GUIDE TO KEEPING NEW ZEALAND LIZARDS IN CAPTIVITY

Richard Gibson

This Best Practice Guide has been written to help you understand how to best care for the native New Zealand lizards you hold in captivity and how you can meet your obligations under your Wildlife Act Authorisation.

The Guide outlines broad principles some practical steps to help you meet the conditions of your Authorisation. The Guide provides general advice; it is not possible to deal with every situation that may arise. When using this Guide, discretion and judgement will be needed and it may be necessary to seek expert assistance.

The Guide is regarded as a 'living document' which will be regularly reviewed and updated as necessary. Readers are encouraged to send in feedback so that the guidelines can be further improved through an ongoing process of communication and co-operation. To contribute, please contact OutsideIn@doc.govt.nz.

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1. UNDERSTANDING THE NEEDS OF ECTOTHERMS

Lizards are ectotherms, meaning that they rely on external sources of heat or cooling to maintain their body temperatures (humans are endotherms, and can maintain constant body temperatures independent of their environment). The environment in which you keep captive lizards is critical. Indeed, good lizard husbandry is really about providing and maintaining an appropriate environment and climate. If this is done well, the lizards will largely look after themselves!

1.1 TEMPERATURE

As ectotherms, lizards demonstrate behavioural control of their body temperature by, for example, utilising heat sources in the environment, altering body posture in relation to the sun, darkening/lightening their skin pigmentation, seeking shade or other cool environments, and varying their activity and behaviour.

Failure to provide an appropriate thermal environment for captive lizards may lead to:

- lethargy and inactivity
- regurgitation of undigested food
- failure to feed
- failure to breed
- hypothermia, systemic infection and death
- hyperthermia and death.

Native lizards are of course well adapted to New Zealand's temperate climate and are known to remain active at much cooler temperatures than most reptiles. Most are comfortable and will remain active and feeding at **ambient** temperatures (between 10^{o}C and 25^{o}C), provided they have access to sunshine or other heat sources and cool retreats to thermoregulate. A few species may remain active at temperatures below 10^{o}C, but it is best not to feed them at such low temperatures, as failure to digest their food could result in them becoming ill and even dying.

In general, short periods of excessive heat (>30^{o}C) are more dangerous than extreme cold; however, prolonged exposure to temperatures below 5^{o}C are likely to cause health problems and any exposure to temperatures below freezing will likely result in death. Understanding the concept of microclimates is essential to successful lizard husbandry.

Seasonal variation in temperature plays a crucial role in lizard biology. The cooler temperatures during winter bring a period of reduced activity with little or no feeding and growth, providing cues for reproductive cycles and possibly facilitating spermatogenesis in some species.

1.2 HUMIDITY AND WATER

All lizards need constant access to fresh water for drinking and require adequate humidity to maintain hydration and support healthy ecdysis (skin sloughing). However, excess humidity and inadequate humidity can both cause health problems.

A relative humidity of 60–70% is ideal for most species, as long as they have the opportunity to seek out higher humidity areas in the enclosure when they choose. Humidity consistently below 50% or above 90% is likely to bring about health concerns for the majority of species. Ventilation plays a fundamental role in managing humidity and provision of microclimates is essential.

Failure to provide lizards with adequate water and/or access to appropriate humidity may lead to:

- Dehydration
- Refusal to feed
- Disecdysis (problems sloughing their skin)
- Fungal skin lesions and respiratory infections
- Gout, kidney failure and death

1.3 ILLUMINATION

Light is extremely important to lizards, even so-called nocturnal species. The quantity and quality of light reaching your lizards can affect their activity, behaviour (including appetite and reproduction) and health.

Quantity of light needs to be addressed in two parts:

1. The amount, or brightness (measured in Lux), of light provided.

   At midday on a summer's day in New Zealand we would expect to measure in the region of 5000-10,000 Lux, even in the shade or on an overcast day, and 80,000–100,000 Lux in the full sun. In contrast, the average office has a Lux of <1000.
2. How long that light is provided each day.

   This is known as the photoperiod and of course varies dramatically throughout the year in New Zealand.

Keepers of lizards should aim to provide natural **quantities** of light, in terms of both brightness and how long it is provided.

Quality of light refers to the wavelengths and relative proportions of particular wavelengths, in the light source. There are two primary considerations:

1. Colour-temperature (measured in Kelvin) or 'tone'. Light is often described as 'warm' meaning yellow-toned or 'cold' meaning blue-toned. Outdoors, the colour temperature of light varies from warm (red-yellow) at dawn, to cooler in the middle of the day and back to warm at sunset. This is a result of the different wavelengths in the sunlight reflecting differentially off the Earth's atmosphere.

   When choosing artificial light sources for indoor vivaria, it is therefore important to choose good-quality lamps which produce natural 'daylight' wavelengths (approximately 5500 Kelvin).

2. Ultraviolet (UV) light is essential to practically all vertebrate life on the planet, especially lizards and, indeed, humans. There are three wavelengths of UV light: UVA, UVB and UVC.

   UVA (400–320 nm)—UVA is abundant in sunlight and specialist reptile lamps are designed to emit significant quantities of this wavelength. There is much evidence that UVA promotes good health and appetite in reptiles and may enhance colour and vision, since many reptiles see UV wavelengths.

   UVB (320–280 nm)—UVB is present in sunlight and good-quality specialist reptile lamps emit carefully controlled quantities to deliver essential health requirements. Exposure to UVB wavelengths at 290–315 nm allows lizards to produce an essential hormone in the body through a process known as photobiosynthesis. UVB falling on the skin, in conjunction with adequate warmth, catalyses the transformation of vitamin D into vitamin D3. Vitamin D3 is one of the most important hormones in vertebrate bodies, being implicated in many bodily processes including immune system function, cancer prevention and neuromuscular and cognitive function. But it is best known for its essential role in controlling calcium and phosphorus metabolism.

   Deficiencies in vitamin D3 and/or dietary calcium (even with sufficient vitamin D3) can lead to serious health conditions in lizards, including:

- hypocalcaemic fits
- poorly calcified eggs shells
- inadequately provisioned and therefore weak babies which may not survive or which may be permanently disadvantaged
- soft, bent or broken bones (metabolic bone disease—MBD), especially of the lower jaw, toes and long limb bones (known as rickets in humans)
- death

Vitamin D3 is not common in food items and few animals receive adequate amounts from their diets. It can be supplemented orally but an overdose can be dangerous, even fatal, as there is no self-regulation via this route. However, adequate exposure to appropriate wavelengths of UV light in conjunction with a good supply of dietary calcium is all that is required to ensure correct levels of D3 in most animals, as the biological process is self-regulating. This is equally true of diurnal and putatively nocturnal species that will very likely bask either openly or surreptitiously for short periods (see Fig. 1).

Figure 1: A 'nocturnal' Raukawa gecko basking in full sun, Motutapu Island.

All captive lizards should therefore be provided with access to either unfiltered sunshine throughout the year when housed outdoors or, when housed indoors, to specialist reptile UV-lamps which provide similar quantities of UV as would be experienced in the wild. UV light can be measured and monitored with specialist meters, which can be bought (see Appendix 1 for models and suppliers) or hired from the New Zealand Herpetological Society (NZHS).

UVC (280–180nm)—UVC is the dangerous end of the UV spectrum. Normally, there is barely a trace of UVC in natural sunshine, though the erosion of the Earth's ozone

layer is affecting the permeability of the atmosphere to this dangerous radiation. Specialist reptile lamps are designed NOT to produce any UVC and provided you use recognised, quality brands and models (see Appendix 1), are completely safe.

Many reptiles, especially those from temperate climates, experience varied photoperiods, temperatures and periods of rainfall throughout their year in the wild. If these are not reproduced in captivity, their reproductive cycles may be compromised and breeding will be sporadic or not occur at all. You will need to read all you can about the species you intend to keep and research the climate and seasons of the area it originates from.

1.4 MICROCLIMATES AND HABITAT

In any environment, natural or artificial, lizards will choose specific habitats, locations and refuges and alter their behaviour to take advantage of localised differences in temperature, humidity and light—this is the behavioural exploitation of microclimates. For example, on a very hot day a lizard will retreat to the cool, moist environment beneath leaf litter or inside a hollow log, and on a cold day it will seek out the warmth of the sun. The provision of microclimates within a lizard's enclosure is a fundamental principle of husbandry and is essential for success in long-term maintenance and breeding of lizards in captivity.

Of less consequence to lizards' physiological requirements but of great importance for their behaviour, is consideration of appropriate habitat. Knowledge of a lizard's natural history will allow for appropriate enclosure design and decoration to provide for arboreal, terrestrial and fossorial (burrowing or underground-living) species, highly active versus sedentary species and habitat specialists.

These aspects of husbandry are discussed in greater detail in sections 2.1.2 and 2.2.2.

1.5 IMPLICATIONS FOR HOUSING

It is tempting to assume that lizards kept in outdoor enclosures will automatically experience a natural and seasonal climate, including the appropriate quantity and quality of light. However, this rarely is the case as the design of the enclosure, choice of materials, and aspect/location have the potential to greatly influence all of these factors. Furthermore, the comparatively small volume of the average lizard enclosure presents significant challenges in providing and controlling microclimates and avoiding extremes of temperature in the face of New Zealand's highly changeable weather. Mitigating for this is discussed in greater detail in section 2.1.2.

Summary of key points:

- Lizards are ectotherms and rely on climate to control their body temperature.
- Native lizards must be kept at ambient temperatures of 5 to 25°C.
- Avoid ambient temperatures above 25°C and never let your animals experience sub-zero temperatures.
- Humidity of 60–70% is ideal for most species. Higher than this may cause fungal and respiratory disease. Lower may lead to shedding problems.
- Microclimates within the vivarium allow lizards to choose their preferred environment at any time.
- Lighting is often overlooked but is critical to healthy lizards. It is essential, therefore, to provide a natural quantity (brightness and day-length) and good quality (natural colour-tone and including UVA and UVB) of light for all lizards, including those considered nocturnal.
- If you have access to a UVI or UVB meter (see appendix 1), aim to match the UV levels in the vivaria to ambient levels outdoors or, in general, UVI of 1–3 for primarily nocturnal and fossorial species and UVI 3–5 for diurnal species.
- Native New Zealand lizards must experience seasonality in climate, especially ambient temperature and photoperiod.
- Do not assume that keeping lizards outdoors automatically achieves all of the above requirements.

2. HOUSING NEW ZEALAND LIZARDS—THE VIVARIUM

There are many options for housing New Zealand lizards. Outdoor and indoor enclosures (or vivaria) each come with their own suite of challenges and benefits, while the design and materials used also have great bearing upon the suitability and success of the vivarium. Key considerations in choosing materials, designing and constructing a vivarium are:

- providing the environmental parameters previously discussed
- ensuring it is escape and predator proof
- ease of cleaning
- flexibility and portability
- life span of materials
- appearance and cost.

These subjects are discussed in detail in sections 2.1 and 2.2 on **Outdoor vivaria** and **Indoor vivaria** respectively.

Any enclosure for lizards, whether outdoors or indoors, must:

- provide appropriate thermal gradients via methods suited to the species housed, and which can be controlled and varied
- provide multiple microclimates (temperature, humidity) that allow for lizard choice
- provide good quantity and quality of unfiltered light, including UV light, with a seasonal photoperiod
- be well ventilated and drained
- provide fresh drinking/bathing water at all times
- be of adequate size to provide for climate control and variation and establishment of suitable furnishings and fixtures (habitat)
- be of a size appropriate to the lizard species and group-size—larger species need larger vivaria and increased group sizes need larger enclosures and a lot of habitat complexity
- approximate a habitat and environment suited to the natural history of the species housed (fossorial, terrestrial, arboreal)
- be easy to maintain to ensure high standards of hygiene
- Have easy access, preferably not from the top, as many lizards perceive any movement from above as a predatory threat
- Allow clear views of the interior, especially around door frames and hinges

- include a lip of at least 10 cm beneath the door which prevents fast-moving skinks from escaping during servicing
- be escape proof (bearing in mind the size of the smallest likely inhabitant and the possibility of new-born skinks/geckos) and, ideally, lockable
- provide protection from possible predators including rodents, mustelids, cats and, potentially, magpies and gulls

2.1 OUTDOOR VIVARIA

Pros:- All necessary climatic factors can be provided at no cost—but see below.

- Sunshine is the BEST source of natural light.
- Photoperiod is automatically correct (approximately).
- Seasonality is provided naturally.
- Some food items will enter the vivarium.

Cons: - Climate inside the relatively small space of a vivarium is difficult to control outdoors.

- It is challenging to provide variable micro-climates and avoid dangerous extremes.
- Extreme weather might damage the vivarium and or its occupants.
- Pets and even predators are more likely to enter or interfere with the vivarium.

2.1.1 OUTDOOR VIVARIUM OPTIONS/MATERIALS

Most keepers of native lizards in New Zealand have traditionally built or purchased vivaria made out of timber and wire mesh (Fig. 2). Whilst these are well-tried and trusted, the use of timber brings with it the disadvantages of significant weight, especially when water-logged (making them clumsy and awkward to re-position), warping, mould, difficulty of cleaning and, of course, eventual rot.

Figure 2: Vivarium made out of timber and wire mesh.

