

Evaluation of Natural and Synthetic Repellents Against the Adult Vector Mosquitoes of *Culex quinquefasciatus* Say

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Abstract

Mosquitoes are one of the most dreadful creatures which are responsible for the transmission of various diseases to human beings. It is evident to find out suitable tool to control mosquitoes. In the present study, certain plant materials, plant oils and synthetic repellents were tested for their efficiency against *Culex quinquefasciatus*. Synthetic repellents exhibited a reasonably high protection time and suppression effect on the biting population of *Cx. quinquefasciatus*. Plant oils exhibited similar protection time and the percentage of suppression was on par with the synthetic repellents. The plant materials showed very low protection time but reasonably a high degree of suppression of biting population of *Cx. quinquefasciatus*. By using either synthetic or plant derived materials one can easily avoid mosquito bites. Since the plant materials are safer one can employ these materials to avoid mosquito biting problem and also the mosquito-borne diseases.

Keywords: Mosquitoes, *Culex quinquefasciatus*, Synthetic repellents, Plant extracts, Plant oils.

1. Introduction

Mosquitoes are one of the most prominent groups of insects which are acting as nuisance pests and also dangerous vectors for the transmission of several diseases like malaria, filariasis, chikungunya, Japanese encephalitis, dengue fever etc. to human beings (Naseem et al. 2016; Webb et al. 2016). Annually, more number of people suffer due to mosquito-borne diseases all over the world especially in tropical countries like India. Hence, it is inevitable to take necessary steps to control the mosquitoes and their impacts on public health (WHO 2014; Hotez et al. 2014; Suhrcke et al. 2011). *Culex quinquefasciatus* are the primary vectors which are responsible for the transmission of several pathogenic organisms. They are the main household pests in several urban areas and also frequently enter into human dwelling territories during night times for blood meal (Pickett et al. 2010; Kalita et al. 2013; Janssen et al. 2015; Bhattacharya et al. 2016).

Numerous methods including application of repellents are employed to control mosquito-borne

diseases. Repellents play an effective role in reducing the human vector contact and also help in reducing the disease transmission. Many synthetic and plant-derived repellents are available for the control of mosquitoes. More number of plant-based components show physiological and behavioral activities towards mosquitoes. On the other hand, chemicals are always so successful in mosquito control operations. It is essential to find out the effective repellents that could reduce the mosquitoes either by destroying them or preventing them from biting human beings (Irrusappan and Nisha 2018; Choochote et al. 2007; Gillij et al. 2008; Patel et al. 2012; Nooris and Coats 2017). In this context, the present work is planned to make an attempt to screen the selected plant extracts, plant oils and synthetic repellents for their efficiency against *Cx. quinquefasciatus*. The findings will help the future researchers to produce an effective repellent from ecofriendly bioproducts against mosquitoes, and to reduce the biting problem and the transmission of mosquito-borne diseases.



2. Materials and Methods

Study area

The biting behaviour of *Cx. quinquefasciatus* was studied in a house, located in Jaihindpuram in Madurai, Tamil Nadu, India. This area is known for the abundance of *Cx. quinquefasciatus*. Therefore, this mosquito was selected in the present study to screen the efficacy of both synthetic and plant derived repellents against its biting activity.

Assessment of repellent property

The repellent property of a repellent can be assessed by using both the protection time and the suppression effect of the repellents against the biting population of mosquitoes.

Protection time

The time interval between the time of repellent application and the landing of the first mosquito for biting is considered as the protection time. The synthetic repellents and plant derived materials were applied once on the leg and exposed to the mosquitoes for the landing. The mosquitoes were collected, while they were landing for taking a blood meal. Each material was tested for two days and one control collection was made before the experimental trials.

Suppression of biting activity

In addition to protection time offered by a repellent, the percentage of suppression effect of the same repellent against the biting population of mosquitoes was also calculated. The reduction in the number of biting mosquitoes after the application of repellents was compared with that of control. The variation exhibited among the selected repellents was recorded to confirm the efficacy of the repellents.

Three synthetic repellents and six plant materials, which included the oil and leaf extract were screened to assess the efficacy. This was carried out to test whether both the synthetic and natural materials had similar effect or not.

