Journal of Zoological Research
Volume 1, Issue 1, 2017, PP 32-36

Faunistic Study on Species Composition of Mosquitoes and Sand Flies around Mrima Hill a High Radiation Area in Kwale County, Kenya

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ABSTRACT

Mrima hill in Kwale County, along the Kenyan Indian Ocean coast, is known to have high natural background radiation caused mainly by 232Thorium. Despite other parts of the coast having been studied for human disease vectors including mosquitoes and phlebotomine sand flies, no studies have been carried out around Mrima hill to establish the prevalence of these important insects. The aim of this study was to investigate and establish mosquito and sand fly species diversity as well as possible infections. Thirty eight houses were randomly selected and sampled for radiation using Digilert 100 CPMS reader. Light traps were used to trap the insects around houses set at 0600 pm and collected at 0600 am. All females were dissected and examined microscopically for parasites. Mosquitoes and mounted sand flies were identified using standard taxonomic keys. All the numbers were recorded and Data analyzed using SPSS utilizing chi-square and Pearson correlation. A total of 131 mosquitoes and 39 sand flies were caught. Apart from Aedes aegypti (1.9%) which is of medical importance, the other mosquito species caught were Culex pipiens (69.42%), Cx. vansomerenae (1.5%) and Mansonia uniformis (9.6%). Sand flies caught were Sergentomyia bedfordi (74.36%), S. suberecta (15.35%), S. meilloni (5.12%), S. schwetzi (2.56%) and S. inermis (2.56%). None of these are of medical importance. The highest radiation level recorded was 17.5 mlliSieverts/year wheras the lowest was 5.9 mSv/yr, with a mean radiation of 10.52 m Sv/yr. There was no significant relationship between radiation levels number of mosquitoes (x2=103.7, df=99, P=0.353) or sand flies (x2=40.0, df=55, P=0.936). There was also no significant relationship between numbers of mosquitoes and sand flies (x2=36, P=0.165) and also no correlation between radiation levels and elevation (r = -0.389, df=10, P=0.211). It can be concluded from the results that it is unlikely that the insect-borne diseases can occur around Mrima hill, unless the disease causing pathogens are introduced. There is need for further studies to establish the effect of radiation on reproductive capacity and survival of disease vectors in the study area.

Keywords: *Mrima, mosquitoes, sand flies, radiation, 232Thorium;*

INTRODUCTION

The Mrima hill is a small hill rising within a forest located in South coast of Kenya. It is ellipsoidal in plan and has a long axis running NW – SE and is approximately 3km long and 2.1km wide at the widest point. Two small plateaus form the top of hill with elevations of 300m and 285m, respectively, and are separated by a narrow col. The col broadens out to form a wide shallow valley to the north east. This part of the coastal region is known as the low plateau and lies to the west of the coastal plain at altitudes ranging between about 30m to 135m above sea level. Though most of this region is low lying and very gently rising towards the west, the Mrima hill highest point is 300 meters above sea level (msl) [1], and has been reported to have significant deposit of mineral. Considerable mining activities have been undertaken in the area measuring about 390 hectares [2].

The area is known for high background radiation due to the presence of radiogenic heavy metals such as monazites and carbonatites [3]. Apart from the total solar radiation (TSI), the area has high radiation believed to have been caused by elements such as Zinc (Zn), Lead (Pb), Strontium (Sr), Yttrium (Y), Niobium (Nb) and 232 Thorium (Th) [4. Radioactivity studies have shown that the upper and lower parts of

Mrima Hill have an annual radiation of 10,670 mrems (106.7 milliSieverts (mSv) and 1,372 mrems (13.72 milliSieverts (mSv), respectively. These doses are approximately 53 times higher than the natural background dose of 240 mrems (millirems) (2.4 mSv per year) (mSv/yr) what the Commission on International Radiological Protection considers normal [5]. Their presence raises some concern about the effects of radiation on the local population.

Thorium has been identified as the major source of radiation generating 106.7 m Sv/yr in the Mrima area [4]. The high concentration of this radionuclides in the lower parts of the hill has been attributed to the weathering and washing away of carbonatite rocks from the hill [6]. It has been suggested that an epidemiological study needs to be done in the area since ionizing radiation is known to cause health problems [3].

