Revitalizing natural history in the 21st century

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Abstract

Ecological knowledge is produced through hypothetico-deductive methods fueled by natural history observations. Nevertheless, the biologist-naturalist is becoming a rare species. The lack of incentive and financial investment to natural history related courses, as taxonomy, field biology, and organismal biology is constantly diminishing the graduation of ecologists with first-hand knowledge about nature. The interdependence between natural history and ecology science demands more student training in natural history while updating college curricula and teaching strategies to increase the number of graduates with significant field experiences.

Viewpoint

Revitalizing natural history in the 21stcentury

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Abstract

Ecological knowledge is produced through hypothetico-deductive methods fueled by natural history observations. Nevertheless, the biologist-naturalist is becoming a rare species. The lack of incentive and financial investment to natural history related courses, as taxonomy, field biology, and organismal biology is constantly diminishing the graduation of ecologists with first-hand knowledge about nature. The interdependence between natural history and ecology science demands more student training in natural history while updating college curricula and teaching strategies to increase the number of graduates with significant field experiences.

The scientific nature of Ecology and Evolution

Ecologists and evolutionary biologists produce scientific knowledge by applying the hypothetico-deductive method, which consists of proposition of hypotheses based on theory, and of test of predictions based on observation of natural phenomena (Mentis 1988). A set of observations have the power to improve, modify,

falsify, and propose new hypotheses and theories that, in turn, require a new set of observations to be tested (Mentis 1988). Therefore, progress in ecology and evolutionary biology strongly depends on fresh observations, which is often basic natural history, even if they are done with novel technologies or inside laboratories. Nonetheless, the scientific value of natural history and its recognition in promoting advances across disciplines has been neglected.

Since the 1960s the number of graduated biologists with first-hand knowledge about nature has been decreasing at a constant rate (Futuyma 1998; Noss 1996; Schmidly 2005; Tewksbury et al. 2014). Moreover, field and organism-oriented biology courses are no longer requirements to obtain degrees and are being removed from curricula (Tewksbury et al. 2014). The broad understanding of taxonomy, field and organismal biology are being replaced by specialized in-door technical knowledge (Drew 2011; Fleischner et al. 2017). Such decrease in graduating "functional" biologist-naturalists goes beyond academic interests. As an example, if professional ecologists do not have sufficient training in field biology and taxonomy (Drew 2011; Fleischner et al. 2017), environmental regulations might be compromised if early-professionals fail to recognize changes in natural systems, hindering also the development of effective conservation and restoration strategies. The intimate connection of natural history and ecology cannot be forgotten or taken for granted. Here, I advocate in favor of the return of a natural history mindset across biology disciplines, while arguing that it needs to be revised taking advantage of new methods and technologies (Tosa et al. 2021). Influential nineteenth century naturalists had the privilege to dedicate their lives to carefully observe nature, collect specimens, and extensively ruminate to understand the natural world. First-hand experiences during formative phases are necessary to generate insightful contributions. Since most biology students graduate lacking hands-on experiences, educational institutions need again to incentivize the practice and teaching of natural history, in order to promote practical experiences in the field while revitalizing it to merge it once again with biology.

Natural history & ecology as alternative stable states

The alternative stable states concept in ecology posits that disruptions of ecological processes can alter the structure of communities and ecosystems, shifting them to a novel alternative state (Beisner et al. 2003). The relationship between natural history and ecology can be understood through extending this concept to the history of the field itself. Each has its own basin of attraction, with their internal feedback regulations promoting their stability as prestigious relevant disciplines at the socio-academic levels. In the case of natural history, discoveries and propositions of innovative hypotheses stimulated debate and curiosity, while influencing new naturalists motivated to understand nature. However, developments on computational and mathematical applications in the twentieth century promoted a desire on early ecologists to propose theories to solidify the field, causing the fuss capable of changing the course of natural history to an alternative stable state as modern ecology.

Ecology started to transform in the mid-twentieth century from a purely descriptive science to a quantitative field. Early ecologists with an above average mathematical affinity, aimed to propose models that represented fundamental aspects of nature in a predictable mathematical fashion. However, the breakthroughs did not come out of nowhere, and influential figures, like G.E. Hutchinson, R.H. McArthur, J. Roughgarden, J. Lubchenco, R. Levins, E.C. Pielou, E.O. Wilson, and others, had strong natural history backgrounds. A genuine, and somewhat passionate, interest for their systems of study allowed them to propose significant hypotheses and theoretical advances. However, ecology was subjected to an educational paradigm shift. The modern era transitioned from organism-oriented to become a question-oriented field (Greene 2005), where researchers first asked and then searched for ideal systems, with no strings attached.

