Predation starts small: rethinking an ecological concept from microbes to macrobes

Marie Vasse
CNRS – University of Bordeaux, UMR 5164, 33076 Bordeaux, France

Abstract

Predation is a central concept in ecology, structuring food webs, population dynamics, and evolutionary processes. Despite its importance, ecologists have long disagreed on how predation should be defined. Many influential definitions implicitly rely on adaptationist assumptions, treating predation as killing for feeding by organisms evolved for prey capture. This paper argues that such definitions generate conceptual and empirical difficulties, especially when predation is examined beyond familiar macroscopic systems. Microbial interactions frequently involve killing followed by consumption of victim-derived nutrients, yet these interactions are often excluded from predation due to the absence of stable predator–prey roles or clear evidence of adaptive specialization.

I propose a process-based definition of predation as the killing and consumption of one organism by another, independent of evolutionary history. This account aligns predation with causal-role approaches to ecological function, preserves empirical tractability, and clarifies boundaries between predation, competition, and scavenging. By integrating microbial and macrobial systems within a single conceptual framework, the paper shows how rethinking predation improves ecological explanation across scales.

Keywords: Predation, Ecological roles, Philosophy of ecology, Microbial ecology, Function

Introduction

Predation occupies a central place in ecological research. It has been studied empirically and theoretically as a core interaction underlying food-web structure, population dynamics, and evolutionary change. Yet this long-standing focus has not led to agreement on how predation itself should be defined. As Robert Taylor famously noted his 1984 book *Predation* “nearly every textbook dealing with ecology offers a unique definition of predation” (Taylor 1984). What unifies many of these definitions, however, is a commitment to adaptation: predation is typically understood as killing for feeding, where the killing behavior is assumed to be an evolved trait selected for prey capture and consumption.

This adaptation-centered understanding creates a conceptual tension. On the one hand, philosophers of ecology have repeatedly argued that selected-effect accounts of ecological function are either untenable or ill-suited to ecological explanation (Odenbaugh 2019; Elliott-Graves 2024; Dussault 2018). On the other hand, ecological concepts such as predation continue to rely heavily, although often implicitly, on evolutionary adaptation to fix interaction types and organismal roles.

This tension becomes particularly acute when predation is examined beyond familiar macroscopic systems. Microbial interactions frequently involve killing followed by victim-derived nutrient uptake, yet often lack stable predator–prey roles, specialized predatory traits, or clear evidence of selection for killing. As a result, many such interactions are excluded from predation by definition, rather than by empirical assessment. This raises a puzzle: should microbial killing-and-consumption events be excluded from predation altogether, or does this exclusion reveal a deeper problem with how predation itself is conceptualized?

In this paper, I argue that the difficulty lies not with microbes, but with the definition of predation. I propose a process-based account of predation that resolves long-standing ambiguities in microbial ecology while also reshaping how predation is understood in macrobial systems. More broadly, the argument contributes to ongoing debates in the philosophy of ecology concerning function, ecological roles, and the scope of ecological concepts.

1. Predation as an ecological role: functions, definitions, and conceptual tensions

1.1 Predation and ecological role functions

Predation is commonly treated as a paradigmatic ecological role. In ecological theory, role functions refer to the roles played by species or other biological units within ecological systems, such as pollination, browsing, or predation, and are distinct from the functioning of ecosystems as wholes) (Elliott-Graves, Stanford Encyclopedia). Role functions are central to ecological explanation because they connect individual interactions to their functions in higher-level systems, such as communities and ecosystems. Predation occupies a distinctive position among ecological roles because it cuts across multiple explanatory levels: it is for example central to community ecology, where it shapes coexistence, trophic structure, food webs, and extinction risk, and it is equally important in ecosystem ecology, where it influences energy flow, nutrient cycling, biomass production, and system stability.

Philosophical analyses of ecological roles have shown that there is no single, unified account of what it means for a species or activity to have an ecological function. A range of accounts coexist, each illuminating different explanatory practices in ecology. Etiological or selected-effect (SE) accounts, derived from Larry Wright's theory of function (Wright 1973), define a function in terms of the evolutionary history of a trait: a trait's function is what it was selected for. Roberta Millstein has argued that ecological role functions can sometimes be understood as coevolved functions, thereby directly linking the evolutionary history to the interactions between species (Millstein 2020).

