GECKOS IN GENERAL

Geckos are a mainly primitive group of lizards, with over 2000 species distributed worldwide, mainly in the tropics but also extending into the temperate zones. They are on the whole fairly small animals, ranging from 5 cm to about 60 cm in total length. Approximately half of the length is tail. They can be found in a variety of habitats; in forests, swamps, and deserts, on mountains and on islands.

New Zealand's genera are endemic, but similarities to present day New Caledonian species suggest that our geckos originated there, and probably arrived in New Zealand during the Miocene Period (7-26 million years ago).

The geckos of New Zealand are currently divided into seven genera, *Dactylocnemis, Hoplodactylus, Mokopirirakau, Naultinus, Toropuku, Tukutuku,* and *Woodworthia.* The taxonomy of New Zealand's geckos has undergone considerable change in the last couple of decades, and must still be regarded as being in a state of flux. Despite the recent expansions in classification, it is clear that a close relationship exists between all species, given that hybridisation in captivity is not uncommon, with even intergeneric hybrids having been recorded. Hybid zones, where the range of separate species overlap, have been recorded in the wild.

Perhaps the most well-known characteristic of geckos is their ability to climb, obtaining a footing in the most inaccessible places. Indeed, some tropical species can walk upside down across a ceiling, and while no New Zealand species seems capable of this feat, some of them (in particular, *Dactylocnemis* and *Woodworthia*) can negotiate a vertical sheet of glass with apparent ease.

The toes of a typical gecko are somewhat dilated, placing a large flattened area in contact with the surface on which the animal is walking. On the underside of each toe is a series of plates called lamellae, which are in fact modified scales. The surface of each lamella is covered with enormous numbers of tiny hair-like projections. These catch in the minute irregularities which occur on even the smoothest of surfaces, and provide the necessary adhesion to support the weight of the gecko. Geckos have also evolved a specialised gait in which foot placement is much more precise than in most animals, the toes being applied from base to tip in a "peeling-on" movement, and are removed in exactly the reverse manner by "peeling-off" from tip to base. As well, their feet contain a complex system of musculature and blood sinuses, enabling maximum contact to be obtained between the lamellae and the substrate. That the system is very effective is demonstrated by the fact that for most of the time they are moving, geckos have only two feet in contact with the

surface, and at times only one foot. It is this peculiar method of foot placement which causes the geckos' characteristic wriggling gait. In all geckos, the muscles of the legs are well developed, and the digits are large and well formed.

Among New Zealand species, the ability to walk on smooth surfaces is most highly developed in *Dactylocnemis and Woodworthia,* although all retain the primitive lamellar structure, the lamellae being arranged in single rows under each toe. The more arboreal *Naultinus* and *Mokopirirakau* use their toes with a grasping action on twigs and leaves, although there is undoubtedly some lamellar function. In common with other lizards, the digits of geckos are tipped with claws, which are used to some extent in climbing.

An interesting feature of geckos is that the eyelids have fused in the closed position, evolving into a continuous and immovable transparent covering, called the ocular disc. It is rather difficult to see what advantage this may be, although in desert-dwelling species it obviously keeps the eyes free of sand or dirt particles. This would not seem to apply to New Zealand species to any great extent. When the ocular disc becomes soiled, it is cleaned in a manner characteristic of geckos, by licking with the broad, fleshy tongue.

The pupil in all New Zealand geckos is vertical. The margins of the pupil may be serrated in certain species which are active mainly at night, but which also have periods of daylight activity, or which emerge regularly in daylight to bask. This arrangement probably enables the gecko to obtain a sharp image, even when the pupils are fully contracted and a minimum of light is entering the eye, and the light-sensitive retina is protected from damage. This kind of arrangement is most obvious in some tropical species, but can be observed in *Mokopirirakau granulatus,* although the use of a hand lens may be necessary to observe the rather small serrations of the pupil margins.

The ears of New Zealand's geckos appear as small openings in the head some distance behind the eyes. The tympanic membranes, or eardrums, can be readily seen a short distance inside these openings. Geckos seem to hear quite well.

Unlike some tropical species which have tails variously ornamented with knobs or leaf-like appendages, all New Zealand geckos have the typical gekkonid tail; that is, cylindrical in cross-section, and tapering from base to tip. The tail of most species is prehensile to some degree, naturally more so in species which live in trees. *Naultinus elegans* in particular uses the tail frequently for anchorage as the gecko clambers amongst the leaves and twigs in its natural habitat. However, none of the New Zealand species has developed sub-caudal lamellae as some overseas species have done. In common with other lizards, geckos may shed their tails when threatened, a process known as caudal autotomy. This is

a useful means of defence, the violently wriggling tail often distracting a predator while the lizard makes good its escape. When the tail is lost in this manner, the breakage occurs through special fracture planes or weak spots in the vertebrae, and fibrous partitions between segmented muscle blocks. This enables a very clean break to be achieved, with the muscles of the severed tail spreading out in a fan-like pattern, and those in the tail stump contracting tightly to clamp the broken blood vessels, reducing blood loss to a minimum.

