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Population dynamics study of Mosquitoes in urban and rural areas of Gwalior district, Madhya Pradesh, India

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Abstract
Mosquitoes are vectors of various diseases since time immemorial. Madhya Pradesh is endemic to various mosquito borne diseases like malaria, dengue and chikungunya. A survey on species composition and seasonal variation of mosquitoes found in Gwalior was conducted in 2014. A complete year study was conducted to determine the abundance & diversity of various mosquito species present in both rural and urban areas of Gwalior district. Various breeding habitats for immature forms of mosquitoes were also studied during this tenure, as larval residing places plays an important role in disease transmission. A total number of 2658 mosquitoes were collected that belonged to 4 genera and 9 species. The most abundant species in rural areas was found to be *Culex quinquefasciatus* followed by *Aedes albopictus* while in urban areas *Culex quinquefasciatus* was found to be most dominating species followed by *Aedes aegypti* species. The various indices like Margalef's index of richness (D_{mg}), Shannon-weaver index of Diversity (H'), Simpson index of dominance were also calculated for mosquito richness, diversity and dominance respectively for rural and urban areas of Gwalior. Even the genera perceentage were analysed for the study area during study tenure. The present study will be essential in controlling vector borne diseases and implementing vector control strategies against the mosquito species of Gwalior district of Madhya Pradesh, India.

Keywords: Mosquito, Gwalior, Species composition, larval breeding habitats

1. Introduction
Today mosquitoes are creating a great havoc in lives of mankind by acting as carrier for many diseases. These small creatures belong to family Culicidae of Order Diptera. Mosquitoes acts as vectors for the transmission of viruses, protozoa, bacterias etc. and causing diseases like malaria, dengue, chikungunya, dengue haemorrhagic fever, filariasis, west nile virus fever, yellow fever, encephalitis, etc. About 3700 known species of mosquitoes are found all over the world except for Antartica which are categorized under 37 genera including Culicinae, Toxorhynchitinae & Anophelinae (Nagpal, 2005) [12]. Mosquitoes are adaptable insects which continue to co-exist with man and transmit many diseases to more than 700 million people per year (Taubes, 1997) [22]. Annually 2 million people die due to these mosquito borne diseases while morbidity rates are still higher many times. (WHO, 2009) [25].
Several factors affects the role of transmission of diseases through mosquitoes. Mosquitoes breeds in almost all types of lentic bodies. The larval stages of mosquitoes breed in these aquatic water bodies along with conspecifics and heterospeifics. The mosquito population density in an area is one of the major factors responsible for transmission of diseases in a particular area. Epidemiological studies are helpful in knowing the disease transmission and vector density correlates with environmental conditions (Ramaiah & Das, 1992) [17]. The disease transmission and its magnitude depends mainly on presence of vector species in an area. The efficiency of any vector control method adopted needs a complete understanding of vectors residing in an area and process of seasonal fluctuations in population density under natural conditions. It will help to undertake a more strategic approach to control and implement various economical, efficient and effective mosquito control program.
In India, studies on fauna of mosquito species in various area has already been conducted. But no study had been done in Gwalior district. This study was carried out to know the mosquito species composition and their relative abundance in Gwalior District both in rural areas as well as in urban areas.

2. Materials and Methods
2.1 Study Area
Gwalior district is located in northern part of Madhya Pradesh. The city is spread over 5214 sq.km, covering 1.1% of total land area of Madhya Pradesh with a population of 2032036. Its forest area is around 1193 sq.km. It has an elevation of 197m (646 feet) above sea level. It has a sub-tropical climate with summers hot starting from late March to end of June, Rainy or humid season starting from late July to early October, while a cool dry winter starting from early November to late February, while average precipitation recorded is 75-100cm.The city is 321kms from Delhi, 121kms from Agra (The city of Taj Mahal) and 398 kms from Bhopal. It is 46th most populated city in the country.

2.2 Research Methodology
The research study was conducted from Jan.2014 to Dec 2015. We found no published data regarding species composition and abundance of mosquito fauna of Gwalior district. Thus, with the aim of contributing towards knowledge about

mosquito diversity in Gwalior, this study was conducted.

