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Knowledge and self-reported practice of the local inhabitants on traditional insect repellent plants in Western Hararghe zone, Ethiopia

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ABSTRACT

Ethnopharmacological relevance: This paper reveals the trend of knowledge and self-reported practice of traditional insect repellent plants (TIRPs) and could serve as a baseline data to identify/formulate novel plant-based insect repellents in the near future.
Aim of the study: Insect repellent plants usage is a long-standing and age old tradition. Thus, the major objective of this survey was to assess the knowledge and self-reported practice of the local inhabitants on TIRPs in Western Hararghe zone, Ethiopia.
Materials and methods: The ethnobotanical survey was conducted between January and March 2011 via administering pre-tested questionnaire by involving the selected 150 household members in the study area.
Results: The survey results clearly reveal that nearly 92.1% [90.1% (99/110) of female and 97.5% (39/40) of male] of the respondents have had adequate awareness on TIRPs. Leaves were the most widely applied plant parts and burning/smoldering the plant materials in order to generate smoke was the most common practice. Chi-square statistical analysis shows that there was no significant difference observed in the knowledge of the repellent plants between the gender (P-value = 0.134), average monthly income (P-value = 0.529) and educational status (P-value = 0.107) but there was a significant association with the age (P-value = 0.012) of respondents. However, repellent plants usage custom is significantly associated with gender (P-value = 0.021) and educational status (P-value = 0.003) of the respondents but, there was such no significant relationship between the age (P-value = 0.312) average monthly income (P-value = 0.111) and repellent plants usage custom.
Conclusion: Conducting more ethnobotanical survey on TIRPs is extremely important in order to generate and maintain the data-base. Besides, identifying the bio-active molecules, which are responsible for the repellent activity and eventually conducting laboratory and field based studies to evaluate their efficacy and safety are extremely imperative to formulate new classes of plant-based insect repellents/insecticides in the near future.

1. Introduction

Vector-borne diseases continue to inflict high morbidity and mortality in the tropical and sub-tropical countries particularly in the resource constrained developing countries (Karunamoorthi et al., 2010a). Mosquitoes are the principle and well-known vectors of several disease causing pathogens, which affect several millions of people world-wide in terms of morbidity and mortality. Considering the mosquito-borne diseases like Lymphatic filariasis, it affects at least 120 million people in 73 countries including India and in the remaining countries in Africa, Southeast Asia, and Pacific Islands (Hotez et al., 2004). According to WHO (2009) about two-fifths of the world's population are now at the risk of dengue. But malaria is the most prevalent among the mosquito-borne diseases and the devastating nature of malaria in the sub-Saharan Africa is indubitably intolerable (Karunamoorthi and Ilango, 2010).

The WHO Malaria Report (2009) estimated that nearly half of the world's populations are at the risk of malarial infection. Even though there is adequate prevention measures and effective case management available, malaria remains to be one of the most important public health diseases resulting in approximately 300 million cases and an estimated 781,000 deaths annually (World Malaria Report, 2010).

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In Ethiopia, An estimated 68% (50 million people) of the population lives in areas at the risk of malarial infection. Malaria was reported as the primary cause of health problems in 2004–2005 accounting for 17% of out-patient visits, 15% of hospital admissions and 29% of in-patient deaths (CSA, 2006). Despite the availability of effective interventions malaria remains to be one of the most important causes of maternal and childhood morbidity and mortality (Karunamoorthi et al., 2010b). Malaria is not only a health issue but also has tremendous impact on the socio-economic development of the country attributable as the main transmission season coincides with the harvesting and plantation seasons (Karunamoorthi and Bekele, 2009).

In order to achieve the sustainable malaria control new tools are required to help maintain and improve the effectiveness of currently available tools like long lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) too. Intervention of new tools can be helpful to interrupt transmission in circumstances where the existing tools cannot reach (Alonso et al., 2011). IRS is costly and logistically challenging to undertake in remote rural areas and needs to be undertaken indefinitely at high coverage rates in order to be effective in highly endemic settings (Kolaczinski et al., 2007).

Personal protection with insect repellents is a popular method for preventing contact with arthropod disease vectors. While their modes of action may vary, repellents generally prevent host seeking vectors from landing on or biting the user (Bernier et al., 2007). DEET (N,N-diethyl-3-methylbenzamide) is the gold-standard insect repellent, keeps insects away, but it wears off with sweat and can cause health problems in sensitive people, including rashes, skin and mucous membrane irritation, dizziness, headaches, disorientation, and nausea. Although DEET shows broad-spectrum activity against biting insects, it apparently does not work as well against malaria carrying strains of mosquitoes. Moreover, DEET smells bad, and it can damage plastic eyeglass lenses and watch faces (Potera, 2008).

In developing countries (particularly sub-Saharan Africa) alternative methods such as insecticide-treated bed nets (ITNs) and IRS are thought to be the most appropriate method of control. However, in some regions, mosquito populations are less susceptible to these control methods owing to insecticide resistance (N'Guessan et al., 2007; Protopopoff et al., 2008). The majority of the synthetic repellents are expensive, difficult to distribute and to incorporate with local traditions and practices (Worrall et al., 2005; Moore et al., 2007).

