



Historical summary of terminologies in community ecology

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ARTICLE INFO	ABSTRACT
Received : 12 April 2023 Revised : 19 June 2023 Accepted : 13 July 2023 Available online: 16 November 2023 Key Words: Ecological guilds Species ecological niche Biodiversity	This article highlights the importance of terminology in ecology as a fundamental tool for clear and objective communication among scientists, as well as for standardizing study methods and techniques used by ecologists. Terminology refers to a set of terms, concepts, and definitions that are established and accepted by professionals in the field, enabling precise descriptions of species, ecosystems, and ecological processes. However, it is important to note that terminology in ecology is constantly evolving, and it is essential for ecological professionals to stay up to date with changes to contribute to the advancement of science. Understanding the historical process of ecological terminologies is also necessary to comprehend their meanings and how their interactions can affect the understanding of ecology itself. In this sense, we have provided a historical contextualization of several important concepts in community ecology, such as biodiversity, trophic levels, ecological niches, ecological guilds, and functional groups. We have also made comparisons and differentiations between these concepts throughout the history of these terms.

Introduction

Ecology is a science that seeks to understand the interactions between living beings and the environment in which they live. Due to the complexity of this science, one of the fundamental tools for communication and understanding in ecology is terminology. Terminology refers to the technical and specialized language used by ecological professionals to describe and classify natural phenomena (Kempton, 1982). The importance of terminology in ecology is related to the need to establish clear and objective communication among scientists. Terminology allows concepts and information to be transmitted precisely and unambiguously, avoiding misunderstandings and errors. Furthermore, terminology is essential for standardizing the study methods and techniques used by ecologists, contributing to comparative research and the advancement of scientific knowledge (Mayr, 1976). Therefore, terminology is composed of a set of terms, concepts, and definitions that are established and accepted by professionals in the field. These

terms are used to describe characteristics of species, ecosystems, and ecological processes, such as ecological succession, biodiversity, and the food chain. It is important to note that terminology in ecology is constantly evolving, influenced by new discoveries and scientific advances. Therefore, it is essential that ecologists stay up-to-date and attentive to changes in terminology to communicate effectively and contribute to the development of science (Pickett & Ostfeld, 1995). In conclusion, terminology is an essential tool for ecology, allowing clear and precise communication among scientists and contributing to the standardization of study methods and the advancement of scientific knowledge. It is crucial that ecological professionals are familiar with terminology and keep up with its evolution to contribute significantly to the advancement of science. In this sense, summarizing the historical process that terminologies in this science have gone through is necessary to understand their meaning over the years and publications and how the interaction of

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these terminologies can affect the understanding of ecology itself.

1. Biodiversity

Biodiversity, also known as biological diversity, is a fundamental concept in ecology. It can be summarized as the sum of all biotic variations from the genetic level to the scale of ecosystems (Purvis & Hector, 2000). In 1992, the Second Convention on Biological Diversity of the United Nations proposed a broader concept of biodiversity, which includes the variability of living organisms of all origins. This encompasses intra- and interspecific variation, diversity of terrestrial and aquatic ecosystems, and the ecological complexes of which they are a part (Brazil, Ministry of Environment - MMA, 2000). In this context, the term refers to the quantification of the diversity, quantity, or multitude of species within a limited geographic area, encompassing genetic and phenotypic variations, distinct taxonomic classification, and endemism (Tilman, 2001). Therefore, biodiversity is a multidimensional concept that cannot be reduced to a single index, as it would be unable to represent the variety of life forms in the environment (Barbault, 1995; Purvis & Hector, 2000).