Synthetic repellents tested for the repellent property

Cream

Odomos cream contains N, N-diethyl benzamide as an active ingredient. It is manufactured by Balsara Hygiene Ltd, Mumbai, India

Lotion

Good Knight Lotion contains diethyl toluamide as an active ingredient. It is manufactured by Godrej Sara Lee Ltd., Mumbai, India

Gel

Good knight gel contains diethyl toluamide and ethyl alcohol as ingredients. It is manufactured by Godrej Sara Lee Ltd., Mumbai, India

Plant materials tested for the repellent property

Plant oils

Citronella oil

The citronella oil has been distilled from *Cymbopogon nardus* Rendle, commonly called as 'lenabatu'. The colour of oil ranges from yellow to light brown. The main constituent of citronella oil is d-citronellal, an aldehyde (C₁₀H₁₉O). In this

citronellal fraction, 1-lorneal, geramiol, geranyl acetate, famesol, methyl eugenol and sesquicimonellene are present. Other constituents as camphene, limonene, dipentene and heptenone are also present in the citronella oil. The oil is chiefly used for scenting soaps, sprays, disinfectants and polishes.

Eucalyptus oil

The Eucalyptus oil is obtained from many eucalyptus species. The main constituent of eucalyptus oil is lineole, which is used for medicinal purpose. The other main constituents are volatile aldehydes, piriene, terpineol phellandrene, citronellal, geranyl acetate, eudesmol and piperitone. This oil is chiefly used for medicinal purpose and in the manufacture of disinfectants and germicides.

Lemon grass oil

The Lemon grass oil is distilled from *Cymbopogon flexuosus* staff, commonly called as 'red grass'. The colour of this oil ranges from yellow to reddish brown with a powerful lemon like odour. The main constituent of lemon grass oil is citral. This is an aliphatic terpene, n-decylaldehyde, with traces of aldehyde C₁₀H₁₆O₆, nerol, geraniol and farnesol. Citral as such is used in flavours, cosmetics and perfumes.

Plant extracts

Mentha piperita (pudina) extract

It is mainly used in food, cosmetics, industries and pharmacy. It contains anethole, cineole, eugenol, safrole and stearyl alcohol. It possesses antiseptic, carminative and antispasmodic properties.

Coleus amboinicus (Omavalli) extract

It is used to treat bronchitis, asthma, chronic coughs, sores, burns and insect stings. It contains thymol, carva oval, eugenol and chamicol. It also contains ethereal oil with phenol and potassium.

Ocimum basilicum (Thiruneetru pacchellai) extract

It is known for its medicinal properties. It contains pinene, borneol and thymol. It is used in cosmetics, soaps, medicines and perfumes.

Method of the application of repellents and evaluation of repellent property (protection time and suppression activity)

Cream, gel and lotion

Odomos cream, Good knight gel and Good knight lotion were applied on one hand while the other hand was left free as control. The repellents were applied once at 17.00 h and the protection time was calculated for each repellent and the percentage of suppression of biting activity was also calculated.

Plant oils

Citronella oil, Lemon grass oil and Eucalyptus oil were tested individually for their repellent activity. These oils were applied on one hand and the other hand was kept as control. The repellents were applied at 17.00 h and the protection time and the percentage of suppression of biting activity were calculated.

Plant materials (leaf and paste)

Leaf extracts of pudina (*Mentha piperita*), omavalli (*Coleus amboinicus*) and thiruneetru pacchellai (*Ocimum basilicum*) were applied and their repellent activity was tested individually.

The repellents were applied at 17.00 h and the protection time and percentage of suppression of biting activity were calculated.

3. Results

The assessment of repellent activity of synthetic products, plant oils and plant materials have been carried out during early part of the dark phase of the day.

The protection time was recorded for each repellent. N, N-diethyl benzamide (odomas cream) showed a protection time of 4.50 hrs and 77.9% of suppression of biting activity (Fig.1).

