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Copepod activity and mosquitocidal activity of berry extract against dengue vector *Aedes aegypti*: A mini review

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Abstract
The previous research was reported on the extract of *Solanum xanthocarpum* fruit and the copepods *Mesocyclops thermocyclopoides*, which were reported under laboratory conditions for the control of the dengue vector *Aedes aegypti*. The previous report therefore evidently demonstrates that the fruit extract of *S. xanthocarpum* and under laboratory conditions, copepod *M. thermocyclopoides* may serve as a potential for the highest rate of mortality against mosquito larvae. This is a modern eco-friendly system for the management of the target species the *Ae. Aegypti* mosquito. This study therefore provides a basic report on the collective impact of this fruit extracts and the copepods of *M. thermocyclopoides's* anti dengue vector *Ae. Aegypti* from India.

Keywords: *Solanum xanthocarpum*, *Mesocyclops thermocyclopoides*, *Aedes aegypti*, dengue

Introduction

Globally, the most rapidly spreading vector-borne disease is dengue, a mosquito-borne viral infection. And the dengue fever is prevalent in more than 100 countries including India (Tiwari *et al*., 2020) [1]. Dengue, caused by the dengue virus (DENV) is found throughout the world in tropical and subtropical climates, mostly in urban and semi-urban areas. Due to its effect on the health system worldwide, the World Health Organization (WHO) has deemed it as a major global health concern (WHO, 2010) [2]. In India, the burden of dengue infection in northern, western and southern regions is heterogeneous with high transmission rate (Murhekar *et al*., 2019) [3]. The National Vector-Borne Disease Control Program (NVBDCP) reported about 135,000 laboratory-confirmed dengue cases in India during 2019 which indicates that the disease is grossly under-reported (NVBDCP, 2020) [4].

A global map of the distribution of dengue epidemic activity was released by the WHO in 2006 which shows entire India in red. A comparison of similar maps prepared in previous years indicates that the activity of both the vector and the virus has expanded to new regions, gaining global significance for public health. In more than 100 nations, an estimated 2.5 billion individuals are at risk of contracting dengue viral infection with more than 50 million new infections expected annually, about 500,000 hospitalised cases of DHF and between 20,000 and 25,000 deaths, mainly in children (Chaturvedi and Shrivastava, 2004) [5]. Dengue was an urban epidemic, but has now spread to India's rural areas as well (Tewari *et al*. 2004) [6].

There are approximately 90 genera and 3,000 species in the Solanaceae family that are widely distributed in the world. They is a rich source of secondary metabolites that are active (Colettoda Silva *et al*. 2004) [7]. Within this family, with more than 1,500 species the Solanum genus is the largest and most complex one (Chowdhury *et al*. 2007) [8]. A wide number of steroidal saponins and glycoalkaloids are of ecological and human health concern. Numerous species of Solanum are known to possess a variety of biological activities including antimy-cotic.

In Ayurvedic medicine, *Solanum xanthocarpum* (family Solanaceae) is an important medicinal herb. Various studies have proposed that *S. xanthocarpum* has anti-asthmatic, hepatoprotective, antibacterial, hypoglycemic and insect repellent properties. Several steroidal alkaloids such as solanacarpine are reported in the fruits. Other components like caffeic acid, coumarins such as aesculetin and aesculin are from the fruits, steroids were identified from carpesterol, diosgenin, campesterol and daucosterol and triterpenes such as cycloartanol and cycloartenol (Sato and Latham, 1953) [9]. Naturally steroidal glycoalkaloids are secondary plant metabolites produced in a variety of foods including potatoes, tomatoes and eggplants (Friedman and McDonald 1997) [10]. The objective of this study is to assess S's hepato-protective effect and xantho-carpum fruit extract against anti-tubercular drug induced liver toxicity in laboratory animals (Talib *et al*. 2012) [11].

The use of natural enemies for controlling mosquito populations is biological control or "biocontrol." There are many forms of biological control, including the direct introduction of mosquito targeting parasites, pathogens and predators. An alternative solution to the systemic failure of the use of insecticides tends to be biological regulation, utilising the natural enemies of Aedes. Secondly, by contaminating soil, water and air, synthetic insecticides are harmful and diversely affect the environment. Hence, alternatives to these synthetic insecticides need to be sought. Plants can be an alternative source of agents for mosquito control because they are a rich source of bioactive chemicals that inhibit development. (Sharma *et al*. 2006) [12]. As they are rich in bioactive chemicals, they are active against a small number of organisms, including unique target insects and are biodegradable. And plants can be a source of alternative agents for vector control. In this respect, phytochemical insecticides have gained a great deal of attention because they are considered more environmentally biodegradable and safer than conventional insecticides (Cetin *et al*. 2004) [13]. Several researchers have recorded on the effectiveness of plant extract against mosquito larvae (Govindarajan *et al*. 2008; Kovendan *et al*. 2012b, c) [14-16].