Other approaches reject adaptation as a necessary condition for ecological function. Cummins-style accounts define functions as contributions that help explain system-level capacities, without requiring that the contributing component be adaptive. Variants of this view have been developed for ecological contexts (Odenbaugh 2010; Maclaurin and Sterelny 2008), including refinements such as counterfactual insensitivity criteria to distinguish functions from mere effects (Morrow 2023). Still other approaches emphasize persistence and organization rather than selection history: persistence-enhancing propensity accounts link ecological functions to contributions to ecosystem resilience (Dussault and Bouchard 2017), while organizational accounts define functions in terms of contributions to the self-maintenance of ecological systems (Nunes-Neto et al. 2014).

Despite their differences—and despite widespread endorsement of explanatory pluralism—these approaches converge on a point that is central for the present discussion: ecological role functions need not be adaptive (e.g. (Nunes-Neto et al. 2014; Dussault 2018; Odenbaugh 2019; Elliott-Graves 2024). Whether an activity plays an ecological role depends on what it does within a given ecological context, not on whether it was selected for or on the evolutionary trajectory of the traits involved.

None of this denies that predation can constitute a powerful evolutionary pressure (Bengtson 2002), nor that many predatory interactions have been shaped by natural selection. The point, rather, is that ecological role attribution does not depend on establishing such evolutionary histories.

1.2 A mosaic of definitions of predation

Definitions of predation form a mosaic, varying in scope, criteria, and underlying assumptions; however, many influential definitions implicitly rely on adaptation-based reasoning (Taylor 1984). Predation is commonly described as “killing for food,” where killing is assumed to be an evolved behavior shaped by natural selection for prey capture and consumption. Drawing on Antoine Dussault’s discussion of ecological role functions in light of Achinstein’s distinction between design, use, and service functions (Achinstein 1977; Dussault 2018), predation can be seen as implicitly treated as a design function in many definitions: predators are implicitly understood as organisms designed, by evolution, to kill and consume prey. Such definitions thereby align predation with selected-effect accounts of function, despite the broader philosophical consensus that ecological role functions need not be understood in design or etiological terms.

The problem is not that predation lacks evolutionary significance, on the contrary predation is widely recognized as a major selective force, but that evolutionary adaptation is often treated as a criterion for identifying predation, rather than as something to be explained once predation has been identified.

This adaptation-centered framing generates several well-known difficulties. Demonstrating that a behavior or trait is an adaptation requires evidence of heritability, fitness effects, and a relevant selection history, as well as the exclusion of alternative explanations such as exaptation or incidental by-products. Such evidence is not in principle inaccessible and indeed, a range of empirical approaches, including comparative methods and experimental evolution, have been developed to test adaptive hypotheses. However, in many ecological contexts adaptation is not explicitly investigated, and even when it is, it is often difficult to determine which traits are adaptive *for predation* in a given setting, especially when traits are multifunctional and their effects depend on environmental and community context. As a result, definitions of predation that hinge on adaptation risk rendering the concept difficult to apply consistently in practice, or excluding interactions by default rather than by empirical assessment.

A related consequence is the tendency to treat predation as a fixed taxonomic role: predators and prey are assumed to be stable kinds of organisms, rather than participants in context-dependent interactions. I develop this point further below (section 2.2).

At this point, an objection may arise: many ecologists would deny that their use of the concept of predation commits them to a strong adaptationist or selected-effect theory of function. In practice, predation is often treated as a pragmatic category, applied without explicit claims about evolutionary history or trait design. This objection is well taken. The claim here is not that ecologists always consciously endorse selected-effect theories when they study predation. The difficulty lies in the criteria used to demarcate predation from other antagonistic interactions. Definitions that distinguish predation from competition by appeal to killing "for feeding," nutritional intent, or evolved predatory traits implicitly rely on assumptions about adaptation and design, even when these assumptions remain unarticulated.