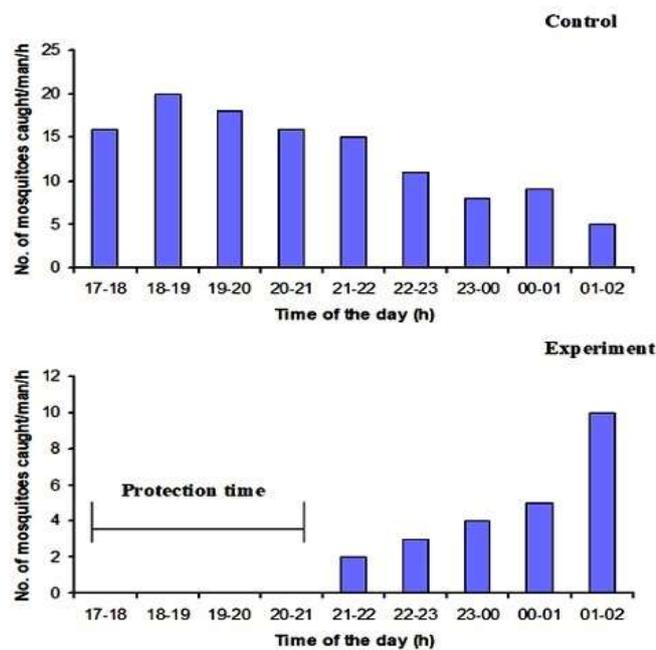


Fig (1): Efficacy of repellent activity of Odomas cream against the mosquito, *Cx. quinquefasciatus*

Diethyl toluamide (Good knight lotion) showed a protection time of 5.00 hrs and 92.6 % of suppression of biting activity (Fig.2).

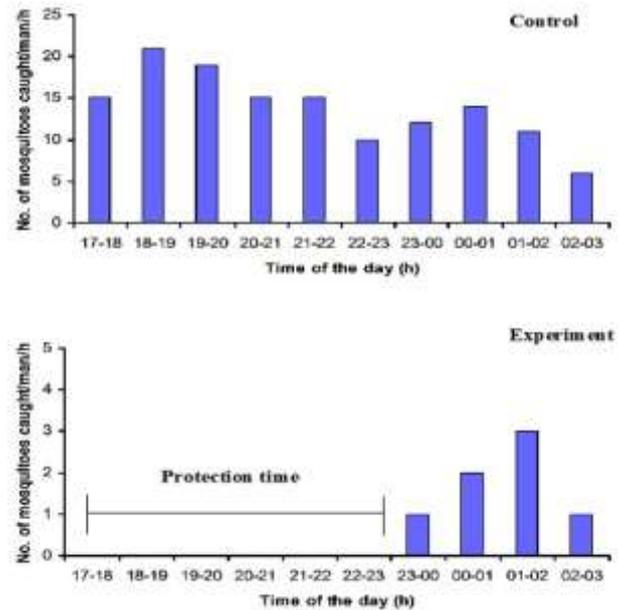


Fig (2): Efficacy of repellent activity of Good knight lotion against the mosquito, *Cx. quinquefasciatus*

Diethyl toluamide with ethyl alcohol (Good knight gel) provided a protection time of 7.25 h and 95.7 % of suppression of biting activity (Fig.3).

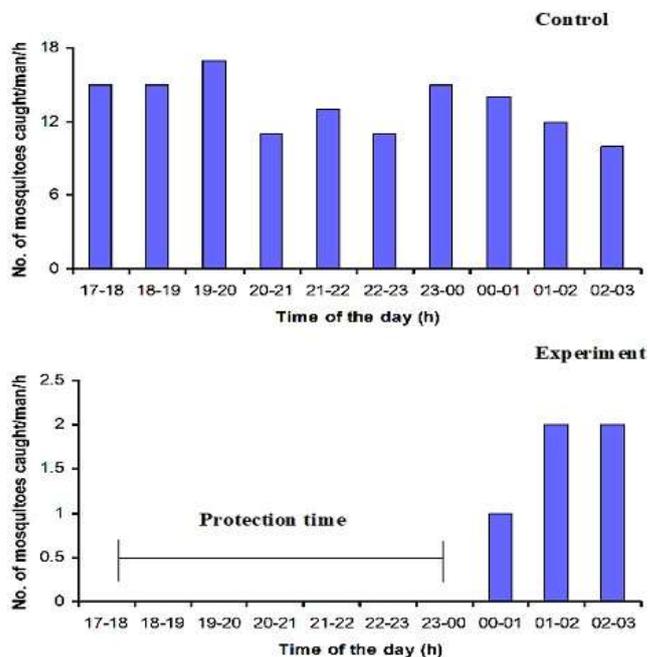


Fig (3): Efficacy of repellent activity of Good knight gel against the mosquito, *Cx. quinquefasciatus*

The Citronella oil provided a protection time of 3.00 h and 95.5% of suppression of biting activity (Fig.4).