The understanding that different organisms interact with each other and with the environment is not new. This observation has permeated society since the dawn of civilizations (Mayr, 1998). Raymond F. Dasmann first used the term "biological diversity" in ecology in his 1968 book, "A Different Kind of Country." However, it was not until the 1980s that the term became prevalent in the scientific community, largely due to the efforts of Thomas Lovejoy. Lovejoy used the term in the preface of a collection of works titled "Conservation Biology: An Evolutionary-Ecological Perspective," edited by Michael E. Soulé and Bruce A. Wilcox in 1980 (Dasmann, 1968; Soulé & Wilcox, 1980). The term "biodiversity" as a replacement for "biological diversity" was first proposed by Professor Walter G. Rosen of the National Research Council/National Academy of Sciences in the United States (NRC/NAS) in 1985. Rosen suggested the use of "biodiversity" while organizing a forum on the topic, titled the National Forum on BioDiversity (Wilson, 1997; Sarkar,

2002; Noss, 2006). This forum was subsequently published in the first issue of the journal *Conservation Biology* as a scientific dissemination vehicle on issues related to biodiversity conservation (Lewis, 2007).

The term "biodiversity" was first officially published in 1988 in the book "Biodiversity," edited by Edward O. Wilson. This book presented the results of the National Forum on BioDiversity and included articles authored by 60 leading experts on the subject, including Wilson himself, Paul R. Ehrlich, Norman Myers, David Ehrenfeld, Robert E. Jenkins, Thomas E. Lovejoy, Lester R. Brown, Michael Soulé, and James Lovelock. However, despite the publication of this book, the concept of biodiversity remained ambiguous, and categorizing biodiversity in nature remained a challenging task.

In his 1992 book "The Diversity of Life," Edward O. Wilson emphasized the importance of species as the fundamental unit of biodiversity. Wilson believed that the concept of species was essential for studying biodiversity, as it provided a natural unit for the comparison and evaluation of research findings. Without species, ecosystems could only be analyzed using imprecise and changeable descriptions of their constituent organisms. Thus, species played a crucial role in the study of biodiversity, enabling a more accurate analysis of ecosystems and their components (Wilson, 1992, p. 48). In the 1960s, to early 1970s, researchers George E. Hutchinson and Robert H. MacArthur began studying biotic interactions, especially interspecific competition between different species, creating significant momentum for studies on community structure. In the 1980s, in addition to competition, spatial (abiotic and geographic data) and temporal (seasonal, etc.) variations became important topics in community analysis (Barbault, 1995). In the late 1980s, research began to seek a better understanding of species interactions, considering the relationship between distribution and environmental variations. It is understood that biological diversity represents the balance of biogeochemical processes, evolutionary history, and the extrinsic portion of changes in abiotic factors (Brown & Heske, 1990; Naeem & Wright, 2003). In the early 1990s, studies on the relationship between biodiversity and ecosystem functioning using combinatorial analyses aimed at

manipulating taxonomic diversity for the representation of functional sets gained prominence (Naeem & Wright, 2003). By the end of the same decade, ecologists increasingly used studies of ecosystem structure and function with an emphasis on the use of nonphylogenetic classifications of organisms (Gitay & Noble, 1997). According to Lévêque (1999), biodiversity specifically refers to three interconnected levels of biological hierarchy: (a) species diversity, which involves identifying and inventorying species as the simplest way to describe the biological diversity of a geographic area; (b) genetic diversity, which encompasses the set of genetic information contained within all living beings, corresponding to the variability of genes and genotypes among species and within each species; and (c) ecological diversity, in which ecosystems are composed of complexes of species (or biocenosis) and their physical environment. Numerous types of natural ecosystems can be distinguished, such as tropical forests, coral reefs, mangroves, savannas, tundras, etc. In his book, he also emphasizes:

"Biodiversity is not a simple catalog of genes, species, and environments. It must be perceived as a dynamic and interactive set of the different levels of biological hierarchy. According to current theories of evolution, it is thanks to the existence of genetic diversity within species that they can adapt to changes in the environment that have always marked the history of the Earth. Reciprocally, the genetic diversity of a species evolves in response to these changes in the environment as well as to mutations. The same is true of plant and animal communities, which constitute ecosystems and respond through qualitative and quantitative changes to fluctuations in the environment in which they live. This dynamic of biological systems and ecological conditions to which they are confronted explains why species evolve and diversify and why ecosystems host richer or poorer floras and faunas, depending on their history. In this regard, biological diversity is a modern version of the sciences of evolution, which synthesizes recent advances in molecular biology and ecology..." (Lévêque, 1999, 18-19).