Collection of Mosquitoes: The larval forms of mosquitoes were collected from various breeding habitats using long dipper (popularly known as laddle). Various water bodies i.e., breeding habitats of mosquitoes were randomly selected and collection was made regularly for a particular time period in a week (thrice in a week). The collected larvae were than transported to laboratory and were reared upto adult stage for identification. The rearing process requires a well maintained laboratory maintaining temperature of 25±2°C, Relative humidity of 75±5% with a photoperiod of 14L:10D. The collected larvae were placed into white enamel bowls containing 2L of dechlorinated water and dead larvae were sorted out. The larvae were fed with yeast powder and dog biscuits (in the ratio of 1:3). The pupae emerged were than collected and transferred into white plastic bowls containing 250 ml of water and kept into wooden cage (650x650x650 mmmosquito cage). The emerged adults were fed with cotton pads soaked in 10% sugar solution. The adults were identified on morphological features by using a microscope using various taxonomic keys by "The fauna of British India, including Ceylon and Burma" written by Barraud. Various other taxonomic keys like Christophers, Nagpal and Sharma. The identification was done upto species level. The identified adults were than labeled, mounted and pinned and were preserved in insect collection box containing naphthalene balls and deposited in Zoological Museum of Science College, Gwalior (M.P.).

Data Analysis

Quantitative Analysis

1. **Density:** It expresses numerical strength of the species. It is calculated by dividing the total number if individuals of each species in all quadrats with total number of quadrats studied.
2. **Diversity Index:** There are various diversity indices which are used to know more about species diversity in an area. In our study we have used Shannon Weaver Diversity Index (H'). It is a diversity index taking into account the number of individuals as well as number of taxa. Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. The equation for calculating is as follows:-

$$H' = -\sum p_i \ln p_i$$

Where, H'= Shannon index, pi= proportion of important value of *ith* species, i.e., p*i* = *ni*/N, where *ni* = important value index for *ith* species, N= important value index of all the species

3. **Dominance Index:** Here we have used**,** Simpson's index of dominance (1949) (D). Ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely). The formula to calculate is as follows:-

$$D = -\sum (p_i)^2$$

Where, D = Simpson's index of dominance

4. **Species Richness Index:** Here we have used Margalef's index of richness (D_{mg}). - It is the first and oldest method to know the relative wealth of species in a community (Margalef, 1958). The number of species per sample is an indicator of richness. When more species are present, more-rich is the sample and vice-versa. It can be calculated by the formula:

$$D_{mg} = \frac{S-1}{\ln N}$$

Where, S = number of species in sample, N= Total number of species

Table 1: Mosquito species Percentage found in rural areas of Gwalior in 2014.

Mosquito diversity found in rural areas of Gwalior in 2014.		
Mosquito species	**Total number of larvae found**	**Percentage**
Aedes albopictus	151	13.23
Aedes aegypti	120	10.51
Anopheles stephensi	94	8.23
Anopheles annularis	82	7.18
Anopheles subpictus	98	8.58
Culex quinquefasciatus	368	32.25
Culex vishnui	66	5.78
Culex tritanaerhyncus	101	8.85
Armigeres subalbatus	61	5.34
Total	1141	100

Table 2: Mosquito species Percentage found in urban areas of Gwalior in 2014.

Mosquito diversity found in urban areas of Gwalior in 2015.		
Mosquito species	**Total**	**Percentage**
Aedes albopictus	143	9.42
Aedes aegypti	245	16.15
Anopheles stephensi	45	2.96
Anopheles annularis	92	6.06
Anopheles subpictus	156	10.28
Culex quinquefasciatus	545	35.92

Culex vishnui	102	6.72
Culex tritanaerhyncus	135	8.89
Armigeres subalbatus	54	3.55
Total	1517	100

