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REVIEW OF LITERATURE

The literature pertaining to the study, "***In silico* studies to screen ovicidal and repellent activity of selected plant extracts against the filarial vector, *Culex quinquefasciatus* (Diptera: Culicidae)**" is reviewed under the following headings:

2.1 Ovicidal activity of plant extracts

Bassole *et al* (2003) carried out ovicidal and larvicidal activity of essential oils extracted from three spontaneous plants of Burkina Faso against *Ae. aegypti* and *An. gambiae complex.* Pushpanathan *et al* (2006) evaluated the larvicidal, ovicidal and repellent activities of the essential oils extracted from *Cymbopogan citratus* against the filarial mosquito, *C. quinquefasciatus*.

Mullai and Jebanesan (2007) tested the larvicidal, ovicidal and repellent activities of the leaf extracts of two cucurbitacious plants, *Citrullus colocynthis* and *Cucurbita maxima* against the mosquito, *C. quinquefasciatus*. The ethyl acetate leaf extract of both plants were found to be more effective than the methanolic extract.

Kuppusamy and Murugan (2008) evaluated the whole plant ethanolic extracts and petroleum ether seed extracts of *Euphorbia hetrophylla* for its larvicidal, pupicidal, adult repellency and ovicidal properties against the *Bancroftian filariasis* vector, *C. quinquefasciatus*. Ethanolic and petroleum ether seed extracts were effective against the larvae of all instars and pupae.

Elango *et al* (2009) tested oviposition-deterrent, ovicidal, and repellent activities of leaf acetone, ethyl acetate, and methanol extracts of *Aegle marmelos*, *Andrographis lineata* Wallich and *Cocculus hirsutus* against *An. subpictus* Grassi.

Govindarajan (2009) studied the larvicidal, ovicidal and repellent activity of leaf extract of *Cassia fistula* with different solvents against *Ae. aegypti*. The

percentage hatchability was inversely proportional to the concentration of extract and directly proportional to the eggs.

Elango *et al* (2010) evaluated the repellent, ovicidal and oviposition deterrent potential of leaf hexane and chloroform extracts of indigenous plant on malarial vector, *An. subpictus*. Govindarajan (2011a) tested the mosquito larvicidal and ovicidal activity of crude hexane, ethyl acetate, benzene, chloroform, and methanol extracts of the leaf of three plants, *Eclipta alba, Cardiospermum halicacabum*, and *Andrographis paniculata* against *An. stephensi*.

Govindarajan (2011b) investigated the larvicidal and ovicidal efficacy of crude leaf extracts of *Cardiospermum halicacabum* with five different solvents like benzene, hexane, ethyl acetate, methanol and chloroform against the early third instar larvae of *C. quinquefasciatus* and *Ae. aegypti*.

Govindarajan *et al* (2011a) determined the ovicidal and repellent activities of methanol leaf extract of *Ervatamia coronaria* and *Caesalpinia pulcherrima* against *C. quinquefasciatus, Ae. aegypti* and *An. stephensi.* Elango *et al* (2011) studied the ethyl acetate, acetone and methanol extracts of *Andrographis paniculata, Eclipta prostrata* and *Tagetes erecta* leaves for oviposition-deterrent, ovicidal and repellent activities against malaria vector, *An. subpictus* Grassi.

Lalchhandama (2011) examined the larvicidal and ovicidal activity of the root bark of *Millettia pachycarpa* against the dengue vector mosquito, *Ae. aegypti*. Rajkumar *et al* (2011) assessed the larvicidal property of the leaf essential oil of *Coccinia indica* against first, second, third and fourth instars of *An. stephensi* using WHO protocol.

Valarmathy *et al* (2011) tested ovicidal activity of plant oil formulation with different concentrations for its ovicidal activity against the eggs of *An. stephensi* (Liston), *C. quinquefasciatus* (Say) and *Ae. aegypti*.

