

Vaccines for vector control: Exciting possibilities for the future

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Arthropod vectors such as mosquitoes, ticks and sand flies transmit diseases that greatly impact human and animal health. Emerging and re-emerging vector-borne diseases (VBDs), some of which affect large populations in tropical and subtropical countries, include malaria, dengue, Yellow fever, louse-borne typhus, plague, leishmaniasis, sleeping sickness, West Nile encephalitis, Lyme disease, Japanese encephalitis, Rift Valley fever, anaplasmosis, babesiosis and Crimean-Congo hemorrhagic fever (Gubler, 1998 and Jones et al., 2008). However, despite the impact of VBDs on human and animal health, few VBDs such as Yellow fever have effective vaccines. The factors affecting the occurrence of VBDs include (a) the abundance of vectors and reservoir hosts, (b) the prevalence of pathogens adapted to vectors and vertebrate hosts, (c) the local environmental conditions, and (d) the behavior and immune status of the human and animal populations at risk. Thus, the control of arthropod vectors is important for the eradication of VBDs (de la Fuente et al., 1998, de la Fuente et al., 2007, de la Fuente et al., 2011 and Merino et al., 2011). The review paper by Luís Parizi and Naftaly Githaka and their colleagues, published in this issue of *The Veterinary Journal*, clearly covers the need and potential to develop universal vaccines for the control of multiple tick species infestations (Parizi et al., 2012). Vaccination is an environmentally friendly alternative for vector control that allows control of several VBDs by targeting their common vector (de la Fuente et al., 1998, de la Fuente et al., 2007, de la Fuente et al., 2011 and Merino et al., 2011). Almost 30 years ago, Elvin and Kemp (1994) proposed that a candidate tick protective antigen should fulfil certain important criteria, namely, (1) host antibodies should be able to gain access to the target protein in sufficient quantities; (2) the formation of the antibody–antigen complex should disrupt the function of the target protein and/or induce physiological changes that affect vector biology, and (3) the antigen should share conserved epitopes among several tick species to protect against multiple vector infestations. These criteria are still valid for the discovery of vector protective antigens, perhaps with the added rider that the vaccine should also reduce vector populations and vector capacity for VBDs. In their review, Parizi et al. (2012) address these criteria for tick protective antigens with special emphasis on the need to produce cross-reactive antibodies in immunized hosts to control multiple tick species infestations – a factor critical for tick control in many regions of the world. The experience with BM86-based vaccines, the only commercial vaccines that have been developed against arthropods, supports the possibility of controlling multiple tick species and suggests that reduction of tick populations has an impact on the prevalence of some tick-borne pathogens (de la Fuente et al., 1998 and de la Fuente et al., 2007). Despite the limitations of BM86-based vaccines for the control of some tick species and the fact that these vaccines do not affect tick vector capacity, the development of tick vaccines based on BM86 orthologs is still a viable and valid option for tick control as part of integrated control strategies aimed at reducing tick populations and the use of chemical acaricides that have resulted in the selection of acaricide-resistant ticks in some regions. However, as Parizi et al. (2012) point out, novel antigens are required to develop the next generation of vaccines for a more effective control of multiple tick species.

Ultimately, these antigens should also allow control of other arthropod vectors and the transmission of vector-borne pathogens. Recent developments using subolesin and akirin, ortholog proteins in ticks and insects that affect the expression of signal transduction and innate immune response genes (Goto et al., 2008, Galindo et al., 2009 and de la Fuente et al., 2011) have provided evidence of the possibilities for controlling multiple vector species (hard and soft ticks, mosquitoes, sand flies, poultry red mites and sea lice) and the infection by tick-borne pathogens (*Anaplasma phagocytophilum*, *A. marginale* and *Babesia bigemina*) using conserved antigens (de la Fuente et al., 2007, Moreno-Cid et al., 2011 and Merino et al., 2011). Experiments with subolesin/akirin also showed that it might be possible to use intracellular antigens to develop vaccines for the control of vector infestations (de la Fuente et al., 2011). The exact mechanisms by which anti-subolesin/akirin antibodies affect vector infestation and fertility are unknown, but may include interference with protein biological function and/or interaction with conserved epitopes in other proteins essential for the parasite (de la Fuente et al., 2011). Systems biology approaches to research on vectors and vector-borne pathogens and on the vector–host–pathogen interface are generating data allowing the identification of key molecules and pathways involved in vector infestations and pathogen infection and transmission. However, this huge amount of information requires novel algorithms to be developed so that these data can be used to advance knowledge on basic biological questions and to develop improved vaccines for the control of vector infestations and VBDs. So, the control of VBDs could be achieved using vaccines containing arthropod vector antigens alone or in combination with pathogen-derived antigens to control both arthropod populations and the infection and transmission of vector-borne pathogens. An important advantage of arthropod vaccines will most likely be the ability to reduce or prevent transmission of several pathogens through immunization of reservoir hosts and human and animal populations at risk. The review by Parizi et al. (2012) convincingly emphasizes the need to produce vaccines to target multiple vector species in vaccinated hosts. These vaccines could be obtained using highly immunogenic antigens conserved across multiple vector species and targeting functionally relevant proteins and pathways for both vector infestations and pathogen infection and transmission. The efficacy of antigen combinations and chimeras containing protective epitopes from different antigens is difficult to predict and require empirical evaluations, but should be considered for the development of next generation vaccines for the control of VBDs. The development of vaccines for vector control is still in its infancy but the results obtained in the last 20 years have demonstrated the possibilities and advantages of this approach to control vector infestations and pathogen infection and encourage support to expand research in this area to contribute to the eradication of VBDs.