Other definitions attempt to avoid adaptation by appealing to energy or matter flow, defining predation as any process by which energy moves from one organism to another. While attractive from an ecosystem perspective, such definitions are often overly permissive. They collapse predation into generalized energy flow, erasing the interactional specificity that distinguishes predation from scavenging, competition, or detrital pathways. As a result, predation loses much of its explanatory traction as a distinct ecological interaction.

2. A process-based definition of predation

To resolve the tensions identified in the previous section, I propose adopting a process-based definition of predation[1]:

> *Predation is the killing and consumption, whether partial or complete, of one organism—the prey—by one or multiple other(s)—the predator(s).*

This deliberately broad and flexible definition promotes transparency regarding underlying assumptions on involved traits. It encompassing all events of killing and victim consumption, regardless of whether these outcomes result from specialized predatory traits, exaptations, physiological by-products, or context-dependent effects. Importantly, this definition does not deny that many organisms are highly adapted for predation. Rather, it highlights that different forms of predation need then to be distinguished using modifiers, thereby making assumptions explicit. For example, predation can range from highly adapted

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[1] Versions of this definition have appeared implicitly or explicitly in parts of the ecological literature. Here, I introduce it as a deliberately explicit stipulation designed to clarify ecological practice and facilitate cross-system comparison.

(*e.g.,* obligate predators with specialized traits) to opportunistic (*e.g.,* organisms that only occasionally engage in predation when conditions favor it). Adaptation then becomes an object of empirical investigation rather than a prerequisite for classification.

Adopting a process-based definition of predation does more than resolve a classificatory puzzle. It reshapes how predation is identified, investigated, and compared across ecological systems. Below I highlight three major consequences: it changes the methodological questions and approaches related to predation; it focuses predation on the interaction rather than on the interacting partners; and it clarifies long-standing ambiguities between predation and competition.

2.1 Predation without a priori commitment to evolutionary adaptation

Perhaps the most immediate advantage of the proposed definition is methodological. By removing adaptation-based filters, it allows predation events to be identified in systems where they would otherwise remain obscured or excluded by definition. Predation can be recognized whenever killing and consumption co-occur, without requiring prior reconstruction of selection histories.

This shift avoids the epistemic difficulties associated with adaptation-centered definitions, which often demand evidence that is difficult or impossible to obtain, especially in context-dependent or poorly characterized systems. At the same time, the definition remains fully compatible with evolutionary explanation: when evidence of adaptation is available, it can explain *why* predation occurs, rather than to determine *whether* predation is occurring at all. In this way, evolutionary adaptation becomes an object of inquiry rather than a gatekeeping criterion for ecological classification.

2.2 Predation without fixed predators

When we think of predation, vivid images of predatory hunts—lions chasing gazelles, wolves stalking deer—immediately come to mind. These familiar scenes of claws, teeth, and blood are deeply embedded in our collective representation and understanding of predation. Adaptation-based definitions of predation often attribute it to particular kinds of organisms and predators and prey are assumed to be stable categories, grounded in evolutionary specialization or stereotypical behavioral repertoires.

Removing adaptation from the definition allows predation to be treated as ecologically contingent. Whether an interaction counts as predation depends on what organisms do in a given context, not on whether they belong to taxa typically labeled as predators or possess canonical predatory traits. In other words, predation, under this definition, is not a label that organisms earn by virtue of their evolutionary history, but a process that can be instantiated whenever killing and consumption coincide. This perspective avoids reifying predator–prey roles while accommodating role reversals driven by environmental conditions, life stages, or community composition. It reflects broader moves in the philosophy of ecology toward interaction-centered and process-oriented explanations, emphasizing what happens in ecological systems rather than who organisms are taken to be.

2.3 Clarifying boundaries between predation and other antagonistic interactions

The process-based definition preserves a principled distinction between predation and other antagonistic interactions. Scavenging involves consumption without killing and therefore does not count as predation. Parasitism qualifies as predation only when the parasite kills the host before or after consuming all or part of it. Interference competition consists of organisms restricting access to resources through direct antagonistic interactions between competitors; even when such interactions lead to death, they do not constitute predation unless the victim is consumed by its killer.