Nonetheless this paradigm shift undermined the natural history state of mind of biology. Natural history-oriented researchers were referred to as old-fashioned and out of touch with the cutting-edge; "naturalist" as an adjective became pejorative, meaning lack of hypothesis-testing (Futuyma 1998). Accordingly, in the last 50 years the number of offered courses in organism biology, taxonomy, and field biology at colleges and universities declined by approximately 50%, and the number of textbook pages dedicated to whole-organism biology by 30% (Tewksbury et al. 2014). However, we should recognize that science and society benefit from a detailed knowledge of organisms in their environment (i.e., natural history). As the COVID-19

pandemic demonstrated, the improvement of human health and prophylaxis depends on understanding the interface between people, organisms, and eco-evolutionary dynamics (Banerjee et al. 2021; Roche et al. 2020). More than 70% of emerging infectious diseases are associated with animals, consequently affecting humans as part of their life cycles (WHO 2015). Therefore, strategies developed to control disease outbreaks rely on knowledge about the distribution, behavior, and physiology of final and intermediate hosts, and of the pathogens themselves, helping to reduce infection, spread, and deaths. And the acquisition of this knowledge is the essence of natural history.

How can biologists embrace natural history once again?

A unique organism can be vastly explored to understand the basis of genetic and biochemical regulations, developmental processes, morphology, physiology, and behavior. Organisms are the starting point to understand dynamics across organizational scales. Current frontiers aim to integrate these processes, but without the guidance of natural history information this will not be possible. Additionally, organisms are usually the "face" of conservation and connection with the general public. Ecological descriptions support public engagement, attract financial support, and help the development of effective conservation plans. Still, natural history continues to be overlooked, affecting the formation of young ecologists and precluding postmodern scientists from recognizing it as a promoter of advances in specialized fields.

The formation of ecologists and evolutionary biologists must consist of a strong theoretical foundation and practical experiences achieved through a balance between active learning inside laboratories and out in the field. The lack of incentive and financial support to natural history related courses, as taxonomy, field biology, and organismal biology, has deep impacts on the formation of new generations of ecologists and on the future of ecology science. To revert this scenario and change the view that naturalists are old-fashioned, it will be necessary to upgrade field teaching practices with technology. The twenty-first century naturalist must take advantage of high-tech devices that become each day more accessible to obtain high-quality data (Tosa et al. 2021). Notebooks and binoculars, inseparable tools of nineteenth century naturalists, should be improved with camera-traps capturing 24/7 HD wildlife footage, nano tracking devices, microcontrollers, high quality acoustic recorders, drones, and eDNA analysis (Tosa et al. 2021). However, to incorporate these methods while changing the prejudiced view of natural history, an educational reform is necessary. The change of the mindset strongly depends on educational institutions to appraise a naturalist approach of professors on research and in class. Furthermore, it is essential that students learn ecology once again from practical experiences while in the field. Field teaching promote integration among students, research partnerships, and, more importantly, it builds the consciousness that ecology science is not only made of models and analytical tools, but also of "live" biological history that can only be documented while observing and collecting data on natural phenomena. Thus, the toolkit of the twenty-first century naturalist has an inherent power to promote the education of ecology to a state where natural history is not only recognized but acknowledged as part of the scientific process. By revitalizing the teaching of taxonomy, organismal biology, and field courses (Agnarsson & Kuntner 2007; Fleischner et al. 2017), students will also be more motivated to learn about nature with hands-on experience.

At the same time attention must be given to current socio-economic inequalities that might become a barrier. It is important to mind that not all institutions and countries will have the same opportunities and possibilities to improve teaching, courses, and curricula. Still, ecology as a unified scientific discipline must thrive from a global endeavor (Nuñez et al. 2021), not only at the research and co-authorship publication levels (Armenteras 2021). To overcome these barriers, more educational partnerships will be required within and between countries, to provide training on the technologies of next-generation natural history, exchange and loan of equipment, and exchange of students as well. Such educational reciprocity will assist to reduce asymmetries in the restricted access of knowledge and technology that science currently faces, while also contributing for a more diverse learning environment, especially on field courses (Zavaleta et al. 2020).

The endless search for order in nature is what connects the ecologists and evolutionary biologists of today with naturalists of the nineteenth century. The vitality of natural history depends, more than ever, on us, biologists, to recognize ourselves first as naturalists to then promote its appreciation by future generations.

Allying new technologies, global partnerships, and inclusive teaching in an out-door class environment can help to revitalize natural history and merge it once again with biology. The toolkit of the twenty-first century naturalist has the power to inspire enthusiasm and creativity in new generations. This educational change will be a critical step to increase the numbers of graduated biologists with hands-on knowledge about nature by the end of the century, while contributing to ecological theory and many aspects of society, such as health, food security, conservation, and restoration of degraded habitats.

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