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The roles of natural history during ecological research

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Abstract. It is commonly posited that natural history is an essentially descriptive activity focused on local case studies, lacking an explicit link with theory. Still, some authors suggest that patient observation of natural history must be valued as 'an essential first step in the scientific method'. We think that there is a strong connection between ecology and natural history, and thus delve into such relationship to propose that a) natural history observations are necessary for science problematization (i.e., for the detection of meaningful ecological research problems) and, in some specific contexts, for generating low-level or pattern hypotheses. Notwithstanding, these natural history observations themselves play a secondary role in inspiring explanatory, mechanismic or theoretical hypotheses, and b) a fundamental role of natural history during ecological research is to provide key assumptions (i.e., initial conditions) used to define the experimental design and collect the appropriate data, as well as to deduce hypotheses and predictions. This latter function fruitfully articulates natural history with ecological theory.

[Keywords: assumption, epistemology, explanation, hypothesis, prediction, problematization]

Resumen. Los roles de la historia natural durante la investigación ecológica. Se suele sostener que la historia natural es una actividad esencialmente descriptiva centrada en estudios de caso y que carece de una conexión explícita con la teoría. A pesar de ello, algunos autores sugieren que la observación paciente que aporta la historia natural debe valorarse como 'un primer paso esencial en el método científico'. Aquí planteamos que historia natural y Ecología tienen relaciones estrechas porque a) las observaciones de historia natural son cruciales durante la problematización científica (i.e., contribuyen a detectar problemas de investigación ecológicos sustantivos) y, en ámbitos específicos, ayudan a generar hipótesis de bajo nivel o de patrones, pero esas observaciones solo juegan un rol secundario en la creación de hipótesis explicativas, mecanísmicas o teóricas, y b) la historia natural juega un papel fundamental en la investigación ecológica al aportar los supuestos (i.e., las condiciones iniciales) necesarios para definir el diseño experimental y la toma de datos apropiados, como también para deducir hipótesis y predicciones. Esta última función articula fecundamente la historia natural con la teoría ecológica.

[Palabras clave: supuesto, epistemología, explicación, hipótesis, predicción, problematización]

Introduction

The definition of natural history (NH) in the Oxford Dictionary is "the study of plants and animals; an account of the plant and animal life of a particular place". This definition agrees with the common idea that NH is an essentially descriptive activity focused on local case studies and that it lacks an explicit connection with theory (Peters 1991; Jaksic 1999; Cousens 2023). Anderson (2017) suggested that NH began as a descriptive practice and that it is usually criticized as an old-fashioned form of science. However, according to him "done well, NH could provide a rich and informative encounter with the nonhuman world that may be essential for a successful program in conservation and Earth stewardship … [because] patient observation must be valued as an essential first step in the scientific method". He thus recognized an explicit role for NH in the method of science, although not delving into that role.

Elton (1927) had stated that "ecology is a new name for a very old subject. It simply means scientific NH". His assertion opened a venerable tradition that maintains that ecology is rooted in NH or that NH fuels ecology (Jaksic 1999; Anderson 2017; Cousens 2023; Friedman and Van Natto 2023). The relationship between NH and ecology most frequently invoked in the literature is that initial observations

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of NH give rise to working [ecological] hypotheses that could then be tested, leading to generalization and theoretical advance (Anderson 2017; Friedman and Van Natto 2023). According to those authors, the intertwined histories of the two fields show that most theoretical breakthroughs are preceded by the observational work of NH.

Calling attention to a possible linkage in the opposite direction, Jaksic (1999) noted that sometimes NH information arises as a by-product of rigorous science, aimed at testing hypotheses. The apparent links between ecological research and NH, therefore, require further study, especially because some authors deny any productive relationship between them. For example, Fleischner (2001) affirmed that NH is "a practice of intentional, focused attentiveness and receptivity to the more-than-human world, guided by honesty and accuracy", and Peters (1991) considered NH as "an art, a knowledge for individual consumption, the goal of which is the subjective development of the individual practitioner and, therefore, a knowledge that cannot be shared like the predictive power of a scientific theory". Indeed, Peters (1991) went further by emphasizing the distinction between these two disciplines: "... the historical explanations [typical of NH] have their legitimate purposes, but we gain nothing by confusing these with science or allowing them to supplant predictive power" (see also Cousens 2023).

