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Mosquito larval habitat mapping using remote sensing and GIS for monitoring the filarial infection regions in Alkorin village, Sharkia Governorate (Egypt)

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Abstract
No doubt that the mosquitoes are the main vector for many fatal human diseases, such as malaria, filariasis, and several arboviral diseases. Mosquito *Culex* (*Culex*) *pipiens* L. implicated as a vector of filariasis in Alkorin Village, Sharkia Governorate (Egypt). Potential larval habitats of mosquito were identified using integrated remote sensing (RS) and geographic information system (GIS) analyses during successive two years (2015- 2016). Mapping mosquito breeding habitats were the basis for management and control of endemic filariasis transmitted by *Culex* mosquitoes. By using satellite image digital data and GIS, maps for the temperature, salinity, turbidity and mosquito larval habitats of the study area were constructed. Data analyses show clear effectiveness of temperature and turbidity on the abundance of the mosquito larvae. Consequently, the distribution density of the filariasis on the study area modeled using GIS. The optimum water temperature for the highest larval growth rate ranged from 27 to 33 ^{o}C and turbidity was ranged from 5 to 145 NTU. Meanwhile, salinity ranges had no effect on the abundance of mosquito larvae. In conclusion, remote sensing and GIS technologies with computer modeling are useful tools in providing a solution for future disease eradication planning and management to government especially in formulating policy related to the mosquito and disease control.

Keywords: *Culex pipiens* larvae, RS, GIS, Filariasis, Sharkia, Egypt

1. Introduction
Mosquitoes are responsible for the transmission of many human diseases than any other arthropod groups [1]. The report of World Health Organization, 2008, shows that more than a half of the world's population lives under a constant risk of pathogens transmitted by mosquitoes. About 120 million people in tropical and subtropical areas of the world are infected with lymphatic filariasis. Out of this number, 25 million men have genital disease (most commonly hydrocele) and almost 15 million, mostly women, have lymphoedema or elephantiasis of the leg [2]. Approximately 66% of those at risk of infection live in the South-East Asia region and 33% in the African region [2]. In Egypt, mosquitoes have a crucial effect on disease transmission, including malaria, filarial, dengue and yellow fevers [3]. Filariasis is a wide spread disease in some regions of Egypt (Sharkia, Qaluobia & Ezbet Elborg in Damietta) with an incidence ranging from 4 to 6% in Sharkia Governorate [4]. It was investigated that the main vector responsible for filariasis transmission in Egypt is *Cx, pipiens* [5]. Geospatial mapping for the distribution of mosquito breeding habitats is facilitating the control practices [6, 7, 8]. In Egypt, although there is no clear evidence for applying GIS in health sector, health mapping techniques has been used to identify environmental indicators for villages at high risk of filaria transmission [9]. Thus in the present work, RS and GIS were used for monitoring and mapping *Cx. pipiens* larval habitats, which provide excellent means for visualizing and analyzing images for mosquito larvae to detect the filarial infection regions in Sharkia Governorate.

2. Materials and Methods
2.1 Study area
The present study (Figure 1) was carried out at Alkorin village, Sharkia Governorate, Egypt. It lies in the east of the Nile Delta and is circumscribed by coordinates 31.7816 N 30.6369 E,

31.7843 N 30.5856 E, 31.7055 N 30.6381 E and 31.7047 N 30.5807 E. Sharkia Governorate is bordered by Lake Almanzlah from the north, Ismailia from the east, Qalyubiah and Cairo Governorates from south and Daqahliyha Governorate from west. Alkorin covers about 50 squares Km^2 with a population of 30000 inhabitants [10].

2.2 Larval surveys site selection

27 points of different water sites at study area were selected to collect mosquito larvae, seasonally, during 2 successive years (2015- 2016). The survey site was considered positive where mosquito larvae were found breeding in the water body. Larvae were collected by sweeping the surface water with a long-handled larval net [11]. Fourth larval instars of the *Culex* mosquitoes were identified morphologically according to the key of the Egyptian mosquitoes [12, 13].