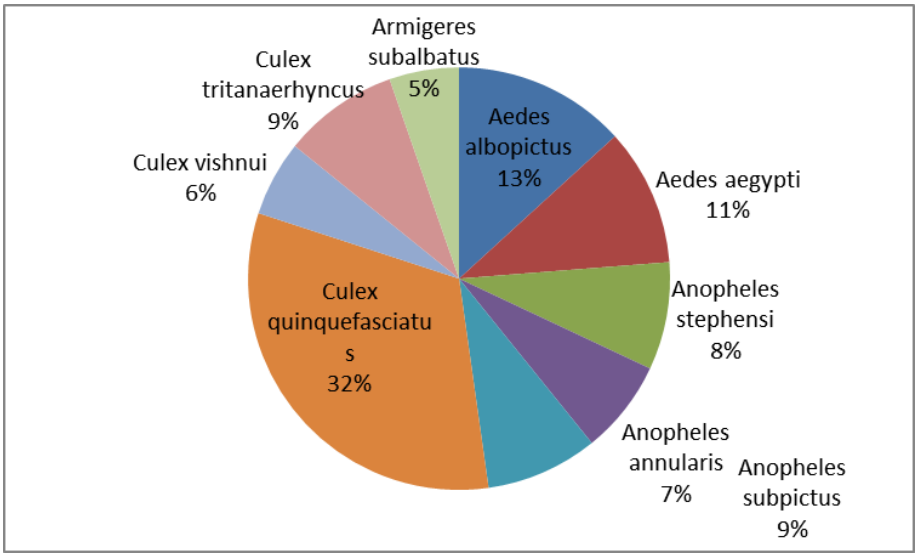

Fig 1: Mosquito species Percentage found in rural areas of Gwalior in 2014.

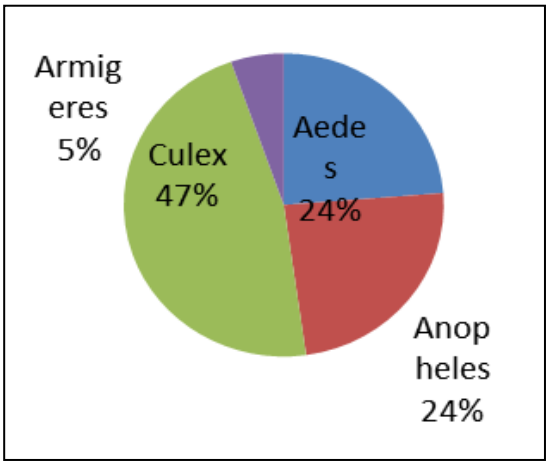

Fig 2: Genus wise percentage data of mosquitoes in rural areas of Gwalior

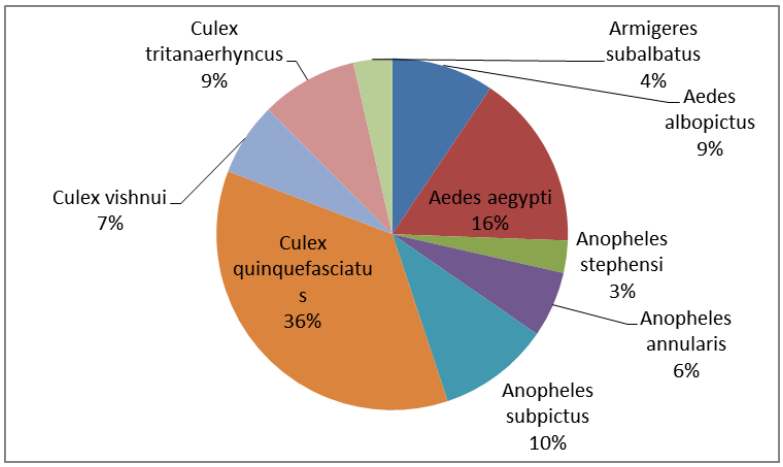

Fig 3: Mosquito species Percentage found in urban areas of Gwalior in 2014.

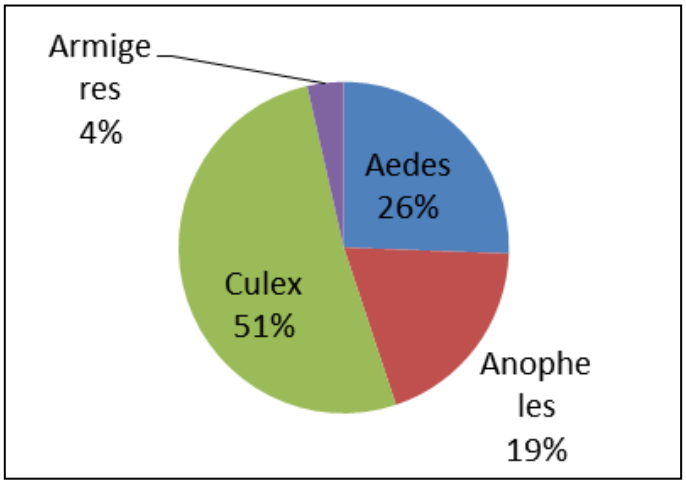

Fig 4: Genus wise percentage data of mosquitoes in urban areas of Gwalior

Table 3: Mosquito breeding habitat preferences found in both rural and urban areas of Gwalior during 2014.

