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ECOLOGY OF MOSQUITOES FROM KOLHAPUR DISTRICT, INDIA

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ABSTRACT

Kolhapur district of Maharashtra, India contains several small and large water bodies as natural and artificial breeding places for mosquitoes. The distribution of various mosquito genera in natural and artificial habitats and their relative species abundance was studied during the years 2009-2011. In all, 22 mosquito species belonging to three genera viz. *Anopheles, Culex* and *Aedes*, which were potential vectors of malaria, dengue, chikungunia, filaria and Japanese encephalitis of human in the district were surveyed. A total of 2113 mosquito larvae were collected from artificial sources and 1993 larvae were harvested from natural sources. *Anopheles (Cellia) culicifacies* Giles, *Culex* (*Culex) fatigans* Widemam, *Aedes (Stegomyia) aegypti* Linnaeus and *Ae (S.) albopictus* Skuso were dominant over other species. Favorable environmental conditions for breeding mosquitoes and impact of human activities on population dynamics of mosquitoes have also been studied.

KEY WORDS

Mosquitoes, ecology, diversity, human activities, mosquito borne diseases, control.

INTRODUCTION

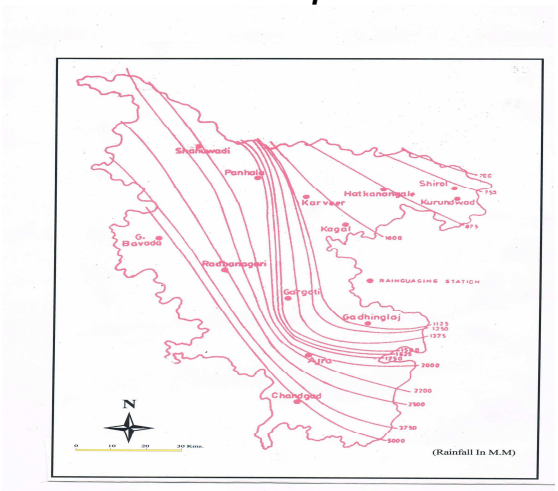
Mosquitoes cause a huge medical and financial burden by spreading malaria, yellow fever, dengue, chikungunya, filaria, Japanese encephalitis, RV fever, WNV, etc. (Fang, 2010). Malaria alone infects some 247 million people world wide each year and kills nearly one million. The incurable filaria, confusing dengue and fatal JE have showed increasing trend of infections and casualities in India (Sathe *et al*., 2010). Hence control of mosquitoes becomes a necessity to control of above diseases. Control of mosquitoes by pesticides is chronic problem since mosquitoes have developed resistance against most of the pesticides of major groups viz., Chlorinated hydrocarbons, organophasphorus, carbamates and pyrethroids.

Mosquitoes can live on almost every continent and habitat. There are 3,500 described species of mosquitoes in the world (Sathe & Tingare, 2010). Therefore, hoping the biological control of mosquitoes through natural enemies, ecological studies of mosquitoes have been objected. Review of literature indicates that Bates (1949), Causey & Santos (1949), Service (1963), Okorie (1978), Guimaraes *et al*. (2000), Godwin *et al*. (2005), Silver (2008), Fang (2010) etc. worked on ecology of mosquitoes from abroad while, from India Christophers (1933), Barrauds (1934), Rao (1984), Tewari *et al*. (1987), Nagpal & Sharma (1995), Sathe & Girhe (2001, 2002), Sathe & Jagtap (2008, 2009, 2010), Jagtap & Sathe (2008), Jagtap *et al*. (2008, 2009), Sathe & Bhusnar (2010) and Sathe *et al*. (2010) etc. contributed on biodiversity and ecology of mosquitoes.

MATERIALS AND METHODS

Ecological studies of mosquitoes have been carried out from Kolhapur district of Maharashtra, India from ten tahsils namely Karveer, Hatkanangale, Shirol, Kagal, Ajara, Chandgad, Radhanagari, Gaganbawada, Panhala and Shahuwadi. The tahsils were selected on climatic and geographic features (Fig. 1). Kolhapur district is located between 15^{o} to 17^{o} North latitutde and 73^{o} to 74^{o} East latitude, containing 1,46,575 hectares land and uneven rainfall from 6000 mm at Gaganbawada to minimum 500 mm at Hatkanangale. Therefore, the district contains 2 major, 10 medium and minor 31 water bodies, the sources of breeding mosquitoes.

