



SYMPOSIUM

Introduction to the Symposium: Parasites and Pests in Motion: Biology, Biodiversity and Climate Change

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From the symposium “Parasites and Pests in Motion: Biology, Biodiversity, and Climate Change” presented at the annual meeting of the Society for Comparative and Integrative Biology, January 3–7, 2016 in Portland, Oregon.

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Synopsis Although climate change can cause extreme alterations to ecosystems, only limited research has investigated how altered physical conditions (e.g., warming, extreme temperature events, sea level rise, ocean acidification, and altered precipitation) influence species interactions. In particular, the interplay between host and parasites in such a changing world is in need of study. Our objective in organizing this symposium was to bring together researchers working on a wide variety of natural enemies (parasites, pathogens, and pests), to exchange knowledge on how aspects of global climate change may alter the distribution and ecology of these organisms and their hosts. It is our intention that the symposium and the resulting articles will foster more accurate modeling of and predictions about the impacts of climate change on the biology and ecology of natural enemies and their hosts.

Introduction

Climate change is now recognized as causing major alterations to ecosystems, with recent years (2014–2015) being the hottest on record and with suggestions that this trend is continuing (Tollefson 2016). Temperature-induced environmental changes will likely dramatically alter the global distributions of species in water and on land (O'Neill and Oppenheimer 2004; Marcogliese 2008; Chen et al. 2011; Doney et al. 2012; Storch et al. 2014; Smith et al. 2015). Climate change may extend the range of natural enemies (including parasites, pathogens, predators, and vectors) of some species, thereby exposing hosts, including potentially novel ones, to risk in areas where they had previously been free from natural enemies (Harvell et al. 2002; Brooks and Hoberg 2007; Macnab and Barber 2011; Paull et al. 2012; Pickles et al. 2013). Some of these natural enemies are of special interest to humans, as they can cause significant commercial, ecological, and/or medical impacts. Habitat alterations (via warming or other events such as increased severe weather) also

have the potential to cause significant harm to hosts through increased spread of disease (e.g., Behie et al. 2013). In other cases, climate change may cause parasites to become more restricted in range and their hosts could be released from negative stress, causing cascading effects potentially at the level of ecosystems (e.g., Rohr et al. 2011; Altizer et al. 2013). A third alternative exists, in which natural enemies may not exhibit expansion of their ranges, but rather shift in ranges due to changing areas of habitat suitability (Lafferty 2009a; Ostfeld 2009; Rohr et al. 2011). The role of a warmer climate in the expansion, contraction, or shift of ranges is extremely difficult to assess, and factors other than temperature may play larger roles (Lafferty 2009a; Ostfeld 2009).

Thus, understanding how climate change modifies the distributions of host-parasite relationships has important implications for ecosystems (e.g., Brooks et al. 2014; Burge et al. 2014). The potential magnitude of the ecosystem changes is staggering (e.g., Perry and Randolph 1999; Lafferty 2009a, 2009b;

Bundy et al. 2013; Lafferty et al. 2015) and many will directly affect humans in a range of ways, including: medical (parasites of humans, disease vectors), veterinary (parasites of pets, livestock), and food safety (parasites, pathogens and pests in agriculture, aquaculture, livestock; e.g., Robertson et al. 2013; USGCRP 2016). In addition, the ecological impacts of parasites include their potential influence on hosts that are ecosystem engineers or provide critical ecosystem services (Thomas et al. 1999; Hatcher et al. 2012), as well as playing a vital role in food webs (Kuris et al. 2008).

Although forums and workshops have been conducted to advance the study of climate change impacts on parasites (Lafferty 2009a, 2009b; Brooks et al. 2014), there remains much work to be done, particularly in terms of rigorously testing casual variables. With increasingly numerous reports on range extensions of a wide diversity of parasites and pests, we believed it was important to organize an across-the-board taxonomic and ecological symposium to enable the exchange of knowledge on this critical topic. In fact, at the 2016 SICB meeting ours was not the only symposium focusing on climate change as the symposium “Beyond the Mean: Biological Impacts of Changing Patterns of Temperature Variation” explored how high climate variability could influence organisms, and included some presentations on natural enemies. Two other sessions during the meeting (“Coral Reef Biology and Ocean Acidification” and “Environmental Factors, Host Susceptibility, and Parasite Success”) also focused on aspects of climate change and host-parasite relationships.

The speakers in the SICB symposium represented a wide range of researchers working on parasites and pests in terrestrial, marine, and freshwater ecosystems and who discussed a broad taxonomic range of parasites/hosts. In total, the symposium included 11 presentations. Five of the presenters (Hopper, Krasnov, Kuris, Mordecai, and Shields) reviewed their recent work (e.g., Krasnov et al. 2005; Lafferty and Kuris 2005; Mordecai et al. 2013; Hopper et al. 2014; Groner et al. 2016; Maynard et al. 2016) through the lens of climate change. Hopper, Kuris, and Shields presented work on marine taxa, while Mordecai and Krasnov explored vectors of terrestrial hosts; their talks were as listed below:

Hopper JV. Parasites and hosts in motion: two case studies from California.

Krasnov BR, Khokhlova IS. Climate or hosts? Factors determining flea species composition at a local versus a regional scale in the Palearctic.

Kuris AM. The role of infectious processes in ecosystems as climate changes.

Mordecai EA, Weikel DP, Gudapati P, Johnson LR, Stewart-Ibarra A, Ryan SJ. Climate change and the future of vector-borne disease transmission.

Shields JD. Environmental influences on disease processes in crabs and lobsters.

Six of the presenters (Barber, Burge, Costello, David, Marcogliese, and Okamura) submitted new papers published in this volume. The following is a brief summary of their contributions.