Govindarajan and Karuppannan (2011) investigated the larvicidal and ovicidal activities of benzene, hexane, ethyl acetate, methanol and chloroform leaf

extracts of *Eclipta alba* against dengue vector, *Ae. aegypti.* Kumar *et al* (2012) determined the phytochemical composition and mosquito ovicidal and repellent activity of aqueous extract of *Calotropis procera* leaves using *in vitro* methods for the control of *C. tritaeniorhynchus* and *C. Gelidus.*

Govindarajan *et al* (2012) studied larvicidal and ovicidal properties of leaf and seed extracts of *Delonix elata* against mosquito vectors, *An. stephensi* and *Ae. aegypti*. Krishnappa *et al* (2012a) investigated the larvicidal, ovicidal and pupicidal activities of *Gliricidia sepium* against the malarial vector, *An. stephensi.*

Marimuthu *et al* (2012) undertook a study to assess the larvicidal and ovicidal potential of the crude hexane, benzene, chloroform, ethyl acetate, and methanol solvent extracts from the medicinal plant, *Delonix elata* against the mosquito vectors, *An. stephensi* and *Ae. aegypti*.

Samidurai (2012) undertook a study to assess the larvicidal and ovicidal potential of the crude methanol, benzene and acetone solvent extracts from the medicinal plant, *Pemphis acidula* against the mosquito vectors, *C. tritaeniorhynchus* and *An. subpictus*.

Kovendan *et al* (2013) assayed the leaf extracts of *Acalypha alnifolia* for their ovicidal, repellent, adulticidal activity against three important vector mosquitoes, viz., *Ae. aegypti*, *An. stephensi* and *C. quinquefasciatus*. Roni *et al* (2013) studied the ovicidal and adulticidal activity of *Nerium oleander* extract against *An. stephensi* Liston. The extract was tested for its ovicidal and adulticidal activity using different plant parts under laboratory conditions.

Krishnappa and Elumalai (2013) **i**nvestigated the larvicidal and ovicidal activities of acetone, benzene, hexane and methanol leaf extracts of *Basella rubra* and *Cleome viscosa* against dengue vector, *Ae. aegypti*. Twenty five early third instar larvae of *Ae. aegypti* were exposed to various concentrations and were assayed in the laboratory by using the protocol of WHO (2005).

Krishnappa *et al* (2013) examined larvicidal and ovicidal activities of acetone, benzene, ethyl acetate and methanol leaf extract of *Cissus quadrangularis*

and *Combretum ovalifolium* against *An. stephensi*. Twenty five early fourth instar larvae of *An. stephensi* were exposed to various concentrations and were assayed in the laboratory by using the protocol of WHO (2005).

2.2 Repellent activity of plant extracts

Thavara *et al* (2002) evaluated forty four formulations of mosquito repellents containing plant extracts as active ingredients for repellency against *Ae. aegypti* under laboratory conditions at the National Institute of Health (NIH), Thailand. These extracts included citronella oil, eucalyptus oil, tea tree oil, turmeric oil, bergamot oil, lavender extract, tobacco leaves extract, clove extract and neem leaves extract.

Das *et al* (2003) evaluated the repellent properties of three plant extracts viz., essential oil of *Zanthoxylum limonella* fruits, *Citrus aurantifolia* leaf and petroleum ether extract of *Z. limonella* fruits against *Ae. albopictus* mosquitoes in mustard and coconut oil base. Repellents in mustard oil afforded longer protection time against the bites than those in coconut oil.

Oshaghi *et al* (2003) evaluated the repellent effect of extracts and essential oils of *Citrus limon* and *Melissa officinalis* against *An. stephensi* in laboratory on animal and human and compared with synthetic repellent DEET as a standard. There was no significant difference between DEET and lemon oil, whereas the difference between lemon and *Melissa* oils was significant.

Choochote *et al* (2004) investigated the potential of crude seed extract of Celery, (*Apium gravelolens*) against the mosquito, *Ae. aegypti* for its larvicidal, adulticidal and repellent activities. The ethanol extract of *A. graveolens* possessed larvicidal, adulticidal and repellent activities against *Ae. aegypti*.

Barnard and Xue (2004) carried out laboratory evaluation of mosquito repellent against *Ae. albopictus, C. nigripalpus* and *Ochlerotatus triseriatus*. Four synthetic mosquito repellents and eight natural product based repellents were tested.

Rajkumar and Jebanesan (2005) tested the oviposition deterrent and skin repellent activities of *Solanum trilobatum* leaf extract against the malarial vector *An. stephensi* under laboratory conditions. Different concentrations of plant extracts reduced egg laying by gravid females from 18 to 99% when compared to ethanol treated controls. The skin repellent tests using different concentrations also provided 10 to 120 minutes protection against mosquito bites.

Ansari *et al* (2005) evaluated the larvicidal and mosquito repellent activities of *Pinus longifolia* oil against the mosquitoes, *An. culicifacies* and *C. quinquefasciatus*. The results showed that pine oil is effective against mosquito larvae at very higher doses and showed stronger repellent action against both mosquito species.