In this essay we propose that there are strong links between NH and ecological research, although some of them are seldom explicitly considered in the literature. Our first thesis is that NH observation and description is an essential part of detecting and characterizing research problems in ecology, but they are only one source (among several others) for inspiring deep ecological-evolutionary research hypotheses. In other words, although patient observation may be valued as helping problematization, its role in hypothesis generation is to be nuanced. Second, we propose a role for NH during hypothesis testing, given that NH information provides essential assumptions that articulate with theory and fuel the scientific method of predictive ecology. We will show several examples of this from articles that recently appeared in Revista Chilena de Historia Natural and Ecología Austral, and will ponder some possible advantages of adhering to our proposition.

Is natural history a first step in ecological research?

Research problems are knowledge gaps that, in principle, can be addressed in a promising way and which —to be authentic— must arise in the context of some background knowledge rather than in a vacuum (Bunge 1998; Marone 2019). Some examples follow: Why is the ground dove *Columbina picui* observed less frequently in urban settings than in peri-urban areas of some Argentine cities, if it is an urban-tolerant species (Leveau et al. 2017; Camín et al. 2022)? How can the southernmost lizard in the world, *Liolaemus magellanicus*, withstand the low temperature and high humidity typical of its habitat (Jaksic 2022)? Why does *Zonotrichia capensis*, a granivorous bird with a very broad diet of grass and forb seeds, abandon grazed areas undergoing the loss of grass seeds but not of forb seeds (Sagario et al. 2020)? These problems, here stated as questions, arise from the clash of certain specific observation of NH with some background knowledge or 'expectation'. In other words, the observation was not expected according to some plausible hypothesis as it provides potentially contradicting evidence. In the above examples, we expected that the urban tolerant *C. picui* would prevail in the cities rather than in their surroundings, that lizards with a typical metabolism would not reach regions with low temperatures and high humidity, and that *Z. capensis* would not abandon sites with high forb-seed density. Failure to observe these well-founded expectations creates respective scientific problems. Summing up, NH observations are the first steps of the method of science when they are employed to detect research problems, but acting not as isolated observations but rather as observations that challenge some theoretical expectation (Bunge 1998).

What about the relationship of NH with deep ecological hypotheses? A hypothesis is a testable assertion with some degree of generality proposed to answer some scientific question (Bunge 1998). More often than not, such answers are causal explanations (i.e., deep hypotheses). In the above examples it could be that *C. picui* is intolerant of certain perceived threats (e.g., presence of humans) and consequently develops risk-taking or escape behavior in the cities, that *L. magellanicus* has adapted its thermoregulatory capacity to harsh environments, and that *Z. capensis* —despite its broad diet— is not an opportunistic consumer but an expansive-specialist consumer that always prefers grass

over forb seeds. Mechanisms like risk-taking behavior and adaptation, and conditions like being an expansive-specialist consumer cannot be observed directly, and because NH relies heavily on attentive observation, there is little that NH can do for producing explanatory hypotheses in ecology and evolutionary Biology. Ecological explanations require contact with the unobservable objects or mechanisms of the theoretical 'world', objects and processes that are not directly available even to attentive observers (Laudan 1981; Allen 2001; Bunge 2001; Peterson 2020). In short, NH cannot provide explanatory (e.g., causal) hypotheses per se.

Notwithstanding, low-level, pheno_ menological or pattern hypotheses that arise through inductive reasoning have a more clear-cut relationship with NH. Some ecological rules or regularities (e.g., Kleiber's allometry, population-dynamics equations, or macroecological patterns) may be considered as more sophisticated developments from initial correlations born from NH. Then, if patient observation is to have a role in the

Figure 1. The hypothetico-deductive method outlined to test an a priori hypothesis. On the right side, the assumptions regarding data gathering and analyses (e.g., about the sampling design, techniques and materials used in the field or the lab, as well as the statistical analyses used to draw inferences) are emphasized. On the left side of the schematic, the assumptions highlighted are those corresponding to the starting theories used together with the initial conditions necessary to deduce the working hypotheses and predictions to be tested (see Marone 2024). Our thesis is that a fundamental role of natural history during ecological research is to provide critical assumptions to deduce hypotheses and predictions as well as to collect meaningful data (evidence). Examples of its use in ecological research are given in Table 1.

Figura 1. Resumen del método hipotético deductivo empleado para poner a prueba una hipótesis concebida a priori. A la derecha de la prueba, los supuestos vinculados con la obtención y el análisis de datos (e.g., los que subyacen las técnicas y materiales empleados en el campo o el laboratorio y los asociados al análisis estadístico usado para hacer las inferencias). A la izquierda del esquema, las hipótesis y teorías de partida que, junto con algunas condiciones iniciales pertinentes, se emplean para deducir las hipótesis de trabajo y sus predicciones (véase Marone 2024). Proponemos que el conocimiento de historia natural cumple un rol fundamental en la investigación proveyendo supuestos esenciales para deducir las hipótesis y predicciones, y para colectar la evidencia necesaria para ponerlas a prueba. Ejemplos de este uso en la investigación ecológica se entregan en la Tabla 1.

