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Diet and trophic interactions in an introduced population of the Moorish gecko, *Tarentola mauritanica* (Linnaeus, 1758), of central Chile

Claudio Reyes-Olivares[1], Benjamín Salinas[2], Juan Valdivia-Villagra[3], León Chávez-Jofré[4], Fernanda Alarcón-Toledo[2,5], Tomás Miquio-Portell[2], Rocío Olate-Ávila[6], Carezza Botto-Mahan[2,7]

1 *Escuela de Medicina Veterinaria, Facultad de Medicina Veterinaria y Agronomía, Universidad de Las Américas, Manuel Montt 948, Providencia, Santiago 7500975, Chile*
2 *Laboratorio de Ecología de Interacciones, Facultad de Ciencias, Universidad de Chile, Ñuñoa, Santiago 7800003, Chile*
3 *Facultad de Ciencias de la Vida, Universidad Andrés Bello, Santiago, Chile*
4 *Centro de Ecología Aplicada (CEA), Santiago, Chile*
5 *Laboratorio de Parasitología y Enfermedades Parasitarias, Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, La Pintana, Santiago, Chile*
6 *IDMA - CFT Medio Ambiente, Santiago, Chile*
7 *Research Ring in Pest Insects and Climate Change, Santiago, Chile*

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Corresponding author: Claudio Reyes-Olivares (creyeso@udla.cl)

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Abstract

Exotic species impact native biodiversity, with alien lizards acting as direct predators and indirectly as prey for other alien species (i.e., trophic subsidies). *Tarentola mauritanica*, a gecko introduced in Chile, lacks ecological data, complicating threat assessment. It is described as eating arthropods and lizards, and as a trophic subsidy for invasive mammals (e.g., cats) in its native range. Here, we evaluate diet and food availability between two seasons (spring and summer) and identify potential and effective predators in Santiago, Chile. The diet was analysed based on stomach contents, food availability from arthropod traps, and predator occurrence, using an integrative approach that combined faunal surveys, literature, citizen science, fieldwork, camera-traps, and faecal analysis. *Tarentola mauritanica* has an insectivorous diet that varies between the sampled seasons, consuming mainly Lepidoptera in spring and Coleoptera in summer, with no native lizard prey detected. A mismatch between diet dominance and environmental dominance was observed, which is consistent with some degree of selectivity. Twelve potential predators, primarily birds, were identified, and cats were confirmed as probable predators through the integrative approach. The gecko is mainly insectivorous, and seasonal selective foraging could affect arthropods, especially in urban areas with lower prey diversity and abundance. No native lizards were detected in its diet, but monitoring is advised due to its known saurophagous behavior. The data indicate that cats are probable predators; however, the highly localised scope and exploratory nature of the predator component warrants further evaluation. These findings enhance our understanding of community dynamics and the potential trophic impacts of *T. mauritanica* in Chile.

Key Words

biodiversity loss, biological invasions, Coleoptera, Embioptera, *Felis catus*, Lepidoptera, *Liolaemus tenuis*, trophic ecology

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PENSOFT

Introduction

Biological invasions are a consequence of increasing human population and globalization (Meyerson and Mooney 2007; Turbelin et al. 2017; Pyšek et al. 2020; Roy et al. 2024). The number of invasive alien species (IAS) expanding into non-native regions, impacting the environment and economy, is rising (Dickey et al. 2018; Seebens et al. 2018; Pyšek et al. 2020). Their ecological impacts are evident at multiple ecosystem levels (Ricciardi et al. 2013; Blackburn et al. 2014b; David et al. 2017; Blackburn et al. 2019). These impacts depend on factors like IAS taxa, abundance, and trophic level (Hejda et al. 2009; Ricciardi et al. 2013; Blackburn et al. 2014a; Bradley et al. 2019) and are influenced by mechanisms such as predation, competition, parasites, disease transmission, and trophic interactions (Blackburn et al. 2014a; Kraus 2015).

Alien lizards are intriguing for studying potential community impacts because they occupy intermediate trophic levels (Spiller and Schoener 1994), and thus can influence native species through both 'top-down' and 'bottom-up' control (Kraus 2015). Predation is a primary form of top-down control by lizards (Dunn and Hatcher 2015; Kraus 2015). Most lizards are generalist insectivorous predators that can impact native communities in new areas (Makihara et al. 2004; Huang et al. 2008; Abe et al. 2011). For instance, the alien lizard *Anolis carolinensis* Voigt, 1832 preys on native pollinators in Japan, allowing introduced bees, *Apis mellifera* Linnaeus, 1758—mainly pollinators of exotic plants—to increase the invasion rate of these plants indirectly (Abe et al. 2011). Additionally, many alien lizards prey on native vertebrate eggs or juveniles (e.g., Cole et al. 2005; Dame and Petren 2006; Hoskin 2011), leading to declines in these vertebrate populations (Lal and Nadim 2021). Considering that alien species contribute to the global decline in insect (Sánchez-Bayo and Wyckhuys 2019) and vertebrate populations (e.g., reptiles; Lal and Nadim 2021), evaluating the diet of introduced exotic lizards can clarify their role in local and global declines of these groups.

Alien lizards also exert bottom-up control through trophic subsidies that support alien predators and affect indirect native populations (Kraus 2015). For example, in Guam, invasive lizards such as *Carlia ailanpalai* Zug, 2004 and *Hemidactylus frenatus* Duméril & Bibron, 1836 are abundant and exhibit high recruitment rates. These traits support the population of an invasive predator, the brown treesnake [*Boiga irregularis* (Bechstein, 1802)], which has been depleting native vertebrate populations (Rodda and Fritts 1992; Fritts and Rodda 1998). As a result, native species face high predatory pressure, which has impeded their demographic recovery (Kraus 2015). It is therefore essential to recognize this trophic interaction among alien species to understand how populations of larger and more intense exotic predators are sustained.

The Moorish gecko, *Tarentola mauritanica* Linnaeus, 1758 (Squamata, Phyllodactylidae), is native to the Mediterranean Basin (Harris et al. 2004; Rato et al. 2016) where it exhibits highly anthropophilic habits, a trait that has aided its spread by human facilitation into new regions (Salvador 2015): the islands of Tenerife, Madeira, and the Balearic Islands (Mizerakis and Strachinis 2017), the Azores (Barreiros et al. 2010), and Bulgaria (Jablonski et al. 2022), in Europe, as well as American countries: Argentina (Achaval and Gudynas 1983; Díaz-Fernández et al. 2019), Chile (Arredondo and Núñez 2014), the USA (Mahrdt 1998), Mexico (Ortiz Medina et al. 2019), and Uruguay (Achaval and Gudynas 1983; Baldo et al. 2008).

In Chile, *T. mauritanica* was first identified in 2005 in the urban area of the San Miguel district, Santiago, Metropolitan Region (Arredondo and Núñez 2014), where it is considered a naturalized species (Fuentes et al. 2020) and has not yet been recognized for its impacts on local biodiversity. This species possesses characteristics that could affect native fauna, either through predation or indirectly via trophic subsidies (Demangel 2016). On the one hand, in its original distribution, this gecko is a generalist insectivore that can occasionally eat lizards (Salvador 2015; Speybroeck et al. 2016). It has been observed feeding on various groups of invertebrates, mainly beetles, arachnids, hymenopterans, and lepidopterans, which range in size from 0.5 to 42.0 mm (Salvador 2015), with an observed success rate of 9 captures out of 19 attempts (Pérez-Mellado 1994). Among vertebrate prey, it occasionally eats lizards [e.g., *Podarcis lilfordi* (Günther, 1874), *P. hispanicus* (Steindachner, 1870), *P. liolepis* (Boulenger, 1905), *Hemidactylus turcicus* Linnaeus, 1758], including some from its own species (reviewed by Bauer 1990; Salvador 2015; Speybroeck et al. 2016). Moreover, *T. mauritanica* is known to be prey for various birds, mammals, and reptiles within its original range (reviewed by Salvador 2015), including dangerous invasive predators such as domestic cats (*Felis catus* Linnaeus, 1758) (Martínez Rica 1974; Millan 2010). In Chile, we can find these potential invasive predators (Iriarte 2008), suggesting that *T. mauritanica* might become a trophic subsidiary of them, especially in central Chile, where most of the country's invasive species are concentrated (Fuentes et al. 2020).