In most cases regeneration of the lost tail occurs, but the new tail is not identical to the original one. The lost vertebrae are not regrown, but are replaced by a rod of cartilage, and there is no proper replacement of the spinal cord. The scales on the regenerated portion usually differ in form and colour from the original.

The readiness with which geckos shed their tails varies from one species to another. Among New Zealand species, *Woodworthia. chrysosiretica* and *Dactylocnemis pacificus* will shed their tails quite readily, sometimes after merely being disturbed by the movement of the rock or log under which they are sheltering. On the other hand, arboreal species such as *Naultinus elegans* and *Mokopirirakau granulatus,* which use the tail a great deal during their life amongst the branches, are much more reluctant to lose it, although they are quite capable of doing so if hard-pressed.

Sometimes, due to injury or partial detachment of the tail, a further tail may grow from the site of the injury. Double and triple tails have been recorded.

The voice of the gecko probably has some value as a defence mechanism, in being used to deter would-be predators. New Zealand geckos are not known to be particularly vocal, although *Naultinus elegans* has been described as "making a noise similar to a cork being rotated in a bottle neck". It has been observed that at times, some *Naultinus* adopt a defensive posture by raising the head and front part of the body as high as possible, sometimes lifting the front legs clear of the ground or branch, and opening the mouth wide, at the same time producing a surprisingly loud chirping sound. It is not obvious how the sound is produced, although it is possible that the tongue and palate are involved. It is interesting to note that this kind of defensive behaviour occurs mainly at lower temperatures; when the temperature is higher the animal normally elects to flee. Some of the geckos from other genera have been observed to adopt the same open-mouth posture, but without the vocal accompaniment, and several species have been known to produce low volume chirps or squeaks when handled, or when interacting with others of their kind.

The skin of geckos is, like that of all reptiles, covered with scales. Geckos have skins which are rather loose-fitting, sometimes resulting in creases and folds under the throat and around the limbs. The scales are formed from thickenings of the epidermis, (the outer layer of skin), and are composed of a hard substance called keratin, which is also found in the outer skin of mammals, and is present in feathers, horns and hair. Keratin is in fact dead material which, in the case of geckos and other lizards, is renewed from the deeper, living tissues of the epidermis. When this occurs, the outer layer is shed at intervals by a process called sloughing. Geckos usually cast their slough entire, after the manner of snakes. Sloughs of the arboreal species can often be found amongst the leaves of trees and shrubs in the geckos' habitat. The sloughing process begins when the old layer of skin, having become detached from the new layer beneath, breaks away around the lips. The gecko then presses its body against twigs, rocks or other rough objects, and peels the old skin off like a glove, turning it inside-out in the process. Some geckos will at times grasp the loose skin in the mouth, and peel it off in this way. The period between sloughs is variable, and dependent on temperature. In most New Zealand species, sloughing occurs every six to eight weeks in summer, but takes place infrequently if at all during the winter months.

The pigment cells which give geckos their coloration are present mainly in the dermis, the deepest region of the skin, and are responsible for the phenomenon of colour change exhibited by some of our geckos This is most evident in the genus *Mokopirirakau*. As there are very few pigment cells in the upper layers of skin, discarded sloughs are mainly whitish in colour, although markings are usually faintly visible.

The form and arrangement of scales is very consistent within a given species, and this is particularly true of the large scales on the head, often described as shields. They can therefore be useful as a key to distinguishing between species which may be otherwise similar in appearance.

The gecko skeleton shows some primitive features; the relatively thin-boned skull lacks post-orbital and temporal bony arches, and is lower and broader than in most other lizards, in keeping with the gecko's usually flattened shape. The vertebral column is similar to that of the tuatara in many details, the vertebrae being hollowed out at both ends.

All New Zealand geckos feed largely on invertebrates such as insects, amphipods and spiders. Some geckos may take very small prey such as soil mites. In most cases it is the movement of the prey which arouses the geckos' feeding instincts. Dead prey is very seldom taken, although some geckos living on islands are known to take semi-digested fish regurgitated by nesting seabirds when feeding their young.

Many people seem to be under the misapprehension that geckos use their tongues to secure their prey, the way chameleons do. This is not so; the prey is either actively pursued or carefully stalked (depending on how hungry the gecko is), and is then seized with a rapid lunge of the jaws. The tongue may play some part in securing the prey once it has been seized.

Like all lizards, geckos have teeth, which are however small, peglike and rather unspecialised. Their main function appears to be to hold the prey and manoeuvre it into position for swallowing, rather than for chewing the food.

In the wild, New Zealand's geckos have been observed consuming nectar and berries, and there is evidence that in doing so, they may play a significant part in the pollination and seed dispersal of some native plants. They certainly display a taste for sweetened liquids in captivity, readily taking diluted honey or sugar solutions and fruit juices, as well as soft fruit such as banana and pears.

