They include techniques based on mosquito release (SIT, IIT, RIDL, gene drive for elimination) or existing techniques (chemical, biological, physical and environmental control techniques), only RIDL and gene drive techniques using GM mosquitoes.

[3] Population modification techniques refer to techniques aiming at reducing vector competence and/or longevity. They include only techniques based on mosquito release, namely gene drive for population modification, using GM mosquitoes, and *Wolbachia*-mediated spread of PI.

[4] Self-limiting techniques refer to vector control techniques with effects that are limited in space and time unless application of the technique is maintained. They include most existing vector control techniques (e.g., chemical control) as well as the sterile insect technique SIT and the derived techniques RIDL and IIT.

[5] Self-sustaining techniques refer to vector control techniques whose effects spread across space and last over time without calling for any maintenance. They include some existing techniques such as biological control (to an extent), gene drive techniques and *Wolbachia*-mediated spread of PI. More rigorously, there is a continuum of techniques between these two extremes of self-limiting and self-sustaining.

[6] The objective of eradicating a species, which would be a specific feature of gene drive techniques for elimination, is theoretical at this stage.

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A transdisciplinary consideration of sand flies & leishmaniasis

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It has been hundred years since Phlebotomine sand flies were first identified as transmitters of the medically important parasites called *Leishmania*. The key players, investigated by scientists during the first 60 years, were the insect, the parasite, and the mammalian host. Forty years ago, plants were included as potentially influential players in the transmission process. During the past ten years, we have witnessed a further expansion to include bacteria and viruses as influencers of transmission and the realisation that there is a fascinating network of microbes interacting with surprising consequences for the control of the leishmaniases.

This presentation focussed on the recent inclusion of the bacterial players in the sand fly–*Leishmania* drama. It was also a personal reflection on the urgent need for entomologists and other biologists to harness their creative endeavours to engage with policy makers and the public about what insects can teach us and the huge importance of insects and their microbes in a human centred world.

Influence of gut microbiota on Leishmania interactions

I am very fond of the writing of US-based insect pathologist, Ed Steinhaus, who wrote the following apt statement in 1960 "A comprehensive understanding of the biology of insects requires that they be studied in an ecological context with microorganisms as an important component of the system". There is certainly ample opportunity for Phlebotomine sand flies to interact with elements of the microbial world. Adult sand flies are plant feeders; the male only feeds on plants and females require plants as well as blood for egg development. The *Leishmania* parasite develops entirely inside the female gut of the fly and is therefore exposed to the fly gut microbiota. Hence microbes may be acquired during feeding on plants or animals as well as being vertically transmitted via the larvae and pupal stage. During the 1980's and early 1990's, the idea that bacteria may have an important influence on *Leishmania* was often met with some incredulity; experts even stated their belief that the sand fly gut was 'sterile'. The recognition of the importance of bacterial interactions with *Leishmania* and the sand fly vector finally started to gain some attention post 2010 after a few published studies on the sand fly gut microbiota. Our work on the gut microbiota of sand flies was the first to ask the important question: "Does the gut microbiota influence *Leishmania* development in sand flies?" We examined the effect of yeast and bacterial colonisation of the gut on the subsequent development of *Leishmania mexicana* population in the gut of the South American vector *Lutzomyia longipalpis*. We showed that certain species of bacteria and yeast, previously isolated from wild caught sand flies, significantly suppressed the *Leishmania* [1]. This demonstrated the potential for other microbes already present in the sand fly to interfere with *Leishmania* transmission. Kelly et al. [2] questioned whether some gut microbes might be beneficial to *Leishmania* survival in the sand fly. They showed that, although bacterial diversity decreased in their model of *Lu. longipalpis*, there was a dominance of Acetobacteraceae associated with an increase of the *Leishmania* population. If we think of the sand fly gut as an ecological niche, the initial occupation of that niche will therefore determine the potential for *Leishmania* transmission and the potential of the sand flies to act as successful vectors.

There are potential costs for the sand fly to harbour *Leishmania* and we posed the question: "Does *Leishmania* infection of the sand fly gut confer any benefit on the sand fly?" Are there circumstances under which *Leishmania* might protect the sand fly during its occupation of the gut? We found that *Leishmania* infected sand flies were able to survive for longer after being fed with a bacterial insect pathogen compared to control flies [1].

So, we finally understand that the gut microbiota are important players in the activity of the sand flies as hosts of *Leishmania*. A more recent study extended the influence of the fly microbiota to include a role in the development of *Leishmania* in the mammalian host. When the female sand fly acquires a blood meal through a bite, there is a transfer of *Leishmania* gut bacteria into the wound [3]. The co-transfer of bacteria seemed to be significant as the bacterial antigens primed the host immune system by triggering the inflammasome, leading to an increase in *Leishmania* dissemination through the body of the mammalian host [3]. These recent studies served to underline the importance of the microbial ecology of insect vectors and the need to consider the unseen players in predictive models for determining transmission of medically important parasites and pathogens by insects.

