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Nectar feeding and external pollen loads in *Podarcis lusitanicus* Geniez et al., 2014: evidence for trophic niche expansion in an Atlantic island ecosystem

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Pollination is a key ecological process primarily performed by insects, birds and mammals. Yet, other, less studied vertebrates also contribute to pollen transfer, especially on islands where ecological interactions often differ from those on the mainland (Olesen and Valido, 2003; Justicia Correcher et al., 2023). Island ecosystems are characterised by reduced species richness, relaxed competition and lower predation pressure, which in turn promote high population densities and broader resource use, favouring ecological release and trophic niche expansion (MacArthur et al., 1972; Cox and Ricklefs, 1977).

Lizards are among the most abundant vertebrates on many islands and can exploit alternative or fluctuating resources, including fruits, nectar and other floral rewards (Van Damme, 1999; Losos, 2009; Olesen and Valido, 2003). In insular systems, these dietary shifts have led to recognition of lizards as seed dispersers and, less frequently, as floral visitors with potential roles in pollination. Although evidence for lizard-mediated pollination remains limited, studies have shown that lizards can transport pollen and, in some cases, act as effective pollinators (Traveset and Sáez, 1997; Pérez-Mellado and Casas, 1997; Pérez-Mellado et al., 2000). A recent global review compiled more than 450 documented lizard-flowering plant interactions, highlighting the ecological relevance of these associations despite their historical underrepresentation (Justicia Correcher et al., 2023).

Within the Mediterranean region, nectar feeding and floral visitation have been documented mainly for insular wall lizards from the genus *Podarcis*, especially in *P. lilfordi* (Günther, 1874) from the Balearic Islands (Sáez and Traveset, 1995; Pérez-Mellado and Casas, 1997; Pérez-Mellado et al., 2000). Comparable information is lacking for the recently described *Podarcis lusitanicus* Geniez et al., 2014, a species restricted to the western Iberian Peninsula and recognised as distinct from the former *P. hispanicus* complex on taxonomic and genomic grounds (Geniez et al., 2014; Caeiro-Dias et al., 2021; Rato et al., 2025). As a result, ecological observations formerly attributed to *P. hispanicus* sensu lato cannot be automatically extrapolated to *P. lusitanicus*.

Here, we report nectar-feeding behaviour and the presence of external pollen loads in *P. lusitanicus* on an Atlantic island of the Cíes archipelago, Spain. By combining direct behavioural observations with non-invasive pollen sampling, we provide evidence of a previously undocumented plant-lizard interaction involving this species and discuss its implications for trophic niche expansion in insular ecosystems. *Podarcis lusitanicus* is the only *Podarcis* species present on the Cíes Islands where it reaches high densities and is one of the most common vertebrates in open habitats (Galán, 2003).

Field observations were conducted on the Cíes Islands (Galicia, northwestern Spain), at the study site (42.2295°N, 8.9061°W), within the Islas Atlánticas de Galicia National Park, an Atlantic archipelago with a mild oceanic climate. Observations focused on coastal shrubland where *Angelica pachycarpa* Hoffm. is locally abundant during flowering. During the flowering period of *A. pachycarpa* in April 2023, we used opportunistic observations during daylight hours under favourable weather conditions to document interactions between lizards and flowers. When nectar-feeding behaviour was observed, the interaction was recorded using a handheld

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digital device.

Individuals of *P. lusitanicus* were repeatedly observed visiting inflorescences of *A. pachycarpa* during its flowering period (Fig. 1). Lizards approached umbels and inserted their heads into individual flowers while performing repeated licking movements consistent with nectar feeding. Most observations involved individuals moving directly across the inflorescences, although some lizards accessed flowers from adjacent rocky substrates (Fig. 1B). In both situations, the snout, head and throat contacted floral reproductive structures (see videos available at Zenodo: https://doi.org/10.5281/zenodo.19573477). Nectar-feeding bouts lasted several seconds and were sometimes repeated on the same inflorescence before the lizard moved to a neighbouring umbel or plant. Several complete events were recorded on video, clearly showing active nectar uptake under natural conditions without experimental manipulation.

