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First observation of pollen transport in endemic Cape Verdean *Chioninia* scincid lizards (Scincidae)

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Abstract: Atlantic oceanic islands host a unique fauna of endemic lizards, at least some of which closely interact with local native and alien plants. Knowledge of these interactions is necessary for effective protection of the island's biodiversity. Interactions between the endemic Cape Verdean skink *Chioninia stangeri* (Scincidae) and three native plant species – *Tribulus cistoides*, *Zygophyllum simplex* (both Zygophyllaceae) and *Lotus* sp. (Fabaceae) were studied and photographically documented on the island of São Vicente (Cape Verde Islands) in September 2024. Florivory appears to have an important place in the feeding strategy of *C. stangeri*. Lizards frequently consumed the flowers of all three plant species studied. Flowers of *Z. simplex* and *Lotus* sp. were eaten completely. In the case of *Tribulus cistoides*, the lizards consumed mainly the petals and stamens, leaving most of the pistils undamaged. While eating the petals, the lizards touched the reproductive organs of *T. cistoides* and the pollen grains stuck to their snout. This is the first observation of pollen transport in *Chioninia* scincid lizards. Possible contribution of *C. stangeri* to the pollination of *T. cistoides* is discussed.

Keywords: *Chioninia stangeri*, florivory, *Lotus*, Macaronesia, oceanic islands, pollination, *Tribulus*, *Zygophyllum*

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Introduction

Mutualistic interactions between lizards and flowering plants leading to pollination and seed dispersal have evolved mainly in specific island environments that are poor in arthropods and predators. Lizards that are primarily insectivorous need to use additional food sources, and often turn to herbivory (e.g., van Damme 1999, Olesen et Valido 2003, Valido et Olesen 2019). Many recent observations document that lizards licking nectar or eating pollen, flowers and fruits can act as pollen dispersers, or even directly as pollinators (e.g., Olesen et Valido 2003, Godínez-Álvarez 2004, Sazima et al. 2009, Valido et Olesen 2010, Ratto et al. 2018, Wester 2019). Lizards can mediate pollination services on islands, benefitting both native (Rodríguez-Rodríguez et Valido 2008, Ortega-Olivencia 2012, Jaca et al. 2018, Hernández-Teixidor 2020) and alien plant species (Fariña et Mangani 2020, Koppetsch et al. 2020). In at least some cases, the plant-lizard relationships have the character of unique endemic interactions, in which the lizards seem to play a key role in the distribution and survival of the respective island plants (e.g., Pérez-Mellado et Traveset 1999, García et Vasconcelos 2017, González-Castro et Siverio 2024).

In Macaronesia, which includes four volcanic archipelagos of Atlantic oceanic islands, lizard-plant interactions leading to pollen transport and pollination have been repeatedly reported from Madeira (e.g., Elvers 1977, Olesen et Valido 2003, Esposito et al. 2021) and the Canary Islands (e.g., Rodríguez-Rodríguez et Valido 2008, Jaca et al. 2018, Hernández-Teixidor 2020, González-Castro et Siverio 2024). In the case of the Cape Verde Islands, information on such interactions between lizards and plants is still lacking. However, observation of pollen on the snout of the endemic gecko *Tarentola gigas* (Bocage, 1875) (Gekkonidae) on Branco Island (Pinho et al. 2018) suggests that such relationships may exist. In addition, Valido et Olesen (2010) hypothesized that endemic skinks of the genus *Chioninia* Gray, 1845 (formerly *Mabuya*; Scincidae) may also visit flowers in the Cape Verde Islands.

Chioninia skinks (six extant and one extinct species) appear to be omnivorous lizards feeding partly on plants – see Schleich (1987) for *C. delalandii* (Duméril et Bibron, 1839), *C. nicolauensis* (Schleich, 1987) and *C. vaillantii* (Boulenger, 1887); Pinho et al. (2022) for *C. coctei* (Duméril et Bibron, 1839); and Moravec (2023) for *C. stangeri* (Gray, 1845). *Chioninia stangeri* occurs in arid habitats on the islands of São Vicente, Santa Luzia, Branco and Raso (Miralles et al. 2010, Uetz et al. 2024), and is classified as "Near Threatened", according to the IUCN Red List criteria (IUCN 2024). The finding that the flowers of *Lotus* sp. form part of the diet of *C. stangeri* on São Vicente (Moravec 2023) suggests that eating flowers (florivory) belongs to the feeding strategy of this species. Closer relationships between skinks and plants can therefore be expected.

Since detailed knowledge of the habitat and biology of *C. stangeri* is an important prerequisite for its effective protection, we aimed to (i) document florivory in *C. stangeri*, (ii) describe potential interactions between *C. stangeri* and plants, and (iii) evaluate the possible role of *C. stangeri* in plant pollination.

