Review of Literature
REVIEW OF LITERATURE

The richness of species in an ecosystem can generally be associated with the variety in habitats in the region and may show variations within the same geographical region. Changes in the composition of mosquito fauna concomitant with the changes in ecosystem have been well demonstrated by studies carried out in different phases during the establishment of an irrigation project in a forested area (Mahaweli project) in Sri Lanka (Amerasinghe and Ariyasena, 1990; Amerasinghe and Indrajith, 1994; Amerasinghe and Munasinghe, 1988a and 1988b).

An extensive survey of mosquito fauna and their breeding habitat were carried out by Khan et al. (1998) in the upper Brahmaputra valley in Assam around the bordering areas of Arunachal Pradesh. A total of 22 different types of habitats have been identified in their study. Bamboo stumps, mud pools, ponds, irrigation channels, spring pools, stream pools, rain water pools and manure pits were the breeding habitats where more than ten species of mosquitoes were recorded.

Dev (1994) undertook studies to ascertain the breeding habitats of mosquitoes in the rice growing areas of Sonapur PHC, Assam. Streams and ponds were major sites for a good number of species for oviposition, whereas wells, ditches and roadside pits supported breeding of fewer species.
Mosquito larvae can be found in numerous habitats. Habitat and climate determine which mosquito species will be present in any given area. Each habitat produces specific mosquito species and show a seasonal progression of the species. Habitats can be generally grouped into four types running water, transient water, permanent water or containers.

WELLS

Wells and intradomestic breeding sources were the main breeding habitats of *An. stephensi*. *An. varuna* was also found to breed mostly in wells and ponds (Yadav et al., 1989). Russell and Rao (1940a) collected *An. stephensi* and *An. varuna* predominantly from wells during their study on anopheline mosquitoes in Tanjore district.

Wells are important sources of water to meet both domestic and irrigation needs. In urban areas, domestic wells are common while in rural areas both the domestic and irrigation wells are present. Wells comprise the major breeding sites of vectors of malaria, filaria and dengue. In villages around Delhi, profuse breeding of *Culex quinquefasciatus* has been reported to occur in wells and the species is occasionally replaced by *An. culicifacies* and *An. stephensi* (Sharma, 1985).
Mosquito breeding is more frequently encountered in unused and abandoned wells than in wells that are frequently used (Tiwari and Tyagi, 1989). Dev (1994) recorded the breeding of 20 species of mosquitoes in domestic wells. Robert et al. (1998) observed the breeding of Culicines (80.1%) and Anophelines (11.9%) in wells.

Sharma and Kumar (1996) reported the breeding of Culex and Anopheles species in unused wells. Anopheles culicifacies and An. stephensi breed along with Culex quinquefasciatus in wells (Rao, 1984; Sharma, 1985). All these vector species transmit malaria and filaria throughout the year.

An. stephensi is often associated with household 'tanka' and village community based 'beri wells (Tyagi et al., 1996). Kar et al. (1996) reported the breeding of An. stephensi in domestic wells in Dindigul, Tamil Nadu. An. arabiensis is the unique species of An. gambiae complex observed in the wells dug by market-gardeners in the Dakar area (Awono and Robert, 1999).

reported to breed in wells (Covell and Harbhagwan, 1939; Rao, 1945; Puri, 1931; Russell and Rao, 1940a, 1940b and 1941; Tewari et al., 1987; Das et al., 1989; Rajnikant et al., 1993; Rao, 1984; Bhatt et al., 1993 and Nagpal and Sharma, 1994). An. annularis, An. barbirostris, An. hyrcanus, An. jamestii and An. pallidus were the other species that were reported to be predominantly breeding in wells.

In Nadiad Taluk of Kheda district, Gujarat, Rajnikant et al. (1993) observed the breeding of An. stephensi in both domestic wells and irrigation wells. The domestic wells are preferential breeding sites of An. stephensi (Kaliwal, 1991; Mariappan et al., 1992). An. culicifacies, An. subpictus, An. annularis, An. nigerrimus, An. fluviatilis and An. theobaldi were the other anopheline species that were found breeding in wells.

_**Culex quinquefasciatus** dominates among the culicines. Cx. vishnui, Cx. fuscanus, Cx. gelidus and Ae. aegypti were the other culicine species that were found breeding in wells. Cx. quinquefasciatus, Cx. vishnui group, An. stephensi and An. culicifacies were the mosquitoes reported to breed in disused wells (Chandrahas and Sharma, 1987). Cx. quinquefasciatus breeding in wells with 25% salinity was observed by Roberts (1996).

