# CONSIDERING THE USE OF NULL HYPOTHESIS IN MARINE BIOLOGY SCIENTIFIC RESEARCH

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ABSTRACT. The null hypothesis (Ho) is a logical and philosophical resource that grants rigor and precision to scientific research. Its use in abidance to scientific method has been less frequent than the alternative hypothesis (H1). Nonetheless, when used it adds to the systematic logic inherent to the abduction of H1, derived through critical analysis within the basic theory in a given topic. The underlying difficulty in hypothesis construction, and ignoring its link to scientific method, tempts and taunts science students and researchers to sidestep it, with the risk of proposing it by sheer administrative obligation. Even so, the elaboration of Ho works as (self)criticism, allowing for a broader vision and to value H1 scientific formality, warranting that it be a rational, theory sound statement. An attempt is made to demonstrate the above by analyzing several examples in marine biology research. In this way, the Ho is a dialectic means that contrasts (hypo)thesis against anti(hypo)thesis, allowing us to examine the pros and cons of the H1, that helps in the generation of logical, theory based arguments that grant it plausibility.

KEY WORDS. Null hypothesis, alternative hypothesis, scientific method, systematic formality, abduction, critical analysis, marine biology, theory based arguments.

## INTRODUCTION

In essence, hypotheses in general are philosophical propositions formally constructed, supported by logical analysis within established knowledge. The latter serves as premise to the proposed statement elaborated in a syllogistic form. There are many types of syllogisms, where the following are more clearly related to hypothesis construction. Categorical syllogisms consist of two axiomatic premises that are combined to reach an obvious conclusion by deduction, such as A=B and B=C, then A=C; or A>B, B>C, then A>C. Whereas, hypothetical syllogisms read as: *p implies q, and p is True, thus, q is also True*, which is known as *modus ponendo ponens* (it affirms by affirming); or: *p implies q, and p is False, thus, q is also False*, known as *modus tollendo tollens* (denies by denying). Unlike the former, these syllogisms

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are inferred through abduction and require to be contrasted empirically and deemed either true (partially) or false.

In particular, a scientific hypothesis is defined as a statement logically supported on scientific theory in a given knowledge discipline (premise), that predicts or describes an upcoming event or finding concerning a certain phenomenon, or that asserts functional relations either between implied variables or processes. Such statement is abductively inferred through critical analysis of the correspondent theory, whether based (post-facto hypothesis) or not (pre-facto hypothesis) on empirical observations of the phenomenon of interest. Didactically and operatively, it consists in a likely answer to a sound and concise question derived from the logical examination of the related theory, empirically supplemented or not by observing the phenomenon under study.

Previously, caveats have been made in several forums on the relevance of using hypothesis in all scientific research, including lectures, conferences, seminars, books and scientific journals, particularly within marine biology topics (Siqueiros Beltrones, et al., 2015; Siqueiros Beltrones, et al., 2017). In all occasions, the ongoing argument is that the hypothesis is an element within scientific method that is seldom given the deserved attention when training scientists. Moreover, to avoid it, baseless pseudo-arguments are wielded, rejecting along the implicit and explicit scientific rigor of its logical structure.

Experience confirms that to properly construct a hypothesis, it is required to know precisely what it is, how it is elaborated, how it works, and how it is linked to the process of scientific research (scientific method) and consequently to the scientific paper. Thus, it has to be emphasized that a hypothesis is a logical proposition representing a tentative answer to a research question (problem), and that goes beyond a mere assumption or hunch by implying formal logic. As it is inferred through abduction (Siqueiros Beltrones, et al., 2105, 2017), it is required to be founded on a plausible premise and to be contrasted empirically and, so, deemed either true (partially) or false. It identifies here with Popper's (1962) falsifiability requirements for scientificity.

Notwithstanding the above, the difficulty for science students to elaborate and write hypotheses tempts them to find excuses for avoiding the effort, which, by the way, is exhausting, but is worth it. Unfortunately, future scientists and even established researchers simply comply with including hypothesis as an administrative requirement for their thesis reports, research projects, and publications that frequently obviate it. Mentors and thesis director also tend to sidestep it do to their lack of conviction on its importance in the ongoing research. This way of viewing the issue and the consequent avoidance of hypothesis construction is related to the

incomplete comprehension of scientific logic, and to how the utmost importance of hypothesis in any scientific study is underestimated.