Plants have been used since ancient times to repel/kill blood-sucking insects in the human history and even now, in many parts of the world people are using plant-based substances to repel/kill the blood-sucking insects. At the moment, we are all just around the corner to reinstate the chemical substances by plant-based products in the insect control (Karunamoorthi et al., 2008b). Plant-based repellents are still extensively used in this traditional way by almost all the rural communities in the tropics as they are the only means of protection from mosquito bites for the poorer communities (Moore et al., 2006). There are several plants in sub-Saharan Africa reported to constitute effective repellents against arthropods of vector-borne disease (Curtis et al., 1991; Berger, 1994; Berger and Curtis, 1995; Palsson and Jaenson, 1999). Some of these plants, for example citronella (*Cymbopogon nardus* L.) and pyrethrum (*Chrysanthemum cinerariifolium* Trevir.), have been commercialized and are effectively used as mosquito repellents (Curtis et al., 1991).

At the moment repellent of plants origin have been receiving massive attention due to their environmental and user friendly nature which demands more scientific survey to identify new repellent/insecticidal plants (Karunamoorthi et al., 2009a). Repellent plants usage custom is a result of thousands of years of experience. This expertise has been passed down to many generations mostly through word of mouth. This mode of information conveyance may result in distortion or loss of indigenous knowledge and usage custom of repellent plants. Therefore, right now documenting and safeguarding these practices have become crucial core issues (Karunamoorthi et al., 2009a).

Besides, information regarding the links between socioeconomic factors, knowledge and usage custom of (TIRPs), remarkably among unprivileged section of the society in Africa particularly in Ethiopia, is limited (Karunamoorthi et al., 2009b). In this context, the present ethnobotanical survey becomes more significant and the objective was to determine the knowledge and self-reported practice of the local inhabitants on traditional insect repellent plants in Western Hararghe Zone, Ethiopia.

2. Materials and methods

2.1. Description of the ethnobotanical survey setting

The survey was conducted in Badeye Kebele (small local administrative unit in Ethiopia), Western Hararghe zone, Oromia region. It is located 245 km away from Addis Ababa, the federal capital of Ethiopia. It has been an estimated to contain a total number of households and population of 820 and 3575, respectively. It has one primary school and a health center. If any of the local inhabitants become sick, habitually they approach the local health center and if it is unmanageable to the physician, he may perhaps refer to neighboring health facilities in the Matahara town, approximately 45 km away from the study setting. Currently there is no electricity; however there is a digital generator, which is owned by the community itself and operated between 7 pm and 12 am. Majority of the houses are traditional tukuls built from mud and covered with thatched roofs. Malaria is one of the leading causes of morbidity and mortality. Because of prolonged period of exposure to malaria, the residents have traditionally been applying several repellent plants to drive away biting insects.

The local people cultivate cereal such as sorghum, wheat, barely, sweet corn and boloke (which is primarily used for making washing soap). Besides, this kebele is also known for the cultivation of the cash crop like khat and coffee and raising livestock. The study area is surrounded by nearly five springs, among them three are almost perennial. These act as a primary water source for the daily household needs and irrigation purpose. These springs also serve as the vector mosquitoes breeding sites. Moreover, the people prefer to sleep outdoor throughout the harvesting season in order to guard their crops from the wild animals. These factors might have substantially contributed to the rapid increase of malaria cases in the recent years.

2.2. Interview

The source population was all households established in the Badeye Kebele and the study population of 150 household members was selected by adopting systematic sampling technique. In order to evaluate the clarity of the questionnaire, validity of the instrument, and reactions of the respondents to the questionnaire a pre-test was conducted on 10% of the study population, i.e. about 15 respondents by the enumerators, in an area different from the study area, but with the similar socio-demographic pattern. One adult from each selected household was interviewed on the knowledge and traditional uses of repellent plants, using a pre-tested questionnaire specifically designed for this purpose. Male and female respondents from all age-groups were included. To avoid biased information and variables, the questionnaire prepared in English language was translated into native local language (Oromifa) in order to make it easy to understand and to administer by the interviewers and interviewees.

2.3. Ethical considerations

The study was approved by the ethical clearance committee of the Jimma University, Jimma, Ethiopia. Before the commencement of the survey, meetings with community health workers, community leaders and members of the neighborhood associations were held in which the objectives of the survey were clearly explained. Written consent was obtained from each study participant. Every participant was assured to withdraw the interview at any phase if they wish to do so. However, all the informants actively involved and no one declined to finish the interview.

2.4. Ethnobotanical data collection

The ethnobotanical survey was conducted between January 2011 and March 2011. A team of well-trained and closely supervised local interviewers conducted the household survey using a pre-tested questionnaire to interview with the representative of selected household. Interviewers collected information regarding socio-demographic and ethnobotanical data. Study participants were asked to share their knowledge and usage custom about the repellent plants. The main questions focused on (1) usage and knowledge of insect repellent plants, (2) names of plants used or known, (3) insects against which the plants are used, (4) methods of application, and (5) parts of the plant material used as insect repellent.