The breeding behavior of _Aedes aegypti_ in wells has been reported by Liston and Akula, (1972) and Panicker et al. (1982). _Aedes_ breeding in wells was reported by Vu et al. (1998). The other breeding sites recorded
by him was large cement tanks, Ceramic Jars and domestic containers. Russel et al. (1996) recorded 9 out of 10 wells examined were positive for *Aedes aegypti* immatures. Gionar et al. (1999) reported 33% of wells sampled were positive for *Aedes aegypti* while Souza (1999) recorded well positivity as 0.93%.

*An. varuna*, a vector of minor importance in some parts of India (The national society of India for malaria and other mosquito borne diseases, 1961) was predominant in both urban and rural wells whereas *An. stephensi* was found breeding in wells within the towns.

Sahu et al. (1990) observed the breeding of *An. culicifacies* in wells to be higher in the rainy season showing a peak in the month of August and September in the Koraput district of Orissa. A total of 15 anopheline species were recorded breeding in the wells.

Rao (1984) reported the breeding of *An. minimus* in shallow 'Katcha' wells in Assam. *An. sundaicus, Cx. quinquefasciatus* and *Cx. tritaeniorhynchus*, the established vectors of malaria, filaria and japanese encephalitis respectively were found to breed in Katcha wells in the Great Nicobar Islands (Das et al., 1989).

arabiensis, An. sergenti, An. multicolor, An. tenebrosus, Cx. pipiens, Cx. quinquefasciatus, Cx. theileri, Ae. caspicus and Culiseta subochrea in wells. The other breeding sites reported by them include springs, shallow streams and reservoirs.

Sharma (1994) observed the dominance of Cx. quinquefasciatus, Cx. tritaeniorhynchus, An. subpictus and An. annularis in unused wells. Mariappan et al. (1996) reported, that the wells act as perennial breeding habitat for Cx. quinquefasciatus, An. subpictus, Armigeres subalbatus, Ae. aegypti and Ae. albopictus.

INTRADOMESTIC BREEDING SOURCES

In the tropical and subtropical regions of the world, people store water in different types of containers that may be made of cement, ceramic, unglazed earthenware or metals. The water storage practices in different regions may be due to different cultural needs or prevailing local conditions. (Macdonald, 1956 and Barrera et al., 1993). Even in areas where piped water supply is provided, frequent disruptions in regular supply necessitates storage of water. In places where lack of water due to drought exists storage of water is of acute necessity. Rapid urbanisation and population explosion, which lead to water shortage, have also increased the need for water storage practices. Unfortunately, the water in stored containers/tanks have turned out to be a potential breeding habitat of mosquitoes in many regions. Aedes aegypti, the
potential vector of Dengue and Yellow fever has been found to breed extensively in containers/cisterns.

Mattingly (1957) has highlighted on the subspecies queenslandensis of (Aedes aegypti) to have adapted to breed in artificial containers and to be distributed in the Mediterranean area, India and Australia. Success in Aedes control by source reduction in Singapore has been reported by (Chan, 1985; Chan and Bos, 1987; Tan et al., 1998).

Kar et al. (1996) observed the breeding of Ae. aegypti to predominate in the cisterns (outside and inside temporary cement tanks) whereas An. stephensi was found to dominant in the permanent water storage tanks in Dindigul town, Tamil Nadu. Breeding of An. stephensi, An. subpictus, An. barbirostris, Cx. quinquefasciatus and Ae. aegypti in cisterns has also been reported from Kheda, Gujarat (Gupta et al., 1992). In rural areas of Gujarat Ae. aegypti, Ae. vittatus, Ae. albopictus, Cx. quinquefasciatus, Cx. (Lutzia) sp and Anopheles sp. were reported to breed in cisterns (Mahadev et al., 1993b).

In Chennai, Chandrahas (1990) reported Cx. quinquefasciatus to be the predominant breeder in Cisterns followed by Ae. aegypti and An. stephensi. The preference of An. stephensi to breed in shaded conditions with sunlight for a period of time was reported by Rao (1984), while its preference of breeding in outdoor water bodies was also reported by Biswas et al. (1992).
In Southern India, Russell and Rao (1941) found more members of *An. stephensi* in the month of April and May though the conditions for breeding were present throughout the year. In Bengal, Chowdhury (1936) observed *An. stephensi* to be more prevalent in seasons with average rainfall not less than 5.0 cms and relative humidity of 85% and temperature between 77°F and 89°F.