This distinction does not deny that predation and competition are often intertwined. On the contrary, it allows their relationship to be studied explicitly. In macroscopic systems, consumption is often visible and alters the prey in discernible ways. In microbial systems, by contrast, the uptake of prey-derived nutrients is harder to detect and what happens with the victim biomass is often unknown. Emphasizing realized consumption rather than adaptive predatory traits redirects empirical attention to whether, how, and by whom released nutrients are exploited.

We have argued elsewhere (Vasse et al. 2024) that many cases described as interference competition in microbes plausibly involve predation, when killing results in partial or complete consumption of the victim. Very few studies, however, explicitly investigate victim consumption, thereby overlooking a potentially substantial nutritional benefit. Crucially, killing not only reduces competition for pre-existing resources, but also unlocks an additional resource: the victim itself. When victim-derived nutrients are assimilated by the killer, what begins as interference competition becomes predation under the present definition.

Recognizing this distinction has important empirical and theoretical consequences. It bears directly on how nutrient flows are traced through ecosystems, how trophic links are represented in food webs, and how population and community dynamics are modeled. In particular, treating killing solely for its competitive effect captures only a reduction in opponent density, whereas if linked to predation it also accounts for a direct growth potential for the consumer. In established microbial communities, where a large fraction of nutrients is stored in living biomass, recycling nutrients from lysed cells is likely to fuel a significant proportion of microbial growth, whether following direct lysis or subsequent decomposition. Failing to distinguish these mechanisms risks mischaracterizing both energy flow and the drivers of population dynamics.

The consequences of this ambiguity are not merely theoretical. In the next section, I examine concrete experimental cases in which killing, competition, and consumption are variously conflated or left unresolved. These case studies illustrate how a process-based definition of predation clarifies the mechanisms at play and reshapes the interpretation of empirical results.

3. Why microbes expose the conceptual problem

The process-based definition of predation proposed above gains its main inspiration from microbial systems, where killing is common but the fate of victim-derived nutrients is rarely investigated. The following case studies show how adopting this definition enables distinguishing predation from competition and illustrate how environmental conditions shape trophic interactions.

3.1 Context-dependent predation and role reversal

While investigating predation by the bacterium *Myxococcus xanthus* on various prey, we got confronted to a surprising observation (Vasse et al. 2024). *M. xanthus* has long been described as a paradigmatic bacterial predator, while *P. fluorescens* is not traditionally considered predatory (even if it has already been reported to kill other bacteria). Yet, the outcome of their interaction was dramatically shaped by the temperature at which *P. fluorescens* had been grown. Under standard laboratory conditions, *M. xanthus* kills and consumes *P. fluorescens*, consistent with a century of work framing *Myxococcus* as a bacterial predator. However, when *P. fluorescens* is cultured at a lower temperature prior to interaction (22°C instead of 32°C), the outcome reverses: *M. xanthus* is killed by compounds secreted by *P. fluorescens*, and *P. fluorescens* subsequently grows on nutrients derived from lysed *Myxococcus* cells.

This reversal challenges the idea that predation is a fixed property of taxa rather than a context-dependent process. Crucially, the toxic compounds produced by *P. fluorescens* are not induced by the presence of *M. xanthus* and are not known to have evolved for predation. They are likely byproducts of broader metabolic pathways whose primary functions lie elsewhere. Nevertheless, because *P. fluorescens* directly benefits from consuming the nutrients released from its victim, it functions as a predator under these conditions.

This case illustrates two points central to the present argument. First, predation is better understood as an event or process rather than as a role attached to particular organisms. Environmental context can determine whether an organism functions as predator or prey, and roles can reverse without any change in species identity. The temperature-dependent reversal observed in this study raises important questions about the nature of microbial predatory interactions in natural environments, where abiotic factors fluctuate regularly. If 22°C is a temperature at which *P. fluorescens* can be commonly exposed when growing in soil where it interacts with *M. xanthus*, it questions how frequently *M. xanthus* actually behave as the predator of *P. fluorescens* in natural environments.