Fig. 1
Rainfall of Kolhapur District.



The survey of mosquitoes was carried out during the years 2009-2011 from Kolhapur water bodies, and tahsils by visiting 15 days interval and one man one hour search method was adopted for study specially evening hours. The adult mosquitoes were collected with the help of suction tube and larvae by ½ litre glass beaker. Random samples from breeding places both natural (small lakes, streams, ponds, mud pools, springs pools, rivers, tree holes etc.) and artificial (Irrigation channels, wells, cement tanks, container type like plastic, metal cans, tyres, earthern ware pots, bamboo strips etc.) were taken. Later, the larvae have been reared in the laboratory for adult emergence. The mosquitoes were identified consulting Barraud (1934), Christophers (1933), Rao (1984), Sathe & Girhe (2002) and Sathe & Tingare (2010). Environmental temperature, rainfall and relative humidity were monitored during the study. Impacts of human activities and increasing environmental modifications in the breeding places of mosquitoes have been identified by spot observations.

RESULTS AND DISCUSSION

The results recorded in table 1 & 2 indicates that 22 species of mosquitoes belonging to the genera *Anopheles, Culex* and *Aedes* which were potential vectors of Malaria, Dengue, chikunguniya, Filaria and JE of human in the district were prevalent. The most prevalent species in the district were *Anopheles (Cellia) culicifacies*, *An. (C.) stephensi, An. (C.) subpictus, Culex (Culex) fatigans, Aedes (Stegomyia) albopictus* and *A. (S.) aegipti*. Other prominent mosquito species with adult and larval catches are shown in table-1. Population of *Anopheles* mosquitoes was abundant in wet months leading to malaria cases. From November to March, dry months, *Aedes* and *Culex* mosquitoes were more prevalent leading to Dengue, Chikunguniya, JE and Filaria in the region. The combination of favorable environmental temperatures, rainfall and high relative humidity were responsible for higher number of mosquito larvae harvestation at onset of rainfall and biggest in July-August and gradual fall in October. *C. (C.) fatigans*, which is vector of bancroftian filariasis was quite abundant in most of the tahasils of Kolhapur. Similarly, vector of JE *C. (c.) albopictus,* and *Ae. (S.) vittatus*, vectors of alboviruses in general were also dominant in Kolhapur district.

Table 1

Mosquito collection at various tahasils of Kolhapur district

Sr. No.	Species	Tahsils									
		Shahu-wadi	**Karveer A(L)***	**Panhala A(L)***	**Hatkanangle A(L)***	**Shirol A(L)***	**Kagal A(L)***	**Gagan-bawada A(L)***	**Radha-nagari A(L)***	**Azra A(L)***	**Chandgad A(L)***
1	*Anopheles* (*Cellia*) *culicifacies* Giles, 1901	119 (141)	188 (149)	119 (139)	139 (133)	129 (130)	200 (241)	112 (143)	159 (135)	142 (159)	149 (148)
2	*Anopheles* (*Cellia*) *stephensi* Liston, 1901	50 (89)	72 (75)	93 (90)	59 (72)	42 (60)	32 (49)	54 (51)	99 (95)	94 (99)	78 (102)
3	*Anopheles* (*Cellia*) *subpictus* Grassi, 1899	12 (31)	48 (58)	42 (59)	14 (31)	10 (23)	39 (52)	5 (15)	20 (39)	48 (59)	49 (57)
4	*Anopheles* (*Cellia*) *theobaldi* Giles, 1901	-- (--)	17 (20)	14 (23)	-- (--)	-- (--)	7 (30)	-- (--)	21 (29)	23 (34)	21 (39)
5	*Anopheles* (*Cellia*) *annularis* Vander Wulp, 1884	12 (19)	15 (15)	-- (19)	09 (14)	05 (12)	02 (19)	-- (--)	-- (--)	11 (18)	9 (19)
6	*Anopheles* (*Anopheles*) *gigus* Giles, 1901	31 (30)	54 (59)	34 (40)	14 (24)	-- (--)	20 (29)	67 (77)	19 (25)	15 (20)	54 (19)
7	*Anopheles* (*Anopheles*) *barbirostris* Vander Wulp, 1884	5 (15)	14 (19)	12 (18)	-- (--)	-- (--)	10 (19)	28 (34)	14 (19)	17 (28)	24 (31)
8	*Culex* (*Culex*) *epidesmus* Theobald, 1912	-- (--)	24 (30)	14 (19)	19 (24)	15 (16)	09 (23)	19 (29)	20 (32)	23 (25)	18 (23)