2.3 Environmental factor measurements

Parameters that were measured periodically during the collection of larvae for each sample including: water temperature, salinity and turbidity. Temperature was measured using mercury thermometer expressed by Celsius, salinity was measured by Gondo salinity pen 5011 expressed by ppm and turbidity was measured for each water sample which expressed by NTU (Nephelometric Turbidity Unit).

2.4 GIS database

The database was built in ArcMap 10.3 GIS (ESRI). An administrative map of Egypt delineating the Governorate boundaries was digitized and used as a base map to which all thematic data were spatially linked. Digital map of Egypt was used to show the various divisions of Egypt with different feature classes for drains, rivers and roads. Coordinate system used in digital maps was GCS_WGS_1984 and Datum D_WGS_1984. Computer program ArcMap 10.3 was used for producing cartographic maps of the correlated parameters showing study sites in Alkorin, Sharkia Governorate.

2.5 RS and Satellite data

Landsat-8 multispectral satellite was used in this study where data collected through its Enhanced Thematic Mapper Plus with a spatial resolution of 30 x 30 meters for the eight spectral bands possessing a thermal and panchromatic band. These files were collected through the satellite image database on *http://www.usgs.gov/* (Landsat-8). Techniques of image processing were done using ENVI 5 software.

2.6 Surface water temperature from Landsat-8

Thematic Mapper (TM) sensors acquire temperature data and store this information as a digital number (DN) with a range between 0 and 255. It is possible to convert these DNs to degrees Celsius. A Landsat ETM+ image acquired in 12 October 2015 (Path 176 and Row 39) was used in this study as this date was the most available for the analysis. The image was registered to the Universal Transverse Mercator (UTM) Projection. A subset image covering the boundaries of the Alkorin region was created. At this subset image, by using algorithm, the raw DN was converted to radiance value then converted to temperature [14].

2.7 Water salinity from Landsat-8 TM

The data acquired in 12 October 2015 by path 176 and row 39 was used for retrieving salinity from Landsat TM-8 at Alkorin region. Interpretation of algorithm for the image was done using the salinity equation of Cimandiri algorithm [15].

2.8 Water turbidity

The digital image classification procedure automatically categorizes all pixels into classes. Normally multi-spectral information present within the digital data for each pixel is used as a numerical basis of categorization. A digital thematic map is a special type of image, where each pixel is given a color or grey level value representing a user-selected "class". Google earth Quick bird image with 60cm spatial resolution was used for the mapping turbidity sites. In order to get the water area from the image onscreen, digitization was done on Google earth [16].

2.9 Modeling of data

Modeling of mosquitoes larval density is to demonstrate the high density of filarial region using ArcMap 10.3 program and Arc toolbox by spatial analyst tools of kernel density.

3. Results

During two years of field survey, autumn 2015 was the highest rate of larval collection in all studied sites. 1361 mosquito larvae were collected during autumn 2015 from 27 study sites. Mosquitoes larvae collected in all studied sites showed that the optimum water temperature for the highest larval growth rate ranged from 27–33 ºC. From a satellite image, the temperature ranged between 25.8 ºC to 33.9 ºC and average temperature were 28.6 ºC comparing to 29.1 ºC measured in field (Figure 2).

In all studied sites, salinity ranged from 339.5 to 810 ppm from satellite image and ranged from 340 to 810 ppm that measured in study sites. Mosquito larvae recorded at all salinity ranges. The study showed large differences in the tolerance of mosquito larvae to water salinity but salinity has convergent ranges. Average of salinity for satellite images was 447.5 and average of salinity from field examination was 453.7 (Figure 3).

From Figure 4, the satellite image showed 14 turbid sites (sites 1, 2, 4, 6, 8, 10, 11, 13, 3, 5, 7, 9, 22, and 24) and indicates that turbidity from field examination ranged from 5 to 145 NTU. An observation of the studied water habitats revealed that the major sources of turbidity were; phytoplankton, clays and organic wastes from wastewater discharges (Figure 4).

By utilizing the surveyed data, the larval development in water bodies has been known at 27 locales, out of which 16, 17, 18, 19, 20, 21, 23, 25, 26, 27sites. Pixel values at the point1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,22,24 shows that the mosquito hatchlings were existed along the review zone. The characters found after picture examinations and ground truthing were measurably related.