In Chile, unlike in its native range, the diet composition and potential predators of *T. mauritanica* remain largely unknown. There are no records regarding what type of prey is being consumed or if native lizards are part of its diet. Only juveniles of sympatric native lizard species, such as *Liolaemus* lizards (Huerta-Vera 2016; Díaz-Vega et al. 2020), are identified as potential occasional prey for this gecko (Demangel 2016). Lizards are of interest for conservation, as most are classified in some conservation category in Chile (Ruiz de Gamboa 2020). Similarly, it remains uncertain which predators effectively prey on this gecko. Only domestic cats have been identified as animals that would attack them (Arredondo and Núñez 2014). Considering this background, the present study aims to identify and characterize the prey and potential/effective predators of *T. mauritanica* in the urban

population of the San Miguel district, where the densest population of the Moorish gecko in Chile exists (24 ind/ha), inhabiting in sympatry with *Liolaemus* lizards and relatively abundant potential exotic predators (e.g., domestic cats; Arredondo and Núñez 2014; Díaz-Vega et al. 2020). This initiative will facilitate the recognition of potential impacts on native biodiversity, primarily through predation and trophic subsidy mechanisms. The following research questions are addressed: (1) What is the diet composition of *T. mauritanica* in Chile? (2) Does this gecko consume lizards in Chile? (3) How does diet relate to seasonal prey availability? (4) Who are the potential and effective predators of this gecko in Chile? Answering these questions is crucial for evaluating the community dynamics associated with the invasive process of *T. mauritanica* in Chile.

Material and methods

Study model

Tarentola mauritanica is a gecko that can grow up to 19 cm in total length (Salvador 2015) and is mainly active at night. Nonetheless, it has been observed basking in the sun during the daytime (Speybroeck et al. 2016). It inhabits rocky areas and human-made environments, often found on walls. Its lamellae on the toes allow it to move effortlessly across various surfaces, including vertical ones (e.g., walls; Speybroeck et al. 2016).

Study site

The study was conducted during the spring and summer seasons in Ciudad del Niño, San Miguel district, Santiago (33°30'47.04"S; 70°39'2.25"W; altitude = 568 m), an abandoned former orphanage spanning approximately 12.5 hectares. Due to neglect, this area comprises several abandoned and deteriorating buildings, sparse tree cover, and large grass-covered open spaces. Here, geckos are primarily sighted on the walls of abandoned buildings, as well as on the ground nearby (Díaz-Vega et al. 2020).

Diet analysis

We manually captured 31 geckos (18 females and 13 males) in the spring (October 2023) and 32 geckos (15 females and 17 males) in the summer (February 2024) to characterize their diets across seasons. Although the sample size may be modest for detecting rare prey (e.g., native lizards), it will provide a preliminary estimate of the diet of a population of *T. mauritanica* in Chile. We analysed diet composition by examining stomach contents collected using a modified version of the gastric suctioning protocol established by Barreto-Lima (2009): a 0.5 mm caliber tube was inserted into the animal's mouth until it reached the stomach. A small amount of saline solution (0.2–0.3 ml; 0.9% NaCl) was then slowly drained from a previously collected 0.1 ml syringe. The stomach contents were suctioned, then slowly aspirated, and then transferred and fixed in Eppendorf tubes containing 70% ethanol. This procedure was repeated up to three times for each individual. This method is regarded as a rapid and reliable method for collecting stomach contents immediately after capture, thereby preventing further degradation within the stomach (Barreto-Lima 2009).

We identified the sexes of the captured individuals by directly observing the cloaca, and we measured their snout–vent length (**SVL**) using a digital calliper (to the nearest 0.1 mm). All captured animals were transferred to the vivarium of the Laboratory of Ecological Interactions (**LEI** hereafter), Faculty of Sciences, University of Chile, where we sedated them with isoflurane by inhalation, then euthanised with an intracoelomic injection of 0.5% sodium thiopental (100 mg/kg) and stored in this laboratory for future studies.

Fixed diet items were identified to the lowest possible systematic level using a 7–45× stereoscopic magnification, complemented with relevant literature (e.g., Klimaszewski and Watt 1997; Marvaldi and Lanteri 2005; Elgueta and Marvaldi 2006; Shepard 2009; Rengifo-Correa and González 2011; Beutel et al. 2013) and grouped into "operational taxonomic units" (hereafter OTU/OTUs). Items were counted and measured (length and width) with a digital tape measure (precision = 0.01 mm). We determined dietary item volume using a modified version of the spheroid equation (Vitt et al. 1996; Barreto-Lima 2009):

$$\text{Volume} = \frac{4}{3\pi}\left(\frac{\text{Length}}{2}\right)\left(\frac{\text{Width}}{2}\right)^2$$

Prey availability

The availability of prey was assessed at 10 points within the study area by capturing potential prey from adjacent concrete walls and ground. The methods used for capture were (Hódar et al. 2006): (1) Sticky traps, or adhesive strips made of strong cardboard for vertical mounting, with an adhesive surface approximately 19 × 6 cm (model 288-ICatchmaster®). These traps were placed on the walls at each site: five were set 0.5 m above ground level, and another five were set 1 m above ground level. The five traps at each height were spaced 2 meters apart. (2) Pitfall traps, 9 cm in diameter, were half-filled with water and detergent. Ten traps were arranged in a line along the walls at each of the 10 study locations, spaced 1 m apart. In summary, 100 sticky traps and 100 pitfall traps were placed simultaneously at each station for two consecutive weeks. Arthropods caught in the pitfalls were preserved in 70% ethanol. Prey captured in both trap types were identified at least to the order level using the same method applied to the dietary items.

Potential predator identification

We identified potential predators of *T. mauritanica* at the study site as those known to be lizard-eaters (saurophagous), omnivorous, or carnivorous. Thus, in October 2023, a survey was conducted to assess the richness, abundance, and density of vertebrate fauna (reptiles, birds, and mammals) and spiders (Arachnida, Araneae) living in sympatry. Spiders were included because they are known predators of lizards (Reyes-Olivares et al. 2020). The diets of the sympatric species were identified from the literature or from online photographic records. The collection of information on richness and abundance was carried out using a specific methodology for each taxon:

(1) Transects (reptiles, carnivorous mammals, and spiders): between 10:00 and 20:00 h, an active search for reptiles (*Liolaemus* spp. and *T. mauritanica*) and spiders was conducted along eight linear transects (100 × 20 m), distributed across the study area. Between 10:00 and 22:00 h, an active search for carnivorous mammals was conducted to collect direct and indirect evidence (i.e., footprints, bone remains, and faeces), covering eight fixed-width transects (100 × 40 m) that coincided spatially with the reptile and spider transects. The target species were domestic dogs (*Canis familiaris* Linnaeus, 1758) and cats, as they are exotic carnivores that inhabit the urban area of Santiago (Iriarte 2008; D'Elía et al. 2020). (2) Live-trap capturing (micromammals): omnivorous rodents were identified by capturing them using wire mesh live animal-traps (a collapsible box of 24 × 8 × 9 cm), baited with oatmeal mixed with vanilla extract and peanut butter. Sixty traps were set and left active for eight nights, arranged in six lines of 10 traps each across different areas of the study site, and checked every morning. The target species were omnivorous rodents reported from the city of Santiago: *Rattus rattus* Linnaeus, 1758, *R. norvegicus* Berkenhout, 1769, and *Mus musculus* Linnaeus, 1758 (Iriarte 2008; D'Elía et al. 2020). (3) Observation points (diurnal and nocturnal birds): between 8:00 and 12:00 h and between 17:00 and 20:00 h, the richness and abundance of diurnal birds were recorded for 20 minutes at eight fixed observation points spread across the study area, considering an observation range of approximately 30 m. The presence and abundance of nocturnal birds, mainly raptors, were assessed between 20:00 and 22:00 h by monitoring their behavioral responses (e.g., vocalizations, movements) to the playback of their sounds at four fixed points in the study area.