Table 1. Collection of articles from volumes 93-97 (2020-2024) of Revista Chilena de Historia Natural, published by Sociedad de Biología de Chile, and from volume 34 (2024) of Ecología Austral, published by Asociación Argentina de Ecología. We only include papers with explicit or detectable biological hypotheses and/or predictions to facilitate the search of a) some antecedent theories or more general hypotheses and/or patterns —e.g., a correlation— implicitly or explicitly used to deduce the working hypothesis or prediction; b) some assumptions employed —along with the theories, more general hypotheses, or patterns— to deduce the working hypotheses or predictions, and c) some assumptions used to justify the experimental design or the techniques used to collect data —our objective here is to highlight that those assumptions are strongly anchored in natural history knowledge—. Our assessment of each paper includes the detection of examples of (a), (b) or (c), but it does not intend to exhaust all the possible examples present in each article. Texts are usually transcribed literally, in the language they appeared in the journal, although in a few cases paragraphs were shortened seeking simplicity. Our added comments appear in square brackets. The transcribed texts do not include the original bibliographic citations, which can be found in the corresponding open-access papers. Other articles that appeared in the journal but that do not mention hypotheses explicitly could have been included in our analysis, but we did not because our assessments may not faithfully correspond with the original authors' aims. Our selection and classification of the texts do not imply any epistemological or methodological appraisal of the articles. * TANS: theory of adaptation by natural selection.

Tabla 1. Colección de artículos seleccionados de los volúmenes 93-97 (2020-2024) de la Revista Chilena de Historia Natural, publicada por la Sociedad de Biología de Chile, y del volumen 34 (2024) de Ecología Austral, publicada por la Asociación Argentina de Ecología. Solo incluimos artículos con hipótesis o predicciones biológicas explícitas o detectables para facilitar la búsqueda de a) algunas teorías antecedentes o hipótesis o patrones más generales (por ejemplo, una correlación) utilizados implícita o explícitamente para deducir las hipótesis de trabajo o sus predicción; b) algunos supuestos empleados —junto con las teorías, hipótesis más generales o patrones— para deducir las hipótesis de trabajo o sus predicciones, y c) algunos supuestos utilizados para justificar el diseño experimental o las técnicas para recopilar datos —nuestro objetivo aquí es resaltar que esos supuestos están fuertemente anclados en el conocimiento de la historia natural—. Nuestra evaluación de cada artículo incluye la detección de ejemplos de (a), (b) o (c), pero no pretende agotar todos los ejemplos presentes en cada artículo. Los textos suelen transcribirse literalmente, en el idioma en que aparecieron en la revista, aunque en algunos casos se resumió algún párrafo por simplicidad. Nuestros comentarios agregados aparecen entre corchetes. Los textos transcritos no incluyen las citas bibliográficas originales, que se pueden encontrar en los correspondientes artículos de acceso abierto. Otros artículos que aparecieron en las revistas pero que no mencionan explícitamente hipótesis podrían haberse incluido en nuestro análisis, pero no lo hicimos porque nuestro análisis podría no corresponder fielmente a los objetivos originales de los autores. Nuestra selección y clasificación de los textos no implica ninguna valoración epistemológica o metodológica de los artículos. * TANS: teoría de la adaptación por selección natural.