The studies undertaken by Sangita *et al.* (1998) on *An. stephensi* breeding in cisterns showed similar results with intense breeding in the months of June, July, August, September and October. A study to understand the daily fluctuations in the oviposition was undertaken for *Cx. pipens* and *Cx. restuans* by Madder *et al.* (1983). They observed that rain or strong winds during the ovipositional period, reduced ovipositional activity substantially.

Lopes (1996) reported the breeding of *Anopheles* species in water containers close to human residences, while the other species were captured in tyres beside a gallery forest. Major *Ae. aegypti* breeding sites are associated with flower vases, drums, used tyres, artificial containers and watering places while *Culex quinquefasciatus* (nuisance mosquito) breeding sites are mostly associated with sewage treatment plants, septic tanks and stagnant drains (Yebakima, 1996a).

Lopes (1997) collected larvae of *Aedes fluviatilis*, *An. albitarsis*, *An. evansae*, *An. strodei*, *Cx. bhamensis*, *Cx. bigoti*, *Cx. coronator*, *Cx.*
*eduardol*, *Cx. mollis*, *Cx. quinquefasciatus*, *Cx. sp.*, *Limatus durhamii* and *Psorophora cingulata*, in containers found around dwellings in municipios of Cambe and Londrina, Brazil. *Ae. aegypti*, *Ae. madiovittatus*, *Ae. scapularis*, *Ae. taeniorhynchus*, *Anopheles albimanus*, *Cx. quinquefasciatus*, *Cx. nigripalpus*, *Cx. atratus*, *Psorophora confinis* and *Uranotaenia sapphirina* were found to breed in drains, ditches, ponds, artificial containers, low tanks, tubes, tyres and larvitraps (Marquetti et al., 1996).

Survey on the container breeding/inhabiting mosquitoes in Clemson, South Carolina by Richardson et al. (1995) revealed the breeding of *Ae. alboptictus*, *Ae. triseriatus*, *Cx. restuans*, *Cx. territans*, *Cx. pipens* complex, *Toxorhynchites rutius septentrionalis* and *Orthopodomyia signifera*.

*An. stephensi* had been found breeding extensively in the intradomestic sources (Gupta et al., 1992; Yadav et al., 1989). *Culex quinquefasciatus* breeds in ground water habitat, plant habitat and domestic/peridomestic habitats, whereas *Ae. aegypti* breeds only in tyres (Kulkarni and Naik, 1989).

*Culex quinquefasciatus* preferred containers in habitats with no canopy cover or light canopy cover compared to those with heavy canopy cover. *Cx. quinquefasciatus* larvae were significantly more common in high-water-volume sites (Becker, 1995). *Aedes aegypti* breeding was
noted in potable water storage containers, its most prolific breeding sites were, however, sites of water storage for bathing and washing. (Mahadev et al., 1993a).

Breeding of *Aedes aegypti* and *Aedes albopictus* was confirmed in a few coastal villages with high human densities. (Mogi et al., 1996; Yebakima, 1996b). Larvae and pupae of *Ae. aegypti* occur mostly in artificial breeding sources like water storage containers and discarded containers (Roddain, 1996; Igbinosa, 1989; Mc Hugh, 1993). *Ae. aegypti* larvae were detected in locations with great concentrations of water containers; and greatest occurrence in tyres (Chiaravalloti, 1997; Moore, 1998).

The most frequent *Ae. aegypti* breeding sites are small containers discarded outside, while other less frequent breeding sites are flower pots and large containers outside (Fouque and Carinci, 1996; Yebakima, 1996a). Vu et al. (1998) reported that *Aedes* breeding sites are wells, large cement tanks, ceramic jars and domestic containers. Larvae of *Ae. aegypti* were collected from various water containers, including jars, vases and basins (Augier, 1998). Washbasins and metal drums are important sources of *Ae. aegypti* in much of Latin America. (Fernandez et al., 1998).

The 5 main Aedes larval habitats are 200 litre water-storage drums, discarded tins and bottles, coconut shells, automobile tyres and
tree holes. *Ae. aegypti* preferred water-storage drums and tyres to breed. (Samarawikrema et al., 1993). Mariappan et al. (1992) reported that the major larval habitats were cement tanks, wells, cesspools, ponds, canals, drains, septic tanks, water meter chambers and miscellaneous peridomestic habitats such as tree holes, tree stumps, containers, tyres and pots. Cement tanks, overhead tanks and wells are found to support the highest numbers of larvae of *An. stephensi*.