Effective predator identification

We aimed to identify effective predation events on *T. mauritanica* using an integrative weight-of-evidence approach, combining (1) literature records, (2) citizen-science observations, (3) field prospection evidence, (4) camera-trap records, and (5) faecal analyses:

(1) Literature records: an exhaustive literature review of predation records on *T. mauritanica* was conducted globally, distinguishing between countries within its native and invaded ranges, with emphasis on Chile. Peer-reviewed publications were searched through Web of Science, Scopus, Google, and directly in two herpetological journals focused on natural history: Herpetological Review (1967–2025) and Herpetology Notes (2008–2025). These journals were selected because they include numerous naturalist notes on cases of reptile predation. The search for publications was conducted using combinations of the following terms: "*Tarentola mauritanica*", "Moorish gecko", "predator", "consumed", and their variants in English, Spanish, French, Italian, and Portuguese. (2) Citizen-science observations: a survey on public sightings of *T. mauritanica* predation was designed using the Survio online survey system (Survey: https://www.survio.com/survey/d/F4C-4D2C8S2E4G8K1P). This included questions about the identities of the prey and predator, the date, time, and location of the sighting, and the frequency of sightings. The form asked respondents to classify prey as "gecko", "other lizard", or "not sure", and predators as "cat", "dog", "rat", other mammal", "lizard", "bird", or "other". Photographs of *T. mauritanica* and other native Chilean lizards found in Santiago were included to help people distinguish them, as these lizards are less well known than mammals or birds in Santiago. The selection of species noted in the survey was based on a literature review (see Results) and our knowledge of the most common urban predators observed in Santiago. The survey also provided a space for respondents to include additional information about their observations. It was active online between September and November 2023, and was disseminated through social media (e.g., Facebook groups, Instagram), institutions in the San Miguel district, and wildlife-specialized online groups: 'Reptiles de Chile RED (Registros, Educación y Difusión)' (https://www.facebook.com/groups/257430541577209), 'Flora, Fauna y Fungi Chile' (https://www.facebook.com/groups/617542534991537), 'Biodiversidad Chilena' (https://www.facebook.com/biodiversidadchilena). This methodology should be viewed as anecdotal support rather than as systematic evidence, due to the uncertainty surrounding public prey/predator identification (3) Field prospection evidence: between October and November 2023, a total of 300 h of field prospections were conducted during the most active hours of *T. mauritanica* at the study site (19:00–02:00 h; C. Reyes-Olivares, unpublished data). At least two observers actively searched with headlamps for predation events on geckos or indirect evidence of their consumption (e.g., corpse remains). The evidence was photographed with a Canon EOS Rebel T5 camera (Canon, USA). (4) Camera-traps: To document possible predation events on geckos, five camera-traps (Prime Low Glow Trail Camera, Bushnell Corporation, USA) were set up at preidentified

locations where more than 10 *T. mauritanica* individuals gathered. The traps remained active for one month. (5) Faecal analyses: faeces from carnivorous mammals were collected during transects and night prospecting to assess whether they contained gecko remains. These were stored in a Falcon tube containing 70% ethanol for subsequent analysis at the **LEI**. The faeces were broken up with distilled water and then analysed under a stereomicroscope (Zeiss Primo Star and Motic). If reptile bones were found, they were identified to the lowest possible taxonomic level, using osteologically relevant literature for *T. mauritanica* (e.g., Villa et al. 2018) and native reptiles of the study area (*Liolaemus* spp.; e.g., Lobo and Abdala 2002).

Data analysis

We calculated Index of Relative Importance (IRI) to estimate the importance of each prey category in the diet (Pinkas et al. 1971):

$$\mathrm{IRI} = \%\mathrm{O}(\%\mathrm{N} + \%\mathrm{V}),$$

where %O is the relative occurrence in a given category, %N is the relative number in stomach contents containing a given category, and %V is the relative prey volume of each category. We recorded only occurrences of shed skins and plant remnants found in stomach contents (see Results).

Intra-annual and sexual variation in diet composition was assessed using a permutational multivariate analysis of variance (PERMANOVA), based on Bray-Curtis distances, implemented with the *adonis2* function in the *vegan* package of R. Season (spring, summer), sex (male, female), and their interaction were included as fixed factors, with significance assessed using 999 unrestricted permutations. Individuals with empty stomachs were excluded from the multivariate analyses to avoid undefined dissimilarities. The homogeneity of multivariate dispersions between groups was evaluated using the *betadisper* function, followed by permutation tests to ensure that differences in dispersion did not skew the PERMANOVA results. To describe the contribution of individual categories to between-season differences in diet composition, a similarity percentage analysis (SIMPER) was performed in R. Besides, between the sampled seasons we assessed the breadth of the dietary niche (*B*) seasonally using the inverse of Simpson's diversity index (Simpson 1949):

$$B = \frac{1}{\sum_{i=1}^{n} p_i^2},$$

where *p* is the proportion of prey category *i* and *n* is the number of categories. Niche breadth values range from 1, indicating exclusive use of a single prey category, to *n*, representing equal proportional use of all *n* categories (Costa 2009).

We performed the G test of likelihood ratio to evaluate differences in OTU composition between the diet and the microhabitats (wall and ground) using the *Desctools* package in R. We evaluated the diversity of prey in the diet and in the environment (walls and ground) in each season using the Shannon-Weaver diversity index (Magurran 2013):

$$H' = -\sum_{i=1}^{S} p_i ln\,(p_i),$$

where p_i corresponds to the proportion of taxon *i* and *S* to the total number of recorded taxa. Taxa with a proportion equal to zero were not considered in the calculation. The differences in diversity among sources were evaluated at each station using a non-parametric bootstrap approach with 9,999 resamples, implemented in R using the *dplyr* and *tidyr* packages.

Additionally, we analysed prey selection based on the relative abundance of OTUs in the diet and arthropods available in the environment, using the selectivity index (E*) of Vanderploeg and Scavia (1979):

$$E^* = (r_i - s_i) / (r_i + s_i),$$

where r_i is the proportion of prey *i* in the stomach contents, and s_i is the proportion of the prey in the environment. This index takes values between -1 and 1 and can be interpreted as a deviation from random feeding (E* = 0) (Vacheva and Naumov 2024). Following Vacheva and Naumov (2024), the index values were interpreted as follows: E* > 0.5, preferred OTUs; 0.5 ≥ E* ≥ -0.5, neutral OTUs, i.e., diet proportional to environmental prey availability; E* < -0.5, avoided OTUs.

The density of all recorded potential predator species was calculated as: Density(ind/ha) = (Abundance /Total area of transects or bird points (m^2))10,000. The integrative weight-of-evidence approach for effective predators considers the presence or absence of evidence from each source, which was recorded as binary data (1 = present, 0 = absent). A cumulative evidence score was calculated by summing the scores from all sources. Predator species were subsequently classified as confirmed (≥ 3 evidence sources), probable (2 sources), or potential predators (1 source). Data manipulation was performed using the *dplyr* package in R. No inferential statistical tests were applied to predator identification because predation records were infrequent and opportunistic.

All statistical analyses were performed using the R program v. 4.5.2 (R Core Team 2025).

The Institutional Animal Care and Use Committee (CICUA) of the University of Chile reviewed and approved the animal-handling protocols used in this study (Certificate No. 23671 –FCS– UCH). The Local Biosafety Committee of the Faculty of Sciences of the University of Chile issued the Biosafety Certificate (2023_CLB_FC_UCH_027).

Results

Diet analysis

We obtained a total of 63 stomach content samples from 31 *T. mauritanica* individuals in spring (all adults, except one juvenile; mean **SVL** ± SD = 61.0 ± 5.9 mm) and 32 in summer (all adults, except one juvenile; mean **SVL** ± SD = 59.0 ± 4.9 mm). We found prey items in 12 of 31 (38.7%) individuals captured in spring, and in 17 of 32 (53.1%) individuals captured in summer. We identified 13 prey categories in both seasons. Insects were the primary food source, with ten prey categories, while other categories were other invertebrate groups (Chelicerata), keratophagy (consumption of gecko's shed skin), or plant remnants (Table 1). Keratophagy was observed in seven individuals. No evidence of native lizard remains were found in this sample. Plant remnants were observed in only one adult individual in the summer (Table 1).

Diet composition showed a marked seasonal shift in the dominant prey categories (Table 1). In spring, the diet was strongly dominated by Lepidoptera, which represented the main volumetric and relative importance component, while Embioptera and Isopoda contributed consistently but with much lower volumetric relevance (Table 1). In contrast, during summer, Coleoptera became the dominant prey item, replacing Lepidoptera as the most important dietary component (Table 1). Several prey categories were recorded exclusively in one season, such as Blattodea and Diptera in spring, and Chelicerata, Neuroptera, and Hymenoptera in summer (Table 1), indicating seasonal variation in prey availability and/or foraging behavior. Despite these changes, some prey groups, such as Isopoda and Dermaptera, were present in both seasons (Table 1), suggesting a stable secondary component of the species' diet.