The traditional approaches used to quantify biological diversity can be broadly grouped into two categories: quantification based on several

species and indices of species diversity that take into account both diversity and relative abundance. The first group includes three diversity measures proposed by Whittaker in 1970: (i) alpha diversity, which represents the number of species found in a habitat or sample unit within a region and is a measure of local species richness; and (ii) beta diversity, which measures community heterogeneity in a given territory and quantifies differences in species composition among ecological communities. Beta diversity is the result of two distinct processes, species turnover and gain or loss of species. (iii) Gamma diversity represents the total number of species in a region or the regional set of species, generally covering large extents of ecosystems (Anderson *et al.*, 2011).

These measures are not able to elucidate the processes present in communities that can lead to diversity. Currently, there are diversity measures that take into account important - but usually ignored - information about species. The most notable are measures that incorporate the relationships between species and those that take into account the functional characteristics of organisms present in the community (McGill *et al.*, 2006). Ecological communities are composed of different species that may compete or interact with each other. These communities are the result of various ecological processes, such as competition (Hutchinson 1959, Leibold 1998) and environmental filters (Weiher & Keddy 1995, Chase 2003), as well as evolutionary processes that have occurred over time (Tofts & Silvertown 2000, Ackerly 2003). Therefore, the composition and dynamics of ecological communities are influenced by both ecological and evolutionary factors.

2. Trophic levels

The scientific community became increasingly concerned about the Earth's ability to support life and its expansion with the publications of Thomas Malthus. In the early 19th century, this concern led to the development of a mathematical basis for the study of populations by biologist Raymond Pearl (1920), mathematician Alfred James Lotka (1925), and physicist/mathematician Vito Volterra (1926). This mathematical framework enabled researchers to investigate predator-prey interactions, competitive relationships between species, and population control through experiments. During the

early 20th century, European botanists initiated the study of plant communities, including their composition, structure, and distribution. Meanwhile, in the United States, research has focused on understanding the development of these communities, known as succession. These studies expanded the understanding of plant-animal interactions, acknowledging the importance of all biotic components in shaping ecological communities. In 1920, August Thienemann introduced the concept of trophic levels, which describes the transfer of energy through a series of organisms from green plants (producers) to various levels of animals (consumers). This concept was further developed by English ecologist Charles Sutherland Elton in 1927, who introduced the concept of ecological niches and pyramids of numbers. Birge and Juday, two American biologists, built upon Elton's work in the 1930s by measuring the energy reserves of lakes and developing the idea of primary production, which refers to the proportion of energy generated or fixed by photosynthesis.

A new concept gained strength in the early 20th century, stoichiometry, which means "The application of the laws of conservation of matter and definite proportions for understanding the rates and products of chemical reactions of a group of reactants," according to Elser & Hamilton (2007). Lotka and other authors began to analyze the stoichiometric ratios of essential chemical elements between organisms and the abiotic environment. Alfred Redfield, for instance, focused on the relationship between the availability of chemical elements in the oceans and the elemental composition of marine plankton (Redfield, 1934).

In 1986, American William A. Reiners initiated the discussion between the energy and matter flow approach and proposed the use of the stoichiometry of living beings and their mechanical structures as a way to interconnect matter and energy in ecosystems. The abundance of chemical elements in organisms, especially C, N, and P, provides a perspective on the ecosystem and the stocks and flows of matter and energy in the environment (Sternner & Elser 2002). Thus, it is possible to establish a communication network between levels of organization because it becomes feasible to calculate the elemental composition and estimate

the flows of chemical elements in a enormous variety of biological entities, from organelles and cells to ecosystems and the entire biosphere (Elser *et al.*, 2000, Sternner & Elser 2002). The trophic-dynamic concept of ecology was developed by Raymond Laurel Lindeman in 1942, providing detailed information on energy flow in ecosystems. This approach was later expanded upon by Americans Eugene and Howard Odum and Australian John Derrick Ovington, who integrated quantitative data into their research. As new techniques such as radioisotopes, microcalorimetry, computing, and applied mathematics became available, studies on energy flow, nutrient cycling, and stoichiometry were stimulated, allowing for a better understanding of the structure and functioning of ecosystems.