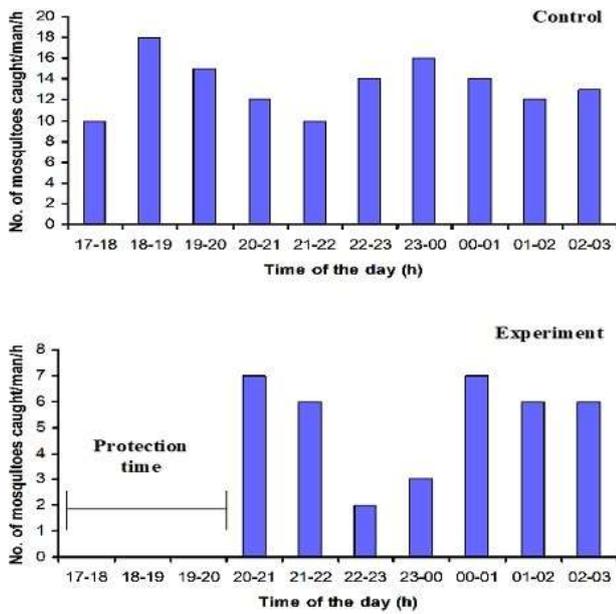


Fig (4): Efficacy of repellent activity of Citronella oil against the mosquito, *Cx. quinquefasciatus*

The eucalyptus oil showed a protection time of 4.00 h and 78.7 % of suppression of biting activity (Fig.5).

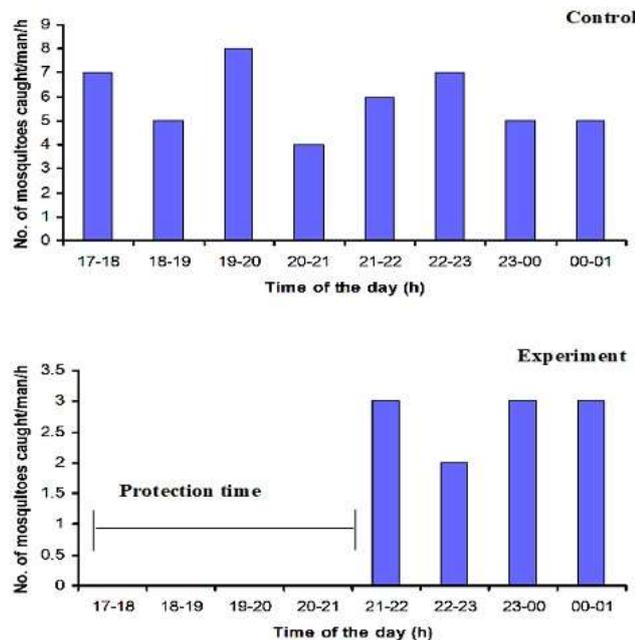


Fig (5): Efficacy of repellent activity of Eucalyptus oil against the mosquito, *Cx. quinquefasciatus*

Lemon grass oil offered a protection time of 5.00 h and 64 % of suppression of biting activity (Fig.6).

