# Editorial: Disease Ecology: Novel Concepts and Methods to Track and Forecast Disease Emergence, Transmission, Spread, and Endemization

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**Editorial on the Research Topic**

**Disease Ecology: Novel Concepts and Methods to Track and Forecast Disease Emergence, Transmission, Spread, and Endemization**

Disease ecology focuses on host-pathogen systems in the context of their environment and evolution, analyzing how species interactions and abiotic components of the environment affect patterns and processes of infectious diseases (de Garine-Wichatitsky et al., 2021b; **Figure 1**). The discipline has emerged during the past two decades, and is particularly relevant for improving our understanding and management of diseases in complex wildlife-livestock-human interfaces across the globe. The need to collate the latest advances in disease ecology was identified and discussed by the guest-editors in 2019, and this Research Topic was launched with Frontiers in March 2020, just after the SARS-CoV-2 virus had emerged and spread, shaking entire societies and ecosystems and profoundly changing health perceptions and practices around the world. The wildlife origin of the SARS-CoV-2 virus has highlighted the relevance of inter-disciplinary approaches, integrating disease ecology with biomedical and social sciences in order to understand the complex intertwined ecological, genetic, socio-economic and cultural drivers of pathogen emergence from wildlife. In addition, the spread of COVID-19 pandemic, and the diversity and magnitude of its impacts, has dramatically demonstrated that national public health services cannot handle such crisis alone, calling for more integrated intersectoral and cross-scale One Health/Planetary Health collaborations (de Garine-Wichatitsky et al., 2020). In this Research Topic, we have collated nine articles that illustrate the diversity of approaches developed to anticipate and better manage diseases associated with wildlife.

Three papers in this volume focus specifically on diseases in wild host populations, adopting various approaches to identify threats and proactively reduce the risks to wildlife populations, and two papers illustrate the associated risks to human populations. Russel et al. review theoretical and empirical examples of how populations can persist in the face of emerging threats of disease.
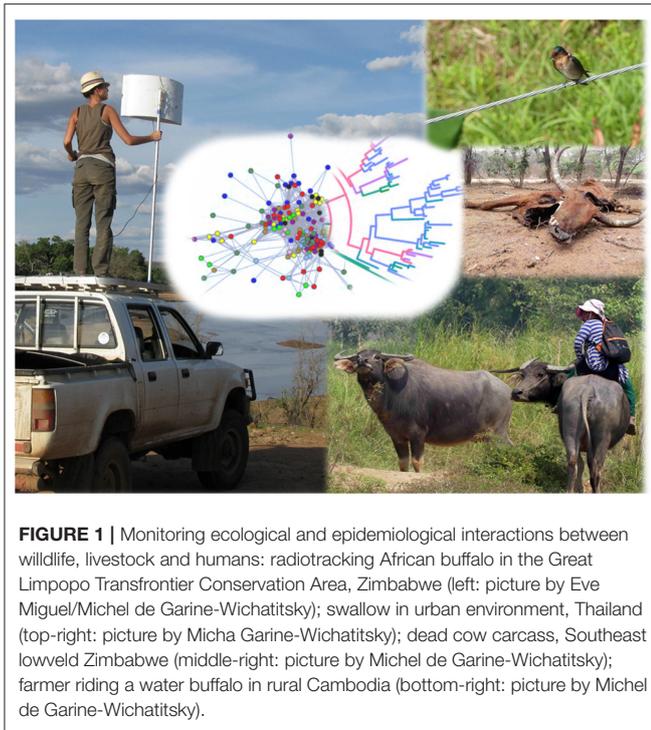
FIGURE 1 | Monitoring ecological and epidemiological interactions between wildlife, livestock and humans: radiotracking African buffalo in the Great Limpopo Transfrontier Conservation Area, Zimbabwe (left: picture by Eve Miguel/Michel de Garine-Wichatitsky); swallow in urban environment, Thailand (top-right: picture by Micha Garine-Wichatitsky); dead cow carcass, Southeast lowveld Zimbabwe (middle-right: picture by Michel de Garine-Wichatitsky); farmer riding a water buffalo in rural Cambodia (bottom-right: picture by Michel de Garine-Wichatitsky).

Excitingly, the authors identify five principles of persistence spanning population, landscape, and species levels of organization. They illustrate each principal with case studies from a variety of taxa and show how demographic, evolutionary and geographic processes can help determine the ability of hosts to persist with disease. Ultimately, the authors provide a useful synthesis that, for example, can guide wildlife health practitioners and land managers alike to manage disease in wildlife populations. Belsare et al. bring out the value of incorporating analytical approaches from other disciplines, which is the heartbeat of disease ecology, to showcase how disease can be managed in a wildlife population. Obanda et al. focus on a zoonotic disease, anthrax, and expose some of the abiotic predictors modulating its endemization, and Choi et al. further show how host life history traits, such as migration, substantially increase infection rates by *Salmonella* in barn swallows, which has major implications for pathogen movement. The opinion paper by Campos and Lourenço-de-Morae unravels the adaptations and evolutions of diverse coronaviruses as they spill across human-animal hosts and the consequences of the emergence of novel infectious diseases.