Studies on trophic interactions have been developed for this purpose, particularly the organization of food webs (Dunne 2005, Montoya *et al.*, 2006, Giacomini 2007). A food web is a representation of the feeding relationships between predators and prey in an ecological community (Pimm 1982, Cohen 1978). Trophic interactions are essential components for understanding population dynamics and, consequently, the emerging patterns of coexistence and diversity in ecosystems (Tokeshi 1999, Chesson 2000, Giacomini 2007). However, the patterns of interaction in communities are much more complex and diverse than was assumed in the 1970s and 1980s (Brown *et al.*, 2001, Woodward & Hildrew 2002), and as a result, a large number of attributes are needed to understand community structure (Cattin *et al.*, 2004, Williams & Martinez 2008, Vermaat *et al.*, 2009).

3. Ecological niche

Joseph Grinnell introduced the concept of the ecological niche in 1917, which he defined as "the smallest unit of distribution within which each species is maintained due to its instinctive and structural limitations." This approach emphasized environmental factors while ignoring the potential effects of other species on the niche. For Grinnell, the niche was a characteristic of the environment, not the species itself. Therefore, the Grinnellian niche can be defined by noninteractive variables (cenopoietic) and broad-scale environmental conditions, which are relevant to understanding ecological and geographical properties on a large

scale. This concept was further elaborated by subsequent authors, such as James *et al.*, (1984) and Austin (2002), leading to a better understanding of the niche and its role in ecological processes. Following this, Charles Sutherland Elton (1927) provided one of the most widely used definitions, describing the ecological niche as the role an organism plays within an ecosystem, without considering the location of individuals. Elton's approach is primarily based on trophic relationships, defining niches based on predator-prey interactions, where resources consist of living organisms for higher trophic levels. As a result, the niche is defined by an organism's place in the biotic environment, its interactions with food resources, and its competitors or predators. The distinction between Grinnell's and Elton's ideas generally lies in their concepts of niches, attributing a primarily abiotic character to the former and a biotic character to the latter. Thus, Grinnell's definition was similar to "habitat," and Elton's was similar to "functional niche." Colwell (1992) groups these two definitions under what he calls the environmental niche.

George Evelyn Hutchinson introduced a broader definition of the niche concept in 1944, which considers it as the combination of all environmental factors that affect the survival and reproduction of a species. Accordingly, the niche can be regarded as a hypervolume in the n-dimensional space that encompasses all the factors that shape the distribution and abundance of a species. Hutchinson also postulated that, by the principle of competitive exclusion, two similar coexisting species necessarily occupy different niches. Hutchinson changed the notion that the niche is an attribute of the environment, considering it as a characteristic of the species and delimited by the combination of factors that allow it to persist in the environment. However, his concept does not elucidate questions such as: (1) some regions of the niche must be better than others in terms of the species' survival probabilities; (2) not all variables that affect an organism can be represented linearly; and (3) it does not consider a temporal dimension, i.e., his model refers to a single moment in time (Pulliam 2000). In the mid-1960s, researchers Robert MacArthur, Richard Levins, and Eric Pianka, among others, began to develop a new definition of

niche, creating what is known as the modern niche theory. The focus of the niche was shifted to consider a diversity of environmental conditions that enable a species to survive, including the distribution of resource use by the species. In this sense, theoretical models were developed to investigate how many species (and how similar) can coexist in a given community under the premise that competition for resources is the mechanism that determines the ecology of populations. This representation allows the evaluation of some niche properties, such as their amplitude or overlap. This idea was heavily criticized because it lacked an adequate null hypothesis and statistical rigor. Additionally, several ecologists argued that competition was not necessarily the main process driving ecological dynamics.

