
**Fruit and Nectar Feeding by
Podarcis lilfordi (Lacertidae) on
Cabrera Archipelago (Balearic Islands)**

Although only about 2% of lizard species are strictly herbivorous, many others consume plant and animal material in variable proportions (e.g., Busack and Jaksic 1982; Heatwole and Taylor 1987; Iverson 1979; Pough 1973). Omnivorous lizards often prefer flowers and fruits over leaves, presumably because reproductive parts are more efficiently assimilated than vegetative parts (Durtsche 1992; Heatwole and Taylor 1987; Pough 1973).

Lizard nectarivory has only been described on islands, in species of the families Gekkonidae (from Seychelles: Cheke 1984; Evans and Evans 1980; Gardner 1986; from New Zealand: Whitaker 1987a, 1987b), Scincidae (from Seychelles: Cheke 1984), Teiidae (from Bonaire, Lesser Antilles: Dearing and Schall 1992) and Lacertidae (from Madeira: Elvers 1977, 1978). Most reports of frugivory also result from studies of insular populations: Racine and Downhower 1974; Christian et al. 1984; Schluter 1984 (Galapagos Islands); Barquin and De La Torre 1975; Valido and Nogales 1994 (Canary Islands); Sadek 1981 (Madeira and Salvages Islands); Iverson 1985 (Bahamas); Whitaker 1987a (New Zealand); Auffenberg 1988 (Philippines); Sylber 1988 (Gulf of California); Castilla and Bauwens 1991 (Columbretes Archipelago, Spain); and Dearing and Schall 1992; Lichtenbelt 1993 (Netherlands Antilles). Nevertheless, continental populations may be frugivorous (e.g., Hernández 1990; Traveset 1990).

Here we report our observations on herbivory in *Podarcis lilfordi* (Günther 1874), a small lacertid lizard (81 mm maximum SVL) endemic to the islands that surround Mallorca and Menorca, Balearic Islands, Spain. The few references on the diet of this lizard describe it as an insectivorous species, although mentioning flower and fruit consumption (Pérez-Mellado 1989; Salvador 1986). Mayol (1985) points out that these lizards also eat nectar, but he does not specify, however, whether such nectar is collected without consuming the flowers. Pérez-Mellado (1989) reports that *P. lilfordi* reaches the nectar of *Crithmum maritimum* (Umbelliferae) by consuming its stamens.

Our data are based upon direct observations of foraging lizards, made during the peak of their daily activity period, mostly from January through September, 1993, in the archipelago of Cabrera and on Moltona islet (south of Mallorca island). The vegetation of these islands is dominated by a Mediterranean scrubland. We followed some individual lizards or watched particular plant species, from a distance of 2–3 m, during 20 min or until the animals disappeared. For each observation period, we recorded the number of plant parts consumed with a hand counter, and timed the feeding behavior with a stopwatch. Some additional data were obtained by examining stomach contents (gathered using stomach flushing) and fecal samples (taken haphazardly from the ground), collected during 1992 and 1993.

In the flowering period (mid March–mid April) of *Euphorbia dendroides* (Euphorbiaceae), a highly branching shrub that can reach 2 m in height, *P. lilfordi* was observed climbing up the trunk or the lowest branches near the ground to reach the yellow insect-pollinated flowers. This plant produces hundreds to thousands of inflorescences, 5 mm in size, that are in turn assembled in umbels of one to five. Each inflorescence consists of several minute flow-

ers surrounded by 4–5 glands, which secrete a copious and highly concentrated nectar. We observed lizards up to 1.1 m above ground surface, moving from branch to branch with no difficulty. After finding an umbel, the lizard stops and, placing its snout in front of the glands, starts lapping up the nectar. The lizard usually feeds from all inflorescences of a whole umbel before moving to the next, usually nearest umbel. The feeding rate averaged 8.8 ± 7.3 (SD) lapped inflorescences/minute ($N = 10$ individuals; total time spent on plants 109 min). Not all visited inflorescences are lapped, which suggests that lizards are examining and selecting those richer in nectar. The period that an individual lizard remained in a shrub varied from several seconds to 18 min ($N = 16$ individuals). Up to five individuals were counted simultaneously feeding on a single shrub, which is equivalent to 2.4 lizards/m² of cover ($N = 9$ plants observed). Nectar feeding was observed with greatest frequency on sunny days (with a photoperiod length of 12 hours) between 0800 h (1.5 hours after local sunrise) and 1100 h (GMT), although some individuals were seen on inflorescences until mid-afternoon.

When feeding upon nectar of *E. dendroides*, the lizard rubs its snout against the anthers that jut out from the male flowers. Also, while moving among inflorescences within the shrub, the ventral part of its body brushes against both male and female flowers, with the possibility of laying the collected pollen from males on the stigmas of females, and thus favoring pollination. This is supported by our direct observations (with binoculars) of several individuals with the snout covered by pollen while they were feeding upon nectar.

Podarcis lilfordi was also observed feeding upon nectar of *Rosmarinus officinalis* (Labiatae), a shrub widely distributed in Cabrera that blooms during winter. Its bluish insect-pollinated flowers are about 8 mm long, located in racemes at the distal ends of the branches, and produce abundant nectar. Up to six individual lizards were counted under a shrub about 1 m in diameter. Lizards concentrate under the shrubs not only to eat but also for refuge since the stems are multi-branched and densely foliated. To reach the nectar, *P. lilfordi* introduces the tip of its snout into the tube of the corolla and, extending its tongue, starts lapping from the bottom. As in the case of *E. dendroides*, lizards do not feed from all flowers visited.