Aidaross *et al* (2005) tested the repellent and larvicidal activity of *Ocimum basilicum* and *Cymbopogon citratus* against *C. quinquefasciatus*. *O. basilicum* extract gave 50% mortality within the concentration 1000-10000 ppm, while the *C. citratus* showed negative activity. Zaridah *et al* (2006) examined the extracts of Malaysian plants for their ability to kill the larvae or to repel the adults of *Ae. aegypti*. Observation of mortality was made after 24 hours of exposure.

Rajkumar and Jebanesan (2007) investigated the repellent activity of the essential oils extracted by steam distillation from leaves of *Centella asiatica*, *Ipomoea cairica, Momordica charantia, Psidium guajuva* and *Tridax procubens* against malarial vector, *An. stephensi.* The results obtained from this study suggested that essential oil of *I. cairica. M. charantia* and *T. procumbens* are promising as repellents against *An. stephensi* and could be useful in the search for new natural repellent compounds.

Misni e*t al* (2008) investigated the repellency of *Piper aduncum* essential oil against *Ae. aegypti*. The concentration of 0.4g showed an immediate 100% reduction in *Ae. aegypti* mosquito bite, which reduced to 70.30%. Singh *et al* (2009) studied the mosquito repellent efficacy of *Ocimum sanctum* plant extract against *Anopheles, Culex* and *Aedes* mosquito species in small net, large net and large room conditions.

Bream *et al* (2009) studied the toxicological and repellent activity of ethanol and petroleum ether derived from the indigenous water plant, *Phragmites australis* against second instar larvae and adult of *C. pipiens.*

Rajkumar and Jebanesan (2010) assessed the potential repellent activity of essential oil isolated from *Clausena dentata* against the bites of *Ae. aegypti.* The increase in the concentrations of essential oil increased the mean protection time against the bites of *Ae. aegypti*. Aarthi and Murugan (2010) recorded the larvicidal and repellent activity of *Vetiveria zizanioides*. *Ocimum basilicum* and the microbial pesticide spinosad against malarial vector, *An. stephensi* Liston.

Oparaocha *et al* (2010) examined the mosquito repellent and mosquitocidal activities of volatile oil of *Ocimum gratissimum* at three different locations in Imo state, Eastern Nigeria. Bream *et al* (2010) studied the larvicidal and repellent activity of aquatic plant *Echinochloa stagninum* against *C. pipiens*. Petroleum ether extracts were more efficient than ethanolic extracts of the different plant parts tested.

The three different oils namely, plant oil, essential oil, essential oil with ethyl alcohol were tested for its repellent activity against *Ae. aegypti, An. minimus* and *C. quinquefasciatus* under laboratory conditions. The essential oil from *Citronella* grass was effective as repellents, feeding deterrents and exhibited protection against biting from all three mosquito species (Phasomkusolsil and Soonwera, 2010).

Govindarajan (2011c) determined the larvicidal and repellent activities of *Coccinia indica* extract against *C. quinquefasciatus*, *Ae. aegypti* and *An. stephensi* at various concentrations ranging from 50-300ppm under the laboratory conditions. The repellent efficacy was determined at three concentrations viz., 1.0, 2.5 and 5.0 mg/cm^2.

Prabhu *et al* (2011) evaluated the larvicidal, pupicidal and repellent activity of the methanolic extracts of *Moringa oleifera* seeds against malarial vector, *An. stephensi* at different concentrations. The plant extracts exhibited larvicidal and

repellent activities on different instars, pupae and adults of *An. stephensi*. The LC_{50} and LC_{90} were determined by a probit analysis program.

Kumar *et al* (2011) assessed the larvicidal and repellent activity of oil extracted from the leaves of peppermint plant, *Mentha piperita* against the larval and adult stages of *Ae. aegypti*. The results showed that the essential oil extracted from *M. piperita* possessed excellent larvicidal efficiency against dengue vector.

Sritabutra *et al* (2011) investigated the repellent activity of herbal essential oils from garlic, clove, lemon grass, citronella grass, peppermint, eucalyptus and orange against *Ae. aegypti* and *An. dirus*. Essential oil from lemon grass exhibited protection against biting from the two mosquito species. The combinations from eucalyptus oil and sweet basil oil were effective as repellents and feeding deterrents against both the species.

