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Novel Approach of Geographic Information Systems on Recent Out-Breaks of Chikungunya in Tamil Nadu, India

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ABSTRACT

The study aimed to provide detailed picture and baseline data about recent outbreak of chikungunya virus in public health sectors. The data were collected from the Director of Medical Science (DMS) department of economic and statistics in Chennai. The present investigation, chikungunya outbreak in different districts of Tamil Nadu was plotted in Geographic Information Systems (GIS) software and rainfall was correlated to forecast with recent outbreak. Smoothing methods was adapted to filter the data. Chikungunya outbreak was high at 8 districts; chikungunya fever cases were not recorded in 1 district, chikungunya prevalence was very low in 2 districts and in the rest of 19 districts, chikungunya fever cases were moderately recorded in Tamil Nadu. The re-emergence and epidemics are unpredictable phenomena but the impact of such events can be ameliorated by appropriate knowledge and by being in the right state of preparedness.

Key words: Chikungunya fever, *Aedes aegypti*, outbreak, GIS, Tamil Nadu

INTRODUCTION

Chikungunya is a crippling disease caused by a chikungunya virus (CHIKV) belonging to the genus alpha virus of the family Togaviridae. It is an enveloped, positive-strand RNA virus capable of causing an acute infection characterized by joint pain, muscle aches, head ache and rash. It is a mosquito borne disease transmitted by *Aedes aegypti* or *Aedes albopictus*. The genus *Aedes* are considered disease vectors as they are responsible for the transmission of a number of viral and parasitic human pathogens worldwide. This is because this genus has a cosmotropical distribution and exhibits a distinct preference for human habitats (Ahmed *et al*., 2008).

This disease is almost always self-limited and rarely fatal. Chikungunya has become a global concern due to an escalation in the disease outbreaks in Africa, India and south East Asian countries (Yadav and Murthy, 2006). In India, first outbreak of chikungunya virus infection was reported in 1963. Consequently, there has been no active or passive surveillance carried out in the country and therefore, it seemed that the virus had 'disappeared' from the sub-continent. How ever, recent reports of large scale outbreak of fever caused by chikungunya virus infection in several parts of southern India have confirmed the re-emergence of this virus. Vector borne disease exhibits a distinct seasonal pattern, which clearly suggests that weather sensitive. Rainfall,

temperature and other weather variables affect in many ways both vector and the pathogens they transmit. The epidemics were a consequence of heavy rains favoring the active breeding of these mosquito species in urban habitats that host chikungunya virus (Yadav and Murthy, 2006). Geographical Information system has become another major tool for public health professionals to track the status and distribution of health indicators. Epidemiologists, public health administrators, certified environmental hygienists and other public health professionals are utilizing GIS to map out the spatial distribution of various diseases and its variation over space and time. In addition they use these maps for decision making and design the health policies accordingly. At present GIS is playing a very important role in public health in many spheres.

In addition, the virus gained the ability to infect a new vector *A. albopictus*, enhancing the opportunity for that mosquito concurrently infected with microfilaria transmit arboviruses more effectively (Zytoon *et al*., 1993). Because a large proportion of reported cases of chikungunya from India belong to areas where the prevalence of filarial parasitic infection could be modulating the re-emergence of chikungunya Mishra and Ratho (2006). Chikungunya virus, also known as buggy creek virus belongs to the Family-Togaviridae and the Genus alpha virus. Chikungunya fever is a self-limiting viral disease characterized by arthritis mostly involving the wrist, ankle, knee and small joints of the extremities associated with rashes and fever (Benenson, 1995). Many question concerning health and ill-health to space, however the incorporation of geography analysis into public health science and practice has been slow. A major deterrent has been the lack of adequate tools for the management and analysis of spatially defined date, the use of geo-information technology is offering new opportunities for research and planning public and policy (Loslier, 1995). GIS has been described as one of the most exciting of the new information technology (Yasnoff and Sondik, 1999).