Breeding of *Ae. aegypti* was noted in cement tanks (58.49%) followed by buried mud pots (10.51%) and drums (9.7%). It was also noted to breed in drinking and cooking water storage and sun-dried containers (Mahadev, 1983). In the residential areas of both villages and townships *Ae. aegypti* and *Ae. vittatus* were observed to breed largely in cement tanks. (Mahadev et al., 1993a)

Lee (1991) reported that larvae of both *Ae. aegypti* and *Ae. albopictus* were found indoors and outdoors in a variety of containers. Larvae of *Ae. aegypti* were predominant in indoor containers. Larvae preferred clear, although not necessarily clean water. *An. culicifacies*, *An. stephensi*, *An. annularis*, *An. subpictus*, *An. barbirostris*, *Culex quinquefasciatus* and *Ae. aegypti* were found to breed in intradomestic water containers in Gujarat, India (Gupta et al., 1992).

*Cx. quinquefasciatus* and *Aedes fluviatilis*, breed more frequently in vases made of clay and concrete compared with other materials (Lozovei
and Chahad, 1997). *Culex quinquefasciatus* accounted for 93.4% of all mosquitoes collected from artificial breeding containers in urban areas of Curitiba City, Brazil. (Silva et al., 1996).

The most common breeding sites of *Ae. aegypti* are flower pots, followed by buckets, bottles, automobile tyres, refrigerator receptacles, earthenware jars and concrete tanks. More breeding places and positive containers for both *Aedes* species (*Ae. aegypti* and *Ae. albopictus*) are present outdoors (Hwang and Chao, 1991). *Aedes* larvae were found mostly in containers made of plastic, followed by those made of porcelain, rubber, cement, metal and glass (Hwang et al., 1995). Drinking water jars were least likely to contain *Ae. aegypti* larvae (Huang et al., 1998).

In a survey carried in Fuzhou city, Fujian, China, construction site revealed, that an average pool could produce 3000 female mosquitoes per night, whilst, a construction site could produce 1,00,000. (Xu, 1996).

Breeding of mosquitoes in urban areas of Dehra Dun was recorded by Mahesh et al. (1995). Based on their report, *Cx. quinquefasciatus* and *An. subpictus* breed in the tree holes, flower vases, burrow pits, underground and overhead tanks, drains and domestic containers. *Cx. quinquefasciatus*, *Ae. aegypti* and *Ae. subpictus* were recorded to breed in tree holes. Underground tanks supported the breeding of *An. stephensi*. 
VECTOR CONTROL (BOTANICALS AS INSECTICIDES)

The synthetic pesticides are extensively used to control the agricultural and domestic pests below the threshold level to achieve desired results. The indiscriminate utilization of synthetic pesticides world over in integrated pest control management programs has created serious threat to the environment (Amonkar and Banerjee, 1971; Rajan, 1993). Because of their non-biodegradable nature these chemicals enter into the food chain and, as a result of biological magnification, the concentration reaches many fold above the acceptable limit in non-target organisms (Tremblay, 1982; Schmutterer, 1990).

The huge accumulation of these chemicals in vital parts of plants and animals alters the various metabolic processes, which may cause serious problems to them (Jabbar et al., 1994). Apart from this, some synthetic pesticides are frequently used as insecticides to restrict the population of insects, which are vectors of many dangerous diseases, below the threshold level. Thus, excessive use of these chemicals is causing serious challenge to the pest control management programs, as the insects become resistant to these chemicals.

In this view of the above problem, there is a need to evolve ecofriendly pesticides from biological origin known as biocides which are biodegradable and safer to nontarget organisms (Tremblay, 1982; Schmutterer, 1990). Long before the advent of synthetic insecticides,
plants and their derivatives were used to kill pests of agriculture, veterinary and public health. Insecticidal activity of plant derived compounds such as nicotine, rotenoids and pyrethroids have been evaluated and some of these compounds have been exploited commercially (Jacobson and Crosby, 1971).

Various plants offer great promise as sources of phytochemicals for control of both pest and medically important vectors. Nowadays, the growing use of plants for control of these vectors may be attributed to the fact that population throughout the world are coming to witness the danger inherent in the use of conventional insecticides, particularly physiological resistance of vectors and detrimental effects on non-target organisms, man and environment.

Azadirachtin rich fraction from *Azadirachta indica* has been observed to possess antifeedent, repellent, growth-inhibiting and ovicidal activity against insect pests. Its properties and potentialities has been highlighted and discussed by Schmutterer (1990). Sensitivity towards NeemAzal 40% decreased with increasing age of the larvae. In female *Ae. aegypti* a tendency was observed to lay fewer eggs with increasing NeemAzal concentration to which they had been exposed during larval development (Boschitz and Grunewald, 1994).