In some OTUs (three in spring and four in summer), prey could be identified at a taxonomic level below order (Suppl. material 1). In spring, an individual of the infraorder Isoptera (Blattodea, Blattoidea) was identified, along with two adults and one larva of the family Noctuidae (Lepidoptera, Heteroneura), and an earwig of the species *Forficula dentata* J. Fabr., 1775 (Dermaptera, Forficulidae). In summer, four hemipterans, three from the suborder Heteroptera, one of which was identified belonging to the family Rhopalidae (Hemiptera, Pentatomorpha), and one from the infraorder Fulgoromorpha (Hemiptera, Auchenorrhyncha), four neuropterans from the family Chrysopidae (Neuroptera, Hemerobiiformia), two beetles from the family Carabidae (Coleoptera, Adephaga), four of the genus *Listroderes* (Coleoptera, Curculionidae), and two of the species *Monocrepidius* cf. *chilensis* (Coleoptera, Elateridae), as well as the earwig species *Euborellia annulipes* (H. Lucas, 1847) (Dermaptera, Anisolabididae) and *F. dentata*. The geographical origin of only a few specimens could be recognised; the order Embioptera and the earwigs *F. dentata* and *E. annulipes* were recognised as introduced in Chile (Román-de la Fuente 2025). In contrast, only the beetle *M.* cf. *chilensis* was recognized as a native species (Pineda and Francioli 2025) (Suppl. material 1).

The PERMANOVA did not detect significant effects of sex, nor a season × sex interaction, on diet composition ($p = 0.065$). Consequently, a reduced model was used, indicating that diet composition differed significantly between seasons but not between sexes. A new PERMANOVA revealed significant differences between seasons in prey composition (pseudo-$F = 3.36$, $R^2 = 0.11$, $p = 0.002$). Multivariate dispersion did not differ significantly between seasons (PERMDISP, $F = 1.10$, $p = 0.285$), indicating that differences were driven by changes in prey composition rather than by differences in dispersion heterogeneity. Indeed, the Simpson's Index of Breadth of Diet (B) values showed that *T. mauritanica*

Table 1. Diet composition of the gecko *Tarentola mauritanica* in spring and summer in an introduced population from Chile. O = total number of each prey category in stomach content; N = frequency of stomach content containing a given category; V = volume (mm^3) of each prey category; IRI = Index of Relative Importance. % = percentage value over total. - = Not calculated.

OTU	Spring							Summer						
	O	O%	N	N%	V	V%	IRI%	O	O%	N	N%	V	V%	IRI%
Blattodea	1	5.9	1	7.1	1.5	0.2	0.9	0	0	0	0	0	0	0
Chelicerata	0	0	0	0	0	0	0	4	11.4	3	13.6	4.1	3.0	5.7
Coleoptera	0	0	0	0	0	0	0	10	28.6	8	36.4	60.6	44.5	68.6
Dermaptera	1	5.9	1	7.1	35.4	5.2	1.5	2	5.7	2	9.1	52.8	38.7	8.1
Diptera	1	5.9	1	7.1	3.1	0.5	0.9	0	0	0	0	0	0	0
Embioptera	5	29.4	3	21.4	7.3	1.1	13.8	3	8.6	1	4.5	1.4	1.0	1.4
Hemiptera	1	5.9	1	7.1	1	0.1	0.9	5	14.3	3	13.6	8.8	6.5	8.5
Hymenoptera	0	0	0	0	0	0	0	1	2.9	1	4.5	1	0.7	0.4
Isopoda	3	17.6	2	14.3	34.3	5.0	7.1	4	11.4	2	9.1	3.9	2.9	4.1
Lepidoptera	5	29.4	5	35.7	604	88.0	75.8	2	5.7	1	4.5	0.8	0.6	0.9
Neuroptera	0	0	0	0	0	0	0	4	11.4	1	4.5	2.9	2.1	2.3
Keratophagy	4	–	2	–	–	–	–	3	–	3	–	–	–	–
Plan remnants	0	–	0	–	–	–	–	1	–	1	–	–	–	–

has a greater amplitude in summer (B = 6.41) than in spring (B = 4.59). SIMPER analysis showed that differences between spring and summer diets were mainly driven by Coleoptera, which alone accounted for 21.8% of the overall dissimilarity and were almost exclusively consumed in summer (Suppl. material 2). Additional contributions were provided by Lepidoptera and Embioptera, which were more frequent in spring, and by Isopoda and Hemiptera, which were more abundant in summer. Together, these prey categories explained approximately 60% of the observed between-season dissimilarity (Suppl. material 2).

Prey availability vs. diet

Terrestrial arthropods collected from walls (using sticky traps) and on the ground (using pitfall traps) were classified into a total of 13 OTUs (Fig. 1). Chelicerata and Diptera were the dominant groups on walls and ground during spring, respectively (Fig. 1). Likewise, Hymenoptera was the most prevalent on the walls during summer, and Isopoda was most common on the ground (Fig. 1). The OTUs present in the diet did not differ from those available in microhabitats (wall and ground) in either season ($G < 2$, $p > 0.9$ in all cases). Indeed, Shannon-Weaver diversity (H') was consistently higher in the diet than in the environmental supply in both seasons. In spring, dietary diversity (H' = 1.81) exceeded that of ground (H' = 1.48) and wall habitats (H' = 0.95). A similar pattern appeared in summer, with the highest diversity recorded in the diet (H' = 2.02), followed by ground (H' = 1.59) and wall habitats (H' = 1.12). However, pairwise bootstrap comparisons did not reveal statistically significant differences in diversity between diet, wall, and ground within each season ($p > 0.5$ in all cases).

The selectivity index values showed that OTU preferences varied between seasons (Fig. 2). In spring, five OTUs were categorized as preferred (Blattodea, Dermaptera, Embioptera, Lepidoptera, and Isopoda), three as neutral (Hemiptera, Hymenoptera, and Neuroptera), and the rest were avoided (Fig. 2). In summer, five OTUs were preferred (Dermaptera, Embioptera, Hemiptera, Lepidoptera, Neuroptera), two were neutral (Chelicerata and Coleoptera), and the rest were avoided (Fig. 2). Notably, Chelicerata were not consumed in spring. Diptera were avoided in spring, as were Hymenoptera and Isopoda in summer, even though these groups were the most abundant in the environment during these seasons (Figs 1, 2).

Potential predator identification

Twenty-nine animal species were identified in sympatry with *T. mauritanica* at the study site: 24 bird (82.76%), three mammal (10.34%), one reptile (3.45%), and one spider (3.45%) species (Suppl. material 3). Of these, 13 (44.83%) were considered potential predators of *T. mauritanica* (Suppl. material 3). All these animals were observed in the same environments inhabited by geckos (i.e., abandoned buildings).

Among potential predators (Fig. 3), the most abundant species were mainly diurnal birds: the austral thrush (*Turdus falklandii* Quoy & Gaimard, 1824; Fig. 4), chimango caracara [*Daptrius chimango* (Vieillot, 1816)], and long-tailed meadowlark [*Leistes loyca* (Molina, 1782)]. Also, false black widow spiders (*Steatoda triangulosa* Walckenaer, 1802) were common (Fig. 3). Regarding reptiles, the native thin tree iguana (*Liolaemus tenuis* Duméril & Bibron, 1837) was the only one found, exhibiting a lower density (2.5 ind/ha) compared to *T. mauritanica* (11.9 ind/ha) (Fig. 3). Mammals were present at relatively low densities, with cats being the most common (Figs 3, 4).

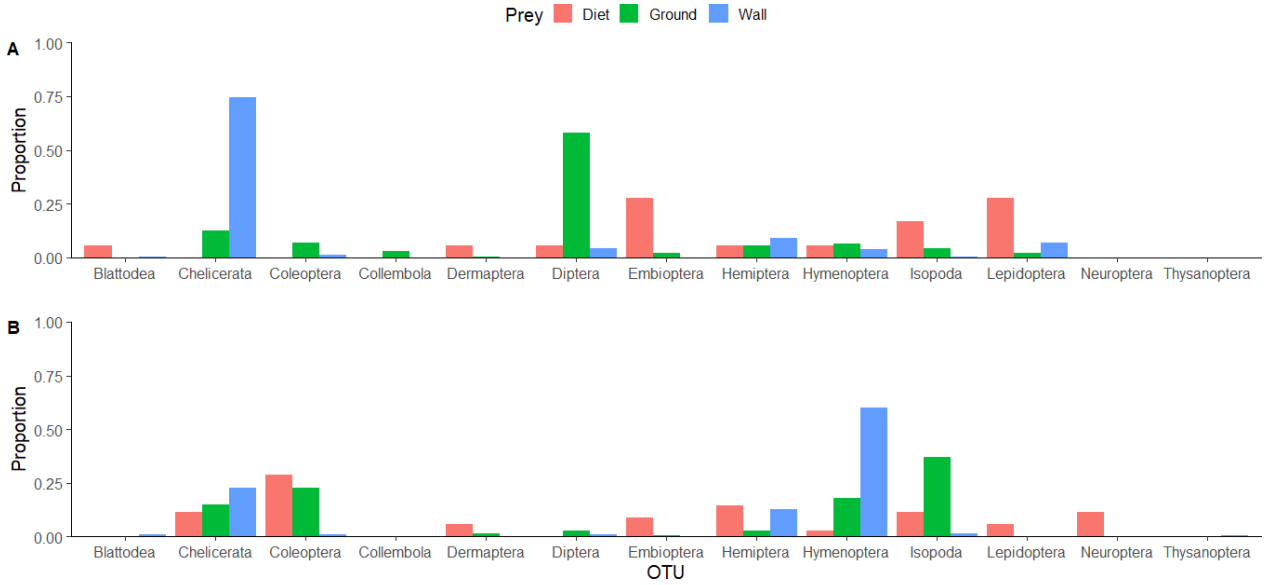

Figure 1. Proportion of prey (OTUs) present in the diet of *Tarentola mauritanica* or available in the environment (ground or walls) in the spring (**A**) and summer (**B**) seasons in a population of the San Miguel district, Santiago, Chile.