Authors and reference	Working hypothesis or prediction	Antecedent theory, more general hypothesis, or pattern articulated with the working hypothesis	Assumptions used to deduce hypotheses or predictions	Assumptions used to define experimental design or data collection
Zelada-Perrone et al. (2024) RCHN 97:4	"We assessed five new populations of tuco-tucos of Entre Ríos province by characterizing cytochrome-b sequences to test the hypothesis of the presence of one of the two species reported for the region"	[Pattern based on previous data on geographic distribution; biogeographic theory implicit]	"*Ctenomys pearsoni* Lessa and Langguth, 1983, primarily found in Uruguay, has been reported in Entre Ríos referred as *C. torquatus* … *C. rionegrensis* Langguth and Abella, 1970, also was reported for Entre Ríos in its original description, and previously mentioned by Reig et al. as *C. minutus*"	"We took tissue samples preserved in 95% ethanol from *Ctenomys* spp. specimens collected at five locations within Entre Ríos, Argentina" "To estimate the phylogeny of *C. rionegrensis*, we included Genbank sequences…"
Vázquez et al. (2023) RCHN 96:4	[inferable from this text…] "Studies on marine species have accumulated evidence that genetic diversity increases resistance, resilience, and productivity. However, studies regarding benthic marine species are scarce"	[TANS* implicit; hypothesis on the genetic diversity-resilience relationship] "Genetic diversity … affects individual biological fitness … particularly during periods of environmental stress, providing higher resilience capacity…"	"… the term resilience refers to the capacity of a system to resist and to recover from a disturbance" [Implicit: Salmon and mussel farming centers perturb benthic marine populations]	"Studies included are only those in which genetic diversity was the predictor variable, and resilience was the dependent response variable" "Genetic variation among populations may be evaluated based on degrees of relatedness among individuals"
Utsumi et al. (2022) RCHN 95:9	"We test two main hypotheses. First, that [lizard] social structure is independent of habitat type (e.g., cobble fields vs. rock outcrops). We predict that the social structure present in the cobble fields (e.g., social network) will be preserved on the large inland rocks"	[TANS implicit] "Social structure is frequently tied to fitness, as interactions modulate access to resources"	"Social structure describes how individuals in a social unit interact and the relationships that form from repeated interactions (i.e., competitive and cooperative relationships)" "Social structure encompasses affiliative, cooperative, or tolerant social bonds as well as agonistic relationships"	"The distance between the two sites ensured that the lizards at each site represented separate populations"
Vilela et al. (2022) RCHN 95:5	[Inferred from the following text] "The underline assumption is that if we are able to show that protected areas help to alleviate poverty, then decision-makers might feel that supporting protected areas is a wise investment as they conserve nature and positively impact local communities"	[Pattern based on previous data] "Several studies done for countries other than Chile find a correlation between the presence of protected areas and high poverty levels. But these studies failed to demonstrate a causal link between these two variables"	"We employ a differences-in-differences econometric design using Census data from 1982 to 2002. This time frame was defined based on the availability of data"	"Table 1 shows the five household characteristics from the census surveys used to create the poverty index … [we] decided not to use [other] because of the large amount of missing data" "We use the Principal Component Method … This reduces the dimensionality of the data set by combining the variables linearly"
Farfán-Beltrán et al. (2022) RCHN 95:4	"We expected a higher [arthropod] richness, diversity and abundance [and better ecosystem functioning] in conserved sites than in disturbed ones, according to declining arthropod diversity with plant-species loss hypothesis, with the restored sites closer to conserved ones"	[TANS and co-evolution of plants and animals implicit] "… plant-species loss hypothesis" "… trophic structure is a proxy for ecosystem function"	"… changes on the community structure of the taxa inhabiting such ecosystems … also implies [changes] in functional structure"	"The sampling was performed in September 2013, corresponding to the wet season where more density of arthropods has been observed in the reserve"