The authors also made observations in the field on the general habitats and the traditional repellent plants collected by accompanying traditional users, translators and field assistants. Specimens of the reported repellent plants were collected during the regular walk in the fields. The collected voucher specimens were pressed, numbered, dried, identified and deposited at Jimma University Regional Herbarium and The National Herbarium (ETH) in Addis Ababa University. Identification of specimens was made with the help of herbarium materials, experts and taxonomic keys in the Flora of Ethiopia and Eritrea (Hedberg and Edwards, 1989, 1995; Edwards et al., 1995, 1997, 2000; Hedberg et al., 2003, 2004).

2.5. Statistical analysis

Statistical analysis was carried out using SPSS, version 9.0. Range and mean were analysed and appropriate tables, graphs and percentage details were displayed. Level of significance was also determined by using 95% of confidence intervals and *P*-value.

3. Results

3.1. Socio-demographic characteristics of respondents

Socio-demographic characteristics of respondents are shown in Table 1. The female respondents constituted about 73.4%. More than half of the respondents (52.6%) were illiterate. The majority of the informants (59.3%) monthly income was >300 Ethiopian Birr (1$ = 17.04 Eth. Birr). Most of the study participants (67.3%) belong to Oromo ethnic group and 38.1% of the respondents' family size is 5–7. Overall, 92.1% respondents had adequate awareness on TIRPs (Table 1).

Table 1
Study of respondents with gender, age, educational status, average monthly income, religion, ethnicity, family size and knowledge of insect repellent plants among the local inhabitants in the BadeyeKebele.

Socio-demographic characteristics of the respondents	*n* = 150	Percent
Gender		
Male	40	26.6
Female	110	73.4
Age of respondents		
<20 years	18	12.1
20–39 years	92	61.3
40–59 years	20	13.3
>60 years	20	13.3
Educational status		
Illiterate	79	52.6
1–8th grade	42	28.1
9–10th grade	10	6.6
11–12th grade	5	3.3
Higher education	14	9.4
Average monthly income [Ethiopian Birr (1 USD = 17.05 Eth Birr)]		
≤100	29	19.3
101–300	32	21.4
>300	89	59.3
Religion		
Orthodox	32	21.4
Muslim	109	72.5
Protestant	9	6.1
Ethnicity		
Oromo	101	67.3
Amhara	29	19.4
Argoba	16	10.6
Gurage	4	2.7
Size of the family		
1–2 person	33	22.1
3–4 person	29	19.3
5–7 person	57	38.1
>7 person	31	20.5
Do you have any awareness about traditional insect repellents?		
Yes	138	92.1
No	12	7.9

3.2. Knowledge of traditional insect repellent plants

Nearly thirteen types of various TIRPs have been most commonly known and used by the local villagers and 26.1% of the respondents use Shita (a mixture of various repellent plants stem, root, resin, leaves and bark (the outermost layers of stems and roots of woody repellent plants)) and it is abundantly available in majority of the Ethiopian towns. It is mainly prepared by the folk with approximately 5 gm of repellent plants materials wrapped in a plastic paper and commercialized. I have personally used and experienced the unique pleasant odour of Shita. Some of the plant species like Etan (*Boswellia papyrifera* (Del) Hochst) resin is the main constituent in the preparation of Shita. The most commonly known repellent plants among the local inhabitants are compiled in Table 2 (vernacular names are written in local native language Amharic) woira, tej-sar, etan, wogert, tinjute, keberacho, dokma, bissana, gicha, bahir zafe, limich, wayba and fetto.

3.3. Self-reported traditional usage custom of insect repellent plants

Leaf was the most commonly used plant part. Virtually all TIRPs are used to drive-away various types of insects more particular mosquitoes (Table 2). Overall, 99.3% and 93.2% of the local residents perceive that TIRPs are easily accessible as well as affordable, respectively. About 90.1% and 85.6% of them believe that TIRPs are effective and pleasant too, respectively (Fig. 1). Almost 92.2% of the study participants burn/smolder the dried plant parts on the traditional charcoal stove in order to generate smoke and it is observed to be the most widespread and well-known common practice (Fig. 2). Overall, 88.1% and 84.7% of the respondents apply TIRPs in the early evening and morning time, respectively (Fig. 3). The association between respondent's knowledge and self-reported usage custom of insect repellent plants with their age, gender, monthly income and educational status were tested with the chi-square analysis and the results are given in Table 3.

Table 2
Information on repellent plants from ethnobotanical survey in relation with repellent plant parts used, method of application and types of insects repelled between January and March 2011.