Intuitively, GIS can be defined as an information technology that uses to take new relationship between variables, as one can bring together many different types of data (i.e., health, resource use/allocation, census, transportation, etc.). This in turn provides the social and physical context necessary for enhancing analysis in health planning and policy to emerge (Maguire *et al*., 1991). The analysis of spatial data can focus on the relationships between attribute variables, or on the spatial and space-time dimensions or a combination of attribute and space/space-time. The methods used in spatial data analysis can be broadly categorized into those concerned with visualizing data, those for exploratory data analysis and methods for the development of statistical models (Bailey and Gatrell, 1995). Globally, there are many studies proving applicability of remote sensing in vector habitat identification and for optimization of vector control operations (Hugh-Jones, 1989). Using satellite remote sensing data, identification and categorization of mosquito larval habitat associated with plant communities, wetlands and other aquatic locations as well as relationship between land use and land cover categories have also been reported (Bergquitst, 2001). The temporal multi-spectral remote sensing data provide a means for understanding varying degrees of victor born disease incidence with vegetation cover, moisture and waterlogged areas and associated environmental factors, including social and economical factors (Sabesan, 2003). In addition three human trends have to be taken into account: population growth, urbanization and the growing demand for water and food, these factors indicated the survival cannot be separated nor can the impacts of climate change on future security policy be analyzed in isolation (Matouq, 2008). The main objective of the study was to generate the basic information on the recent outbreak of chikungunya in the state of Tamil Nadu.

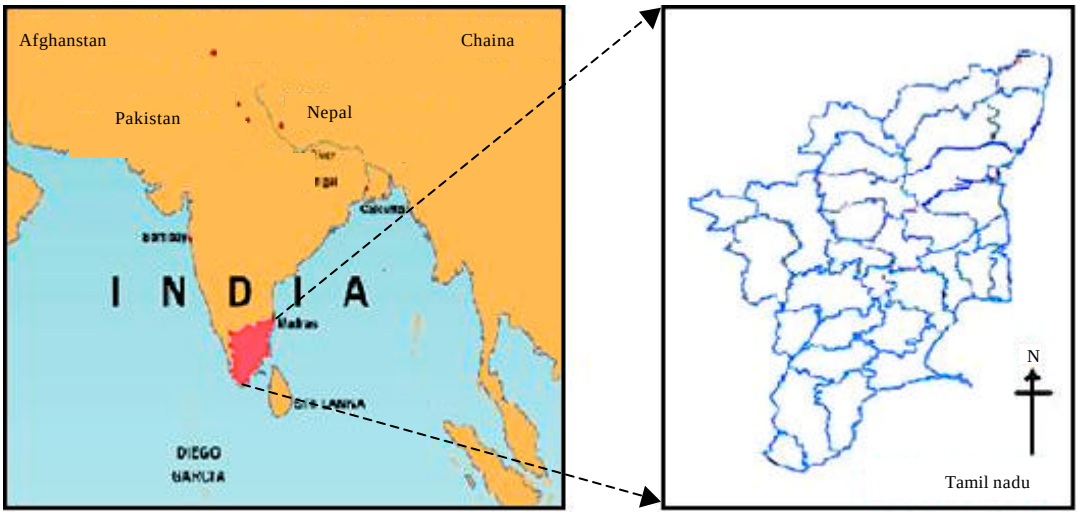

Fig. 1: Description of the study area

MATERIALS AND METHODS

Study area: Tamil Nadu is a state at the southern tip of India. It is situated in (8 5' 13° 35' N and 76 15' 80° 20' E (Fig. 1). It is bordered by Pondicherry, Kerala, Karnataka and Andhra Pradesh. Tamil Nadu has a population of approximately 6, 24,05,679. It is 1,30,058 km^2 and comprise 16,317 villages and 832 towns and the area is more epidemic with Chikungunya during 2006. The Chikungunya fever cases and Rainfall data of Tamil Nadu was taken from the Director of Medical Science (DMS) department of economic and statistics in Chennai. The fever cases files that provide statistics on all the districts in the county level for individual month for the period of one year (2006).

Study methods: Two commonly used methods for mapping spatial variation in disease are maps of relative risk and maps of statistical significance. The former approach is a popular choice and has the advantage of easy interpretation. The software GIS Arcview (version 8) was used to plot the data and has the advantage of easy interpretation. However, such maps tend to display the most extreme values in areas of small population (Clayton and Kaldor, 1987). The approach, including maps of probabilities, has the problem of potentially extreme significant level in areas of large population, due to sample size effects. Alternatively, smoothing methods have been suggested as a compromise, and are often used as an alternative approach. Smoothing methods were designed to filter out variability in a data set based on function on the data in surrounding areas and kernel-based smoothing methods have received much attention in recently years by Bailey and Gatrell (1995). GIS is highly scaleable software and as such can handle any volume of data. It can be integrated with any existing software across a wide range of hardware/operating platform.