Therefore, the definition of ecological niche considers the relationship of species with the environment, but how this configuration is structured differs from author to author; below are some examples:

"The position or status of an organism within its community and ecosystem resulting from its structural adaptations, physiological responses, and specific behavior (by inheritance and/or learning)." (Odum, 1959). "Ecological niche is the total sum of biotic and abiotic resource use by an organism in its ecosystem." (Campbell, 1996)

"The relationship of the individual or population to all aspects of its environment - and thus the ecological role of species within the community." (Ricklefs, 2003). Hubbell proposed the "Neutral Theory of Biodiversity and Biogeography" in 2001, which suggests that niche differences are not essential. He argued that the principle of competitive exclusion often takes a long time, so other processes such as dispersal and random ecological drift become dominant, along with certain population characteristics (birth, mortality, and reproduction).

Chase and Leibold put forth a new interpretation of the ecological niche concept in 2003. They proposed that the niche can be defined as the combined set of environmental factors that permit a species to meet its basic needs, such that the local population's birth rate equals or exceeds its death

rate, taking into account the impact of individuals on the environment.

In 2004, Eugene Odum proposed: The ecological niche is a term with a greater scope that includes not only the physical space occupied by an organism but also its functional role in the community (such as its trophic position) and its position in the environmental gradients of temperature, humidity, pH, soil and other conditions of existence. Consequently, the ecological niche of an organism depends not only on where it lives but also on what it does (how it transforms energy, behaves, responds to its physical and biotic environment and modifies it) and how it is limited by other species. By analogy, it can be said that the niche is its "profession," biologically speaking (Odum 2004, p.375).

The modern concept of ecological niche is considered to be the ecological relationships, resource availability, and conditions for an individual or species. However, the niche is not rigid; there is a tolerance in niches, meaning that an individual can live in a spectrum of temperature, pH, or resource availability. These parameters are said to be dimensions of a niche; thus, a niche can have n dimensions.

Hubbell has recently presented a compelling challenge to the conventional niche concept by introducing a neutral theory of diversity. In this theory, diversity is defined in terms of species distribution and abundance, and it posits that all species occupy the same niche, with individuals having equal fitness regardless of species (Hubbell, 2001). According to neutral theory, community dynamics are random and independent of species composition. This perspective stands in stark contrast to the Darwinian approach, which emphasizes competition as the driving force behind community assembly (Leigh, 2007).

In their theory of island biogeography, MacArthur and Wilson explained large-scale distribution patterns by considering fluctuations in colonization and extinction rates, following a probability distribution (MacArthur and Wilson, 1963; Wilson and MacArthur, 1967). Interestingly, MacArthur did not appear to explore the potential link between biogeography theory and niche theory.

Furthermore, the competitive exclusion principle, which suggests that one species will exclude

another through competition, has been challenged by spatial ecology studies. These studies have demonstrated that limited dispersal can indefinitely delay the exclusion of one species by another, even without any trade-offs (Hurtt and Pacala, 1995). Hubbell found support for his intuitions in these works (Hubbell, 2001), as he believed that competitive exclusion lacked sufficient empirical evidence. He consolidated neutralist models in his influential monograph, "The Unified Neutral Theory of Biodiversity and Biogeography" (Hubbell, 2001), which gained widespread popularity (Leigh, 2007) and generated considerable controversy.

The concept of symmetry, also known as equivalence, can be perplexing in discussions surrounding niche and neutrality. Symmetry can be defined at various levels, such as the intraspecific or interspecific level (Kimura, Hubbell). Importantly, asymmetry at one level can coexist with symmetry at another level.

4. Functional groups

Despite the fact that each species has a distinct evolutionary trajectory shaped by its interaction with the environment, it is widely acknowledged that there is a certain degree of functional redundancy among species in regard to their role in ecosystem processes. This means that there are species that perform similar functions within the ecosystem. The idea of formalizing groups that structure the environment has emerged repeatedly in the history of ecological concepts (Barbault 1995). The classification of plants based on the functionality and physiology of species has been found since Theophrastus, approximately 300 BC (Barbault 1995, Gitay & Noble 1997). In the descriptions of pollinator studies, Kölreuter in 1761 and Sprengel in 1793 suggested that organisms with similar behavior and similar interactions on flowers could be grouped. This represented an important step in studies of pollination syndromes, with Darwin and other scholars in 1862 developing the perspective that combinations of floral characteristics could reflect the type of associated pollinator (Fenster *et al.*, 2004).