Experimental laboratory studies have shown that radiation has detrimental effects on insects. Radiation has been used to generate sterile tsetse fly populations for control of the *Glossina* species [7]. It was observed the dengue virus mosquito *Aedes aegypti* [8] when exposed to gamma radiation, there is a significant reduction in fecundity, hatchability, adult emergence, sex ratio and longevity [9]. Ionizing radiation has also been shown to induce lethal mutations in insect life cycles [10]. In their natural habitats with high radiation such as Mrima Hill, no report on its effect on insect fauna has been reported. This study aimed at investigating the effects of natural radiation on species composition and diversity of mosquitoes and phlebotomine sand flies on around Mrima Hill.

Material and Methods

Study Area

Mrima hill is located in Msambweni location in Kwale County, a distance of 70 kilometers south of the city of Mombasa in the Coast of Kenya (39^0 16.00’E, 4^0 28.00’ S). People living in this area are mostly peasant farmers practicing both small scale farming and animal keeping. Sampled study sites were areas inhabited by humans around the Mrima hill and homesteads in areas showing radiation levels that were above the normal level of 240 Roentgen equivalent man units (rems). Sources of water in the area of study included boreholes and swamps with radioactivity which was 50 times higher thn the normal natural background radiation as reported by [4].

Sampling procedure

The study adopted the formula by Yates et al.[12] as follows for household calculation:

$$P = 1 - \frac{N-1}{N} \cdot \frac{N-2}{N-1} \ldots \frac{N-n}{N-(n-1)} .$$

$$\text{Cancelling} = 1 - \frac{N-n}{N}$$

$$= \frac{n}{N}$$

$$= \frac{100}{1000} = 10\%$$

Total number of houses in the study area is 384. Taking ten percent of that gave a sample size of 38 houses. A number of houses were selected randomly and the radiation levels taken using a hand held Digilert 100 CPMs reader and recorded. Selection criterion was based on the total numbers of homesteads in the study area. A total of 12 homesteads with 38 houses were randomly sampled in the village.

Insect Trapping

Mosquitoes and sand flies were trapped for five consequent nights during the rainy season in August 2011 using Solid State Army Miniature (SSAM) light traps (John W. Hock Co, Gainesville, Fla, USA). Depending on the numbers of houses in each homestead, a light trap was suspended outside each house to trap the insects entering or leaving houses. The traps were set before sunset at 6.00 pm and retrieved at 6.00 am as described by [13]. The insets were aspirated, washed in sterile normal saline, dissected and the alimentary canals and mouthparts examined microscopically for the presence of parasites. Mosquitoes were then identified using the keys of Gilles and de Meillon [14]. Sand flies were mounted on slides using chloral hydrate mountant, left to clear for 24 hours, and then identified microscopically using Abonnenc and Minter [15] standard taxonomic keys.

Results

The total numbers of mosquitoes collected was 131. Indicating that the area does not have many mosquitoes. *Culex pipiens* Linn was the most abundant at 91 (69.42%), in 9 out of 12 sampling sites, at elevations ranging from 33 meters above sea level (masl) up to 82 within natural radiation ranging from 5.9mSv/yr to 17.5. *Mansonia Africana* Theobald were 24 (18.32%) in three sites of elevations 82, 51 and 44 masl and radiation levels 8.3, 12.2 and 9.9 mSv/yr respectively. *Mansonia uniformis* was the next in abundance 12 insects (9.16%) caught in one site only at 45 masl and a radiation of 7.97 mSv/yr. *Aedes aegypti* Linn and *Culex vansomerenae* Edwards comprised of two insects each (1.5%). The former was collected at a site with elevation 30 masl and radiation 6.48 masl and radiation 6.48 mSv/yr, wheras *Cx. vansomerenae* was cought at a site at elevation 51 masl and radiation 12.2 m Sv/yr.

Like for mosquitoes, very few phlebotomine sand flies were caught in the area. Throughout the entire collection, period, in all sites, a total of 39 sand flies were collected. Only sand flies of the genus *Sergentomyia* Franca and Parrot were caught. *Sergentomyia (Sergentomyia) bedfordi* was the most abundant with 29 insects (74.36%) in three sites with elevations 75, 30, 74 and 82 masl and radiations 10.08, 6.48, 10.9 and 8.3 mSv/yr. Six (6) *Sergentomyia (Parvidens) suberecta* accounting for 15.38% were trapped only in one site at 75 masl and radiation 10.08 mSv/yr. Two *S. (Grassomyia) meilloni* (5.12%) at only one site, 75 masl, radiation 10.08 mSv/yr. *Sergentomyia (Parvidens) inermis* and *S. (Sergentomyia) schwetzi* were the lowest species caught at a single site each at 44 masl, radiation 9.9 mSv/yr and 82 masl and radiation 8.3 mSv/yr respectively, accounting for 2.56% each for the total catch. No sand fly species was found infected with flagellates. No *Phlebotomus* species were caught.

