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Future challenges for parasitology: Vector control and one health in the Americas

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ABSTRACT

"One Health" is a term that encapsulates and underscores the inherent interrelatedness of the health of people, animals, and the environment. Vector-borne infections are central in one health. Many arthropod vectors readily feed on humans and other animals, serving as an ideal conduit to move pathogens between a wide spectrum of potential hosts. As ecological niches flux, opportunities arise for vectors to interact with novel species, allowing infectious agents to broaden both geographic and host ranges. Habitat change has been linked to the emergence of novel human and veterinary disease agents, and can dramatically facilitate expansion opportunities by allowing existing vector populations to flourish and by supporting the establishment of new pathogen maintenance systems. At the same time, control efforts can be hindered by the development of parasiticide and pesticide resistance, foiling efforts to meet these challenges. Using examples drawn from representative diseases important in one health in the Americas, including rickettsial infections, Lyme borreliosis, Chagas disease, and West Nile virus, this paper reviews key aspects of vector-borne disease maintenance cycles that present challenges for one health in the Americas, including emergence of vector-borne disease agents, the impact of habitat change on vector-borne disease transmission, and the complexities faced in developing effective control programs. Novel strategies will be required to effectively combat these infections in the future if we are to succeed in the goal of fostering an environment which supports healthy animals and healthy people.

1. Introduction

In recent decades, the importance of vector-borne diseases in both human and veterinary medicine worldwide has dramatically expanded. At the same time, greater awareness has been drawn to the interrelatedness of the health of people and animals. Incursion of arthropod vectors to new areas, geographic spread of pathogens, and recognition of novel disease agents have all contributed to the greater importance and awareness of vector-borne infections. A number of vector-borne infections compromise the health of humans and other animals in the Americas (Table 1). Some of these, like Chagas disease caused by *Trypanosoma cruzi*, have been known for more than a century, while others, like the human ehrlichioses, are more recently recognized. Still others, such as West Nile virus, were recently introduced to North America and then dramatically and rapidly expanded throughout both continents, exploiting local bird and mosquito populations to establish a sustainable maintenance cycle. With few exceptions, such as Lyme borreliosis in dogs or West Nile virus and the equine encephalitis viruses in horses, vaccines are not available to prevent these infections. Protecting human and animal health from vector-borne infections requires a continued focus on controlling vector populations, including development of novel, sustainable strategies that will limit transmission of vector-borne disease agents.

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Table 1
Etiologic agent, primary vector, primary vertebrate host, and hosts most affected by vector-borne zoonoses discussed in this review.

Disease	Pathogen	Primary vector (s)	Primary vertebrate host(s)	Host(s) affected
Anaplasmosis	*Anaplasma phagocytophilum*	*Ixodes* spp.	Rodents, other mammals	Dogs, people
Chagas disease	*Trypanosoma cruzi*	*Triatoma* spp.	Rodents, raccoons,	Dogs, people
		Rhodnius spp.	Opossums, dogs	
Ehrlichiosis	*Ehrlichia chaffeensis*	*Amblyomma americanum*	Deer	People
	Ehrlichia ewingii	*Amblyomma americanum*	Dogs, deer	Dogs, people
	Ehrlichia canis	*Rhipicephalus sanguineus*	Dogs	Dogs, people
	Ehrlichia muris-like	*Ixodes* spp.	Undetermined	Dogs, people
Lyme disease	*Borrelia burgdorferi*	*Ixodes* spp.	Rodents	Dogs, people, horses
Rocky Mountain	*Rickettsia rickettsii*	*Dermacentor* spp.	Rodents	Dogs, people
Spotted fever		*Amblyomma* spp.	Rodents	
		Rhipicephalus sanguineus	Dogs	
West Nile virus disease	West Nile virus	Mosquitoes	Birds	Horses, people