In tropical and subtropical areas, *Mesocyclops thermocyclopoides* is a very common species and has been evaluated as a biological control agent against Aedes. This copepod feeds on the first and second instar of mosquito larvae, injuring about seven people every day fatally (Schaper and Hernández 1998) [17]. The possible biological agents of Ae have been identified as thermocyclopoides, *Mesocyclops guangxiensis*, and *Mesocyclops longisetus*, *Aegypti aegypti* (Schaper 1999; Locantoni *et al*. 2006) [18, 19]. In the laboratory, the efficacy of plant extracts and copepods for dengue vector control was checked (Murugan *et al*. 2011) [20]. And there has been a lot of effort focused on plant chemicals and their essential oils.

They are environmental friendly and readily biodegradable as possible sources of mosquito control agents. There are a wide number of agents including copepods, used in the biological control of mosquitoes. These agents are micro-crustacea, which present globally in freshwater bodies. Mesocyclops is one of the copepod genera that has been most studied as a mosquito larva antagonist and has been shown to be successful in various countries including India (Madhupratap 1999) [21]. In addition a clear negative association has been identified between *Mesocyclops* species in many ponds and small water bodies. Copepods have been shown to be successful especially in eliminating the development of Aedes from water storage tanks and other confined breeding environments that have long-term water. In fact, virtually all published instances of copepods in Aedes container habitats have been responsible for the use of copepods in the potential for the destruction of larval mosquitoes by certain cyclopoid copepods.

These water fleas were seen preying on larvae that were freshly hatched. The technology for controlling mosquitoes using predatory cyclopoids is "appropriate" at modest costs. However in countries plagued by mosquito borne diseases, biological controls using cyclopoids as predators against mosquito larvae have not received serious consideration. An additional benefit of cyclopoids over other marine predators is that they are wasteful hunters with the potential to consume more than they actually ingest mosquito larvae. They consume a small part of each larva if the larvae are numerous, which means that each copepod has the potential to kill 30 to 40 larvae every day, much more than they actually eat (Kumar and Rao 2003) [22]. However, only about 10% of water areas where mosquitoes may breed contain natural cyclopoid populations that can dramatically reduce the survival of mosquito larvae (Brown *et al*, 1991) [23]. The objective of the present statement was to explore the mosquito control agents, assessed mosquito species (*Ae. Aegypti*) under laboratory conditions, fruit extract (*S. xanthocarpum*) and the copepod (*M. thermocyclopoides*) for dengue vector control.

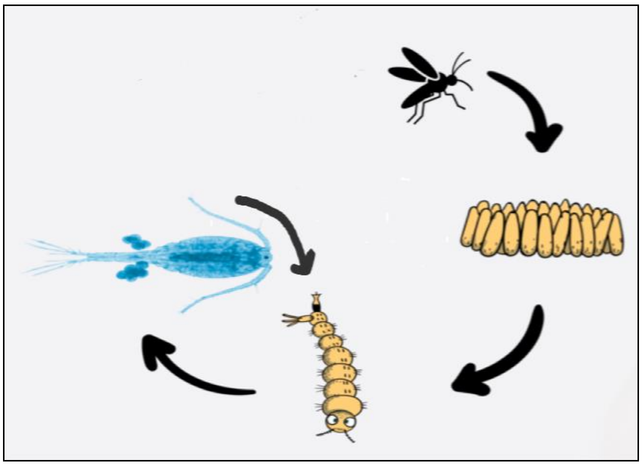

Fig 1: The copepod against dengue vector larvae

Table 1: Destructive efficiency of copepods, *M. thermocyclopoides* against *Ae. Aegypti* larval stage after the treatment of *S. xanthocarpum* fruit extract

Mosquito larval instars	No. of copepods introduced	Predation Time Control	Day- 1 response*	Day-2 response*	Day-3 response*	Day-4 response*	Day-5 response*	Total Predation	Percentage predation	Predatory efficacy of a single copepod/day	Reference
I	10	0	+	-	+	+	-	436a	87.2a	+	(Maheshkumar *et al*., 2012) [24]
II	10	0	+	-	-	+	-	295b	59b	-	(Maheshkumar *et al*., 2012) [24]
III	10	0	+	-	+	-	+	63c	12.6c	-	(Maheshkumar *et al*., 2012) [24]
IV	10	0	+	+	+	-	+	18 d	3.6 d	-	(Maheshkumar *et al*., 2012) [24]

Discussion

Mosquito control

Dengue is an arboviral disease transmitted predominantly by the *Ae. Aegypti* mosquito. *Ae. Aegypti* has become a significant international public health issue in recent years. It is found around the world in tropical and subtropical regions, mainly in urban and semi-urban regions. A global map of the distribution of dengue epidemic activity was released by the WHO in 2006, showing entire India in red. Worldwide, more than 50 million people are at risk of exposure to the dengue virus. 2 million infections, 500,000 cases of dengue hemorrhagic fever, and 12,000 deaths are recoded annually (Guha and Schimme 2005) [25].