Fernández et al. (2022) RCHN 95:3	“Forest cover in the landscape, patch connectivity, and contiguity would be positively related to *D. gliroides* occurrence and abundance, while a high number of patches and patch isolation will be negatively related to its occurrence and abundance"	[Theories of habitat fragmentation and animal dispersion; TANS and co-evolutionary theory implicit]	“the arboreal marsupial *Dromiciops gliroides* is … the main seed disperser agent at these forests" “*D. gliroides* [has] arboreal habits and limited movement capabilities through non-forested habitats”	“FRAGSTATS offers a complete toolkit of landscape configuration metrics, which can be used to assess how sensitive species are to habitat fragmentation" "For those reasons, we will treat [two species] as a single species for the purposes of this work"
Alanís-Rodríguez et al. (2021) RCHN 94:6	“Our hypothesis is that the assisted ecological succession and control areas will show similar vegetation structure and composition, as well as in terms of the ecosystem service carbon sequestration"	[Pattern based on previous data; theory of ecological succession implicit] “the assisted ecological succession (active restoration), usually shows better results, allowing the establishment of a higher canopy that improves the ecological conditions of the ecosystems in less than ten years"		“The species registered were identified at the species level by qualified personnel of the Faculty of Forest Science of the Universidad Autónoma de Nuevo León (UANL)"
Boric-Bargetto et al. (2021) RCHN 94:5	“We propose that some riverine barriers from Mediterranean zone of Chile shape the genetic diversity of *Tylamys elegans*, triggering the genetic divergence of its lineages through vicariant events as primary riverine divergence, or persistence of its genetic differentiation with rivers acting as geographic boundaries of lineages previously differentiated and posterior secondary riverine differentiation"	[Evolutionary and biogeographic theories] "The riverine barrier hypothesis proposes that populations of different river banks become progressively isolated…"	“If rivers represent a barrier to populations of some species, it is expected that the diversification between populations from opposite riverbanks coincide with the formation of the river" "Rivers have been reported as geographic range boundaries or as barriers to gene flow in [other] populations of didelphid marsupials…"	“Specimens were collected with Sherman traps using a mixture of oat, banana and canned fish…” "Collection and handling recommendations were followed according to the American Society of Mammalogists” "Samples were obtained from different tissues such as blood, hair or liver"
Hernández-Miranda et al. (2021) RCHN 94:1	“The general working hypothesis is that the benthic macrofauna community from sites closer to farming centers [perturbation] are in poorer ecological condition (i.e., less diversity of sensitive ecological groups) than those far from farming centers"	[Ecotoxicological hypotheses] “Continued increases in organic matter over time modify community structure (loss of diversity), with a final persistence of tolerant and opportunistic species until the environment becomes anoxic and eventually produces the complete loss of species"	“For a proper interpretation of the observed community patterns, it is important to know other aspects of the species such as ecology, life history and sensitivity to pollution, because some of these features could mask the effects of perturbation"	“This study incorporates biological and environmental information near six active aquaculture farms…" "All organisms found in the samples were separated with the aid of a stereomicroscope and identified to the lowest taxonomic level possible"
Valladares-Gómez et al. (2020) RCHN 93:6	“Because the differences in the vagility and adaptive local response of both species, we expect to find higher levels of morphological differentiation along the Patagonian range in A. olivacea with respect to *O. longicaudatus*"	[Evolutionary theory of morphological traits]	“The higher geographic structure of *A. olivacea* would be consequence of its lower vagility and home range (730 to 2530 m^2) when compared with *O. longicaudatus* (320 to 4800 m^2 (data for the Temperate Forests)"	“*O. longicaudatus* inhabit mostly in forest and bushy areas, whereas *A. olivacea* is found across bushy and grassland environments"

Barrientos et al. (2024) Ecología Austral 34: 25-35	"Exotic [forest] species stands possess a lower ant taxonomic and functional diversity than native [forest] species stands"	[TANS* and co-evolutionary theory implicit] "It is expected that the implantation of native [forest] species have less impact on the environment [and ants]"	"Several authors use the functional groups…"	"There were nine functional groups" "Sampling was carried out in spring, summer and autumn… The collected ants were classified by species…"
Gonzalez et al. (2024) Ecología Austral 34: 52-65	"Las semillas presentan dormición asociada a su ambiente de origen: dormición fisiológica o morfológica en ambientes húmedos y dormición física en ambientes secos" "Esperamos que las semillas de ambientes húmedos rompan la dormición con la aplicación de una estratificación húmeda-fría mientras que las semillas de ambientes secos lo hagan con la aplicación de escarificación mecánica" [predicción]	[TANS and evolutionary theory implicit] "Las semillas de las especies nativas presentan mecanismos de dormición que evitan su germinación inmediata (luego de la dispersión primaria). El tipo de dormición depende de una combinación de características con una marcada señal filogenética a nivel de familia, género o especie, como el grado de adaptación a la estacionalidad y a las condiciones ambientales del entorno (i.e., humedad, luz, temperatura)"	"Semillas de especies de ambientes áridos tienen [han evolucionado] dormición física por cubiertas duras e impermeables que evitan la deshidratación, pero dificultan la posterior hidratación necesaria para la germinación. Las semillas de especies de climas templados estacionales a menudo presentan dormición fisiológica, que retrasa la germinación hasta la primavera, y es interrumpida por la acción de bajas temperaturas y humedad durante cierto período"	"Se descartaron semillas vanas y con ataque visible de insectos u hongos" "La especies a usar debían estar presentes en taludes viales y en áreas cercanas consideradas ecosistemas de referencia" "… para las especies nativas no se conocen las condiciones de almacenamiento óptimas" [assumption unknown] "… las semillas fueron desinfectadas con una solución de hipoclorito de sodio (2%)"
Amione et al. (2024) Ecología Austral 34: 82-95	"Burrowing parrots will show a more active risk-taking behavior against recreational activities [disturbance]. They will show longer flight initiation distance and latency time with increasing number of beach users"	[TANS implicit, behavioral theories] "Knowledge of animal behavior has proven to be a useful tool for addressing conservation solutions to wildlife threats … Risk-taking behavior [theory] has been broadly addressed for understanding the tolerance of a species against a perceived threat"	"The burrowing parrot can perceive recreational users as potential disturbance" "Shyer behavior (e.g., longer flight initiation distances) was reported from birds inhabiting rural areas (habitats with low disturbance), in contrast with their conspecifics occupying urbanized areas like cities [disturbance], where they show less risk-aversion behavior"	"We assumed that any individual at the entrance of a nest was a breeding adult" "In a pilot study, we determined that an observer could estimate the alert behaviors of burrowing parrots from a distance at least 50 m apart"
Allasino et al. (2024) Ecología Austral 34: 106-120	"Las plantas expuestas a polinización entomófila presentarán mayores tasas de formación de frutos y semillas, y esas semillas serán de mayor calidad (en términos de peso y poder germinativo) que las producidas bajo polinización anemófila y autógama"	[TANS implicit] "La polinización entomófila es importante para algunos cultivos de gran relevancia económica en ciertos países y regiones …"	"Las especies mencionadas (achicoria, cebolla, rabanito, repollo, zapallo) dependen en diferentes niveles de los polinizadores para su reproducción; y algunas de ellas muestran cierto grado de autogamia"	"En cuanto al zapallo, al tratarse de una planta diclina monoica con flores solitarias, los ensayos de polinización se realizaron únicamente sobre flores femeninas"
Navoa et al. (2024) Ecología Austral 34: 171-188	"Como resultado de la variación a lo largo del área de distribución de la especie, los parámetros poblacionales de *M. schmitti* en la Patagonia Central difieren de los estimados para otras áreas de su distribución"	[Pattern based on previous data] "En base a los estudios previos que sugieren ciertas variaciones en los parámetros de crecimiento de *M. schmitti* asociadas a cambios latitudinales…"		"La obtención de muestras estuvo condicionada por la presencia estacional de la especie en el área costera entre noviembre y marzo"

