Herpetology Notes, volume 13: 415-419 (2020) (published online on 26 May 2020)

A new record of nectarivory for *Tarentola delalandii* (Duméril and Bibron, 1836) pollinating the introduced palm *Dypsis lutescens* (H.Wendl.) Beentje and J.Dransf. (Arecaceae) on Tenerife, Canary Islands

Thore Koppetsch[1,*], Gustavo Sánchez Romero[2], Eberhard Fischer[3], and Wolfgang Böhme[1]

Interactions between different species can include both positive and negative relationships, often developed as coevolutionary traits. Especially, mutualism, as an interaction in which both partners benefit from each other (Bascompte, 2019), is reported for a variety of ecological interactions. For terrestrial habitats, plant-pollinator interactions can be considered as one of the most detailed studied mutualistic relationships (Bronstein et al., 2006), also comprising various and complex mutualistic networks (Olesen and Jordano, 2002). Although insects are the most common and widespread pollinators (Pellmyr, 1992), there are numerous non-insect pollinators known to be involved in pollination systems, especially vertebrates, e.g. bats (Fleming et al., 2009), marsupials (Goldingay et al., 1991), birds (Cronk and Ojeda, 2008), or lizards (Godínez-Álvarez, 2004).

In particular, the role of lizards as pollinators has been underestimated for a long time, since those phenomena have been observed in the late 20th century for the first time (Elvers, 1977; Eifler, 1995; Olesen and Valido, 2003a). At least nectarivory and frugivory have been already recorded for many lizards in the past (Cheke, 1984; Whitaker, 1987; Valido and Olesen, 2007, 2019). By serving as pollinators or seed dispersers, important interactions with plants have been demonstrated in at least 37 lizard taxa of several families, e.g. species of Cordylidae, Iguanidae, Gekkonidae, Lacertidae, Scincidae, Teiidae, Varanidae (Olesen and Valido, 2003a; Godínez-Álvarez, 2004; Valido and Olesen, 2007). Apparently most cases in which lizards act as mutualistic agents were recorded from islands (Olesen and Valido, 2003a). There are even cases where a lacertid lizard is the only pollinator of a plant species on its island, thus monopolizing the reproductive ability of the plant, e.g. *Podarcis lilfordi* (Günther, 1874) pollinating *Crithmum maritimum* on a small Balearic islet (Perez-Mellado and Traveset, 1999). Compared to continental systems, on islands a reduced complexity and diversity of pollination networks or interactions can be found by showing a decreased pollinator species richness and consequently lower pollinator-plant ratios (Olesen and Jordano, 2002; Trøjelsgaard and Olesen, 2013; Traveset et al., 2016). Limited dispersal abilities on islands are considered as the main cause of a depauperate pollinator diversity (Gillespie and Roderick, 2002; Traveset et al., 2015, 2016). A well-studied example of pollination networks on islands and their distinctive characteristics are the Canary Islands (Dupont et al., 2003, 2004; Valido and Olesen, 2010). The Canary Islands are located west of the Moroccan coast in the Northern Atlantic Ocean and are part of the Macaronesian archipelago that comprises also the Azores, the Selvagens Islands, Madeira, and Cape Verde. For Macaronesia, several lacertids are known for their interactions with flowers: Apart from *Teira dugesii* (Milne-Edwards, 1829) visiting flowers on Madeira (Elvers, 1977; Beyhl, 1990) and the Azores (Olesen and Valido, 2003b; Valido and Olesen, 2010), on the Canary islands at least four cases of plant pollination have been recorded for species of the genus *Gallotia* (*Gallotia atlantica* (Peters and Doria, 1882), *G. caesaris* (Lehrs, 1914), *G. galloti* (Oudart, 1839) and

[1] Herpetology Section, Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, 53113 Bonn, Germany.

[2] Dragon Tree Park, Icod de los Vinos, 38430, Tenerife, Canary Islands.

[3] Institute for Integrated Sciences, Department of Biology, University of Koblenz-Landau, Universitätsstr. 1, 56070 Koblenz, Germany.

