Revista Chilena de Historia Natural
69: 339-342, 1996

Seed dispersal by lizards in Chilean rainforest

Dispersión de semillas por lagartijas en el bosque lluvioso de Chile

MARY F. WILLSON[1], CARLOS SABAG[2], JAVIER FIGUEROA[2], JUAN J. ARMESTO[2] and MARCELO CAVIEDES[2]

[1]Forestry Sciences Laboratory, 2770 Sherwood Lane, Juneau AK 99801, USA. E-mail: /s=M.WILLSON/OUI = R10A@MHS-FSWA.ATTMAIL.COM
[2]Departamento de Biología, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile

ABSTRACT

Lizards *(Liolaemus pictus)* of the south-temperate rainforest of Chile eat fruits of *Nertera granadensis*, *Relbunium hypocarpium*, and occasionally other species. Seeds may be retained in the digestive tracts for several days. *Nertera granadensis* seeds that passed through lizard digestive tracts germinated more rapidly than untreated seeds. Thus, these lizards are capable of dispersing viable seeds of *N. granadensis*.

Key words: frugivory, *Liolaemus pictus*, seed dispersal, south-temperate rainforest, *Nertera granadensis*.

RESUMEN

La lagartija *(Liolaemus pictus)* de los bosques lluviosos del sur de Chile come frutos de *Nertera granadensis*, *Relbunium hypocarpium*, y ocasionalmente de otras especies. Las semillas pueden ser retenidas en el tracto digestivo durante algunos días. Las semillas de *N. granadensis* ingeridas por la lagartija germinan más rapido que las semillas control. Por tanto, esta lagartija puede ser un agente dispersor de semillas de *N. granadensis*.

Palabras clave: frugivoría, *Liolaemus pictus*, dispersión de semillas, bosque lluvioso templado del sur, *Nertera granadensis*.

INTRODUCTION

The fleshy fruits produced by many species of seed plants are an adaptation for seed dispersal by animals, especially vertebrates (Ridley 1930, Van Der Pijl 1982). Birds and mammals are by far the most commonly studied seed vectors among the vertebrates, although reptiles and fishes are also known to disperse seeds regularly (references in Willson 1983). Indeed, reptiles were probably the earliest terrestrial animals to interact with seed plants in seed-dispersal mutualisms (Weigelt 1930, Chalchoner & Sheerin 1981, Tiffney 1984, Herrera 1989, Fleming & Lips 1991), although amphibians should not be discounted out of hand (Da Silva et al. 1989). Among reptiles, tortoises are perhaps the best-known –though little studied– agents of seed dispersal, but evidence is slowly accumulating that lizards may be important mutualists in many areas, both tropical and temperate (e.g., Symon 1979, Clifford & Hamley 1982, Iverson 1985, Barquin et al. 1986, Whitaker 1987, Traveset 1990, Fleming & Lips 1991, Cortes Figueria et al. 1994, Valido & Nogales 1994). Frugivory by lizards of the Chilean rainforest has been suspected for some time (Armesto & Rozzi 1989, C. Villagrán, pers. comm.); we here document frugivory and transport of intact, germinable seeds by *Liolaemus pictus chiloëensis* (Muller & Hellmich) (Tropiduridae).

METHODS

Ten individuals of *L. pictus* were captured in late November, 1992, and 62 individuals were captured in January 1994, near the edge of mature secondary forest near Huelden, northeast Isla de Chiloé (approx. 42°S 74° W). They were housed individually, for one-

(Received 20 July 1995; accepted 15 March 1996; managed by Javier A. Simonetti and Fabián M. Jaksic).

two weeks, in cages made of perforated plastic soda bottles. Body size of the captives ranged from 5-8 cm snout-vent length (approximately). We inspected each cage periodically for seed-containing feces. At the end of these observations, most lizards were released near the site of capture; two were returned to Santiago for confirmation of identification.

Two species of seeds commonly found in the feces of captive lizards were used in the germination experiments. *Nertera granadensis* (Mutis ex L. f.) Druce (Rubiaceae) is a ground-hugging herbaceous species that produces red-orange fruits, 2-3 mm in diameter, both in exposed positions above the leaves and in concealed positions beneath the leaves *Relbunium hypocarpium* (L.) Hemsl. (Rubiaceae) is an herbaceous species that commonly twines among the branches of small shrubs. The orange fruits are about 2 mm in diameter. There are usually two seeds per fruit in both species, and the pulp of both kinds of fruits is very watery (ca. 96% water in *N. granadensis*).

