



# When size matters: a morphological measurement that informs on the potential pest control function by soil arthropod communities

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## Abstract

Promoting pest control provided by soil arthropod communities can enhance sustainable agricultural production. Despite years of research aimed at predicting the pest control potential of these communities, few studies have described natural enemy communities composed of multiple taxonomic orders through a functional lens and identified traits involved in predator–prey interactions. Arthropod predator communities consist of individuals from several taxonomic orders exhibiting significant physical and behavioral differences that likely contribute differently to pest control. These inter-order differences justify the adoption of a functional approach, rather than a taxonomic one, to describe predator communities. However, there is no generalized functional trait identified to describe arthropod predator communities and predict the pest control potential by these communities. To address this knowledge gap, we reviewed 194 relationships from the literature, examining various traits and feeding characteristics for different groups of ground-dwelling arthropod predators (spiders, Coleoptera, and Chilopoda). We tried to determine whether a functional trait can be identified to explain the pest control potential across a multi-taxonomic assemblage. Each relationship was described in terms of the trait, the feeding characteristic, and the direction of the relationship in quantitative studies. Across all taxonomic groups, we consistently observed a positive relationship between predator body size and prey body size. This relationship was the most tested and the most shared among orders. Consequently, this study provides a proxy trait (body size) that can be used to predict a potential of predation and therefore inform on the pest control provided by multi-taxonomic assemblages of predators.

**Keywords** Biological regulation · Functional trait · Body size · Measurement proxy · Soil macroinvertebrates predator

## Key message

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- We asked if there was a common trait to several orders of arthropod related to the pest control.
- A review of 194 relations examined traits of ground-dwelling predators to find a common trait.
- A positive relationship between predator body size and prey body size was consistently observed.
- The study helps characterize the function of multi-taxonomic assemblages of predatory arthropods.
- This research advances pest control characterization by diverse predatory arthropod communities.

## Introduction

Since the middle of the twentieth century, the crop protection against pest population has been based on the utilization of pesticides (Tilman et al. 2002). In addition to be deleterious for the soil biodiversity (Hainzelin 2013), the continuous use of pesticides leads to a pest resistance and therefore the need to increase pesticide uses (Tilman et al. 2002). To reduce pesticide use and promote sustainable agriculture, we must leverage the pest control service provided by biodiversity to manage pest populations and protect crops (Zhang et al. 2007; Sandhu et al. 2010). Pest control service relies on predators, parasitoids, and parasites within the environment that consume pest populations (Hainzelin 2013). Soil fauna makes a significant contribution to pest control (Barrios 2007), making it a crucial tool in an integrated pest management strategy (Hainzelin 2013; Perrot et al. 2021; Xu et al. 2011; Rayl et al. 2018; Pearsons and Tooker 2017).

Although the potential of natural enemies in pest control is well recognized (Gagic et al. 2015) (Perez-Alvarez et al. 2019), methods to predict the efficiency of arthropod assemblages in controlling pest populations initially focused on quantifying predator abundance activity (Bianchi et al. 2006), for the sake of simplicity. Indeed, more direct measurements of pest control, such as counting prey eaten (on live prey or predation cards) or quantifying leaf damage, can be conducted within crops (Perez-Alvarez et al. 2019; Boetzel et al. 2020), but these approaches are time and labor-intensive or even biased with artificial measurement in protocol. As a result, the potential of biological control is often summed up in the idea that a community with a high number of predators, regardless of their identity, is often considered more effective in controlling pest populations than a less abundant predator community (Karp et al. 2013). However, predation efficiency varies depending on the species composition of the community (Miller-ter Kuile et al. 2022). Despite this, studies often focus on a limited number of taxonomic groups used as proxies for biological control services, analyzing each group independently (Bianchi et al. 2006). In contrast, biotic interaction networks are complex and encompass numerous species and taxonomic groups (Wong et al. 2019). As such, ground-dwelling arthropod predators encompass various orders, including Araneae (Shackelford et al. 2013), Coleoptera, whose main representatives are ground beetles (Carabidae) and rove beetles (Staphylinidae) (Lövei and Sunderland 1996; Crist and Peters 2014; Devine et al. 2022) and Lithobiomorpha (Günther et al. 2014). Therefore, expanding the taxonomic range studied to include the entire predator community appears essential for understanding the full spectrum of prey consumption and incorporating biotic interaction networks to assess pest control potential.

In soil predator communities, individuals from different taxonomic orders exhibit diverse morphological and behavioral traits, likely making each a unique contributor to trophic interactions and pest control services. This makes the use of taxonomic descriptors alone insufficient to assess ecosystem functioning (Cadotte et al. 2011), predict their total prey consumption (Honek et al. 2011; Pekár et al. 2011; Turney and Buddle 2019), and ultimately quantify the pest control service provided by ground-dwelling predator communities (Rusch et al. 2015). Functional traits, described as morphological, physiological, or phenological characteristics measured on individuals, impact their fitness (Violle et al. 2007). Using functional traits, such as body size, has been proposed to explain pest control (e.g., aphid control by spiders, ground beetles, or rove beetles) (Rusch et al. 2015). While the functional approach is applied to individuals (from species to family level), a community-based functional approach that considers a variety of orders to explain ecosystem functioning remains underutilized (Neyret et al. 2024). Therefore, identifying a common functional trait, meaningful across all taxonomic orders is a crucial first step. Describing multi-order assemblages with a trait-based approach that consider feeding characteristics can greatly enhance our understanding of ecosystem functions related to pest control. However, we must determine which predation features (i.e., prey characteristics or the amount of food consumed by predators) are common and which traits (i.e., morphological or behavioral characteristics) are necessary.