Companion animals are susceptible to many of the same vector-borne infections as people, developing severe, often life-threatening disease due to these pathogens (Little, 2010; Nicholson et al., 2010). In addition, dogs are particularly well suited to serve as sentinels for disease agents and critical to consider in any one health focus. Canine Rocky Mountain spotted fever cases may precede human cases in a given locality, alerting public health authorities to the presence of disease in a community (Gordon et al., 1983; Paddock et al., 2002). Dogs are susceptible to other spotted fever group *Rickettsia* spp., and thus may be useful in monitoring for transmission of these agents as well (Tomassone et al., 2010; Grasperge et al., 2012). Serologic testing of dogs has been used to map the distribution of tick-borne disease agents, including Lyme disease, anaplasmosis, and ehrlichiosis, and prevalence of antibodies in dogs has been shown to correspond with reports of human disease (Bowman et al., 2009; Hamer et al., 2010; Beall et al., 2012). Similarly, equine cases of West Nile virus, together with wild bird fatalities, served as a bellwether of human infection as the disease became established across North America from 1999 to 2002 (Kilpatrick, 2011). Effectively combating vector-borne infections requires a comprehensive one health approach that includes early recognition of newly emerged pathogens as human and veterinary disease agents, greater understanding of the effect of environmental changes on transmission risk, and development of control programs that capitalize on our ability to intervene in the cycles which conspire to maintain a risk of infection in nature.

2. Emerging vector-borne pathogens

Vector-borne disease agents are recognized in new areas for a number of reasons, including improved detection methods and greater awareness, which may lead to recognition of previously overlooked organisms or identification of entirely novel pathogens; slow geographic expansion of natural maintenance cycles into new areas; adaptation of pathogens to new vectors; and point source introduction of a pathogen which is then able to establish and flourish in the new location. Recent examples of each of these scenarios can be found in vector-borne disease agents transmitted in the Americas.

2.1. Enhanced detection and awareness

Disease agents occasionally seem to emerge in areas where they have been present but had gone previously unrecognized. *Borrelia miyamotoi* is a tick-borne agent that, although only recently recognized, likely has been present in North America for some time (Krause et al., 2013). *Ehrlichia chaffeensis* and *E. ewingii* are established disease agents in people and dogs throughout the southern United States (Paddock et al., 2001; Paddock and Childs, 2003; Little, 2010; Beall et al., 2012). However, a novel *Ehrlichia muris*-like (EML) agent was only recently described in people in the upper midwestern United States (Pritt et al., 2011). Subsequently identified in dogs, the EML-agent was likely responsible for an unexpected focus of serologic activity to *Ehrlichia* spp. in a canine serology-based survey using samples tested from 2001-2007 (Bowman et al., 2009; Hegarty et al., 2012). Ehrlichiosis is also well-recognized in people and dogs in South America (Unver et al., 2001; Calic et al., 2004; Costa et al., 2007; Vieira et al., 2011). Indeed, human infection with *E. canis*, a canine pathogen largely considered restricted to dogs, was first reported from people in Venezuela (Perez et al., 2006). The predominance of *E. chaffeensis* as a human ehrlichiosis agent in the United States together with serologic cross-reactivity between *Ehrlichia* spp. (Childs and Paddock, 2003; Dawson et al., 2005) may allow human *E. canis* infections to go unrecognized in North America.

Although autochthonous cases of Chagas disease are rarely diagnosed in people in the United States, such infections are not uncommon in dogs, particularly in the south-central states, and natural maintenance cycles of *T. cruzi* have been identified in both wildlife and triatomine bug vectors (Yabsley and Noblet, 2002; Kjos et al., 2008; Maloney et al., 2010; Bern et al., 2011). Indeed, infection with *T. cruzi* in the United States is considered to be under recognized, with as many as 300,000 people estimated to be harbor the parasite (Bern and Montgomery, 2009), most human cases in the United States and Canada are identified in individuals with a travel history to Latin America (Diaz, 2008) and Chagas disease is not reportable in the great majority of states in the US (Sarkar et al., 2010). In Central and South America, where spillover from natural maintenance cycles more readily occurs due to vector infestation of homes, an estimated 10–20 million people are considered infected (Reithinger et al., 2009). Although sustained