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Special Issue: Tribute To W.G. Eberhard & M.J. West-Eberhard

The importance of detailed observations of behaviour and natural history for generating and answering novel questions

This Special Issue, and the symposium at the 2022 Animal Behavior Society meeting in Costa Rica that inspired it, have twin purposes. We seek to explain and showcase the importance of attention to detail in observations of behaviour and natural history as a means to promote discovery in modern-day science. In doing so, we want to honour William G. Eberhard and Mary Jane West-Eberhard; to recognize their dedication to mentoring and supporting scientists, particularly in Latin America; and their lifelong research contributions to evolution, behaviour and tropical natural history. The world is a better place for them, and they deserve to hear that.

The research approach we wish to promote is one that Bill and Mary Jane exemplify and one that they might call the naturalist's approach; they are, in fact, among the greatest naturalists of our era. Concern regarding a decreasing profile for the naturalist's approach is not new (West-Eberhard, 2025), and its virtues have been extolled before. Naturalists view organisms as original causes of wonder and curiosity, not 'mere models or vehicles for theory' (Anderson, 2017; Futuyma, 1998; Greene, 2005; Janovy, 2004; West-Eberhard, 2001). Naturalists are primarily interested in figuring out what organisms actually do and how they actually live; in designing and interpreting their research they are mindful of their organisms' peculiarities (Alonzo, 2023; Futuyma, 1998; Peretti, 2012; West-Eberhard, 2001). They respect their study organisms as living things, value them aesthetically and develop intuitions about what matters in their lives (West-Eberhard, 2001) (Fig. 1). A referee for this paper noted: 'Naturalists adjust their lives to the organisms they study, not the other way around' (Anonymous, personal communication).

The naturalist's approach offers an unhurried pace of study with ample time for observation and curiosity. This helps protect researchers from the chase after impact and productivity metrics, rather than actual impact and productivity, that compromises decision-making procedures for funding, hiring and assessment (Lawrence, 2007; Steele et al., 2006) and even the pace of scientific progress (Fraser et al., 2018; Park et al., 2023). Counter to the modern perception, the naturalist's approach may be more effective in advancing knowledge, not less.

A remarkable feature of naturalists, one well exemplified in Bill and Mary Jane, is their lack of topical or organismal territoriality. They actually encourage others, especially beginning researchers, to come to their topics and study species, never adopting an attitude of ownership (Fig. 2). Maybe researchers prone to go the naturalist route happen to be especially good people? That certainly is true of Bill and Mary Jane. But there is also a broader factor at play. Natural history is not a scarcity economy. We barely know how many species there are out there for most groups (Hamilton et al., 2010; May, 1988; Mora et al., 2011; Stork, 2018). Of those, we have barely named a small fraction (Mora et al., 2011; Pim et al., 2014). And of any of those quantities, we have barely studied a tiny proportion to see what they do and how they live. What call is there for territoriality, given such rich opportunities?

To be a naturalist does not require avoiding organisms considered 'model systems'. A researcher can well work with model organisms, taking full advantage of the wealth of background information and technical resources that come with them, and yet be curious about biological detail relevant to the organism's life beyond the kinds of questions that the organism is 'usually' used for (West-Eberhard, 2001). Such a researcher knows not to overgeneralize their findings to other organisms and considers whether those findings make sense outside of a laboratory setting (Zuk & Balenger, 2018).

And yet the naturalist's approach is hugely undervalued by current 'mainstream' biology, despite eloquent efforts to change this situation (e.g. Anderson, 2017; Barrows et al., 2016; Futuyma, 1998; Greene, 2005; Janovy & Major, 2009; West-Eberhard, 2001). Explanations offered for this disfavour include 'excessive technophilia', whereby researchers pursue the newest high-tech approaches for their own sake, rather than for their utility in answering questions (Greene, 2005; Zuk & Balenger, 2014). By putting method and industrial-scale amounts of data ahead of concepts and hypotheses, this trend actually risks hindering discovery and innovation (Frégnac, 2017; Janovy & Major, 2009; Rockman, 2012; cf. Travisano & Shaw, 2013; Zuk & Balenger, 2014). But note that correctly applying novel technologies to interesting questions is a powerful avenue for discovery (Alberts, 2004; Frégnac, 2017; West-Eberhard, 2025; Zuk & Balenger, 2014).