Pannerselvam *et al* (2012) studied the larvicidal, pupicidal, repellent and adulticidal activities of methanol crude extract of *Artemisia nilagirica* for their toxicity against *An. stephensi* and *Ae. aegypti*. The results showed that, the plant crude extracts were highly effective and gave protection against mosquito bites.

Baluselvakumar *et al* (2012) evaluated the ovicidal and repellent activities of *Melothria maderaspatana* plant leaf extracts against *Ae. aegypti*. The hatch rates were assessed 48h post treatment. The repellent efficacy was determined against selected mosquito species at three concentrations viz., 1.0, 2.0 and 3.0 mg/cm^2 under laboratory conditions. The crude extracts of acetone, benzene, ethyl acetate, hexane and methanol *M. maderaspatana* exerted 100% egg mortality at 240, 200, 160, 160 and 120 ppm for *Ae. aegypti*.

Lawal *et al* (2012) evaluated the repellency activities of four formulated herbal mosquito repellents from the essential oils of selected six plants of Nigeria against *An. gambiae*. The result of the study demonstrated the potential for using essential oils from medicinal plants as mosquito repellent.

Pannerselvam and Murugan (2013) assessed the adulticidal, repellent, and ovicidal potential of the crude hexane, ethyl acetate, benzene, aqueous, and

methanol solvent extracts from the medicinal plants *Andrographis paniculata*, *Cassia occidentalis* and *Euphorbia hirta* against the medically important mosquito vector, *An. stephensi*.

2.3 Phytochemical screening

Edeoga *et al* (2005) assessed the medicinal plants namely *Cleome nutidosperma, Emilia coccinea, Euphorbia heterophylla, Physalis angulata, Richardia bransitensis, Scopania dulcis, Sida acuta, Spigelia anthelmia, Stachytarpheta cayennensis* and *Tridax procumbens*.

Sampathkumar and Ramakrishnan (2011) screened *Naringi crenulata* stem for phytochemical compounds and GC-MS analysis. The presence of phytochemical compounds were screened by qualitative method. The results showed the presence of carbohydrates, proteins, lipids, phenols, flavonoids, saponins, alkaloids, quinones, anthraquinones and terpenoids.

Ramasubramaniaraja (2011) evaluated the ethanolic leaf extracts of *Abutilon indicum* for macroscopic characters. GC-MS analysis revealed that the ethanolic extract of *A. indicum* contain terpenes, fatty acids, ketones, vitamin E and aldehyde eluting at different retention times with varied percentage of peak area.

Devendran and Balasubramanian (2011) carried out qualitative phytochemical screening and GC-MS analysis of *Ocimum sanctum* leaves. The qualitative analysis of the extracts of *Ocimum sanctum* leaf showed the presence of phytochemical constituents such as tannins, saponins, flavonoids, steroids and terpenoids. GC-MS analysis revealed the presence of ten compounds namely eugenol, caryophyllene, cyclopentane, cyclopropylidene, cyclohexane,1,2,4-triethenyl, octadecane, 1,1-dimethoxy and benzene methanamine and N,N,a,4-tetramethyl. Rani *et al* (2012) identified the phytochemicals present in the *Bougainvillea glabra* leaves and evaluated the antioxidant potential of the extract.

Selvi and Anusha (2012) carried out phytochemical analysis and GC-MS profiling of leaves of *Sauropus androgynus.* The results indicated the presence of proteins, resins, steroids, tannins, glycosides, reducing sugar, carbohydrates,

saponins, sterols, terpenoids, acidic compounds, cardiac glycosides, phenols, alkaloids and flavonoids.

Mordi and Akanji (2012) examined the phytochemical constituents of leaf extract of *Cnidoscolus aconitifolius.* Both the aqueous and ethanolic leaf extracts of *Cnidoscolus aconitifolius* showed the presence alkaloids, tannins, phlobatannin, saponin and phenols. Phlobatannin and saponin were found in appreciable amounts in the aqueous extract than the ethanolic extract.

Kavit *et al* (2013) evaluated for phytoconstituents present in the leaf extract of *Phyllanthus fraternus*. The plant extract contained alkaloids like morphine and boldine and also contained tannin, saponin, terpenoid and steroid. Nishaa *et al* (2013) screened the phytochemicals present in the rhizomes of *Maranta arundinacea* and extracted based on the increasing order of polarity.