[*] Corresponding author. E-mail: t.koppetsch@leibniz-zfmk.de

G. stehlini (Schenkel, 1901)) (Font and Ferrer, 1995; Valido and Olesen, 2010; Ortega-Olivencia et al., 2012). In contrast to the important role of *Gallotia* lacertids as pollinators, and apart from their role as seed dispersers (recorded for all extant and even extinct representatives (Valido and Olesen, 2019) and even evidence for involvement in secondary seed dispersal (Padilla and Nogales, 2009)), for the other lizards occurring on the Canary islands mutualistic interactions with plants by visiting flowers remained unknown for a long time. Not only the Canary Islands host outstanding examples for mutualistic pollen dispersal interactions: on the Socotra Archipelago, Yemen, three species of geckos (*Hemidactylus dracaenacolus* Rösler and Wranik, 1999, *H. granti* Boulenger, 1899, and *Haemodracon riebeckii* (Peters, 1882)) carry pollen grains of *Dracaena cinnabari* (Asparagaceae), a tree with a key function for ecological networks of the endemic Socotran reptiles (García and Vasconcelos, 2017; Vasconcelos et al., 2020). Recently, it was shown that *Tarentola delalandii* (Duméril and Bibron, 1836) pollinates *Euphorbia lamarckii* and *E. canariensis* (Euphorbiaceae), being the first record of plant pollination for *Tarentola* geckos (Hernández-Teixidor et al., 2019), regardless of the fact that fruit consumption and implications for herbivory have been reported for other normally insectivorous *Tarentola* species before (Salvador, 1978; Pinho et al., 2018; Valido and Olesen, 2019).

Here we report the first record of *T. delalandii* visiting flowers of the introduced palm species *Dypsis lutescens* (H.Wendl.) Beentje and J.Dransf. (Arecaceae) (Fig. 1). On 11 October 2019 a single adult individual of *T. delalandii* was observed taking up nectar from several florescences in the late evening hours. This observation took place in a garden in the village Icod de los Vinos on Tenerife, Canary Islands. The gecko was found at a height of 3.2 meters above the ground on the stem of a *Dypsis lutescens* palm tree (Fig. 2). The gecko was observed in the late evening (20:00 h) in the darkness and the duration of the observation lasted approximately

Figure 1. *Tarentola delalandii* visiting the palm tree *Dypsis lutescens*. (A) Licking nectar from single flowers. (B) Using the broad smooth surface of the palm's spathe to reach the nectar-bearing flowers. Photos by Gustavo Sánchez Romero.

Figure 2. *Dypsis lutescens* is endemic to Madagascar, but was spread as an ornamental plant circumtropical, also on the Canary Islands. Photo by Gustavo Sánchez Romero.

35 minutes. The specimen moved along the palm's main stem, reaching almost the crown, climbing then into one of the spathes. This smoothed sword-like structure encloses the inflorescence (compound flower) that was opened and exposed. Perched there, and also moving along the inflorescence main stems, the gecko slowly approximated the tiny white flowers. In many different positions, even upside down, it reached for the small flowers, licking the nectar at different times and touching the pollen-bearing stamina.

Tarentola delalandii is distributed on the islands of Tenerife and La Palma (Báez et al., 1998; Carranza et al., 2000). Similar to *T. mauritanica* (Linnaeus, 1758), a species widespread in the Mediterranean region, *T. delalandii* can be considered as synanthropic due to its occurrence on buildings or stone walls. However, specimens can also be found far from humans hiding under stones in a nearly unvegetated landscape, e.g. in Teno (T. Koppetsch, pers. observ.). Different from lizards that might approach even florescences difficult to reach by climbing or clinging on narrow twigs, like the New Caledonian geckos *Eurydactylodes* (Bauer and Sadlier, 2000) or some skinks pollinating trees (Sazima et al., 2005), *Tarentola* geckos usually prefer more plane or broadened surfaces (de Fuentes-Fernández et al., 2016). Therefore, an introduced plant species like *Dypsis lutescens* with its tree-like appearance might allow easier access to nectar bearing florescences than other endemic Canary shrub-like plant species. A Canarian palm species, like *Phoenix canariensis* (Arecaceae), also offers suitable surfaces for *Tarentola* geckos, however, the height of their florescences might restrain accessibility and detectability of nectar sources.