Mosquito species	Larval Habitat Preferences
Anopheles stephensi	Cement tanks, fountains, paddy fields, artificial containers, construction sites, water channel leakages
Anopheles subpictus	Natural ponds, plastic containers, cement tanks, polluted water bodies, ground water collections
Anopheles annularis	Streams, ground water collections, borrow pits, canal margins, tanks with vegetations
Aedes albopictus	Tree holes, water coolers, flower pots, Discarded tyres, Junk materials, cement tanks, Broken glass wares, iron drums,
Aedes aegypti	Cement tanks, earthen pots, tubs and Tanks, Discarded tyres, Junk materials, tree holes
Culex vishnui	Riverbeds, constructed sites, sewer lines, cisterns,polluted ground water, discarded tyres
Culex tritaeniorhynchus	Cement tanks, drums, tyres, cisterns,construction sites, water channel leakages,polluted water bodies
Culex quinquefasciatus	Irrigation canals, sewer lines,septic tanks, polluted ground water collecting bodies, artificial containers, artificial ponds
Armigeres subalbatus	Artificial ponds, overhead tanks

Table 4: Statistical Analysis of dominance, evenness and diversity indices in rural and urban areas of Gwalior district.

Parameter	Rural Gwalior	Urban Gwalior
Total number of Species (S)	9	9
Number of Individuals (n)	1141	1517
Simpson index of dominance (1-D)	0.834	0.8071
Shannon weaver index of diversity (H')	2.011	1.909
Margalef index of richness (D_{mg})	1.136	1.092

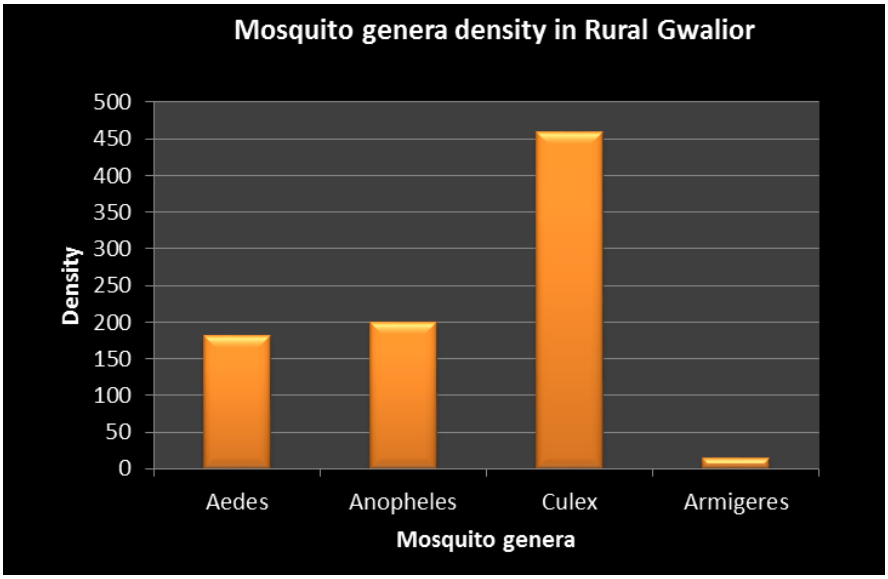

Fig 5: Density of mosquito's genera in rural Gwalior during 2014.