RESULTS AND DISCUSSION

Chikungunya is spread by the bite of an *Aedes aegypti*, humans are thought to be the major source or reservoir of chikungunya virus for the mosquitoes. In India, the dominant carrier of

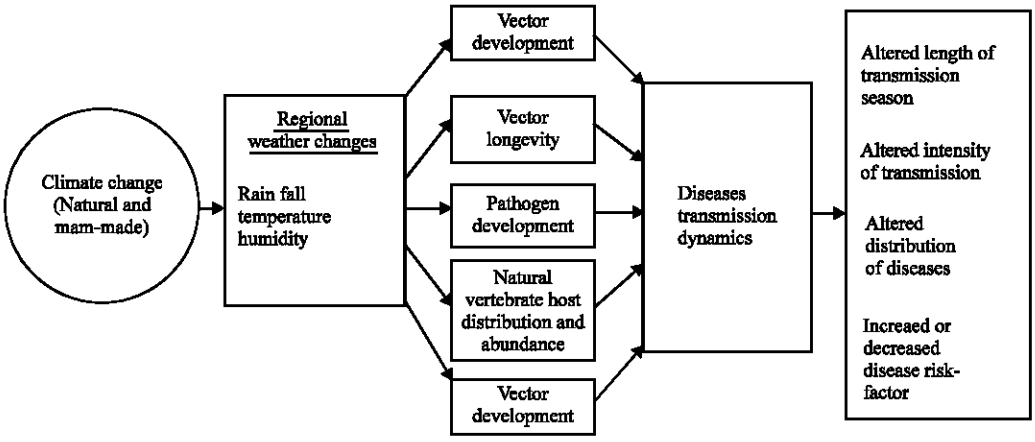

Fig. 2: Climate forecasts for early warning of favorable conditions for diseases transmission

chikungunya virus is *A. aegypti*, which breeds mainly in stored fresh water in urban and semi-urban environments. Outbreak dynamics characterized by the absence of an animal reservoir and the ability to spread rapidly among human beings via domestic and peridomestic mosquitoes. Indian chikungunya outbreak seems to have followed the outbreak in the Indian Ocean islands and may be related to the heavy tourist traffic between the two regions. The transmission patterns of these diseases may, therefore, be affected by ambient rainfall. However, rainfall is only one of many factors that influence transmission dynamics (Fig. 2).

Chikungunya fever cases of each districts, monthly average of rainfall and total population of each districts in the state of Tamil Nadu during 2006, which was plotted in geographical information system, soft ware Map-Info. Figure 3 shows that chikungunya out-break was high at Namakkal district (11498) followed by Vellore (7666), Krishnagiri (5747), Tirunelveli (5062), Chennai (4569), Coimbatore (4170), Dinidigul (3808) and Ramanathapuram (3265). Chikungunya fever cases were not recorded at Nilgiri (0) and the prevalence was very low at Tiruvannamalai (9) and Thiruvallur (44) districts. In rest of the districts chikungunya outbreak was noticed in different frequencies. The rainfall was recorded in different frequencies and the population of district was very high in Chennai (4343646), Coimbatore (4271856) and Vellore (3477317) and very low in Perambalur (493646) and Nilgiri district (762141) (Table 1). Among the entire district Coimbatore and Vellore ranked high in both chikungunya and rainfall, respectively. So it is clearly understood that rainfall is one of the climatic factor which enables the transmission of CHIK-V virus from mosquitoes to humans at irregular intervals. The intra-outbreak studies, point towards recent changes in the viral genome facilitating the rapid spread and enhanced pathogenecity. The available published scientific literature on chikungunya virus was searched to understand the natural history of this disease, reasons for the current outbreak and the causes behind re-emergence of the virus in India.