In this study, we focus on ground-dwelling arthropod predators and review articles that identify quantitative or qualitative information from direct relationships between predator feeding characteristics and various traits at the individual or population level. We targeted the most abundant taxa of ground-dwelling predators in agroecosystems: spiders (Araneae), ground beetles (Carabidae), rove beetles (Staphylinidae), and chilopods (Lithobiomorpha, Geophilomorpha, Scutigermomorpha, and Scolopendromorpha). Specifically, the study aims at consistently characterizing the relationship between prey and predators with a trait-based approach in order to generalize the relationships observed among multiple arthropod taxonomic groups. Since pest control relies on predator–prey interactions, predicting these interactions within multi-trophic assemblages is a key step forward to understand and predict pest control in agricultural areas and protect this service in the future. Our objectives are to (1) summarize the direct relationships for the seven common taxonomic orders listed, (2) analyze the nature and direction of these relationships, and (3) determine whether there are common functional traits related to feeding across the different orders. Given its ease of measurement and close relationship with the energy needs of individuals (Kleiber 1947), we hypothesize that body size will be a predominant feature with a strong functional effect (Reichle 1968).

## Material and methods

### Literature review

We conducted a comprehensive review of studies published between January 1st, 1970, and February 2nd, 2023, to examine the relationships between feeding characteristics and various traits (i.e., morphological, behavioral, or population-based) in ground-dwelling arthropod predators. Our literature search utilized the Web of Science research engine and involved a structured search equation designed to capture relevant studies. Population and community traits were defined as description of the structure of the community in term of abundance, taxonomical or functional description (number of individual or species diversity). To be included in our review, articles had to present at least one direct relationship between a trait and a feeding characteristic (for instance, the relation between the predator and the prey size). The search equation was divided into three distinct components. (1) *Feeding Characteristics*: This component focused on selecting articles based on specific feeding characteristics (Table 1.a). (2) *Direct traits*: This component targeted articles based on the presence of direct traits (Table 1.b). (3) *Taxonomic Groups*: This component included keywords unique to each taxonomic group (Table 1.c). Although not all ground beetles are predators, with some being granivorous and considered notable crop pests (e.g., *Zabrus tenebrioides* (Honek et al. 2007)), we included these beetles under the assumption that their seed consumption contributes to pest control by limiting weed populations. We tested the consistency of the response comparing granivorous and carnivore ground beetles (figure S1). To ensure a comprehensive search, we developed a thesaurus for each of the three components. The search equation was executed independently nine times for each of the different target groups. Targeted articles should present the following criteria: the biological model studied belonged to one of the targeted arthropod predator orders/families, and a direct relationship between a feeding characteristic and a trait was observed. Feeding characteristics were considered any quantitative or qualitative information regarding the feeding behavior of individuals or populations, including prey morphology or the quantity of food ingested. Characteristics related to the nature of what is consumed, the quantity consumed, or the method of consumption were all included.

### Articles selection

Articles selected by the search equation were initially screened based on their title and abstract (Fig. 1). Titles were used to exclude articles that did not pertain to the

selected taxa (i.e., Carabidae, Staphylinidae, Araneae, and Chilopoda). Abstracts were then evaluated to ensure they met criteria. Articles were retained if there was any doubt about meeting at least one of the selection criteria. Each pre-selected article was then fully read (Fig. 1), and only those presenting a statistical relationship between a trait and a feeding characteristic were selected. Traits included any quantification of morphology, behavior, or population characteristics.

### Articles reading grid

To summarize the relationships between traits and feeding characteristics, we created a standardized data extraction grid. This grid listed all relationships between a single trait and a single explanatory variable related to feeding characteristics (Fig. 1). Consequently, multiple relationships were often obtained from a single article (e.g., Saska et al. (2019) described relationships with two traits: body size and body mass). The extraction grid also gathered general information such as the publication date, authors, taxonomical information on the predator model, information on feeding characteristics measured, and prey biological model when available. More specific information related to the biological proxy was collected, including the nature of trait, the nature of the statistical relationship, its significance, and the direction of the relationship when applicable. To discuss the methodologies used to create relationships between traits and feeding characteristics, we also noted whether the data were obtained through experiments or from literature.