Bartholomew *et al* (2013) evaluated the antioxidant and phytochemical properties of leaf extracts of the Nigerian *Oxytenanthera abyssinica* using chromatographic and spectrophotometric methods**.** The results revealed the presence of steroids, alkaloids, saponins, tannins, cardiac glycosides, flavonoids, phlobatanins, anthroquinones and terpenes.

Jeyakumar *et al* (2013) determined the phytochemical constituents in *Caralluma umbellata* by GC-MS analysis. The phytochemical analysis showed the presence of potent phytochemicals like flavonoids, terpenoids, tannins, glycosides sterols, phenols and saponins.

Suresh *et al* (2013) reviewed the potential herb *Calotropis gigantea* to find out its various medicinal properties. The phytochemical analysis of the plant revealed the presence of many bioactive compounds namely flavonoids, triterpenoids, alkaloids, steroids, glycosides, saponins, terpenes, enzymes, alcohol, resin, fatty acids, esters of calotropeols, volatile long chain fatty acids, glycosides and proteases.

Visweswari *et al* (2013) extracted and detected the active phytochemical compounds from different extracts of *Withania somnifera* root. Phytochemical

screening of different extractions revealed the presence of phenols, flavonoids, tannins, saponins, alkaloids, steroids, terpenoids, glycosides and reducing sugars.

2.4 GC-MS analysis

Tasdemir *et al* (2003) analysed the volatile constituents of various solvent extracts of leaves, flowers and fruits of five Rhododendron species growing in Turkey with head-space solid-phase micro extraction (Hs-SPME) technique and was analyzed by GC-MS. A total of 200 compounds were detected and identified from organic extracts.

Jacques *et al* (2007) carried out the GC-MS characterization of tea leaves extracts obtained from high-pressure CO_2 extraction. Quinn *et al* (2007) examined the compounds from *Etonia rosemary* to identify compounds for examination as insect repellent. *Etonia rosemary* samples were passively extracted with hexane, dichloromethane and methanol and analyzed by GC-MS.

Ogunlesi *et al* (2009) analyzed the essential oil obtained from the dried leaves of *Euphorbia hirta*. Analysis of oil was carried out on a combined gas chromatography mass spectrometer. The major components identified include 3, 7, 11, 15-tetramethyle-2-hexadecen-1-01, 6, 10, 14-trimethyl-2-pentadecanone, hexadecanal, phytol and n-hexadecannoic acid.

Gerige *et al* (2009) carried out the GC-MS analysis of *Nigella sativa* seeds. The GC-MS analysis of the *N. sativa* volatile oil showed thirty one compounds, which included two new chemical compounds viz., naphthalenone and ovdin. Derwich *et al* (2010) analyzed the essential oils of leaves of *Mentha pulegium* extracted by hydrodistillation using Gas Chromatography equipped with Flame Ionisation Detector (GC-FID) and Gas chromatography coupled to Mass spectrometry (GC-MS), to determine the chemical composition of the volatile fraction and to identify their chemotypes.

Nisha *et al* (2011) isolated the essential oil of the leaves of *Psidium guajava* and analyzed it by Gas chromatography coupled with Mass spectrometry. The components of the essential oil were identified by comparing their retention indices and mass spectra fragmentation patterns.

Manjamalai *et al* (2011) investigated the antifungal, anti-inflammatory and GC-MS analysis of the methanol extract of *Plectranthus ambomicus* leaf. The results of GC-MS analysis showed the presence of active phytochemical compounds in the essential oil of fresh leaves of the plant. Velanganni *et al* (2011) studied the GC-MS analysis and the chemical composition of ethanolic root extract of *Mallotus philippensis*.

Vohra and Kaur (2011) analysed the chemical composition of essential oil and antibacterial activity of the leaves of *Ajuga bracteosa*. The main components present in the essential oil of leaves were limonene, α-humulene, β-myrcene, elemol, camphene, β-caryophellene, α-phellendrene.

Charles *et al* (2011) reported the GC-MS analysis of bioactive components on the bark extract of *Alseodaphne semecarpifolia* Nees. Twenty eight bioactive phytochemical compounds were identified in stem bark of *A. semecarpifolia*. Phenolic derivatives, hydrocarbons, carbohydrates, fatty acid, fatty acid ester, alcoholic compounds, alkaloids, ketones and alkenes compounds were detected in the extract.