Second, microbial predation needs not be an evolved trait. If predation is defined strictly by adaptive criteria, the killing and consumption of *M. xanthus* by *P. fluorescens* at 22°C would not qualify as predation. Decoupling predation from evolutionary adaptation better accommodates microbial interactions and acknowledges that predatory behaviors can emerge opportunistically as byproducts of other physiological processes. These observations are not idiosyncratic. Recent work on bacterial antagonism mediated by molecular secretion systems further shows that killing and subsequent nutrient exploitation can arise as collateral effects of competitive or defensive traits (Stubbusch et al. 2025).

3.2 Predation, competition, and explanatory ambiguity

A second case highlights how adaptation-centered definitions generate ambiguity even when predation is explicitly invoked. In experiments involving *M. xanthus* and *Sinorhizobium meliloti*, both species produce siderophores to access iron. The study is framed in terms of how iron competition modulates predation, with *M. xanthus* designated as the predator and *S. meliloti* as prey (Contreras-Moreno et al. 2020). However, at least three mechanisms can explain the outcomes of the interactions here: (i) higher capacity to chelate iron with siderophores, (ii) increased access to iron by killing the competitor, and (iii) growth on nutrients derived from killed competitors.

The first mechanism is resource competition, by which one bacterium performs better than its competitor at a given trait (here siderophore production to access environmental iron). The second is interference competition, where killing the competitor ensures higher access to the iron resource (simply because there are fewer bacteria to compete against). The last mechanism is predation (under the definition of killing and consuming another organism).

The authors describe reversals of “the outcomes of predation” when *S. meliloti* overproduces siderophores, yet it remains unclear whether *M. xanthus* is actually killed, or whether *S. meliloti* consumes nutrients released from lysed cells. Without clear criteria distinguishing competition from predation, explanatory categories slide into one another. The process-based definition makes explicit what must be shown empirically: predation occurs only if killing and consumption are jointly established, while questions of adaptation, specialization, and evolutionary stabilization remain open for further analysis.

3.3 Conceptual implications

Taken together, these cases show why defining predation in terms of killing and consumption provides a more reliable conceptual foundation for microbial ecology. It captures ecologically consequential interactions that adaptation-based definitions exclude, accommodates role reversals and context-dependence, and sharpens distinctions between predation, competition, and scavenging. More broadly, they illustrate how microbial systems expose a mismatch between contemporary ecological practice, which routinely investigates context-sensitive interactions, and inherited definitions that tie predation to evolutionary design.

In this sense, microbes do not merely add new examples to an existing category. They force a reconsideration of what predation is. By treating predation as a process rather than an evolved role, the proposed definition aligns ecological concepts with causal-role accounts of function, while leaving open the investigation of how, when, and why predation becomes an object of selection. In the next section, I argue that this reconceptualization does not apply only to microbes, but also reshapes how predation should be understood in macrobial ecology.

4. From microbial predation to macrobial ecology: gradients and evolutionary rethinking

Treating predation as an ecological process rather than as a role grounded in evolutionary specialization (i.e. as a pattern of interaction defined independently of its evolutionary origin) makes it possible to apply the concept coherently to microbial systems. They, in turn, illuminate dimensions of predation that are often backgrounded or naturalized in macroscopic contexts, and they suggest alternative ways of classifying, comparing, and explaining predatory interactions across the tree of life.

In this section, I develop two such contributions. First, I argue that microbial predation invites a gradient-based view of predation, and in particular a gradient organized around the accessibility of prey-derived nutrients, rather than around taxonomic or behavioral archetypes. Second, I show how the process-based definition reshapes questions about the evolutionary origins of predation, by highlighting pathways through competition, opportunism, and facultative predation that cut across microbial and macrobial systems.

4.1 Predation along gradients of nutrient privatization

One striking feature of microbial predation is the diversity of mechanisms through which killing and consumption are coupled. These mechanisms differ not only in how prey are killed, but in how prey-derived nutrients are distributed among organisms, and become accessible beyond the killer. In microbial systems, predation spans a continuum from interactions in which nutrients are entirely privatized by the killer to interactions in which nutrients are largely shared with the surrounding community.