The specific territory in the water body, where the larval thickness increases, has been distinguished and the outcomes given in the Figure 5 from autumn 2015 demonstrates that the regions incorporated into circle having larval thickness and instances of mosquito-borne sicknesses as the zone close to the water body.

GIS is a capable PC mapping and investigation frameworks for spatial examples and forms which are pertinent to various controls including the review of mosquito larval environment.

Concentrate the mosquito rearing destinations and resulting sickness transmission. GIS can be utilized to guide and investigate the spatial dispersion of pixel or DN values related to immediate field of-view (iFOV) on satellite picture [17] and to survey the natural elements that add to watched circulation of reproducing grounds as shown in Figures 5.

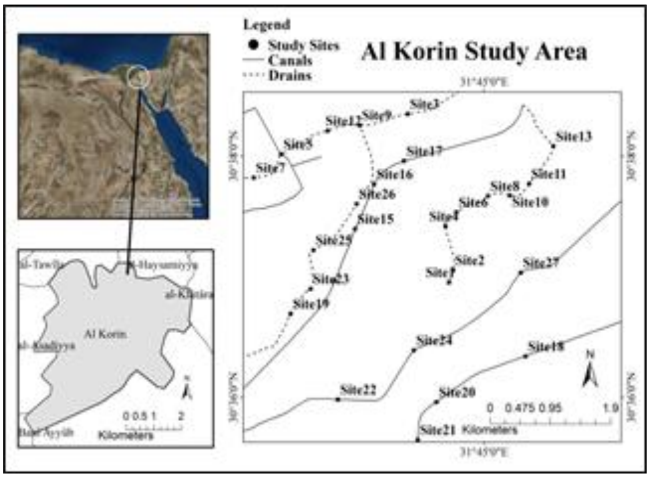

Fig 1: Location of study area and sites of collection.

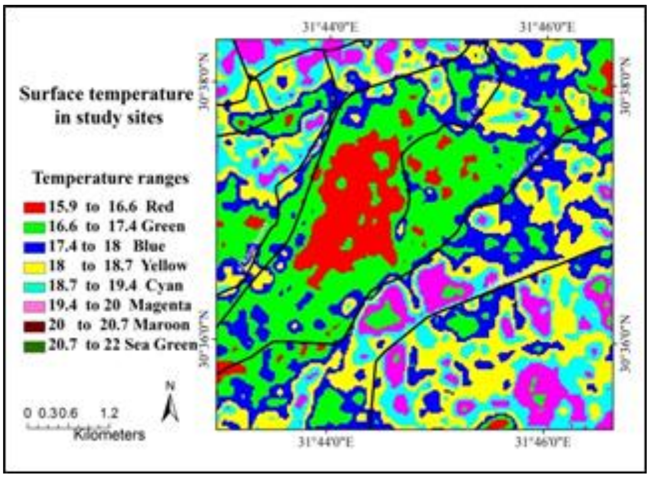

Fig 2: Satellite image for study area show temperature ranges in autumn 2015.

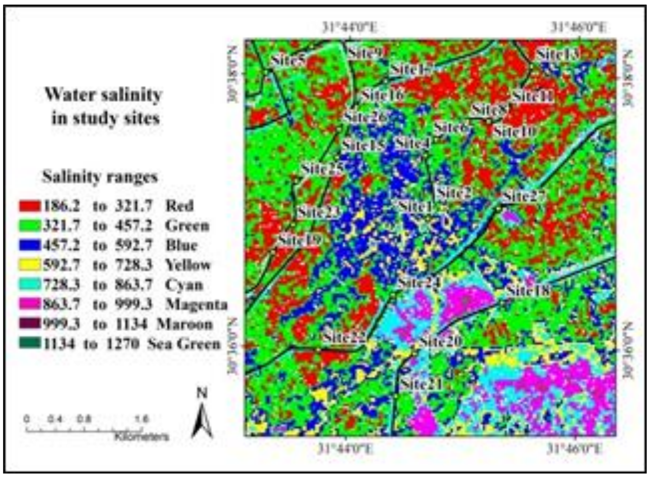

Fig 3: Satellite image for study area show salinity ranges in autumn.