Another explanation that has been advanced for the current disfavour of the naturalist's approach is the twilight of classes with natural history, organismal and field content in high schools and universities. Such classes are increasingly rare, and institutions hire fewer and fewer faculty that can teach them (Anderson, 2017; Janovy & Major, 2009; Tewksbury et al., 2014). This is a highly counterproductive move on the part of supposedly tuition- and retention-minded institutions. Where still offered, those classes are hugely popular with undergraduate students. But early-career and senior professionals in environmental, physical, biological and ecological sciences often feel their training lacks the natural history content necessary for their work or teaching (Barrows et al., 2016). This dearth is reflected in the trouble that

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Figure 1. The problem with scientists. Reprinted from xkcd.com under Creative Commons Attribution-NonCommercial 2.5 License.

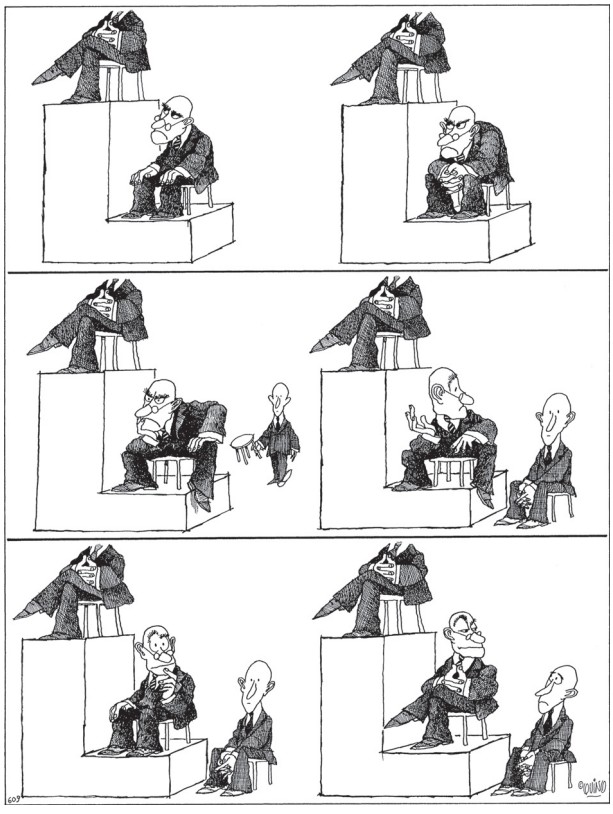

Figure 2. This comic strip by Argentinian cartoonist Quino emphasizes, by contrasting, Bill and Mary Jane's welcoming attitude. Bill had this cartoon posted, among others, on his office door at the University of Costa Rica. Reprinted with permission from Sucesores de Joaquín Salvador Lavado.

environmental agencies face in hiring qualified personnel to conduct surveys and assessments mandated by law (Anderson, 2017).

The lack of natural history content in education represents a further opportunity cost: it fails to leverage our human curiosity and deep psychological need to engage with organisms and the natural world, our biophilia (Wilson, 1984), towards effective teaching and outreach to the public. And it deprives students of much needed inspiration and training in attentive description (Anderson, 2017; Futuyma, 1998; Greene, 2005; Janovy & Major, 2009; Mammola et al., 2017; Tewksbury et al., 2014). Even in a 'regular' class, a naturalist instructor can make a huge difference. Pablo Allen, who obtained his M.S. with Bill Eberhard and was a reviewer for this Special Issue, recalled his experience in Introductory Biology lab with Bill:

> *On top of critical thinking, Eberhard always preached the importance of observation of the real world through simple exercises and activities by younger students. As an undergraduate student I had the good fortune of having Eberhard as a professor in my first year, in the introduction to biology lab. He would have us watch the behavior of a fruit fly, just observe it and write everything we saw. He also had us dissect June bugs and quails, and draw what we saw. As a 17-year old kid I was not sure what was the purpose of these activities at the beginning but soon I understood that the goal was to write or draw exactly what we were seeing and not allow our imagination to make things that were not there. We then had to hypothesize what was the objective of the behavior or the function of the structures we were seeing. The lesson was clear: our hypotheses were only as good as our observations.* **(P. Allen, personal communication)**

We think that the above suggested explanations are symptoms of the lack of favour of the naturalist's approach, however, not the main cause. The main problem is that the naturalist's approach is often (erroneously) viewed as in opposition to rigorous, conceptually important, hypothesis-driven, experimental, mechanism-elucidating research (Anderson, 2017; Futuyma, 1998; West-Eberhard, 2025). And there is a concomitant lack of funding for it (Anderson, 2017; Greene, 2005; Tewksbury et al., 2014). Greene (2005) tells of asking at a debate whether anybody knew 'the program director for natural history at the U.S. National Science Foundation'. The quip still stings.

