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Review Article

ROLE OF NEGLECTED WILDLIFE DISEASE ECOLOGY IN EMERGENCE AND RESURGENCE OF PARASITIC DISEASES

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ABSTRACT
Wild animals can be considered as important source of a number of emerging and re- emerging parasitic diseases, which are posing serious threat to the life of human beings and domestic animals. Changing habitats and environmental conditions have rendered wildlife more prone to diseases due to excessive stress, exposure to new vectors and increased interaction with humans and domestic fauna. Emergence and epizootics of new parasitic diseases have prompted researchers to understand disease ecology, parasite dynamics and important role of humans, domestic animals and wild animals acting as hosts of these diseases. In the past, there was easy contraction of the parasitic disease due to absence of reliable methods and information about the identification of wild animal parasites and inappropriate surveillance tools. But, with the advances in technology, especially molecular techniques, surveillance models and advance monitoring systems are enabling easy diagnosis and study of the flow of the parasites between the hosts, which surely will enhance our knowledge of host specificity, particularly the host targets/ range of the novel parasites introduced in the ecosystem, their vectorial capacity and transmission.

KEY WORDS: Emergence, Monitoring, Parasites, Resurgence, Spill- back, Spill- over, Surveillance, Wildlife.

INTRODUCTION

Wild animals play important role in transmission of parasitic diseases as well as other infectious pathogens to human beings and domestic animals (Bengis *et al* 2004; Polley 2005; Singla *et al* 2008; Rhyan and Spraker 2010; Plowright *et al* 2011; Wood *et al* 2012; Kooriyama *et al* 2013) and it has also been quoted by certain researchers that most of the diseases emerge from wildlife (Jones *et al* 2008). In fact transmission of parasitic diseases from wild animals to human beings and domestic animals and vice versa leads to re-distribution and emergence of diseases in new domains (Hardy 2003; Holmes 1996).The emergence of new diseases in wild animals can be classified into different groups based upon following criteria: (i) diseases contracted by the wild animals from the domestic animals living in periphery (ii) disease transmission due to human interventions in wild areas, leading to the translocation of wild animals, and (iii) emergence of new diseases without any involvement or intervention of humans or domestic animals into wild habitat. All these facts lead to following outcomes: firstly, wild animals possess or contract parasitic diseases which pose serious threat to humans and domestic animals; secondly, emerging wild animals parasitic diseases cause remarkable threat to global biodiversity (Daszak *et al* 2000). The major shortcoming resides in the fact that very little is known about the presence of a particular species in wild animal and how efficient is it in infecting and establishing in domestic animals and human beings (MacPhee and Greenwood 2013).

Drivers of emergence and resurgence of parasitic diseases

In certain disease conditions, human beings and wild animals may prove harmful to wild animal population by transmitting diseases, which act as amplifiers for the same disease conditions and further pose serious threat to domestic animals and human beings residing at the periphery of wild habitat (Kruse *et al* 2004). Various drivers are governing the flow of parasites amongst wildlife, human beings and domestic animals are depicted in table 1 with their potential impacts.

Morgan and Wall (2009) stated that "global climate change predictions suggest that far-ranging effects might occur in population dynamics and distributions of livestock parasites, provoking fears of widespread increases in disease incidence and production loss. Climate change is influencing the host–parasite interactions and disease emergence. Understanding the influence of climate change on parasitic diseases can be challenging because of numerous complicating biological and socio-economic factors. There is changing trend in the incidence of parasitic diseases with the change in the environmental factors including vector prevalence, temperature, climate, changing habits, urbanization etc. Government of India has also taken initiatives for studying the vulnerability assessment and adaptation measures to address the threat of climate change in the field of vector-borne diseases (Dhiman *et al* 2008). Various other factors responsible for emergence of the parasitic diseases are enlisted by Thompson (2013) involve poor

housing, socioeconomic factors, lack of surveillance, climate change, hunting, vaccination of wild animals for disease control, therapeutic intervention in wild hosts, lack of control of domestic hosts and landscape changes.