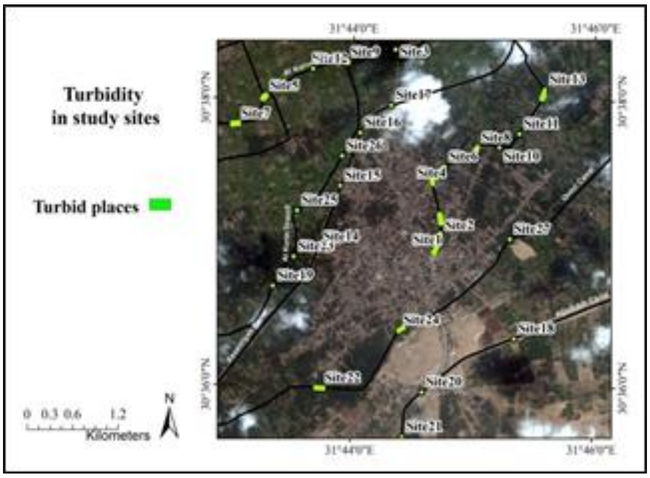

Fig 4: Satellite image for 14 turbid sites and 13 non turbid sites in study area.

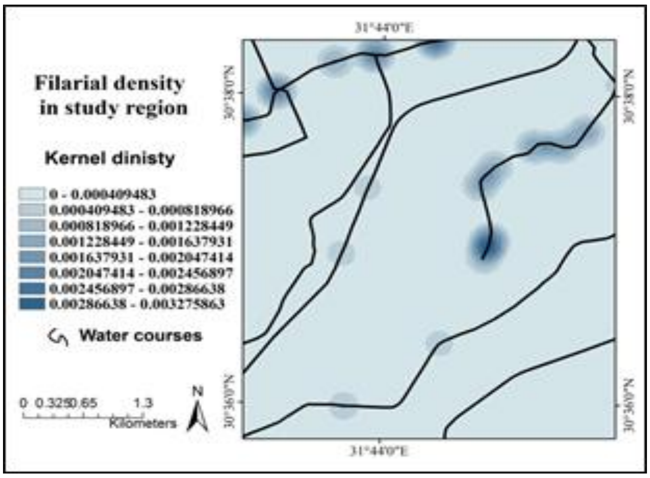

Fig 5: Modeling of filariasis density in study region.

4. Discussion

Mosquito-borne diseases and their occurrence are especially remarkable by understanding the connections between water, mosquito habitats and environmental conditions. These conditions were methods in the field, to investigate of vector environment in disease transmission [18].

Cx. pipiens was incriminated as a principal vector of filarial infection in Egypt, the transmission was depended on the intensity of breeding habitat [4]. *Cx. pipiens* larval habitat can be monitored at large scale in a rapid cost effective way. Water properties were important for separation larval habitats. In this study, the classification procedures presented models for larval habitats of water bodies [19]. In this study, water temperature in mosquito larvae breeding habitat was optimum for larval growth and this is in the same range stated by [11, 20, 21, 22]. Surface water temperature can be determined from RS data at large scale for retrieving larval habitat regions.

During this study, the majority of mosquito larvae were found in fresh waters, *Cx. Pipiens* larvae were found in all types of breeding places, but there are several species that show high salinity tolerance [23, 24]. Optical RS data from Landsat-8 provide good information about salinity. The integration between RS and GIS with salinity algorithms provides a powerful tool for retrieving salinity [25].

The results showed that mosquito larval abundance increased with turbidity rising. The turbid water was found to be a proper habitat for larval breeding and this affects larval occurrence [26, 27, 28].Turbidity pattern evaluation in complex environments require non-traditional methods. Advantages of RS techniques include the ability to offer reliable observations and understand complicated procedures operating on different space-time scales, especially in large areas with difficult and sometimes restricted access [29].

This study provides a tool to identify *Cx. Pipiens* species larval habitats. In this study, the technique of classifying the larvae habitat of mosquitoes was developed professionally to generate a spatially distribution at the large scale. The outcomes of temperature, salinity and turbidity subsequently give extremely helpful data to distinguish the positive locales of mosquito larval-breeding in water bodies.