S. No	Family name	Plants species name	Vernacular name (Amharic)	Plant parts used	*n* = 150	Percent[a]	Mode of application	Type of insects drive away
1.	Oleaceae	*Olea europea* L.	Woira	Leaf, stem and root	138	92.1	Smoking	Mosquito, house fly and cockroach
2.	Graminae/Poaceae	*Cymbopogon citratus* Stapf	Tej-sar	Leaf	87	58.1	Smoking and surfacing over floor	Mosquito, house fly and fleas
3.	Burseraceae	*Boswellia papyrifera* (Del) Hochst.	Etan	Barks and resin	132	88.1	Smoking	Mosquito and house fly
4.	Caryophyllaceae	*Silene macroserene* L.	Wogert	Leaf and Root	17	11.4	Smoking and spray	Mosquito, house fly,bedbugs and fleas
5.	Lamiaceae	*Otostegia integrifolia* Benth.	Tinjute	Root, leaf and stem	18	12.1	Smoking and spray	Mosquito and house fly
6.	Asteraceae	*Echinops* sp. L.	Keberacho	Leaf, root and stem	22	14.7	Smoking and spray	Mosquito and house fly
7.	Myrtaceae	*Syzygium guineense* (Willd.) DC.	Dokma	Leaf and stem	27	18.1	Smoking	Mosquito and house fly
8.	Euphorbiaceae	*Croton macrostachyus* Hochst.	Bissana	Leaf and stem	28	18.6	Smoking, hanging and surfacing over the floor	Mosquito, house fly, bedbug, fleas and cockroach
9.	Cyperaceae	*Cyperus rigidifolius* Steud	Gicha	Stem	14	9.4	Smoking	Mosquito and house fly
10.	Myrtaceae	*Eucalyptus citriodora* Hook.	Bahirzafe	Leaf and stem	19	12.7	Hanging and surfacing over the floor	Mosquito, house fly, fleas and cockroach
11.	Rutaceae	*Clausena anisata* (Willd.) Hook. f. ex Benth.	Limich	Leaf and stem	13	8.7	Smoking	Mosquito, house fly, bedbug and cockroach
12.	Fabaceae	*Acacia decurrens* Willd. var. mollis Lindley	Mimosa	Leaf and stem	12	8.1	Smoking and surfacing over the floor	Mosquito and house fly
13.	NA	NA	Shita[b]	Churn of several repellent plant parts	39	26.1	Smoking and spray	Mosquito and house fly
14.	Brassicaceae	*Lepidium sativum* L.	Fetto	Seed	13	8.7	Spray	House fly and cockroach

NA: the relevant information is not available.

[a] Percent does not add up to 100, because of multiple responses.

[b] Shita is a mixture of various traditional repellent plant parts such as stem, root, resin, leaves and bark (the outermost layers of stems and roots of woody repellent plants). It is widely available in the marketplace in the majority of the Ethiopian towns.

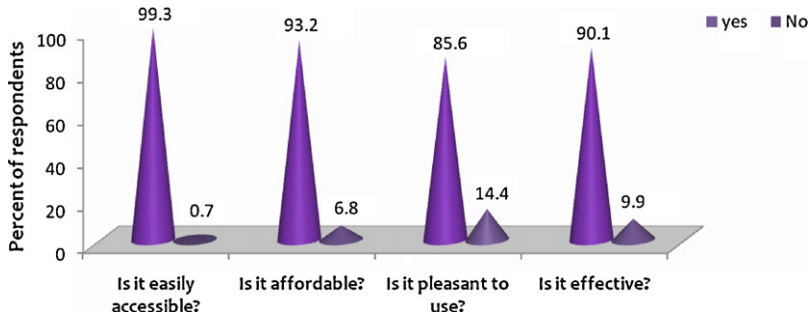

Fig. 1. Perception of the study participants regarding the traditional insect repellent plant accessibility, affordability and effectiveness.

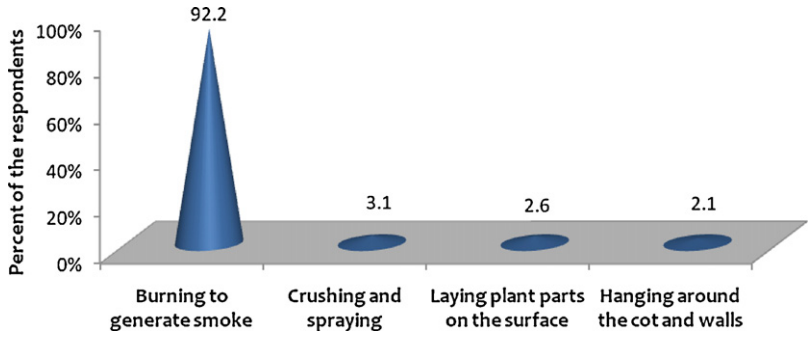

Fig. 2. Self-reported practice and usage custom of respondents regarding method of applications of insect repellent plants.

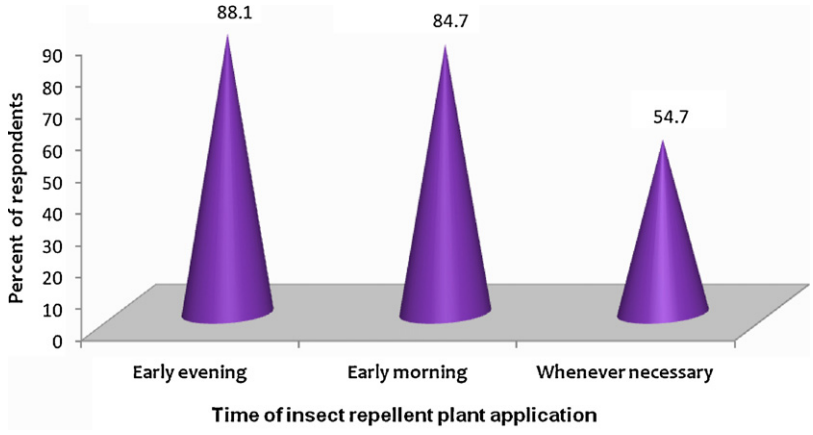

Fig. 3. The time period of repellent use by the study participants. Note: percent does not add up to 100, because of multiple responses.