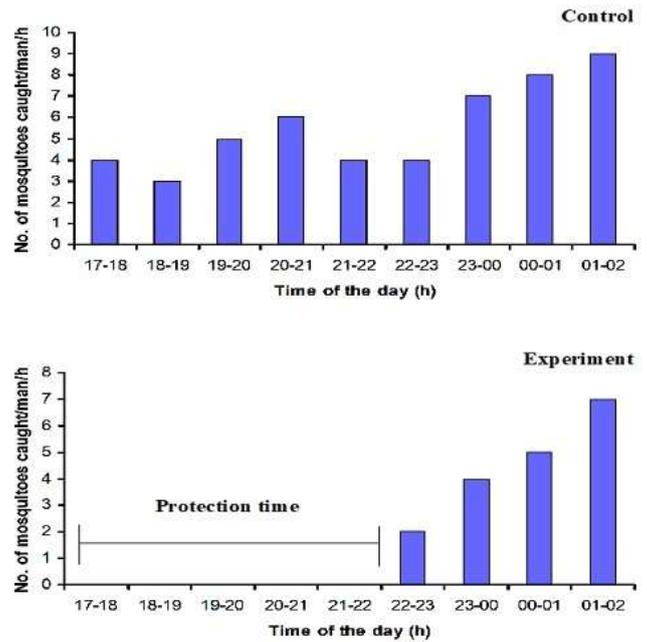


Fig (6): Efficacy of repellent activity of Lemongrass oil against the mosquito, *Cx. quinquefasciatus*

Pudina offered a protection time of 1.00 h but 26.5 % of suppression of biting activity (Fig.7).

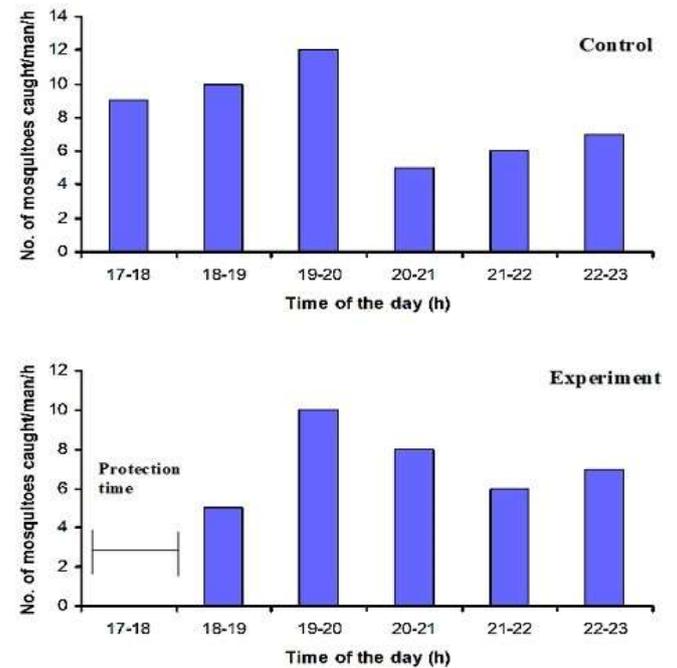


Fig (7): Efficacy of repellent activity of Pudina (*Mentha piperita*) against the mosquito, *Cx. quinquefasciatus*

Omavalli showed a protection time of 1.00 h but 44.3 % of suppression of biting activity (Fig.8).

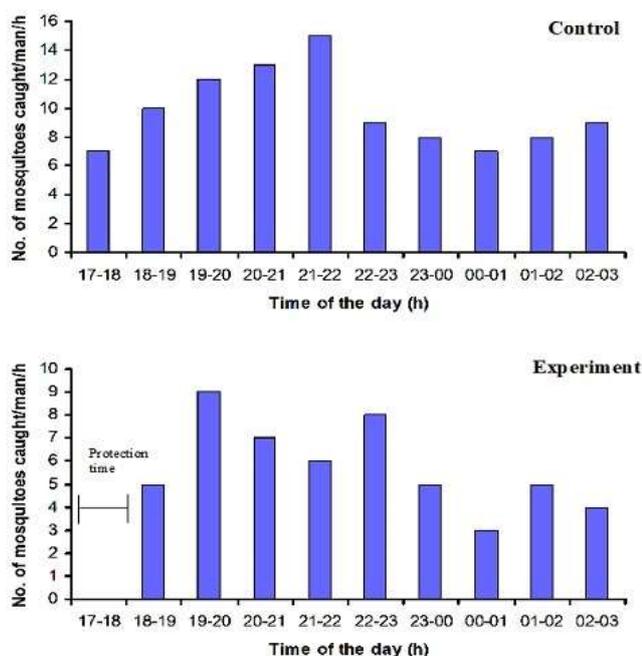


Fig (8): Efficacy of repellent activity of Omavalli (*Coleus amboinicus*) against the mosquito, *Culex quinquefasciatus*

Thiruneetru pacchellai showed a protection time of 1.10 h but 28% of suppression of biting activity (Fig.9).