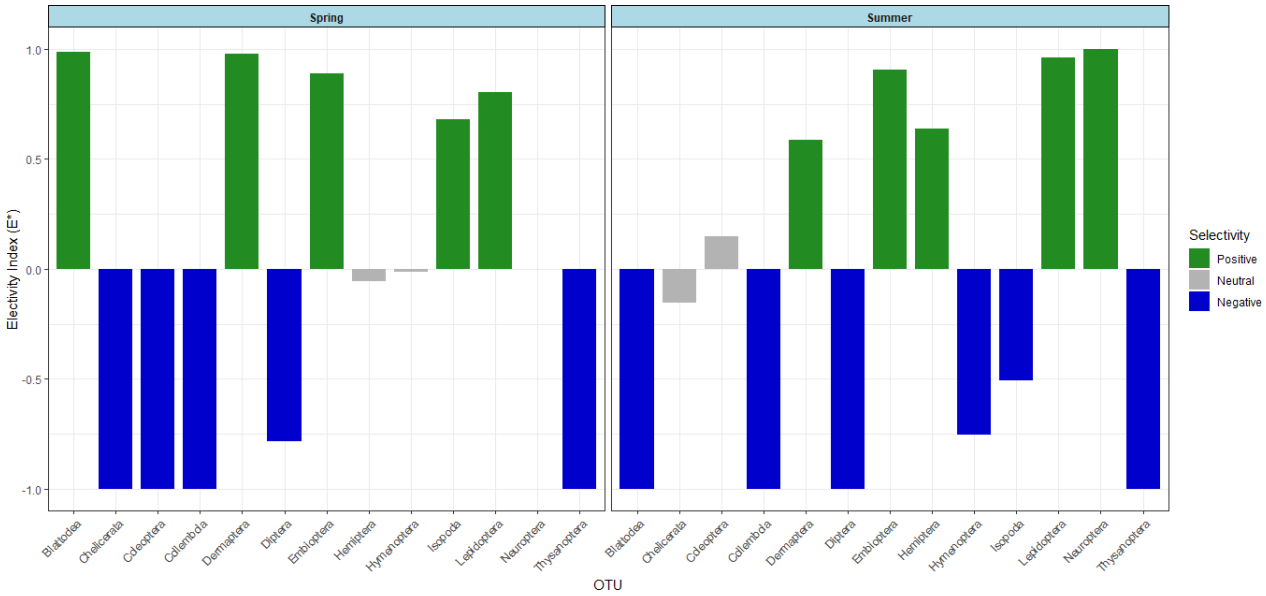

Figure 2. The prey selectivity of *Tarentola mauritanica* during spring 2023 and summer 2024 in Santiago, Chile. Positive values (green) indicate prey preference, while negative values (blue) show prey avoidance. Values close to zero suggest proportional consumption (grey). A value of 1 means the OTU was present in the diet but not in the environment. A value of -1 indicates the OTU was present in the environment but not in the diet.

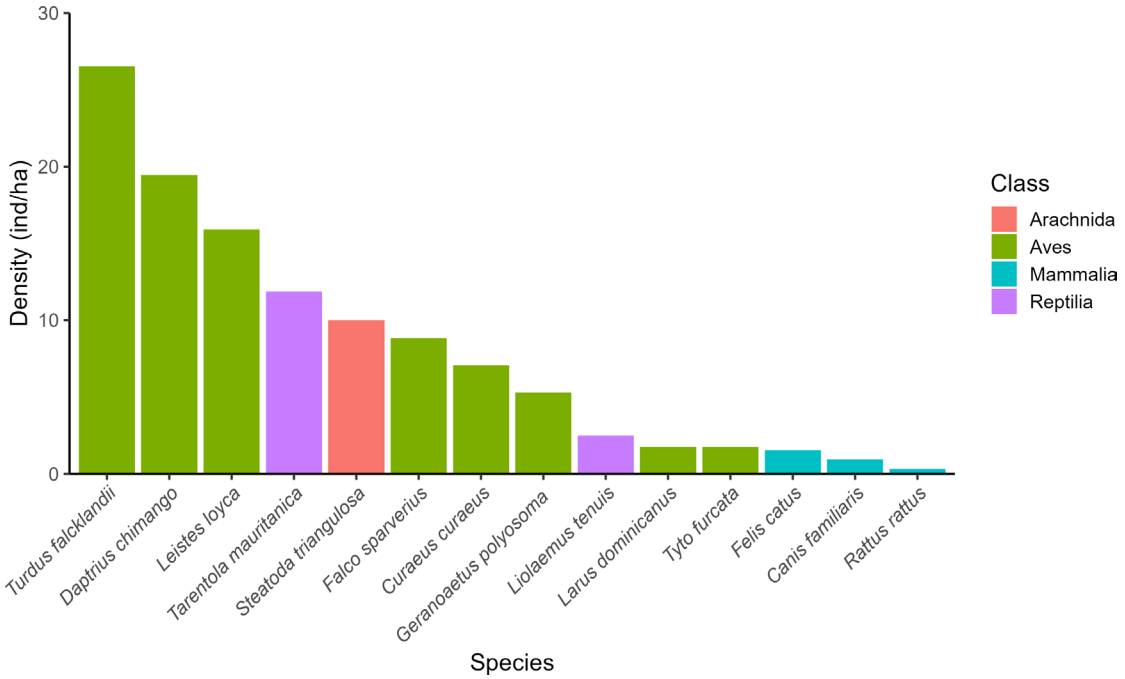

Figure 3. Density (ind/ha) of potential predators of *Tarentola mauritanica* and of this species in San Miguel district, Santiago, Chile. Colours denoted their taxonomic class.

Predator identification

Literature records

The literature review identified 24 different predator species worldwide (Table 2): 12 birds (50%; mainly raptors), six reptiles (25%), four mammals (16.7%), and two arthropods (8.3%). Most of the records originate from the gecko's native distribution (Southwest Europe and North Africa), while three are from its invaded range in the Americas: two from Buenos Aires, Argentina (Pereiro et al. 2019), and one from Santiago, Chile (Arredondo and Núñez 2014) (Table 2). Among the recognized predator species, three inhabit Chile: the Harris's hawk [*Parabuteo unicinctus* (Temminck, 1824)] (Couve et al. 2016), and two exotic mammals: domestic cats and dogs (Fig. 4; D'Elía et al. 2020). It is worth noting that cats have the most records as predators of *T. mauritanica* and are the only species identified as an effective predator of this gecko in Chile (Table 2).

Table 2. Predators of *Tarentola mauritanica* identified from the literature review. Records of predator species present in Chile or localities found within the invasive geographic distribution of *T. mauritanica* are highlighted in bold.