Research is linked to scientific method through hypothesis once thorough analysis of the theory and creativity give way to an original question that, like the correspondent hypothesis, it is logically sustained by the theoretical frame and thus is the plausible answer to the posted question. In such way, the hypothesis serves in guiding the investigative efforts (methodology) toward the objective, that is, to solve the problem, while simultaneously being supported or rejected. However, the diversity of research problems, even within the same discipline, e.gr., marine biology, makes risky to perceive the correspondent hypothesis. Still, any established scientist and science student at the PhD level, is expected to have an acceptable idea on what hypotheses are and on how different types necessarily may be constructed (Siqueiros Beltrones and Hernández-Almeida, 2015) and adequately used.

Considering all of the above, when dealing with the null hypotheses (Ho) matters turn worse. It is no surprise since the difficulties in constructing hypothesis remain and, although based on the same deductive-abductive logic, it gets complicated by its dialectic (thesis/antithesis) nature of Ho, similar to the falsifiability approach (Popper, 1962).

## POSING THE PROBLEM

In a recent peer review process on one of my papers, the referee disqualified my proposed null hypothesis by stating: "Null hypothesis is a term related to statistics in a design that poses to test hypotheses using a statistical tool. I suggest it be eliminated because it is but the working hypothesis" (yet our paper was rejected, of course). To begin with, when he refers to a statistical "tool", a semantic levity is shown that should be avoided in scientific writing, whereas "resource" or "references" are more suited terms. More important, his expressed concept on what a null hypothesis is suggests little concern on methodological and philosophical issues within scientific endeavor. Statistical hypotheses, null and alternative, are subordinate resources to the scientific hypothesis (H1) and are solely used based on mathematical probability to help contrast elements of the H1, which contribute to add or deny its plausibility. That is, as discrete contrasts or tests for population parameters or sets of numerical data on variable(s) where they always supply the same outcome, either if there are (alternative) or not (null hypothesis) significant differences between population parameters or numerical data. Whilst, the alternative, and null research hypotheses directly decide the outcome of the research problem that we are set to resolve (aim or objective), concerning biological populations or a phenomena under study.

Again, research hypotheses are considered formal statements within a sound supported study, that are highly plausible, and thus are usually proposed by established researchers or doctorate students having more experience and deeper knowledge of the respective theory. These may be posed as null hypotheses, either formally, or consciously intended to increase scientific rigor by denying that which we may directly infer (alternative hypothesis), whose supporting evidence is positively related with our premises derived by analyzing the respective theory. Because H1 is directly inferred it is also preferred, and being partial to it is risky, so it is useful to avoid biasing our contrast and interpretation (Lipton, 2005). In other words, elaboration of Ho works as (self)criticism, allowing to visualize this and to value a H1 scientific formality, warranting that it be a rational, theoretical sound statement. Concomitantly, a Ho questions also the soundness of the theoretical basis on which the H1 is supported, glimpsing a possible change of paradigm. It is in this way that the Ho is a rational dialectic means that functionally contrasts (hypo)thesis against anti(hypo) thesis.

To sum up, trying to be rhetorical rather than redundant, occasionally we make plausible efforts to elaborate our research hypothesis, However, in most cases we choose to go with H1, despite the risk of seeking for preferred results (bias) that may lead us to accept it (Lipton, 2005). This is related to the confusion between a premise (inferred deductively) and a hypothesis (inferred abductively), whereas the former actually serves as support for the latter and would be only extraordinarily rejected (change of paradigm), but in most cases being confirmed or complemented. Consequently, Ho is an effective reference for examining and showing such confusion. With this, scientific rigor is warranted in a way, by using inverse logic. Additionally, it allows to examine pros and cons of the H1, which helps in the detection of eristic elements (in discussion), that widen the contrast possibilities between our results (hypothesis support or rejection) and the established theoretical basis, especially when contemplating the feasibility of H1 being false.