9	*Culex* (*Culex*) *fatigans* Wiedemann, 1828	119 (143)	233 (252)	219 (241)	98 (149)	72 (142)	177 (192)	229 (244)	241 (240)	211 (219)	204 (241)
10	*Culex* (*Culex*) *vishnui* Theobald, 1901	5 (19)	28 (62)	22 (48)	17 (23)	9 (19)	20 (47)	28 (53)	23 (53)	19 (42)	18 (45)
11	*Culex* (*Culex*) *tritineorhynchus* Giles, 1901	7 (19)	-- (--)	12 (27)	-- (--)	-- (--)	-- (--)	12 (17)	17 (19)	19 (24)	24 (27)
12	*Culex* (*Barraudus*) *modestus* Ficalbi, 1890	14 (19)	7 (14)	19 (20)	15 (19)	14 (19)	13 (27)	3 (28)	28 (30)	14 (19)	16 (17)
13	*Culex* (*Mocthogenes*) *malayi* Liecester, 1908	-- (--)	-- (--)	2 (19)	-- (--)	-- (--)	-- (--)	-- (--)	19 (19)	11 (17)	09 (18)
14	*Culex* (*Neoculex*) *tenulipalpis* Barraud, 1924	12 (17)	19 (27)	12 (19)	11 (14)	-- (--)	-- (--)	-- (--)	17 (19)	-- (--)	-- (--)
15	*Aedes* (*Aedes*) *uniformis* Theobald, 1910	18 (19)	27 (19)	14 (19)	13 (14)	5 (11)	4 (11)	-- (--)	-- (--)	11 (14)	11 (19)
16	*Aedes* (*Aedes*) *indicus* Theobald, 1907	2 (9)	7 (19)	11 (18)	-- (--)	-- (--)	-- (--)	24 (29)	21 (30)	7 (10)	-- (--)
17	*Aedes* (*Mucidus*) *indica* Sathe & Girhe, 2002	-- (--)	9 (19)	2 (5)	-- (--)	-- (--)	-- (--)	-- (--)	5 (12)	-- (--)	-- (--)
18	*Aedes* (*Mucidus*) *scatophagoides* Theobald, 1901	-- (--)	14 (19)	-- (--)	-- (--)	-- (--)	3 (9)	11 (10)	12 (13)	14 (19)	19 (20)
19	*Aedes* (*Stegomyia*) *unilineatus* Theobald, 1906	11 (9)	9 (11)	-- (--)	-- --)	-- --)	2 (15)	5 (9)	5 (11)	-)	-)
20	*Aedes* (*Stegomyia*) *albopictus* (Skuso), 1894	148 (151)	217 (253)	149 (166)	54 152)	97 (111)	148 (157)	141 (157)	211 (213)	31 (39)	14 (42)
21	*Aedes* (*Stegomyia*) *vittatus* Bigot, 1861	-- (--)	2 (10)	3 (19)	17)	-- --)	-- (--)	-- (--)	7 (11)	1)	7 (9)
22	*Aedes* (*Stegomyia*) *aegypti* Linnaeus, 1762	159 (162)	201 (223)	211 (231)	01 198)	148 (172)	209 (233)	143 (151)	231 (236)	17 (31)	13 (19)

* A = Adults, L = Larvae

Table 2

Seasonal abundance of mosquitoes in various tahasils of Kolhapur district

Sr. No.	Species	Abundance in Months											
		Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	*Anopheles* (*Cellia*) *culicifacies*	+	+	+	+	+	+	+	+	+	+	+	+
2	*Anopheles* (*Cellia*) *stephensi*	-	+	-	+	+	+	+	+	+	-	-	-
3	*Anopheles* (*Cellia*) *subpictus*	-	-	+	-	-	+	-	+	+	+	+	-
4	*Anopheles* (*Cellia*) *theobaldi*	-	-	-	-	-	+	+	-	+	-	-	-
5	*Anopheles* (*Cellia*) *barbirostris*	+	-	+	+	+	+	+	-	-	+	+	+
6	*Anopheles* (*Anopheles*)	+	+	+	+	+	+	+	+	-	-	-	-