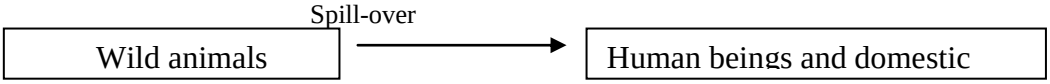
Table 1: Drivers governing the flow of parasites amongst wildlife, human beings and domestic animals

Drivers	Impact of the driver	Parasite example	Reference
Human invasion in wild habitat	Exposure to parasites of wild animal's	*Toxoplasma, Echinococcus, Trichinella* species	Daszak *et al* 2001
Urbanisation and sub-urbanisation	Exposure/introduction to novel parasites	*Plasmodium, Leishmania* sp.	Patz *et al* 2004
Translocation of wild animals	Introduction of parasites to newer areas	*Baylisascaris procyonis*	Eberhard *et al* 2003
Immigration and emigration	Exposure/introduction to novel parasites	*Sarcocystis, Trichinella* sp.	Thompson 2013
Introduction of newer agricultural practices	Maintenance of wild animals parasites in the pastures	*Echinococcus multilocularis*	Thompson 2013
Distribution and redistribution of vector population in naive areas	Distribution and redistribution of parasites	*Leishmania; Trypanosoma; Echinococcus multilocularis*	Thomson *et al* 2009
Biological mechanisms and changed husbandry practices	Expansion and transmission into currently non-endemic areas	*Schistosoma Spp.*	Zhou *et al* 2008
Climate change	Emergence of diseases in newer area	Vector borne haemoprotoza	Dobson *et al* 2003; Dhiman *et al* 2008

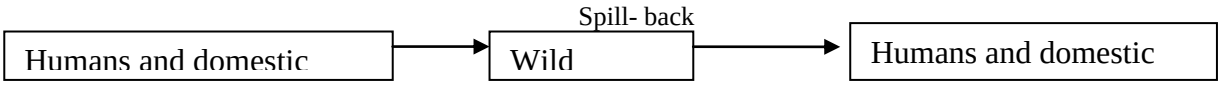
Due to industrialisation, urbanisation and sub- urbanisation and implementation of newer agricultural practices, human beings have targeted the wild animal habitats, leading to their translocation to newer areas. Thus, introduction to new environment, climatic conditions and exposure to different vector population have rendered wildlife more prone to diseases due to excessive stress (Lederberg and Morgan 2003) and these diseases are further introduced to domestic animals and human being and vice versa (Patz *et al* 2004). Various other factors which govern the transmission of parasites or parasitic diseases in a population are the health status and previous exposure of the parasite to the population. These factors emphasize on the ability to resist the disease and the level of the protective immunity generated by the hosts (Polley 2005).

Spill-over and Spill-back parasitic infections

In order to understand the disease ecology, it is very important to understand the direction of the flow of the parasitic infection. When the infection is present in the wild animal hosts and it is being transmitted to the human beings and domestic animals due to their intrusion in wild habitats, it is called as spill over (Thompson *et al* 2009) infection *e.g.* angiostrongylosis (Lindo *et al* 2002).



But, sometimes wild animals act as amplifiers for the parasitic infections contracted from the domestic animals and human beings and these infections are further transmitted back to the human beings and domestic animals residing at their periphery, which are called as spill back infections *e.g.* echinococcosis (Storandt *et al* 2002).



The exciting fact about the diseases associated with the wild animals as definitive or reservoir host exhibit very little clinical signs as the disease run as overt condition (Thompson 2013).

Disease ecology of parasitic diseases

The flow of the parasites among the hosts and the relationship between hosts, parasites and vectors *i.e.* all the components of the parasitic web is complex. Thus, the study of all the possible contributors of a disease condition in an ecosystem is called as disease ecology (LoGiudice 2003; Real 1996). Disease ecology of parasitic diseases involves various domains of expertise, mainly tools of surveillance targeting the geographical distribution of the hosts, study of the vectorial distribution and various biotic and abiotic components of the ecosystem, contributing to transmission of the parasitic disease (Patz *et al* 2004; Daszak *et al* 2004). The disease ecology of the parasitic diseases of human beings and domestic animals have been targeted by the researchers for long but the area comprising the study of the

components of the parasitic webs of the diseases of wildlife origin have been neglected due to absence of reliable methods and information about the identification of wild animal parasites and inappropriate surveillance tools. But, with the advances in technology, especially molecular techniques, surveillance models and advance monitoring systems are enabling easy diagnosis and study of the flow of the parasites between the hosts, which surely will enhance our knowledge of host specificity, particularly the host targets/ range of the novel parasites introduced in the ecosystem, their vectorial capacity and transmission (Thomson and Murrell 2005).

Knowledge of the parasitic fauna of wild animals

Due to excessive hurdles in tracing wild animals, leading to excessive scarcity of the information about the distribution of hosts and geographical distribution of their zoonotic parasites have rendered the veterinarians and biologists helpless to adjudge the actual distribution of the parasites in wild fauna (McCallum and Dobson 1995). Changing wildlife host density and population size also makes parasite transmission characterisation difficult (Alexander *et al* 2012). But, development and employment of newer molecular and laboratory techniques have ensured some development in diagnosis, monitoring and surveillance methods *e.g.* development of new coproantigens for the detection *Echinococcus multilocularis* in wild foxes (Pleydell *et al* 2004). New mathematical models can act as important device to study these complex parasitic webs and hence there is a strong need to engage computational focus on spill over dynamics between humans and wild animals (Alexander *et al* 2012).