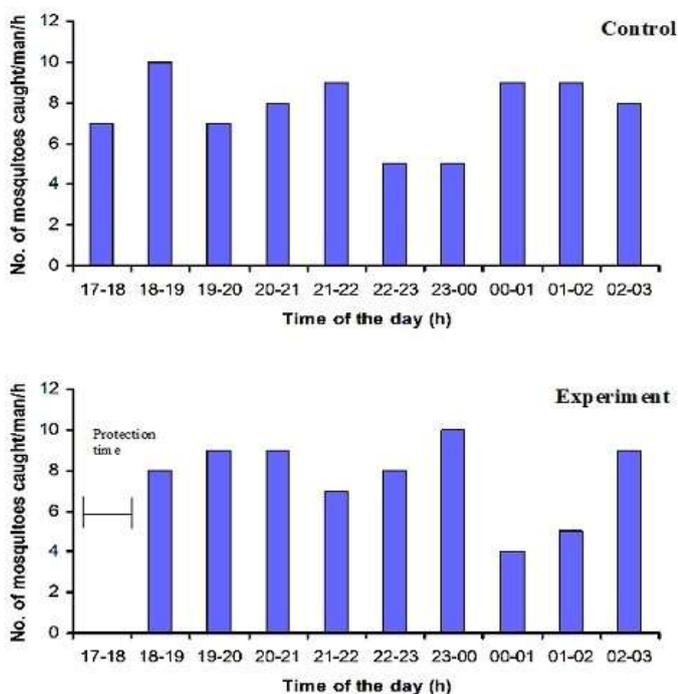


Fig (9): Efficacy of repellent activity of Thiruneetru pacchillai (*Ocimum basilicum*) against the mosquito, *Cx. quinquefasciatus*

Among the synthetic products Good knight gel and Good knight lotion offered a high protection time. Among the plant oils, Lemon grass oil showed a good protection time. Among the plant materials, Thiruneetru pacchellai provided a good protection time (Fig.10).

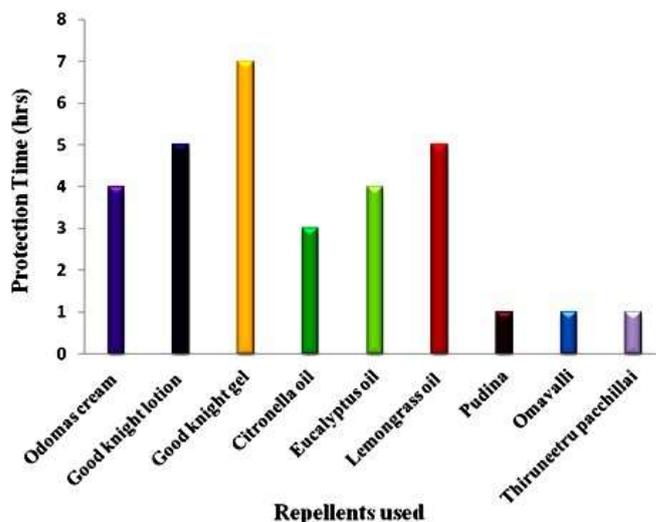


Fig (10): Comparative repellent activity of selected repellents against the mosquito, *Cx. quinquefasciatus*

The synthetic repellents, plant oils and plant materials were tried against this species and showed a reasonable protection time and effective suppression of biting activity. However, they showed a variation in their effects among themselves.

4. Discussion

Mosquitoes are more than just pests and they can transmit diseases like malaria, encephalitis and yellow fever. There are more than 2500 species of mosquitoes in the world and mosquito-borne diseases are posing a threat to the world. Mosquitoes transmit diseases to more than 700,000,000 people each year. No single method will provide adequate control of mosquitoes and so a combination of biological, chemical and environmental management and repellents is needed at present to attack mosquitoes. In this context, the knowledge about the behaviour of mosquitoes and suggestion of suitable alternative methods are desirable. *Cx. quinquefasciatus* is found predominantly in the urban areas and it breeds enormously in all the available habitats and multiply in large numbers (Fang and Janet 2010; MedGhosh et al. 2012; Petersen et al. 2013).