The notion that the naturalist's approach lacks conceptual and experimental rigour is profoundly mistaken, for many reasons. First, biological hypotheses, whether regarding genetic and developmental mechanisms or ecological and evolutionary processes, are embodied in organisms and in their interrelationships (Deutsch, 2011; Greene, 2005; Mammola et al., 2017). Research questions should thus arise and stand on a foundation of knowledge of organisms in nature (Barrows et al., 2016; Greene, 2005;

Tewksbury et al., 2014; West-Eberhard, 2001). As a referee for this paper noted: 'Observing and understanding the evolution of behaviours and the multiple forms in which organisms express their phenotypes under changing environments is the motor that moves the evolutionary patterns that often confluence in new hypotheses and theories, and that permits a clearer understanding of diverse systems, including human genetic research' (Anonymous, personal communication).

Second, progress in biological knowledge, in terms of expanding the scope of what needs to be explained as well as falsifying dearly held hypotheses, often comes from discoveries of new organisms and how they live and behave (Alonzo, 2023; Anderson, 2017; Burns & Low, 2022; Greene, 2005; Mammola et al., 2017; Sedivy, 2009). A reason for this is that biologists, like all humans, are prone to confirmation bias. Unless we really try to look, we often do not see evidence we do not expect (Greene, 2005). Witness, for an animal behaviour audience, the extent to which we first missed the prevalence of courtship after mating begins. It was reported in 36% of species in the literature, but a researcher with a naturalist's eye uncovered it in over 80% of species examined (Eberhard, 1991, 1994). Or witness the extent to which we have missed how often seemingly antagonistic mating interactions actually involve give-and-takes of stimulation and cooperation between the sexes (Asgari & Seiedy, 2025; Briceño & Eberhard, 2017; Oviedo-Diego et al., 2025; Peretti & Córdoba-Aguilar, 2007; Rodríguez, 2015; Rodríguez & Barbosa, 2014).

More broadly, there is no avoiding bias in research. 'All observation is theory-laden' (Deutsch, 2011; Popper, 1959), starting with the perceptual and psychological adaptations by which we navigate the world (Deutsch, 2011; Harris, 2014; Hawkins & Blakeslee, 2004). But we can counter bias by cultivating an active interest on the details and complexities of what organisms actually do. To 'put oneself in the organism's shoes', as Bill and Mary Jane might say, helps understand the challenges it faces and avoid bias. It creates a beautiful connection between researcher and organism, as such appreciation is often what draws naturalists to their study organism in the first place. This engagement actually provides a boost towards robust hypothesis testing. Tests are more powerful when experiments make sense from the point of view of the natural history of the study organism. The naturalist's approach should therefore be seen as central to experimental design.

Third, consider what some might call the driest (we think romantic), hardest-core view of science: Popper's fallibilism (Deutsch, 2011; Popper, 1959). This view of science emphasizes seeking and correcting errors in our knowledge, not establishing knowledge as secure. But even this philosophy, in fact, *especially* this philosophy, places creativity and inspiration at the heart of scientific progress. Those are the wells from where we draw new explanations and robust ways to test them. In this philosophy, creativity is to mutation as criticism and experiment are to selection (Deutsch, 2011). And what better source of inspiration than behaviour and natural history? Here is a beautiful notion: the creative forces of thought, inspired by nature, brought to bear to help explain the creative forces of nature.

There is also a deeper truth at work: actual ground-breaking research, research that produces results that change minds, open frontiers and create new knowledge, *is impossible to foresee* (Gravem et al., 2017). This may come as a surprise to some researchers (and many funding agencies), but it is necessarily the case. *New knowledge is impossible to foretell before it has been created* (Deutsch, 2011; Flexner, 1939/2017). An observation of an organism doing something it is not supposed to be doing (Alonzo, 2023) is impossible to anticipate. But we can allow curiosity about organisms to give us a leg up and begin to lead us to new ideas. Observations do not provide their own explanation, of course (Deutsch, 2011). But a mind alert to the problems of the day, or era, may find help at arriving at new explanations in novel, even unguided, observation (West-Eberhard, 2025).

CONTENTS OF THIS SPECIAL ISSUE

Throughout their careers, Bill and Mary Jane have argued for, and demonstrated the power and beauty of, the naturalist's approach. This issue presents a collection of observational and experimental studies, along with thoughtful essays by young and senior researchers from diverse backgrounds. Each contribution seeks to explain and showcase in its own way how the authors have been inspired by Bill and Mary Jane in the naturalist's approach, and how they have sought to use it. We are also privileged to have contributions from Bill and Mary Jane themselves.

Asgari and Seiedy (2025) analyse the nature of male–female behavioural and morphological interactions during courtship and copulation in dung flies to test hypotheses about the causes of divergence in sexual traits. Remarkably, attention to detail in this study provides novel evidence of male courtship and selective cooperation by females in study species that have often been proposed as case studies of sexual conflict and forceful interactions.