Preliminary germination trials with seeds of *N. granadensis* in growth chambers at the Facultad de Ciencias showed that exposure to light enhanced the germination rate (75% of seeds) compared to germination in dark conditions (10%). Subsequent experiments were therefore conducted with 12 hours of exposure to light each day. Seeds were placed in Petri dishes, 10 seeds/dish, and the dishes were placed in a growth chamber at 20° C. Experiment 1 began on 9 August and ended on 7 October 1994; the seeds were checked five times during this period. Experiment 2 began on 28 October and ended on 2 December 1994; the seeds were checked seven times during this period. Germination data were analyzed by Mann-Whitney U tests comparing the number of seeds germinated in each replicate in treatment and control and, secondarily, by x^2 tests on the total number of germinated seeds in treatment and control.

RESULTS

Most lizards produced 2-5 feces during the observation period, each deposit composed chiefly of insect remains (especially Coleoptera). Seven of the ten lizards in 1992 defecated intact *Nertera* seeds from fruits consumed before capture. Some of the defecated seeds appeared as long as 5-7 days after capture. In 1994, 32 of the 62 lizards (52%) passed seeds of *N. granadensis*, eight individuals (13%) passed seeds of *R. hypocarpium*, one individual (2%) passed seeds of *Gaultheria sp.*, and 21 individuals (34%) passed no seeds during the captive period. Among the lizards that had eaten some fruit, the estimated median number of *N. granadensis* fruits eaten per lizard was 2 (range 1-8) and of *R. hypocarpium* was 3 (range 1-14). Of all the seeds (n = 285) passed by captive lizards in 1994, 62% were *N. granadensis*, 28% were *R. hypocarpium*, and 10% were *Gaultheria*.

Germination of *R. hypocarpium* was very low (maximum = 2 seeds/replicate) and no difference could be detected between treatments. *Nertera granadensis* seeds generally germinated faster after passage through lizard digestive tracts. The median percentage of seeds germinating after passage was 50%, compared to 5% in the control in Experiment 2 (Mann-Whitney U = 1, n = 8,8; $P < 0.001$). There was no significant difference in Experiment 1, although some seeds germinated in the treatment replicates but none did in the controls. The total proportion of seeds germinating was greater after gut-passage than in controls in both experiments (Experiment 1: 29% vs. 0%, n = 70, 50; $x^2 = 15.2$, $P < 0.0001$; Experiment 2: 51% vs. 6%, n = 80,80; $x^2 = 39.5$, $P < 0.0001$). Almost all germination of *N. granadensis* occurred in a pulse, 2.5-3.0 weeks after initiation of the experiment.

DISCUSSION

These observations document frugivory and transport of intact seeds by *L. pictus* in the rainforest of southern Chile. Although Donoso-Barros (1966) described this species as fundamentally arboreal, on Chiloé they are commonly found on the ground and have ready access to fruits of plants such as *Nertera*. Seed retention times were much longer (several days) than is usual in small passerine birds (usually < 3 hr), although the residence time of seeds in the digestive tract might be somewhat less in free-ranging, actively foraging lizards than in our captive animals, which ate very little.

That *N. granadensis* seeds germinate faster after exposure to light may be associated with our observations that this species commonly grows in forest light-gaps and at forest edges, rather than in forest interior. In addition, lizards commonly bask in the light, raising their body temperatures and metabolic rates. Higher metabolic rates might increase rates of gut passage and the probability that seeds would be defecated in well-lit sites. If so, then components of lizard behavior would enhance their ecological role as agents of seed dispersal. The low germination rate observed for *R. hypocarpium* need not mean that lizards are poor dispersal agents for this species. We must know more about the germination requirements of this species before we can assess adequately the possible role of lizards in dispersal.

Chile and New Zealand offer unusual opportunities to examine seed dispersal by lizards in temperate forests: Both regions have relatively depauperate faunas of avian and mammalian seed dispersers, local radiations of lizard taxa, and fruiting species that seem well-suited to lizard dispersal (Whitaker 1987 for New Zealand). *Liolaemus* is a speciose genus in Chile (Donoso-Barros 1966), and other species may well be involved in such mutualisms. Other Chilean fruits that may be consumed by lizards include, for example, *Gunnera Magellanica* (C. Villagrán pers. comm., Armesto & Rozzi 1989), small *Pernettya* fruits, and fallen fruits of *Aristotelia chilensis*. Given the widespread occurrence of frugivory and seed transport by lizards in many parts of the world, and the relative ease of tracking lizards in the field, a detailed ecological study of seed dispersal by lizards would be desirable.