Govere et al. (2000) reported that the three commercial repellents Mosi-Guard towellets, skin care and standard DEET provided complete protection against *Anopheles arabiensis* for upto 3-4 hours post application. Debboun et al. (2000) evaluated the repellent efficacy of DEET and piperidine against the mosquito, *Aedes communis*. The incidence and geographical distribution of dengue have greatly increased in recent years. Millions of dengue cases occur worldwide each year. An outbreak of dengue occurred in Texas and Hawaii (Rodriguez-Tan and Weir 1998). This must be contained by using appropriate repellents. In North America, the insect repellents containing N, N-diethyl-m-toluamide (DEET) were used for the prevention of mosquito-borne diseases. (Mark and

Fradin 1998). In the present work, similar substances were tested and they showed a good protection time. The repellent action of Good knight gel and Good knight lotion is more and it may be due to the ingredients present. The odomos cream has low protection time compared to Good knight gel and lotion. The testing of these commercial products was made in order to compare the efficacy of selected phytochemicals against *Cx. quinquefasciatus*.

Many plant extracts of terrestrial origin and marine origin have been used to suppress mosquito population and suggested to be advantageous for field use of mosquito control programme (Govindarajan et al. 2012; Ali et al. 2012). Topical application of essential oils derived from clove (*Syzygium aromaticum*), Citronella (*Cymbopogon nardus*), patchouli (*Pogostemon cablin*) or makaen (*Zanthoxylum limonella*) may repel *Aedes aegypti* mosquitoes for upto two hours (Trongtokit et al. 2005). The active ingredient in catnip is the essential oil nepetalactone. A study at Iowa State University demonstrated that nepetalactone was ten times more effective at repelling mosquitoes than comparable concentrations of DEET. Odour of nepetalactone masks human odours that are attractive to mosquitoes (Bernier et al. 2005).

Citronella candles have been promoted as an effective way to repel mosquitoes in the backyard (Moore et al. 2014). When tested with *Aedes* mosquitoes under field conditions, persons near the citronella candles had 42% fewer bites than controls, who had no protection. However, the burning of ordinary candles reduced the number of bites by 23%. The efficacy of citronella incense and plain candle did not differ. The ability of plain candles to decrease biting may result from their action as a decay source of warmth, moisture and carbon dioxide (Mark and Faradin 1998).

Bite blocker is a plant-based repellent that was released in the United States in 1997. Bite blocker combines soybean oil, geranium oil and coconut oil in a formulation that has been available in Europe for several years (Malai and Moore 2011; Islam et al. 2017). Research conducted at the University of Guelph, Ontario, Canada showed that this product gave more than 97% protection against *Aedes* mosquitoes under field conditions, even 3.5 hours after application. During the same period, a 6.65% DEET-based spray afforded 86% protection, and Avon skin-so-soft citronella-based repellent gave only 40% protection (Lindsay et al. 1996a). A second study showed that Bite blocker provided a mean \pm S.D of 200 ± 30 minutes of complete protection from mosquito bites (Lindsay et al. 1996b).

Lemon grass oil has been considered as a carminative and insect repellent (Karpagam et al. 2016). Formulations of lemon grass oil in different classes of base have been tested for repellency in *Aedes aegypti* with 2-3 hours of protection time (Oyedele et al. 2002). In the present study, three

plant extracts were tested and they showed a low level of protection time. *Mentha piperita* and *Coleus amboinicus* exhibited 1.0 h of protection time. *Ocimum basilicum* showed the highest protection hour of 1.0 h. When the repellent activity of synthetic mosquito repellents and phytochemical repellents are compared, plant oils exhibited a high protection time and effective suppression of biting activity, which is on par with synthetic repellents. But leaf extract of the plants used also exhibited an almost equal effect of suppression of biting activity but poor repellent activity. Hence, plant oils and plant extracts can be used as repellents and the health hazards can be minimized.

Declaration of Competing Interest: None

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