The GIS was used for monitoring endemic filariasis in the region, in another way its vital tool for mapping the disease occurrence, disease morbidity and management of public health data [30]. Simply, image classification can be repeated and adopted, with the wide availability of Landsat TM data and this classification procedure can be applied more generally in the future [19].

The present study gives a brief review of the utilization of RS and GIS to the ecological issues, mosquito observation program and administration of mosquito control mediations. It additionally indicates how GIS when joined with RS can possibly aid water bodies for vector thickness thus as to limit disease flare-up [31].

In spite of the fact that the best mosquito control intercessions on expansive scale to avoiding larval spread are by larviciding and adulticiding, yet they are much costly and furthermore cause natural contamination. By utilizing remote detecting and GIS viably and effectively mosquito larval control can be target arranged in accomplishing the assignment at less cost. Thus in this review GIS and remote detecting is used to complete productive larval distinguishing proof.

5. Conclusion

This study reveals that monitoring of filariasis diseases using RS and GIS. *Cx. pipiens* was the main vector of filariasis in the study area. Water parameters used as an indicator to habitat availability for mosquito larval density. RS and GIS were used to monitor water parameters. Field investigation of temperature, salinity and turbidity were linked by mosquito larval density for modeling *Cx. pipiens* occurrence. The model, generate map of filarial region extents.

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7. References

1. Simsek FM. Seasonal larvae and adult population dynamics and breeding habitat diversity of *Culex theileri* Theobald. Turkish Journal of Zoology. 2004; 28:337-44.
2. World Health Organization. A Handbook for national elimination programmes on Lymphatic Filariasis Elephantiasis. WHO, Geneva. 2013, 51.
3. Gad AM, El-Said S, Soliman BA, Hassan AN, Shoukry A, EL-Said S. *et al.* Distribution and bionomics of Egyptian *Culex univittatus* Theobald. Journal of Egyptian Society of Parasitology. 1987; 17(1):17-31.
4. Rashed SS. Survey of mosquito species in Sharkia Governorate with special reference to population density of culicids transmitting filarial. M.Sc. Thesis, Faculty of Science, Zagazig University.1981, 1-169.
5. Southgate BA. Bancroftian filariasis in Egypt. Tropical Diseases Bulletin. 1979; 76(12):1045-1068.
6. Hayes RO, Maxwell EL, Mitchell CJ, Woodzick TL. Detection, identification and classification of mosquito larval habitats using remote sensing scanners in earth orbiting satellites. Bulletin of World Health Organization. 1985; 63:361-374.
7. Dale PE, Ritchie SA, Territo BM, Morris CD, Muhar A, Kay, BH. *Et al.* An overview of remote sensing and GIS for surveillance of mosquito vector habitats and risk assessment. Journal of Vector Ecology. 1998; 23:54-61.
8. Hay SI, Snow RW, Rogers DJ. Predicting malaria seasons in Kenya using multi-temporal meteorological satellite sensor data. Transactions of the Royal Society of Tropical Medicine and Hygiene. 1998; 92:12-20.
9. Sowilem MM, Bahgat IM, El-Kady GA, El-Sawaf BM. Spectral and landscape characterization of filarious and non-filarious villages in Egypt. Journal of the Egyptian Society of Parasitology. 2006; 36(2):373-388.
10. Central Agency for Public Mobilization and Statistics. http://capmas.gov.eg/Pages/GISBoundaries.aspx?pageid=5074. 2011.
11. World Health Organization. Manual on practical Entomology in malaria. Part I: Vector, Bionomics and Organization of Anti-Malaria Activities. Division of Malaria and other Parasitic Diseases. WHO, Geneva. 1975, 160.
12. Kirkpatrick TW. The mosquitoes of Egypt. Egyptian Government, Antimalaria Commission. Government Press. 1925, 224.
13. Harbach RE, Harrison BA, Gad AM, Kenawy AM, El-Said S. Records and notes on Mosquitoes Diptera: Culicidae Collected in Egypt. Mosquito Systematic. 1988; 20(3):317-243.
14. Hereher ME, Salem MI, Darwish DH. Mapping water quality of Burullus Lagoon using remote sensing and geographic information system. Journal of American Science. 2010; 7(1):138-143.
15. Supriatna L, Supriatna J, Koestoer RH, Takarina ND. Algorithm model for determination of Cimandiri Estuarine boundary using remote sensing. AIP Conference Proceedings 1729, 020079. 2016.
16. Shivangi S, Kunwar P, Singh NB, Kachhwaha TS. Water turbidity assessment in part of Gomti river using high resolution Google Earth's Quick bird satellite data. Dimension and Direction of Geospatial Industry. India. 2011, 18-21.
17. Barnes CM, Cibula WG. Some implications of remote sensing technology in insect control programs including mosquitoes. Mosquito News. 1979; 39:271-282.
18. Ceccato PS, Connor J, Jeanne I, Thomson MC. Application of geographical information systems and remote sensing technologies for assessing and monitoring malaria risk. Parasitolology. 2005; 47(1):81-96.
19. Zou L, Miller SN, Schmidtmann ET. Mosquito Larval Habitat Mapping Using Remote Sensing and GIS:

Implications of Coalbed Methane Development and West Nile Virus. Journal of Medical Entomology. 2006; 43(5):1034-1041.
20. Kenawy MA, Rashed SS, Teleb SS. Characterization of rice field mosquito habitats in Sharkia Governorate, Egypt. Journal of Egyptian Society of Parasitology. 1998; 28(2):449-459.
21. Ramachandra RT. The anophelines of India. Revised edition, Delhi. Malaria Research Centre ICMR. 1984; 1-518.
22. Afolabi OJ, Simon-Oke IA, Osomo BO. Distribution, abundance and diversity of mosquitoes in Akure, Ondo State, Nigeria. Journal of Parasitology and Vector Biology. 2013; 5(10):132-136.
23. Sinka ME, Bangs MJ, Manguin S, Coetzee M, Mbogo CM, Hemingway J. The dominant *Anopheles* vectors of human malaria in Africa, Europe and the Middle East: occurrence data, distribution maps and bionomic précis. Parasites & Vectors. 2010, 3-117.
24. Salit AM, Al-Tubiakh SS, El-Fik, SA, Enan OH. Physical and chemical properties of different types of mosquito aquatic breeding places in Kuwait state. Second International Conference on Urban Pests. 1996; (2):185-193.
25. Hasaba HA, Ahmada A, Marghany M, Ziboon A. Landsat TM-8 Data for retrieving salinity in AL-HUWAIZAH marsh, south of IRAQ. Jurnal Teknologi. 2015; 75:201-206.
26. Kenawy MA, El-Said SH. Characterization of Culicinae mosquito habitats in the Nile Delta, Egypt. 14th International Conference for Statistics, Computer Science, Social and Demographic Research. 1989; 1:211-231.
27. Kenawy MA, El-Said, SH. Factors affecting breeding of culicine mosquitoes and their association in the Canal Zone, Egypt. 15th International Conference for Statistics, Computer Science, Social and Demographic Research. 1990; 1:215-233.
28. Gimning JE, Ombok M, Kamau L, Hawley W. Characteristics of larval anopheline Diptera: Culicidae habitats in Western Kenya. Journal of Medical Entomology. 2001; 38:282-288.
29. Fabio NG, Simona N, Francis G. Turbidity retrieval and monitoring of Danube Delta watersusing multisensory optical remote sensing data: An integrated view from the delta plain lakes to the western–northwestern Black Sea coastal zone. Remote Sensing of Environment. 2013; 132:86-101.
30. Palaniyandi M. A geo-spatial modeling for mapping of filariasis transmission risk in India, using remote sensing and GIS. International Journal of Mosquito Research. 2014; 1(1):20-2.
31. Lopes P, Lourenco P, Sousa C, Novo T, Rodrigues A, Almeida PG *et al.* Modelling patterns of mosquito density based on remote sensing images. Proceedings of the Second International Conference and Exhibition on Geographic Information. Estoril, Portugal. 2005, 251-258.