### Characterization of the relationships

#### Creation of traits and functional expression classes

Traits that conveyed similar information were grouped. For instance, isometric growth correlations exist between body part traits (Moretti et al. 2017), such as those between morphological body part traits in carabid beetles (Ribera et al. 1999) or between body size and body mass in spiders (Penell et al. 2018). We categorized traits into classes according to their nature and expected functional signals. These classes were based on the trait classes described by Moretti et al. (2017) but we modified the original twenty-nine classes into twelve trait classes to fit our data. These twelve classes included any trait conducted at the individual or population level surveyed in the review. Feeding characteristics provided direct or indirect information on nutrition, but only those with direct information were retained. For example, spider web characteristics were considered indirect and thus excluded from the analysis. Feeding characteristics were classified into three classes (Fig. 1): (1) prey morphology (morphology), (2) predator trophic guild (trophic

**Table 1** Number of articles provided by the keyword association in the Web of Science Core collection database from the 01-01-1970 to the 01-02-2023 and the number of articles selected for the analysis: all over the taxonomical groups with the first part related to the feeding characteristic keywords (a), the trait keywords (b), and keywords for each of the taxonomical groups (c), the number articles of provided by the research word equation (d) and the number of selected articles (e)

Equation part one: feeding characteristics a.	Equation part two: Trait b.	Equation Part three: Taxonomical group c.	Number of articles d.	Number of selected articles e.
Feed* OR food OR prey OR predat* OR regulat* OR control OR diet OR trophic OR *vore OR seed OR *phagous OR *phagous OR natural NEAR/0 enem* OR consumption OR preference* OR hunt* OR mas-ticat* OR eat* OR forag* OR *search OR explor* OR inspect* OR invest* OR parasite* OR ((Auxiliary OR ancillary) NEAR/0 (crop OR culture)) OR attack OR laceration OR bite OR chew OR devour OR swallow OR digest OR supply OR sting OR prink OR catch OR capture	Amount OR amplitud* OR analys* OR anatomy OR architecture OR area OR arrangement OR aspect OR attribute OR breadth OR bulk OR cafeteria OR capac* OR character* OR choice OR clout OR com-plex OR component OR configuration OR conforma-tion OR construction OR content OR decision OR density OR design OR detection OR determination OR diameter OR dimension OR discrimination OR distance OR duration OR evaluation OR experiment* OR extent OR force OR format* OR frame* OR frequene* OR height OR invest OR largeness OR length OR limit OR magnitude* OR mark OR mass OR measure* OR morphol* OR network OR number OR option OR order OR organization OR preference OR proportion OR quality OR quant* OR ration OR size OR strength OR structure OR study OR sum OR system OR test OR thickness OR volume OR weight OR width	(carab* OR "ground beetle" OR "insect adephage spider* OR arane* OR arachnid* chilopod* OR centipod* OR myriapod* staphylini* OR "rove beetle")	4538 24,141 655 1317	18 39 2 2

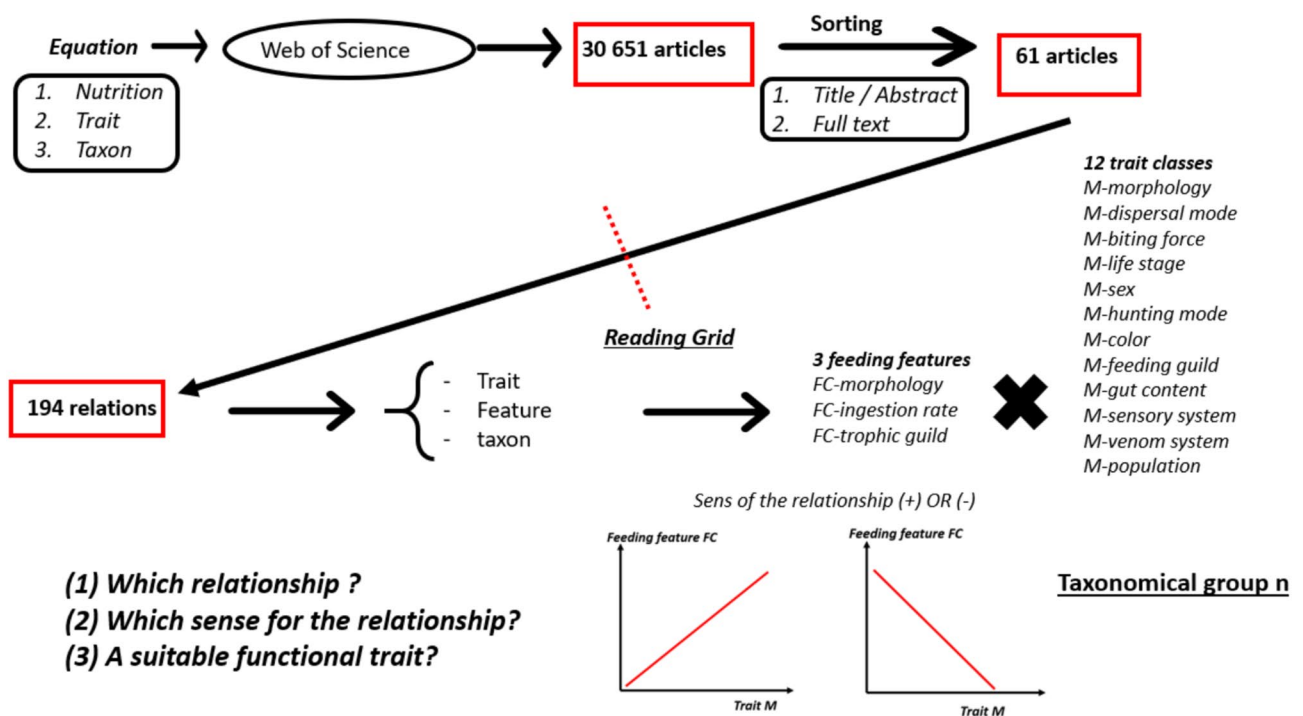


Fig. 1 Diagram of article selection process and information retrieved from articles

guild), and (3) predator ingestion rate (ingestion rate). These classes were expected to provide relevant information on trophic interactions within an ecosystem, predicting both the nature and quantity of consumption according to the predator assemblage.