The leaf extract of *Vitex negundo*, *Nerium oleander* and seed extracts of *Syzygium jambolanum* have larvicidal activity against *Culex*
quinquefasciatus and *Anopheles stephensi* (Pusphpalatha and Muthukrishnan, 1995). Fruit and seed extracts of *Abrus precatorius* were toxic to mosquitoes (Grainge and Ahmed, 1988) and crude extracts of *Lithospermum arvense* were toxic to *Ae. aegypti* larvae (Madrigal et al., 1979). The steam distillation of the floral parts of *Quassia amara* acted as potential larvicide against *An. stephensi*, *Ae. aegypti* (Perich et al., 1995). Green et al. (1991) reported that larvicidal activity of *Ae. aegypti* was found in aqueous solvent of the whole plant of *Tagetes minuta*, *Tagetes patula*, and *Tagetes erecta*.

Subramonia Thangam and Kathiresan (1992) reported larvicidal activity and LC₅₀ concentration of acetone root extracts of *Acanthus ilicifolius* against *Ae. aegypti*. The bark and fruit acetone extracts of *Avicennia officinalis*, *Exoecaria agallocha*, and *Lumnitzera racemosa* showed larvicidal activity against the III and IV instars of *Ae. aegypti*. The stilt root acetone extracts of *Rhizophora apiculata*, *R. lamarckii* and *R. mucronata* have shown larvicidal activity of *Ae. aegypti*.

Subramonia Thangam et al. (1993) evaluated the larvicidal action of *Salicornia brachiata* acetone shoot extracts and *Sonneratia apetala* acetone root extracts on *Ae. aegypti*. The acetone extracts of *Caulerpa peltata*, *C. racemosa*, *C. scalpelliformis*, *Dictyota dichotoma*, *Enteromorpha clathrata*, and *E. intestinalis*, showed larvicidal activity against the III and IV instar larvae of *Ae. aegypti* and *Cx. quinquefasciatus* (Subramonia Thangam et al., 1993).
Geerts et al. (1994) tested aqueous leaf extract of *Ambrosia maritima* for the larvicidal and growth inhibition effect on early III and IV instars of *Ae. aegypti* and *An. stephensi*. Kelm et al. (1997) evaluated the larvicidal and growth inhibition of stem, leaf, fruit, and flower hexane and ethyl acetate extracts of *Pongamia glabra* and *Magnolia salicifolia* against *Ae. aegypti*.

The hexane, ethyl acetate and methanol extracts of rhizome and leaf of *Curcuma longa* possess larvicidal activity against *Ae. aegypti* larvae (Roth et al., 1998) and leaf methanol extract of *Cyperus tria* showed larvicidal and growth inhibition on larvae of *Ae. aegypti* (Schwartz et al., 1998). Sharma et al. (1999) evaluated the larvicidal action of acetone, methanol, and aqueous extracts of stem, leaf and fruits of *Parthenium camera* against *Ae. aegypti* and acetone, methanol, and aqueous seedcake extracts of *Pongamia glabra* showed larvicidal efficacy against *Ae. aegypti*.

Extracts of *Jatropha circus*, *Acorus calamus*, *Tagetes erecta*, *Lantana camera* showed excellent larvicidal activity against the instars of *Ae. aegypti* (Sharma et al., 1999). The lethal effects of seed extracts of *Azadirachta indica* on the fecundity and metamorphosis in *Ae. aegypti* were studied by Sagar and Sehgal (1997). Relative efficacy of the various parts such as flower, leaf and stem of the plant *Achillea millefolium* showed high mortality of *Ae. aegypti* (Thorsell et al., 1998). Steam distillation of the leaves of *Eucalyptus maculata* by Schreck and
Leonhardt (1991) on the larval forms of *Ae. aegypti* had shown promising results.

The repellent action of *Pelargonium citrosum* by the steam distillation of the leaf parts against *Aedes spp.* was found to be more effectual by Matsuda *et al.* (1996). Aqueous solvent of the floral parts of *Lantana camara* was used as a repellent by Dua *et al.* (1991) against the adults of *Ae. albopictus*. Tyagi *et al.* (1997) steam distilled the whole plant of *Tagetes minuta* was found to be an effective repellent against *Ae. aegypti*, *An. stephensi* and also *Cx. quinquefasciatus*.

In Malaysia, Jantan *et al.* (1999) prepared nineteen mosquito coil formulations, each containing a different plant and investigated their knock down and 24hr mortality values against *Ae. aegypti*. The larvicidal efficacy of *Calophyllum inophyllum*’s seed and leaf extracts of ethyl acetate and petroleum ether on *An. stephensi, Ae. aegypti*, and *Cx. quinquefasciatus* was studied by Pusphpalatha and Muthukrishnan (1999). Venkatachalam and Jebanesan (2000) evaluated repellent properties of leaf methanol extract of *Ferronia elephantum* on *Ae. aegypti* mosquito.