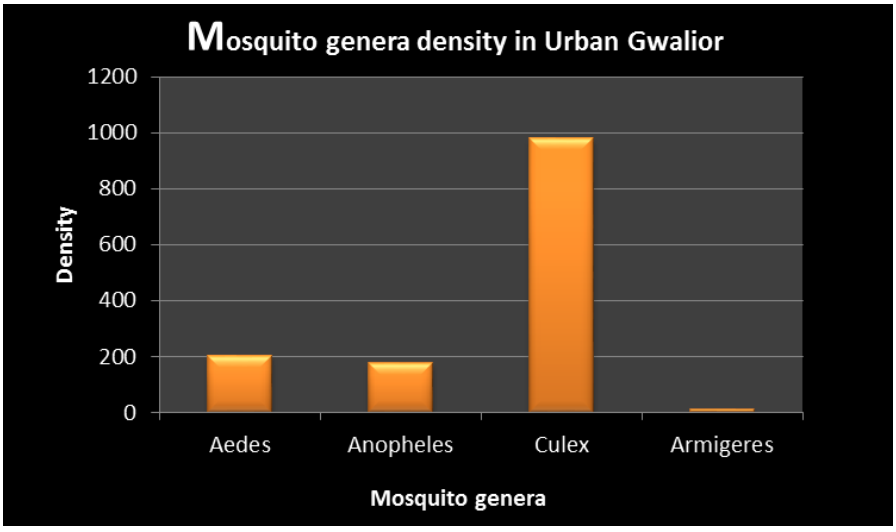

Fig 6: Density of mosquito's genera in urban Gwalior during 2014.

3. Results and Discussion

The present study has done a complete year survey on breeding sites to collect larval forms of mosquitoes in both rural as well as urban areas of Gwalior. A total number of 2658 mosquito larvae were collected during whole year of which 1141 larvae were collected in rural areas while 1517 larvae were recorded from urban areas of Gwalior (Table 1 & 2). In rural areas males collected were 647 while 494 were females, similarily in urban areas 734 were males while 783 were females. The study reveals that in Gwalior we found 9 species comprising of 4 genera i.e., *Aedes, Culex, Anopheles* and *Armigeres.* The insect species recorded were *Aedes albopictus, Aedes aegypti, Anopheles stephensi, Anopheles annularis, Anopheles subpictus, Culex quinquefasciatus, Culex vishnui, Culex tritanaerhyncus* and *Armigeres subalbatus.* In rural areas *Culex quinquefasciatus* were found in highest number (32.25 %) while *Armigeres subalbatus* was recorded in lowest number (5.34 %), while in urban areas *Culex quinquefasciatus* were found in highest number (35.92%) while *Anopheles stephensi* were found in lowest number (2.96 %). The various breeding habitats are listed in Table 3. Table 4 indicates the statistical analysis of dominance, evenness and diversity indices in rural and urban areas of Gwalior district. From the results we found that Margalef's index of richness is high for rural area (1.136) while slight low for urban area (1.092) which speaks that rural mosquito fauna is richer than urban area. Shannon diversity index is also high for rural area (2.011) while low for urban area (1.909) which shows that mosquitoes are more diverse in rural area than urban areas. Simpson's index of dominance was also high for rural area (0.834) than urban area (0.8071), which indicates that mosquitoes dominance is higher in rural area than urban areas.

Fig 5 & 6 shows density of mosquitoes genera in rural and urban areas of Gwalior district during 2014 which reveals that *Culex* density was higher in both rural and urban areas while *Armigeres* density was at lowest in both rural and urban areas of Gwalior district.

Saxena *et al.,* (1992) [19] gave entomological data in 5 cities i.e., Bhopal, Gwalior, Indore, Jabalpur, Indore and Raipur of Madhya Pradesh in relation to malaria epidemiology. The mosquito population difference in various months throughout the study period can be attributed to environmental variables which influences biology of mosquitoes as well as affects the availability of breeding habitats.

The habitat preferences of *Culex quinquefasciatus* ranges from polluted water bodies to fresh containers, and turbid water bodies also, i.e., this species shows great adapatability for breeding to numerous water bodies. Sirivanakaran (1976) [20] also reviewed the bionomics of *Culex quinquefasciatus* in relation to breeding habitats which include different types of habitats i.e., from fresh water, turbid to polluted water bodies. *Culex vishnui* and *Culex tritaeniorhynchus* also showed varied degree of breeding habitats, which were same with the findings of Sirivanakaran (1976) [20] who described the breeding habitats of these species ground pools like ditches, ponds, swampy ground having numerous grasses and various vegetations in open or cleared land such as rice fields serves as potential breeding habitats. Muturi *et al.,* (2007) [10] found high density of *Culex quinquefasciattus* in different types of larval habitats, i.e., paddy fields, ditch, canals, streams pools, marsh, tree holes, water reservoirs, sewer lines, etc from Kenya, similarly we found presence of *Culex quinquefasciatus* in almost same larval areas from Gwalior.