Thougnon-Islas et al. (2024) Ecología Austral 34: 240-255	“Las distintas intensidades de uso del suelo afectan a los parámetros ecológicos de la nematofauna presente en los diferentes sistemas estudiados. Predicciones: los suelos con mayor intensidad de uso presentarán menor abundancia de nematodos omnívoros y depredadores y una red trófica más disturbada, con respecto a los sitios agrícolas con menor intensidad de uso de suelo y a las pasturas"	[Pattern based on previous data; theory of ecological succession] “Las prácticas agrícolas —sobre todo, la incorporación de fertilizantes y el tipo de labranza— impactan en el enriquecimiento del ecosistema suelo, generan alteraciones físicas y químicas que interrumpen la trayectoria sucesiona de los nematodos y provocan cambios en la composición y en la diversidad de estos organismos”	“Los nematodos omnívoros y depredadores son más sensibles a los disturbios causados por las prácticas agrícolas, y son fundamentales en las redes tróficas ya que depredan organismos de menor tamaño, incluido a los nematodos fitófagos"	“La intensidad de uso del suelo estuvo dada por el tipo de cultivo y las prácticas de labranzas asociadas" "Se determinó la abundancia de nematodos por observación en lupa binocular" "Se clasificó a los nematodos según sus hábitos alimentarios en 5 grupos tróficos: fitófagos, bacteriófagos, fungívoros, omnívoros y depredadores …"
Ronco et al. (2024) Ecología Austral 34: 330-345	“Crop intensification by inclusion of cover crops and/or crop rotation as an alternative to monocrop, influences the initial water infiltration in the soil profile due to changes on soil microbiota and total organic carbon"	[Pattern based on previous data; soil (physical, chemical) theories] “Lower sorptivity is associated with a higher organic content, which could benefit water infiltration"	“Agricultural systems with prevailing dominance of diverse and active roots, would change the soil water dynamics when compared to environments with less diverse root systems… this could be supported by the presence of elevated microbial activity, as laboratory studies have shown that it is correlated with reductions in sorptivity"	“T-GRSP was extracted and quantified according to the methodology described by Wright et al. (2006), with modifications"
Rojo et al. (2024) Ecología Austral 34: 377-392	“La restauración de estos ambientes a través de la remoción de las castoreras aumenta la riqueza de especies y favorece la distribución uniforme de los salmónidos introducidos a lo largo de todo el curso de agua, con la consiguiente variación de su condición y densidad energética"	[predator-prey theory implicit]	“La alteración del ambiente por *C. canadensis* favorece el crecimiento de los salmónidos, potenciando así la presión de depredación sobre las especies de peces nativos (Arismendi et al. 2020) o alterando la dieta a través de cambios en la diversidad de macroinvertebrados, que son la principal fuente de alimento de los peces de agua dulce presentes en Tierra del Fuego"	“Para ello, se evaluó la presencia de madrigueras recientes …" "En cada muestreo se midieron, en simultáneo a la captura de peces, las variables ambientales profundidad media (m), velocidad media de la corriente (m/s), caudal (m^3/s), pH, conductividad (µS/cm), O2 disuelto (mg/L), temperatura del agua (°C) y sólidos en suspensión (mg/L)"
Ayala et al. (2024) Ecología Austral 34: 322-329	“*S. campanulata* es una amenaza para la entomofauna nativa debido a que su néctar y su mucílago tóxicos, adaptados a los polinizadores propios de su zona de origen (aves), causan la mortalidad de este tipo de visitantes florales"	[TANS and co-evolutionary theory implicit]	“Se documentó que esta especie secreta sustancias tóxicas en el néctar, lo que causa mortalidad en los insectos que la ingieren; sobre todo, abejas, moscas, avispas y hormigas"	“Se colectaron flores directamente del suelo … evita sesgos de muestreo … cualquier flor que haya estado en el árbol a cualquier altura tiene la misma posibilidad de estar presente en los datos" "Se determinaron los insectos … utilizando claves entomológicas"
Rechencq et al. (2024) Ecología Austral 34: 422-434	“La hipótesis de este trabajo es que el incremento en la urbanización de las cuencas de drenajes andinas se refleja en la eutrofización de sus ecosistemas fluviales"	[Theories and hypothesis on chemical reactions in inorganic and organic material]	“El estado trófico de los arroyos se puede determinar a partir de sus concentraciones de nitrógeno total y fósforo total, así como de la concentración media de la clorofila a de la comunidad del perifiton"	“… existen diferencias entre las cuencas de estudio, de las cuales podemos destacar sus áreas y su nivel de urbanización (Tabla 1)" "… se utilizaron como variables indicadoras de urbanización de la cuenca de drenaje la densidad poblacional y el porcentaje de su área modificada"