The golden cane palm, areca palm or yellow palm *Dypsis lutescens* (H.Wendl.) Beentje and Dransf. (syn.: *Chrysalidocarpus lutescens* H.Wendl.) is endemic to the coastal forests of eastern Madagascar. As a flowering plant, this species has been cultivated and spread throughout the subtropics and tropics, but is also grown in greenhouses and conservatories in temperate zones. The genus *Dypsis* includes approximately 140 species, especially on Madagascar, including several local endemics that were described in the late 20th century (Dransfield and Beentje, 1995).

Floral anatomy and the small size of the female (pistillate) flowers in *Dypsis* indicate insect pollination (Rudall et al., 2003). Nevertheless, geckos of the genus *Phelsuma* (*P. grandis* Gray, 1870 and *P. inexpectata* Mertens, 1966) have been observed to occur on *Dypsis lutescens* either to visit flowers or feed on fruits (Sanchez et al., 2009; Dervin et al., 2013; Sanchez and Probst, 2014). Those strong associations between *Phelsuma* geckos and plants are especially known for Mauritius Island (Nyhagen et al., 2001; Hansen and Müller, 2009), even inducing floral adaptations to these pollination systems, like coloured nectar as a visual signal (Hansen et al., 2006). On *Dypsis lutescens* frugivory was not only recorded for geckos but also for flying foxes (Nyhagen et al., 2005). Therefore, pollinator-plant relationships of this palm species can be expected to be more generalistic than assumed based on floral anatomy.

Although the effectiveness of the pollination performances of *T. delalandii* has not been examined for the pollination record reported here, carrying pollen grains of several other plant species, e.g. *Euphorbia* (Euphorbiaceae), *Erica* (Ericaceae), or *Echium* (Boraginaceae) was already demonstrated for this (Hernández-Teixidor et al., 2019) and also related species (García and Vasconcelos, 2017). Therefore, nectarivory on introduced plant species, like *Dypsis* might allow the exploitation of new and previously inaccessible food sources. Especially generalistic or even synanthropic species like *T. delalandii* represent potential candidates for pollination services on islands, where super generalization and wide ecological niches are common (Olesen et al., 2002). Therefore, further similar observations might be expected in future.

Acknowledgements. GSR is grateful to Tomás Cornelio Álvarez and Juan Carlos González for sharing their observation. We thank Salvador Carranza for valuable comments on the manuscript.

References

Báez, M., Hielen, B., Rykena, S. (1998): *Tarentola delalandii* (Duméril & Bibron, 1836) – Kanarengecko. In: Die Reptilien der Kanarischen Inseln, der Selvagens-Inseln und des Madeira-Archipels, p. 161–175. Bischoff, W., Ed., Wiebelsheim, Germany, Aula Verlag.

Bascompte, J. (2019): Mutualism and biodiversity. Current Biology **29**(11): R467–R470.

Bauer, A.M., Sadlier, R.A. (2000): The Herpetofauna of New Caledonia. Ithaca, USA, Society for the Study of Amphibians and Reptiles.

Beyhl, F.E. (1990): Observations on the flower-visiting lizards of the island of Madeira, Portugal (Reptilia: Sauria: Lacertidae). Courier Forschungsinstitut Senckenberg **129**: 153–158.

Bronstein, J.L., Alarcón, R., Geber, M. (2006): The evolution of plant–insect mutualisms. New Phytologist **172**(3): 412–428.

Carranza, S., Arnold, E.N., Mateo, J.A., López-Jurado, L.F. (2000): Long-distance colonization and radiation in gekkonid lizards, *Tarentola* (Reptilia: Gekkonidae), revealed by mitochondrial DNA sequences. Proceedings of the Royal Society of London, Series B **267**: 637–649.

Cheke, A.S. (1984): Lizards of the Seychelles. In: Biogeography and Ecology of the Seychelles Islands, p. 331–360, Stoddart, D.R., Ed., The Hague, Netherlands, Dr W. Junk Publishers.

Cronk, Q., Ojeda, I. (2008): Bird-pollinated flowers in an evolutionary and molecular context. Journal of Experimental Botany **59**(4): 715–727.

de Fuentes-Fernández, M., Suárez-Rancel, M.M., Molina-Borja, M. (2016): Variation in body size and morphometric traits of males and females of the wall gecko, *Tarentola delalandii* (Phyllodactylidae) from different environments on Tenerife. African Journal of Herpetology **65**(2): 83–98.