Barbosa (2024, this issue) examines case studies with soldier flies and bean beetles in which detailed observations of behaviour inspire simple yet powerful experiments that reveal the function of copulatory courtship in cryptic female choice. This paper illustrates how the naturalist's eye, coupled with theory, can immediately open new research avenues and bring insight with new study species. Moreover, it shows how this approach can readily contribute to a deeper, improved understanding even of popular, well-studied species.

Barrantes et al. (2025) showcase how attention to detail in behaviour and natural history, and the readiness to pay such attention in real time, carries great epistemological power. In this case, it led to the discovery of a whole novel predation strategy in spiders that exploits a previously unreachable resource by means of a novel web design. The strength of the study comes from the conceptual weight of the behavioural details that the authors had the acumen to appreciate.

Farji-Brener (2025) contributes an inspiring essay on how to stimulate curiosity and critical thinking in class and afield. Based on detailed observations and carefully taken notes of Bill in action over years of acquaintance, this paper elegantly showcases some of Bill's teachings and techniques in field courses such as those organized by the Organization for Tropical Studies.

Gadagkar (2025) unveils an intrinsic passion for solving mysteries in our natural world, in this case, the secluded and complex social life of a polistine wasp. This paper also demonstrates how an inspiring mentor like Mary Jane can change a student's whole life for the better. Gadagkar also reminds us that discovery is an ongoing process that can be enjoyed over decades (and see also his blog: *More fun than fun*, https://science.thewire.in/tag/more-fun-than-fun/).

Miranda and Orlich-Ramírez (2025) write about the process of moulting in treehoppers. They illustrate how the naturalist's approach can find entirely new avenues for research, even with well-studied groups, and discuss the role of organism-inspired creativity in this process. This contribution also demonstrates how detailed observations of behaviour can even contribute to our understanding of physiological processes that are hidden from view and that whole new research paths may be sitting in our own backyards (literally and figuratively) if we pay attention well.

Oviedo-Diego et al. (2025) analyse a complex suite of male–female behavioural interactions during courtship in a scorpion

with mutual mate choice. They detail a 'dialogue' between the sexes in which males and females adjust their behaviour and selectivity according to their own individual features and those of their potential mating partners. The wealth of observational detail in this study allows a reinterpretation of seemingly aggressive female resistance behaviour as having a communication function instead.

Sequeira et al. (2025) study the mating behaviour of endemic and introduced weevils in the Galápagos Islands and try to explain an intriguing observation of introgression from an endemic species into an introduced species. The results suggest that introgression does not follow overall similarities in mating and courtship behaviours, but rather key particular copulatory courtship details.

Soley (2025) reviews the behavioural and cognitive 'rules' that a frail insect uses to attack its very risky prey, web-building spiders. This paper constitutes a case study of how the naturalist's approach turns cases where animals 'do not do what they are supposed to be doing' into springboards to discovery rather than sources of frustration. It also details how observations of behaviour can help untangle the predictions of competing hypotheses.

Villaseñor-Amador et al. (2025) present a simple but illuminating field experiment inspired by close observation of how wolf spiders move about in their environment. This study reveals the spiders' ability to compensate for bearing the load of eggsacs and how this is influenced by ambient temperature.

Bill's contribution (Eberhard, 2025), on the sexual behaviour of a hover fly, offers a window into the life of a craftsman at his work. It clearly illustrates some of his teachings in using the naturalist's approach: go outside and pay attention to organisms and what they do. Questions will emerge eventually, and many will be possible to answer with further careful observations and clever, inexpensive equipment set-ups. This paper further showcases that patient observation in and of itself, if planned carefully, can provide powerful tests of hypotheses.

Mary Jane's essay (West-Eberhard, 2025) offers a historical perspective in which the study of animal behaviour and natural history were once intimately intertwined but became separated, in part by a push for boundaries between more specialized disciplines. This contribution explains the advantages that the naturalist's approach brings for discovery and conceptual interpretation and discusses some of the difficulties in getting researchers to adopt it; it can be a nerve-wracking proposition for beginners even though it would bring them great benefits. But it also presents an optimistic view of a way forward in which natural history is promoted and the 'mainstream' comes to appreciate the framework it provides for taking advantage of technological advances to understand the lives of organisms in their natural settings.

We hope that this special issue will inspire new and experienced researchers to emphasize the naturalist's approach in their own individual ways. We also dare hope to encourage journals, scientific societies, funding agencies and class instructors to recognize and support its value and contributions.

Author Contributions

Rafael L. Rodríguez: Writing – review & editing, Writing – original draft, Conceptualization. **Fernando G. Soley:** Writing – review & editing, Writing – original draft, Conceptualization.

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