Material and Methods

The field research was conducted in the northeastern part of the island of São Vicente, on September 12–17, 2024. Interactions between *Chioninia stangeri* and local plants were studied at two localities: Locality A (the northeastern coast of the island between the settlements of Baía das Gatas and Calhau; 16°52'13.18"N, 24°54'11.91"W to 16°51'48.27"N, 24°53'46.60"W; 0–80 m a.s.l.) and Locality B (the sea coast south of the settlement of Calhau; 16°50'48.98"N, 24°52'3.97"W; 0–10 m a.s.l.). At Locality A, *C. stangeri* inhabited stony areas and scree slopes bordering coastal sand dunes. The habitat had an arid character and was covered with very sparse vegetation. During the survey, the following plant species were observed to flower at this locality: *Frankenia ericifolia* C.Sm. ex DC. (Frankeniaceae), *Heliotropium ramosissimum* (Lehm.) Sieber ex DC. (Heliotropiaceae), *Lotus* sp. (Fabaceae), *Tribulus cistoides* L., and *Zygophyllum simplex* L. (both Zygophyllaceae). At Locality B, skinks were associated with small lava-stone fields covered by xerophilous halophytic plant communities, scattered among the sand dunes. At the time of the research, only two plant species showed larger and noticeable flowers on this site: *Sesuvium portulacastrum* (L.) L. (Aizoaceae) and *Zygophyllum fontanesii* Webb & Berthel. (Zygophyllaceae).

The research was conducted for three days at each locality. The feeding behavior of skinks was documented during the morning hours between 07:30–11:00 h. The skinks were photographed from approximately 2–10 m with a Nikon Coolpix P900 camera (no individuals were captured or swabbed for pollen grains). The obtained photographs were deposited in the herpetological collection of the National Museum of the Czech Republic (NMP-P6F). For more detailed monitoring of the interactions between *C. stangeri* and *T. cistoides*, a 250 m long transect was selected, where the changes in ratio of intact and nibbled flowers were recorded. Diameter of the corolla of *T. cistoides* was measured by a digital caliper to the nearest 0.5 mm.

Results

Florivory in *Chioninia stangeri* was observed and documented at Locality A. Skinks repeatedly ate flowers of *Lotus* sp., *Tribulus cistoides*, and *Zygophyllum simplex* (Figs. 1A–E). According to our observations, they preferred *T. cistoides* over the other two species. Of the flowers of *T. cistoides*, the lizards consumed mainly the petals and stamens (Figs. 1D, E). In the case of *Lotus* sp. and *Z. simplex*, the lizards ate whole flowers (Figs. 1C, 3). At Locality B, *C. stangeri* visited and climbed both *Sesuvium portulacastrum* and *Zygophyllum fontanesii*, but flower consumption was not directly observed. However, lizards were rare in this locality, and the number of observations was not sufficient for solid conclusions.

The foraging behavior of *C. stangeri* differed, depending on the species of plant visited. The skinks crawled through the compact plants of *Lotus* sp. and *Z. simplex*, and ate individual flowers. Occasionally, they used these plants as shelters. Interaction between *C. stangeri* and less compact creeping *T. cistoides* seemed to be more complex. The skinks were attracted directly by individual large yellow flowers of *T. cistoides* (corolla diameter: mean = 22.7 mm, range 20–27 mm, SD = 1.83, n = 15). They repeatedly visited both the same and different flowers of the same or different plants, and nibbled on their petals. The visits were short, to minimize time spent in the open. The skinks usually ate the petals by parts (Fig. 1B). Therefore, it took several visits to eat them all. Very often stamens and distal parts of the calyx were grasped and eaten together with the petals, but the pistils (both stigmas and ovaries) of the flowers were mostly left unharmed (Figs. 2C, D). In several cases (10.2% of 59 monitored flowers on the transect of 250 m), the lizards tore off and ate the entire flower together with its pistil. However, all inspected *T. cistoides* plants bore numerous fruits (schizocarps) at different stages of development (Figs. 2D, E), and the reproductive potential of the plants did not appear to be seriously reduced. The attractiveness of *T. cistoides* flowers for *C. stangeri* was very high. In places where skinks were consistently present, all petals of open flowers were eaten between 07:00–09:00 h; that means during the first two hours of the morning activity of the lizards. The next morning, when new flowers opened, the situation repeated itself.

