

## New records of frugivory and ovophagy in *Podarcis* (Lacertidae) lizards from East Mediterranean Islands

Kinsey M. BROCK<sup>1,\*</sup>, Colin M. DONIHUE<sup>2</sup> and Panayiotis PAFILIS<sup>3</sup>

1. School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI, USA.

2. School of Forestry and Environmental Studies, Yale University, New Haven, CT, USA.

3. Department of Zoology and Marine Biology, School of Biology, University of Athens, Panepistimioupolis, Ilissia, Greece.

\*Corresponding author, K.M. Brock, E-mail: kbkinsey@umich.edu

Received: 26. August 2013 / Accepted: 24. November 2013 / Available online: 28. January 2014 / Printed: June 2014

Insular lizard populations deviate in numerous ways from their mainland kin (Losos & Ricklefs 2009). Variation in body size, morphology, life history and behavior are only few of the cases that have been reported (Meiri 2007, Herrel et al. 2008, Pafilis et al. 2008, 2011). Feeding ecology is not an exception to this general rule. Food scarcity imposes drastic constraints, and island populations must expand their diet by adopting uncommon practices such as cannibalism (Pérez-Mellado & Corti 1993, Castilla & Van Damme 1996, Pafilis et al. 2008, Zuffi & Giannelli 2013), or even extreme solutions such as the consumption of scorpions or marine prey (Castilla & Herrel 2009, Castilla et al. 2009). Herbivory is another typical adaptation to insularity; island lizards often increase their consumption of plant material so as to compensate for low food availability (Van Damme 1999, Espinoza et al. 2004, Vervust et al. 2010).

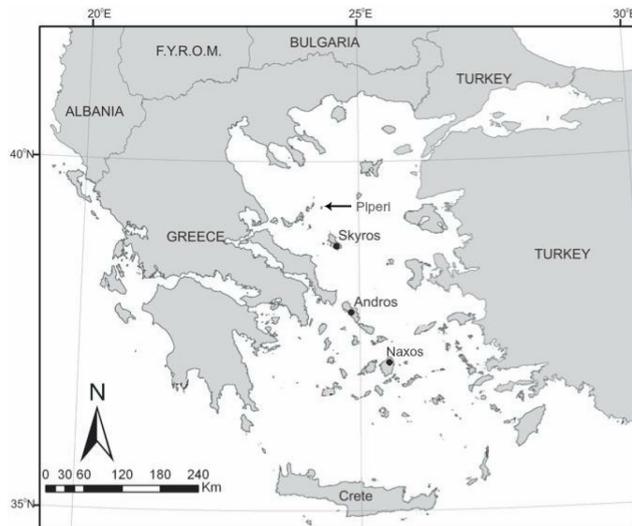
Many of the 21 *Podarcis* species are found on Mediterranean islands (Corti et al. 1999). Their diet largely consists of terrestrial invertebrates, primarily insects (Arnold & Ovenden 2002), though they are known to prey on a wide array of invertebrates, vertebrates, and even plant matter (Van Damme 1999, Carretero 2004). Though cannibalism and herbivory are well-documented in many of these populations around the Mediterranean, ovophagy (consumption of eggs) and frugivory (consumption of fruits) have seldom been reported, and only from the western part of the basin (Pérez-Mellado et al. 2000, Fici & Lo Valvo 2004, Dappen 2011, Celedon-Neghme et al. 2013). Here we relate the first observations of these two dietary strategies in two east Mediterranean species of *Podarcis*.

Our behavioral observations refer to two lizard species from Greece: the Skyros wall lizard (*Podarcis gaigeae*), an endemic species from the Skyros Archipelago (Fig. 1) and the Aegean wall lizard (*P. erhardii*), a lacertid with wide distribu-

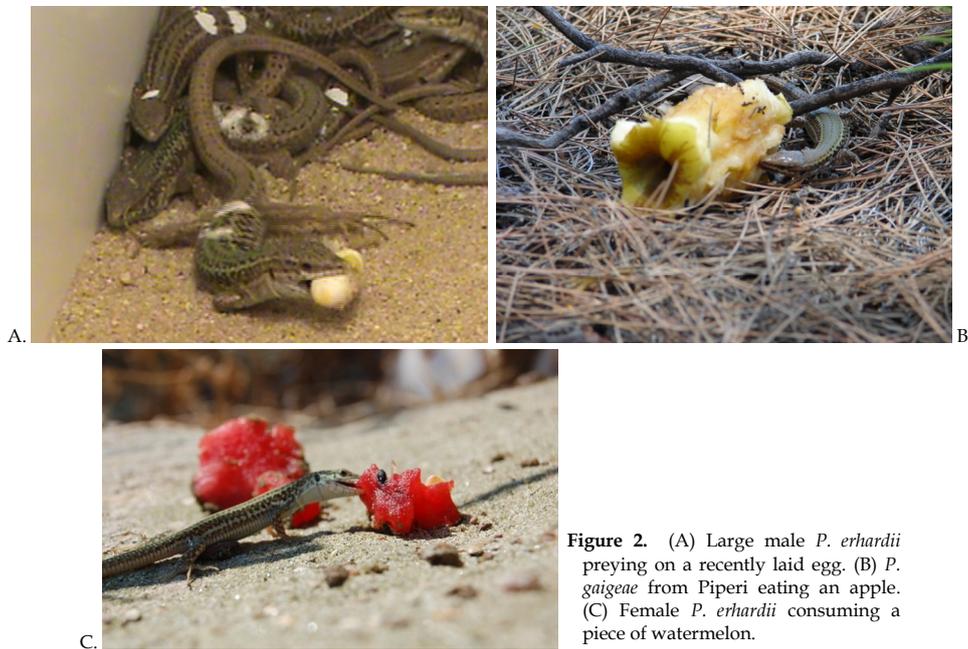
tion south of the Balkans (Valakos et al. 2008). Both species are medium-sized, ground-dwelling lizards (snout-to-vent length 49-78 mm) that feed mainly on insects, especially Coleoptera (Valakos 1986, Arnold 1987). *P. gaigeae* has a reputation for its cannibalistic propensities (Adamopoulou et al. 1999, Pafilis et al. 2009).

