from the secondary data i.e. based on some reports in the literature or some bio-ethnological knowledge from the farmers, traditional healers, key informants and local residents. In Ethiopia, the local rural residents have been using this indigenous plant for various curative and miscellaneous purposes. The collected voucher specimen has been pressed, numbered, dried, identified and deposited in the Jimma University Regional Herbarium, Ethiopia.

2.2. Taxonomy of J. procera Hochst. ex Endl

Kingdom	Plantae
Division	Pinophyta
Class	Pinopsida
Order	Pinales
Family	Cupressaceae
Genus	Juniperus
Species	procera

2.3. Description and traditional usage of J. procera

The Tedh is commonly known in English as African Juniper or East African Juniper. It is a coniferous tree native to the mountains of eastern Africa from eastern Sudan south to Zimbabwe, and the southwest of the Arabian Peninsula. In traditional African medicine, the smoke of fruiting branches of Tedh is used to get relieved from rheumatic pains and an infusion of ground twigs and buds is consumed against intestinal worms. Stem is used as a tooth brush and leaves are used to treat or cure tonsillitis. The vapour from a leaf decoction has been inhaled several times a day for the treatment of flu like illness.

2.4. Selection of mosquito species

Nearly all members of *An. gambiae* complex, that are potent vectors of malaria in tropical Africa, have shown various degrees of resistance to commonly applied insecticides like DDT (dichlorodiphenyltrichloroethane) and pyrethroids. *An. arabiensis*, and *An. gambiae s.s.* are the most important vectors of human malaria in sub-Saharan Africa particularly Ethiopia (Coetzee et al., 2000). Thus, the Adama Malaria Research Centre, Ethiopia laboratory reared *An. arabiensis* was chosen for the evaluation of repellent activity. It was maintained at 27 ± 2 °C, 75–85% RH, under 14 L:10 D photoperiod cycles.

2.5. Preparation of mosquitoes

The colony was maintained in the laboratory at 27 ± 1 °C and 85% relative humidity. The larvae were fed with dog biscuits and yeast powder in the ratio of 3:1. Adults were provided with 10% sucrose solution and 1-week-old chick for blood meal. The mosquitoes were starved for 3–4 days before the commencement of each experiment. Conditions during the test followed a standard diel cycle, with air temperature