Table 3
Knowledge and usage custom of insect/mosquito repellent plants in relation with age, gender, educational status and monthly income of the respondents among the local inhabitant in the BadeyeKebele.

Variables	Total no. of respondents	Knowledge about insect repellent plants		*P-value*	Insect repellent plant usage custom		*P-value*
		Yes	No		Yes	No	
Age (years)							
≤20	16	16	0	P – 0.012*	10	6	P – 0.312
21–39	94	87	7	χ^2 = 11.0	50	44	χ^2 = 3.57
40–59	20	15	5	df = 3	7	13	df = 3
>+60	20	20	0		12	8	
Gender				P – 0.134			P – 0.021*
Male	40	39	1	χ^2 = 2.24	27	13	χ^2 = 5.33
Female	110	99	11	df = 1	93	17	df = 1
Average monthly income [Ethiopian Birr (1 USD = 17.05 Eth Birr)]							
≤100	29	24	5	P – 0.529	26	3	P – 0.111
101–300	32	25	7	χ^2 = 1.27	27	5	χ^2 = 4.39
≥301	89	77	12	df = 2	65	24	df = 2
Educational status				P – 0.107			P – 0.003*
Illiterate	79	77	2	χ^2 = 2.59	75	4	χ^2 = 8.72
Literate	71	65	6	df = 1	56	15	df = 1

* P < 0.05 statistically significant.

4. Discussion

The present ethnobotanical survey is an attempt to understand the level of the local inhabitants' knowledge and usage custom on TIRPs and importance of TIRPs in their day-to-day undertakings to drive-away nuisance insects and insect disease transmitters. The result clearly demonstrated that nearly 92.1% of the respondents have had adequate awareness on TIRPs. The level of knowledge and usage custom is marginally lower than the previous study, which was conducted in Addis Zemen town of Ethiopia, where 97.2% of the respondents had adequate awareness on repellent plants Karunamoorthi et al. (2009b) however, it is considerably higher than the very recent study reported by Karunamoorthi et al. (2009a). It is quite interesting to note that the above cited surveys were carried out in the urban-settings nevertheless the present investigation has been conducted in the remote rural-settings where even at present there is a dearth of organized fixed electricity. In general, traditional plant-based repellent products are extremely or essentially useful in the inaccessible rural areas, more often due to the lack of electricity. Furthermore, plant-based repellent products are inexpensive, easily available, locally known, and culturally acceptable (Karunamoorthi et al., 2008a) (Table 1).

The great majority of the interviewed villagers relies upon TIRPs and has indicated that they have easy accessibility and affordability too. The relatively sizable fraction of the villagers perceives that TIRPs are effective as well as pleasant to use (Fig. 1). The results quite comparable with the previous studies carried out in Ethiopia (Karunamoorthi et al., 2009a,b) and in Tanzania by Kweka et al. (2008) who reported that the majority of respondents admitted that they could not afford to use synthetic commercial mosquito repellents or insecticides because of high cost. Similar finding have been reported elsewhere in African, such as Guinea Bissau and Kenya, where the majority of the villagers could not afford to synthetic commercial mosquito insecticides due to poverty (Palsson and Jaenson, 1999; Odalo et al., 2005). Generally, in the rural kebeles (villages) are surrounded by copious repellent plants, which are easily accessible and freely available virtually throughout the year (Karunamoorthi et al., 2009a). Consequently, the local residents are capable to acquire TIRPs than the synthetic chemical repellents. We have personally witnessed in various circumstances that the preponderance of the Ethiopian TIRPs are rationally effective and pleasant to employ too.

Overall, thirteen plants are mentioned by more than one informant as effective repellent against insects and the most commonly cited five traditionally insect repellents plants were viz., Woira [*Olea Europea* L. (Oleaceae)]; Etan [*Boswellia papyrifera* (Del) Hochst (Burseraceae)]; Tej-sar [*Cymbopogon citratus* Stapf (Poaceae)]; Bissana [*Croton macrostachyus* Hochst. (Euphorbiaceae)] and Dokma [*Syzygium guineense* (Willd.) DC. (Myrtaceae)]. However, noticeably shita [a mixture of various TIRPs parts such as leaves, resin, root, stem and (a mixture of various repellent plants stem, root, resin, leaves and bark (the outermost layers of stems and roots of woody plants)] is the most widely/locally brand-named and easily accessible plant-based substance available in majority of the Ethiopian towns. It is also well-known and customarily used by the local residents (Table 2).