While surveying *P. erhardii* individuals in the Moni valley of Naxos Island (Fig. 1, 37° 0'49.37"N, 25° 29'50.75"E), CMD observed a fallen orange fruit under its tree (*Citrus sinensis*), whose rind had been chewed (seemingly by a small mammal; rats are abundant in this area) creating a 5 cm hole. The fruit flesh had been chewed out, and a large male *P. erhardii* was half-inside the rind-shell. CMD then took another fallen orange, cut it in half, and, after setting up a video camera on a tripod, placed it near the first orange at the base of a dry stone terrace. The video recorded for 25 minutes, and during that time the male lizard previously observed and a large female *P. erhardii* were seen nearly continuously lapping up orange juice and eating the fleshy pulp. At one point another adult male approached the orange and was immediately chased away, suggesting this was a valuable food resource. After half an hour, orange flesh had noticeably been removed from both orange halves.

Wild-caught *P. erhardii* from Moni, were also brought back to the lab and held in captivity for 48 hours. Ten males and ten females from the same population were housed in a 1 m corridor where they were fed and watered ad libitum, and allowed to thermoregulate across a thermal gradient. Shortly after a feeding, KMB observed a freshly laid egg in the arena. The egg was subsequently picked up by a large male (Fig. 2a) and carried around the arena. The focal male was contested by several other males, but successfully warding off all competitors. The egg was consumed 5 minutes later.



**Figure 1.** Map of Greece and Aegean islands where we observed wild *Podarcis* lizards engaging in previously undocumented feeding behaviors.



**Figure 2.** (A) Large male *P. erhardii* preying on a recently laid egg. (B) *P. gaigeae* from Piperi eating an apple. (C) Female *P. erhardii* consuming a piece of watermelon.

In a field trip to the island of Piperi (Fig. 1, 39° 20'44.03"N, 24° 19'17.71"E) PP left a half-eaten apple on the ground. Soon a female *P. gaigeae* arrived and started licking the juices of the fruit (Fig. 2b). After a while another female approached but the first one chased it away and returned to its trophy for 4 minutes. When the first female abandoned the apple, her rival reappeared and fed on the fruit.

On the sandy north coast of Andros Island

(Fig. 1, 37° 54'34.07"N, 24° 50'20.58"E) PP watched a juvenile *P. erhardii* approach the remains of a picnic. A piece of watermelon attracted its attention (Fig. 2c). The juvenile lizard remained on the spot for approximately 3 minutes, during which it consumed a considerable part of the fruit.

Under the demanding conditions of islands, lizards are doing their best to make the most of the limited resources they encounter. Particularly in the case of east Mediterranean islands, the pri-

mary obstacle to overcome is the harsh lack of water. One documented mechanism for obtaining water in this region is through dietary shifts. For example, island *Podarcis* include more mealworms in their summer diet (Valakos et al. 1997, Adamopoulou et al. 1999). Fruits, with their high water content, represent an excellent water source and are likely exploited when found out. Eggs, on the other hand, are a high-energy food that provides a high amount of calories and nutrients.

Dietary research remains an important topic in the study of reptilian biology and new studies are badly needed (Pérez-Mellado et al. 2011). Our observations expand upon previous stomach content analyses on the diet of *Podarcis* lizards to give a more complete view of the natural history of the genus. These four incidents also reflect previously hypothesized, but undemonstrated similarities with members of the genus on western Mediterranean islands. This suggests that additional work to elucidate inter-island context-dependent differences in *P. erhardii* diet may provide similarly interesting insights.