Class	Order	Predator species	Locality	Reference
Arachnida	Araneae	*Latrodectus lilliniae*	Granada, Spain	Hódar and Sánchez-Piñero 2002
Aves	Pelecaniformes	*Bulbulcus ibis*	Andalusia, Spain	Herrera 1974
Aves	Accipitriformes	***Parabuteo unicinctus***	**Buenos Aires, Argentina**	Pereiro et al. 2019
Aves	Falconiformes	*Circus pygargus*	Central Spain	Garzón 1973
		Falco eleonorae	Kef Amor, Algeria	Samraoui et al. 2022
		Falco neumanni	Iberian Peninsula	Valverde 1967
		Falco tinnunculus	Lazio, Italy	Trotta et al. 2015
Aves	Passeriformes	*Turdus merula*	Córdoba, Spain	Román 2022
		Turdus rufiventris	**Buenos Aires, Argentina**	Pereiro et al. 2019
Aves	Strigiformes	*Asio otus*	Sierra de Guadarrama, Spain	Veiga 1978
		Bubo bubo	Provence, France	Orsini 1985
		Strix aluco	Algeria	Hamdine et al. 1999; Tergou et al. 2014, 2016
		Tyto alba	Andalusia, Spain	Vargas et al. 1982,
			Algeria	Tergou et al. 2014, 2016
Insecta	Mantodea	*Mantis religiosa*	Andalusia, Spain	Scholer and Onrubia 2012
Mammalia	Carnivora	***Felis catus***	Mallorca, Spain	Millan 2010,
			Santiago, Chile	Arredondo and Núñez 2014,
			France	Castañeda et al. 2023,
			Madeira, Portugal	Galão et al. 2025
		Canis familiaris	Italy	Sogliani et al. 2023
		Gennetta genetta	Iberian Peninsula	Valverde 1967
		Mustela nivalis	Iberian Peninsula	Valverde 1967
Reptilia	Squamata	*Coronella girondica*	Alicante, Spain	Vericad and Escarré 1976
		Eumeces algieriensis	Tafraoute, Morocco	Herrmann and Herrmann 2003
		Hemorrhois hippocrepis	Alicante, Spain	Pleguezuelos and Moreno 1990,
			Ibiza, Spain	Hinckley et al. 2016
		Malpolon monspessulanus	Alicante, Spain	Díaz-Paniagua 1976
		Podarcis liolepis	Western mediterranean	Guillaume 1987
		Teira dugesii	**Madeira, Portugal**	Rato et al. 2022

Citizen-science observations

The citizen survey yielded 33 responses. Of these, only five people (15.2%) reported observing one or more predation events on *T. mauritanica*. It was reported that these actions were primarily carried out by cats (five cases), followed by austral thrush, chimango caracara, American barn owl [*Tyto furcata* (Temminck, 1827)], and domestic dogs (one case each). Of particular interest was the observation of an austral thrush consuming a gecko in the neighbourhoods adjacent to the former study site; however, no visual record was provided. All events occurred mainly during the gecko's peak activity hours, i.e., twilight and night (Salvador 2015), in urban environments of Santiago.

Field prospections, camera-traps, and faecal analyses

No direct predation events were observed in *T. mauritanica* during field prospections and camera-trap analysis. However, indirect evidence of predatory attacks on two geckos was found (Fig. 4). First, a juvenile gecko's carcass was found on the floor of one of the abandoned building, with clear signs of predation: its head, tail, and one of its forelimbs had been torn off (Fig. 4A). Another adult gecko was also found with lacerations in the abdominal area, exposing its entrails (Fig. 4B). Additionally, the camera-traps record four potential predators of *T. mauritanica* that surround areas where these reptiles gather: cats, dogs, and austral thrushes (Fig. 4C–E). Faecal samples (n = 8) contained no bone nor any reptile remains, only unidentified mammal hairs.

The integrative weight-of-evidence approach enabled the identification of cats as probable predators of *T. mauritanica* (Fig. 5). In contrast, the dog, austral thrush, chimango caracara, and American barn owl were considered only potential predators (Fig. 5).

Discussion

Tarentola mauritanica, a gecko now established in central Chile, has ecological interactions with its prey and predators that remain unknown, complicating assessments of its impact on native biodiversity. This study examined, for the first time, the diet and predators in Chile to begin evaluating their potential impacts on the native fauna. Results indicate an insectivorous diet (Fig. 6) that varies between the sampled seasons in response to prey availability and/or a possible selectivity. It also coexists with potential predators, mainly the introduced cat, which is its probable predator (Fig. 6).

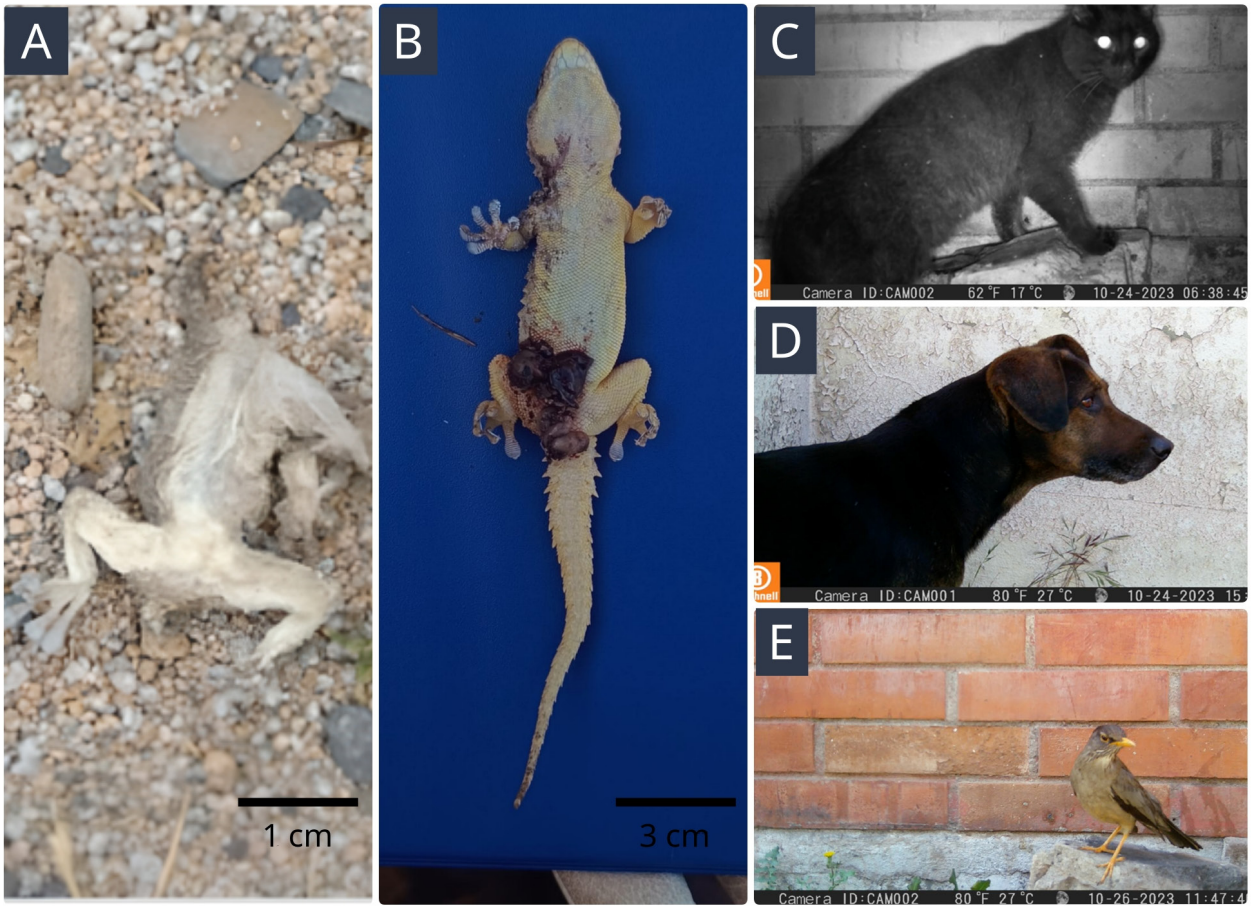

Figure 4. Remains of *Tarentola mauritanica* individuals (**A**, **B**) and records of their potential predators from camera-traps in the San Miguel district, Santiago, Chile (**C–E**). **A.** Ventral view of a decapitated individual, without a tail and without one front limb; **B.** Ventral view of an individual with a laceration on the abdomen; **C.** Cat; **D.** Domestic dog; **E.** Austral thrush.