In 1934, Raunkiaer indicated that groupings of plant life forms were useful in analyses of the influence of climate on plant composition and dynamics. This practice took into account the

morphological foundation found in specimens, but as important aspects of vegetation are not expressed solely by morphological references, it became necessary to recognize additional characteristics related to habitat and plant ecology (Barbault 1995). The ideas presented above have led to inconsistency in the terminology used to describe them, resulting in the emergence of numerous terms that express the same concept. For instance, growth forms, life forms, and strategies are terms that have been used interchangeably to convey these ideas (Semenova & Van der Maarel, 2000). The modern development of the concept began with suggestions raised in the 1960s by ecologists who, following Hutchinson and MacArthur, adopted the consensus on the organization of communities into assemblies of species defined by their functional basis (Barbault 1995, Gitay & Noble 1997).

In 1974, ecologist Kenneth W. Cummins recognized the need to define "functional groups" of organisms based on their ecological processes rather than relying solely on traditional taxonomic classifications. Other biologists, such as Korner (1993) and Hobbs *et al.*, (1995), have similarly defined functional groups as associations of individuals with similar roles or functions. Gilbert (1980) proposed a framework that demonstrated how the diversity in neotropical ecosystems is organized through chemical mosaics and mutualism, emphasizing the importance of functional groups. For instance, he identified groups of species, such as hummingbirds, bats, moths, and bees, that perform critical functions such as pollination, as well as birds and bats that aid in seed dispersal and ants that protect plants from predators. These species belong to different functional groups and play distinct roles in shaping their environment.

Presently, a more straightforward description can be formulated wherein a functional group comprises organisms that share comparable sets of functional attributes, co-occur together, and exhibit similar responses to external factors and/or impacts on ecosystem processes (de Bello *et al.*, 2010).

5. Ecological guilds

The term "ecological guild" was first introduced in 1903 by German Andreas Franz Wilhelm Schimper, who translated the German word "Genossenschaften" into English as "ecological

guild," referring to the distribution of plants with the same life form. The term "guild" had already been used by geographers and botanists (Schimper 1903, Clements 1905). In 1904, Grinnell used the term guild to define the concept of subdivision of the habitat in which an organism lives, including all the components necessary for the survival of the species.

From there, various authors began using this terminology for different meanings, such as groups of invasive species, functional groups, and species occupying the same environment (Wilson 1999). In 1927, Charles Sutherland Elton suggested that animal communities would be structured in groups with similarities in terms of survival ability or food acquisition, coining the term "ecological guild." This idea gained more structure in the 1950s when the emphasis of ecological studies was on interspecific competition as a process of community structure. Following Elton's ideas, George Evelyn Hutchinson (1957) considered a guild as a group of species that share maximum overlap in their multidimensional niche characteristics, understanding that species could act similarly in the ecosystem, being ecologically similar in their functions.

In 1967, Richard Bruce Root created the definition of "ecological guilds" to be used today:

"A guild is defined as a group of species that exploit a class of environmental resources in a similar way. This term groups species that present significant overlaps in their niche requirements, regardless of their taxonomic position. (...) just as for the genus in taxonomy, the boundaries that circumscribe the membership of any guild are necessarily somewhat arbitrary. To be considered a member of the guild of foliage-gleaning birds of oak woods, the major fraction of a bird's diet must consist of arthropods gleaned from the foliage zone of the oaks. As a result, birds that only occasionally use the foliage zone are excluded, even though they exert some influence on the food resource supply of the guild."

In summary, the term ecological guild refers to groups of species that derive their subsistence from the same types of resources and use the same strategies in the occupation of their niches (Terborgh & Robinson 1986), indicating that the ecological relationships between the species of the

guild are shaped by competition for limited resources. Ecologists Hutchinson and MacArthur (1959) described guilds as coevolved entities and "arenas of intense interspecific competition." However, Root's definition was not the only one presented. Considering the potential taxonomic limitation imposed by the term "in a similar way," James MacMahon and his collaborators 1981 proposed the removal of this term from the definition of guilds (MacMahon *et al.*, 1981). Thus, the concept of a guild came to make sense only in relation to the individual in the environment, encompassing larger and more diverse groups of species that can use the resource in different ways and for different purposes.