### Characterization of traits and feeding characteristics at the community level

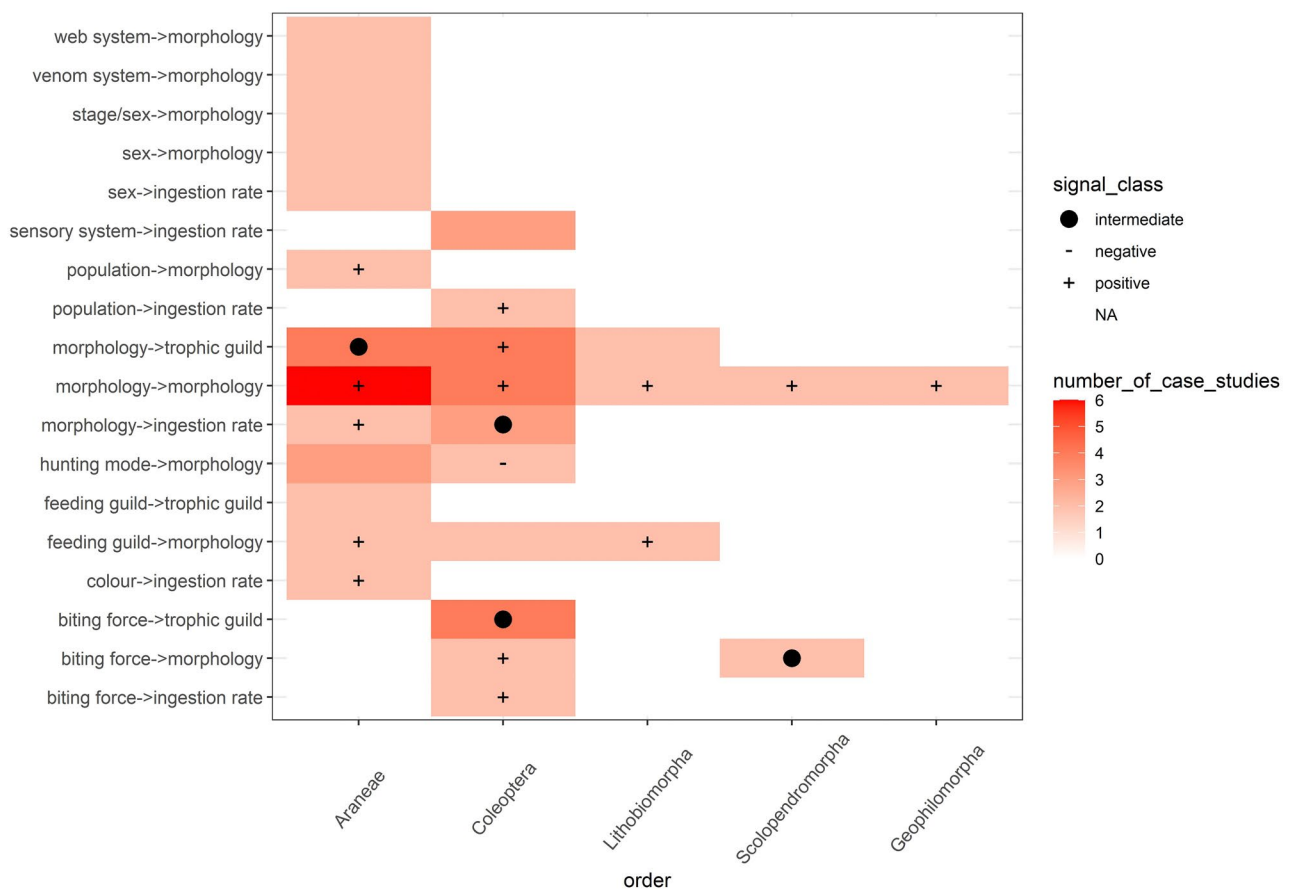
Based on the reviewed literature, we analyzed potential pairwise relationships between the twelve trait classes and the three feeding characteristic classes, along with their direction for each order separately (Fig. 1). We first separated qualitative and quantitative relationships, focusing solely on quantitative ones to establish a framework for using common functional traits to characterize the pest control potential of multi-taxonomic predator assemblages. Among the one hundred ninety-four case studies examined, 23% were qualitative and were thus excluded from the analysis of relationship direction. We characterized relationships by their direction (i.e., positive, negative, or non-significant) using a 90% threshold: positive if > 90% of studies were positive, negative if > 90% were negative, or insignificant in all other cases. To justify the strength of the examined relationships, we also counted the number of studies in which each relationship appeared. A detailed analysis was conducted on morphology traits and morphology feeding characteristics relationship. Finally, we examined the relationships for

different families within Coleoptera and Araneae, the two most studied orders in the reviewed literature, focusing on the relationship between morphology traits and morphology feeding characteristics.

