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New Zealand lizards have long been known to consume large amounts of fleshy fruit. Recent studies have shown they also take considerable quatities of nectar. Summarises a forth coming paper which examines how geckos and skinks may aid in the pollination and seed dispersal of several native plants.

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OF HERBS AND HERPS

New Zealand lizards have long been known to consume large amounts of fleshy fruit. Recent studies have shown they also take considerable quantities of nectar. Here Tony Whitaker *summarises a forthcoming paper which examines how geckos and skinks may aid the pollination and seed dispersal of several native plants.*

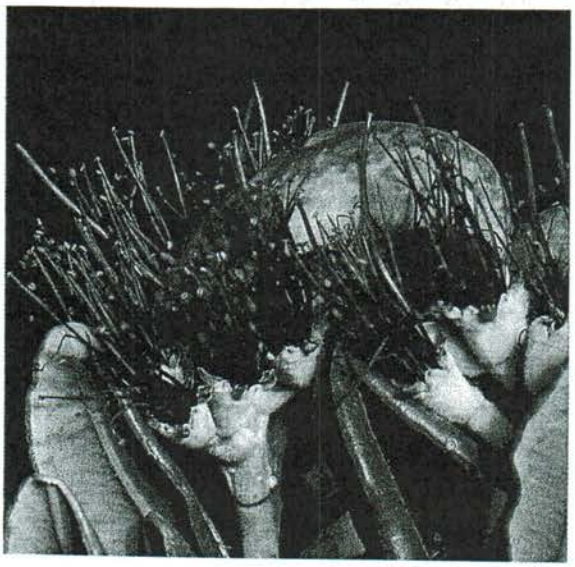
The combined impacts of habitat destruction and introduced predators have taken their toll on the New Zealand lizard fauna. Some species have become extinct, several are now confined to predator-free islands, and yet others show disjunct or markedly reduced ranges. The species which remain on the New Zealand mainland are generally secretive, elusive and/or nocturnal, and of small size. Furthermore, in most districts they are now relatively scarce. It is hardly surprising, therefore, that botanists have failed to recognise the potentially important role these animals may play in the reproductive strategies of many New Zealand plants.

Pollination

For many decades the instructions for keeping lizards in captivity (before they were protected under the Wildlife Act) usually said they could be fed on "honey-water". Whilst such a diet is hardly a balanced one it provides a long-neglected clue to their potential role in pollination.

First records of lizards taking nectar in the wild were obtained in New Zealand over 20 years ago but the significance of these observations to pollination biology was overlooked. More recently reports from other parts of the world have shown several species of small lizards regularly visit flowers to feed on nectar or pollen but only one of these studies suggested lizards should be seriously considered as pollinators. Work with New Zealand lizards over the last few years has now shown that some geckos are indeed capable of acting as pollinators for some native plants.

In New Zealand the lizards most commonly seen feeding on nectar are the nocturnal geckos, in particular the giant (or Duvaucel's) gecko and the Pacific gecko. Where these two species are still abundant, such as on the northern off-shore islands, they can easily be observed feeding from the flowers of a variety of trees and on honey dew. There are also records of the diurnal green geckos feeding on manuka nectar but as yet there have been no reports of skinks visiting flowers.



Above: **While feeding on nectar from flax flowers a giant gecko becomes covered in pollen – visible here on its jaws, throat and even on it's eye. Geckos feeding on flax prise the petals apart and lap the nectar through the side of the flower.** *Photo: Tony Whitaker*

Left: **When feeding from pohutukawa flowers Pacific geckos crawl over the blossoms and push their heads down between the stamens to reach the nectar. In doing so pollen adheres to their feet and the underside of their body, particularly the throat. Ultrastructural differences of the skin on the throat may indicate a specific adaptation for pollen transmission.** *Photo: Tony Whitaker*

– The possible roles of lizards in plant reproduction

Above: **Pacific geckos congregate on newly opened pohutukawa flowers to feed on nectar. As many as five geckos have been seen crowded on to a single inflorescence and geckos preferentially seek out trees in bloom.**
Photo: Tony Whitaker

geckos appear to be pohutukawa, ngaio and flax. The geckos emerge from their hiding places at dusk and quickly gather in trees or flax plants that are in bloom, often travelling considerable distances to do so. They forage through the foliage seeking blossoms that have recently opened as these seem to produce the greatest amount of nectar. The geckos lap the nectar from each flower in turn in an inflorescence and then move on in search of further flowers.