In his review of competition studies, Schoener (1974) noted that the degree of niche overlap between species is dependent on the abundance of resources. Specifically, when resources are plentiful, there tends to be less co-occurrence and greater overlap in resource use among species compared to situations where resources are scarce.

In 1983, Ralph C. MacNally proposed the inclusion of taxonomic criteria. The taxonomic criterion could alleviate a priori judgments of how species relate, usually assumed in a competitive context. The taxonomic limitation, but not necessarily as a criterion, was indeed present in most guild studies, both for practicality and lack of information and for the general validity of the premise on greater niche similarity among phylogenetically closer species.

In 1996, John E. Fauth and colleagues proposed subdividing the concept of the guild into its global and local components, maintaining the term guild with its broader definition, as the set of all species that exploit the same type of resource similarly, without the need for co-occurrence, and adding the term "local guild" for a subset of species in the guild that co-occur in the same community.

In 1999, John Bastow Wilson suggested subdividing ecological guilds into "alpha guilds" (use of resources within a community) and "beta guilds" (distribution according to environmental conditions). Both categories are subdivided into four classes that depend on the criteria commonly used for groupings; thus, it is possible to incorporate the different senses for the term guild, functional groups, and other taxocenoses.

Theoretically, the guild is independent of the phylogenetic relationship between species, but guild members are often closely related species; they probably share traits and life history adaptations similar to resources and habitats (Blondel 2003). The concept of guilds emphasizes the importance of a resource that can be exploited "in a similar way," which is more readily observable in animals than in plants and difficult to categorize and quantify (Simberloff & Dayan 1991, De Kroon & Olff 1995). MacMahon *et al.*, (1981) noted that the identity of the resource used is less important than the fact that it was used, as users of the same resource belong to the same guild. Guilds are typically distinguished based on differences in morphological characteristics that are closely associated with feeding techniques and often linked to character displacement in phylogeny (Blondel 2003). Moreover, the same species may belong to different guilds over the course of its life due to ontogenetic changes in resource use (Simberloff & Dayan 1991, Gerking 1994).

Guilds provide a convenient way to separate complex communities into manageable ecological units and offer an alternative perspective on community composition that is different from richness-based metrics or taxonomic identity, as they focus on life strategies. Guilds are also useful for comparative studies across different communities, even when there is no direct overlap in species composition (Hawkins & MacMahon 1989, Terborgh & Robinson 1986, Wilson 1999). The application of the concept of guilds is particularly valuable in ecological studies because guilds group organisms that have significant overlap in niche requirements and share resources (Jaksic 1981, Pianka 1980). The use of classification models in ecological guilds of animals, especially insects, is uncommon because it requires obtaining various ecological information about the animal under study, as well as the correct taxonomic characterization of the animals. When these conditions are met, it is possible to use the information through variables with several categories. For example, in a category related to the type of termite nests, the inserted categories would be arboreal nests, epigeal nests, or subterranean nests. When all the information is compiled, we can use it for clustering analysis, in which guilds are

revealed by the distance between clusters. Objective methods for describing clusters can also be used (Farias & Jaksic 2006). In some cases, guild models are not appropriate, such as the application of models in communities where there are animal species that differ in ecology during different developmental stages and/or in different sexes (Hawkins & MacMahon 1989). Communities that contain species that alternate resource consumption in different seasons of the year are not suitable for this type of study (Jaksic 1981).

6. Ecological guilds or functional groups?

The correct use of terms and concepts is particularly important in the development of research that uses, for example, modeling land use and responses to environmental changes (Wilson 1999, Blaum *et al.*, 2011, Blondel 2003). In the past, ecological groups were the basis of indices initially used to quantify functional diversity (Petchey *et al.*, 2004, McGill *et al.*, 2006), as well as the recognition of bioindicator groups (Stork & Samways 1995, Dufrêne & Legendre 1997).

Simberloff & Dayan (1991) conducted a review of the concepts of ecological guilds and functional groups, and they concluded that these terms are often used interchangeably by researchers. They found that the majority of researchers prefer the term "guild" due to its metaphorical reference to professions, which they considered more elegant.