The most of the TIRPs are already reported by Karunamoorthi et al. (2009a,b) in Ethiopia. However, as per our understanding and knowledge the following five plants have been reported for the first time in Ethiopia as the insect repellents; Dokma [*Syzygium guineense* (Myrtaceae)], Gicha [*Cyperus rigidifolius* Steud (Cyperaceae)], Shey [*Clausena anisata* (Willd.) Hook. (Rutaceae)], Mimosa [*Acacia decurrens* Willd. (Fabaceae)] and Fetto [*Lepidium sativum* L. (Brassicaceae)] in the study area (Table 2). It evidently shows that the plant kingdom is a potential ware-house to identify the various plant-based insect repellents/insecticides. Moreover, Africa in particular Ethiopia has been considered as a repository to have variety of repellent plants on account of its varied climatic and topographic features.

The great majority of the respondents stated that leaves are the major repellent plant part conventionally employed and as far as method of application is concerned burning/smouldering of the dried plant materials in order to generate smoke on the traditional charcoal stove (Table 2, Fig. 2) is the most common practice. The results are quite consistent with various studies conducted in Ethiopia (Karunamoorthi et al., 2009a,b), Eritrea (Waka et al., 2004) and Guatemala (Klein et al., 1995). Almost 100% of the Kenyans burn plants to repel mosquitoes (Seyoum et al., 2002), and in Guinea Bissau 55% of people burn plants or hang them in the home to repel mosquitoes (Palsson and Jaenson, 1999). The result is also comparable with a study reported by Kweka et al. (2008) that methods of application were mostly incense burning/smouldering and the plant parts mostly used were leaves (70%), barks (10%), mixed plant parts (13%) or roots (7%). It is always generally considered that usage of the leaves of TIRPs is one of the most sustainable option/solution for potential large scale use than using the roots, resin and bark (the outermost layers of stems and roots of woody plants) this shall not interrupt the plants growth as well as density much.

Results presented in Table 2 indicate that although burning/smouldering to generate smoke is the most common method of application, there are various other modes of applications which have also been reported such as leaves of *Cymbopogon citratus* placed over the floor of the house, *Echinops* species, *Silene macroserene* L. and *Otostegia integrifolia* L. plant parts are applied as a spray on the floor by crushing them. *Syzygium guineense* plant is used by hanging around the sleeping cot and on the wall and windows. The result is quite comparable with a few earlier studies (Waka et al., 2004; Karunamoorthi et al., 2009a,b). The similar practice of hanging the repellent plants inside the house is concurrent with the other reports from other parts of the Africa (Bockarie et al., 1994; Seyoum et al., 2003).

The interviewed villagers mentioned that they used to apply TIRPs in the early evening (88.1%), early morning (84.7%) and whenever necessary (54.7%) (Fig. 3). The finding is contrary with the study conducted in Tanzania and affirmed that the application of repellents was mostly done between 7 pm and 10 pm, such timing corresponds with the mosquito active biting cycle in the evening (Kweka et al., 2008). It may possibly explain that the Ethiopian principle malaria vector mosquito *Anopheles arabiensis's* (Patton) menace, although commonly begins in the early evening, its continuous biting activity has been observed to be almost throughout the night-time (Maxwell et al., 1998) and so repellent plants application time may possibly vary significantly.

The chi-square statistical analysis shows that there was no significant association between the respondents knowledge on insect repellent plants and the gender (P-value = 0.134), average monthly income (P-value = 0.529) and educational status (P-value = 0.107) (Table 3). The present ethnomedicinal survey findings are quite consistent with an earlier study carried out by Karunamoorthi et al. (2009b). However, in Table 3 the chi-square test reveals that there was a significant association between the respondents knowledge on TIRPs and their age (P-value = 0.012). It could be possibly explained that the elderly people tend to have more knowledge on TIRPs than the younger individuals as a result of frequent exposure to traditional insect repellents. The present survey finding is quite comparable with earlier studies conducted in Ethiopia with respect to age and knowledge on TIRPs (Karunamoorthi et al., 2009a,b).

The chi-square analysis shows that the repellent plants usage custom is significantly associated with gender (P-value = 0.021) and educational status (P-value = 0.003) of the respondents (Table 3). It could be possibly explained that in general women mainly engaged

with the household activities (rather than men) have more usage custom of TIRPs. Congruently the illiterate may not have the accessibility and capability to procure the modern personal protective devices such as bed nets and other commercialized repellent products which may lead to the application of TIRPs by illiterates everyday than the educated respondents. Nevertheless, the chi-square analysis shows that there was no significant relationship between the usage custom and respondents age (P-value = 0.312) and average monthly income (P-value = 0.111) (Table 3). The present study results are consistent with that those of the earlier studies carried out to assess the knowledge and usage custom of traditional repellent plants, in which it was found that there was no significant relationship between the age of respondents' usage custom concerning the insect repellent plants (Karunamoorthi et al., 2009a,b).

5. Conclusions

In conclusion, conserving our traditional knowledge and long-standing age old custom on TIRPs is extremely imperative for the betterment of humankind in order to minimize the many arthropod-borne diseases in particular malaria. Besides, at the moment generating the regional and international data-base on TIRPs could pave the way to isolate/identify the untapped pool of bio-active molecules accountable for the repellent efficacy. Furthermore, conducting more laboratory and field based studies to evaluate their repellent efficiency and human safety is extremely inevitable. We strongly believe that these kind of pioneer research and development investigations could pave the way to explore/formulate a new class of plant-based novel eco-friendly and user-friendly repellents in the near future.