scientific method, this role would be more directly tied to the origin of ecological-research problems than to the origin of mechanismic, explanatory research hypotheses, albeit some empirical rules of ecology can be deemed as an offspring of NH.

Natural history data as assumptions of ecological research

Hypothesis alone does not make specific predictions on its own. A great deal of extra theory and data about initial conditions (i.e., assumptions) are required to make any forecasts at all, let alone precise predictions (Colyvan and Ginzburg 2003). This can be seen on the left side of Figure 1, a schematic of hypothesis-driven research. Testing more or less formal hypotheses with the hypothetico-deductive method (Popper 1959; Jaksic 1981; Bunge 1998; Marone and Galetto 2011) requires deducing such hypotheses or predictions (second column in Table 1). The premises of the deduction are some starting theories or general hypotheses (third column in Table 1) along with other assumptions or initial conditions. The knowledge supporting these initial conditions is often based on NH (fourth column in Table 1): definitions (e.g., resilience, social structure, dispersal barrier, avoidance behavior), patterns inferred from previous results on the species studied (e.g., distribution, seed dormancy mechanisms, time frame of activity, diet, defensive-, reproductive- or feeding-behaviors), or on their environment (e.g., soil, climate, disturbance) (see Table 1 for detailed examples).

There is yet another way that NH plays a role in hypothesis testing, this time associated with the right side of the scientific method depicted in Figure 1. During testing, the data take the form of a number of observational statements that should reflect some facts in nature. Well-validated data are therefore those that reliably correspond to the facts, which depend on the careful consideration of the assumptions that surround data gathering (Bunge 1998; Marone 2024). Was sampling carried out in the appropriate season? Were species identified correctly? Did the study design (e.g., the distance between sampling units) assure sampling independence? Were guilds or functional groups defined adequately? Was the bait in the traps effective in catching the target species? Were the environmental variables measured pertinent to the hypothesis? Can certain specific behaviors be inferred from the empirical indicators used? Did a pilot study show that the sampling design was correct? (see the last column in Table 1). The answers to these questions about data acquisition belong among the large amount of extra theory (e.g., the fundamentals of the research techniques) and data (e.g., NH information) that constitute the assumptions in the pursuit of the method of science (see Table 1 for detailed examples).