## Results

### Bibliographic research

The search equation yielded a total of thirty thousand six hundred and fifty-one articles across the four taxonomical groups (Table 1). Despite the high number of articles initially identified, only sixty-one articles (less than 1%) were deemed suitable for detailed analyses (Table 1). Of these, thirty-nine articles (63.9%) focused on spiders, eighteen (29.5%) on ground beetles, two (3.2%) on rove beetles, and two (3.2%) on chilopods. From these articles, we extracted a total of one hundred ninety-four pairwise relationships at either the individual or population level. These relationships were categorized into three feeding characteristic classes: one hundred and two (52%) focused on morphology, sixty-three (32%) on trophic guild, and twenty-nine (14%) on ingestion rate. Most traits concerned the morphology, totaling one hundred and seven (65%). In terms of the prey studied, one hundred seventy-five relationships (90%) involved arthropod prey, while nineteen (10%) involved weed seeds (consumed only by ground beetles). Experimental traits were



**Fig. 2** The number of relations between a given trait class and a feeding characteristic class all over the taxonomical orders with the information of the sense of the relationship for the quantitative rela-

tion. The sense of the relationship is indicated by + when positive, by – when negative and by O when there is no consensus on the meaning of the sense of the relationship

the primary data source, with only twelve relationships (6%) derived from literature.

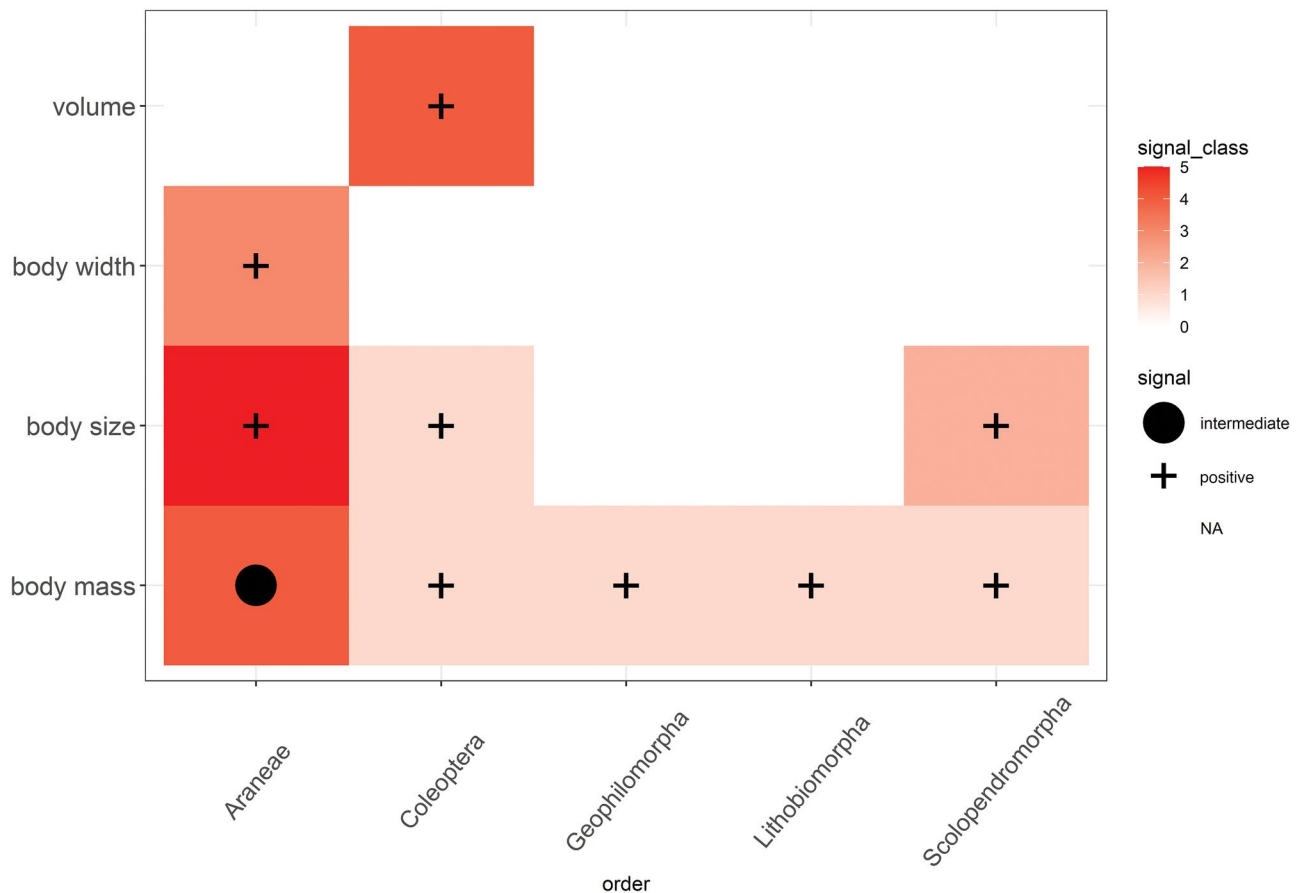
### Relationship between traits and feeding characteristics at the order scale

Among the thirty-six potential pairwise relationships (12 Traits  $\times$  3 Feeding characteristics), twelve were observed (Fig. 2). The three feeding characteristic classes were not equally related to the trait classes, with the feeding characteristic morphology related to nine classes, ingestion rate to six, and trophic guild to three.

