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In This Issue

Home is Where the Risk Is

Using a cross-sectional survey investigation, Azar et al. report that prevalence of childhood diarrheal disease in an impoverished Lebanese community is significantly affected by behavior in the home environment. Specifically, they find that diarrheal prevalence in children is inversely proportional to in-home water treatment (such as boiling or filtering), as well as to the bathing habits of the female homemaker. In addition, girls are at much greater risk for diarrhea than boys, possibly due to greater involvement in domestic activities where the frequency of pathogen encounters may be greater. Despite a clear connection between illness, personal hygiene, and/or domestic cleanliness, some women in the community do not recognize the relationship between health and behavior. Thus, future interventions should incorporate gender considerations, as well as education, on household water treatment and hygiene behavior.

Of Pigs and Pathogens

Ferran and Bastos provide the first consolidated summary of African swine fever (ASF) and its transmission cycles between ticks and pig hosts, as well as within and between pig host populations. As the authors point out, the evident complex interactions of multiple hosts, high pathogen diversity, altered habitats, and mixing of wild and domestic populations underscore the need for numerous new research priorities.

It Takes a Village

It is increasingly recognized that wildlife conservation efforts must involve all stakeholders, with priorities that are driven by community input. Brook et al. describe an exemplary implementation of a 6-year community-based program in the Northwest Territories. Specifically, these authors incorporate local ecological knowledge, multi-stakeholder collaborations, citizen participation and training, and science education to achieve unified common goals for monitoring and preserving wildlife health within the rapidly changing socioecological systems of the arctic and subarctic. Their participatory action research demonstrates how interdisciplinary needs can be simultaneously integrated and successfully met.

Encountering Diversity

Clay et al. investigate both the frequency and duration of encounters between mice, along with Sin Nombre virus (SNV) prevalence in mice, at sites in the Great Basin Desert of Utah that exhibit different levels of species diversity. Their manipulative field experiment provides support for the Dilution Effect, in which species diversity decreases pathogen prevalence. Moreover, they find that the mechanism by which mice diversity influences pathogen prevalence is via reduced frequency of encounters between conspecific deer mice (i.e., the primary SNV rodent reservoirs). That is, SNV prevalence declines when the opportunities for pathogen transmission between deer mice hosts are diminished by fewer encounters. The alternative hypothesis, that diversity reduces SNV prevalence via decreases in host encounter duration, is not supported.

Old Pathogen, New Findings

Historically, bacteria of the family Anaplasmataceae have been a frequently observed and geographically widespread

blood-borne parasite of many ectotherms, such as frogs, turtles, and salamanders. However, the parasite's precise taxonomic status and ecology have remained mysteries. Using molecular techniques, Davis et al. report that such bacteria found infecting salamanders from the eastern United States constitute a completely new bacterial genus. Thus, these ubiquitous and morphologically similar parasitic bacteria could harbor higher levels of taxonomic diversity than is currently recognized solely from morphological comparisons. Davis et al. also describe findings that begin to illuminate the ecology of salamander hosts and their bacterial parasites. For example, these investigators find that the bacterial infection favors the largest male salamanders. This association supports the hypothesis that a mite ectoparasite vector, which is found in leaf litter habitats preferentially occupied by the largest male salamanders, transmits the bacteria. What immunological costs these parasites may extract from their salamander hosts remain unknown, with numerous new questions arising from these new findings.

Exotic Interactions

Derraik reports that, following invasion to New Zealand, exotic possums and mosquitoes are now interacting in association with human-induced landscape changes, ecologically affecting each other as well as native species. In particular, fauna surveys by these authors show that smaller forest habitats host communities with increased proportional abundances of exotic mosquitoes and possums, but decreased proportions of native mosquitoes. Indeed, an introduced mosquito species, which is a potential vector of arbovirus relevant to human disease, dominates the smaller forest habitats. Their increased relative abundance may be facilitated by a moderate abundance of possums, which serve as primary mammal blood meals. This research suggests that human health issues, invasive species management, and forest conservation in New Zealand are ecologically intertwined.

No Wonder! Waterborne in Winter Watersheds

In the Greater Toronto Area, the increased frequency of Norovirus infections during winter months is found by Greer et al. to be associated with lower temperatures and higher river flow in the surrounding watershed. These associations with environmental conditions, combined with knowledge of wastewater discharges into local drinking water sources, lead the authors to suggest that a waterborne Norovirus reservoir is maintained during winter. This winter reservoir maintenance could be achieved via increased viral persistence in the watershed at lower temperatures. These data and hypotheses begin to provide a long-sought explanation for the seasonality of Norovirus outbreaks.

A Landscape Level Approach

Incidence of mosquito-borne human diseases is affected by landscape level habitat changes, suggesting the need for landscape level approaches to the study of the disease mechanisms. Junglen et al. demonstrate the use of such an approach, by comparing how mosquitoes and their pathogens vary in abundance and diversity along a 10-km swath of varying habitat in West Africa. They find that the abundances of African mosquito genera differed between habitat types, and certain mosquitoes tend to carry only certain pathogens. Thus, links exist between habitat conditions, mosquito type and abundance, as well as pathogen type and prevalence, from which the authors derive mosquito-borne disease infection rates. The authors find that mosquito genera known to transmit pathogens are most common, or only in, disturbed habitats and villages. In addition, these mosquitoes carry significantly more pathogens. In contrast, pristine forest is dominated by a mosquito genus that harbors relatively few pathogens. Thus, human-disturbed habitats are predicted to produce much higher disease infection rates than primary forest portions of the landscape.