Aluminium extrusion/box-frame is an alternative which, although more expensive than timber, will last forever (see appendices 1 and 2). 'Square hollow' extrusion is especially easy to work with, as plastic fittings (e.g. Kubeloc) can be purchased which simply slot into the end of the extrusion to form corners and T-joints (see Fig. 3 and Appendix 1). Vivaria made from aluminium are light weight and therefore easy to move around, easy to keep clean and sterilise in the case of disease outbreak, will not grow mouldy and retain damp, and will not rot and fall apart.

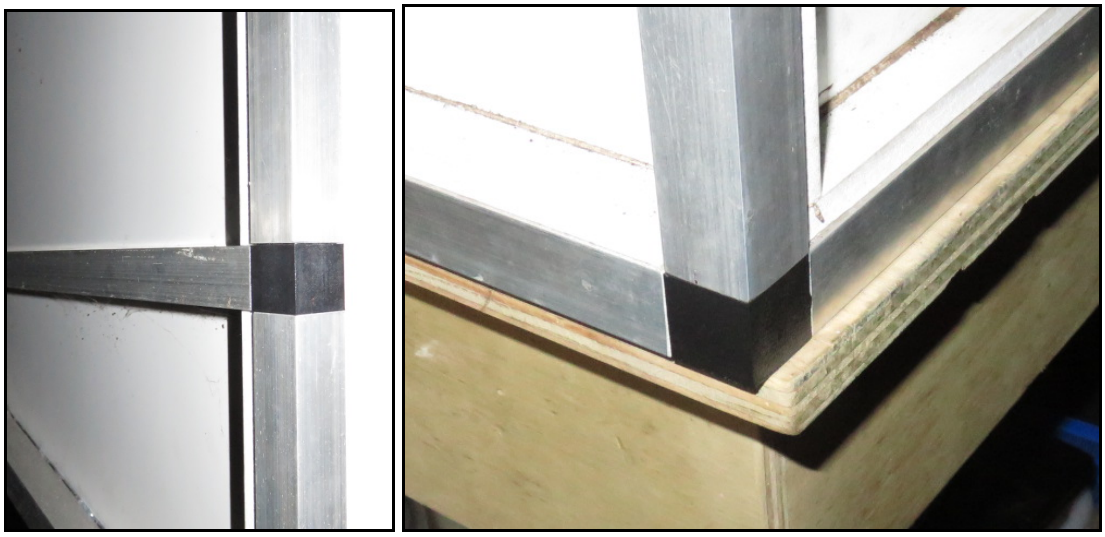


Figure 3: Kubeloc joints for steel or aluminium box frame construction.

Regardless of your choice of frame material, the sides of your vivaria must be constructed from a combination of mesh (to allow ventilation and UV light) and more impermeable materials to provide shelter from wind and rain and shade from excess sun. For the latter, timber is perhaps the simplest and cheapest option but suffers all the same drawbacks as it does in frame construction (above) with the additional drawback, in certain uses, of also blocking out all light. Alternative materials with different properties and uses include:

- corrugated/sheet metal
- corrugated or sheet plastics such a plexiglass, perspex, acrylic, polycarbonate
- twin-walled plastics like Corflute and 'twin-wall'
- solid-opaque plastic sheets such as PVC Multiboard
- other materials—see, for example, http://www.psp.co.nz/plastic-sheets.

See appendix 2 for a summary of the pros and cons of these different materials.

Mesh should be metal rather than plastic, for strength and pest exclusion, and stainless steel will last longer than galvanised steel. In general, you should aim for the maximum hole-size and minimum wire gauge that will contain your lizards and their possible offspring, as this will maximise ventilation and minimise loss of light, including essential UV wavelengths. Remember that whatever material lies between your lizards and the sun (or artificial lighting in the case of indoor vivaria) will detract from the light levels reaching your lizards and most specifically the UV light. Glass and the vast majority of clear plastics may not affect brightness or tone significantly but will block ALL beneficial UV wavelengths. Mesh too, significantly reduces light penetration. The thicker the wire and the smaller the holes the less light penetrates, including UV. Even the colour and finish of the wire will make a difference, with shiny stainless steel reflecting more light through into the vivarium.
However, in an outdoor environment you must balance this requirement against the need to be safe from predators. This is best achieved by choosing the most favourable mesh type for your lizards for the vivarium walls (ideally, 3–5 mm hole size stainless steel) and then installing an additional screen of fine-gauge mesh (e.g. chicken wire, which will deter cats, rats, and stoats) with a gap of at least 2 cm but ideally 5 cm between the two mesh panels. See Appendix 2 for further details on mesh characteristics.

Consider carefully the needs of your lizards, the physical placement of the vivarium/vivaria and the likely exposure to mammalian pests. Choose the best materials you can afford and use a variety of materials and techniques to ensure you provide for the variable environmental parameters discussed above. Section 4.1.2 discusses some of the ways you can do this.

Glass vivaria should never be used in outdoor locations where the sun may cause dangerous, perhaps fatal, over-heating and desiccation.

4.1.2 MANAGING YOUR LIZARDS' ENVIRONMENT OUTDOORS

Though it is easy to assume that the natural climate outdoors will provide for all your lizards' needs, the very act of confining them to an enclosure greatly limits the variety of microclimates available to them. The smaller the vivarium, the less variation will exist naturally and the harder it is to manipulate the environment and provide protection from extremes of temperature. A small cage in direct sunshine will become uniformly hot, with interior temperatures rising to potentially dangerous or even lethal levels.

The dimensions of outdoor enclosures should, therefore, **never be less than 50 x 50 x 100 cm**—the longer dimension should be the length for predominantly terrestrial skinks and the height for predominantly arboreal geckos.

The base of the vivarium can be made of one of the solid, rot-proof materials discussed in section 2.1.1 (perforated with many small holes for drainage), or a perforated steel sheet or a strong mesh. One long side and at least 50% of the top must be made of, or covered with, a solid material to provide shade from the sun and shelter from wind and rain. The rest of the enclosure should be made of the best quality mesh you can afford (as per section 2.1.1). See Fig. 4 for a generic vivarium design which can be used vertically for geckos or horizontally for skinks. This design is especially suitable for geckos; during winter months it is positioned facing north to gather winter sunshine and in summer it is rotated 180° to face south, with the reflective and highly-insulating plastic wall sheltering the enclosure from the hottest midday sunshine.

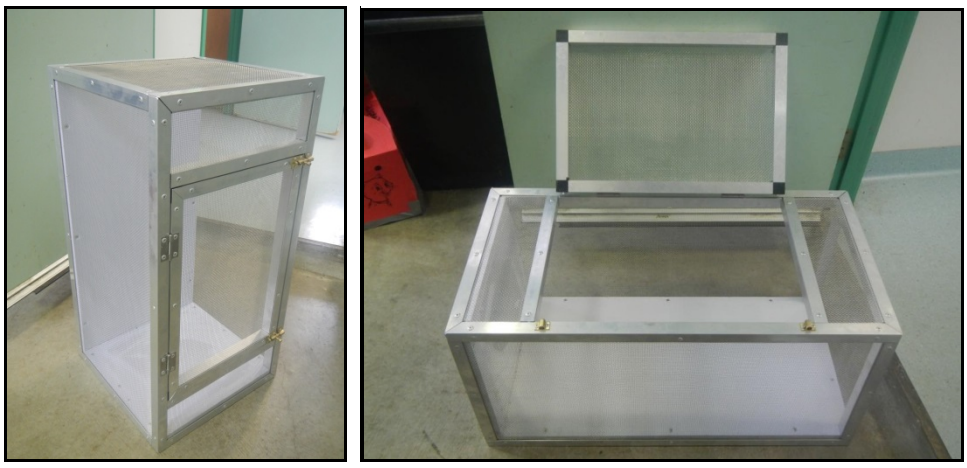


Figure 4: Aluminium frame, steel mesh and PVC multi-board vivaria for geckos or skinks.

Outdoor vivaria must be positioned very carefully. Ideally, they should be placed where they receive **full winter sunshine** but are **shaded during midday in summer**, have free air flow but do not receive the full-force of the wind, receive moderate rainfall but with some shelter from deluges. In practice, this can be hard to achieve in one location, so you should consider relocating your vivaria at different times of the year.

If you choose to include a glass panel for better viewing, ensure that this is placed facing south to avoid dangerous overheating and loss of beneficial UV light.

Vivaria substantially larger than that described above and well-protected with insulating materials, provide greater protection and therefore a greater degree of reassurance that your lizards can find a suitable microclimate whatever the weather.

If your vivaria are small and light, and/or you live in a very windy location, they must be secured to whatever they are standing on. This can be achieved by pegging them to the ground through the base (good in very cold climates where the cage will be warmer sitting on the ground than with cold air beneath it) or by screwing them to a wooden shelf or bench.

Having provided a vivarium with good mesh for ventilation and light penetration, and at least one solid wall and half the roof to provide shade and shelter, you can use these structural features (plus other temporary additions), along with vivarium furnishings and materials, to help manage the microclimates available to your lizards:

- use the solid wall to provide shade from the sun in summer
- use the solid wall as a wind break
- add clear plastic panels (see section 2.1.1) in winter as additional rain-protection, wind-breaks and insulation from the cold without blocking out all the light—but take care not to reduce the ventilation too much, which can lead to excessive humidity
- provide good refuges (bundles of flax leaves, manuka branches, small plastic or bamboo pipes, dense live plants, piles of punga, pieces of bark and leaf litter etc.) beneath the roof in the part of the enclosure sheltered from rain and wind—these will be the coolest places in summer and the warmest in winter
- provide the same refuges where they are not protected from wind and rain—these will be warmest places in summer and the coolest in winter
- ensure good perching for geckos (Fig. 5) and basking spots for skinks (exposed logs and rocks) in spots where sunshine shines through the mesh all day in winter and morning and late afternoon in summer

Figure 5: A forest gecko basking in dappled sunlight, Maud Island.

- Allow one half of the floor to be constantly damp, including the refuges, while the sheltered end and associated refuges stay much drier
- Provide damp substrates, piles of damp leaf-litter, damp hollow logs (punga) and dense live vegetation, as many lizards will seek out very humid (>90%) locations such as these, especially when preparing to slough their skin
- Place the water bowl in the open area where rainfall will naturally refresh drinking water in wet weather;
- Position plants where natural rainfall will water them and their foliage will hold water for geckos to drink;
- remember to provide 'artificial' rainfall by spraying the vivarium if it becomes too dry and during long periods of dry weather.

Consider, too, the natural habitat and behaviour of the species you are keeping. Terrestrial and fossorial species from forests need deep substrates and leaf litter, while terrestrial coastal species will fare better with a sandy/soil substrate with a scattering of leaves and pebbles with some larger flat stones or similar objects to hide beneath (take care to secure them firmly). Arboreal species, on the other hand, require suitable climbing in the form of taller rocks, branches and live plants. Some species prefer to use horizontal surfaces/branches to lie on while others are happy clinging to vertical trunks, so provide a mixture.

Live plants are best provided in their pots as this makes it easy to control their watering without soaking the whole vivarium substrate and to replace them if and when needed. With a little thought, the constant damp required by plants can be exploited for the lizards by providing refuges on top of or slightly buried into the potted substrate. However, you must remember to check for any sheltering lizards before removing a potted plant from your vivarium!

2.1.3 INVERTEBRATE PESTS

Giant centipedes *Cormocephalus rubriceps* and large spiders pose a threat to captive lizards. Centipedes can only be deterred by ensuring that all doors and any other openings are accurately constructed and fit tightly. An excluder plate can be added to door frames (see Fig. 6), or household draft excluders (bristle or rubber strip) to the doors to minimise gaps.

Picture required

Figure 6: Excluder plate fitted to the vivarium door

Regular inspection of likely hiding spots inside vivaria and removal of centipedes is advised. Spiders, both native and introduced, have been implicated in the deaths of captive lizards, geckos in particular. Preventing their entrance into vivaria is impossible owing to the tiny size of their offspring and their abundance in the environment. Some keepers of native lizards recommend keeping at least one moderate-sized adult skink in any enclosure with geckos as a predator of small spiders, but bear in mind that not all skinks will predate spiders equally or co-habit peacefully with geckos. Maintain high levels of vigilance and remove any spider with a greater than 1.5 cm leg-span, with particular attention to:

- Those of the 'widow' family including the introduced false widow or false katipo *Steatoda capensis*, the Australian red-back *Latrodectus hasseltii* (rare but now established in several places in New Zealand) and the endemic katipo *Latrodectus katipo* (a threatened species, **so do not kill these spiders)**.
- Two introduced species of white-tailed spiders—*Lampona murina* (widespread in the North Island) and *L.cylindrata* (widespread in the South Island).

See https://www.healthed.govt.nz/resource/spiders-new-zealand for more information on how to identify these different spiders.

Ants can also cause a problem for captive lizards, especially newborn or sick animals. Remain vigilant for ant invasions and either remove them manually before they increase in number or use commercial ant-bait stations with Fipronil bait (e.g. Vanquish Pro and Xstinguish). If ants become a regular problem, they can be deterred, but rarely completely excluded, by creating a water-moat around your vivaria by placing them on bricks/legs/table within water-holding receptacles.