When individuals of *C. stangeri* nibbled on *T. cistoides* flowers, they touched the stamens with their snouts and the sides of their heads (Fig. 1E), and the pollen grains got attached to the surfaces of their heads (Fig. 2A). On subsequent visits to the same or different *T. cistoides* plants, skinks carried pollen on their heads (this is the first documented observation of pollen transport in endemic Cape Verdean *Chioninia* scincid lizards). Because the skinks also touched the flower stigmas, it is highly probable that they participated in the pollination and crossing of *T. cistoides*. In this regard, it is important to mention that only a minimum of insect pollinators was observed on the flowers of *T. cistoides* at the given location. The only effective pollinator was a small bee from the family Halictidae (Fig. 2B), but its visits to flowers were not frequent at the time of observation. Among insects, only two species of small hymenopterans, two dipteran species and one species of ant (Formicidae) were observed on the flowers of *T. cistoides*. Diptera and small Hymenoptera species visited the flowers very rarely. The small ants searched for nectar at the base of the petals and acted like typical nectar robbers.

The role of *C. stangeri* in the potential transport of the pollen of *Z. simplex* remains open. The skinks crawled through various parts of the plant and touched the reproductive organs

Fig. 1. **Florivory in Cape Verdean skink** *Chioninia stangeri*, **northeastern coast of São Vicente Island, 12–17 Sep. 2024: A)** *C. stangeri* **examining flower of** *Lotus* **sp.; B) another** *C. stangeri* **examining partially bitten flower of** *Tribulus cistoides*; **C) another** *C. stangeri* **eating whole flower of** *Zygophyllum simplex*; **D) another** *C. stangeri* **eating petal of** *T. cistoides*; **E) another** *C. stangeri* **touching stamen of** *T. cistoides* **flower with its snout while eating petals of visited flower. Photos: J. Moravec.**

of its flowers with their entire bodies (Fig. 1C). However, the presence of pollen on their bodies could not be confirmed from the photographs.

Discussion

Cape Verdean skinks of the genus *Chioninia* appear to have adopted omnivory as an advantageous feeding strategy in dry island conditions. Eating fleshy fruits, flowers and nectar is common among many island lizards (van Damme 1999, Olesen et Valido 2003, García et Vasconcelos 2017, Valido et Olesen 2019). Our findings prove that florivory is