*Examples*

To explain the logic underlying the Ho and to demonstrate how resorting to its use may help in accepting its inherent importance, several examples are reviewed.

1) The first example is taken from Siqueiros Beltrones, et al. (2017), and is further analyzed here. In this case, a (descriptive) hypothesis is proposed to answer this scientific question: How do assemblages of benthic (marine) diatoms respond to the influence of potentially toxic elements (PTE) derived from mining activities? The general premise synthesized from the related theory is that benthic diatom assemblages, whatever

their habitat, show similar structure in terms of species diversity, richness, dominance, and equitability (Siqueiros Beltrones, 2005). Thus, under the influence of PTE, a plausible H1 dictates that those assemblages will exhibit a different structure from assemblages in undisturbed habitats, that is, with "abnormally" low values of species diversity, richness and equitability, as well as high species dominance. Inasmuch (premise), the low values are characteristic of diatom assemblages in polluted (fresh-water) environments; and high dominance indicates occurrence of few taxa that exclusively tolerate these conditions. Thus, the H1 seems a reasonable and plausible abductive inference.

The correspondent Ho, on the other hand, states that the structure of benthic diatom assemblages in an area contaminated by these PTE will not differ from those inhabiting an undisturbed environment and, then, values of species diversity, equitability and dominance will fall within the observed intervals in undisturbed habitats (Siqueiros Beltrones, 2005). Thus, if our results lead us to reject the null hypothesis, i.e., values fall below the reference intervals, our H1 gains support but, due to the contrasting strategy focused on Ho, we are not demonstrating the H1, and we maintein in this way scientific rigor by not rejecting neither accepting it. Albeit, if we are directly testing the latter, we would be enticed to think otherwise and accept it, compromising further research for effectively describing the correspondent model through testing a new (post-facto) hypothesis.

The construction of Ho, however, is not a mere logical effective stratagem, inasmuch there is the possibility that those diatom assemblages in the area contaminated by PTE may derive from tolerant taxa that have developed adaptations and/or opportunistic taxa. Further, this should have to be considered in a more comprehensive research proposal. In this way, the Ho serves to dimension our investigation, delimiting the scope objectively.

Besides the above mentioned, although closely related, is the use of the Ho approach to identify premises mistaken for hypotheses (H1). An analog example for a very common mistake within the current topic would be this one: It is expected that the benthic diatom assemblages exposed to PTE in the marine environment off Santa Rosalía, México, where mining activities pollute the environment, will be affected. Actually, this constitutes a premise that, unlike the earlier H1, fails to compromise because it doesn't provide precise references for contrasting against a predicted (objective or real) response, that is, precisely how will structural elements such as species diversity and dominance vary.

2) A second example jumps into a different topic. To understand the confusion between hypothesis and premise, and to use the Ho to identify the error in H1 construction, the following statement is examined:

**"Under the hypothesis that every reef is mostly self-restored within a short spatiotemporal scale because of a rather reduced planktonic period, the practice of aggregating mature adults of pink abalone in a reef would improve local recruitment" (Díaz-Viloria, et al., 2013).**

What is presented as a hypothesis (H1) is actually a premise, i.e., synthesis of ecological theory that serves as axiomatic support for the second part of the proposal, which is the hypothesis. As is stands, when transforming the H1 into a Ho, the statement would not be sound, since it is established theory in contrast with the second part.

Notice that by adjusting the syntax the error can be corrected. The statement should read:

*Under the **premise** that reefs are mostly self-restored within a short spatiotemporal scale due to rather reduced planktonic periods… we propose the **hypothesis** that aggregating mature adults of pink abalone in a reef will improve local recruitment.*

Now, focusing on the real hypothesis allows for a logical Ho, i.e., **aggregating mature adults of pink abalone in a reef will not improve local recruitment**. Anyhow, to be congruent with the Ho, syntax should be again modified to something like: *Although reefs are mostly self-restored within a short spatiotemporal scale due to rather reduced planktonic phases, we propose the null hypothesis that aggregating mature adults of pink abalone in a reef will not improve local recruitment, inasmuch… (Here is where the author's expertise comes into play but I will take a risk)… certain ecological factors that might have influenced the diminish of pink abalone together with overfishing, may well preclude effective recruitment*… This adds ecological meaning to the null hypothesis preventing it to work solely as a mere stratagem and, in turn, the discussion may be enriched under this feasible scenario.