At one end of this continuum lie forms of predation such as engulfment, where predators swallow their prey whole. Here, nutrient privatization is high: access to the prey's resources is largely restricted to the organism that performed the killing. At the opposite end lie forms of remote killing, in which predators secrete antagonistic compounds that kill prey at a distance. In such cases, prey-derived nutrients are released into the environment[2], diffuse away from the site of killing, and become accessible to multiple organisms, including those that did not participate in the killing event. Between these extremes lie intermediate cases, such as epibiotic or endobiotic predation, where predators get privileged access to prey nutrients but less exclusively than engulfers.

This gradient-based perspective suggests a way of classifying predation that does not hinge on the identity of predators, but on the ecological consequences of killing for resource distribution. Importantly, this perspective is not restricted to microbes. Macrobial predation also varies along similar dimensions, although these differences are rarely foregrounded conceptually.

Consider, for example, contrasts between predators that consume prey rapidly and entirely, predators that cache or abandon partially consumed prey, and predators whose kills are routinely exploited by or shared with conspecifics or heterospecifics. Large carnivores that monopolize kills differ markedly, in terms of nutrient privatization, from predators whose kills become focal points for scavenger guilds. Likewise, forms of predation involving external digestion or delayed consumption mirror the remote killing in microbial systems in that the prey is more likely to be shared[3].

Seen through this lens, microbial predation does not introduce exotic exceptions to macrobial norms. Instead, it makes explicit a dimension of predation that is already present but often under-theorized: the degree to which killing generates private versus public

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[2] How fast this release occurs depends in particular on the timing of prey lysis and the viscosity of the environment.

[3] See Vasse and Velicer for reflections about how such shared benefits of killing could be conceptualized as kin-predation (Vasse and Velicer 2026).

resources. Treating predation as a process allows these differences to be captured within a unified framework, replacing categorical distinctions with ecologically meaningful gradients.

4.2 Rethinking the evolutionary origins of predation

The process-based definition of predation also invites a reassessment of how predation may originate and diversify over evolutionary time. Classical models often assume that predation emerges as a consequence of relative size phenotypes (e.g. (Loeuille and Loreau 2005; Allhoff and Drossel 2016; Pillai et al. 2011). Yet, many macro-predators consume prey bigger than themselves (Sinclair et al. 2003); a pattern that is also common among microbes, where (at least) epibiotic, endobiotic, and telebiotic predators can successfully exploit organisms of greater size (Vasse and Velicer 2026).

Recent theoretical work by Yaroslav Ispolatov, Carlos Doebeli, and Michael Doebeli challenges this view and instead treats predation as a distinct lifestyle that emerges once organisms acquire a suite of specialized traits, such as sensory systems, locomotion, or weaponry, that enable them to search for, capture, and consume prey (Ispolatov et al. 2023). On this view, predation stands in contrast to competition for abiotic resources, and organisms are assumed to face a trade-off between specializing in one or the other. Their model allow for the emergence of facultative predators, organisms that primarily rely on external resources but opportunistically exploit prey, and see facultative predation as a potential pathway toward obligate predation.

The process-based definition proposed here complements and extends this perspective. By defining predation as killing followed by consumption, it becomes possible to identify predation events even when no specialized predatory traits are present. This, in turn, supports an alternative evolutionary scenario in which predation emerges not as a sharply distinct strategy, but as an extension of competitive or antagonistic interactions. In microbial systems such as the *M. xanthus* – *P. fluorescens* case described in section 3.1, traits that support interference competition can simultaneously eliminate competitors and release nutrients into the environment. When organisms are able to exploit these released nutrients, killing and consumption become coupled, and predation emerges without any prior adaptation for prey capture or hunting. In such cases, the same traits serve dual functions: they reduce competition for existing resources and create access to a new resource in the form of the victim's nutrients.