The radiation levels recorded ranged from the lowest 5.9 mSv/yr to the highest 17.5 mSv/yr whereas the elevation levels recorded from the lowest at 30 masl to the highest at 92 masl. Pearson Chi-square test on the numbers of sand flies and mosquitoes collected indicated no significant association between the two variables (the numbers of mosquitoes did not relate to the numbers of sand flies). (x^2=36, df=35, P=0.165). Pearson correlation analysis on radiation (mSv/yr) and numbers of mosquitoes collected per site indicated that there was no significant correlation between the two variables 9r=0.026, df=10, P=0.937). Similarly, the same was observed for sand flies (r=0.031, df=10, P=0.923). Variation between the elevation and radiation levels showed no significant correlation (r=0.389, df=10, P=0.211).

Discussion

The study area is characterized by poor sanitation, lack of toilets and clean water which could explain the high numbers of *Culex pipiens*. reported that this mosquito species is a common pest in urban and suburban areas and indicator of polluted water in the vicinity, where oviposition is done in polluted water [16, 17]. This species has been shown to be a competent vector of West Nile Fever virus (WNV) [18], suggesting that its presence in the area should be of medical concern. *Culex vansomerenae* was found in very low. Like *Culex pipiens* it is able to transmit WNV [19]. *Mansonia africana* was mainly caught in high elevation and moderately high radiation whereas *M. uniformis* was caught at low levels of elevation and radiation even though radiation and and elevation did not significantly affect the availability of mosquito species. These two species have been shown to be active transmitters of Wuchereia bancrofti in Ghana [20] (Ughasi *et al*., 2012), but polymerase chain reaction studies on the same species caught in the study area showed that they are no susceptible to infection with the parasite [21] (Kinyatta *et al*., 2011).

Aedes aegypti was caught in low numbers. Its role as a vector of dengue and yellow fever viruses makes it a species of public health concern considering that an outbreak of the two diseases was reported in the nearby Kilifi County [22] (Johnson *et al*., 1982). The absence of *Anopheles* species can be attributed to the lack of favourable breeding places and clean water. The finding of only *Sergentomyia* species around Mrima is an indication that a leishmaniasis focus cannot be established in the area.These sand flies are a biting nuisance and can cause harara. Harara which is a form of delayed-type hypersensitivity towards sand fly saliva [23] (Dostrovsky, 1935) is still seen in places where sand flies are found, mainly in neonates and non-immunized persons sensitized with saliva[24,25] (Theodor, 1935; Alexander, 1984). According to Theodor [24] (1935), following the bite, itching begins and is sufficient to cause insomnia. Painful impegnitised crusted lesions develop from scratching and sometimes eruptions resembling popular urticarial and clear or haemorrhagic vesicles develop. The areas chiefly affected are the dorsa of the hands, volar aspects of of the wrist, dorsal surface of the fore arms and upper arms, feet and the face [26] (Alexander, 1984).

This could be happening in neonates in Mrima area.

Species of *Sergentomyia* are known to feed on birds and reptiles, but some feed on mammals. They are the vectors of *Sauroleishmania* spp [27,28] (Lewis, 1987; Parvizi and Amirkhani, 2008). Wild-caught *Sergentomyia* spp. have been shown to harbor Phlebovirus (Family Bunyaviridae), Vesculovirus (Family Rhabdoviridae) and Orbivirus (Family Reoviridae)[29,30] (Depaquit *et al.*, 2000; Alkan *et al.*, 2013). *Sergentomyia schwetzi* is a common human biter in East Africa [31] (Lawyer *et al.*, 1990). The possibility of phlebovirus transmission in the area should be investigated. The effects of high radiation on both mosquitoes and phlebotomine sand flies was not be established.

ACKNOWLEDGEMENTS

The authors would like to thank the Mrima area community chairman Mr. Omar Bakari for offering introduction to the community and Kevin Kamanyi for technical support.

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