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References

Alonso, P.L., Besansky, N.J., Burkot, T.R., Collins, F.H., Hemingway, J., et al., 2011. A research agenda for malaria eradication: vector control. PLoS Medicine 8, e1000401.

Berger, A., Curtis, C.F., 1995. Natural plant products as pesticides. In: Swedish University of Agricultural Sciences, Alnarp, Sweden, pp. 45–49.

Berger, A., 1994. Using natural pesticides: current and future perspectives. In: Swedish University of Agricultural Sciences, Alnarp, Sweden.

Bernier, U.R., Kline, D.L., Posey, H.P., 2007. Human emanations and related natural compounds that inhibit mosquito host finding abilities. In: Debboun, M., Frances, S.P., Strickman, D. (Eds.), Insect Repellents: Principles, Methods and Uses. CRC Press Taylor and Francis Group, New York, pp. 77–100.

Bockarie, M.J., Service, M.W., Barnish, G., Momoh, W., Salia, F., 1994. The effect of wood smoke on the feeding and resting behaviour of *Anopheles gambiae* s.s. Acta Tropica 57, 337–340.

CSA, 2006. The Ethiopian demographic and health survey 2005. Central Statistical Agency, Addis Ababa, Ethiopia.

Curtis, C.F., Lines, J.D., Baolin, L., Renz, A., 1991. Natural and synthetic repellents. In: Curtis, C.F. (Ed.), Control of Disease Vectors in the Community. Wolf publisher limited, London, pp. 75–92.

Edwards, S., Demissew, S., Hedberg, I. (Eds.), 1997. Flora of Ethiopia and Eritrea Hydrocharitaceae to Arecaceae, vol. 6. The National Herbarium/Department of Systematic Botany, Addis Ababa, Ethiopia/Uppsala, Sweden.

Edwards, S., Tadesse, M., Demissew, S., Hedberg, I. (Eds.), 2000. Flora of Ethiopia and Eritrea Magnoliaceae to Flacourtiaceae, vol. 2. The National Herbarium/Department of Systematic Botany, Addis Ababa, Ethiopia/Uppsala, Sweden.

Edwards, S., Tadesse, M., Hedberg, I. (Eds.), 1995. Flora of Ethiopia and Eritrea Canellaceae to Euphorbiaceae, vol. 2. The National Herbarium/Department of Systematic Botany, Addis Ababa, Ethiopia/Uppsala, Sweden.

Hedberg, I., Edwards, S. (Eds.), 1989. Flora of Ethiopia and Eritrea Pittosporaceae to Araliaceae, vol. 3. The National Herbarium/Department of Systematic Botany, Addis Ababa, Ethiopia/Uppsala, Sweden.

Hedberg, I., Edwards, S. (Eds.), 1995. Flora of Ethiopia and Eritrea Poaceae, vol. 7. The National Herbarium/Department of Systematic Botany, Addis Ababa, Ethiopia/Uppsala, Sweden.

Hedberg, I., Edwards, S., Nemomissa, S. (Eds.), 2003. Flora of Ethiopia and Eritrea Apiaceae to Dipsacaceae, vol. 4. The National Herbarium/Department of Systematic Botany, Addis Ababa, Ethiopia/Uppsala, Sweden.

Hedberg, I., Friis, I., Edwards, S. (Eds.), 2004. Flora of Ethiopia and Eritrea Asteraceae, vol. 4. The National Herbarium/Department of Systematic Botany, Addis Ababa, Ethiopia/Uppsala, Sweden.

Hotez, P.J., Remme, J.H.F., Buss, P., Alleyne, G., Morel, C., Breman, J.G., 2004. Combating tropical infectious diseases: report of the disease control priorities in developing countries project. Clinical and Infectious Diseases 38, 871–878.

Karunamoorthi, K., Bekele, M., 2009. Prevalence of malaria from peripheral blood smears examination: a 1-year retrospective study from the Serbo Health Center, Kersa Woreda, Ethiopia. Journal of Infection and Public Health 2 (4), 171–176.

Karunamoorthi, K., Deboch, B., Tafere, Y., 2010b. Knowledge and practice concerning malaria, insecticide-treated net (ITN) utilization and antimalarial treatment among pregnant women attending specialist antenatal clinics. Journal of Public Health 18 (6), 559–566.

Karunamoorthi, K., Ilango, K., 2010. Larvicidal activity of *Cymbopogon citratus* (DC) Stapf. and *Croton macrostachyus* Del. against *Anopheles arabiensis* Patton (Diptera: Culicidae), the principal malaria vector. European Review of Medical and Pharmacological Science 14 (1), 57–62.

Karunamoorthi, K., Ilango, K., Endale, A., 2009a. Ethnobotanical survey of knowledge and usage custom of traditional insect/mosquito repellent plants among the Ethiopian Oromo ethnic group. Journal of Ethnopharmacology 125 (2), 224–229.