	gigus												
7	*Anopheles* (*Anopheles*) *annularis*	+	+	+	+	+	+	-	-	-	+	+	+
8	*Culex* (*Culex*) *epidesmus*	-	-	-	-	+	+	+	+	+	+	-	-
9	*Culex* (*Culex*) *faligans*	+	+	+	+	+	+	+	+	+	+	+	+
10	*Culex* (*Culex*) *vishnui*	-	-	-	-	+	+	+	+	+	+	+	+
11	*Culex* (*Culex*) *tritineorhynchus*	-	-	-	-	-	-	+	+	+	-	-	-
12	*Culex* (*Barraudus*) *modestus*	-	-	-	-	-	+	+	-	-	+	-	-
13	*Culex* (*Mocthogenes*) *malayi*	+	-	-	-	-	+	+	-	-	-	-	-
14	*Culex* (*Neoculex*) *tenulipalpis*	+	+	-	-	-	-	+	+	+	+	+	-
15	*Aedes* (*Aedes*) *uniformis*	-	-	-	-	-	-	+	+	+	+	+	-
16	*Aedes* (*Aedes*) *indicus*	-	-	-	+	+	-	+	-	+	+	-	-
17	*Aedes* (*Mucidus*) *indica*	-	-	-	-	-	-	+	-	-	-	-	-
18	*Aedes* (*Mucidus*) *scatophagoides*	-	-	-	-	-	+	+	+	+	+	+	+
19	*Aedes* (*Stegomyia*) *unilineatus*	-	-	-	-	-	-	+	+	+	+	-	-
20	*Aedes* (*Stegomyia*) *albobictus*	+	+	-	-	-	+	+	+	+	+	+	+
21	*Aedes* (*Stegomyia*) *vittatus*	-	-	-	-	-	+	+	+	+	+	+	+
22	*Aedes* (*Stegomyia*) *aegypti*	+	+	+	+	+	+	+	+	+	+	+	+

+ = Present , - = Absent.

Mosquitoes related to natural breeding sites in the study area specially tree and rock holes were mainly *Ae. (S.) vittatus* and *Ae. (S). aegypti*. In the breeding places such as rock holes, pools, leaves stalks, plants and animal shells, tyres, plastic containers and discarded house materials were mostly *Anopheles* species. Terraces drinking water containers, tyres, unused plastic container or broken containers, earthen pots, etc harvested mainly *Aedes* species. Plastic wares had a significant high breeding of *Aedes* and *Anopheles* than of *Culex*. *Culex* can breed in dirty waters through out the year but slowed down in hot months. The seasonal abundance of mosquitoes is shown in table-2. Impact of human activities such as carelessness of disposal of household plastic or earthen pot wastes, open containers, keeping tyres on terraces or near human habitation, leakage in drinking water system, leakages / cracks to latrine, open latrine pipes and drainages greatly facilitated mosquitoes in the district. Human creations such as dams, ponds, channels, wells, cement water tanks etc also widely stimulated mosquito populations and provided endless scope to mosquitoes to breed in the open environment.

The mean monthly temperatures ranged between 17^{o}C to 40^{o}C in Kolhapur district and the lowest temperature was observed between the months of December to January (7^{o}C to 15^{o}C). The lowest rainfall occurred between the months January to March with a

peak in July-August. *Ae.indica* the largest *Aedes* mosquito in the world (Sathe & Girhe, 2002) has been reported in very heavy and continuous rains in Kolhapur. Very high rainfall (5000 mm) in Chandgad and Gaganbawada yielded *An. (An.) barbirostris* in higher number than other tahasils. However, *An. (An.) stephensi* yielded higher number of mosquitoes in Radhanagari and Panhala, having moderate rain suggesting plenty artificial and natural sources for mosquito breeding in the tahasils. Some species were mostly found in rainy season includes, *C. (M), malayi, C. (B.) modestus, Ae. (S.) uniliniatus* and *An.(C.) theobaldi*. Therefore, it is advised that the contribution of human activities and increasing environmental modification to the breeding of mosquitoes should be minimized and selective vector (mosquito) control measures including mosquito larvae be initiated before onset of rainy reason. The control measures may be biological, use of Guppy and naids of dragonflies or pesticides.