Summary of key points:

- Provide an enclosure of minimum size 50 x 50 x 100 cm—with the long wall aligned vertically for geckos and horizontally for skinks. Larger species like Duvaucel's gecko and Falla's (Three Kings), robust and Otago skinks should have correspondingly larger vivaria.
- Choose materials to build your vivarium which will be long-lasting, hygienic and easy to clean and secure.
- Choose a combination of materials that will maximise ventilation and light penetration and provide shade in summer and shelter in winter. At least one long side and half of the roof should be impermeable to wind, rain and sun while the rest should be of high-quality mesh.
- Never use an all-glass vivarium outdoors.
- Remember to install predator protection around your outdoor vivaria.
- Position your vivarium with care, avoiding full sunshine in summer and securing against high winds.
- Use the weather, cage design, temporary additional panels for winter and internal furnishings and landscaping to maximise the range of microclimates available to your lizards.
- Provide a habitat, including live plants, that caters for the natural behaviour of the lizards you keep.
- Take measures to exclude giant centipedes from your vivaria and remove large spiders, as both pose a risk, particularly to geckos.
- Be vigilant for ants and prevent them from getting out of control, as they too pose a threat to young and sick lizards.

2.2 INDOOR VIVARIA

Pros: - climatic needs can be controlled and manipulated as desired
- photoperiod and seasonality can be altered to extend activity periods
- dangerous extremes of climate are easily avoided
- risks from pests and predators are greatly reduced

Cons:- all your lizards' environmental needs must be monitored and controlled
- the necessary technical equipment is moderately expensive
- UV-emitting lamps expire and must be replaced
- UV-emitting lamps may be damaging if used incorrectly

2.2.1 INDOOR VIVARIUM OPTIONS/MATERIALS:

Since climate can be controlled and dangerous extremes easily avoided, indoor vivaria can be safely constructed from glass, provided they incorporate adequate ventilation. Converted aquariums are **not** ideal in this regard as they provide ventilation only from above, so keepers wishing to exploit the superior visibility afforded by glass vivaria should consider purchasing purpose-designed enclosures such as those made by Exo-Terra®, which are now widely available in New Zealand in a range of shapes and sizes (see Appendix 1 for details). These enclosures have been on the international market for more than a decade and are well tried and tested, having front/rear opening doors with latches, ventilated roof panels (through which an acceptable amount of UVB will pass, provided you choose suitable lamps at an appropriate distance) and ventilation strips beneath doors to allow a current of air (Fig. 7). With a little know-how and care it is straightforward to add bottom drainage by drilling a hole in the base with a specialist glass-bit and silicone-gluing a plastic pipe in place.

Figure 7: An Exo-Terra® glass vivarium. Great for indoor lizard keeping.

All mesh enclosures are also perfectly functional indoors and can be home-made (in which case incorporating one or more glass panes for viewing is a straightforward process) or bought 'off the shelf'. Commercially available, inexpensive and very practical mesh enclosures include:

- Hailea Reptile Mesh Cage—see Fig. 8
- EcoTech Screen Habitat Mesh Vivarium which comes in two sizes—see Fig. 9
- ZooMed Reptibreeze, available in four sizes.

Figure 8: Hailea's screen vivarium is an excellent off the shelf product for small geckos.

Figure 9: The EcoTech mesh vivarium. Lightweight and easy to put together.

Bear in mind that all of these cages are constructed with light-weight metal fly-screen mesh and therefore should not be considered predator-proof. They should not be used outdoors

without additional protection, unless (as shown in Fig. 10) you are lucky enough to live on an island free from mammalian predators!

Figure 10: EcoTech mesh vivaria set up for Cook Strait striped geckos on predator-free Maud Island.

Any outdoor vivarium can also be used indoors. Those made of light-weight easily cleanable materials are more flexible in their placement and more easily moved.

2.2.2 MANAGING YOUR LIZARDS' ENVIRONMENT INDOORS

Place indoor vivaria in a well-lit room but away from direct sunshine from windows which might cause dangerous over-heating. Ensure that the room does not become too hot in the summer, remember the range of ideal ambient temperatures (15–25°C in summer and cooler in winter) and do not choose a room which you plan to heat through the winter, as this will interfere with essential seasonal cooling. An unheated, east- or south-facing room is ideal and should provide an ambient room temperature year-round which avoids you needing to worry about protection from over-heating in summer or freezing in winter.

Provided the ambient room temperature remains reliably within the preferred range of 5–25°C throughout the year, the benefits of large vivaria (as previously described) are less significant. Vivaria as small as 30 x 30 x 50 cm are adequate for a pair of small geckos (such as elegant (Auckland green) geckos) and 30 x 30 x 70 cm for a pair of small skinks (such as

moko skinks). Larger species such as Duvaucel's gecko and grand, Otago, robust and Falla's (Three Kings) skinks always require larger vivaria of 50 x 50 x 100 cm. Neonate (baby) and juvenile lizards can be housed temporarily, perhaps for the first 6–12 months of their lives, in 'Small Pal Pens' (Fig. 11) (http://www.petware.co.nz/#/Product/info/H354) measuring 20 x 20 x 30 cm.

Figure 11: Small Pal Pen suitable for rearing baby lizards and temporary hospitalisation of sick lizards indoors.

Additional lighting must be provided to ensure adequate quantity and quality of light (particularly UV). The best lamps available in New Zealand are the Arcadia T5 D3 reptile lamps, available in 600 mm and 900 mm lengths and 6% and 12% UVB output. These are high output T5 fluorescent lamps (also available from Zoo Med Laboratories Inc., although there was no supplier of these lamps in New Zealand at the time of writing) and do not fit in a standard fluorescent lamp fitting. They require a dedicated T5 fitting which are widely available in New Zealand, as T5 lamps are commonly used by aquarium hobbyists (e.g. Aquazonic's T5 Superbright, available from Petware). The additional investment in these lamps and fittings is well worth it as they produce far more light, of a better tone (colour temperature) and more UVB than any other lamps on the market. Fig. 12 shows a vivarium with lights set up.

Figure 12: An Exo-Terra® vivarium for baby Falla's (Three Kings) skinks. Note T5 fluorescent UV lighting and, barely visible in the picture, the halogen basking lamp at rear right

More familiar T8 (wider tube diameter) fluorescent tubes will, of course, suffice, but it is best to keep to mainstream and well-proven brands such as Arcadia, Exo-Terra®, Zoo Med and a recent arrival on the scene, Trixie. ReptileOne (a familiar brand in NZ) is cheaper, but may be correspondingly inferior. In general, the conditions your lizards get reflect what you are prepared to pay for. Mainstream brands generally provide better quality products, which are more reliable and effective. They are usually correspondingly more expensive. Cheaper alternatives are likely to be less effective and may even be dangerous. There have been several examples of cheap copy-cat UV lamps from unrecognised manufacturers/suppliers causing health problems for lizards as a result of their emitting inappropriate wavelengths.

Whichever lamps you choose, install them **outside** the vivaria above the mesh roof at a proximity that will provide appropriate UV levels (aiming to replicate outdoor levels) and always use a shiny metal reflector behind the lamp(s)—most T5 fittings include reflectors as an integral part of their construction, as this will greatly improve (almost double) the efficacy of the lamp.

Follow the instructions on the box and, if possible, use a UV meter (see Appendix 1 for details. The NZHS hires these out to members for a nominal charge to cover postage) to confirm the output at the closest point to the lamp your lizards are able to bask. For

primarily nocturnal, fossorial and deep forest species, aim for 1–3 UVI (UV Index) as measured with a Solarmeter 6.5 or up to 100 µW UVB as measured with a Solarmeter 6.2. Diurnal species should be exposed to higher levels, around 3–5 UVI and up to 250 µW UVB. Real sun-loving species like grand and Otago skinks, which are adapted to very high UV exposure in the wild, happily bask in 5–8 UVI / 300–350 µW UVB .

Remember that it is the UV light levels where the lizards live that are important—i.e. skinks living mostly on the ground and geckos sharing the same cage but living mostly in the plants, will be exposed to very different levels of UV light from lamps fitted above the enclosure. You can manage the lighting levels in one or more of a number of ways:

- the further you move the lamps away from the lizards the less UV that will reach them
- the thicker the wire and the smaller the holes in the mesh between the lamps and the lizards, the less UV that will reach them
- plants and other objects beneath the lamps will absorb and scatter the light, creating UV shade spots
- plants and other cage furniture at different distances below and horizontally away from the lamps will provide a UV gradient

Plug the UV fluorescent lamps into an automatic timer and adjust this monthly to match the natural photoperiod outside, switching-on an hour or two after dawn and switching-off an hour or two before dusk.

Fluorescent UV lamps do not provide much heat. One or more basking spotlights must therefore be directed at the same location as the lizards are exposed to the UV. This is essential for effective use of the UV by the lizards and for regulation of body temperature. The easiest way to provide this is with a halogen spotlight of wattage suitable to create local basking spots of 25–35°C. For small enclosures like the Hailea screen cage, a 35 W or 50 W lamp is usually adequate. You can adjust the temperature at the basking spots by changing the wattage of the lamp and/or the distance between the lamp and the basking spot. Plug basking lamps into a separate timer that allows you to vary the length of time and time of day when basking is available. An hour each morning and afternoon is adequate in winter while 2–3 hours morning and afternoon in summer is appropriate. Fig. 13 shows a Hailea vivaria housing different green gecko species with florescent UV tubes above and halogen basking spotlights.

Figure 13: A Hailea mesh cage housing elegant (Auckland green) geckos, one of several on a single shelf. T5 fluorescent UV lighting above and a clip-on, halogen basking light to the rear right.

With large vivaria, at least 50 x 50 x 100 cm, where lizards can move well away from the basking spots, lamps can be left on all day provided they do not affect the ambient temperature in the room. Use lower wattage lamps in winter and higher wattage lamps in summer to replicate the strength of the sun and seasonal variation in temperature.

Remember to provide at least half as many basking opportunities as there are lizards in the vivarium. You can do this with multiple lamps as in Fig. 14 (which can be on different timers) and/or by carefully structuring the basking locations to provide multiple basking opportunities under one lamp with visual barriers (foliage, branches, rocks etc.) between them to reduce likely competition or aggression.

An alternative type of lamp is the UV and heat-emitting tungsten lamp. In New Zealand, the only readily available lamp of this type at the time of writing was Trixie's 'Reptiland ProSun Mixed D3'—available in 70 W, 100 W and 160 W (see Appendix 1). These lamps provide localised heat and UV light, but owing to the heat output and strength of the UV emitted

they must be used at greater distances from your lizards. All the same techniques as for the other lamps apply for managing your lizards' UV exposure with these lamps, but bear in mind that higher wattage lamps need to be used in relatively larger vivaria to prevent dangerous heat build-up. Owing to the localised nature of lighting from these lamps, natural 'daylight' fluorescent lamps will be required to illuminate the rest of the vivarium.

Figure 14: A simply landscaped Exo-Terra® housing a subadult robust skink. T5 fluorescent UV lighting above and a metal halide basking lamp suspended to top left.

Since it never rains indoors, keepers of indoor lizards must also provide for this aspect of climate. Replicate rainfall with a good hand-spray of the enclosure regularly and at least 3–4 times per week. A good rule of thumb is to provide a good spray whenever it rains outdoors. Spraying the enclosure and watering plants (best kept in their pots) both provide temporary and localised increases in humidity which are a critical part of microclimate provision.

If humidity is too low and increased spraying is difficult in an indoor location consider these options:

- add more live plants with dense foliage, the damp soil in their pots and the foliage will both increase humidity
- add substrates that hold water for a longer time, like pieces of punga, moss, piles of leaf-litter
- add a designated humid-hide', a small plastic box or pipe, piece of bamboo or similar, loosely filled with damp sphagnum moss or leaf-litter

- install a simple drip system (as simple as a plastic container of water with a pin-pick in the bottom, standing on the roof of the vivarium) which drips water over the foliage of a plant
- as a last resort, gradually reduce the amount of mesh/ventilation to reduce evaporative loss, but take care not to cause excessive humidity (>80%) for prolonged periods

As with outdoor vivaria, furnish and manage indoor vivaria in accordance with the ecological and behavioural preferences of the lizards you keep.

Summary of key points:

- **Use a light-weight outdoor-style vivarium indoors, or commercially available screen-mesh or glass vivaria designed for reptiles (not a fish tank).**
- **With careful selection of the room in which vivaria are placed, dangerous extremes of climate can be easily avoided indoors.**
- **All aspects of climate must be provided and controlled, including year-round temperature within acceptable limits of 5–25°C, 'rainfall' and humidity, and seasonal variation in these and day-length.**
- **Use good-quality, specialist UV-emitting lamps and follow the instructions on the packaging or, if possible, use a Solarmeter to measure the UV and aim for similar levels as outdoors.**
- **Provide basking spots of 25–30°C with halogen spotlights and control these and the UV lights with timers to provide daily and seasonal variation.**
- **Position the lights and furnishings to ensure multiple opportunities to bask—at least half as many options as there are lizards in the vivarium.**
- **Supply 'rain' by regular spraying and consider a simple drip-system to ensure constant water and increase humidity locally.**
- **Provide lots of choice in microclimate with plants, varied substrates and other furnishings like hollow punga and deep leaf-litter.**

3. HANDLING AND RESTRAINT

Many New Zealand geckos and some skinks seem to adjust well to handling, becoming seemingly 'tame' with repeated gentle handling. However, do not underestimate the stress that handling may cause to animals, even when they seem calm. In general, it is not recommended that lizards be handled without good reason. Those reasons may include husbandry-related needs such as transferring animals between enclosures (although, if possible, do this by transferring geckos on a small branch or potted plant, and for both geckos and skinks by moving them while they are inside a secure retreat) and for veterinary reasons (such as examining and treating injuries).