The chikungunya virus was first isolated in India in Calcutta in 1963 (Dandawate *et al*., 1965). Subsequently, it seems that the virus has 'disappeared' from the subcontinent (Pavri, 1986). However, outbreaks of fever caused by chikungunya virus infection in several parts of South India in 2006 have confirmed the re-emergence of this virus. Chikungunya fever cases was first recorded in Calcutta in 1963, after that episode, there have been several reports of chikungunya virus infection in different parts of India. In Tamil Nadu, we investigated the outbreak in Gowripet area

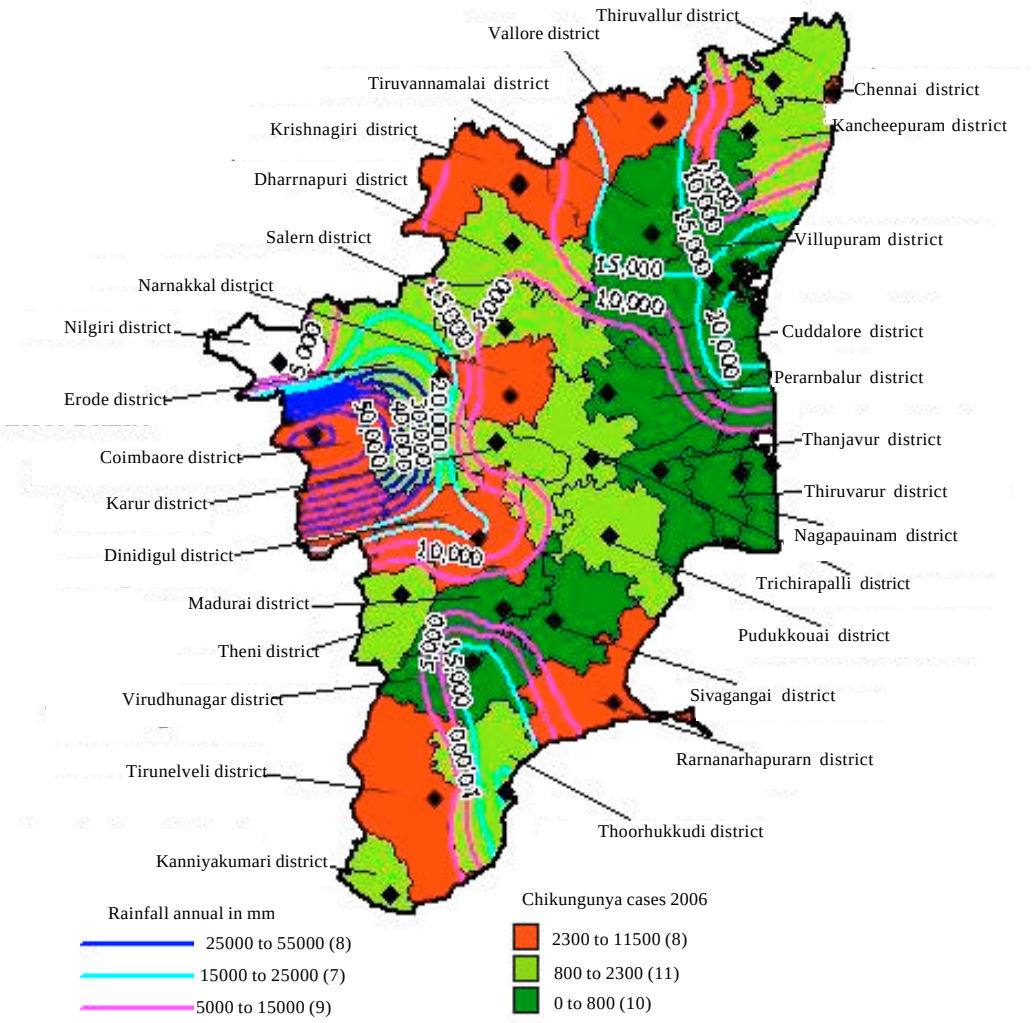

Fig. 3: District map showing different degrees of chikungunya out-breaks in Tamil Nadu (2006)

(2006 population: 2,649) of Avadi, a suburban locality of Chennai City where a large number of persons with fever and joint pain were reported in June 2006 (Kaur *et al*., 2006).