The role of NH as assumptions is important because it is clearly detectable in the scientific method and justifies assertions like 'ecology is rooted in NH' or 'NH fuels ecology'. Although NH plays other roles during research (e.g., supplying essential observations that encourage problematization), its function as provider of key assumptions to deduce or test hypotheses could explain 'why ecology needs NH' (Anderson 2017) in a more comprehensive way.

More on the relationship between ecology and natural history

Stressing the role of assumptions in ecological research

Our epistemological approach brings to light the key role that assumptions play during research, the recognition of which (e.g., by apprentice scientists) could stimulate a more careful search for data (i.e., those gathered under reasonable assumptions). Trustworthy results are necessary to nurture applied ecology and to face the 'reproducibility crisis' (Oza 2023; Marone 2024) because the reproducibility of research findings constitute a requisite for predictive science, and reproducibility failures are among the major concerns of the scientific community (Baker and Penny 2016; Kaiser 2021).

The result of the test of a hypothesis depends not just on the 'truth' of the hypothesis, but also on the 'truth' of the assumptions for testing it (Bunge 1998; Colyvan and Ginzburg 2003; Marone and Galetto 2011). For example, when the hypothesis that functional diversity is higher in protected than in perturbed environments is put to trial it could be confirmed (or refuted) because the hypothesis is either true (or false) or because the species were incorrectly assigned to certain guilds or functional groups (and several combinations of verified or falsified hypotheses and

assumptions). The reliability of the evidence depends on the reliability of the approaches used to collect and interpret it. Given that our methodological approach emphasizes the role of NH in hypothesis testing, it invites a systematic review of at least the most critical assumptions before reaching any conclusions in a given study.

Biological research as a reliable generator of natural history information

The results of hypothesis testing in a discipline (e.g., behavior, physiology) could provide NH information for testing hypotheses in other disciplines (e.g., ecology) (Jaksic 1999). For example, the results from hypothesis-guided research that defined the patterns and causes of seed preferences by seed-eating birds in the Monte desert of Argentina (e.g., Camín et al. 2015; Marone and Camín 2022; Marone et al. 2022) were used as initial conditions in a subsequent research. This conditions —together with a more general hypothesis on the feeding behavior and habitat selection of the birds— allowed the deduction of predictions about dietary shifts among different bird species (e.g., specialists and generalists) (Marone et al. 2017), or about eventual reductions in the populations of these birds under grazing or drought conditions (Sagario et al. 2020). This interplay of ecology and NH —among other reasons— led Jaksic (1999) to distinguish between 'old' and 'new' versions of NH. The new version sometimes draws on hypothetico-deductive exercises based on 'systematic' (i.e., not anecdotal) observations of, for example, behavior, physiology, morphology and genetics, that may then act as trustworthy assumptions for ecological research.

The role for natural history in predictive ecology

Although Anderson (2017) recognized that NH "began as a descriptive practice [which aims at] spending as much time as possible examining animals in the outdoors" and that its "important goals … are always to get the data, collect the specimen, and have the experience", he unexpectedly asserted that "such endeavors would not represent data collection for the sake of data collection". According to Anderson (2017), by integrating information over broad areas with the help of current technologies, NH would avoid sheer data gathering and "lead to novel hypotheses and theoretical explanations". As has been mentioned above, a direct path from NH to theoretical explanation is not supported. Nevertheless, NH —far from just being a local, historically situated, contingent and anecdotal type of knowledge— plays a detectable and precise role as assumptions during ecological hypothesis testing. In so doing, although NH is not deep theoretical knowledge by itself, it contributes to predictive and explanatory ecology. We can thus hypothesize that when Peters (1991) asserted that we gain nothing by confusing NH with science or allowing historical explanation to supplant predictive power, he had some descriptive or anecdotal-based version of NH in mind and not its role as provider of premises of ecological research involved in prediction.

Authors that have argued about the existence of authentic ecological laws have sometimes emphasized the methodological similitudes between physics and ecology (Berryman 2003; Colyvan and Ginzburg 2003, 2010). According to them, the laws of nature describe the dispositions that natural systems have to behave in certain ways in idealized setups. In real setups the natural systems have the same tendencies, but their behavior is different because of the influence of the variable 'initial conditions', which affects the process in nature. Just as in physics, the accurate prediction of the orbit of Uranus by using Newton's law of gravitation required the consideration of the appropriate initial conditions (i.e., concerning the correct number of planets, their masses and distances from each other), ecological dispositional laws also need to be articulated with the appropriate NH information that -acting as biological initial conditions- help formulate the predictions to test hypotheses or theories, and to inform the application of ecological knowledge.

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