Bowers *et al.* (1995) studied the larvicidal activity of leaf and stem chloroform extracts of Turkish medicinal plants, *Sinapis arvensis, Reseda lutea, Onobrychis atmena, Convolvulus arvensis, Echium italicum, Biphora radians, Veratum album* and *Maclura pomifera* against *Ae.*
*aegypti* and *An. gambiae* larvae. The water and methanol root extracts of *Stemon a tuberosa* showed larvicidal activity against the larvae of *Ae. aegypti* and *Cx. quinquefasciatus* (Lee and Chiang, 1994). Wang *et al.* (1990) reported that larvicidal activity of *Ae. aegypti* was found in dichloromethane extract of the whole plant of *Artemisia borealis*.

The use of neem derivatives for the control of vectors is desirable as they are environmentally safe and rapidly degraded in the environment (Stocke and Redfern, 1982), non-toxic to natural enemies as well as non-hazardous to human beings (Oroumchi and Lorra, 1993; Sundaram and Curry, 1994; Schumutterer, 1997). Neem products have been reported to affect insects as oviposition deterrents and they also reduce their reproductive potential (Singh and Srivastava, 1983; Chen *et al.*, 1996; Prabhakaran and Kamble, 1996; Saikia *et al.*, 1996).

Activities similar to those of insect growth regulators, for neem substances are well documented (Osman, 1993; Lowry and Isman, 1994; Singh *et al.*, 1996). Efficacy of neem endosperm extract against IV instar larvae of *Aedes aegypti* was reported by Baqui *et al.* (1993). Extracts of *Lansium domesticum* and *Annona squamosa* exerted an insecticidal effect on the larvae of *Aedes aegypti* and *Culex quinquefasciatus* (Monzon *et al.*, 1994).

Dhillon *et al.* (1982) reported the insect growth inhibitory activity of *Rhizoclonium heteroglyphicum* against *Aedes aegypti, Culex*
*quinquefasciatus* and *Culiseta incidens*. Nicholas *et al.* (1998) reported that the acetone extracts of *Polygonum senegaclense* assess the growth inhibitory activity against *Aedes aegypti* larvae. Midiwo *et al.* (1995) reported that the benzoquinone, embelin and two new benzoquinines isolated from *Rapaneamela pholes* showed inhibition of growth of second instar larvae of mosquito, *Aedes aegypti*. Still *et al.* (1994) reported the mosquito larvicidal effects of pyrethrum powder against *Aedes aegypti*.

Campbell *et al.* (1933) reported that ethanolic extract of *Anabasia aphylla* showed larvicidal activity against *Culex pipiens*, *Culex quinquefasciatus* and *Culex territans*. Sinniah *et al.* (1994) tested the neem oil extracts as larvicides against *Culex quinquefasciatus* and *Aedes aegypti* it was found to be effective even at 0.01% concentration. Toxic effect to ethanol extract of *Giltridictia septum* against larvae of *Anopheles stephensi*, *Aedes aegypti* and *Culex quinquefasciatus* was studied by Shah *et al.* (1991). Subramonia Thangam and Kathiresan (1992) studied the acetone extract of *Acanthus illicifolius*, *Avicennia officinalis*, *Excoicria agallocha* and *Rhizophora ariculata* were tested for mosquito larvicidal activity against *Aedes aegypti*.

Mittal *et al.* (1995) concluded bioassays to determine the efficiency of 6 neem products against early IV instar larvae of *Anopheles stephensi*, *Aedes aegypti* and *Culex quinquefasciatus*. The products proved to have good insect growth regulator activity. Preethi and Srivastava (1998) studied the toxicity of alcoholic extracts of *Artemisia annua*, *Cariea*
papaya, Cuscuta reflexa and Lantana indica against Culex larvae. Ethanolic extracts of Kaemferia galanga, Illicium vernum and Spilanthes acmella were screened for larvicidal potential against Culex quinquefasciatus by Pitasawat et al. (1998).