Cyclones and Storms Enhance *Vibrio* Vibrancy

Vibrio bacteria are a causative agent of diarrheal diseases, which can afflict human populations with high morbidity and mortality rates. Deriving from coastal marine and estuary habitats, aquatic *Vibrio* bacteria can become a greater threat especially during flooding and other hydrological disturbances. In an estuary near the city of Chittagong, Bangladesh, Lara et al. investigate how *Vibrio* abundance and distribution are altered by extreme weather

events. After a cyclone, tidal surge resulted in deeper intrusions of seawater into the estuary and resuspension of sediment in the water column. Both of these hydrological changes were associated with significantly increased populations of *Vibrio*. After particularly heavy rainfall, the increase in *Vibrio* was not as great, perhaps due to lower salinities. However, flooding from the storm resulted in greater sewage outflows, and *Vibrio* abundance was enhanced near sewage inputs into the estuary. These results importantly demonstrate how climatic events can change *Vibrio* populations via changes in local environmental conditions, and thereby drive human diarrheal disease outbreaks.

Toward an Integrated Approach

The need for integrated and systems-level approaches toward human health that combine ecological factors with their associated socioeconomic and cultural contexts is increasingly recognized. Nguyen Viet et al. address this need with the introduction of a conceptual framework for intervention approaches that takes into account the multifactorial nature of human health processes, including human perceptions of risk vulnerability and behavior, as well as the need for sustainability. The authors demonstrate validation and usage of this framework with three case examples from developing countries. This framework is especially useful for identifying and implementing key interventions in an integrated, efficient, cost-effective, sustainable, and equitable way within a given social and cultural context.

A Spotty Disease Outlook

The fungal pathogen *Batrachochytrium dendrobatidis* (Bd) is implicated in declines of amphibians at many locations across the globe, and an investigation by Pearl et al. reveals that it is widespread in the Pacific Northwest as well. These investigators report that Bd has high prevalence in the majority of the remaining populations of the endangered Oregon Spotted Frog. Indeed, their survey finds one of the highest prevalence levels of the Bd pathogen reported to date. Moreover, Bd is most common in juvenile frogs, which then subsequently experience decreased body condition after overwintering. However, the pathogen is infrequently found in larval stages. What exact role this pathogen may play in the decline of Oregon Spotted Frog is unknown, but its extremely high and widespread prevalence may not bode well for the outlook on the incidence of amphibian disease overall.

Global Diseases, Local Impacts

What effects do infectious diseases have on local species communities? Smith et al. investigate this question by reviewing three different cases of wildlife disease emergence, and find disparate outcomes on species diversity. For example, chestnut blight in North America ultimately resulted in increased evenness and richness of tree species, but red-spot disease outbreaks in Pacific sea urchin populations appear to have only minor effects on overall species diversity in coastal marine communities. However, decimation of North American prairie dog populations by sylvatic plague results in species assemblages that are decidedly less diverse. Thus, Smith et al. conclude that the effects of disease are difficult to predict, result in variable outcomes, and represent an inconsistent threat to species diversity at the local scale. Such complexity warrants future emphasis regarding the local impacts of globally relevant diseases.

Where the Wild Things Are

Human-induced changes to African landscapes are reducing habitats suitable for tsetse flies, which are vectors for sleeping sickness disease. As a result, tsetse flies are instead more abundant within protected areas, as Van den Bossche et al. report for the case for the Malawi Nkhotakota Game Reserve and surrounding areas. They sampled tsetse fly populations within, outside, and along edges of the game reserve, and examined correlations between fly abundance, sampling location, and vegetation cover. Their results indicate that flies are significantly more abundant where both tree cover and interior distance from the reserve edge are greatest. Thus, high tsetse fly densities also coincide with interior reserve locations, where wildlife hosts tend to be concentrated. These data suggest that disease prevention programs should focus on reducing human and livestock intrusions into game reserves.

A Fly in the Ointment?

Outbreaks of gastrointestinal disease caused by *Campylobacter* bacteria have long been noted for summertime sea-

sonality in many places of the world, yet prevention and research attention has mostly focused on simple nonseasonal food-borne transmission causes. However, causative processes may ultimately be much more complex, as revealed by the investigation of *Campylobacter* disease incidence conducted by White et al. in the urban United States county of Philadelphia. From more than a decade of data, these investigators report that incidence of this disease is associated with increases in air temperature and humidity, and with lower river temperatures. Such environmental associations suggest that the local watershed acts as a pathogen reservoir, because cooler water temperature is known to enhance survival of these bacteria. The authors further hypothesize that increased temperature and humidity could enhance rates of reproduction in flies, a possible intermediary for bacterial transmission from surface water reservoirs to human food sources. Thus, the seasonal association of *Campylobacter* with environmental conditions may not represent a simple causal pathway, and warrants more sophisticated ecological investigation.

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