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Guidelines to site selection for population surveillance and mosquito control trials: A case study from Mauritius

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ABSTRACT

Many novel approaches to controlling mosquito vectors through the release of sterile and mass reared males are being developed in the face of increasing insecticide resistance and other limitations of current methods. Before full scale release programmes can be undertaken there is a need for surveillance of the target population, and investigation of parameters such as dispersal and longevity of released, as compared to wild males through mark-release-recapture (MRR) and other experiments, before small scale pilot trials can be conducted. The nature of the sites used for this field work is crucial to ensure that a trial can feasibly collect sufficient and relevant information, given the available resources and practical limitations, and having secured the correct regulatory, community and ethical approvals and support. Mauritius is considering the inclusion of the sterile insect technique (SIT), for population reduction of *Aedes albopictus*, as a component of the Ministry of Health and Quality of Life's 'Operational Plan for Prevention and Control of Chikungunya and Dengue'. As part of an investigation into the feasibility of integrating the SIT into the Integrated Vector Management (IVM) scheme in Mauritius a pilot trial is planned. Two potential sites have been selected for this purpose, Pointe des Lascars and Panchvati, villages in the North East of the country, and population surveillance has commenced. This case study will here be used to explore the considerations which go into determining the most appropriate sites for mosquito field research. Although each situation is unique, and an ideal site may not be available, this discussion aims to help researchers to consider and balance the important factors and select field sites that will meet their needs.

1. Introduction

1.1. Background

The control of the Asian tiger mosquito, *Aedes albopictus* (Skuse), vector of dengue, chikungunya and other diseases (Cancrini et al., 1992; Mitchell, 1995; Gratz, 2004) is very difficult using conventional methods such as larval control operations because the species oviposits in water-collecting sites often found in inaccessible places such as private gardens, and vegetated areas (Bellini et al., 2010). Moreover, broad-spectrum adulticides, used on a regular basis in many countries, can have negative environmental side effects (Wilson et al., 2003) and may lead to insecticide resistance in the disease vector (Tantely et al., 2010; Vontas et al., 2012). Several alternative approaches to vector control have been proposed for use against mosquito species, among which is the sterile insect technique (SIT) (Knipling, 1959). *Ae. albopictus* is a good candidate for the application of SIT because of the relative ease of mass rearing the species, and its poor active dispersal potential (Hawley, 1988; Honorio et al., 2003; Niebylski and Craig, 1994; Rai, 1991; Takagi et al., 1995). Other vector control methods are in development against *Ae. albopictus* which would also require the release of male mosquitoes, including RIDL (Labbé et al., 2012; Thomas et al., 2000), the use of *Wolbachia*-induced cytoplasmic incompatibility (Incompatible Insect Technique, IIT) early mortality (Calvitti et al., 2012; Mousson et al., 2012), and the replacement of the wild population with one refractory to disease (Gray and Coates, 2004; Sanchez-Vargas et al., 2004). Any such method is reliant on detailed knowledge of the natural population and testing on a small pilot

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scale in a relevant natural setting prior to full scale implementation.

In 2005/2006, Mauritius experienced a severe outbreak of Chikungunya followed by a smaller outbreak of Dengue in 2009, both attributed to *Ae. albopictus* (Beesoon et al., 2008; Ramchurn et al., 2009; Schuffeneker et al., 2006). Besides being a serious nuisance due to its high anthropophily and painful bite, *Ae. albopictus* is a competent vector of other serious diseases such as yellow fever, filariasis, West Nile and Rift Valley fevers to which Mauritius is extremely vulnerable due to high international traffic and wide distribution of the mosquito vector (Cancrini et al., 1992; Mitchell, 1995; Gopaul, 2003; Beesoon et al., 2008; Schuffeneker et al., 2006; Ramchurn et al., 2008).

With its adherence to the International Stockholm Convention in 2001 (aiming to phase out the use of Persistent Organic Pollutants) and in line with its *Maurice Ile Durable* Philosophy (a national policy geared towards sustainable development), the Government of Mauritius opted for an Integrated Vector Management Strategy during the preparation of the Ministry of Health and Quality of Life document of 2010, 'Operational Plan for Prevention and Control of Chikungunya and Dengue'. On-going SIT projects are in place against the melon fly *Bactrocera cucurbitae* (Coquillett) in Mauritius (Entomology Division, Ministry of Agro-industry, personal communication), and this technique has been proposed for use against *Ae. albopictus* in the country. Subsequently, in 2012, with technical and financial support from the International Atomic Energy Agency (IAEA), Mauritius embarked upon a 4-year Technical Co-operation project (MAR5019) to study the feasibility of controlling *Ae. albopictus* through the SIT.