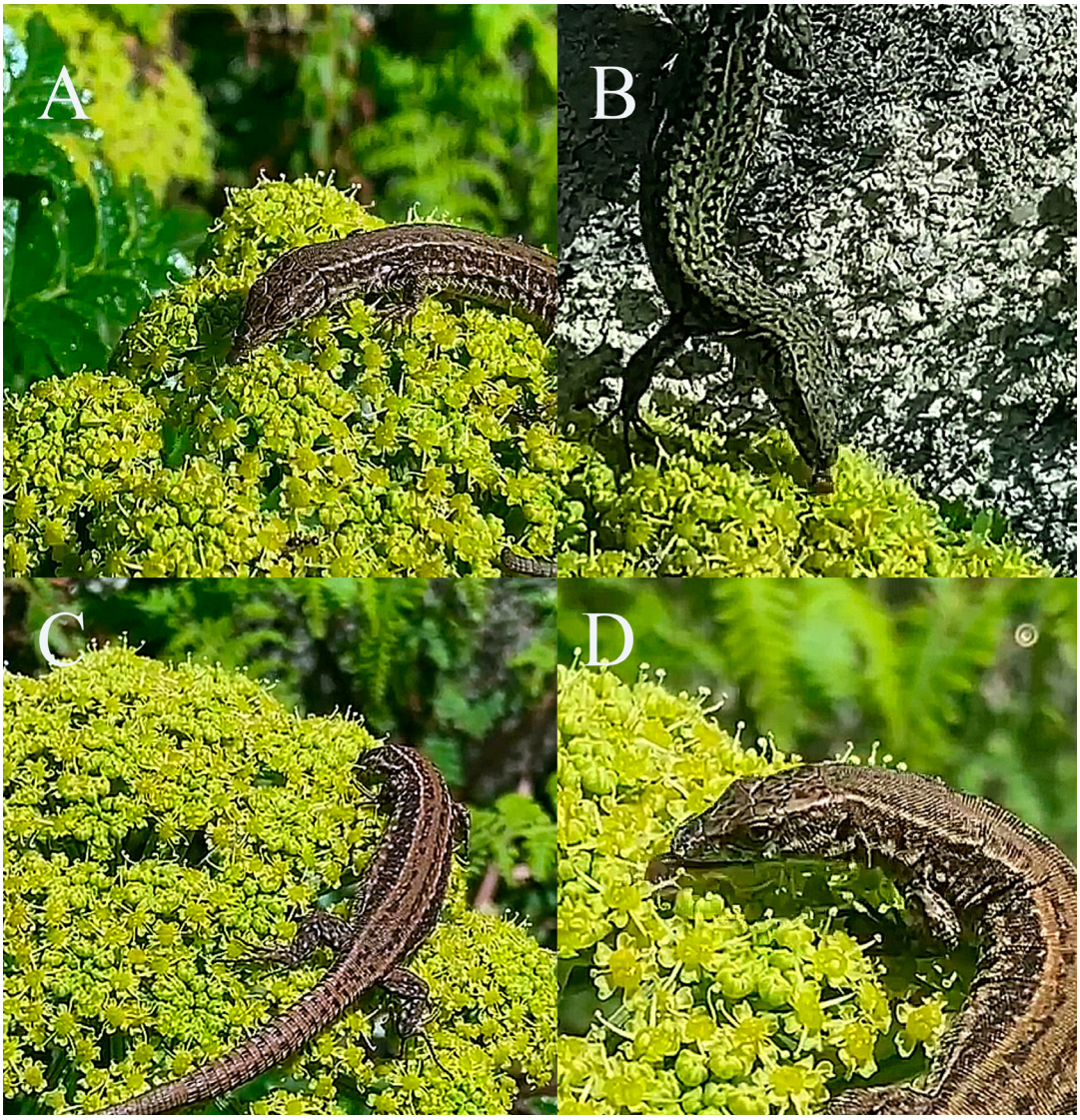

Figure 1. Nectar-feeding behaviour of *Podarcis lusitanicus* on *Angelica pachycarpa* inflorescences on the Cíes Islands. (A, C, D) Lizards moving across umbels while inserting the head into flowers to lick nectar, contacting floral reproductive structures with the snout and throat. (B) Individual accessing nectar from an adjacent rocky substrate and inserting the snout into the flowers. Photos by Ane Navarro-Ayensa.

To evaluate the potential for pollen transport during these interactions, we assessed whether nectar-feeding lizards carried pollen on their body surface. Three adult individuals that we observed foraging on *A. pachycarpa* inflorescences were temporarily captured with a hand-held insect net one week after the initial observations. Pollen sampling followed a non-invasive adhesive tape method adapted from previous studies on insular lizards (Pérez-Mellado et al., 2000). For each individual, three transparent adhesive strips were gently applied to body regions likely to come into contact with floral structures during nectar feeding: dorsal head/neck, throat (gular region), and ventral surface. Each strip was then mounted on a microscope slide. The entire procedure lasted less than three minutes per lizard, after which all individuals were released at the capture site without apparent injury or behavioural alteration.

