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LETTERS AND COMMENTS

Further advancing the expert bioblitz for the rainforest conservation toolkit

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Here, we reiterate the importance of the expert bioblitz to advance conservation, as championed in the excellent article by Parker et al. (2018). We contribute three additional ideas to their advances, using our own case study of a recent bioblitz in Malaysia: (a) prioritize inclusivity of diverse participants and stakeholders; (b) execute whole-forest surveys including canopy access teams and surveying all taxa; and (c) direct the bioblitz toward a specific conservation outcome, in our case a UNESCO biosphere nomination. With the significant degradation of tropical rainforests, we urge colleagues to advocate for expert bioblitzes that specifically lead to long-term conservation of important biodiversity sites and/or critical sites with easy access to large human populations.

KEYWORDS

biodiversity, citizen science, Malaysia, Penang Hill

Ever since Charles Darwin returned from his expedition on the *Beagle* and exclaimed about the species diversity of South American rainforests, biodiversity has become synonymous with ecosystem health and resilience (Wilson, 1992, reviewed in Primack, 2010). But the toolkit for biodiversity has not advanced as significantly over the past century as compared with other scientific disciplines such as genetics, physics, agriculture, or astronomy. Conservation International (CI) created one of the first comprehensive series of biodiversity surveys called the Rapid Assessment Program (RAP) throughout the late-20th century that essentially explored many remote parts of the planet, with outcomes of biodiversity surveys dependent upon the expertise represented within the team. The Radeau des Cimes expeditions, led by Francis Hallé of the Institut de Botanique, France, ramped up the RAP biodiversity survey protocols by including a whole-forest approach from uppermost canopy to forest floor, using a canopy access dirigible and inflatable raft system (Hallé, 1991, 1996, 1999). Their results, however, were often biased by the taxonomists selected for the expeditions, and not surprisingly, were predominantly participants coming from developed countries rather than from local institutions. Most field-based rapid biodiversity

assessments often focus on larger areas and often take many weeks or months to complete (reviewed in Parker et al., 2018).

The advent of citizen science has more recently expanded the scope and breadth of biodiversity surveys, using the concept of a bioblitz with public participation to conduct a rapid assessment of a smaller given area (often with a conservation goal, for example, assigning a protection status to that area) over a relatively short period of time (reviewed in Cooper, 2016 and Parker et al., 2018). Bioblitzes have developed to become effective management tools for species and sites that can contribute to local conservation efforts (Ballard et al., 2017). In addition, mobile phone apps such as iNaturalist (<https://www.inaturalist.org>) have allowed the integration of data from bioblitzes and subsequent dissemination via social media with the general public and ultimately with the scientific community and conservation practitioners.

Building on these well-known, earlier models of global biodiversity surveys (reviewed in Parker et al., 2018), we executed a comprehensive 10-day expert bioblitz (a term recently coined by Parker et al., 2018 to emphasize on the conservation objective of the bioblitz by including

professional scientists and conservation practitioners) in Penang, Malaysia and further advanced the scientific toolkit for rainforest conservation. Here, we share our “recipe” with the conservation community in order to insure greater success in future endeavors, and improve the effectiveness of biodiversity surveys at a global scale. Our important advances on bioblitzes reported in past literature include: (a) execution of comprehensive whole-forest sampling for diverse taxa from the treetops to the forest soils; (b) inclusion of all taxa, from tardigrades to fungi to plants to macrofauna; (c) strategic expert partnerships of local scientists with international scientists; (d) diversity of participants ranging from local and international students to citizen scientists to expert taxonomists; (e) inclusivity of female scientists and youth; and (f) extensive use of social media to share results in real time and engage both local and global communities. And perhaps most important, the business plan for this survey was both affordable and engaged diverse stakeholders. We hosted 117 researchers including senior scientists and postgraduate student assistants for this global expedition. We acquired funds by engaging a prominent local corporate stakeholder as the major funder of the operation and ensured local ownership by involving the federal and regional government as the “owners” of the results. The government agencies that were crucial to sanction this expedition, namely the Department of Wildlife and National Parks Peninsular Malaysia, the Department of Forestry Peninsular, and the Ministry of Natural Resources and Environment were involved from the start in the planning and execution of the project to ensure the compliance with local laws, such as the Wildlife Conservation Act 2010 and National Forestry Act 1984 and the Biological Resources and Benefit Sharing Bill 2017. The temporal loan of specimens to the foreign institutions for identification of certain taxa was legalized through specific Specimen Transfer Agreements between the local and foreign institutions. It is of utmost importance to emphasize the need to conform to local regulations when it comes to involving foreign scientists and collecting of biological samples in this region.

This model of a bioblitz that partnered science, corporate industry, and government on behalf of biodiversity conservation has led to a longer-term collaboration with expanded funding of Malaysian forest conservation activities and a UNESCO Man and Biosphere nomination of this critical forest site.

Penang Hill is situated on Penang Island (Pulau Pinang, Malaysia) and houses pristine virgin lowland and hill rainforests (Zakaria, Mansor, Nik Fadzly, & Mansor, 2009). George Town, a modern metropolis with a unique cultural history, is situated only a few kilometers away, giving almost 2 million residents access to a pristine tropical forest. The vegetation type is classified as hill dipterocarp forest with submontane oak-laurel, coniferous trees and tree ferns (Gardner, Sidisunthorn, & May, 2011) and Myrtaceae,

Lauraceae, and Fagaceae as most abundant plant families (Zakaria et al., 2009). In 1786, Penang Island became the first British acquisition on the Malay Peninsula and Penang Hill served as a retreat where early colonialists could escape the coastal heat and humidity. This site covers approximately 8,000 ha, and locals have long advocated for its nomination as a UNESCO Man and Biosphere site, given its biological, cultural, and historical significance. A biodiversity survey was planned as a major driver to answer several critical questions: (1) *Is the site diverse enough to qualify for a UNESCO nomination?* and (2) *Does its biodiversity indicate that the forest is relatively pristine and absent from significant human degradation?* We also aimed to create this inclusive and comprehensive bioblitz by advancing different methodologies employed from the past.