ACKNOWLEDGMENTS

We are grateful to Fundación Andes, U.S. National Science Foundation - International Programs, and CONICYT, grants 92-1135 and 1950461 for supporting the larger project of which this was a part. We are grateful to Anna Traveset and two anonymous reviewers for helpful comments on the manuscript. This is contribution N° 2 from Estación Biológica Senda Darwin, Ancud, Chiloé, a field station established by the Institute of Ecological Research Chiloé.

LITERATURE CITED

ARMESTO JJ & RR ROZZI (1989) Seed dispersal syndromes in the rain forest of Chiloé: evidence for the importance of biotic dispersal in a temperate rain forest. Journal of Biogeography 16: 219-226.

BARQUIN, E, M NOGALES & W WILDPRET (1986) Intervención de vertebrados en la diseminación de plantas vasculares en Inagua, Gran Canaria (Islas Canarias). Vieraea (Spain) 16: 263-272.

CHALCONER WG & A SHEERIN (1981) The evolution of reproductive strategies in early land plants. In: GGE SCUDDER & JL REVEAL (eds.), Evolution Today: Proceedings of the Second International Congress of Systematic and Evolutionary Biology: 93-100.

CLIFFORD HT & T HAMLEY (1982) Seed dispersal by water dragons. Queensland Naturalist 23: 49.

CORTES FIGUEIRA JE, J VASCONCELLOS-NETO, MA GARCIA & AL TEIXEIRA DE SOUZA (1994) Saurochory in *Melocactus violaceus* (Cactaceae). Biotropica 26: 295-301.

DA SILVA HR, MC DE BRITTO-PEREIRA and U CARAMASCHI (1989) Frugivory and seed dispersal by *Hyla truncata*, a neotropical tree-frog. Copeia 1989: 781-783.

DONOSO-BARROS R (1966) Reptiles de Chile. Ediciones de la Universidad de Chile, Santiago. 458 + cxxxviii pages.

FLEMING TH & KR LIPS (1991) Angiosperm endozoochory: were pterosaurs Cretaceous seed dispersers? American Naturalist 138: 1058-1065.

HERRERA CM (1989) Seed dispersal by animals: a role in angiosperm diversification? American Naturalist 133: 309-322.

IVERSON JB (1985) Lizards as seed dispersers? Journal of Herpetology 19: 292-293.

RIDLEY HN (1930) The dispersal of plants throughout the world. Reeve, Ashford, Kent. 744 pages.

SYMON DE (1979) Fruit diversity and dispersal in *Solanum* in Australia. Journal of the Adelaide Botanical Garden (Australia) 1: 321-331.

TIFFNEY BH (1984) Seed size, dispersal syndromes, and the rise of the angiosperms: evidence and hypothesis. Annals of the Misssouri Botanical Garden 71: 55-576.

TRAVESET A (1990) *Ctenosaura similis* Gray (Iguanidae) as a seed disperser in a Central American deciduous forest. American Midland Naturalist 123: 402-404.

VALIDO A & M NOGALES (1994) Frugivory and seeds dispersal by the lizard *Gallotia galloti* (Lacertidae) in a xeric habitat of the Canary Islands. Oikos 70: 403-411.

VAN DER PIJL L (1982) Principles of Dispersal in Higher Plants (3rd ed.) Springer-Verlag, Berlin. 215 pages.

VILLAGRAN C, JJ ARMESTO, & R LEIVA (1986) Recolonización postglacial de Chiloé insular: evidencias basadas en la distribución geográfica y los modos de dispersión de la flora. Revista Chilena de Historia Natural 59: 19-39.

WEIGELT J (1930) Über die vermutliche Nahrung von Proterosaurus und über einer Körperlich erhaltenen Fruchstand von *Archeopodocarpus germanicus* Aut. Leopolidina 6: 269-280.

WHITAKER AH (1987) The roles of lizards in New Zealand plant reproductive strategies. New Zealand Journal of Botany 25: 315-328.

WILLSON MF (1983) Plant reproductive ecology. Wiley-Interscience, New York. 282 pages.