The feeding characteristic morphology emerged as a common trait anchor across all arthropod taxonomic orders, being analyzed in all five orders (Fig. 2). In some under-represented groups, such as Scolopendromorpha and Geophilomorpha, it was the only class studied. For Araneae, morphology represented 60% of the case studies, with eight trait classes providing relevant information (Fig. 2). For Coleoptera, morphology accounted for 28% of the case studies, with 4 trait classes contributing data (Fig. 2).

Morphology traits was overrepresented in explaining prey morphology, accounting for seventy-four (72%) of the one hundred and two case studies. In all taxonomic orders where the feeding characteristic morphology was studied, morphology trait was consistently included, and the relationships were always positive (Fig. 2). There were also relationships between morphology and ingestion rate, representing 7% of the total relationships, with fourteen observed relations (ten in Coleoptera and four in Araneae).

The morphology class included four different traits: body size, body mass, volume, and body width. The usage of these traits varied across the five taxonomic orders. Body mass was used in all five orders, body size in three orders (Coleoptera, Araneae, and Scolopendromorpha), body width only in Araneae, and volume only in Coleoptera (Fig. 3). Among the 74 relationships between morphology trait and morphology feeding characteristic, body size was the most commonly used trait (44%, thirty-three relationships). Body mass was the second most used trait (27%, twenty relationships), followed by volume (16%) and body width (12%). The relationships were consistently positive for each trait and taxonomic



**Fig. 3** The number of relations between the biological trait from the predator morphology class and the morphology feeding characteristic class according to the taxonomical orders. The sense of the relation-

ship is indicated by + when positive, by – when negative and by O when there is no consensus on the meaning of the sense of the relationship

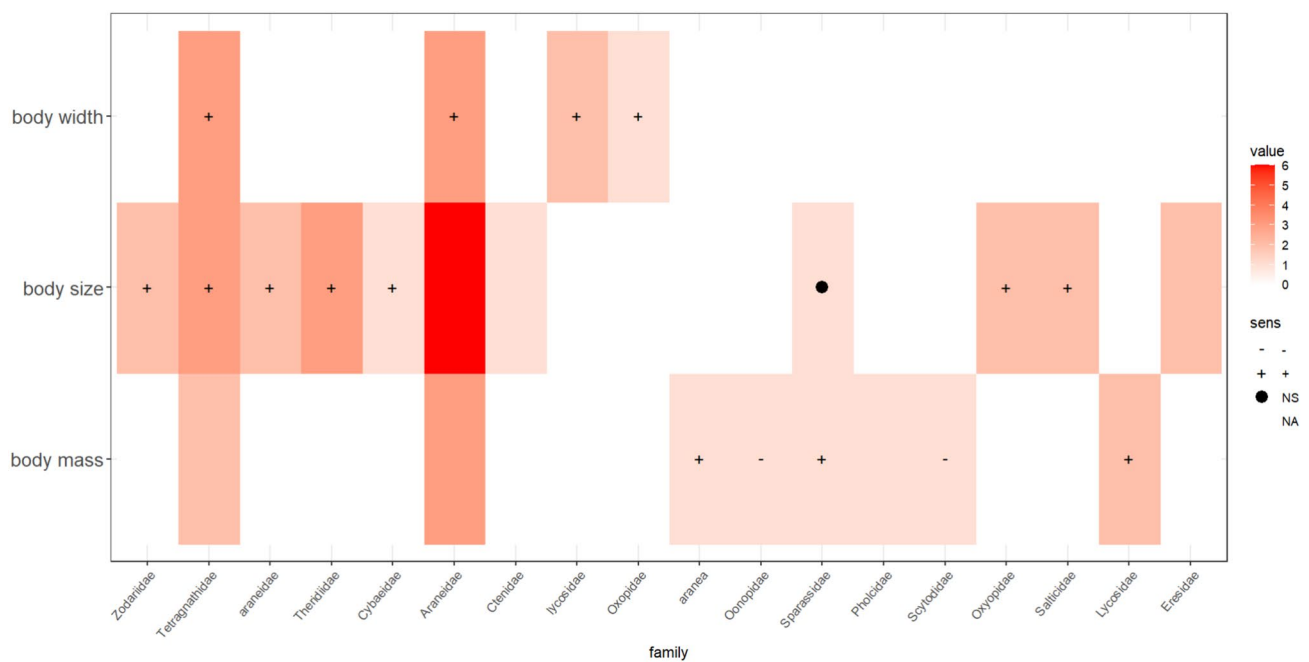
order, except for body mass in Araneae, which showed heterogeneous signals between morphology trait and morphology feeding characteristic among families (Fig. 3).

### Relationship between feeding traits at the family scale

At the family scale within Araneae and Coleoptera, heterogeneous signals were observed. Within Araneae, the direction of the relationship between body mass and morphology feeding characteristic varied among families: two families showed a negative relationship, while three showed a positive relationship. For body size, which accounted for 53% of the relationships, the signal was positive for seven families and mix for one (Fig. 4). In Coleoptera, three raw traits were used: volume (60%), body mass (25%), and body size (15%). All relationships were positive between morphology trait and morphology feeding characteristic (Fig. S2).