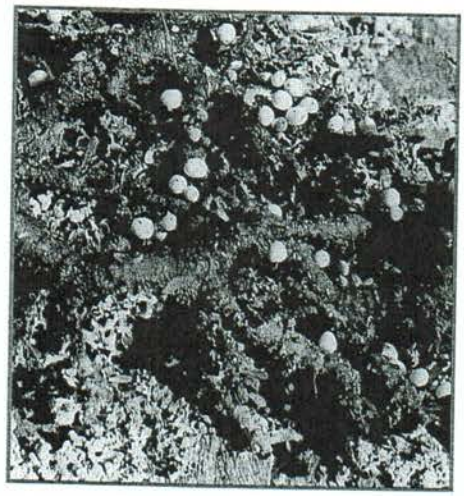
The density of geckos in plants with flowers at the right stage for pollination can be very high. As many as five geckos have been observed crowded on to one pohutukawa inflorescence and overall densities in flowering pohutukawas have been calculated at 5-8 per square metre of canopy surface. At one site every flax flower spike had geckos on it, most with four to six!

When feeding from pohutukawa flowers geckos scramble over the brush-like inflorescences and push their heads down between the stigmas and stamens to get at the nectar. In doing so their heads, and in particular their throats, become covered in pollen. Because of the way they feed, the throat is the best part of the body for transferring

Middle: **Competition amongst lizards for fruit is so fierce in some places that ripe berries are plucked straight from the plant. Here a normally terrestrial shore skink has climbed a metre and a half up the smooth, vertical stems of kawakawa to reach ripe fruit. Any fruit that were dislodged were rapidly snatched up by other skinks and frequent fights developed for choice morsels.**
Photo: Tony Whitaker

Right: **Geckos which feed on nectar commonly accumulate large amounts of pollen on their throats – here yellow pohutukawa pollen on a giant gecko's throat at least 12 hours after it last had access to pohutukawa flowers.**
Photo: Tony Whitaker

Above: **A ripe karaka berry is more than a mouthful for a giant gecko. Maori history tells of feeding large pet lizards on the fruit of tawa. Perhaps in the recent past the extinct *[H]olodactylus delcourti*, at over 60cm long the largest gecko ever, may have eaten and distributed a variety of the larger fleshy fruits of forest trees such as karaka, tawa, taraire and miro.** *Photo: Roy Slack*



Right: **Birds have usually been considered the seed dispersal agents of fleshy fruits, particularly those that are red, orange or black. However, many of New Zealand's divaricating shrubs have white or colourless berries buried inaccessibly within a dense tangle of twigs, the extreme perhaps being *Hymenanthera alpina* shown here turned over to reveal the berries hanging beneath the stems. These fruits are all eaten by lizards and these divaricating shrubs may be specifically adapted to lizard dispersal.** *Photo: Tony Whitaker*

pollen from stigma to stamen and it is certainly the area where pollen adheres longest. Examination of the skin of geckos with a scanning electron microscope has revealed interesting differences between that of the throat and other parts of the body suggesting there may be special adaptations to carry pollen.

The opportunities for carrying pollen from one flower to the next, or one inflorescence to another, are obvious as geckos covered with pollen can be seen scrambling from one pohutukawa or flax flower to the next in a matter of minutes. The opportunities for geckos to carry pollen from one plant to another of the same species that is at an appropriate stage of floral development requires the geckos travel greater distances and retain pollen for longer periods. To test this, pollen smears were collected from inactive geckos and geckos foraging away from a nectar (pollen) source. Pohutukawa pollen was recovered from over 60 percent of the geckos sampled just before they became active, meaning they must have been carrying it for at least 12 hours. Of greater interest was the fact that many geckos collected 20-25m from flowering pohutukawa trees were carrying pohutukawa pollen, and one was over 50m from the nearest tree.