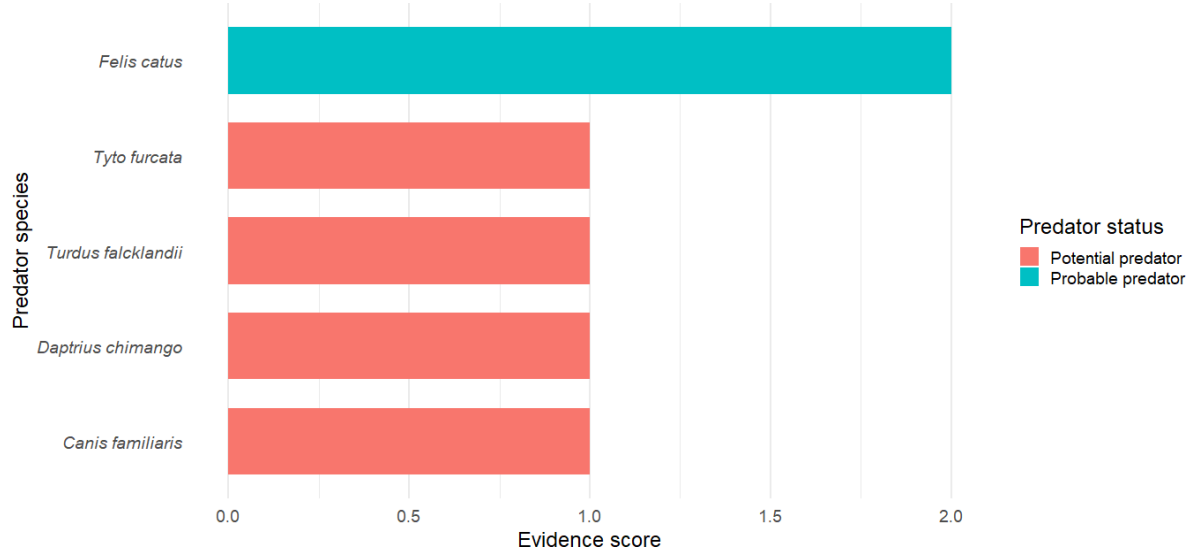

Figure 5. Result of the integrative weight-of-evidence approach on the predators of *T. mauritanica* in the San Miguel district, Santiago, Chile.

Diet composition

Stomach content analysis of *T. mauritanica* revealed a diet mainly consisting of arthropods, especially insects, just like in their region of origin (Martínez Rica 1974; Capula 1994; Hódar and Pleguezuelos 1999; Hódar et al. 2006; Martins et al. 2022; Martín et al. 2023; Ouldaissa and Salaheddine 2025). The prominence of insects in this gecko's diet may be due to their ease of capture or their abundance and diversity (Ouldaissa and Salaheddine 2025). It is noteworthy that Embioptera has been found in its diet, despite this order not being native to Chile (Juárez

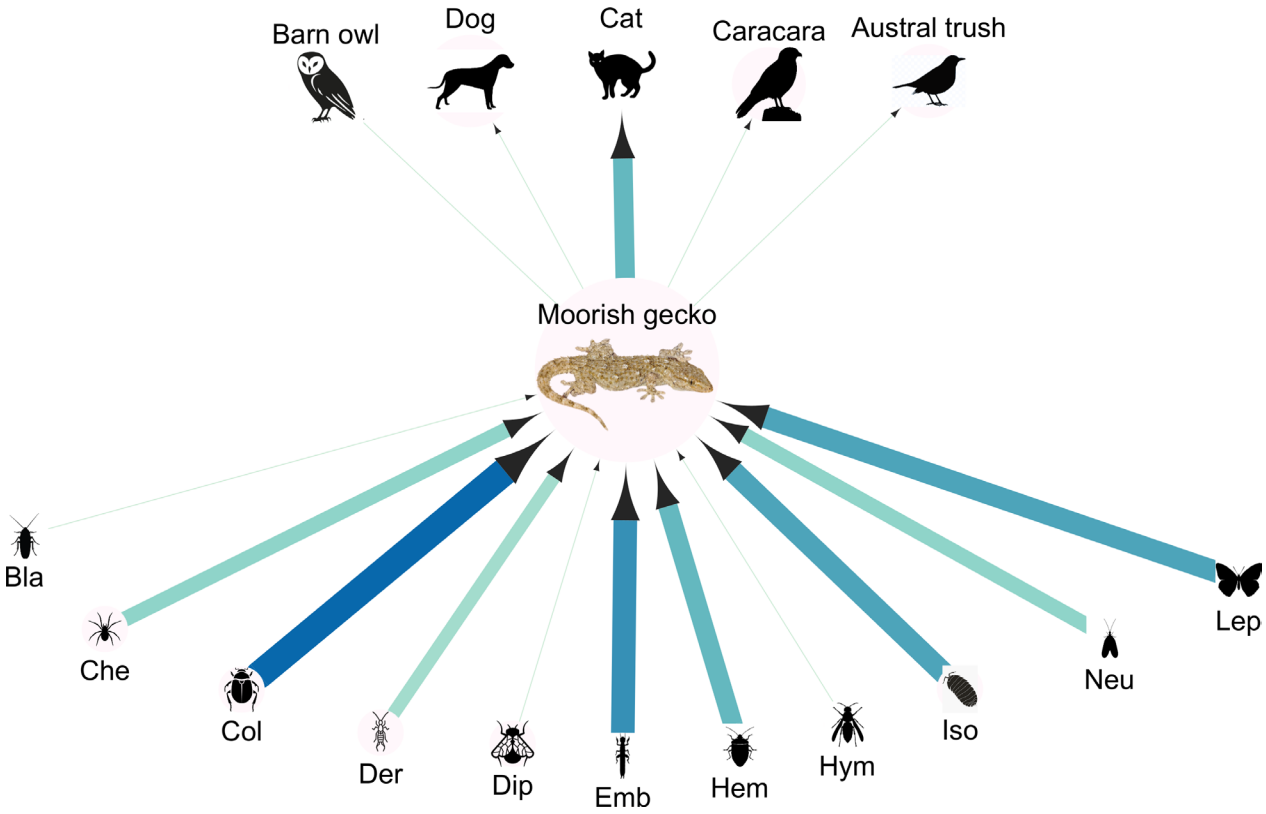

Figure 6. Trophic network of prey and predators of the gecko *Tarentola mauritanica* in the San Miguel district, Santiago, Chile. Each line corresponds to an assigned diet component. Both the greater thickness and intensity of colour indicate that the resource is used more frequently. The gecko's prey includes all OTUs and the total consumption frequencies recorded across seasons (spring and summer). Abbreviations: **Bla**–Blattodea, **Che**–Chelicerata, **Col**–Coleoptera, **Der**–Dermaptera, **Dip**–Diptera, **Emb**–Embioptera, **Hem**–Hemiptera, **Hym**–Hymenoptera, **Iso**–Isopoda, **Neu**–Neuroptera, **Lep**–Lepidoptera.

and Szumik 2023; Román-de la Fuente 2025), confirming its introduction to Santiago. Other arthropods are present in smaller amounts, including Chelicerata (Acari and Araneae), which contrasts with other studies in which this group is more dominant (Capula 1994; Gil et al. 1994; Hódar et al. 2006). Keratophagy was observed in adults, though it is most commonly associated with geckos for nutrient recovery or parasite evasion (Bauer 2013). The plant material in one sample was likely ingested accidentally.

Importantly, no remains of native lizards were found in the stomach contents of *T. mauritanica* in any season. These results align with most dietary descriptions of this species (Capula 1994; Gil et al. 1994; Hódar and Pleguezuelos 1999; Hódar et al. 2006; Ouldaissa and Salaheddine 2025) and suggest that this gecko would not be consuming the lizards at the study site, thereby alleviating conservation concerns. However, numerous records document *T. mauritanica* occasionally consuming juvenile lizards (e.g., *Podarcis lilfordi*, *P. hispanicus*, *P. liolepis*, *Hemidactylus turcicus*; reviewed by Bauer 1990; Salvador 2015; Speybroeck et al. 2016), or even adult individuals [*P. siculus* (Rafinesque, 1810); Pellitteri-Rosa et al. 2015]. Furthermore, DNA metabarcoding has shown that *T. mauritanica* can consume a native lizard [*Teira dugesii* (Milne-Edwards, 1829)] in large quantities (26.8% of samples) in island environments (Martins et al. 2022). We advise caution and ongoing monitoring of *T. mauritanica*'s saurophagy, as it may vary with population density or shifts in food availability (Hódar et al. 2006; Oliveira et al. 2025). Collecting additional stomach samples and extending spatial coverage are also important for a more robust analysis.

Diet between seasons and preferences

Tarentola mauritanica's diet varies between seasons, wider in summer than in spring, due to changes in prey. Lepidoptera and Embioptera are more influential in spring, while Coleoptera dominate in summer. This suggests an increase in available prey from spring to summer, aligning with the typical seasonality of arthropod communities (Hódar et al. 2006). The preference for Lepidoptera might be favored in spring because they are larger and less sclerotized as adults and larvae; meanwhile, Coleoptera might be more consumed in summer because they are more abundant in the drought season, as observed in original *T. mauritanica* populations (Hódar and Pleguezuelos 1999; Hódar et al. 2006; Salvador 2015). Additionally, during summer, greater dietary diversity is associated with *T. mauritanica* shifting to more nocturnal activity (Arad et al. 1997), thereby increasing its prey encounter rates.