Srivastava and Preethi (2000) reported that the alcoholic extracts of Artemesia annua, Carica papaya, Cuscuta reflexa and Lantana indica were examined against anopheline larvae. Sujatha et al. (1988) studied that phenylindane derivative from petroleum ether extract of Acornus calumes showed larvicidal and juvenile hormone activity against different mosquito species viz., Aedes aegypti, Culex quinquefasciatus and Anopheles stephensi. Geoffrey et al. (1998) reported that the isolation of three curcuminoids from Curcuma longa showed inhibition activity on Aedes aegypti larvae. Narendran et al.(1999) investigated the larvicidal and antifeedant activity of Murrya koenigil and Cassia fistula extracts against the larvae of Culex quinquefasciatus.

Joshi et al. (1978) evaluated the toxic action of the natural and synthetic garlic, Allium sativum on Cx. fatigans and An. stephensi larvae. Insecticidal activity of plant derived compounds such as nicotine, rotenoids and pyrethroids have been evaluated and few of these compounds have been exploited commercially (Jacobson and Crosby, 1971).
The reports of laboratory tests and field trials of plant extracts and purified chemicals showed larvicidal activity against mosquitoes. Deshmukh *et al.* (1982) reported larvicidal activity and \( LC_{50} \) concentration of certain plant extracts such as *Acorus calamus* (0.04), *Adathoda vasica* (1.00), *Croton tiglium* (0.16), *Mentha arvensis* (1.58), *Ocimum basilicum* (0.18) and *Vitex negundo* (0.38) against *Culex* larvae.

The alcoholic extracts of *Artemisia annua* were reported to be more toxic than the hexane extract (0.40) and acetone extract (0.71) of *Artemisia vulgaris* against *Culex* larvae. According to Jalees *et al.* (1993) the extract of *Cuscuta reflexa* was more effective than the extracts of *Cannabis sativa*, \( LC_{50} \) being 0.14, against *Culex* larvae.

The extract of *Cuscuta reflexa* was most toxic to *Culex* larvae followed by *Artemisia annua*, *Carica papaya*, and *Lantana indica* (Sharma and Srivastava, 1998). Latha *et al.* (1999) reported *Piper longam* and *Zingiber wightianum* extracts at 80mg/l causing complete mortality on *Cx. quinquefasciatus* and 60mg/l for *Cx. sitiens*.

The leaf extracts of *Vitex negundo*, *Nerium oleander* and seed extracts of *Syzygium jambolanum* have larvicidal activity against *Culex quinquefasciatus* and *Anopheles stephensi* larvae (Pusphpalatha and Muthukrishnan, 1995).
Fruit and seed extracts of *Abrus precatorius* were toxic to mosquitoes (Grainge and Ahmed, 1988) and crude extracts of *Lithospermum arvense* were toxic to *Aedes aegypti* larvae (Madrigal *et al.*, 1979). Isolation of these protective compounds from the plants and their determination of chemical structure would provide valuable pointer to the development of new pesticides and novel methods of vector control.

Traditionally smoke from burning dried plant leaves such as *Vitex, Az. indica* and *Pongamia* and fumigation with balsam have been used; in addition, dried Neem seed kernel powder, *Pongamia* seed kernel powder and *Acorus calamus* rhizome powder have been used for domestic protection. Mosquito coil of the leaves of *Cymbopogon nardus* and *Aloe vera* and the seed kernel of *Azadirachta indica* incorporated with D-trans-allethrin significantly increased their efficiency against mosquitoes in terms of knocking down and killing effects. Therefore, use of these plant materials as organic filters in mosquito coil formulations may allow a reduction in the active concentration of pyrethroid and reduced health hazards.

In view of growing concern about safety of chemical based repellents, interest is revived in oils extracted from plants as repellents for mosquitoes. Traditional repellents not only provide protection against mosquito bites, but also curtail malaria transmission. In early 1947, the efficacy of turmeric, gingelly and mustard oils was demonstrated against *An. fluviatilis*. Varying degrees of repellent action of 40 species of
Cymbopogon, the oils from C. nardus, C. winterianus, C. citratus, C. flesuosus C. martini martini have been used as base creams and the oils were marketed in India and abroad (Osmani et al., 1972; Rutledge et al., 1983).

The essential oils, viz., C. martini martini Sofia (Palmarosa) and C. citratus provided absolute protection against An. culictfacies. However, protection against Cx. quinquefasciatus and the total mosquitoes ranged from 95 to 96%. Cymbopogon nardus has also provided 99.5% protection for Anopheles and 95% for Culex quinquefasciatus (Ansari and Razdan, 1995). The larvicidal efficacy of Hydrocotyle javanica (Whole plant) against Culex quinquefasciatus was recorded lowest in benzene fraction and highest in ethyl acetate fraction (Venkatachalam and Jebanesan, 2001).