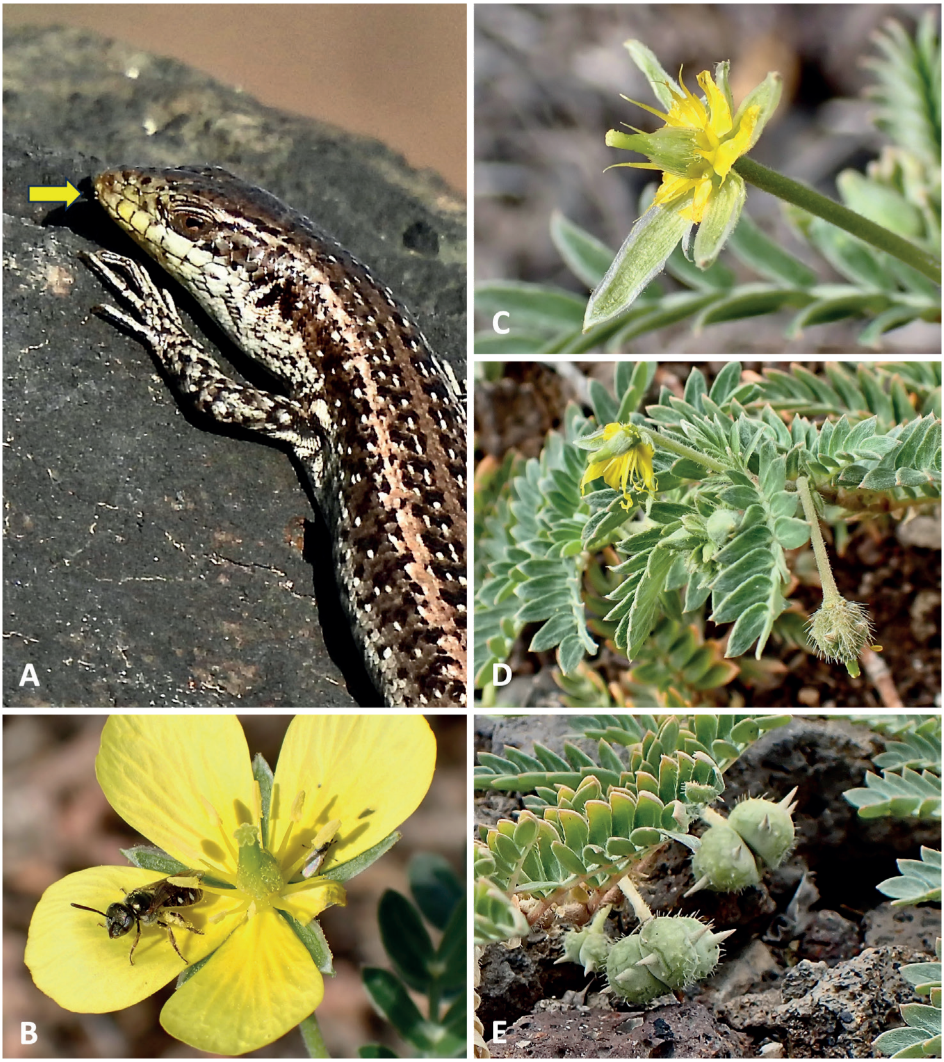

Fig. 2. Pollen transfer by Cape Verdean skink *Chioninia stangeri*, **and flowers and fruits of** *Tribulus cistoides*, **northeastern coast of São Vicente Island, 12–17 Sep. 2024: A)** *C. stangeri* **carrying pollen grains on snout (pollen grains indicated by arrow); B) bee of family Halictidae on flower of** *T. cistoides* **(one petal already eaten by** *C. stangeri***); C)** *T. cistoides* **flower with all petals and stamens eaten by** *C. stangeri* **(pistil not seriously damaged); D) terminal part of** *T. cistoides* **stem, with petals and stamens of flower freshly eaten by** *C. stangeri*, **and with early developing fruit (schizocarp); E) part of** *T. cistoides* **stem with green immature fruits. Photos: J. Moravec.**

at least seasonally an important feeding strategy of *C. stangeri* in the arid habitats of São Vicente Island. It appears that foraging behavior of the skinks may vary depending on the plant species and the size of its flowers.

Small flowers of *Lotus* sp. and *Z. simplex* were swallowed whole. Relatively larger flowers of *Tribulus cistoides* were consumed in parts (individual petals). Consequently, these differences in the lizards' behavior also led to different lizard-plant interactions. In the case of *Lotus* sp. and *Z. simplex*, the skinks picked whole individual flowers (Fig. 3). Therefore, they

Fig. 3. Cape Verdean skink *Chioninia stangeri* **eating the whole flower of** *Zygophyllum simplex***.**
Photo: J. Moravec.

could not visit the individual flowers repeatedly and potentially pollinate them. However, both plant species produce so many flowers that lizards are unlikely to significantly affect their reproductive success.

The interactions between the skinks and *T. cistoides* were more complex. The skinks visited the flowers repeatedly and transported pollen on their heads. Although the lizards ate the petals of virtually all available *T. cistoides* flowers, the plants produced enough fruits. This indicates that interactions between *C. stangeri* and *T. cistoides* do not negatively affect the reproductive success of the plant.

The native range of *T. cistoides* is Cape Verde Islands, Eritrea to Mozambique and Pacific region (POWO 2024). *Tribulus cistoides* is now a weed distributed throughout the drier tropics, including many islands, and occurs mainly in maritime habitats (Porter 1971; Reyes-Corral et al. 2023, fig. 2). The flowers of *T. cistoides* have five petals arranged in a radially symmetric pattern. Their diameter ranges 20–40 mm. The flowers are protandrous and are typically pollinated by a diversity of insects in continental habitats, and by an endemic community of pollinators on islands (Porter 1971, Reyes-Corral et al. 2023). At the studied locality on São Vicente Island, the observed diversity and quantity of insect pollinators of *T. cistoides* was very low. In addition, the duration of exposure of open *T. cistoides* flowers to pollinators was considerably reduced by *C. stangeri*, which ate practically all their petals in early morning hours. An interesting question therefore is, what is the ecology of *T. cistoides* pollination in localities with the presence of *C. stangeri*? Can insect pollinators pollinate the plants before the lizards eat their flowers, or do the lizards compensate for the reduced attractiveness of the flowers by contributing to their pollination? The presence of pollen grains on the heads of *C. stangeri* repeatedly visiting different flowers of *T. cistoides* suggests that it is very likely that lizards contribute to the pollination of this plant. A more complex nature of interactions between *C. stangeri* and *T. cistoides* is shown by the fact that lizards do not eat the pistils, thereby not reducing the reproductive potential of the plants.

Pollination by lizards is a characteristic island syndrome where lizards feed upon flowers, fruits, nectar, and pollen (Whitaker 1987, Olesen et Valido 2003, Valido et Olesen 2019), and *T. cistoides* is considered an excellent system to study the phenotypic variation of reproductive traits on islands in response to species interactions (Carvajal-Endara et al. 2000, Reyes-Corral et al. 2023). Further observations and experiments may therefore reveal more interesting details about the nature of interactions between *C. stangeri* and *T. cistoides* or other Cape Verdean plants.

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