Many approaches to mosquito control have been established. One such way to stop mosquito-borne dysfunction is by killing the mosquito at the larval stage. Synthetic insecticides are the foundation of the new mosquito control strategy. Although they are successful, they have produced many problems, such as insecticide resistance (Liu 2005) [26], contamination and adverse side effects on humans (Lixin, 2006) [27]. This has necessitated the need to study and develop an environmental friendly, biodegradable indigenous vector control system. Prior to the discovery of synthetic organic insecticides, many herbal products were used as natural insecticides. (Indian Council of Medical Research Bulletin, 2003) [28].

Plant extracts and phytochemicals

As products for mosquito control, plant extracts and phytochemicals have potential because many of them are selective, can also biodegrade into nontoxic products, and can be used in mosquito breeding locations in the same way as traditional insecticides (Jayabalan *et al*. 2003; Murugan *et al*, 2007) [29, 30]. It has been stated that the Solanaceae and Rutaceae family species have insecticidal properties against various pests and vectors. In recent years, natural plant products with insecticidal properties have been studied for the control of a number of insect pests and vectors. The LC50 value (45.749 %, 51.04 %, 57.170 %, 68.166 %, and 56.444 % respectively) of I to IV instar larvae and pupae were the methanol extract of Clerodendron inerme and Acanthus ilicifolius at various concentrations (20 to 100 ppm) respectively. LC50 values of 69.579 percent, 76.635 percent, 82.692 percent, 88.230 percent and 87.287 percent respectively, *A. ilicifolius* leaf extract (Kovendan and Murugan 2011) [31]; a leaf extract of *Jatropha curcas* methanol against *Cx. Quinquefasciatus* and the extract of L. Aspera Leaf against An. Stephensi's (Kovendan *et al*. 2011a, 2012a) [32, 33].

The oils of 41 plants were evaluated in a previous study for their effects on the third-star larvae of *An. stephensi*, *Ae. Aegypti* and *Cx. quinquefasciatus*. The oils were tested against *Ae. Aegypti* at first and using a solution of 50 ppm. Thirteen oils (camphor, thyme, amyris, lemon, cedarwood, frankincense, dill, myrtle, juniper, black pepper, verbena, helichrysum and sandalwood) from 41 plants caused 100% mortality after 24 h or even shorter periods.

This research reports on the impact of toxicity on Methanolic fruit extract of *S. xanthocarpum* on dengue vector *Ae. aegypti*. As the concentration increases the mortality percentage increases and especially the mortality in the early instar larvae was higher compared to the later phases. Extract from the petroleum ether of *S. xanthocarpum* with LC50 of 1.41 and 0.93 ppm and LC90 of 16.94 and 8.48 ppm at 24 and 48 h after application, *S. xan-thocarpum* was found to be the most toxic against *An. stephensi*. Methanolic extracts from fruits without seeds were reported by Bansal *et al*. (2009a, b) [34, 35] and *S. xanthocarpum* was tested against larvae *An. culicifacias*, *An. stephensi* and An. aegypti, Cx. quinquefasciatus is an important mosquito vector. As an antagonist of mosquito larvae, Mesocyclops has been studied and its efficacy has been shown in various countries, including the USA .This research shows that the predatory effectiveness of *M. thermocyclopoides* against the various larval instars of *Ae. Aegypti* are important. The predation rate of the copepods may have been limited by the active movements and large size of the older larval instars. Although the late instars have little intake, punctures and injuries to late mosquito instars lead to constrained growth and death.

As a support, report from previous work suggests that a very common species in Costa Rica is thermo-cyclopoides. This copepod feeds on the mosquito larvae of the first and second instars and fatally injuring about seven individuals per day.

Copepods are powerful mosquito predators of the first and second instar, but are not successful against the late instar. Therefore a combined method was effective using botanicals to increase the predatory efficiency of copepods against the late instar. The copepods displayed higher predation rate against Ae .aegypti larvae in combination with fruit. The development and active movement of mosquito larvae may have been disrupted by *S. xanthocarpum* fruit active compounds such as solanocarpine, solanocarpidine, solamagine, solasonine and solasodine present in SFXE, which increased the predatory effectiveness of copepods in the early and late periods. The active chemical compounds in SFXE have also shown no effect on the copepod's survival and growth. There have also been related inquiries using M. aspericornis in combination with other methods of regulation and culminating in the eradication of *Ae. Aegypti*.

Conclusion

The usage of copepod M in combination with *S. xantho* carpum fruit extract (SXFE), thermocyclopoids for mosquito control in jars gave the best results as compared to the application of copepods or individual treatments with fruit extract. For mosquito control in our laboratory, the approach of combined copepods and fruit extract also proves useful. This is a new eco-friendly approach and the target species is the Aegypti mosquito.

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