Geckos, although 'cold-blooded' (or more correctly, ectothemic), can nevertheless control their temperature to a considerable extent, by making use of external heat sources such as the sun's rays, or sun-warmed rocks or earth. If they become cold they bask; if over-heated they move to a cooler area, and in this way keep their temperature within the range necessary for survival.

In some genera (*Dactylocnemis*, *Mokopirirakau, Woodworthia*) the ability to change hue provides a supplementary method of thermoregulation. When cold, they can darken their skin and therefore increase the amount of heat absorbed. The reverse also applies; in becoming pale they reflect the heat and remain cooler than would otherwise be the case.

So although they have no internal means of temperature regulation, geckos' temperatures may at times be well above that of the surrounding air, by the employment of what may best be described as temperature control by behavioural means.

The basking habits of the non-arboreal species consist largely of indirect basking, where the animal absorbs heat from the warm underside of rocks, bark or other objects present in its habitat, or protected basking, where small niches are utilised, in which the lizards can absorb direct solar heat without venturing into the open. This form of thermoregulation is particularly evident in populations of *Dactylocnemis pacificus* living in cracks in clay banks.

The diurnal *Naultinus* spend most of their time on the foliage of shrubs and trees, and therefore much of their heat is gained from direct exposure to the sun. Control of the upper limits is achieved by moving in and out of the foliage. *Mokopirirakau granulatus* is something of an enigma; its thermoregulatory patterns seem similar to those of diurnal geckos, although it forages mainly in the dusk.

Some New Zealand geckos can forage at very low temperatures, down to 5ºC in the *Woodworthia* genus. In many species higher temperatures attained by basking are necessary for digestion of food, but some of our cold-adapted species seem to be able to survive in conditions previously thought unsuitable for the typical reptile metabolism. More study is needed to increase our understanding of how these remarkable animals survive in such apparently hostile conditions.

The sex of adult geckos may be readily determined. In the male, the paired copulatory organs, the hemipenes, are contained in a sac which appears as a swelling at the base of the tail. Just in front of the vent is a triangular patch of pores, which is absent in the female, although females of some species may have enlarged scales in this area.

Most of the world's geckos reproduce by laying eggs, but the New Zealand species are unusual in that they give birth to live young. Outside of New Zealand, only one New Caledonian species has been recorded as a live-bearer. This mode of reproduction is not true live-bearing as occurs in mammals, but has been considered a specialised variation of egg-laying, whereby the eggs are retained in the oviduct until hatching occurs and live young are produced. This may however be an over-simplification, as some species have been shown to have evolved a degree of placental development. This type of reproduction is called ovoviviparity, and enables the geckos to seek out the best available conditions for the development of the eggs, by acting as a kind of 'mobile incubator'.

Mating times vary from one species to another. The gestation period in our geckos is rather variable, but observations of some species in captivity suggest it to be in the vicinity of 8 or 9 months, although recent research has shown that delayed fertilisation occurs in some species, with the female storing viable sperm for a considerable period after mating.

New Zealand geckos breed only once a year, with two young being usual; single births occasionally occur. The offspring are quite large at birth, sometimes nearly half the length of the mother, but normally take at least three years to reach breeding age, although some species have been known to breed in their second year, particularly in captivity. It is likely that in common with several other kinds of reptiles, sexual maturity in geckos is reached,

not at a certain age, but at a certain size, which in turn is dependent on climatic conditions, and the amount of available food.

Authenticated longevity records for New Zealand geckos are scarce. It is clear however that these lizards can live for a remarkably long time. One specimen of *Naultinus elegans* has survived in captivity for an estimated 47 years, and *Hoplodactylus duvaucelii* and *Woodworthia maculata* in excess of 35 years. There are many anecdotal records of *Naultinus elegans, Mokopirirakau granulatus* and *Woodworthia maculata* surviving for up to 20 years in captivity, and in the wild *Hoplodactylus duvaucelii* has been recorded as surviving for 36 years, and *Woodworthia maculata* for 17 years.

New Zealand geckos, particularly those of the genus *Hoplodactylus,* carry small, orange-red skin mites, which gather around the eyes, ear openings and skin folds. *Naultinus* species do not often carry these parasites in the wild, but may become infested in captivity.

Geckos have very few natural enemies. Although several species of native birds may occasionally take them, only the kingfisher kills very many. The tuatara will feed on geckos where the two occur together.

More serious are predators introduced by man. Rats, cats and mustelids all prey in lizards, with rats having the greatest impact. Introduced birds like the myna and the starling have also been observed preying on geckos.

The main threat to New Zealand's geckos however, is the destruction of their natural habitat. Clearing land for farming, subdivision and other development virtually eliminates any geckos which may have been present in an area. Any recovery of gecko populations in regenerating forest areas is, because of their slow breeding rate, a very long process, if in fact it occurs at all. It is in such regenerating areas that breeding for release projects may in the future play a vital role in safeguarding the survival of some of our gecko species.