Guimaraes *et al*. (2000) studied the ecology of mosquitoes in areas of Serra do Mar State Park, State of Sao Paulo, Brazil. They systematized monthly human bait collections for three times a day, for periods of 2 or 3 h each, in sylvatic and rural areas for 24 consecutive months (1991-92). A total of 24,943 specimens of adult mosquitoes belonging to 57 species were collected during 622 collective periods. *Coquillettidia chrysonotum* was the most frequent collected mosquito (45.8%) followed by *Aedes serratus* (6.8%), *Cq. venezuelensis* (6.5%), *Psorophora ferox* (5.2%) and *Ps. Albipes* (3.1%). They further reported that temperature and rainfall influenced the incidence of the mosquito species namely, *An. cruzii, An. mediopunctatus, Ae. scapularis, Ae. fulvus, Cq. chrysonotum, Cq. veneruelensis, Runchomyia reversa, Wyeomyia dyari, Wy. confusa, Wy. shanoni, Wy. theobaldi* and *Limatus flavisetosus* influenced by temperature change and relative humidity have effect on incidence of *Ae. serratus, Ae.scapularis, Cq.venezuelenis* and *Ru. reversa* while, rainfall greatly influenced the population dynamics of the species, *An.cruzii, Ae.scapularis, Ae.fulvus, Cq. venezuelensis, Ru. reversa, Wy. theobaldi* and *Li. flavisetosus*.

Godwin *et al*. (2005) studied the ecology of mosquitoes of Midwestern Nigeria by sampling mosquitoes by the method of Hopkins (1952), by dipping pipette or ladle. Their sampling sites were both natural and artificial. They also accounted climatic parameters like temperature, relative humidity and rainfall for studying incidence of mosquitoes. Their results revealed that 17 mosquito species belonging to genera *Anopheles, Culex* and *Aedes* were potential vectors of four human diseases. They encounted a total 736 mosquito larvae from artificial sources and 568 larvae from natural sources by pipette dipping collection method. In the present study comparatively a quite large number of mosquitoes have been collected by ½ litre beaker random sampling method. Godwin *et al*. (2005) further stated that pools, plastics and metal cans were the predominant artificial sources of mosquito larvae. More or less same situation is observed in the Kolhapur district. The probable reason for this might be the modified style of life of Indians.

Mosquito control by pesticides is chronic problem since mosquitoes have developed resistance to most of the compounds belonging to chlorinated hydrocarbons, organophosphorus, Carbamates and pyrethroids. Therefore, biological control as ecofriendly is good option for mosquito control (Sathe, 2006). Mosquitoes are delectable things to eat and they are easy to catch. In the absence of mosquito larvae hundreds of species of fish would have to change their diet to survive. Many species of insect, spider, salamander, lizard, frog have primary food as mosquitoes. Bat feed on mosquitoes containing its gut about 2% diet of mosquitoes.

Mosquito larvae get feed on decaying leaves, organic detritus and microorganisms. Therefore, they have associations with

popular flora and fauna. Mosquito larvae of *Wyeomyia smthii* are important members of tight-knit communities in the 25-100 millilitre pools inside pitcher plant *Sarracenia purpurea* in North America. They live with a midge *Metriocnemus knabi* rotifers, bacteria and protozoa. According to Fang (2010) eliminating mosquitoes might affect plant growth. When other insects drown in the water, the midges chew up their carcasses and the mosquito larvae feed on the waste products, making nutrients such as nitrogen available for the plant. Within pitcher plants, protozoan diversity was more in the presence of mosquito larvae (Addicott, 1974). Without mosquitoes, thousands of plant species would lose a group of pollinators.

Eliminating mosquitoes wound temporarily relieve human suffering. The efforts to eradicate one vector species would be futile, as its niche would quickly be filled by another. *Aedes aegypti* from scarp yards in Florida replaced by Asian tiger mosquito *Aedes albopictus* (Fang, 2010).

A survey on incidence of mosquitoes from Kolhapur region was carried out by Sathe & Girhe (2002). They noted *Culex pipiens* as dominant species in the Kolhapur region probably it might now be replaced by *Culex fatigans.* Since it was more abundant than other *Culex* species. Sathe & Girhe (2001) reported *Ae. dorsalis* during the years 2000-2001. However, during the current survey it was not found in the region. That might be replaced by some other species.