Clearly geckos have the potential to be effective pollinators of pohutukawa and, as brush-structured blossoms seem to offer the best opportunities for pollen collection and deposition, they may also have (or have had) a similar association with other spe-

flax, ngaio and other species geckos are probably nectar robbers which effect some pollination.

Seed Dispersal

Worldwide there are many large species of herbivorous lizards which include fruit in their diet, and some of these are recognised dispersers of plant seeds. Smaller species of lizards are almost exclusively insectivorous and this is generally true of the skinks and geckos in New Zealand. For many years it has been known skinks here consume some soft fruits or berries, and more recently it became apparent that geckos do also. Studies have now shown fruit to be present in the diet of many species.

Lizards from all four genera present in New Zealand have been recorded eating fruit, including diurnal and noctural geckos and skinks, and both arboreal and terrestrial species.

The fruits consumed are in a variety of families. All are fleshy and most are small – most are drupes or berries 3-6mm in diameter – although there is one record of a gecko taking a karaka berry. Small fruits such as *Coprosma* or *Hymenanthera* berries or pohuehue fruits are swallowed whole, larger fruits like kawakawa berries are eaten in pieces.

The lizards either take the fruits as soon as they fall, or scramble around the branches in search of those that are ripe. Geckos are all adept climbers but the normally terrestrial skinks can move relatively gled vines and have even been observed scaling the smooth and vertical stems of kawakawa to reach ripe fruit. In some places in Otago skinks strip all the ripe fruit from shrubs of *Hymenanthera* and *Gaultheria*, and pohuehue vines.

Fruit important in diet

Seasonally, fruit is an important component of the diet of many species of lizards. A study of common geckos near Wellington showed that in summer over half of the animals had been feeding on *Coprosma* and pohuehue fruit. Over summer more than 30 percent of the diet of robust skinks is fruit (kawakawa, *Coprosma* and *Solanum*). Over a two year period fruit (*Gaultheria* and *Leucopogon*) comprised 15-18 percent by volume of the diet of common skinks in Otago but over the short season when ripe fruit was available would have been even more important.

Most fruit taken by lizards is swallowed whole and the seeds it contains are undamaged. These usually pass through the gut within 36 hours and germination trials have shown that many are viable. New Zealand lizards commonly forage over tens of metres and clearly have the ability to transport seed well beyond the limits of the parent plant.

Lizards have no aversion to defaecating in their hiding places and often the crevices where lizards live are full of droppings crammed with seeds of a variety of plant species. In some environments, such as arid or exposed ones, these places provide particularly good micro-sites for germination and seedling establishment.

Many of the fruits commonly eaten by lizards are from divaricating shrubs, or densely tangled vines, where they are all but inaccessible to birds. Often these fruits are white or nearly colourless in marked contrast to the red or orange fruits normally associated with bird dispersal. The most extreme example is perhaps *Hymenanthera alpina* which bears white fruit beneath a tight tangle of hard spiny twigs. Perhaps these are plants which are specifically adapted to dispersal by lizards?

Evolution and Adaptation

With the present density of lizards over most of New Zealand it is hard to imagine that lizards could play a significant role in pollination or seed dispersal. At a very few mainland sites and on predator-free offshore islands it is still possible to observe lizards at densities similar to those which must have prevailed over much of New Zealand in the past. At Turakirae Head the number of lizards exceeds 1 per square metre. At that density about a million seeds per hectare per year will pass through lizard guts. When geckos taking nectar from flowering pohutukawa reach densities in excess of 5 per square metre their potential as pollinators is enormous. Reptiles arose long before birds so the new information on their possible involvement in plant reproduction indicates they could have played a role in the evolution of flowering plants.