Dervin, S., Baret, S., Penin, L., Sanchez, M. (2013): Régime alimentaire du grand gecko vert de Madagascar, *Phelsuma grandis* Gray, 1870 (Squamata: Gekkonidae) sur l'île de La Réunion. Cahiers Scientifiques de l'Océan Indien Occidental **4**: 29–38.

Dransfield, J., Beentje, H. (1995): The Palms of Madagascar. Kew, UK, Royal Botanic Garden, Kew and the International Palm Society.

Dupont, Y.L., Hansen, D.M., Olesen, J.M. (2003): Structure of a plant–flower-visitor network in the high-altitude sub-alpine desert of Tenerife, Canary Islands. Ecography **26**(3): 301–310.

Dupont, Y.L., Hansen, D.M., Rasmussen, J.T., Olesen, J.M. (2004): Evolutionary changes in nectar sugar composition associated with switches between bird and insect pollination: the Canarian bird-flower element revisited. Functional Ecology **18**(5): 670–676.

Eifler, D.A. (1995): Patterns of plant visitation by nectar-feeding lizards. Oecologia **101**: 228–233.

Elvers, I. (1977): Flower-visiting lizards on Madeira. Botaniska Notiser **130**: 231–234.

Fleming, T.H., Geiselman, C., Kress, W.J. (2009): The evolution of bat pollination: a phylogenetic perspective. Annals of Botany **104**(6): 1017–1043.

Font, E., Ferrer, M.J. (1995): *Gallotia galloti* (Canary Islands lizard): Nectar feeding. Herpetological Review **26**: 35–36.

García, C., Vasconcelos, R. (2017): The beauty and the beast: Endemic mutualistic interactions promote community-based conservation on Socotra Island (Yemen). Journal for Nature Conservation **35**: 20–23.

Gillespie, R.G., Roderick, G.K. (2002): Arthropods on islands: colonization, speciation, and conservation. Annual Review of Entomology **47**: 595–632.

Godínez-Álvarez, H. (2004): Pollination and seed dispersal by lizards: a review. Revista Chilena de Historia Natural **77**: 569–577.

Goldingay, R.L., Carthew, S.M., Whelan, R.J. (1991): The importance of non-flying mammals in pollination. Oikos **61**(1): 79–87.

Hansen, D.M., Beer, K., Müller, C.B. (2006): Mauritian coloured nectar no longer a mystery: a visual signal for lizard pollinators. Biology letters **2**(2): 165–168.

Hansen, D.M., Müller, C.B. (2009): Reproductive ecology of the endangered enigmatic Mauritian endemic *Roussea simplex* (Rousseaceae). International Journal of Plant Sciences **170**(1): 42–52.

Hernández-Teixidor, D., Díaz-Luis, N., Medina, F.M., Nogales, M. (2019): First record of geckos visiting flowers in the Palaearctic Ecozone. Current Zoology **102019**: 1–2.

Nyhagen, D.F., Kragelund, C., Olesen, J.M., Jones, C.G. (2001): Insular interactions between lizards and flowers: flower visitation by an endemic Mauritian gecko. Journal of Tropical Ecology **17**(5), 755–761.

Nyhagen, D.F., Turnbull, S.D., Olesen, J.M., Jones, C.G. (2005): An investigation into the role of the Mauritian flying fox, *Pteropus niger*, in forest regeneration. Biological Conservation **122**(3): 491–497.

Olesen, J.M., Eskildsen, L.I., Venkatasamy, S. (2002): Invasion of pollination networks on oceanic islands: importance of invader complexes and endemic super generalists. Diversity and Distributions **8**(3): 181–192.

Olesen, J.M., Jordano, P. (2002): Geographic patterns in plant–pollinator mutualistic networks. Ecology **83**(9): 2416–2424.

Olesen, J.M., Valido, A. (2003a): Lizards as pollinators and seed dispersers: an island phenomenon. Trends in Ecology & Evolution **18**(4): 177–181.

Olesen, J.M., Valido, A. (2003b): Bird pollination in Madeira island. Ardeola **50**(1): 67–69.