Barber et al. review what is known about how climate change (including mean temperature rise and increase in extreme temperature events) can influence the life cycles of multi-host parasites. They highlight experimentally amenable host-parasite systems (e.g., trematodes) and how they can be used to test hypotheses on the impacts of changing environments on interactions between hosts and their parasites. They predict that altered temperatures may expose hosts to more variable numbers of infective stages of parasites due to changes in timing of release of these stages and potentially also changes in their distribution. In addition, they suggest that multi-host parasites are likely to be more vulnerable to local extinction because they require the local persistence of all hosts. Similar conclusions were noted in the talk by Kuris, who hypothesized that in this new “warmer and wilder world” the negative effects on hosts could depress populations of natural enemies. Such impacts could be compounded by the fact that introduced species may be favored under altered climates and in their non-native range introduced species are often less parasitized, i.e., exhibit parasite release (Torchin et al. 2001, 2003; Blakeslee et al. 2009, 2012, 2013; Hopper et al. 2014).

Burge et al. review how bivalves and other filter feeders affect the transmission of pathogens (e.g., bacteria and viruses) in aquatic systems. The important ecosystem service of disease mitigation provided by these “biofilters” will be influenced by climate changes (ocean warming, acidification). However, Burge et al. indicate that predicting outcomes in this complex system is extremely difficult due to varied impacts on the biology of the pathogens, the filter feeders and ecosystem changes (Nagelkerken and Connell 2015). More research should be focused on this area because a reduction in numbers of filter feeders has important consequences including potentially exposing humans and wildlife to increased risk of infection.

Costello analyzes the diversity of marine, freshwater, and terrestrial ectoparasites and endoparasites based on data from the World Register of Marine Species (WoRMS; Boxshall et al. 2016) and Catalogue of Life (Roskov et al. 2016), focusing on the rate at which new taxa are described. His data suggest that about half of all parasites have been described, as opposed to two-thirds of hosts. Although in some groups of parasites the number of taxonomists is increasing, the rate of new parasite species described relative to the number of authors has been in decline, a pattern also found in free living taxa (Joppa et al. 2011). This decline can be attributed to many factors, including higher-quality descriptions which are more elaborate and require more time to complete (Sangster and Luksenburg 2015). This is especially true for parasites where multiple life stages may have to be described, and data on host species collected. Thus, the “taxonomic impediment” remains (e.g., Bacher 2012; Paknia et al. 2015) and is troubling: to predict the effects of climate change, we need better estimates of both biodiversity and host specificity.

David et al. present their work on the dispersal potential of an introduced polychaete pest of bivalves used for aquaculture along the southern African coast. Although genetic data show no geographic patterning between sampled sites, the dispersal model of larval polychaetes indicates that Cape Point acts as a strong biogeographic barrier. They suggest that anthropogenic movement of the polychaetes (via movement of infected mollusks) has led to what they call “cryptic dispersal”. The authors discuss how climate change may alter the thermal barriers of some species, and they highlight the potential synergistic effects of climate change and marine invasions that could lead to local extinction of native species.

Marcogliese reviews work on metazoan parasites in aquatic ecosystems, concluding that we should examine other anthropogenic stressors (e.g., acidification, habitat fragmentation, and eutrophication) that may be as or more important than temperature in influencing the distributions of hosts and parasites. As he explains, these stressors may be linked to climate change or a result of warming climate. He discusses the use of trematodes as a model system in studying how climate change can influence host-parasite relationships but warns that the studies focusing on single species or stage of parasite can lead to erroneous predictions. As others have concluded, he notes that climate change impacts are difficult to pin down because of co-varying factors, confounding variables, and the nonlinear nature of some effects due to species interactions.

Okamura provides a review of covert infections (non-horizontally transmitted, asymptomatic infections that may lay “hidden” in hosts but ultimately lead to overt infection and disease) and the influence of environmental change on infection dynamics. Since they are easily overlooked, the natural enemies that cause these covert infections are often poorly studied. Using the examples of myxozoans and viruses, Okamura shows that covert infections are known from a wide range of invertebrate hosts and stresses that seemingly “novel” diseases caused by “exotic parasites” should be carefully assessed since they may be caused by overlooked covert species. She further indicates that climate change could alter how readily infections transition from covert to overt.

Conclusions

The symposium has highlighted what we do not know and has provided a strong impetus for testing hypotheses on key factors that host-parasite relationships and distributions. Alterations in geographic ranges of natural enemies have important ecological and applied implications and a proactive stance to monitoring and responding to parasites under changing environmental conditions (Brooks et al. 2014) will require exchange of ideas between a wide range of workers including environmental scientists, disease researchers, ecologists, invertebrate biologists, vertebrate biologists, evolutionary biologists, as well as agricultural and aquacultural scientists, food security experts and public health experts. In the face of public and political “controversy” surrounding the science of climate change, it is easy for the importance of understanding natural enemies in ecosystems to be drowned out by the static. We hope this symposium has helped to inspire interdisciplinary collaborations and can lead to more informed discussions in both the scientific and public realms.

Acknowledgments

We thank the speakers for their help in making this a successful symposium. We thank Dowling College and Hofstra University for financial and logistical support. In addition, the Hofstra University STEM Collaboratorium Initiative (HUSCI) and the National Center for Suburban Studies (NCSS) made possible the “companion symposium” (Parasites and Pathogens: Ecological and Medical Impacts of Global Climate Change, October 16, 2015) that served as an outreach component of the National Science Foundation grant for the SICB symposium.

Funding

This work was funded by the National Science Foundation (DEB-1543887). We thank the Crustacean Society and the Society of Integrative and Comparative Biology (including the Divisions of Ecoimmunology and Disease Ecology, Ecology and Evolution, and Invertebrate Zoology) for their generous support.

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