However, large scale outbreaks of fever caused by chikungunya virus infection in several parts of Southern India have confirmed the re-emergence of this virus (Yadav and Murthy, 2006). Therefore, it should be included in the differential diagnosis of disease with influenza-like symptoms, especially when patient present with the triad of fever, rash and joint pains. Although chikungunya fever is not a fatal disease, it may cause significant morbidity due to sever and prolonged duration of joint pains. GIS has been extensively used in natural resource management, public work, transportation and government but until recently, has been largely ignored in public health and socio-behavioral research (Albert *et al*., 2000). They explorer this further with GIS using statistical analysis and visualization to generate hypotheses for further study. Findings from traditional epidemiological methods can also be used to corroborate GIS findings further study and test hypotheses generated by the GIS (Lewis-Michl *et al*., 1996). This study confirms the sudden

Table 1: Average rain fall, chikungunya cases and total population of Tamil Nadu

Districts name	Rainfall in mm (2006)	Chik-cases (2006)	Population
Chennai	2893.40	4569	4,343,646
Coimbatore	55770.2	4170	4271856
Cuddalore	25103.8	209	2285395
Dharmapuri	7826.1	1162	2856300
Dinidigul	15011.9	3808	1923014
Erode	19141.5	1417	2581500
Kancheepuram	580.7	1258	2877468
Kanniyakumari	201.4	830	1676034
Karur	57.2	1189	935686
Krishnagiri	7696.2	5747	1546700
Madurai	332.8	208	2578201
Nagapattinam	113.2	292	1488839
Namakkal	110.2	11498	1493462
Nilgiri	201.4	0	762141
Perambalur	68.2	323	493646
Pudukkottai	347.8	1136	1459601
Ramanathapuram	299.8	3265	1187604
Salem	584.2	2201	3016346
Sivagangai	299.0	186	1155356
Thanjavur	347.8	473	2216138
Theni	38.6	1788	1093950
Thiruvallur	110.2	1859	2754756
Thiruvarur	89.2	44	1169474
Thoothukkudi	20536.1	2263	1572273
Tirunelveli	266.2	5062	2723988
Tiruvannamalai	17849.5	9	2186125
Trichirapalli	364.0	980	2418366
Vellore	19370.8	7666	3477317
Villupuram	15300.8	495	2960373
Virudhunagar	17146.6	564	1751301

outbreak of chikungunya fever in Tamil Nadu is because sporadic vectors transmission of the virus from the *Aedes aegypti* and *Aedes albopictus* mosquitoes under suitable climate. The high density of vector mosquitoes and suitable wheather conditions like rainfall and temperature which enables the route of opportunity to the CHIK-V to show their impact. Like other mosquitoes borne diseases, e.g., dengue fever, avoiding contact with mosquitoes and maintaining good environmental sanitation can prevent transmission. *A. aegypti* already showed increased tolerance to both insecticides, indicating that a portion of the population has already developed resistance to the insecticides. If treatment using insecticides is still applied continuously, there is the possibility that those populations will become resistant in the future (Ahmad *et al*., 2007).

Health education programme to improve public awareness of the disease and to encourage mass participation in basic sanitary measures and source reduction to prevent breeding of mosquitoes in peridomestic and carelessly discarded containers should be intensified (Adebote *et al*., 2006). Less than 5% of 2, 500 described mosquito species regularly breed in brackish water, they represent a rather diverse group of species (Balakrishnan *et al*., 2011). Researchers have recently concentrated their efforts on the search of active natural products derived from marine sponges as alternatives

to conventional insecticides. The ethanol extract of *Clathria gorgonids* and *Callyspongia diffusa* were found more effective against *A. aegypti* (Sujatha and Joseph, 2011). Vector control measures include the elimination of potential breeding places of mosquitoes inside and outside homes, schools and offices. Drums, plastic containers and pails used to store water should be covered. Discarded natural and artificial containers, e.g., coconut shells, old tires, empty bottles and cans, should be properly disposed of. Water in flower vases should be frequently changed. Screening of sleeping quarters and bedrooms or the use of insect repellents and mechanical barriers such as mosquito nets help minimize exposure to mosquitoes. Therefore, continuous monitoring of resistance in the future that consequently might lead to more severe DF/DHF/CHIKV outbreaks. For the first time, extensive studies on controlling diseases transmissions by mosquitoes through GIS technology in Tamil nadu have been undertaken and it provides the basic information for future studies in the field of epidemiology.

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REFERENCES

Adebote, D.A., S.J. Oniye, I.S. Ndams and K.M. Nache, 2006. The breeding of mosquitoes (Diptera: Culicidae) in peridomestic containers and implication in yellow fever transmission in villages around Zaria, Northern Nigeria. J. Entomol., 3: 180-188.