Padilla, D.P., Nogales, M. (2009): Behavior of kestrels feeding on frugivorous lizards: implications for secondary seed dispersal. Behavioral Ecology **20**(4): 872–877.

Ortega-Olivencia, A., Rodríguez-Riaño, T., Pérez-Bote, J.L., López, J., Mayo, C., Valtueña, F.J., Navarro-Pérez, M. (2012): Insects, birds and lizards as pollinators of the largest-flowered *Scrophularia* of Europe and Macaronesia. Annals of Botany **109**(1): 153–167.

Pellmyr, O. (1992): Evolution of insect pollination and angiosperm diversification. Trends in Ecology & Evolution **7**(2): 46–49.

Perez-Mellado, V., Traveset, A. (1999): Relationships between plants and Mediterranean lizards. Natura Croatica **8**(3): 275–285.

Pinho, C.J., Santos, B., Mata, V.A., Seguro, M., Romeiras, M.M., Lopes, R.J., Vasconcelos, R. (2018): What is the giant wall gecko having for dinner? Conservation genetics for guiding reserve management in Cabo Verde. Genes **9**(12): 599.

Rudall, P.J., Abranson, K., Dransfield, J., Baker, W. (2003): Floral anatomy in *Dypsis* (Arecaceae–Areceae): a case of complex synorganization and stamen reduction. Botanical Journal of the Linnean Society **143**(2): 115–133.

Salvador, A. (1978): Materiales para una "herpetofauna Balearica" 5. Las salamanquesas y tortugas del archipiélago de Cabrera. Doñana, Acta Vertebrata **5**: 5–17.

Sanchez, M., Probst, J.-M., Deso, G. (2009): *Phelsuma inexpectata* Mertens, 1966 (Squamata: Gekkonidae) sur l'île de La Réunion: écologie, répartition et menaces. Bulletin de la Société Herpétologique de France **132**: 43–69.

Sanchez, M., Probst, J.-M. (2014): Distribution and habitat of the invasive giant day gecko *Phelsuma grandis* Gray 1870 (Sauria: Gekkonidae) in Reunion Island, and conservation implication. Phelsuma **22**: 13–28.

Sazima, I., Sazima, C., Sazima, M. (2005): Little dragons prefer flowers to maidens: a lizard that laps nectar and pollinates trees. Biota Neotropica **5**(1): 185–192.

Traveset, A., Olesen, J.M., Nogales, M., Vargas, P., Jaramillo, P., Antolín, E., Trigo, M.M., Heleno, R. (2015): Bird–flower visitation networks in the Galápagos unveil a widespread interaction release. Nature Communications **6**: 6376.

Traveset, A., Tur, C., Trøjelsgaard, K., Heleno, R., Castro-Urgal, R., Olesen, J.M. (2016): Global patterns of mainland and insular pollination networks. Global Ecology and Biogeography **25**(7): 880–890.

Trøjelsgaard, K., Olesen, J.M. (2013): Macroecology of pollination networks. Global Ecology and Biogeography **22**(2): 149–162.

Valido, A., Olesen, J.M. (2007): Importance of lizards as frugivores and seed dispersers. In: Seed Dispersal: Theory and its Application in a Changing World, p. 124–147. Dennis, R., Green, R., Schupp, E., Westcott, D., Ed., Wallingford, UK, CABI Publishing.

Valido, A, Olesen, J.M. (2010): Pollination on islands: examples from the Macaronesian archipelagos. In: Terrestrial Arthropods of Macaronesia. Biodiversity, Ecology and Evolution, p. 249–283. Serrano A.R.M., Borges P.A.V., Boieiro, M., Oromí, P., Ed., Lisbon, Portugal, Sociedade Portuguesa de Entomologia.

Valido, A., Olesen, J.M. (2019): Frugivory and seed dispersal by lizards: a global review. Frontiers in Ecology and Evolution **7**: 49.

Vasconcelos, R., Pujol-Buxó, E., Llorente, G.A., Saeed, A., Carranza, S. (2020): Micro-hotspots for conservation: An umbrella tree species for the unique Socotran reptile fauna. Forests **11**: 353.

Whitaker, A.H. (1987): The roles of lizards in New Zealand plant reproductive strategies. New Zealand Journal of Botany **25**(2): 315–328.

Accepted by Idriss Bouam