We know that in zoology, the term "guild" was first used by Root (1967), and the parallel term "functional groups" was first used by Cummins (1974). Both terminologies refer to fundamental principles of collective attributes of groups of species, with a group being formed by species that exploit resources in similar ways (the guild) and ecosystem processes that require resource exploitation by species (the functional group).

In the example given by Gilbert (1980) in the subtitle above (Functional groups), we can argue that the species involved in each of the functions, such as seed dispersers and pollinators, belong to the same functional group. However, they can also be considered part of the same guild because they share the same resources, such as fruits or nectar.

It is important to note that the guild concept focuses solely on resource acquisition relationships among guild associates, whereas the functional group concept encompasses a broad range of ecosystem

functions, such as biochemical cycles, resource acquisition, invasion or fire resistance, water absorption, resource storage, defense against herbivory, pollination, seed dispersal, or any physical processes, such as ecosystem engineering, disturbance, and bioturbation (Blondel 2003). A group of species can be classified as either a guild or a functional group depending on the research question being addressed. The term "guilds" is used to identify species that share and utilize resources in a similar way (Root 1967). On the other hand, functional groups emphasize how resources are processed by species, performing the same ecosystem function or playing a similar role.

The guild concept emphasizes the species that utilize resources, whereas the functional group approach emphasizes the resource that is mediated by the members of a functional group (Blondel 2003). In addition, while the guild deals with species at the community scale and addresses existing competition, functional groups deal with species at the ecosystem scale and address functional similarities in a given context (Blondel 2003). Another characteristic that differentiates them is the consequence of removing species from the environment. In guilds, it results in system alteration, while in functional groups, functional redundancy between species does not alter ecological functions (Blondel 2003).

Individuals within a guild commonly utilize the same resources and may develop partnerships through participation in the same ecosystem process. On the other hand, functional groups are composed of partners who are inherently involved in the same ecosystem process. While guilds and functional groups are often viewed as two sides of the same coin, representing structure and function, respectively, the use of resources does not always impact the execution or provision of ecosystem services (Loreau *et al.*, 2001). Theoretically, a functional group can contain more than one guild, while a guild cannot group more than one functional group (Silva *et al.*, 2018).

Wilson (1999) presents a classification of alpha and beta guilds, with alpha referring to resources and beta to environmental characteristics. This structure is quite similar to Blondel's (2003), as the alpha guild corresponds to the guild (*sensu lato*) and the beta guild corresponds to the functional group.

Another purpose is that the niche theory-based guild approach offers a promising avenue for studying interspecific competition and related phenomena in ecological communities. However, it is paradoxical that current ecological dictionaries still adhere to the original Rootian concept when defining guilds. To address this paradox, Blaum *et al.*, (2011) propose a new ecological term, "functional effect group/type," which categorizes species based on their similar environmental effects, as initially suggested by Diaz and Cabido (2001). Notably, the introduction of this new niche theory does not impact the proposed definition of the term guild. By incorporating the functional effect group/type term within the niche theory framework, researchers can enhance their understanding of species interactions and ecological implications.

Conclusion

In conclusion, this study underscores the critical role of terminology in ecology as the cornerstone of effective scientific communication and method standardization within the field. The evolution of ecological terminology highlights the dynamic nature of ecological science, emphasizing the need for continuous learning and adaptation among ecological professionals. By delving into the

historical context of key ecological concepts, such

as biodiversity, trophic levels, ecological niches, ecological guilds, and functional groups, this research not only illuminates their evolution but also enables valuable comparisons and distinctions across different periods. Acknowledging and comprehending these historical processes are paramount, as they enrich our understanding of ecological terminologies and their intricate interconnections, ultimately enhancing the depth and accuracy of ecological research. As the realm of ecology advances, staying cognizant of these historical nuances is indispensable, ensuring that scientists remain adept in their communication and interpretation of ecological phenomena, thereby contributing significantly to the progress of ecological science as a whole

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Conflict of interest

The authors declare that they have no conflict of interest.

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