It is acknowledged, however, that education and advocacy for lizard conservation can be good reasons for keeping lizards in captivity and such activities are enhanced by close-up and personal encounters with these fascinating and beautiful animals. Occasional handling for these purposes is therefore appropriate, as long as there is adequate consideration of the animals' welfare:

- **do not handle a lizard more than once per day**
- **avoid handling in hot weather and direct sun**
- **pay attention to the animal's behaviour and discontinue handling if it shows signs of stress (such as heavy breathing, continued and repeated attempts to escape, excessive struggling and biting or sudden lethargy and immobility)**
- **limit handling to 10–15 mins and leave the handled animal undisturbed back in its familiar environment afterwards;**
- **ensure that the handler and anyone else who has touched the lizard washes their hands thoroughly afterwards with soap and water.**

Even apparently 'tame' lizards may occasionally need to be restrained for examination or veterinary treatment. While New Zealand lizards pose no physical danger to handlers (though see comments on zoonoses in section 8.2), the bite of larger species may cause pain and bleeding. In order to avoid injury to handler and lizard during restraint, grasp the lizard firmly around the shoulders with thumb and forefinger either side of the neck/skull to prevent them from twisting and biting. Take care not to trap limbs in an awkward position or to trap the tail, which may be autotomised (dropped).

While the lizard is being held, remember the stress that this will be causing the animal and do not exacerbate it by carelessly waving it around, turning it upside down needlessly or prolonging the restraint beyond what is absolutely necessary.

Remember to wash your hands thoroughly with soap and water immediately after handling a lizard and before you handle another one, as during restraint lizards will frequently pass faeces and urine/urates.

4. NUTRITION AND FEEDING

New Zealand lizards are omnivores. This means that they consume both plant and animal matter on an opportunistic basis. The proportion of animal versus plant matter in their diet may therefore vary according to availability of native fruits and flowers at different times of the year.

As ectotherms, lizards do not need to eat as much as an equivalent-sized endotherms (such as mammals or birds). The vast majority of the energy locked-up within a lizard's diet is converted into 'new lizard', either in the form of growth, fat-stores or reproduction. Adult lizards that are no longer growing significantly are therefore prone to obesity, especially males and females who are not breeding. Guidance on feeding frequency, quantities and avoiding obesity is given below.

In order to ensure a nutritionally adequate diet which provides protein, fat, carbohydrate and all essential vitamins and minerals, it is important to make as wide a variety of food items as possible available. However, the variety provided in captivity is unlikely to match that consumed in the wild state and, as a precaution, the diet should be supplemented regularly with a multi-vitamin/mineral powder designed for reptiles (see Appendix 1 for recommended brands).

Of particular importance is the balance of calcium and phosphorus in the lizards' diet. Lizards deficient in calcium, even with appropriate UVB exposure, may suffer from a range of debilitating conditions, as outlined earlier in section 1.3. Ideally, the ratio of calcium to phosphorus should be at least 2:1. This can be hard to achieve, as commercially bred food-insects and many of the easily wild-harvested insects are very low in calcium. Including terrestrial crustaceans (slaters and amphipods) in the diets of lizards who will accept them will help address the imbalance, but the use of hi-calcium supplements and cuttlefish bone (see below) is recommended.

There is also an increasing awareness (but still relatively little understanding) of the importance of carotenoids in reptile diets. The best known carotenoid is beta-carotene—the red/orange pigment found in carrots and many other red/orange fruits and vegetables. However, there are numerous other naturally occurring carotenoids. Carotenoids are anti-oxidants and are thought to play a role in decreasing risk of disease as well as in producing normal, vibrant pigmentation of skin and other tissues. Choosing colourful fruits like berries for your lizards may therefore improve both their colouration and their health.

Fresh water must be available to all lizards at all times. Geckos in particular prefer to drink from droplets forming on their own body and/or leaves and other objects in their

environment, so daily rainfall or spraying is important. However, a shallow dish of fresh water should be a permanent feature of any lizard's enclosure.

4.1 NATURAL AND CAPTIVE DIETS

The diet of free-ranging wild lizards includes a wide array of invertebrates including, but not limited to, flies of all shapes and sizes; bees and wasps; ants and termites; butterflies, moths and their caterpillars; beetles and their larvae; crickets, katydids and weta; stick insects; praying mantises; cicadas; cockroaches; spiders; woodlice (slaters) and terrestrial/marine amphipods (both excellent food items as these crustaceans have calcium-rich exoskeletons unlike insects). In captivity, it can be hard to provide such a rich and varied selection of invertebrates but with a little effort and creativity, and the addition of commercially available or home-bred food-insects, it is possible to come quite close.

Wild invertebrates can be harvested by hand (e.g. slaters and amphipods in rotting wood piles); by placing pieces of 'Onduline' or tin in scrubby vegetation as an insect refuge; with sweep nets drawn through the grass (to catch small crickets/grasshoppers, spiders and flies); and using light traps (moths and other flying insects) fly traps, and pitfall traps (for crickets, cockroaches and other terrestrial species—take care not to catch wild lizards!). There are countless resources available on the internet which give advice on how to make and use fly traps, moth-traps and pitfall traps or talk to other lizard keepers and NZHS members.

Take care not to harvest wild invertebrates from areas that may have been contaminated by fertilisers or pesticides.

Commercially available invertebrates include mealworms (which can also be fed out as beetles to larger lizard species), waxworms (better fed-out as moths), crickets and locusts (see appendix 1 for suppliers in New Zealand). All of these can be bred at home with a little know-how, as can flies and fruit flies. Guidance on breeding food insects is beyond the scope of this document, but much information is available from the internet and guidance may be sought from other experienced lizard keepers (New Zealand Herpetological Society (NZHS) - http://www.reptiles.org.nz/).

Depending upon the size/age of your lizards, they should be fed anything from hatchling crickets and fruit flies to full-grown crickets. Often juveniles will progress to larger and different prey as they grow larger themselves. Do not feed invertebrates larger than ½ the width of your lizard's head.

Do not feed wasps/bees, ants, centipedes/millipedes, monarch butterflies and caterpillars, any of the spiders discussed in section 2.1.3, and other large spiders.

Fruit makes up a significant part of native lizard diets at certain times of the year. Skinks are especially partial to native berries but geckos too are known to eat some species, particularly those with juicier, fleshier fruits. More than 20 species of native fruit feature in the diets of native lizards and some native plants are specially adapted to have their fruits harvested by lizards, fruiting deep within the foliage and often close to the ground or rocks on which they are growing to facilitate lizard access.

In captivity, offer your lizards native fruits whenever they are available in the wild. Plants such as *Coprosma* species, korokio/wire-netting bush (*Corokia* spp.), mingimingi (*Leucopogon fasciculatus*), pohuehue (*Muhlenbeckia complexa*), and kawakawa (*Piper excelsum*) all have obvious berries which can be easily harvested. It was discovered very recently that rimu (*Dacrydium cupressinum*) berries are a rare natural food source of vitamin D3. Though observations of lizards eating these berries are lacking, it seems very likely that they would eat them.

If you cannot acquire native fruits, use other berries such as blueberries, raspberries/blackberries and red/blackcurrants. Try to resist the temptation of using chopped or pureed fleshy fruits, especially banana (very high in calories), including commercial baby-foods. Native lizards have evolved to eat native fruit—persevere and be patient, they will eat them!

Most geckos and some skink species are known to feed on the nectar and perhaps pollen of numerous native and introduced plants. Observations of wild nectar feeding include, but are not confined to, pohutukawa (*Metrosideros excelsa*), rata (*M. Robusta, M. Umbellata*) , ngaio (*Myoporum laetum*), kowhai (*Sophora* spp.), flax (*Phormium* spp.), manuka *(Leptospermum* spp.) and kanuka (*Kunzea* spp.). Additionally, geckos frequent plants with scale-insect infestations to feed on these insects' sugary excretions (honey dew).

Provide native flowers for your lizards, especially your geckos, whenever they are available in the wild. Cut small twigs with flowers and stand them in jars of water to keep them fresh (make sure that there is no hole in the lid through which a lizard could squeeze) or keep small-flowering species in pots in the lizards' vivaria and/or additional plants which can be placed inside when flowering/fruiting. If native flowers are not available, Australian bottlebrush (*Callistemon* spp.) is a good alternative, or a few drops (literally) of water

slightly sweetened with honey can be dripped on large leaves or provided in a small receptacle such as a plastic bottle lid.
Twigs infested with scale insects and/or aphids are also a good idea for gecko food, but be aware that you may transfer the infestation to the plants in your vivarium!

Dust all commercially or home-bred food insects with a high-calcium, multi-vitamin and mineral supplement (see Appendix 1 for recommended brands) by placing them in a ziplock bag with a pinch of powder and giving them a gentle shake. Many reproductive female lizards like to eat small pieces of cuttlefish bone, a food rich in calcium and other minerals. Finely chopped pieces of cuttlebone (avoiding the hard/sharp 'shell' on the back) can be scattered in the vivarium or placed in a little receptacle and provided in unlimited quantities. Powdered (dry-blended) cuttlebone is also a good alternative supplement for dusting over or feeding to food insects. If you collect your own cuttlebone off the beach, be sure to soak it in plenty of fresh water for several days and then dry it thoroughly in the sun.
Vitamin D3 is very important to lizards but the lizards should obtain it through exposure to the correct type of light (see earlier in sections 1.3 and 2.1.1). Oral supplementation of vitamin D3 is not recommended as this is a potentially dangerous vitamin if over-dosed and should only be given as a supplement under advice from an experienced veterinarian.

Lizards easily become fat in captivity. Between one and four feeds per week, depending upon the lizard's age or condition (e.g. if pregnant), the time of year (temperature) and the food, is usually enough. Juvenile lizards should be fed more frequently than adults and pregnant females should be provided with extra food during pregnancy and in the weeks immediately after giving birth. Offer more food during warmer months when lizards are active, reduce feeding during cooler temperatures and discontinue below 10°C. Adult, fully grown, lizards should retain more-or-less consistent weight, allowing for female weight-gain during pregnancy and for both sexes to gain a little weight prior to winter and lose a little through winter. Juvenile lizards should grow consistently but slowly. Observe your lizards closely in order to adjust the quantity of food offered. Look for signs of weight loss around thighs (should be slightly rounded and firm) and pelvis (bones should not protrude) or weight gain around tail-base (should not be wider than deep), abdomen (no ripples of fat) and throat (should be no 'jowls'). Increase or decrease the number of feeds and/or quantity of food at each feed and/or types of food accordingly. Appendix 3 shows an excerpt from the diet sheet for native skinks and geckos at Auckland Zoo.

It is important not to follow old traditions in reptile feeding unquestioningly but to research the topic and experiment in order to develop new and better-balanced diets. Good, appropriate, diets are essential for healthy animals and successful breeding.

4.2 FEEDING TECHNIQUES

It is usually best to feed reptiles their diets in a whole and natural state. Invertebrate prey should be presented live, as lizards are generally stimulated by movement. In order to facilitate depredation, reduce escapes of food insects and prolong the period of vitamin/mineral powder adherence before the insect grooms it off, it is sometimes a good idea to make live food a bit sluggish by chilling it in a fridge before presenting it to your lizards.

Place invertebrates in the lizard's vivarium at the time of day when they will be active and feed quickly. This is normally late morning for diurnal species and early to late evening for more nocturnal species—although in captivity 'nocturnal' species may quickly learn to come out and feed at any time of day.

Placing small insects like flies and crickets in a pot with a small hole in the lid and a twig protruding will facilitate the gradual delivery of the insects into the vivarium. This can both prolong the feeding and reduce food-insect loss through escape and hiding, as lizards will quickly come to recognise the feeding pot.

Placing a small container of ripe fruit with a perforated lid will attract wild fruit flies into your vivarium (if you haven't built it of fly-screen!). This is a simple way to supplement the diet of young lizards in particular.

Soft native fruits and non-native berries can be presented whole or squashed. Kawakawa fruits can be squashed or chopped into smaller, bite-size, pieces. Either scatter the fruits randomly or, if you wish to monitor their consumption more closely, use a shallow dish, the location of which you can vary on a regular basis and according to the different behaviours of the lizards. Better still, plant fruit-bearing native plant species in your vivaria or in pots that can be moved in when they are flowering and/or fruiting.

Flowers can be presented on cut twigs/branches in a sealed jar of water (to prevent any lizards entering and drowning) or, as above, by planting/placing flowering species directly in the vivaria.

If honey water is used as an alternative to fruit, be vigilant for ants that may be attracted to this readily available food source. Use tiny amounts that the geckos will quickly consume and remove any surplus within an hour or two.

All reptiles must have permanent access to fresh water. However, many species like to drink from raindrops and by being sprayed. This must be taken into account and provided for, as some species simply will not drink from a bowl and may dehydrate and become ill. Spray your lizards' vivarium daily if housed indoors, and whenever it hasn't rained for a day or two in the case of outdoor vivaria. Take care not to drench the whole environment—focus on a few areas for high humidity (microclimates) and plant foliage to hold droplets for drinking. Consider installing a simple drip-system to provide constant drinking water to geckos.

4.3 FEEDING PROBLEMS

Lizards which refuse to feed (anorexia—see section 8.2) may do so for a number of reasons. If the animal is not obviously ill, pregnant, breeding, or in winter torpor, check the environmental parameters in the vivarium:

- is it too hot/sunny or too cold/shady?
- too wet or too dry?
- is the lighting malfunctioning?
- is there enough cover and availability of microclimates?

Consider also behavioural and social factors:

- are lizards fighting between or within species/sexes?
- are there enough basking, perching/feeding opportunities for all lizards?
- is there enough landscaping to provide visual barriers between animals?