Slides were examined under an optical microscope at 20× and 40× magnification to detect adhering pollen grains. Grains were identified by size, morphology and surface ornamentation and compared with reference pollen from *A. pachycarpa* flowers collected in the study area. Because of the exploratory nature of the study and the small sample size, pollen presence was assessed qualitatively, and no attempt was made to quantify pollen loads or pollination effectiveness.

Microscopic examination of adhesive tape samples revealed pollen grains on all sampled lizards. Grains morphologically consistent with *A. pachycarpa* were detected on multiple body regions, including dorsal, gular and ventral samples, based on comparison with reference pollen collected in the study area. No other Apiaceae species were observed flowering in the immediate vicinity during the study period, reducing the likelihood of misidentification. Pollen was especially frequent on strips from the head and throat regions, which were the areas in most direct contact with the flowers during nectar feeding.

Our observations provide the first documented evidence of nectar feeding and external pollen loads in *Podarcis lusitanicus*, adding a new ecological dimension to this recently delimited species. Although similar interactions have been described for other insular *Podarcis*, particularly for *P. lilfordi* in the Balearic Islands (Pérez-Mellado and Casas, 1997; Pérez-Mellado et al., 2000), equivalent evidence was lacking for *P. lusitanicus*. Given the recent taxonomic resolution of this species (Geniez et al., 2014; Caeiro-Dias et al., 2021; Rato et al., 2025), these observations represent novel ecological information from insular populations and further support the role of island environments in promoting trophic niche expansion, rather than a straightforward extension of records from the former *P. hispanicus* complex.

The behaviour reported on here involved repeated insertion of the head into *A. pachycarpa* flowers, resulting in consistent contact between the snout and throat and the reproductive structures. The presence of pollen grains on those body regions indicates that nectar-feeding individuals can transport pollen externally. Although lizards lack pilosity, pollen retention is plausible through repeated contact with anthers and stigmas, body surface microstructure and occasional moisture associated with nectar feeding. External pollen loads and floral contact do not by themselves demonstrate effective pollination, and robust evaluation would require direct quantification of pollen deposition following visits (King et al., 2013). Even so, our results are consistent with previous reports of lizard-mediated pollen transport in other insular lacertids (Pérez-Mellado and Casas, 1997; Pérez-Mellado et al., 2000).

Insular environments are well known to promote trophic niche expansion and behavioural flexibility, particularly under conditions of ecological release, reduced predation and fluctuating resource availability (Cox and Ricklefs, 1977; Losos, 2009). Lizards often reach high densities on islands and may exploit plant resources opportunistically when arthropod prey availability varies in space or time (Case, 1975; Rodda and Dean-Bradley, 2002). Nectar, fruits and pollen may therefore function as dietary supplements rather than as components of a specialised trophic strategy. This interpretation is consistent with broader evidence that island conditions facilitate novel or previously overlooked plant-lizard interactions (Olesen and Valido, 2003; Justicia Correcher et al., 2023).

The plant species visited by *P. lusitanicus*, *Angelica pachycarpa*, is a geographically restricted Atlantic species that flowers during the season of high activity of *P. lusitanicus* on the Cíes Islands (Galán, 2003; pers. obs. L. Navarro). Although we did not assess pollen deposition on stigmas or reproductive consequences, vertebrate floral visitors, including lizards, can contribute meaningfully to pollination in depauperate or temporally variable insular pollinator assemblages (Rodríguez-Rodríguez et al., 2013). Under such conditions, even occasional nectar feeding by abundant vertebrates may be ecologically relevant.

More broadly, our findings illustrate the importance of revisiting ecological interactions in the light of

taxonomic refinement. As species boundaries within widespread complexes are resolved, ecological traits formerly assigned to broadly defined taxa may mask biologically meaningful differences. Reassessment at the correct taxonomic scale is therefore necessary to characterise species interactions accurately.

In conclusion, this study documents previously unreported nectar-feeding behaviour and associated external pollen loads in *Podarcis lusitanicus*. These observations expand the known trophic repertoire of the species and reinforce the role of islands as natural laboratories for trophic innovation and overlooked plant-vertebrate interactions. Further work will be needed to quantify the frequency and functional consequences of lizard-mediated pollen transfer, but our results add to growing evidence that reptiles deserve greater consideration in studies of insular plant-animal interaction networks.

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