Ahmad, I., S. Astari and M. Tan, 2007. Resistance of *Aedes aegypti* (Diptera: Culicidae) in 2006 to pyrethroid insecticides in indonesia and its association with oxidase and esterase levels. Pak. J. Biol. Sci., 10: 3688-3692.

Ahmed, A.M., E.M. Al-Olayan and M.A. Amoudy, 2008. Enhancing the humoral and melanization responses of *Aedes aegypti* mosquito: A step towards the utilization of immune system against dengue fever. J. Entomol., 5: 305-321.

Albert, D.P., W.M. Gesler and B. Levergood, 2000. Spatial Analysis, GIS and Remote Sensing: Applications in the Health Sciences. 1st Edn., Ann Arbor Press, Chelsea, MI., ISBN-13: 978-1575041018, pp: 217.

Bailey, T.C. and A.C. Gatrell, 1995. Interactive Spatial Data Analysis. Longman Ltd., Harlow, Essex, UK., pp: 413.

Balakrishnan, S., M. Srinivasan and K. Elumalai, 2011. A survey on mosquitoe diversity in parangipettai coast, southeast coast of tamilnadu, India. J. Entomol., 8: 259-266.

Benenson, A.S., 1995. Control of Communicable in Man. 16th Edn., American Public Health Association, USA.

Bergquitst, N.R., 2001. Vector-borne parasitic diseases: New trends in data collection and risk assessment. Acta Trop., 79: 13-20.

Clayton, D. and J. Kaldor, 1987. Empirical bayes estimates of age-standardized relative risks for use in disease mapping. Biometrics, 43: 671-681.

Dandawate, C.N., K.V. Thiruvengadam, V. Kalyanasundaram, J. Rajagopal and T.R. Rao, 1965. Serological survey in Madras city with special reference to chikungunya. Indian J. Med. Res., 53: 707-714.

Hugh-Jones, M., 1989. Application of remote sensing to the identification of the habitats of parasites and disease vectors. Parasitol. Today, 5: 244-251.

Kaur, P., M. Ponniah, M.V. Murhekar, V. Ramachandran and R. Ramachandran *et al*., 2008. Chikungunya outbreak, South India. EID, 14: 1-7.

Lewis-Michl, E.L., J.M. Melius, L.R. Kaleenbach, C.L. Ju and T.O. Talbot *et al*., 1996. Breast cancer risk and residence near industry or traffic in Nassau and Suffolk Counties, Long Island, New York. Arch. Environ. Health, 51: 255-265.

Loslier, L., 1995. Geographical Information System (GIS) from a health perspective. Proceedings of the International Workshop held in Colombo, Sept. 5-10, Sri Lanka, Ottawa, Canada: International Development Research Centre, pp: 13-20.

Maguire, D.J., M.F. Goodchild and D.W. Rhind, 1991. Geographic Information Systems. Longman Scientific and Technical, Harlow, UK.

Matouq, M., 2008. Predicting the impact of global warming on the middle east region: Case study on hashemite kingdom of Jordan using the application of geographical information system. J. Applied Sci., 8: 462-470.

Mishra, B. and R.K. Ratho, 2006. Chikungunya re-emergence: Possible mechanisms. Lancet, 368: 918-918.

Pavri, K., 1986. Disappearance of chikungunya virus from India and South East Asia. Trans. R. Soc. Trop. Med. Hyg., 80: 491-491.

Sabesan, S., 2003. Forecasting mosquito abundance to prevent Japanese encephalitis. Curr. Sci., 84: 1172-1173.

Sujatha, S. and B. Joseph, 2011. Effect of few marine sponges and its biological activity against *Aedes aegypti* Linn. *Musca domestica* (Linnaeus, 1758) (diptera: Culicidae). J. Fish. Aquat. Sci., 6: 170-177.

Yadav, J.S. and U.S.N. Murthy, 2006. A special issue on Chikungunya. Envis News Lett., 3: 1-9.

Yasnoff, W.A. and E.J. Sondik, 1999. Geographic Information System (GIS) in public health practice in the new millennium. J. Public Health Manage. Practice, 5: 8-11.

Zytoon, E.M., H.I. El-Belbasi and T. Matsumura, 1993. Transovarial transmission of Chikungunya virus by *Aedes albopictus* mosquitoes ingesting microfilaria of *Dirofiliaria immitis* under laboratory control. Microbial. Immunol., 37: 419-421.