Abirami and Rajendran (2011a) evaluated the bioactive compounds of the plant *Indigofera aspalathoides* using GC-MS. The major compounds revealed in the study were tetradecanoic acid, 2 methoxy-4α-methylandrost-2-en-17-1-one 5β. Abirami and Rajendran (2011b) evaluated the bioactive compounds of S*olanum surattense* using GC-MS.

Kumaresan *et al* (2011) carried out a study to analyze the active constituents present in the flower of *Spathodea campanulate.* GC-MS analysis resulted in the identification of four compounds. Butane, 1, 1-diethoxy-3-methyl and n-hexadecanoic acid were the major constituents of ethanolic extract.

Kumar *et al* (2011) tested the phytochemical constituents and free radical scavenging activity of methanolic extract of *Litsea decanensis* using GC-MS analysis. It showed a high complexity profile containing eleven components, namely quassin, squalene, stigmesterol, vitamin E and oleic acid.

Senthil Kumar *et al* (2011) compared the phytochemical constituents present in *Withania somnifera* and *Withania obtusifolia.* In the GC-MS analysis, twenty four and twenty one bioactive phytochemical compounds were identified in *W. obtusifolia* and *W. somnifera* respectively. Mirghani *et al* (2012) examined lemongrass on the basis of their usage in traditional medicines throughout Southeast Asia. GC-MS analysis revealed that geranial, neral, geraniol, limonene and β-myrcene were the major constituents.

Janakiraman *et al* (2012) characterized the chemical constituents of *Peristrophe bicalyculata* Nees using GC-MS analysis. The analysis provided different peaks determining the presence of seven different phytochemical compounds namely propane, 1, 1-diethoxy, (6Z)-nonen-1-ol, 4-methyl-2, 4-his (4' – trimethylsilyloxyphenyl) pentene-1, cyclooctyl alcohol, oxirane, butyl, (2H) pyrrole-2-carbonitnle, 5-amino-3, 4-dihydro and ethaneperoxic acid, 1-cyano-1-pentyl ester.

Kale *et al* (2012) analysed the hexane extract from the bark of *Juglans regia*. The GC-MS study revealed that thirteen major peaks showed the presence of hydrocarbons, aliphatic-saturated and unsaturated acids, alkyl halide, cyclic ester-lactone and aromatic ester. The major constituents were n-octedecane, n-hexadecanoic acid, 9-E-hexadecanoic acid, tetratetracotane, 4, 8, 12, 16 tetramethyl heptadecane-4-olide, n-heptadecanoic acid, 1-iodohexadecane, stearic acid, oleic acid, erucic acid and di-n-octyl phthalate.

Kalaivani *et al* (2012) examined the phytochemical constituents present in *Andrographis paniculat*a. The preliminary phytochemical analysis confirmed the presence of various secondary metabolites like steroids, alkaloids, phenols, catechine, flavonoids, saponins and tannins.

Zeeshan *et al* (2012) carried out isolation, purification and evaluation of bioactive compounds from the crude methanol extracts of the leaves of *Ageratum houstonianum*. The most important compounds identified in the crude extract and active bands were 6-acetyl-7-methoxy-2-dimethylchromene, hexadecanoic acid and squalene, respectively.

Sureshkumar (2013) reported the phytochemical property of *Calotropis gigantea*. Acetone, methyl alcohol and chloroform extracts of the plant were reviewed by using GC-MS. The numbers of compounds greatly varied from one solvent to another solvent.

2.5 *In silico* molecular docking

Kee *et al* (2007) carried out a protein-ligand binding interaction study by performing docking of the ligands that were found to be competitively inhibiting the activities of the DEN2 NS2B/NS3 serine protease onto the catalytic triad of a model of DEN2 NS2B/NS3 protease.

Shekinah and Rajadurai (2008) made an attempt to identify the potential drug and to inhibit as well as to modify their side chain to impure the binding efficiency of the enzyme that catalyses the isomerization of D-Glyceraldehyde 3 phosphate to dihydroxy acetone phosphate in the glycolysis of the protozoan *Plasmodium falciparum* which helps in its energy supply.

Azhaguraj *et al* (2010) predicted the biological activity profile of nineteen algal secondary metabolites using PASS, which is able to simultaneously predict more than one thousand biological and toxicological activities from only the structural formulas of the chemicals and were successfully compared to the available information on the pharmacological and toxicological activity of these compounds.