If everything appears to be in order, try:

- varying the types of food being offered—something novel will often promote feeding
- increasing/decreasing the temperature by one or two degrees
- increasing the humidity and/or simulating rain showers
- increasing/decreasing light intensity according to species natural history
- offering food at a different time of day.

If none of these measures is successful, you should consult a veterinarian experienced in lizard husbandry.

Summary of key points:

- Native lizards are omnivores.
- Feed them a wide variety of invertebrates supplemented with calcium/vitamin powder.
- Do not feed invertebrates larger than ½ the width of your lizard's head.
- Do not feed wasps/bees, ants, centipedes/millipedes, monarch butterflies and caterpillars, any of the spiders discussed in section 4.1.3, and other large spiders.
- Offer 2–3 food insects per lizard –-4 times per week depending upon season (more in summer, less in winter) and food type—2–3 small crickets might equate to just one small locust, 10–12 house flies or >50 fruit flies.
- Offer native fruits when in season or if not available, berries and currants grown for human consumption. One or two pea-sized berries/pieces per lizard instead of an invertebrate feed 1–2 times per week.
- Provide native flowers, bottle-brush flowers or a few drops of honey-sweetened water to geckos once or twice per week.
- Don't feed when temperature is less than 10°C.
- Fresh water must be available at all times and gecko enclosures must be sprayed daily.
- If your lizard doesn't eat, try new food items and check that all of its environmental and social conditions are appropriate.

5. BREEDING NEW ZEALAND LIZARDS

Ensuring a sustainable population of captive New Zealand lizards is a joint responsibility of all keepers and will help to ensure that no further animals are taken from the wild—legally or illegally—to support the hobby. However, breeding should not be undertaken lightly, as it carries with it certain consequences and obligations.

Many species of skink and gecko are closely related to other species, so close in fact that they can inter-breed if no partner of the same species is available. Never attempt to breed different species together (hybridisation) and avoid keeping adults of similar species (e.g. green geckos such as Gray's (Northland green), elegant (Auckland green) and barking (Wellington green)) in the same vivarium to avoid accidental breeding.

Breeding closely related individuals (inbreeding) is not to be encouraged because this increases the risk of unhealthy and/or abnormal offspring and, over time and multiple generations, inbreeding-depression will likely be expressed as reduced 'fitness' in terms of lower fertility, poor vigour and survival among babies, stunted juvenile growth, shorter life spans in adults and even morphological changes including malformation. Good record keeping (see section 6), allows breeders of lizards to choose unrelated, or at worst, distantly-related individuals for breeding, thereby minimising inbreeding and associated risks.

Any lizards bred in captivity must remain in captivity. It is illegal to release even native species without an appropriate permit. Breeders of native lizards are therefore obligated to keep any lizards they breed, finding the necessary additional resources (vivaria, food, time and associated costs) to house them in the long term, or to transfer them to other permitted keepers. It is therefore recommended that those wishing to breed native lizards do so only in order to:

1. meet their own aspirations for numbers of each species
2. respond to requests of other permitted keepers
3. follow the recommendations of any organised and managed breeding programme.

With respect to the latter, keepers of New Zealand lizards are encouraged to work together and coordinate their efforts to breed each species responsibly and sustainably. This is best coordinated through the NZHS, which should consider developing studbooks and coordinated programmes for each species.

5.1 TELLING THE SEXES APART

Male and female geckos are relatively easy to tell apart. Male geckos have pronounced bulges at the base of the tail (where the hemipenes are housed) and visible pores in the scales on the underside of the thighs and in front of the cloaca (Fig. 15). These pores my ooze a waxy yellow material in the breeding season.

Figure 15: Adult male elegant (Auckland green) gecko, note the bulges at the base of the tail and the obvious cluster of spiky scales beside the cloaca.

Skinks are much harder to sex. Adult males may have a relatively larger/broader head and will have a thicker base to the tail, sometimes with visible hemipenile bulges. Females will often be stouter around the mid-body. These characters are rather difficult to judge unless at least one animal of each sex can be closely compared. It is possible to confirm the sex of subadult and adult males by visual examination of the cloaca and hemipenile pockets, but this is a specialised process which should only be carried out by experts familiar with the technique required.

Behaviour may also provide clues as to the sex of your lizards. Aggression between animals is more common between males so if you see regular fighting/biting between two animals in a group this may indicate competition between two males (and they should be kept separately). Females will also show dominant behaviour, however, and squabbles between co-habiting females are almost as common. Mating is, of course, a reliable indicator of lizards' sexes. If you are familiar with the behaviours expected you may identify males and females by courtship behaviour as well as actual mating. Females lizards which are gravid (pregnant) require additional warmth for their developing embryos and will therefore often

bask for extended periods. An increase in the visibility and basking behaviour of an animal in late spring (as well as an increase in girth!) is a pretty sure indication that an individual is a female.

Figure 16: A heavily gravid (pregnant) Starred (Nelson green) gecko.

5.2 REPRODUCTIVE CYCLES AND BREEDING

Preparing reptiles to breed can be complicated when they are maintained outside of their natural environment and geographic range. However, keeping native species, and especially within the range of their natural distribution, alleviates many of the difficulties.

The most important thing to remember is that if we want reptiles to breed naturally then we should keep them naturally. 'Naturally' in this context refers not to how the vivarium 'looks' but to how it 'feels'. Providing natural daily and seasonal variation in temperature, humidity and rainfall, and photoperiod is central to successful breeding of reptiles.

Many species of reptile are stimulated to breed by changes in photoperiod. Some, the 'long-day breeders' are stimulated by increasing day length while others, the 'short-day breeders' are the opposite and are stimulated by decreasing day length. New Zealand lizards are known to mate in both spring and/or autumn, depending upon species.

In addition to providing the appropriate seasons, it may be necessary to vary the group size and sex ratio, as simply having lizards of both sexes doesn't guarantee success. Some species of lizard breed better in small groups rather than in pairs. The competition, either physical or chemical, between males helps to stimulate courtship and receptivity in females. However, group breeding has its disadvantages, including the possibility of injury between competing males, interruption of mating attempts by other animals and difficulty in recording parentage of offspring. Keeping pairs of lizards in adjacent vivaria is an alternative strategy, as just the sight or smell of a rival male can stimulate mating.

Courtship in skinks and geckos usually entails the male following the female around, touching, licking and superficially biting it, until the female becomes receptive and submits to the male's advances. Both geckos and skinks bite each other during courtship and mating so if two animals of opposite sex appear to be fighting, don't rush to separate them. Male geckos usually bite the back of the female's neck or around the shoulders while male skinks more often bite their partners around the flanks and lower back. Superficial bite marks and minor scars on female lizards' bodies may therefore be an indication of successful mating.

During mating the female lifts her tail and the male will usually grasp the female as described above, and twists one leg and his cloaca underneath the female's pelvis so that their cloacae meet. The male mates the female with one or other hemipenis, depending upon his alignment, and mating may last a few minutes at most.

5.3 PREGNANCY AND BIRTH

Most New Zealand lizards give birth in late summer or autumn after a pregnancy of several months that may include the previous winter (autumn-mating species). A few species, however, including the commonly kept North Island green geckos, have been observed giving birth in captivity at practically any time of year.

Pregnant lizards are usually referred to as being gravid. Offer gravid female lizards plenty of food and unlimited finely-chopped/powdered cuttlebone as an essential source of calcium for the growing embryos. Gravid females will often spend more time basking than other lizards and may lose their appetite in later stages of pregnancy as their abdomen becomes noticeably swollen.

Geckos almost always give birth to twins, and just occasionally, to a single baby. Some species will give birth under cover of darkness and within the security of a dense shrub or leaf-litter, while the green geckos (genus *Naultinus*) will often give birth in the open during daylight. Skinks will usually give birth on the ground and may do so at any time of day or night, depending upon the species. Skinks usually have 3–5 babies, but some larger species may have 10 or more.

The post-partum female will be hungry and dehydrated after giving birth. Provide plenty of high-water-content food and a lightly spray her immediately after she has given birth and in the next few days. Feed her plenty of protein-rich insects and cuttlebone in the following weeks until she regains her pre-pregnancy body condition.

5.4 SPECIAL REQUIREMENTS OF NEONATES

Several species of New Zealand lizard tolerate their offspring remaining in close proximity for weeks and sometimes months after birth, although there is little evidence of any direct parental care. Otago and grand skinks, for example, will tolerate their offspring until the following year and then chase them away; elegant (Auckland green) geckos seem to live quite peacefully in large groups in captivity (as long as appropriate sex ratios and stocking-density are maintained) and Duvaucel's geckos may live in extended family groups in the wild. However, unless you are an experienced keeper and familiar with the specific behaviour of the species and individuals you are keeping, new-born lizards are best removed from their parents' enclosure as soon as they are found. This will eliminate any chance of aggression from parents and/or other adults or species, or worse, cannibalism.

New-born lizards require more-or-less identical conditions to those of their parents. There is no parental care and they are completely independent from birth. However, their small size makes them relatively more vulnerable to the dangers of climatic extremes and extra care should be taken to ensure consistent temperatures well within the natural ambient range (i.e. 10–25°C) and adequate hydration by regular direct spraying. The addition of a drip-system above a plant is an easy way of delivering a constant supply of drinking water in a consistent manner throughout the day.

Avoid unnecessary complexity in vivarium furnishings to ensure it is easy to observe and therefore monitor the condition of baby lizards. Paper towels are a good preliminary substrate as they can be easily dampened and removed when soiled and make it easy for baby lizards to see and catch prey (and for you to see that the prey has been eaten and the lizards are defecating normally).

Wait 1–2 days after birth before offering baby lizards food to allow the nutrients from the internal yolk sac to be fully utilised. Offer the same diet as provided to the parents, but of an appropriate size (fruit flies, hatchling crickets, small moths etc.) and quantity at each feed and provide food daily for the first 6 months of their life before switching to an adult feeding regime. Baby lizards should grow steadily but not quickly, reaching adult size at approximately 2–3 years of age or older for larger species such as Otago, grand, Falla's (Three Kings) and robust skinks and Duvaucel's gecko.

Most baby lizards can be kept in small groups, but care should be taken during feeding to ensure accidents are avoided and close observation must be maintained to identify animals that are being suppressed and are falling behind in their development. Often it will be necessary to decrease group size or keep juveniles individually as they get older. Fig. 17 shows a litter of new-born Falla's (Three Kings) skinks.

Figure 17: A new-born litter of Falla's (Three Kings) skinks.

Summary of key points:

- Think carefully before breeding any lizards—do you have a confirmed new home for them or the time and space to look after them forever?
- NEVER release surplus animals into the wild. It is illegal and can do untold damage to local resident lizards.
- Never hybridise species deliberately and avoid keeping similar species together to prevent accidental breeding.
- Do not breed from closely related animals to avoid inbreeding and associated health issues.
- Cooperate with other breeders and the NZHS to maintain healthy lizard populations in a coordinated programme.
- Male and female geckos can be identified easily by the presence of bulges at the base of the male's tail. Skinks are much harder to differentiate—ask a more experienced keeper for help.
- New Zealand lizards may mate in autumn or spring, but most will give birth in late summer or autumn.
- Gravid females can be identified by their swollen belly and increased basking behaviour. They need plenty of calcium-rich food at this time.
- Geckos usually have twins, never more and most skinks have 3–5 babies. Post-partum mothers need plenty of fluids and food to regain their condition.
- Raise baby lizards in a separate enclosure from adults (including their parents unless you have experience with keeping mixed-age populations) and treat like a more delicate version of their parents.
- Watch for bullying and suppression in groups of neonate and juvenile lizards—individuals falling behind in size and weight—and separate them as necessary.

6. IDENTIFICATION AND RECORD KEEPING

Accurate record-keeping is an often overlooked but important aspect of maintaining animals in captivity. To do this in a meaningful and accurate way it is desirable that animals are individually identifiable.

Most native lizards can be identified by variably obvious differences in their markings and/or minor scars and other imperfections such as lost toes or tail-loss/regeneration. Digital photographs of each animal in your collection—from both sides and above—cost nothing to take or store and can be updated easily and frequently when/if animals change in appearance.

Toe-clipping, though widely practised in field studies around the world, is not an approved method of marking wild or captive lizards in New Zealand. Micro-chipping is possible on larger specimens, using the appropriate model of micro-chip. Talk to a reptile-experienced veterinarian if you are interested in marking your lizards this way.

Lizards can also be temporarily marked to assist in identification. Use a xylene-free marker pen to make unobtrusive marks on the upper surfaces of body and limbs, but avoid the top of the head and tail. Temporary marks will of course be lost the first time a lizard sloughs its skin (if not sooner).

Animals housed alone, or as a single individual amongst a group of lizards of a different species can, of course, be identified by the vivarium they occupy. Labelling your vivaria is also a good idea, as it helps in locating individual lizards and tracking any patterns of good/bad health or reproductive success within different enclosures.

When recording species names, the most up-to-date list is the Department of Conservation (DOC) Threat Classification System list for reptiles http://www.doc.govt.nz/about-us/science-publications/conservation-publications/nz-threat-classification-system/nz-threat-classification-system-lists-2012-14. This list is revised regularly to take account of any names that have been defined or re-defined in scientific publications and papers.