### Discussion

Reviewing the existing literature on the relationships between feeding traits of ground-dwelling arthropod predators in agricultural systems highlights a common functional description of multi-order community and research gaps. Araneae and Carabidae are the most studied taxa, while research on other groups remains insufficient. Regardless of the order or family, the most studied functional characteristics associated with feeding are linked to morphology, particularly prey size and there is an explicit link with the predator body size. Despite the increasing use of trait-based approaches in ecology and integrated pest management, the literature predicting predator–prey interactions with arthropod predator traits remains surprisingly limited.



**Fig. 4** The number of relations between a trait from the predator morphology class and the morphology feeding characteristic for families belonging to the Araneae order. The sense of the relationship is indicated by + when positive, by – when negative and by O when there is no consensus on the meaning of the sense of the relationship

### Body size is positively related to the prey morphology

Results from the literature review indicated that the primary studied relationship for all taxonomic orders was between predator and prey morphology. Such relationship is expected, as predator choice of prey is influenced by their morphology (Wainwright and Richard 1995). Morphology of the predator, often corresponding to its total body length, being positively correlated to the prey size (Gripshover and Jayne 2021). For all taxonomic orders, the predator morphology (its body size mainly in this work) was positively related to prey morphology. This relationship aligns with the energy requirements associated with individual size (Blanckenhorn 2000). It has been demonstrated that metabolic rate is positively correlated with size or mass across many taxonomic orders (Frears et al. 1996; Hack 1997; Glazier 2009). Therefore, larger predators are likely to prefer prey with higher energy content. This positive prey–predator size relationship has been highlighted for various taxa other than arthropods, including forest shrews (Churchfield et al. 1999), common toads (Crnobrnja-Isailović et al. 2012), and several pelagic fishes (Bachiller and Irigoien 2013). Typically, a change in predator size range corresponds to a change in prey size range (Costa 2009). This review highlights that different soil predator arthropod orders

also follow this rule, making prey range prediction easier based on predator community size distribution. The significant signal between predator morphology and prey morphology is however driven by the type of traits most commonly used in the literature, where predator size is relatively easy and less time-consuming to measure than other traits also related to feeding, such as eye morphology or biting force (Moretti et al. 2017). In addition, the expansion of functional databases has made body size more accessible as a functional trait (Hedde et al. 2012). Similarly, prey morphology remains over-analyzed due to its accessibility, but other important parameters, such as prey nutritional quality or behavior, should also be considered (Schmidt et al. 2012).

Although the predator–prey morphology relationship is observed across taxa, it is only exemplified by one study for some taxa, such as chilopoda and rove beetles. Additionally, studies on arthropod feeding characteristics often use cafeteria experiments (Schatz et al. 2001). These experiments offer a limited range of resources, which may not fully encompass the complexity of prey–predator relationships, necessitating cautious extrapolation from results (Pérez-Harguindeguy et al. 2003).

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## Toward a multi-taxonomic consideration of biological pest control potential

Our review suggests that individual body size can serve as a common trait to obtain information on the prey morphology range eaten by a predator community. Although the prey morphology is function of a set of predator trait (Potapov 2022), the predator body size will partly predict the range of prey sizes consumed. The use of morphological traits for characterizing plant communities is well established (Eric and Navas 2013). Similar traits allow comparisons across different taxonomic orders (Bramley-Alves et al. 2015; Silva et al. 2015). Although less established for terrestrial arthropods, previous studies have used multiple trait analyses to address land use impacts on arthropod communities (Birkhofer et al. 2017; Le Provost et al. 2020). For example, the trait matching between plants (leaf features) and arthropods (mouthparts) has been described (Deraison et al. 2015; Le Provost et al. 2017). However, traits as proxies for pest control functions are still needed. Following plant community approaches, traits should meet four conditions to be considered as functional proxies: (1) related to a function, (2) easy to measure, (3) standardized, and (4) consistently ranked between species (Lavorel et al. 2007). Body size constitutes a good candidate trait for predicting the prey biomass consumption by arthropod predators and crop pest control. Body size trait is easy to measure, and this trait can be standardized across multiple taxonomic groups (Moretti et al. 2017). While standardized protocols for body size measurement exist for Araneae (Gasnier et al. 2002), more standardized protocols are however needed for other taxonomic orders, such as ground beetles (Moretti et al. 2017) since the methodology used to measure body size can vary from one study to the other. Indeed, some studies used the total body length to characterize body size (Duan et al. 2019) while other studies considered proxies such as the size of elytra for ground beetles (Sukhodolskaya 2016). The ranking between species or individuals is therefore biased leading universal measure protocol required.

Summarizing direct relationships between traits and feeding characteristics reveals that predator size can provide information on prey morphology for most orders. The presence of such relationships across taxa suggests a methodology for transitioning from taxonomic to functional assemblages. Measuring predator body size can therefore allow to predict prey biomass consumed and the characterization of trait distribution and diversity among predator communities may then be used as a first approximation to quantify the potential pest control delivered in agricultural areas by multi-orders assemblages (Letourneau et al. 2009). As a first step, our study seeks to develop a functional characterization of predator–prey relationships, considering multiple

taxonomic groups. This foundational work will pave the way for future research to move toward a quantitative evaluation of pest control potential by these assemblages. This study can serve as a basis for proposing an initial approach to predicting the range of prey sizes consumed. It will then be necessary to supplement this relationship with multi-trait studies to specify the nature of the prey and the quantity consumed, based on the functional description of the predator communities. Such quantitative approach may be particularly useful when analyzing data on the diversity and abundance of ground-dwelling arthropods.