Skariyachan *et al* (2010) modeled a 3D structure of Cag A protein by X-ray crystal structure of dihydroorotate dehydrogenase (PDB ID 2B4G: A) using *Trypanosome brucii* as the template. The RMSD value of modeled structure was found to be 1.2A$^{\circ}$. Validation was done by various molecular dynamic empirical force fields. Molecular docking was performed to design and optimize new potential drugs against the disease by *in silico* approach.

Huang and Zou (2010) reported that molecular docking is a widely-used computational tool for the study of molecular recognition, which aims to predict the binding mode and binding affinity of a complex formed by two or more constituent molecules with known structures.

Prakash *et al* (2010) carried out molecular docking studies on anti malarial drug proguanil which stops the malaria parasite, *Plasmodium falciparum* and *Plasmodium vivax* from reproducing once it is in the red blood cells. The most feasible position for the drug to interact with the receptor was found to be with analog 2. So proguanil analog 2 sketched using ChemSketch is detected with more significant energy values in both softwares and probable lead molecules.

Kumar *et al* (2010) find out the mosquito larvicidal compounds by blocking the sterol carrying protein, AeSCP-2, through computational screening and docking strategies. Protein-ligand interactions were carried out with various phytochemicals and the result stated that in virtual screening alpha-mangostin and panthenol were found to be good analogs and were allowed to dock with the mosquito cholesterol carrier protein AeSCP-2.

Rajeswari and Kriushnapriya (2011) aimed to find out Cyclooxygenase inhibiting compounds from *Phellinus adamantinus,* a woodrot mushroom. 3D structures of nine compounds reported from GC-MS analysis of methanol extract of *P. adamantinus* were built using ChemSketch software and biological activity was predicted using PASS. All the compounds analyzed exhibited antiviral, antibacterial, antineoplastic, antidiabetic and anti-inflammatory properties.

Choudhury *et al* (2011) docked the enzyme dihydroorate dehydrogenase (DHOD) present in the fatal malarial parasite, *Plasmodium falciparum* that catalyses the rate limiting step of the pyrimidine salvage pathway, with twenty compounds of triazolopyrimidine group selected from PubChem. All the compounds were found to have good affinity towards pfDHOD and capable of inhibiting the enzyme. Among these twenty compounds, compound 7, i.e. N,5-dimethyl-N-naphthalen-2-yl-[1,2,4] triazolo [1,5-a] pyrimidin-7-amine showed the highest docking score and compound 15, i.e. 5-methyl-N-naphthalen-1-yl- [1,2,4] triazolo [1,5-a] pyrimidin-7-amine showed the lowest docking score which revealed the antimalarial potency of these triazolopyrimidine compounds.

Satpathy *et al* (2011) used the HIV NS3 protease inhibitors to evaluate binding affinity on dengue virus NS3 protease. The NS3 viral protease is a potential

target for antiviral drugs since it is required for virus replication. All total nineteen inhibitors were obtained from PubChem database and after energy minimization docking was performed by taking NS3 protease of dengue virus as a receptor (PDB ID 2FOM). The docking energy for the two of the ligands having PubChem database ID CID 482206 and CID 484561 showed highest value equally as -400.08.

Habeeb *et al* (2011) studied comparative molecular modeling of insect glutathione S-transferases. The 3D models for the GSTs from the insects were built using Modeller9V7. Structure comparison between the GSTs was done using Swiss PDB Viewer and the models were docked with piperonyl butoxide, tagitinin C, a phytochemical from *T. diversifolia.*

Lertkiatmongkol *et al* (2011) carried out a study on homology modeling of mosquito cytochrome P450 enzymes involved in pyrethroid metabolism. Homology models of the three *An. minimus* P450 enzymes were constructed using the multiple template alignment method. The predicted enzyme model structures were compared and used for molecular docking with insecticides and compared with results of *in vitro* enzymatic assays.

Pratheepa (2012) predicted the medicinal property of the plant *Cleistanthus collinus.* Phytochemical analysis was done to know the presence of components like terpenoids, reducing sugars, steroids, flavonoids etc. Suresh *et al* (2012) reported the phytochemical properties of *Calotropis gigantea*. *In silico* docking analysis was also carried out to assess the mosquito larvicidal potential of three terpene compounds isolated from *C. gigantea*. The GC-MS analysis of the chloroform extract revealed the presence of eight terpenes in the plant.

Zhao *et al* (2012) investigated the theoretical model of the three-dimensional structure of mosquitocidal Cry30Ca2 and its molecular docking with N-acetylgalactosamine. The theoretical model of Cry30Ca2 was predicted by homology modeling on the structure of the Cry4Ba. Docking studies were performed to investigate the interaction of Cry30Ca2 with N-acetylgalactosamine on the putative receptor.