In the second part of my presentation I focussed on examples of creative projects featuring my work with microbes and insects. The primary role of the bioscience researcher is to discover more about life around us and to communicate our discoveries firstly to our science peers but also to the public and decision makers. However, I suggest that it is now more important than ever for scientists including entomologists to engage in public debate on issues that affect the health of the planet and all its inhabitants, including insects. There are many ways to engage with the public; clear factual presentations are useful, but the audience may often be selective and narrow. I am interested in engaging with audiences using artistic means, less directly, through emotional engagement, often with playful elements. Engagement may be through unexpected, novel interventions or by modifying a 'known' commonplace activity. My presentation gave three examples of projects developed through my experience of working with insect vectors of disease.

My first example was the production of a children's audio story called *Tropical Tales*, done in collaboration with a group of artists led by Bisakha Sarker, an Indian creative dance performer and choreographer. We developed a folk tale–very loosely based on the story of Jonah and the Whale. In the tale, a young Indian boy dreams that he was swallowed by a sand fly where he fought with *Leishmania* inside a cavernous insect gut. He then woke up and created a cure for his sisters leishmaniasis after dreaming about a plant that kills *Leishmania*. This story was presented as a series of cartoons (Fig. 1) and the user had a 'talking pen'(with which audio can be given in five different languages) activated by touching each picture.

The second example took place in an art gallery in Liverpool. Here we took part in a 'Bed-In'–in celebration of the John Lennon and Yoko Ono peace protest Bed-In. The intervention was called 'Bednets Not Bombs,' which was meant to be a statement about the funding available for research into tropical diseases and insect control in comparison to the vast funding

Fig. 1 Tropical Tales–children's audio story about a child finding a cure for leishmaniasis. Photo Copyright Eimear Kavanagh.

Fig. 2 Bed-In event in Liverpool; Bednets not Bombs, protest about lack of funding for insect vector and bed nets research. Photo Copyright Rod Dillon.

provided for military activity. My partner Viv Dillon and I spent the day in bed covered with a mosquito net (Fig. 2). The installation included a video projected onto the bednet, containing footage of sand flies and mosquitoes together with fighter aircraft, overlayed with sounds of warfare, insects, children, and electrical laboratory equipment.

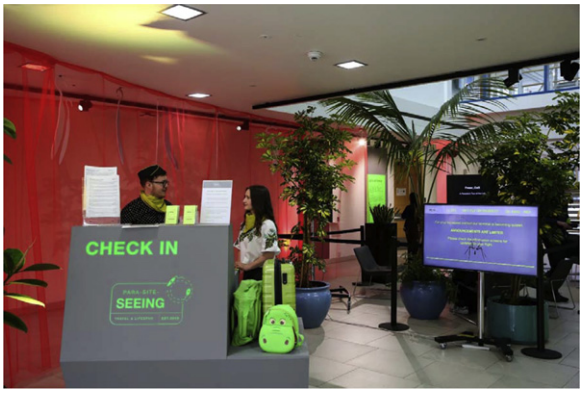

Fig. 3 Parasiteseeing; The Departure Lounge. An art show about travels from the perspective of *Leishmania*. Photo Copyright Erika Stevenson.

The final example was an interactive art show called 'Parasite-seeing; the Departure Lounge'. Artist Jen Southern and myself were commissioned by Dundee University LifeSpace Science Art Research Gallery UK and the Wellcome Centre for Anti-infectives Research. In this show, we exploited the known concept of an airport travel lounge and transformed it into a place where the audience were invited to imagine life from the perspective of a travelling *Leishmania* parasite. The interactive exhibition started with visitors checking in at a check-in desk with a *Leishmania* passport that they were instructed to stamp as they walked through the exhibition (Fig. 3). Final boarding took place in a model area of a sand fly gut, with the final exit being illustrated by a poem about a new anti-leishmanial drug developed at the Wellcome Centre. The exhibition took in many facets of research on *Leishmania*, including historical aspects with many elements of social media following *Leishmania* travels in the wild and in the lab including a twitter feed from @ldBOb72 a *Leishmania* parasite.

Disclosure of interest The authors declare that they have no competing interest.

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The trypanosome journey in the tsetse fly

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Trypanosoma brucei is a flagellated parasite responsible for sleeping sickness in central Africa. It is transmitted from one host to another via the bite of the tsetse fly (*Glossina* genus), which is the major mode of contamination. The tsetse fly (Fig. 1), both male and female, feeds exclusively on blood and exhibits unique features such as viviparous reproduction and lactation. It should be considered as a real host for trypanosomes, since the parasites differentiate and proliferate in several fly tissues such as the gut, the proventriculus, and the salivary glands. Trypanosomes adapt to these various environments by modifications in their cell surface composition, metabolism, and morphogenesis. One of the most prominent characteristics of trypanosomes is the presence of a flagellum that is attached to the cell body and drives parasite movement, but also dictates cell morphology. Its length varies according to the life cycle stage, ranging from 3 to 30 μ m. This organelle is essential for parasite survival. Here, we will discuss the different aspects of trypanosome development in the tsetse fly, with focus on flagellum function.

The disease and the parasite Human African Trypanosomiasis is a disease characterised by two phases, one with rather unspecific symptoms such as bouts of fever, headaches, weakness or lymphadenopathy, and a second one with severe neurological symptoms including disruption of the sleeping pattern, hence the historical name of the disease, sleeping sickness. It is due to a parasitic protist called *Trypanosoma brucei*, with only two subspecies being responsible for human infections: *T. b.*