The **minimum records** you should keep for each individual lizard are as follows:

- **species and sex**
- **date of birth and/or arrival in your collection**
- **origin—e.g. name/permit of breeder or wild location if acquired through rehabilitation**
- **identification of parents, if known**
- **date of removal from collection and destination or**

- **date of death.**

However, the more you record about your animals the more you, and others, may learn about their husbandry and the better placed you will be to address any health or behavioural problems. Consider, for example, the benefits of also recording:

- which enclosure(s) individuals are kept in and when they are moved between them
- with which individuals/groups they successfully cohabit, both of the same and different species
- weights and measurements of growing juveniles and adult animals at different times of the year
- maximum and minimum temperature and humidity
- food preferences and patterns of feeding;
- health concerns such as weight loss, retained sloughed skin, injuries/tail autotomy, ectoparasites (ticks and mites) and other infections
- observations on social behaviours such as fighting, courtship and mating
- observations on other behaviours such as basking, burrowing and activity periods.

7. TRANSPORTING LIZARDS

Lizards' ability to go without food and water for extended periods make them relatively easy to transport. However, these characteristics should not be exploited and great care should be taken to avoid unnecessarily lengthy deprivation, particularly of water, and exposure to excessively high or low temperatures during transportation.

Both skinks and geckos can be placed in small escape-proof boxes, such as plastic food-storage boxes with fly-screen ventilation panels or with small holes drilled for ventilation. Place crumpled kitchen towels or dry leaf-litter in the box for security and keep the container away from extremes of cold or heat (e.g. direct sun or being left in parked cars).

For longer journeys, and for transport by air, boxes should be placed inside a strong, insulated container such as a polystyrene cool-box, plywood crate or commercial chilly-bin.

Alternatively, lizards can be placed individually into labelled cotton bags with the tops twisted, folded and cable-tied (taking care not to catch tails or toes). These are then placed in a suitably insulated box as above.

Travel boxes must be securely fastened and clearly labelled with:

- numbers and species of reptile contained
- name, addresses and contact telephone of sender and receiver
- the words 'LIVE REPTILES'
- instruction to avoid high and low temperatures
- right-way-up and indicator arrows.

Always consult airlines prior to booking reptiles as air cargo to ensure you meet International Air Transport Association (IATA) standards and airline conditions, and to ensure that your lizards travel in the **pressurised** hold.

Never send live reptiles by post or by postal courier. If they must travel unaccompanied, use a specialist animal transport company (e.g. Petmove or Petbus) or an airline experienced in transporting live animals.

Do not stack transportation boxes/containers on top of each other or side by side as this will restrict the ventilation holes and can cause unacceptable temperature variations.

IT IS ILLEGAL TO EXPORT ANY NATIVE REPTILE SPECIES OUTSIDE OF NEW ZEALAND WITHOUT AN AUTHORISATION.

8. LIZARD HEALTH AND HYGIENE

Most ill health in captive lizards is a result of errors or inadequacies in diet and husbandry. Paying regular and frequent close attention to climate, environment, diet and behaviour should ensure fit, healthy and long-lived lizards.

Maintain good hygiene by washing food dishes and water bowls daily, cleaning soiled rocks, branches and vivarium frames weekly, and removing as much loose faeces as possible whenever you observe them. Change soiled substrate regularly—every 6 months for vivaria with just a pair of lizards—but more often for larger lizard groups.

If caught early, many minor ailments can be treated with changes to the environment, anti-bacterial/fungal detergents, good hygiene practices, and manipulations of the social structure/group size. Remain vigilant for even minor changes to lizard behaviour, appetite and body condition and for skin sloughing problems, injuries or infections. Prolonged and/or significant illness will require veterinary attention. However, in all these cases, optimal husbandry will play a significant part in the animal's recuperation. One significant disease in captive reptiles, Metabolic Bone Disease (MBD), is entirely preventable with good husbandry but very difficult to manage once present—providing a good example of prevention being better than cure.

8.1 MINIMISING DISEASE TRANSFER AND QUARANTINE

Native New Zealand lizards should be maintained in isolation from any other reptiles.

If you also keep exotic lizards and turtles, be sure to separate them by:

- housing them in separate vivaria and as far from each other as practical
- never using the same cage furnishings, food/water dishes, and cleaning equipment
- always servicing your native lizards first each day
- practising strict personal hygiene before, during and after servicing.

It is also good practice to keep each of your native lizard vivaria some distance from each other. Using separate feeding/watering containers for each vivarium and washing your hands and/or cleaning utensils between servicing vivaria both help to reduce the chance of disease spreading between animals in different vivaria. Always servicing vivaria in the same order will help you to predict where any disease your lizards experience might occur next.

Lizards new to a collection, or those suspected of being sick, should be separated from all other lizards. Ideally, a quarantine vivarium should be available away from other vivaria and it should **always be serviced after** those of healthy lizards. Sick reptiles should be kept in

simple, easy-to-clean vivaria, without compromising the provision of all necessary environmental requirements for the species. Keep all food and water bowls and cleaning utensils separate and maintain the highest standards of cleanliness in the vivarium. It is prudent to remember that all animals, but especially ill ones, can carry diseases that affect humans, so strict attention to personal hygiene is also important.

Newly acquired lizards should be maintained in quarantine for a minimum of 4 weeks in order to assess their health. Examine them for external parasites and observe their behaviour and appetite closely. Ideally, you should have their faeces examined for bacteria and parasites by a veterinary clinic. If the new lizard came from a breeder with no recent history of disease in their lizards and it appears normal and healthy after 4 weeks, it can then be introduced to other lizards. Veterinary guidance should be sought for any lizard showing inexplicable lethargy, anorexia, weight-loss, abdominal bloat, regurgitation of food, loose or bloody faeces, open-mouthed breathing or muscular tremors. Fig. 18 illustrates a hospital cage set up for lizards.

Picture required

Figure 18: A hospital cage

8.2 COMMON AILMENTS AND TREATMENTS

Anorexia—A loss or lack of appetite in a lizard may be caused by many things. First and foremost, check all the environmental parameters discussed in previous chapters and go through the steps outlined in section 4.3. If your lizard fails to respond to any of these changes and begins to lose weight, seek veterinary advice.

Malnutrition—Weight loss may be caused by insufficient quantity or quality of food, inappropriate presentation of food, or the presence of disease. Weight loss is most evident on the thighs (loss of muscularity and tone), abdomen (becomes gaunt or concave), pelvis (hip bones become prominent) and tail-base (shrinks in diameter). In severe emaciation the spine and ribs may become increasingly visible (Fig. 19).

If your lizard is losing weight, ensure all environmental variables are correct, keep it well-hydrated by daily gentle spraying of the lizard itself and increase the quantity and/or frequency of food offered. If its weight doesn't begin to increase there may be an underlying medical problem and you should seek veterinary advice.

Picture required

Figure 19: A skinny lizard

Obesity—Weight gain is usually most evident around the tail-base (should not be significantly wider than deep), abdomen (should be no ripples of fat at the sides and over the ribs) and the throat (should be no 'jowls') (Fig. 20). Any evidence of these symptoms indicates over-feeding in either quantity and/or quality and is likely to correlate with increased fatty deposits in the abdomen and around the organs. Severe obesity may lead to reproductive failure, illness and death.

Lizards do not lose weight easily or quickly, so remain vigilant for weight gain as prevention is better than cure. At the first signs of weight gain, reduce food intake via reduced quantity rather than frequency and alter dietary items to favour low-fat, high roughage invertebrates such as slaters, beetles and flies, and use small food items which have a larger surface area (exoskeleton—roughage) relative to volume (body content—fat and protein). Make sure you offer only native fruits and berries and in reduced quantities.

Picture required

Figure 20: A fat lizard

Disecdysis—Failure to slough the skin completely is almost always due to a lack of appropriate humidity and/or substrate to facilitate physical removal of the skin. Skin is most commonly retained on tail tips, toes, around cloaca, ear openings and eye spectacles (geckos only—see below). If skin is allowed to remain on tail tips and toes, especially over repeated sloughs, it will likely contract as is dries, constricting blood flow and resulting in the loss of the tail tip or toes affected.

Manual removal is not recommended as it is easy to damage the underlying skin or even the associated structures (toes, ears, eyes). Instead, half-fill a small plastic container, such as a 1L ice-cream tub, with very damp sphagnum moss and some manuka twigs with foliage still on, and puncture at least 20 small holes in the sides and lid. Place the lizard inside this high-humidity environment somewhere reasonably warm (approx. 20°C) for 30–45 min two or three times per day until the skin is sloughed.

Remember to correct the conditions in the lizard's vivarium to prevent reoccurrence. The provision of a high-humidity hide (which should be thoroughly cleaned out every 2 weeks) and daily spraying of parts of the enclosure which will retain moisture is usually enough and should be part of the lizard's standard husbandry.

Retained spectacle—Geckos may sometimes retain the eye-covering scale during sloughing. It is not always obvious unless a fringe of torn skin is visible around the eye, but if the scale

is not sloughed the eye will usually appear slightly larger than the other eye and increasingly dull and/or wrinkled as the scale dries out. If you can see or suspect a retained spectacle, use the same procedure outlined above and spray the eye directly with tepid water as often as you can (up to hourly) in between humid-hide sessions. Placing a tiny drop of honey on the centre of the eye once per day will encourage the gecko to clean its eye, increasing the chance of the spectacle being licked away.

If the scale doesn't come away within a few days and the eye becomes dulled and/or wrinkly, seek advice from an experienced veterinarian or lizard keeper.

Black-spot fungus—Green geckos (genus *Naultinus*) in particular, are often reported to suffer from sooty-black fungal infections of the skin. It is not always obvious in early stages as it may appear indistinguishable from small black speckles of skin pigmentation. However, as the fungus develops, blackening the skin between the scales, the affected lizard may become anorexic and begin to lose weight (Fig. 21). Deaths have been recorded. Like so many health issues, it is usually a result of the environment provided, in this case insufficient ventilation and excessive humidity. Correcting these environmental factors and ensuring good access to UV basking, will often be enough to fix the fungal infection but serious or persistent cases can be treated by washing the affected body parts with cotton wool soaked in 1% iodine:water solution once per day.

Remember that good ventilation is essential and providing high humidity (>70%) microclimates with damp punga logs, piles of leaf litter, dense vegetation etc., is better than maintaining consistently high ambient humidity.

Picture required

Figure 21: A lizard with black spot

Respiratory infection—Signs of respiratory infection include pronounced heavy breathing (pumping throat and/or heaving rib cage) even when stationary, nasal and/or oral discharge and open-mouth breathing. Respiratory infections may be due to bacteria, but are more likely to be brought on by unsuitable climatic conditions. Check all your environmental parameters and manage temperature and humidity to ensure optimum temperatures day and night (25/20°C respectively) and humidity of 60–70%. Ensure plenty of basking opportunity at suitable temperatures and with good UV levels. If your lizards are outdoors and it's not sunny, bringing it/them indoors to a 'hospital vivarium' will facilitate these changes and provide quarantine isolation from other animals. If the symptoms do not

improve within 1–2 days of optimum environmental conditions, seek veterinary advice, as medication will likely be required—a respiratory infection left untreated will likely worsen and may result in the death of the lizard.

Stomatitis—Sometimes referred to as 'mouthrot', (ulcerative) stomatitis is an infection of the mouth/gums/tongue which, if left unchecked, can spread into the bones of the skull, into the respiratory tract and can also become systemic (throughout the body) and ultimately prove fatal. Again, this condition is usually caused by sub-optimal husbandry including over-crowding (which causes stress), and temperatures that are too high or too low and is exacerbated by poor hygiene and/or a mechanical injury to the face/mouth which facilitates invasion of pathogens. Mild stomatitis is easy to overlook, often presenting as thickened saliva and small areas of reddening on the gums and mouth lining caused by bleeding and a loss of appetite. If the underlying causes are not rectified the disease rapidly advances, leading to widespread change in colour (reddening) of the mouth lining and gums and mild swelling of the lips. Pale-yellow/white pus and necrotic plaque will develop inside the mouth, forming a crust inside the lips and causing open-mouth breathing (Fig. 22).

If caught early, hospitalisation in optimum conditions, immaculate hygiene and rinsing the mouth with a 1% iodine:water solution twice per day in conjunction with gentle removal of any pus and plaque with a cotton bud, will usually arrest the disease. Cases which do not respond to this treatment within 2–3 days, or more advanced cases, should be referred to a veterinarian for debridement and antibiotic therapy.

Picture required

Figure 22: A lizard with stomatitis.

Injury, toe bite/loss, tail autotomy—Most physical injuries to captive lizards are minor and result from squabbles between co-habiting individuals and even non-aggressive mating behaviours (see section 5.2). Injuries which result in bleeding often look far worse than they really are.

Bites and scratches that do not draw blood can usually be safely ignored, but you need to be vigilant for any deterioration and remember to observe your animals closely to ensure that the behaviours that resulted in the injury do not re-occur. Take appropriate measures to reduce aggression if they do, such as increasing visual barriers, basking and feeding opportunities and/or removing problem animals and reducing lizard density in the vivarium.

Tail loss (autotomy) (Fig. 23) is a natural phenomenon in skinks and geckos and usually will heal without treatment. Prevention by gentle, correct handling techniques reduces the chance of this happening but aggression between animals or, rarely, animals becoming tangled in vivarium furnishings and/or fittings can be the cause. If the amputation site doesn't heal, or remains swollen and reddened, or produces a discharge, then veterinary advice should be sought.

Wounds that bleed and the stumps of lost toes should be cleaned with a 1% iodine:water solution. If bleeding persists, hold a clean piece of cotton wool or paper towel to the wound and apply light pressure for 2–3 min.