Molecular approaches have been increasingly used to characterize and quantify multi-host disease transmission at wildlife-livestock-human interfaces, including the interactions with their microbionts. Tremendous technical progresses have been made in recent years in order to collect and analyse efficiently (Martínez-López et al., 2021) large datasets of genetic sequences, offering new insights regarding wild and domestic hosts and parasites interactions. In their paper, Choi et al. explore the effects of potential pathogens (i.e., *Salmonella*) on wildlife microbiomes (i.e., barn swallows *Hirundo*

*rustica*). Utilizing 16S rRNA gene sequencing alongside standard culture techniques, they concluded that bacterial community composition and diversity differed between birds based on *Salmonella* status. This illustrates how the monitoring of pathogens in wild birds and investigating the ecology of host microbe-pathogen relationships may provide useful data for prediction and mitigation of disease spillover into domestic animals and humans. The findings from Omony et al. reveal presence of mutations in the predicted immune-dominant fusion (F) and hemagglutinin-neuraminidase (HN) genes of *Avian Avulavirus serotype-1* (AAvV-1) strains from waterfowl or poultry in Uganda, that may influence immunity in vaccinated and susceptible animals. Specifically focusing on COVID-19, Srivastava et al. highlight a significant association of the alternate allele (allele T on plus strand or allele A on minus strand) of variant rs2285666 with the lower COVID-19 infection as well as lower case-fatality rate among Indian populations. It is believed that the data generated from the study will serve as a basis for understanding the role of Angiotensin-converting enzyme 2 (ACE2) in COVID-19 susceptibility.

The interdisciplinary integration of ecological, bio-medical and social sciences into a single discipline of "disease socio-ecology" remains a major research frontier for improved management of wildlife-livestock-human interfaces (Caron et al., 2021; de Garine-Wichatitsky et al., 2021b). A key element for improving knowledge and innovation regarding health and the adoption of effective management is the use of participatory approaches to frame health issues in contextualized social-ecological systems and co-design interventions with relevant stakeholders (de Garine-Wichatitsky et al., 2021a). Mendes et al. provide an illustration of the interdependencies between epidemiological and economic factors, and the usefulness of an epidemiological-economic model for the management of a livestock disease. In many contexts, successful disease control depends on the voluntary uptake of costly control measures by individual actors in the population. Using a modeling approach, they showed that even if some actors implement appropriate control measures, others may free-ride on these actions and thus compromise the benefits of control strategies that rely on collective behavior. The mismatch between individual costs and collective benefits likely contributes to the continued endemicity of many diseases despite substantial investments in control. Another key challenge for improving future health management is how to improve the connections between research and knowledge production entities, with education and policy and decision makers. In their paper, Comizzoli et al. propose an approach to health interconnecting science, culture and education, derived from a One Health framework associating health for all life. Although the proposed framework is specific to the Smithsonian network, grounded on its conservation and education infrastructures (museums, biological collections/zoos, education and research centers...), the lessons learnt through the application of the interconnected framework should benefit other transdisciplinary health research and education initiatives.

In summary, the papers collated in this topic illustrate the diversity of methods and approaches that are currently implemented and combined to improve our understanding of the ecology of disease emergence at wildlife-livestock-human interfaces. More than ever, with the COVID-19 crisis added to the climate change and biodiversity crises, disease ecology must innovate and grow as a leading discipline aggregating multiple tools and disciplines to forecast, prevent and mitigate the next emergences (de Garine-Wichatitsky et al., 2020, 2021b; Caron et al., 2021).

## AUTHOR CONTRIBUTIONS

MG-W, OL, NF-J, KV, and VO contributed to the initial ideas and edition of the Research Topic. MG-W drafted the first version of the manuscript. All authors contributed to revising it critically and approved the final version.

## REFERENCES

Caron, A., Angel Barasona, J., Miguel, E., Michaux, J., and Garine-Wichatitsky, M. D. (2021). "Characterisation of wildlife-livestock interfaces: the need for interdisciplinary approaches and a dedicated thematic field," in *Diseases at the Wildlife-Livestock Interface* (Cham: Springer), 339–67.

de Garine-Wichatitsky, M., Binot, A., Morand, S., Kock, R., Roger, F., and Wilcox, B. A., et al. (2020). Will the COVID-19 crisis trigger a one health coming-of-age? *Lancet Planetary Health.* 4, e377–e8. doi: 10.1016/S2542-5196(20)30179-0

de Garine-Wichatitsky, M., Binot, A., Ward, J., Caron, A., Perrotton, A., and Ross, H., et al. (2021a). "Health in" and "Health of" Social-Ecological Systems: a practical framework for the management of healthy and resilient agricultural and natural ecosystems. *Front. Public Health.* 8, 616328. doi: 10.3389/fpubh.2020.616328

de Garine-Wichatitsky, M., Miguel, E., Kock, R., Valls-Fox, H., Caron, A. (2021b). "The ecology of pathogens transmission at the wildlife-livestock interface: beyond disease ecology, towards socio-ecological system health," in *Diseases at the Wildlife-Livestock Interface,* eds J. Vicente, K. C. Vercauteren, C. Gortázar (Berlin: Springer), 91–119.

Martínez-López, B., Díaz-Cao, J. M., and Pepin, K. M. (2021). "Quantifying transmission between wild and domestic populations," in *Diseases at the Wildlife—Livestock Interface: Research and Perspectives in a Changing World,* eds J. Vicente, K. C. Vercauteren, C. Gortázar (Cham: Springer International Publishing), 369–409.