Anopheles stephensi prefers to breed in cement tanks, artificial containers, fountains i.e., mostly found in fresh water or transparent habitats which is same as described by Nagpal *et al.,* (2005) [12] about *Anopheles stephensi* breeding in overhead tanks, ground water level tanks, paddy fields, etc. Most adaptable breed of Anopheles is *Anopheles subpictus* which we found breeding in great degree of diverged habitats i.e., from fresh water to polluted water bodies which goes in similar accounts with reports of Nagpal *et al*., (2005) [12] who described breeding of *Anopheles subpictus* in variety of habitats such as flowing or stagnant water, clear or turbid water, fresh or brackish water, with or without vegetation etc. Herrel *et al*., (2001) [7] reported high preferences for animal ponds and street pools than other fresh water habitats including agricultural sites. *Anopheles annularis* has been found in vegetational tanks, ponds, river margins etc. Nagpal *et al*., (2005) [12] reported the breeding of Anopheles annularis in ponds, borrow-pits, rice fields and river margins also.

Aedes albopictus and *Aedes aegypti* prefers to breed in coolers, discarded tyres, flower pots, cement tanks, plastics etc. During study *Aedes albopictus* was found more residing in outdoor places which may be due to its adaptation in man made habitats. Pant *et al*., (1973) reported that *Aedes albopictus* prefers to breed outdoor as compared to *Aedes aegypti.*

During our study we found various mosquito species like *Aedes albopictus, Aedes aegypti, Anopheles stephensi, Anopheles annularis, Anopheles subpictus, Culex quinquefasciatus, Culex vishnui, Culex tritanaerhyncus* and *Armigeres subalbatus.* Rajnikant *et al.,* (1992a, b) made the survey of various mosquito species in paddy fields of Gujarat. Amitabh Shad and J. Andrew studied prevalence of Culex species in Agra in 2016 [1]. Galindo *et. al.,* (1955) [6] studied breeding biology of mosquitoes in Panama. T. Ramachandra Rao (1967) [21] studied density, distribution and seasonal prevalence of *Aedes aegypti* in India and South east Asia. Vythilingam *et.al.,* (1993) [24] collected a total of 40072 mosquitoes belonging to 35 species of 8 genera in Selangor, Malaysia from May to June 1992 and from September to December 1992. Jagbir S. Kirti and Jagdish kaur (2003) [8] studied 21 species of 5 genera; *Aedes*, *Anopheles*, *Culex*, *Armigeres* and *Mansonia* from Haryana, India. Kaur (2003) [8] provided the entomological data of 158 species of Aedini tribe. Rajavel *et al.,* (2004) [14] provided records of 64 species of mosquitoes in Pondicherry. Goutam Chandra *et. al.,* (2013) [3] illustrated different indices related to *Culex quinquefasciatus* in rural and urban areas of West Bengal, India.

Larval distribution of mosquitoes depends on various factors such as movement of water, elevation, water conditions (polluted, fresh, etc), vegetation, water temperature, sorce of water, etc. (Rattanarithikul, 2005) [18]. The high mosquito density of Culex in both urban and rural areas of Gwalior may be due to availability of various breeding sites created by suitable rains and humidity with optimum temperature for mosquito development, reproduction and survival and also

due to its adaptable nature to breed in variety of habitats. Tilak *et al*., (2008) [23] also reported high density of Culex than Anopheles from Pune cantonment areas. Fischer and Schweigmann (2004) [5] have reported high larval density of *Culex pipiens* and *Culex dolosus* from Buenos Aires. The results indicate that Culex species was more dominating species in both rural and urban areas during study period. Density of mosquitoes keeps on fluctuating with environmental conditions. This study will be helpful in planning, execution and implementing control strategy for management of vector species in Gwalior district of Madhya Pradesh. Outcome of the study on species composition of mosquitoes in rural and urban areas of Gwalior would improve our understanding for the various control strategy program which were previously adopted and which would be going to be implemented by Municipal Corporation of Gwalior. Source reduction of larval breeding sites can be of utmost importance for mosquito control and hence reducing the outbreak of disease transmission.

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