More serious injuries, including possible fractured limbs and dislocations (indicated by abnormal posture and gait, reluctance to use limb, or misshapen limbs), large open wounds, and injuries to the eyes require veterinary attention as quickly as possible.

Picture required

Figure 23: A lizard with an autotomised tail

Prolapse—Occasionally a lizard may be observed with a piece of internal organ protruding from its cloaca. This is called a prolapse and may be part of the cloaca, gut or reproductive organs. It is usually caused by abdominal straining which can be due to diarrhoea or constipation, ingestion of a foreign body (e.g. plastic), an abnormally high parasite load (see below), low calcium levels, or a hemipenis which is damaged during mating and remains engorged with blood.

Some prolapses will correct themselves given a little help and time. Wash the cloaca and affected tissue gently with tepid clean water. Keep the lizard temporarily in a vivarium with a simple clean substrate that won't stick to the prolapsed—kitchen towel is ideal. Sprinkling a little granulated sugar onto the prolapse can help draw water from the tissue and allow it to shrink. If this doesn't work and the tissue remains visible for more than a few hours, then seek urgent veterinary advice—if the exposed tissues remain outside the body they may suffer permanent damage, resulting in serious complications and death.

Ectoparasites—Mites are small (grain of sugar-sized) arachnids which may be found living on the skin of geckos and skinks (Fig. 24). They are usually red or orange and are most commonly observed around the eyes of geckos, ear openings, armpits and around the base of the thighs and cloaca. Some species are non-parasitic, feeding on dead skin and other detritus on the lizard's skin surface, while others are blood-sucking and in large numbers

may debilitate the lizard. A few mites are usually nothing to worry about, but be vigilant for them increasing in number and be aware that while just one or two lizards may initially be affected in a collection, the mites may spread to other lizards and vivaria. To remove mites, dab them with Vaseline to stop them respiring, wait a few minutes and then wipe them away with a cotton-bud. If the infestation is severe or the mites refuse to let go, then talk to your vet about using a treatment containing Fipronil* (e.g. Frontline). Care must be taken with this medication and the 'spot-on' versions are **not** appropriate—advice from an experienced veterinarian is advised prior to use. Correct use of Fipronil* spray involves spraying a small amount of the product onto a piece of clean cotton cloth, whilst in a separate room from the lizard. Gently wave the cloth for 2 minutes, allowing the alcohol in the product to evaporate. Then you can take this medicated cloth to the lizard—wipe it over the affected areas of skin, taking care to avoid the mouth, nostrils and eyes. Keep the treated lizard in a well-ventilated place until the treatment has dried and then return to a temporary hospital vivarium while you wait for the mites to die and fall off over the next few days. Remember that the geckos' usual vivarium will likely harbour mites and their eggs which will re-infest the lizard, so empty the vivarium, wash it thoroughly with very hot water and detergent (easier if it's not made of wood) and dry thoroughly in the sun before refurbishing with fresh substrates, plants and other furniture.

Ticks are less common but are always parasitic. They will usually feed for 2–3 days and then fall off, but can cause problems, especially in small lizards. Special tick-removers are available from veterinarians and some pet shops—these come with full instructions and if used correctly will remove the tick completely. If the ticks aren't removed carefully, there is a risk of leaving their mouth parts embedded in the lizard's skin which results in a non-healing wound and infection, so it is recommended you seek veterinary assistance with removing ticks. Fipronil* spray can be used on ticks as described for mites. It is worth remembering that the tick may take 1–2 days to die after application, but it will eventually fall off cleanly, without risk of leaving its mouth-parts behind.

*NB: Fipronil has been used safely with many species of reptiles internationally, but has also occasionally been associated with fatalities. Some of these adverse reactions may be due to a reaction to the alcohol in which the Fipronil is dissolved, rather than the drug itself. Its use with New Zealand lizards is not well documented, though there have been some reports of grand skinks reacting badly to it. For these reasons it is advised that this product is only used under the advice of an experienced veterinarian.

Figure 24: A Pacific gecko with mites.

Endoparasites—Like most animals, lizards can be infected by a wide variety of internal parasites. Some of these are commonly referred to as 'worms', but there are many other types as well. They can live in the intestines, as well as in other organs in the body, and some can be harmless, while others can cause disease. Many of these parasites are passed out in the faeces.

Most natural parasites do no real harm to their natural host if the host is healthy and the parasites are at normal levels of abundance. However, if there is high environmental contamination or if a lizard experiences any other kind of ill health (such as stress from over-crowding, fighting or incorrect environmental conditions) any parasites present may exploit the lizard's compromised condition and increase in number, which can lead to debilitation and even death.

As with most health issues, prevention is better and easier than cure and good husbandry is at the root of this. Avoid over-crowding vivaria, as this leads to increased accumulation of faeces (potentially carrying parasites/eggs) and may cause the lizards debilitating stress, and maintain good hygiene.

Signs of heavy parasitisation might include weight-loss despite eating, lethargy, abnormal faeces (e.g. diarrhoea or blood in the faeces), regurgitation and swollen abdomen (bloat). If you suspect parasitism of your lizard(s) seek veterinary assistance. Examination of the

faeces under a microscope, by your veterinarian, will confirm if there is a problem and if an anti-parasitic drug will be required.

If you have a large collection of lizards it is worth investing in regular parasite-screening of your animals by submitting representative faecal samples from each vivarium for examination every 6 months, in early autumn and late spring.

Salmonellosis—*Salmonella* and other bacteria are common in healthy reptiles. Sometimes, however, they may cause disease and even death. This is most likely to occur when a lizard is otherwise compromised by ill-health or stress from over-crowding, fighting or incorrect environmental conditions. Symptoms might include lethargy, weight-loss, and loose faeces (sometimes with blood in it). As with endoparasites, seek veterinary assistance if you see these symptoms.

NB: *Salmonella* and some other bacteria may be 'zoonotic', meaning they can infect and cause illness in people. Always practice good personal hygiene when cleaning and handling lizards and wash your hands thoroughly afterwards with soap and hot water.

Metabolic bone disease (MBD)—As discussed in section 1.3, UV light and dietary calcium are essential for healthy lizard growth and breeding. If both of these have been provided since birth, MBD will not occur. In contrast, however, a lack of UV and/or dietary calcium when lizards are young and growing can lead to abnormal growth of the skeleton and manifest as bent, brittle and broken bones, weak and rubbery jaw bones, bulging eyes, stunted growth, and abnormal bodily proportions (Figs 25 & 26). Some of these conditions can be improved by introducing correct lighting and dietary calcium, but much of the damage done in a lizard's formative years cannot be undone. Adult lizards, even if reared under ideal lighting and with adequate calcium, are still prone to MBD if these critical aspects of husbandry are neglected. Vitamin D3, the production of which is catalysed by exposure to UVB, and calcium are required throughout their lives. Without them a lizard will suffer from low blood calcium, and will strip calcium from their bones to maintain their blood calcium levels. Eventually the skeleton will suffer as described above and muscular tumours and seizures may be observed. Pregnant female lizards are especially at risk because of their increased calcium needs while nourishing the embryos growing within them.

Prevention is **much** better and easier than a cure, so make sure that your lizards always have good access to unfiltered sunshine or high-quality UVB lights and ample calcium in

their diet. If you suspect MBD in your lizard(s) seek veterinary assistance to devise a protocol to reverse it as quickly and safely as possible.

Figure 25: Signs of serious historial MBD in older adult Otago skinks.

Figure 26: Adult Duvaucel's gecko with evidence of MBD.

Behavioural suppression—In a group of lizards or an incompatible pair, it is possible for a lizard to be behaviourally suppressed by the aggression or more subtle dominance of other lizards. This may not be very obvious at first, but the affected lizard will probably be less active and not use prominent basking opportunities, will be observed being chased or displaced regularly and may become anorexic and begin to lose body condition. Though obvious injuries may be lacking and weight loss may be minimal, the stress that the lizard experiences while this situation remains unresolved will likely inhibit its immune system and leave it susceptible to infectious disease should any minor injury occur. It is important therefore, to observe your lizards regularly and carefully to look for signs of behavioural suppression. Act quickly to alleviate any that you see by adding additional enclosure furniture and plants to increase visual barriers and basking and resting opportunities. If this doesn't work, consider changing the group dynamics by adding or subtracting one or more

individuals or changing the sex ratio. It is hard to recommend group sizes and sex ratios since every vivarium and furnishings and lizard group is unique, but the table of species recommendation in Appendix 4 gives some general advice.

Terminal patients and dead lizards—The welfare of sick lizards which fail to respond to optimal environmental conditions and/or treatment and very old lizards which appear to be 'wasting away' is best ensured by humane euthanasia to alleviate further suffering. Seek a veterinary opinion and talk to your local DOC authorities before taking any action.

If one of your lizards dies, talk to your local DOC office before disposing of it in case they have an interest in the body for research or museum purposes.

Summary of key points:

- Many of the health conditions suffered by captive lizards are a result of inadequate diet and/or husbandry. Do your research, read these guidelines thoroughly and talk to other lizard keepers to ensure you provide the very best care for your lizards.
- Hygiene is important in the care of any animal confined to a relatively small space. Keep all food and water dishes spotlessly clean and change soiled plants/branches and substrates regularly.
- Parasites and diseases can spread rapidly between reptiles of the same or different species so maintain your native lizards away from and with separate utensils from any exotic reptiles. Practice good hygiene between native lizard cages too and always wash your hands after servicing them.
- Quarantine any new lizards away from your main collection for 3–4 weeks until you are sure that they are well and not carrying any parasites or other diseases.
- Observe your lizards daily and monitor their weight/condition closely. If you see significant weight loss or gain, act quickly to assess the likely cause and correct this as gaining and losing weight in lizards can take a long time.
- Be watchful for skin sloughing problems, particularly around toes, tail-tips and eyes (geckos). Insufficient localised humidity is usually the cause and is easily corrected.
- Excessive ambient humidity may lead to black-spot fungus and other skin conditions or respiratory infection. Be vigilant for signs of these diseases and act quickly to correct conditions and seek veterinary support.
- Inspect your lizards regularly for mites or ticks and remove these quickly before they become a problem to the individual affected or other lizards in your vivarium/collection.
- Learn to recognise the symptoms/behaviours related to stress and suppression. Act quickly to manage the vivarium environment and/or social groupings to reduce this before it threatens the health of the affected lizard.
- Be familiar with the signs of metabolic bone disease but ensure you never see them by providing ample dietary calcium and good exposure to sunshine or artificial UVB lighting for ALL lizards in your care.
- Whenever you are in any doubt, seek veterinary advice.
- Talk to a veterinarian and DOC before euthanizing any lizard and to DOC before disposing of dead animals.

GLOSSARY OF TERMS

Anorexia	Lack or loss of appetite.
Autotomy/autotomise	Loss of all or part of the tail at a specialised 'breaking plane', usually in response to predation attempt. Not usually a health concern. Tail will regenerate.
Anaemia	Shortage of red blood cells in the blood.
Arboreal	Living mostly or exclusively off the ground in shrubs and trees.
Cloaca	Common bodily opening for digestive, urinary and reproductive systems. Plural: cloacae.
Crepuscular	Most active in low light levels at dusk and dawn.
Disecdysis	Failure to fully slough the skin, caused by inadequate environment or poor health.
Diurnal	Predominantly or exclusively active during daylight.
Ecdysis	Periodic shedding/sloughing of the outer layer of skin.
Ectoparasites	Parasites living on the external surfaces of the host's body; e.g. mites and ticks.
Ectothermic/ectotherm	Having little or no physiological control over body temperature and relying instead on the external environment. Lizards are 'ectotherms'.
Endemic	Found only in a specified location; e.g. a country, island, mountain range or valley.
Endoparasites	Parasites living inside a host's body; e.g. worms and amoebas.
Endothermic/endotherm	Controlling body temperature through internal physiological means. Mammals and birds are 'endotherms'.
Fossorial	Living predominantly or exclusively in shallow soil and leaf-litter, mostly out of plain view.
Hemipenis	One of a pair of male sexual organs located in the base of the tail of squamate reptiles (lizards and snakes). Hemipenile: of, or relating to, the hemipenis.
Homeostasis	The maintenance of internal bodily conditions via regulation of physiological functions.