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REFERENCES

1. Addicott, J.F. Ecology, **55**, 475-492 (1974).
2. Barraud P.J. The Fauna of British India including Ceylon and Burma (*Taylor and Francis, London)* **5**, 1-463 (1934).
3. Bates, M. The natural history of mosquitoes. The MacMillan Company, New York 379 pp. (1949).
4. Causey O.R. and G.V. Santos. Diurnal mosquitoes in an area of small residual forests in Brazil. *Ann. ent. Soc. Am.*, **42**, 471-482 (1949).
5. Fang, J. Ecology : A world without mosquitoes. *Nature*, 466, 432-434 (2010).
6. Godwin R.A. Okoguna, J.C. Anosikeb, A.N. Okereb & B.E.B. Nwokeb. *J. Vect. Borne Dis.,* **42**, 1-8 (2005).
7. Guimaraes A.E., R.P. Mello, C.M. Lopes and C. Gentile. Ecology of mosquitoes (Diptera : Culicidae) in area of Serra do Mar State Park, State of Sao Paulo, Brazil-1. Monthly frequency and climatic factors. *Mem. Inst. Oswaldo Cruz.* **95,** 1-16 (2000).
8. Jagtap Mahendra and T.V. Sathe. Role of Intensified mass surveillance campaign in malaria problematic area of Sangli district. *Perspectives in Animal Ecology & Reproduction,* (ISBN1081-7035-563-X) **5**, 14-24 (2008).
9. Jagtap M., L.S. Sale and T.V. Sathe Studies of *P. falciparum* (PF) resistance to chloroquine in Etapali Block, Dist. Gadchiroli. *Nat. J. Life Sci*., **5**(3), 55-60 (2008).
10. Jagtap M.; Sale L.S.; A.B. Bhosale; Asawari Sathe & T.V.Sathe. Incidence of Dengue and Shifting trend to rural in Kolhapur district, India. *Biological Forum An International Journal,* **1**(2), 69-72(2009).
11. Okorie T.G. The breeding site preferences of mosquito species in Ibadan, Nigeria. *Nig. J. Ent*., **1**(3), 71-80 (1978).

12. Reuben R.; S.C. Tewari, J. Hiriyan and J. Akiyama. Illustrated keys to species of *Culex* (*Culex*) associated with Japanese Eucephalitis in South east Asia (Diptera : Culicidae). *Mosquito systematics*, **26** (2), 75-96 (1994).
13. Rao, R.T. The Anophelines of India. *India Rev. ed.* (Malaria Research Centre, I.C.M.R. Delhi), 1-518 pp. (1989).
14. Sathe, T.V. Biological control of mosquitoes. *Proc. Rec. Trends Malarial Studies*, 11-17 (2006).
15. Sathe, T.V. & Bhusnar A.R. Biodiversity of mosquitovorus dragonflies (Order : Odonata) from Kolhapur district including Ghats; *Biological Forum - An International Journal*, **2**(2), 38-41 (2010).
16. Sathe, T.V. and Girhe B.E. Biodiversity of Mosquitoes (Order : Diptera) in Kolhapur district, Maharashtra. *Riv. Di Parassitologia*, **18** (LXVII-3), 189-194 (2001).
17. Sathe, T.V. and Girhe B.E. Mosquitoes and Diseases, Daya Publ. House, New Delhi pp. 1-96 (2002).
18. Sathe T.V. and Mahendra Jagtap. Three decades trend of malaria from Sangli district of Maharashtra, India. *Animal Ecology Reproduction.* **5**, 25-37 (2008).
19. Sathe, T.V. and Mahendra Jagtap Tree hole breeding and resting of mosquitoes in Western Ghats, Maharashtra, *J. Exp. Zool. India,* **12**(2), 365-367 (2009).
20. Sathe, T.V. and Mahendra Jagtap. Biodiversity of Anopheline mosquitoes from Western Ghats of Maharashtra (India). *Biospectrum,* **5**(2), 215-218 (2010).
21. Sathe, T.V. and B. P. Tingare. Biodiversity of mosquitoes. Pp.1-200. Mangl. Publ. Delhi. (2010).
22. Sathe, T.V., Asawari T. Sathe & Mahendra Jagtap. Mosquito borne diseases. Pp.1-342 (2010). Mangl. Publ. Delhi.
23. Service M.W. Ecology of mosquitoes of Northern Guinea. Savannah of Nigeria. *Bull. Ent. Res., 54*, 601-632 (1963).
24. Silver J.B. Mosquito Ecology. 3rd Ed. XXII, 1477 p. (2008).
25. Tiwari, S.C., Hiriyan, J. and Reuben R. Survey of the Anopheline fauna of the Western Ghats in Tamil Nadu, India. *Indian J. Malariol*, 24, 21-28. (1987).