3) Failing to construct a hypothesis (H1) will reflect on the impossibility to conceive an adequate Ho. Moreover, to abduct a hypothesis should be understood as an answer to a scientific question or problem, which defines our objective and the title of our report or publication. Thus, the problem should be susceptible to be expressed as a question. Even so, in practice we encounter, too frequently, titles such as: "**Trophic ecology of *Pristis pectinata* Latham, 1794, in the Mexican Caribbean**." The corresponding hypothesis, if any in the report, could take various directions. Of course, this title would be adequate if the report fully comprised many topics (as in a book), but they rarely do. More likely the study could be defined as: "**Selectivity in the feeding habits of *P. pectinata* Latham, 1794, in the Mexican Caribbean,"** which is only part of its trophic ecology. Further, it can be modified into a question and, thus, a tentative theoretically supported answer comes into vision, i.e., the correspondent hypothesis. Then the Ho may be derived as straightforward: "**Feeding habits of *Pristis pectinatus* in La Paz Bay, Mexico, are non-selective." Why? That stands for**

**the specialist to explain, and is stated as the premise.** Whereas, changing the syntax of the initial title (problem) does not help to derive (abduct) a hypothesis, much less a Ho.

4) When applying oneself, the fitness of a Ho can be likewise used in taxonomic studies, the preferred underestimated scientific research in terms of hypothesis requirements, specially floristic and faunistic studies. This point of view is accompanied frequently by affirmations such as: "A mere taxonomic list does not require any sort of hypothesis." However, if such a proposal is to be considered as a scientific workpiece, it should explore the possibility that there is a hypothesis hidden somewhere. Maybe even a null hypothesis.

Let's say we set out to determine the *Species composition of teleost fishes in a subtropical coastal lagoon*. Beyond answering the (exploratory) question of which and how many species of fish inhabit the study area, we should stake for transcendence, i.e., scientificity in our study. In this case, what would a suitable (descriptive) hypothesis be? After reviewing the theoretical background one can expect to find: 1) high species richness, certain abundant, common and rare taxa; 2) dominant benthic or pelagic forms; 3) predominance of certain biogeographic affinities; 4) new taxa…Stated with proper syntax and supported on a sound premise, it will result in a formal H1. Yet it will also require redefining the title (problem): *Characterization of the teleost fishes faunistic in a subtropical coastal lagoon*, at least for working purposes. Then, the question would be: What are the faunistic characteristics of the teleost fishes in "this" subtropical coastal lagoon? If we concur with this, would a Ho be justified? Is there any evidence to support characteristics opposite to those mentioned above? If there is, then Ho = the faunistic composition of teleost fishes in "this" coastal lagoon will not show the characteristics in H1. Even if presenting both hypotheses is a little cumbersome, it incites to explore the suggested possibility.

As corollary, let us speculate on the case of the hypothetical taxon *Carcharocles* (*Carcharodon*) *megalodon* as found in Wikipedia. Since it has never been fully contrasted against a complete specimen, the model, although highly plausible or consensual among the scientific community, is still a hypothesis. It is derived from numerous observations on fossil teeth, used to support its enormous dimensions attributed to its hypothetical description. Could a Ho be elaborated not solely as a stratagem? The specialist should have the final word, and historical debate based on accumulating pieces of evidence shows that this has been indeed the practice.

## CONCLUSION

The Ho is a dialectic means that contrasts (hypo)thesis against anti(hypo) thesis, which also allows to examine the pros and cons of the H1, assisting

in the generation of logical, theory based arguments that grant it plausibility. The methodological rationale implying scientific logic and exemplified with research cases in marine biology, expressed in the present exercise, should be considered, at least for working purposes, in this and any other scientific study proposal.

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