First and foremost, our bioblitz spanned from the soils on the forest floor to the uppermost tree canopy, using eight professional tree climbers to facilitate surveys of all taxa at all forest levels. Trees were rigged at intervals throughout the forest and to represent the site's overall arboreal diversity, allowing all scientists to amass collections from vertical transects in the forest engaging our climbers if they did not climb themselves. Second, the survey involved almost all taxa ranging from microbes, algae, tardigrades, arthropods, ferns, and vines to trees and diurnal and nocturnal invertebrates and vertebrates. Of note, this was the first-ever survey of both arachnids and tardigrades in Malaysia. During a 10-day period of field work, unique discoveries were reported: a new ghost scorpion species (Mongabay, 2017) and several other arachnids, new records of several ant species observed for the first time in the treetops, new distributions of several birds and rare ferns, and several new water bear species, and the discovery of ultrasound communication by a cryptic Malaysian mammal (Miard, Lim, Abdullah, Elias, & Ruppert, 2018). Many samples are still being processed and specimens identified in the lab, so we expect to add more new records and/or new species to this list. Third, an enthusiastic collaboration of local-plus-global scientists comprised the underpinning of our field teams, so that nearly each taxon had experts from both Malaysia and around the world. This component of our bioblitz success insured that the rainforest has not only local stewardship for future research opportunities, but also attracted global expertise and importance value. Fourth and an unexpected outcome to all of us, approximately 65% of the 117 participating researchers were women, a first for any rainforest bioblitz expedition to our knowledge. Fifth, we added a youth education component to our bioblitz, by inviting a cadre of high school citizen scientists who volunteered in all aspects of field work. They came from both United States and Malaysia as part of a middle school science education program called Jason Learning and also from Hong Kong funded by World Wildlife Fund. In addition to on-site student volunteers, entire schools “joined” the bioblitz virtually through live

streaming to several continents and YouTube videos. Sixth, new findings were almost immediately uploaded to both local and global audience via the app iNaturalist and social media apps such as Facebook, Instagram, and Twitter using common hashtags (e.g. #PgHillBioBlitz2017), and later published in local news articles of online and print media. Finally, this biodiversity survey was inspired by a unique and important conservation goal—to provide information for the UNESCO Man & Biosphere Reserve nomination of this pristine rainforest site, which serves as the green lung on this rapidly developing island.

The funding component of this bioblitz was also part of its success. We were fortunate that our science leadership forged a trusted relationship with a local corporate entity, whose philanthropy funded all the scientists and students to participate. And as a result of this clout, the regional government joined the planning table, making a powerful triumvirate of science, business, and government driving the success of our bioblitz. This trio of participants not surprisingly became invested in the future conservation success of this forest.

What is the “secret sauce” of a successful bioblitz that can serve to improve the toolkits in other countries to insure successful biodiversity surveys with conservation outcomes? In hindsight, we recognize that the connectivity of local and global scientists was an essential driver of success. Building trust between “outsiders” who bring in their own expertise and the “insiders” who are the long-term stewards of a local conservation region is paramount. This strategic partnership element also inspired media attention and was greatly admired by the government and corporate entities, who may have otherwise overlooked our activities.

We encourage other museum teams, or university science groups, to embark upon similar surveys. Many important global habitats are underserved for scientific expertise (Ethiopia, India, Bhutan, to name but a few); whereas some regions (e.g., Costa Rica, Panama) are comparatively over served, with a larger number of scientists and funds per square kilometer of natural regions. We advocate for more equity in scientific coverage of our planet—using museums as the driver of these opportunities. If every science museum with research collections determined to survey an unexplored ecosystem of the planet, and if all major museums strategized to distribute themselves equitably, we could advance our knowledge of biodiversity by an order of magnitude. It is always tempting in field biology to study the same region as one's advisor, or to apply for a grant in a well-studied habitat since the chances of getting the funds are usually greater. But as a result, we currently have significantly underserved ecosystems on the planet, and all-too-often these places ultimately suffer extinction rates that are arguably higher than elsewhere.

Our expert bioblitz on Penang Hill, with 117 participants and over 50 students, cost US\$100,000. This is—relatively speaking—a rather small amount of funding for a global

initiative, and yet its results are far-reaching. Not only will new publications about new species and new methods be forthcoming, but the expedition jumpstarted a UNESCO Man and Biosphere site nomination. We hope that other museums and biodiversity teams will join forces to increasingly survey the under-served regions of our planet. Not only will our improved formula for a successful bioblitz raise the number of species and knowledge about biodiversity on our planet, but it will also drive sound conservation and stewardship of critical ecosystems.

The research performed during the Penang Hill Bioblitz 2017 fully adhered to local and institutional laws and regulations of Malaysia. Material Transfer Agreements were issued between the respective institutes to loan specimens for identification.

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CONFLICT OF INTEREST

We have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS

The Penang Hill Bioblitz 2017 was jointly organized by the three authors under the initiative of and in collaboration with The Habitat Penang Hill, Penang Hill Corporation and the Penang State Government, and with the support of Universiti Sains Malaysia and California Academy of Sciences. The manuscript was drafted by M.L.; the manuscript was finalized by N.R. and S.A.M.N.; this article was corrected and submitted by N.R.

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