The particular arrangement of the floral pieces of *R. officinalis* allows also that while the lizard is lapping up nectar, the stigma and the anthers come in contact with the upper part of its head. If some of the pollen grains adhere to the head, it is quite possible that the lizard promotes pollination in this plant.

Lizards feed not only upon the nectar of *R. officinalis*, but also consume its flowers. They can ingest entire flowers or just bite a piece of the corolla, often taking stamens and the pistil with it. They have also been observed removing dropped flowers. The examination of stomach contents reveals that during February and March, the flowers of *R. officinalis* constitute, on average, $70 \pm 35\%$ (SD) of stomach content volume ($N = 15$). The flowers of *E. dendroides* were never observed to be consumed by lizards, probably because of the toxic latex that the plant exudes when tissue breaks.

Another species from which flowers are abundantly consumed in Cabrera, though never reaching the importance of *R. officinalis*, is *Globularia alypum* (Globulariaceae), a short shrub with small violet flowers arranged in capitula of about 15 mm diameter. From January to March, lizards were observed climbing with some difficulty, the thin (ca. 1 mm thick) branches which bent under the weight of the animals. While climbing, they appeared to maintain balance with the aid of their tails. Some lizards were observed

jumping from the ground to reach the flowers. They usually tore off the stamens, pistils, bracts, and petals, leaving some capitula almost completely bare of functional flowers.

Six individuals were also seen, in January, tearing off and ingesting the petals of the yellow flowers of *Fumana ericoides* (Cistaceae), a plant sparsely distributed in Cabrera. At the beginning of September, on Na Plana, one of the islets of the Cabrera archipelago, the majority of individuals of *P. lilfordi* were observed on the branches of *Arthrocnemum fruticosum* (Chenopodiaceae) ripping the stamens from the flowers. Flowers from other species, such as *Alyssum maritimum* (Brassicaceae) and *Cneorum tricoccon* (Cneoraceae) also have been occasionally found in stomach contents.

Analysis of about 350 lizard scats of *P. lilfordi* from the Cabrera archipelago showed that it consumes the fleshy fruits of a variety of species (Table 1). The prevalence in the diet of a particular species was dependent on the fruit availability in the place and time of the collection of the samples. With the exception of *C. tricoccon*, which appears to be dispersed mainly by lizards on Cabrera, these fleshy fruits are also consumed by birds (Traveset 1993). The fruits of *C. tricoccon* are available from late winter through late spring and are consumed by lizards as soon as they ripen (turning a red color). Lizards were often seen climbing the shrubs—which can reach up to 1 m in height—and removing the cocci (three per fruit), one at a time. Usually, the lizard takes a coccus in the mouth and transports it some distance from the plant, where it is swallowed. We found up to four seeds of this plant in lizard scats, although two or three is usual. The seeds have been shown to be viable after passing through the lizard's gut, using the TTC (2,3,5 triphenyl tetrazolium chloride) bioindicator (Heydecker 1968).

TABLE 1. Plant species consumed by *Podarcis lilfordi*. N = nectar, Fw = flowers, Fr = fruits.

Plant species (Family)	N	Fw	Fr
<i>Juniperus phoenicea</i> (Cupressaceae)			+
<i>Ephedra fragilis</i> (Ephedraceae)			+
<i>Ficus carica</i> (Moraceae)			+
<i>Arthrocnemum fruticosum</i> (Chenopodiaceae)		+	
<i>Fumana ericoides</i> (Cistaceae)		+	
<i>Alyssum maritimum</i> (Brassicaceae)		+	
<i>Euphorbia dendroides</i> (Euphorbiaceae)	+		
<i>Rhamnus ludovici-salvatoris</i> (Rhamnaceae)			+
<i>Pistacia lentiscus</i> (Anacardiaceae)			+
<i>Cneorum tricoccon</i> (Cneoraceae)		+	+
<i>Withania frutescens</i> (Solanaceae)			+
<i>Rosmarinus officinalis</i> (Labiatae)			
<i>Phillyrea angustifolia</i> (Oleaceae)			+
<i>Phillyrea latifolia</i> (Oleaceae)			
<i>Globularia alypum</i> (Globulariaceae)		+	
<i>Arum italicum</i> s.l. (Araceae) *			+
<i>Asparagus stipularis</i> (Liliaceae)			+

* This species has only been found on Moltona islet.

Preliminary analyses of stomach contents and observations of foraging behavior in *P. lilfordi* reveal that the degree of herbivory varies with season. During February and March plant material constitutes $70 \pm 35\%$ (SD) of the volume of stomach contents,

and appears in 93% of stomachs (N = 15). Percentages decrease to 3 ± 7% and 13%, respectively, in stomach contents examined from specimens (N = 15) captured during August.

Our observations indicate that plant material constitutes an important fraction of the diet of *Podarcis lilfordi* during some months of the year at some localities. *P. lilfordi* consumes flowers and fruits of different plant species, and probably acts as seed dispersers for them. It also obtains nectar of several species by lapping the flowers without ingesting or damaging them. This indicates that, at least for species such as *Euphorbia dendroides* and *R. officinalis*, the lizard may have a role as pollinator. Such a role has been proposed for another lacertid, *Podarcis muralis dugesii* (Elvers 1977, 1978), and for three species of geckos (Whitaker 1987a, 1987b). According to Elvers (1977), the smooth texture of the skin of most lizards would make them inefficient collectors and transporters of pollen. Our observations, however, indicate that body contact with the sticky nectar while visiting the flowers increases pollen adherence to the skin.

We conclude that *P. lilfordi* has the potential of having a relevant effect on the reproduction of several plant species. Besides influencing plant fitness, either positively (pollinating flowers or dispersing seeds) or negatively (consuming flowers, partially or totally), the lizards may well affect the vegetation structure of the island to some degree, especially at those sites where they are most abundant.

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