#### References

- Adamopoulou, C., Valakos, E.D., Pafilis, P. (1999): Diet composition of *Podarcis milensis*, *Podarcis gaigeae* and *Podarcis erhardii* (Sauria: Lacertidae) during summer. *Bonner Zoologische Beiträge* 48: 275-282.
- Arnold, E.N. (1987): Resource partition among lacertid lizards in southern Europe. *Journal of Zoology* 1: 739-782.
- Arnold, E.N., Ovenden, D. (2002): *A Field Guide to the Reptiles and Amphibians of Britain and Europe*. Harper Collins, London.
- Carretero, M.A. (2004): From set menu to la carte. Linking issues in trophic ecology of Mediterranean lacertids. *Italian Journal of Zoology* 2: 121-133.
- Castilla, A.M., Van Damme, R. (1996): Cannibalistic propensities in the lizard *Podarcis hispanica atrata*. *Copeia* 1996: 991-994.
- Castilla, A.M., Herrel, A. (2009): The scorpion *Buthus occitanus* as a profitable prey for the endemic lizard *Podarcis atrata* in the volcanic Columbretes islands (Mediterranean, Spain). *Journal of Arid Environments* 73: 378-380.
- Castilla, A.M., Herrel, A., Gosá, A. (2009): Marine prey in the diet of *Podarcis atrata* from the Columbretes Islands. *Munibe* 57: 295-298.
- Celedon-Neghme, C., Traveset, A., Calvino-Cancela, M. (2013): Contrasting patterns of seed dispersal between alien mammals and native lizards in a declining plant species. *Plant Ecology* 214: 657-667.
- Corti, C., Böhme, W., Delfino, M., Masseti, M. (1999): Man and lacertids on the Mediterranean islands: conservation perspectives. *Natura Croatica* 8: 287-300.
- Dappen, N. (2011): Cold-blooded Cannibals. Observations on cannibalistic egg eating and predation on juveniles within *Podarcis pityusensis*. *Lacertidae (Eidechsen Online)* 2011: art.113.
- Espinoza, R.E., Wiens, J.J., Tracy, C.R. (2004): Recurrent evolution of herbivory in small, cold-temperate lizards: breaking the ecophysiological rules of reptilian herbivory. *Proceedings of National Academy of Science* 101: 16819-16824.
- Fici, S., Lo Valvo, F. (2004): Seed dispersal of *Capparis spinosa* L. (Capparaceae) by Mediterranean lizards. *Naturalista Siciliano* 28: 1147-1154.
- Losos, J.B., Ricklefs, R.E. (2009): Adaptation and diversification on islands. *Nature* 457: 830-836.
- Pafilis, P., Pérez-Mellado, V., Valakos, E.D. (2008): Post autotomy tail activity in Balearic wall lizard, *Podarcis tilfordi*. *Naturwissenschaften* 95: 217-221.
- Pafilis, P., Meiri, S., Foufopoulos, J., Valakos, E. (2009): Intraspecific competition and high food availability are associated with insular gigantism in a lizard. *Naturwissenschaften* 96: 1107-1113.
- Pafilis, P., Foufopoulos, J., Sagonas, K., Runemark, A., Svensson, E., Valakos, E.D. (2011): Reproductive biology of insular reptiles: marine subsidies modulate expression of the "island syndrome". *Copeia* 2011: 545-552.
- Pérez-Mellado, V., Corti, C. (1993): Dietary adaptations and herbivory in lacertid lizards of the genus *Podarcis* from western Mediterranean islands (Reptilia: Sauria). *Bonner Zoologische Beiträge* 44: 193-220.
- Pérez-Mellado, V., Cortazar, G., Lopez-Vicente, M., Perera, A., Sillero, N. (2000): Interactions between the Balearic lizard *Podarcis tilfordi* and the plant *Dracunculus muscivorus*. *Amphibia-Reptilia* 21: 223-226.
- Pérez-Mellado, V., Pérez-Cembranos, A., Garrido, M., Luiselli, L., Corti, C. (2011): Using faecal samples in lizard dietary studies. *Amphibia-Reptilia* 32: 1-7.
- Van Damme, R. (1999): Evolution of herbivory in lacertid lizards: Effects of insularity and body size. *Journal of Herpetology* 33: 663-674.
- Valakos, E. (1986): The feeding ecology of *Podarcis erhardii* (Reptilia-Lacertidae) in a main insular ecosystem. *Herpetological journal* 1: 118-121.
- Valakos, E.D., Adamopoulou, C., Maragou, P., Mylonas, M. (1997): The food of *Podarcis milensis* and *Podarcis erhardii* in the insular ecosystems of the Aegean. pp. 373-381. In: Böhme, W., Bischoff, W., Ziegler, T. (eds), *Herpetologia bonnensis*. Societas Herpetologica Europea, Bonn.
- Valakos, E.D., Pafilis, P., Sotiropoulos, K., Lymberakis, P., Maragou, P., Foufopoulos, J. (2008): The Amphibians and Reptiles of Greece. Chimaira, Frankfurt am Main.
- Vervust, B., Pafilis, P., Valakos, E.D., Van Damme, R. (2010): Anatomical and physiological changes associated with a recent dietary shift in the lizard *Podarcis sicula*. *Physiological Biochemical Zoology* 83: 632-642.