Information about prey type can aid in understanding predator interactions, such as competition or intraguild predation, which can impact pest control (Letourneau et al. 2009). Functional trait diversity generally improves predation level predictions (Greenop et al. 2018). However, there is not enough mathematical quantification of the relation between predator and prey body size. A detail of this relation is needed for each taxonomical group in order to go further in this functional way and additional research for each taxonomical group is therefore mandatory. Moreover, there is no consensus on the number and type of traits needed for accurate pest predation predictions. In some cases, single-trait indicators are the most reliable (Rusch et al. 2015; Ceia et al. 2023), while multiple trait indices are more appropriate in others (Barbaro et al. 2017).

## Limits and perspectives

In addition to indicating prey morphology, body size is positively related to ingestion rate for both Coleoptera and spiders. This relationship suggests that larger predators consume more and thus have higher pest control potential. Since metabolic rate is linked to energy requirements, larger individuals are expected to feed more, providing higher pest control (Rouabah et al. 2014). However, too many large individuals can lead to intraguild predation, reducing pest control potential (Letourneau et al. 2009; Rusch et al. 2015). An optimal predator community for pest control may be characterized by diverse functional traits and a wide range of prey sizes rather than a less diverse community of large individuals (Rusch et al. 2015). Increasing the diversity size of the predator will increase the size range of the prey despite a decrease in the amount of prey consumed in each size class. This approach therefore favors pest control through diversified control rather than intense control over a narrower range of prey. This assumption holds when increased predator size does not lead to increased prey size range, as demonstrated in some cases (Rouabah et al. 2024). For both prey morphology and ingestion rate, analyzed prey mainly belongs to other arthropod groups (Diptera, Collembola, Hemiptera, Isoptera, or Orthoptera) or weed seeds. Our study presents a new characterization of pest control. Indeed, our study

highlights the need to consider predator diversity in order to maximize the diversity of prey potentially consumed. Based on the relationships observed in this study, we can then propose a new characterization of pest control potential that focuses on the quality of pest control (i.e., the diversity of pest species consumed). This innovative tool has several advantages: (1) it encompasses a wide range of arthropod predators, and (2) it focuses on the functional characterization of the assemblage. Consequently, the prey size range consumed by a community depends on both predator size and taxonomic order. Changes in predator size range without taxonomic structure changes result in corresponding changes in prey size range (Costa 2009). Communities with similar taxonomic structures but different predator size distributions will likely consume prey of different sizes.

Although the signal between the predator and the prey morphology is consistent at the order scale, at the family level, this relationship is not always observed, such as for spiders. This result is consistent with previous studies showing that the predator taxonomy can determine the prey–predator size relationship (Miller-ter Kuile et al. 2022). Despite a linking point with the predator body size, differences between taxa suggest that considering the taxa identity or the phylogeny can help to better predict predator–prey interactions (Brousseau et al. 2018). However, considering other traits involved in predator–prey relationships beside body size may overcome these taxonomic differences and help to generalize predator–prey trait matching. While we found a strong relationship between prey and predator size, other traits can predict predator–prey interactions (Brousseau et al. 2018; Potapov 2022). For example, for predator ground beetles, feeding habits and mouthpart morphology is strongly affecting the range of the prey size (Forsythe 1983; Slifer 1970). When considering the phylogeny of predators and preys, a strong relationship between predator biting force and prey cuticular toughness has been identified, and this trait matching had a higher predictive power than the commonly used predator–prey size ratio (Brousseau et al. 2018). Our study is a first step in identifying body size as one of the traits of interest, but future research is clearly needed to determine other functional traits missing in the characterization of the prey–predator relationship. Indeed, differences in feeding strategy between groups make it difficult to understand prey–predator relationships using a single-trait approach.

Another aspect to consider is the probability of meeting between predator and prey. In this way, the spatial distribution of the predator is a key issue in the understanding of the pest suppression (Schellhorn et al. 2014). Predator is limited in their mobility by the structure of the farming environment (Östman et al. 2009) and low predator mobility reduces the likelihood of predator–prey interaction in disturbed environment. While dispersal capacities are often related to predator

size (Neame and Galpern 2025), body size is an integrative trait associated with many other functions that may trade-off with dispersal such as metabolism or stoichiometry (Brown et al. 2004; Hillebrand et al. 2009; Le Provost et al. 2020). In addition, dispersal capacities vary according to the taxonomical order with very long distances that can be covered, for example, by spider using the ballooning behavior (Lee et al. 2015). Hence, considering traits associated with dispersal that determines the spatial distribution of predators and preys should be considered to better predict prey–predator interactions.

## Author contributions

Eugène Maurey, Benjamin Bergerot, and Gaël Caro were conceived the ideas and methodology. Eugène Maurey, Benjamin Bergerot, Théo Brusse, Gaëtane Le Provost, Vincent Le Roux, Ronan Marrec, and Gaël Caro were collected the data. Maurey Eugène was analyzed the data. Eugène Maurey, Benjamin Bergerot, Théo Brusse, Gaëtane Le Provost, Vincent Le Roux, Ronan Marrec, and Gaël Caro were edited the manuscript.

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## Declarations

**Competing interests** The authors declare no competing interests.

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