1.2. General considerations for applying SIT

Population surveillance and dispersal studies, to gain an understanding of the bionomics of the target species in a given area, are important stages in evaluating the feasibility of applying any method of mosquito control involving the release of male mosquitoes. Obtaining baseline data on population density and distribution throughout the year and in response to climatic or other changes are important prior to trial releases, through ovitrapping (Fay and Eliason, 1966; Mogi et al., 1988) and mark-release-recapture (MRR) (Cianci et al., 2013; Service, 1997). Any effect of vector control can be measured against this baseline, which is also useful in predicting and managing disease outbreaks (Lee, 1992; Tham, 1993).

A small scale pilot suppression trial further allows the assessment of the practical and technical challenges associated with initiating and sustaining an extensive suppression programme. The selection of the field site or sites to be used is very important to make sure sufficient and suitable information is gained. The site which is chosen will depend on the study's precise aims and experimental design, scientific and technical issues, affected by the nature of the human and vector population, disease dynamics, geography and ecological structure and stability (McKemey et al., 2008). Community engagement, ethical considerations, and regulatory approval will also need to be considered (Beech et al., 2012). We aim to summarise the current thinking regarding selecting a site for field work involving mosquitoes, illustrating the key considerations with discussion of two sites currently being used for *Ae. albopictus* surveillance with a view to use for an SIT pilot trial in Mauritius. Pointes des Lascars and Panchvati (Fig. 1) were initially selected due to their relative isolation from other villages, and baseline data collection has begun at both sites. The experiences of the field team and some data from these surveillance activities are presented here.

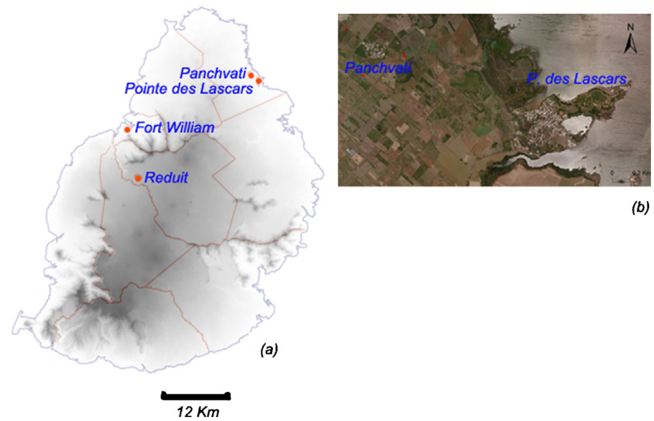

Fig. 1. Two locations proposed as potential SIT pilot sites in Mauritius. (a) Map of Mauritius with location of the selected sites. (b) Pointe des Lascars and Panchvati.

1.3. Eco-geographical setting of Mauritius and the study areas

Mauritius is situated in the Indian Ocean about 890 km to the east of Madagascar. The mainland is 1865 km^2 in area and the land slopes upwards from the shore to a high central plateau reaching an altitude of roughly 600 m above sea level. The prevailing winds are from the South East and by virtue of these physical and meteorological configurations, Mauritius experiences great diversity in climatic conditions. For instance, the coastal climate is hot and the atmosphere is either dry on the leeward (West) side or intensely humid on the windward side of the island, while at higher altitudes, the climate is cooler and an average annual rainfall of 3000–3600 mm is usually recorded on the central plateau (Cader Kalla, 2012). The land use of Mauritius is largely agricultural, with zones of human habitation usually consisting of villages of 5–10,000 inhabitants, mostly aggregated on the higher central plateau, excluding the densely populated coastal district of the capital, Port Louis.

Pointe des Lascars and Panchvati, the two sites selected for this study, are both located in the relatively flat Northern Plains of Mauritius, situated less than 100 m above sea level, extensively cultivated with sugarcane and experiencing a mean summer temperature of >28 °C (>22 °C in winter).

Pointe des Lascars (20°05′01″ S, 57°42′14″ E) is a village of 0.3 km^2 (Fig. 1b), whose 203 concrete-built houses and approximately 800 inhabitants, are divided into 7 'housing blocks' (Fig. 2). A Hindu spiritual park at the village entrance forms a focal point for visitors, and the cemetery located at the north-western part of the locality is important for *Ae. albopictus* oviposition owing to the presence of concrete flower vases and urns that accumulate rainwater during the summer season (Fig. 2). Rainfall averages 1200–1800 mm annually, being heaviest in summer (from November to April). The village was selected for initial population surveillance on the basis of its manageable size and relative isolation.

Located 1.6 km to the northwest of Pointe des Lascars, Panchvati (20°04′60″ S, 57°41′30″ E) is a small village of approximately 0.03 km^2 set within sugarcane fields. Similarly to Pointe Des Lascars, the underlying soil strata appear to be water retentive, although recently constructed drains are currently evacuating much of the accumulated water from previously marshy regions. The village contains 67 houses and approximately 268 inhabitants, divided into 4 'housing blocks' (Fig. 3). The vegetation on the northern and western periphery of the village has been partly cleared to plant vegetables and fruit trees. Climatic conditions are similar to