Josephine (2012) carried out molecular docking of natural compounds extracted from plant species viz., *Artemesia annua, Holarrhena antidysenterica, Lycoris radiate* and *Helianthus annus*. The compounds extracted from plants were taken for *in silico* binding prediction affinities against crystal structure of macro domain of chickungunya virus. Target protein and chemical compounds were retrieved from protein data bank and PubChem compound database.

Patel *et al* (2012) investigated the probability of xanthones as an anti malarial molecules, against *Plasmodium falciparum* erythrocyte membrane protein 1 (PfEMP1) via molecular docking studies. The *in silico* effectiveness of Xanthones was studied based upon the interaction with the protein's active site residues with less binding energy. The interacting Xanthones were further filtered to predict the bioavailability and drug likeness properties. 3, 6-dihydroxyxanthone was shown to be a better interacting ligand with low binding energy and passed all the physicochemical parameters for drug likeness.

Gaddaguti *et al* (2012) carried out GC-MS analysis and *in silico* molecular docking studies of mosquito repellent compounds from *Hyptis suaveolens.* To assess the efficient therapeutic properties with minimum side effects, application of advanced methods like GC-MS and computational techniques play a crucial role in designing and development of drug of interest. Thirteen compounds were identified in aerial parts of *Hyptis suaveolens* methanolic extracts. Stigmast-5-en-3-ol, oleate and gamma-sitosterol and butyl 11-eicosenoate found to represent 51.7% of the thirteen compounds identified in the methonolic extract. Molecular docking studies were performed for all thirteen compounds along with commercially known mosquito repellent compounds including DEET, prallathrin and permithrin against odorant binding protein (3N7H) of *An.gambiae* using Schrodinger Maestro software. The binding affinities of the compounds of *Hyptis suaveolens* were compared with known mosquito repellents for its ability to suppress human seeking behaviour of mosquitoes and for further possibility in designing of potential mosquito repellent from natural compounds.

Annapoorani and Manimegalai (2013) revealed the biological activity of 2, 5-dihydroxybenzoic acid from *Momordica charantia* fruit petroleum ether extract.

Qualitative phytochemical analysis of these plants confirms the presence of various phytochemicals like sterols, flavonoids, teripenoids, proteins, alkaloids, quinones and anthrocyanins. The PASS software was used in the study to predict the biological activity profile and provided all the possible activity of the secondary metabolite.

Rajarajeshwari and Chitra (2013) subjected forty three medicinal plants with numerous phytochemicals are subjected to PASS server for the prediction of their biological activity. The medicinal value of those compounds and its activity for inhibiting specific viral targets are analyzed from the PASS prediction results. Further, molecular docking studies has been carried out using the commercial software Schrodinger USA.

Khanikor *et al* (2013) tested the comparative mode of action of some terpene compounds against octopamine receptor and acetyl cholinesterase of mosquito and human system by the help of homology modeling and docking studies. Five terpene compounds namely eugenol, geraniol, coumarin, eucalyptol and carvacrol were allowed to dock against octopamine receptor and acetyl cholinesterase protein models of *Ae. aegypti* and *Homo sapiens* to evaluate their comparative efficacy in terms of docking performance. All the compounds were found to dock with both the protein models of the two animal systems while some of them were found to better perform against the protein models of *Ae. aegypti* than the protein models of *H. sapiens* which can further be explored in mosquito control programme as a comparatively safe compound.

Shinde *et al* (2013) identified the potential phyto inhibitors that inhibit the enzyme which catalyzes the isomerization of D-Glyceraldehyde 3 phosphate to dihydroxy acetone phosphate in the glycolytic pathway of the malarial parasite *Plasmodium falciparum*, as well as to modify their side chain to impure the binding efficiency. Autodock Vina, a docking tool was used for molecular docking that utilizes information on conformational variability from ensembles of experimental receptor structure of Triosephosphate isomerase.

Affonso *et al* (2013) performed docking and molecular dynamics on potential ligands to the odorant binding protein of the mosquito, *Anopheles gambiae* (*Ag*OBP1), the main vector of malaria. The results suggested that eugenyl acetate is a better repellent than DEET and also revealed the main features of the binding site of *Ag*OBP1, important to the design of new and more efficient repellents.