Despite high consumption of Lepidoptera and Coleoptera, they are not the most abundant in the environment (Fig. 1). Other prey, such as Embioptera and Dermaptera, were also selected, even when scarce. This suggests that seasonal diet choices are influenced by factors such as energy reward, detectability, and/or prey defensive mechanisms (e.g., bites, stings), rather than by prey availability alone (Hódar and Pleguezuelos 1999). Alternatively, the abundance of some groups may have been underestimated in traps due to their movement patterns; for example, flying insects, such as adult Lepidoptera, or subterranean ones, such as Embioptera (Juárez and Szumik 2023), might avoid the types of traps used (sticky and fall traps). Conversely, some OTUs were excluded despite being the most abundant in their respective environments, including Chelicerata and Diptera in spring and Hymenoptera and Isopoda in summer. This pattern of selection suggests that *T. mauritanica* does not behave opportunistically in response to prey abundance but instead exhibits a certain degree of selective foraging between the sampled seasons (Gil et al. 1994).

Dietary prey diversity tended to exceed available microhabitat diversity, suggesting active microhabitat selection. In fact, although the wall is a common substrate for *T. mauritanica* (Salvador 2015), it also preys on ground prey. Primary consumption of ground-dwelling arthropod groups (e.g., Coleoptera, Embioptera, Isopoda) is characteristic of this species (reviewed by Salvador 2015). This pattern is more evident in environments where food scarcity encourages active ground foraging over sit-and-wait strategies (Hódar et al. 2006), which are more typical for this gecko (Capula et al. 1994). Therefore, food availability at the studied site is likely affecting the foraging behavior of this species in Chile.

Predators of *T. mauritanica* in Chile

Various potential predators coexist with *T. mauritanica* at the study site, including birds and spiders, which are most abundant, followed by a lizard and exotic mammals. However, a comprehensive analysis of effective predators indicates that cats showed the strongest support as probable predators of *T. mauritanica*, being the only species supported by two lines of evidence: the literature (Arredondo and Núñez 2014) and the survey that described five attack events. Cats are solitary, opportunistic, and highly efficient predators, hunting a wide range of vertebrate and invertebrate prey (Bradshaw 2006; Stella 2021). Their mainly nocturnal habits, like those of the gecko, increase the likelihood of encounters and, consequently, predatory attacks on these lizards. In the native and invaded ranges of *T. mauritanica*, cats have been recognized as predators (Millan 2010; Mori et al. 2019; Castañeda et al. 2023; Galão et al. 2025). However, at the study site, we found no direct evidence of cats preying on geckos during nocturnal surveys or in camera-traps, nor any indirect evidence in faeces. The gecko remains with amputations and skin injuries, were likely the result of a cat attack, as cats break vertebrae and tear prey skin during handling. The remains weren't fully consumed, consistent with their predatory play behavior (Biben 1979; Bradshaw 2006; Stella 2021). However, we do not rule out the possibility that other mammals or birds may have attacked these remains. In conclusion, although the evidence is limited, cats are expected to prey on *T. mauritanica* in Chile and, consequently, could constitute trophic subsidies for this exotic predator in urban areas. Nevertheless, it will still be necessary to assess the level of consumption of this prey to determine its dietary importance as a subsidy.

Other potential predators of geckos include dogs, as documented in the literature (Sogliani et al. 2023) and mentioned once in the survey. Since only one dog was identified at the study site and no reptile remains were observed in its faeces, this suggests that reptiles are unlikely to be its prey at this site. By contrast, birds, particularly austral thrushes and chimango caracaras, are more likely to be significant predators, as they were recognized in the survey and occur at higher densities at the study site, increasing the likelihood of predatory encounters. In fact, congeners of austral thrushes (Pereiro et al. 2019; Román 2022) and other falconiform birds (Valverde 1967; Garzón 1973; Trotta et al. 2015; Román 2022; Samraoui et al. 2022) are known to consume *T. mauritanica* in both its native and invasive ranges. Another candidate is the barn owl, which is nocturnal and is known to consume these geckos (Vargas et al. 1982; Tergou et al. 2014, 2016). Future studies will allow us to verify the trophic relationships these potential predators might have with Moorish geckos and other lizards.

The lack of records of attacks or predation is primarily due to the generally opportunistic nature of such records and the difficulty of verifying them. In over 300 hours of exhaustive fieldwork, only the remains of dead geckos were found, with no direct evidence of predation. This could be considered evidence that geckos would suffer few predatory attacks. On the other hand, the number of camera traps and faecal samples that yielded negative results for predation is too small to infer the absence of predation. Although employing an integrated approach with various methodologies enabled us to obtain results, future studies are recommended to investigate potential predators using different analytical methods. The use of other techniques, such as DNA extraction from faecal samples to identify consumed prey (King et al. 2008; Nielsen et al. 2018; Paprocki et al. 2024; Galão et al. 2025), will enable the evaluation of the significance of these native and exotic predators in preying on and controlling *T. mauritanica*.

Is this gecko a genuine threat?

From a trophic perspective, *T. mauritanica* behaves as an insectivorous mesodepredator that exploits abundant arthropod groups and adjusts to intra-annual changes. This trait is consistent with observations of many introduced species (Kraus 2015) and could contribute to the decline

of urban invertebrate populations whose diversity is already reduced (Fenoglio et al. 2021), especially in groups preferred by this gecko, such as Lepidoptera and Coleoptera. However, its diet comprises both native (e.g., *Monocrepidius* cf. *chilensis*) and introduced taxa, and there is no detailed taxonomic resolution to determine which aspects are important for conservation. Additionally, we hypothesise its dietary traits may indirectly impact native sympatric lizards, such as *L. tenuis*, through competition for shared resources, as they share temporal and spatial niches (Huerta-Vera 2016). In urban Santiago, where lizard diversity and abundance are declining (Marquet et al. 2010), the introduction of a mesopredator such as this gecko could intensify competition for prey. Future studies should assess the existence of potential dietary competition between these species in Santiago, Chile.

Since cats are considered probable predators of *T. mauritanica*, geckos could serve as trophic substitutes for them in urban areas. While this is an initial step in assessing their role, understanding the interaction's intensity and the gecko's presence in cats' diets is needed to evaluate their real contribution as trophic subsidaries. On the other hand, this information will also help assess whether cats are controlling the introduced gecko, reducing the negative impacts associated with the alien lizard preying on native species. Therefore, it will be necessary to assess how trophic interactions between cats and *T. mauritanica* occur within a community-based approach in urban environments.

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Supplementary material 1

Taxonomic details of the groups of terrestrial arthropods

Authors: Claudio Reyes-Olivares, Benjamín Salinas, Juan Valdivia-Villagra, León Chávez-Jofré, Fernanda Alarcón-Toledo, Tomás Miquio-Portell, Rocío Olate-Ávila, Carezza Botto-Mahan

Data type: xlsx

Explanation note: Taxonomic details of the groups of terrestrial arthropods (OTUs) present in the diet of *Tarentola mauritanica* during the spring and summer seasons in the San Miguel district, Santiago, Chile. The geographical origin of some groups is indicated. The number of individuals belonging to a specific taxonomic category is shown in parentheses.

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Link: https://doi.org/10.3897/herpetozoa.39.e183674.suppl1

Supplementary material 2

Results of the SIMPER analysis

Authors: Claudio Reyes-Olivares, Benjamín Salinas, Juan Valdivia-Villagra, León Chávez-Jofré, Fernanda Alarcón-Toledo, Tomás Miquio-Portell, Rocío Olate-Ávila, Carezza Botto-Mahan

Data type: xlsx

Explanation note: Results of the SIMPER analysis indicate that the average reflects the mean contribution of each prey category to the Bray-Curtis dissimilarity between spring and summer. The values for spring and summer indicate the mean abundances for those seasons. Prey categories are listed from the highest to the lowest contributor to the overall dissimilarity.

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Link: https://doi.org/10.3897/herpetozoa.39.e183674.suppl2

Supplementary material 3

Animal species observed in sympatry with *Tarentola mauritanica*

Authors: Claudio Reyes-Olivares, Benjamín Salinas, Juan Valdivia-Villagra, León Chávez-Jofré, Fernanda Alarcón-Toledo, Tomás Miquio-Portell, Rocío Olate-Ávila, Carezza Botto-Mahan

Data type: xlsx

Explanation note: Animal species observed in sympatry with *Tarentola mauritanica* in the San Miguel district, Santiago, Chile. Species in bold are potential predators of the introduced reptile, i.e., those that are to some degree saurophagous, omnivorous, or carnivorous, according to the literature or internet record (Reference).

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