Recently neem oils extracted from seeds of Azadirachta indica showed repellent action against mosquitoes (Sharma et al., 1993; Mishra et al., 1995). The leaf extract of Aristolochia indica, Leucas aspera, Ocimum sanctum and pulp extracts of Allium sativum and Rhizome extract of Curcuma longa acted as potent repellents against the malarial vector, Anopheles stephensi (Murugan and Jeyabalavan, 1999).

Aquatic plants like stonewarts produce larvicidal toxins to kill mosquito larvae. Stonewarts including the two main genera Chara and Nitella occur in both fresh and brackish waters. These plants can be
easily cultivated and transplanted and the control is permanent without added costs. But they can’t grow in highly polluted sites and their growth is influenced by photoperiod, nutrition and temperature. The carnivorous bladderwort, *Utricularia vulgaris* can feed on mosquito larvae in the aquatic habitat and the seeds of mustard family plants produce a mucilage which traps the mosquito larvae (Anonymous, 1973). Extracts of several plants are tried as larvicides to control the population of mosquito larvae.

Insects in general and mosquitoes in particular have developed resistance to a variety of insecticides. Neem has diverse biological activities against insects. However, except a very few studies, reports on the influence of neem products on mosquitoes are scanty. *Azadirachta indica* has diverse biological activities against insects (Saikia et al., 1996; Richter et al., 1997). However, except a very few studies (Attri and Prasad, 1980; Das et al., 1995), reports on the influence of neem products on mosquitoes are scanty. Neem formulation was found to be effective larvicide against culicine larvae and agree with the work of earlier investigators. Nimbidin obtained from the fruits of the neem trees (*Azadirachta indica*) has been proved to be an active constituent of many drugs and is a powerful antiseptic and germicide (Mitra, 1979). Attri and Prasad (1980) used neem oil for mosquito control.

Aqueous crude extracts of neem leaf showed a potential larvicidal activity against *Anopheles stephensi*. Apart from this, higher
concentrations 8% and 16% of the extract significantly lengthened the period of larval moulting. (Prasad et al., 2001).

The isolation of azadirachtin, a potent insect antifeedant and ecdysis inhibitor from the fruit kernels of neem is a non-toxic insect control agent (Govindachari, 1992). Ragunatha Rao et al. (1988) tested four Azadirachtin rich fractions for their larvicidal activities against An. culicifacies and Cx. quinquefasciatus. Acetone extracts of 12 seaweeds were studied against Cx. quinquefasciatus and An. stephensi (Subramonia Thangam and Kathiresan, 1988).

**NEED FOR HEALTH EDUCATION**

Vector borne diseases cause heavy loss to human life and block the development of the country. Bioenvironmental control of vector depends on the co-operation of community with the government. Health education is an important tool to initiate community to participate in vector control methods. Health education is an important component for community compliance in public health programmes (Trenton et al., 1992). Jajoo (1985) found that in a socio-economically weaker society, education alone could do little to improve community health.

Kalra and Bang (1984) have developed general guidelines for community participation in the control and prevention of vectors of dengue and dengue Haemorrhagic fever in tropical Asia. Shaheen (1997)
described the community involvement in removing the breeding sites of mosquitoes (*Aedes albopictus*) within the district of Baton Rouge, Louisiana, U.S.A.

Health education and community participation substantially contributed to the control of mosquitoes breeding in intradomestic sources (Gupta *et al.*, 1992; Sharma *et al.*, 1993). In the absence of health education, spray coverage was very poor (Tiwari *et al.*, 1990) and this is the common observation in the field from most parts of the country. Experience has shown that coverage could be increased to desired levels by health education (Sharma *et al.*, 1986).

Gramiccia (1981) observed that among the present day tools of malaria control, impact of health education was minimal and he gave a thought-provoking account of the problems in health education in malaria control. Mohaptra *et al.* (1988) stressed the need for a closer link between medical education system and machinery for health care delivery. Observing the inadequacy of health education efforts, the in-depth evaluation committee in its report on the MPO (Modified Plan of Operation) under NMEP in India recorded that active community participation and health education have neither been promoted adequately nor supported in spite of being laid down as a basic approach in MPO.
Community-based bioenvironmental control of malaria was successful in Nadiad, Kheda district, Gujarat (Sharma and Sharma, 1989), Hardwar (Dua et al., 1988), Mandla (Singh et al., 1989), Shahjahanpur, Rishikesh (Sharma, 1991b). In these programmes, communities were motivated and involved by intensive health education and community interest was sustained by introducing income generating and developmental schemes (Sharma and Sharma, 1989). In Sri Lanka, a study reported malaria control through community action (Silva et al., 1988).