Karunamoorthi, K., Ilango, K., Murugan, K., 2010a. Laboratory evaluation of traditionally used plant-based insect repellent against the malaria vector *Anopheles arabiensis* Patton (Diptera: Culicidae). Parasitology Research 106 (5), 1217–1223.

Karunamoorthi, K., Mulelam, A., Wassie, F., 2008a. Laboratory evaluation of traditional insect/mosquito repellent plants against *Anopheles arabiensis*, the predominant malaria vector in Ethiopia. Parasitology Research 103 (3), 529–534.

Karunamoorthi, K., Mulelam, A., Wassie, F., 2009b. Assessment of knowledge and usage custom of traditional insect/mosquito repellent plants in Addis Zemen Town, South Gonder, North Western Ethiopia. Journal of Ethnopharmacology 1121 (1), 49–53.

Karunamoorthi, K., Ramanujam, S., Rathinasamy, R., 2008b. Evaluation of leaf extracts of *Vitex negundo* L. (Family: Verbenaceae) against larvae of *Culex tritaeniorhynchus* and repellent activity on adult vector mosquitoes. Parasitology Research 103 (3), 545–550.

Klein, R.E., Weller, S.C., Zeissig, R., Richards, F.O., Ruebush, T.K.N., 1995. Knowledge, beliefs, and practices in relation to malaria transmission and vector control in Guatemala. American Journal of Tropical Medicine and Hygiene 52, 383.

Kolaczinski, K., Kolaczinski, J., Kilian, A., Meek, S., 2007. Extension of indoor residual spraying for malaria control into high transmission settings in Africa. Transaction of Royal Society Tropical Medicine and Hygiene 101, 852–853.

Kweka, E.J., Mosha, F., Lowassa, A., Mahande, A.M., Kitau, J., Matowo, J., et al., 2008. Ethnobotanical study of some of mosquito repellent plants in north-eastern Tanzania. Malaria Journal 7, 152, doi:10.1186/1475-2875-7-152.

Maxwell, C.A., Wakibara, J., Tho, S., Curtis, C.F., 1998. Malaria infective biting at different hours of the night. Medical and Veterinary Entomology 12, 325–327.

Moore, S.J., Darling, S.T., Sihuincha, M., Padilla, N., Devine, G.J., 2007. A low-cost repellent for malaria vectors in the Americas: results of two field trials in Guatemala and Peru. Malaria Journal 6, 101.

Moore, S.J., Lenglet, A., Hill, N., 2006. Plant-Based Insect Repellents. In: Debboun, M., Frances, S.P., Strickman, D. (Eds.), Insect Repellents: Principles Methods, and Use. CRC Press, Boca Raton Florida.

N'Guessan, R., Corbel, V., Akogbeto, M., Rowland, M., 2007. Reduced efficacy of insecticide-treated nets and indoor residual spraying for malaria control in pyrethroid resistance area, Benin. Emerging Infectious Diseases 13, 199–206.

Odalo, J.O., Omolo, M.O., Malebo, H., Angira, J., Njeru, P.M., Ndiege, I.O., Hassanali, A., 2005. Repellency of essential oils of some plants from the Kenyan coast against *Anopheles gambiae*. Acta Tropica 3, 210–218.

Palsson, K., Jaenson, T.G., 1999. Plant products used as mosquito repellents in Guinea Bissau, West Africa. Acta Tropica 72, 39–52.

Potera, C., 2008. In Search of a Better Mosquito Repellent. Environmental Health Perspectives 116 (8), A337.

Protopopoff, N., Verhaeghen, K., Van Bortel, W., Roelants, P., Marcotty, T., Baza, D., D'Alessandro, U., Coosemans, M., 2008. A significant increase in kdr in Anopheles gambiae is associated with an intensive vector control intervention in Burundi highlands. Tropical Medicine and International Health 13, 1479–1487.

Seyoum, A., Killeen, G.F., Kabiru, E.W., Knols, B.G., Hassanali, A., 2003. Field efficacy of thermally expelled or live potted repellent plants against African malaria vectors in western Kenya. Tropical Medicine and International Health 8, 1005–1011.

Seyoum, A., Palsson, K., Kung'a, S., Kabiru, E.W., Lwande, W., Killeen, G.F., Hassanali, A., Knols, B.G., 2002. Traditional use of mosquito-repellent plants in western Kenya and their evaluation in semi-field experimental huts against

Anopheles gambiae: ethnobotanical studies and application by thermal expulsion and direct burning. Transaction of Royal Society Tropical Medicine and Hygiene 96, 225–231.
Waka, M., Hopkins, R.J., Curtis, C., 2004. Ethnobotanical survey and testing of plants traditionally used against hematophagous insects in Eritrea. Journal of Ethnopharmacology 95 (1), 95–101.
WHO, (accessed 22.01.12), http://www.who.int/mediacentre/factsheets/fs117/en/, 2009.
2009. WHO Malaria Report. World Health Organization, Geneva, Switzerland.
2010. WHO Malaria Report. World Health Organization, Geneva, Switzerland.
Worrall, E., Basu, S., Hanson, K., 2005. Is malaria a disease of poverty? A review of the literature. Tropical Medicine and International Health 10, 1047–1059.