This synergy suggests that predation and competition need not stand in opposition. Instead, predation may arise as a byproduct of competitive interactions whenever organisms are capable of assimilating nutrients from those they kill. Facultative predation, on this view, does not require the evolution of entirely new traits, but can emerge opportunistically from existing antagonistic capacities. Over time, if nutrient acquisition from victims becomes reliable and beneficial, selection may reinforce behaviors or traits that enhance killing efficiency, nutrient uptake, or prey targeting. In some lineages, this process could lead to increasing specialization and, eventually, to obligate predation. Importantly, this scenario is not confined to microbes. Cannibalism and intraguild predation in macrobial systems often occur during territorial disputes, dominance interactions, or density-dependent encounters, where killing is initially driven by competition rather than by feeding. These aggressive interactions among competitors then yield both reduced competition and nutritional gain.

The process-based definition further invites to revisit the importance of searching in predation. Searching, broadly defined as any behavior or mechanism increasing the probability of encounter between the predator and the prey, is often conceived as an essential characteristic of the evolutionary origin of predatory interactions. Yet killing followed by consumption need not initially depend on active prey search. In both microbial and macrobial systems, predation can emerge in contexts where encounters are incidental, forced by spatial proximity, or structured by shared environments rather than by evolved searching behaviors.

By decoupling the identification of predation from assumptions about adaptation, the process-based definition thus allows evolutionary explanations to be reframed. Rather than asking when organisms become predators in virtue of specific traits, we can ask how often killing and consumption coincide, under what ecological conditions this coupling is favored, and how selection subsequently shapes the degree to which organisms rely on prey-derived nutrients. Predation, on this view, is not a fixed endpoint but a spectrum of strategies with multiple evolutionary entry points.

Conclusion

I have argued against the persistent, and often implicit, reliance on adaptation-centered assumptions that tie predation to evolutionary specialization, design, or fixed ecological roles. I have proposed instead adopting a definition of predation grounded in the co-occurrence of killing and consumption, independent of evolutionary history. This process-based account advances a concept of predation that is both empirically operational and philosophically coherent. It aligns predation with causal-role approaches to ecological function, according to which what matters is what organisms do in a given ecological context rather than why they evolved to do it. Crucially, this reconceptualization maintains predation as a key selective driver of species evolution while repositioning adaptation as an object of investigation rather than as a criterion for classification.

Microbial systems make the consequences of this shift especially salient. In microbial communities, killing is widespread, trophic roles are fluid, and consumption of victim-derived nutrients is often overlooked or left unmeasured. As the case studies illustrate, adaptation-based definitions obscure ecologically consequential interactions and generate explanatory ambiguity. By contrast, defining predation in terms of killing and consumption clarifies interaction types, sharpens empirical questions, and reveals predation where it would otherwise go unrecognized.

At the same time, microbes do more than a revision of existing definitions; they expand how predation itself can be understood. Once microbial predation is acknowledged as predation, features often treated as defining of macrobial predation, such as specialized searching behaviors, fixed predator–prey roles, or tight coupling between killing and feeding, appear instead as contingent and variable dimensions of predatory interactions. This perspective supports a graded view of predation, structured along dimensions such as specialization, context-dependence, and the degree to which prey-derived nutrients are privatized or shared within communities (Vasse and Velicer 2026).

Seen in this light, predation is not a narrow interaction type anchored to a handful of charismatic taxa, but a widespread ecological phenomenon instantiated in diverse ways across the tree of life. Statistically speaking, the average predator is far more likely to be a microbe than a large vertebrate! Taking this fact seriously requires ecological concepts that are not tacitly tailored to macroscopic intuition, but that can accommodate the full spectrum of biological interactions.

More broadly, the argument developed here illustrates how philosophy of ecology can contribute to ecological theory by clarifying the concepts that structure empirical inquiry. Revisiting predation through the lens of microbial ecology exposes hidden assumptions, refines explanatory categories, and opens new avenues for studying the dynamics, evolution, and consequences of antagonistic interactions. In doing so, it invites a reassessment of predation not as a role organisms are, but as something organisms do, sometimes deliberately, sometimes opportunistically, and often in ways that challenge our inherited ecological intuitions.

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