Surveillance and monitoring of parasitic diseases of wildlife origin

The increasing parasitic diseases in wild animals have rendered negative effect on their growth (Watson, 2013) and also had been held responsible for decreasing population of new wild animal species (Wyatt *et al* 2008; Robinson *et al* 2010; Cameron *et al* 2011; Ewen *et al* 2012; MacPhee and Greenwood 2013). For application and planning appropriate control strategies, it is important to assess accurately the level parasitic infection in wild animals. Thus, appropriate monitoring and surveillance is required (Salman 2003) with the help of prospective or retrospective disease models. These models will play important role in assessing actual geographical distribution of the hosts, vectors and parasites in prevailing favourable and unfavourable conditions (Chitnis *et al* 2013). The models developed for adjudging the intensity of vector borne parasitic diseases in particular geographical areas had been proved beneficial (Roger, 2006). The biotic and abiotic factors of an ecosystem which actually govern the propagation of disease conditions, their transmission through vectors and range of host population available to acquire those parasitic diseases can easily be assessed with these surveillance and monitoring models targeting a particular geographical area (Wei *et al* 2008). Nowadays, a number of these regional or national monitoring/ surveillance systems have been developed for disease study in wildlife (Morner *et al* 2002) *e.g.* Canadian Cooperative Wildlife Health Centre (CCWHC) database (Leighton e*t al* 1997), which is incorporating the disease reports from different laboratories throughout the country and correlating them with the geographical conditions. Another approach involves mapping of published reports of the parasitic diseases of wildlife origin of a particular geographical area and correlate them with geographical distribution of the disease conditions with the actual incidences of that particular area (Trotz-Williams and Trees 2003).

Assessment of emergence and resurgence of parasitic infections

Assessment and prediction of the emergence and re-emergence of parasitic infections depends upon complete analysis of the risk factors involved and severity of the disease. In case of certain re- emerging diseases the severity can be assessed and hence further check points can be applied for its control (Harrus and Baneth 2005). But, it is a known fact that the identification and discovery of the diseases of parasitic origin related to wildlife is very less as compared to bacterial and viral diseases (Cutler *et al* 2010). Thus, actual assessment of the risk factors involved and estimation of the severity of these conditions is tough, because in certain cases a particular zoonotic parasitic disease may involve a huge chunk of the population, whereas in other case it may affect only a few individuals. The knowledge of the previous exposure of the population with a particular disease condition may also prove beneficial in assessment of the level of its intensity and ability to spill- back the infection (Thompson *et al* 2009).

Public awareness about zoonotic parasitic diseases

The prediction, assessment and control strategies for the disease conditions of the parasitic origin will fetch appropriate results only by making people aware about the disease conditions. More importantly the people residing at the periphery of the wild animal habitats should be made aware about the disease conditions they can contract or transmit to wild animals. The public should also be made aware about the facts which lead to the disease exchange between them, wildlife and domestic animals *e.g.* their encroachment into wild animal habitat and application of newer agricultural practices, causing translocation of wild animals and hence they become more vulnerable to various parasitic, bacterial and viral diseases. A concept of spill- over and spill- back infections should be made clear to the

population so that better precautionary measures should be adopted by them. The measures discussed above are more significantly adopted in developed countries, but a lot of work has to be carried out in developing and underdeveloped countries.

Future perspectives

Better surveillance and monitoring tools for prediction and assessment of a number of parasitic diseases of wildlife origin should be generated for risk assessment and to estimate their ill effects to human beings and domestic animals. Other major steps, which may prove beneficial for early assessment and control of the wildlife derived parasitic diseases are: (i) development of newer tools and facilities for public awareness and encouragement about wildlife-derived parasitic diseases, (ii) development of prospective and retrospective models for actual assessment of disease condition, (iii) be ready and ensure complete management for any new emerging or re- emerging disease condition, (iv) concomitant efforts are required from specialists from different streams for better management of disease conditions *e.g.* concomitant efforts of veterinarians, biologist and health officials, (v) development of newer molecular and laboratory techniques for easy assessment of the emerging and re- emerging parasites, and (vi) adoption and development of tools for assessment of change in biotic and abiotic factors, favouring development of new parasitic diseases in naive geographical locations.

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