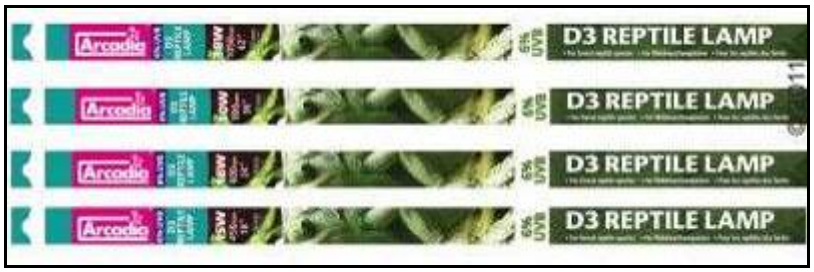
Hyperthermia	Life-threatening condition caused by excessive heat and resulting rise in core body temperature.
Hypocalcaemia	Shortage of calcium ions in the blood, likely resulting from insufficient dietary calcium and/or inadequate exposure to appropriate UVB light.
Hypothermia	Life-threatening condition caused by excessive cold and resulting drop in core body temperature.
Lamellae	Plural—the layered 'plate-like' structures visible on the underside of gecko toes.
Metabolic bone disease (MBD)	Disorders and abnormalities of the skeleton, usually caused by insufficient dietary calcium and/or inadequate exposure to appropriate UVB light.
Microclimate	Environmental conditions in specific localised areas or positions; e.g. in the tree canopy, under leaf litter, within a hollow log.
Neonate	A new-born animal.
Nocturnal	Active predominantly or exclusively (rare) at night.
Onduline	Manufacturer of, and colloquial name for, bitumen-based corrugated roofing material commonly used as cover-objects in reptile surveys.
Oviparous	Egg-laying.
Photobiosynthesis	Bodily process in which one compound is transformed into another, induced and regulated by light.
Photoperiod	The relative proportion of day and night in a 24 hour period.
Prehensile	Capable of grasping/gripping (like a fifth limb).
Systemic	Spread throughout the body (or system).
Terrestrial	Living mostly or exclusively on the ground.
Thermoregulation	The process of regulating body temperature via metabolic or behavioural means.
Vivarium	An enclosure, container or structure adapted or prepared for keeping animals under semi-natural conditions for study or as pets. Plural: vivaria.
Viviparous	Giving birth to fully-formed young.
Zoonoses/zoonotic	A disease that can be passed from animals to humans.

APPENDIX 1—PRODUCTS, MATERIALS AND SUPPLIERS

Aluminium extrusion—great for building light-weight and easy to clean vivarium frames: http://www.ullrich-aluminium.co.nz/extrusions/equal-angle or http://www.ullrich-aluminium.co.nz/extrusions/square-tube

Aquazonic SuperBright T5—affordable T5 fluorescent lamp fitting, available in three different lengths and taking two lamps per fitting. Stocked by Petware.

Arcadia—excellent T5 (narrow) and T8 (normal) UVB-emitting specialist reptile fluorescent tubes: http://arcadia-reptile.com/fluorescent-lamps/



Petware (http://www.petware.co.nz/) is the main NZ vendor for their products.

Corflute—useful light-weight plastic for adding temporary or permanent shelter/shade on outdoor vivaria: http://www.psp.co.nz/plastic-sheets/digital/corflute

Commercially available food insects:

Biosuppliers: http://biosuppliers.nz/ —mealworms/waxmorms/locusts/crickets/earthworms

Insect Direct: http://www.insectdirect.co.nz/ —live and dried crickets only

EcoTech Screen Habitat Mesh Vivarium—easy self-assembly indoor screen-mesh vivarium which comes in two sizes:

https://www.amazingamazon.com.au/screen-terrarium-mesh-cage-stick-insect.html

Exo-Terra® —supplier of excellent reptile-keeping equipment including indoor glass vivaria:

http://www.exo-terra.com/en/products/terrariums.php

and *Reptiglo* 2.0, 5.0 and 10.0 UVB fluorescent lamps:

http://www.exo-terra.com/en/products/linear_fluorescent_bulbs.php

Hailea Reptile Mesh Cage—excellent indoor screen-mesh vivarium for small geckos: https://www.amazingamazon.com.au/hailea-reptile-mesh-cage.html

Hollywood Fish Farm—supplier (shop and online) carrying Arcadia, Exo-Terra and Trixie lighting products: http://www.hollywoodfishfarm.co.nz/product/page/reptile-light-tubes/m/1237/

Kubeloc System—corner and T-joint fittings for building vivarium frames out of steel or aluminium box-bar: http://www.ullrich.com.au/brochure_pdfs/Standard_products.pdf

Multi-vitamin/mineral supplement:

Flukers range of multivitamin and calcium powders—carried by Hollywood Fish Farm: http://www.hollywoodfishfarm.co.nz/product/page/reptile-supplements/m/990/ and Redwood Aquatic: http://www.redwoodaquatics.co.nz/index.html

Repashy range of products are excellent (used by zoos in USA, Europe and Auckland!) but not currently stocked by NZ outlets, although Redwood Aquatics does sell other products by this company, so they could probably be imported.

Osram Ultravitalux—300 W UBA and UVB producing mercury vapour lamp. Produces substantial heat. Use only in large, well-ventilated vivaria for sun-loving lizards such as grand, Otago and Falla's (Three Kings) skink and at a lamp-lizard distance of at least 50 cm. Not readily available in New Zealand but ask around, as some electrical suppliers will import them.

http://www.osram.com/osram_com/products/lamps/specialty-lamps/ultraviolet-lamps/ultra-vitalux/index.jsp

Petware—online pet suppliers carrying Arcadia and many other good products:

http://www.petware.co.nz/

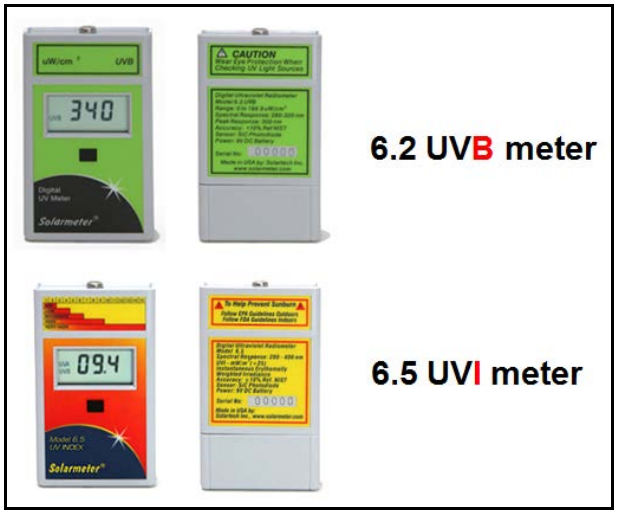
PVC Multiboard—excellent vivarium construction material:

http://www.psp.co.nz/plastic-sheets/pvc/multiboard-pvc

Solartech Solarmeter—https://www.solarmeter.com/ —UV meters for measuring:

6.5 UV Index: https://www.solarmeter.com/model65.html

6.2 UVB: https://www.solarmeter.com/model62.html



NB: Don't be tempted to buy any other meter. These meters are designed to test exactly what we need to know to provide good UV light to reptiles. Any other meter will give results which cannot be interpreted in the same way and are therefore not helpful.

Trixie—German brand of excellent UV lighting including fluorescent tubes and heat/UVB-emitting tungsten lamps in 70 W, 100 W and 160 W (compare with Osram Ultravitalux): https://www.trixie.de/en/grp/Terraristic_Lighting,14885

Stocked by Hollywood Fish Farm—
http://www.hollywoodfishfarm.co.nz/product/page/reptile-light-tubes/m/1237/start/30

Zoo Med Laboratories Inc.—suppliers of excellent T5 (narrow) and T8 (normal) UVB-emitting specialist reptile fluorescent tubes. Product name is *Reptisun* and comes in 5.0 and 10.0, referring to lower and higher UV output respectively.

Also *Reptibreeze* indoor screen-mesh vivaria—
http://zoomed.com/db/products/EntryDetail.php?EntryID=274&SearchID=5
available from several suppliers in New Zealand, e.g.:
http://www.petmountain.com/product/reptile-cages-terrariums/11442-517285/zoo-med-reptibreeze-open-air-black-aluminum-screen-cage.html

APPENDIX 2—PROPERTIES OF DIFFERENT VIVARIUM MATERIALS

Wood/timber—relatively inexpensive and easy to work with but heavy, retains damp and mould and will eventually rot. Can be used for frame or walls/panelling where it provides complete shade, cover from wind and rain and good insulation.

Aluminium extrusion/box-frame—relatively expensive and more difficult to work with, although plastic Kubeloc system facilitates frame construction. Light weight, hygienic and will last a lifetime.

Steel box-frame—less expensive than aluminium but much heavier. Hygienic and will last a long time if painted or stainless.

Corrugated/sheet metal—rather heavy but long-lasting. May get too hot in the summer sun (paint white to minimise this) but that warming may be beneficial in winter. Provides complete shade, cover from wind and rain but little or no insulation.

Perforated steel/aluminium sheet—expensive but relatively light weight, strong and long-lasting if steel is powder coated. Provides partial shade but very little UV light passes through (<40%). Gets hot in the sun which may be beneficial in winter but not in summer. Provides partial cover from wind and rain but little or no insulation.

Glass (toughened/laminated)—heavy and variably fragile. Provides no shade from sun but allows light and solar heat-gain from sun which may be beneficial in winter but detrimental in summer. UV light does **not** pass through. Provides shelter from wind and rain but little or no insulation. Good visibility for viewing.

Corrugated/plane acrylic, plexiglass, perspex, polycarbonate—relatively light weight and some (acrylic/polycarbonate) quite tough. Can be long-lasting but non-UV stabilised plastics will deteriorate in sun. Provides no shade from sun but allows light and solar heat-gain from sun which may be beneficial in winter but detrimental in summer. UV light does NOT pass through. Provides shelter from wind and rain but little or no insulation.

Corflute—inexpensive, very light and easy to use but not very long lasting. Several colours and thicknesses available, but not strong enough to be part of cage structure. Provides shade (opaque grades), shelter from wind and rain and limited insulation.

Twin/multi-wall acrylic or polycarbonate—relatively light weight and some (acrylic/ polycarbonate) are quite tough. Can be long-lasting but non-UV stabilised plastics will deteriorate in sun. Provides no shade from but allows light and some solar heat-gain from the sun which may be beneficial in winter but detrimental in summer. UV light does **not** pass through. Provides shelter from wind and rain and excellent insulation.

PVC Multiboard—light weight and very strong. Can be used as a structural component. Can be cut, drilled, fixed just like timber. UV-stabilised, so long-lasting and easy to clean. Provides complete shade, cover from wind and rain and good insulation.

Steel/aluminium insect mesh—relatively inexpensive but fragile. Not mammal/bird predator proof. Will contain smallest baby lizards and food invertebrates. Excludes wild food invertebrates and also dangerous invertebrates from entering.
Blocks approx. 40% of UV light. Ventilation properties adequate but not good.

Steel welded/woven mesh—inexpensive, strong and long-lasting.
Smallest welded hole-size approx. 5 mm will contain adult and most baby lizards but not all food invertebrates. Mammal/bird predator proof. Will allow wild invertebrates to enter.
Blocks approx. 30% of UV light. Provides excellent ventilation.
Smaller woven hole size approx. 3 mm will contain baby lizards and many food invertebrates. Mammal/bird proof except for cats. Excludes must wild invertebrates.
Excludes slightly more UV light than above. Provides excellent ventilation.

Stainless steel welded/woven mesh—more expensive than above but stronger and longer-lasting. Features are the same as above with the exception that equivalent wire gauges and hole sizes allow slightly **more** UV light to enter the vivarium owing to the shiny, reflective finish of the steel.

Chicken wire—cheap and strong. Does not contain lizards or invertebrates. Mammal/bird predator proof. Use only for this function.

Horticultural shade-netting—cheap but short lived. Provides variable shade according to grade and allows little UV light to penetrate. Provides some shelter from wind and rain but no insulation.

APPENDIX 3—AUCKLAND ZOO NATIVE SKINK/GECKO DIET GUIDELINE

Captive diet and feeding programme
Offer a diet focusing on invertebrate species (70%) but including native fruits and flowers for their and nectar/pollen.

Feed three times per week (Môn, Wed, Fri) during the active season, approx. September through to May. From June through to August, feed only 1–2 times per week and only when ambient temp is >10–12°C and sunshine or UV lamps are available for basking.

Offer items from the following list (in order of preference) of a size suitable to the individual lizard (max size ≤ to lizard's head) and regularly vary what is offered.
Numbers in () are suggested food quantities per average adult. These may need to be reduced/increased according to species/age/body condition; e.g. *Hoplodactylus duvaucelii* and *Oligosoma alani* would require more while *Naultinus elegans* and *Oligosoma moco* may require less, than the quantities indicated in brackets.

'Stock' items
Black crickets (×1–2)
'Slaters'(x2-3)
Mealworm beetles (×1–2)
Galleria moths (×3–5)
Flies (up to 10)
Locusts (×1–2)

Preferred wild items
Beetles
Cicadas
Small spiders
Katydids/weta
Terrestrial amphipods

In late summer and autumn, when native plants are in fruit, offer ripe kawakawa, *Coprosma* and other native fruits or commercially grown berries (raspberry/blackberry/blueberry/red or black currant), 1–2 times per week as an **alternative** to invertebrates.

In addition to these feeds, offer fresh flowers (for nectar/pollen) regularly when available; e.g. pohutukawa, rata, ngaio, manuka/kanuka, flax, bottlebrush. If flowers are not available, place slices of ripe mango or papaya in the enclosure, to allow geckos to lap the juice.

Supplements
All live insects (not slaters or amphipods) should be chilled in the refrigerator for 5–10 min and then dusted with a high-calcium multi-vitamin and mineral powder immediately prior to feeding out.
Finely chopped cuttlebone to be available at all times.

Water
A small, shallow water bowl should be available with fresh water at all times however geckos are more likely to drink from rainfall and/or obtain sufficient water from their food. Spray the enclosure, plants and lizards liberally each morning (unless the enclosure is subject to natural rainfall) and again in the late afternoon in very hot weather.

APPENDIX 4—QUICK GUIDE FOR COMMONLY KEPT SPECIES

ID	Species	Minimum viv. size (LxWxH cm)	Ideal group size (males:females) in minimum size vivarium	Suitable species mix	Habitat type	Temp. °C ambient/ basking	UV target (UVI/UVB)	Mating period	Birth period	Diet preference	Notes
	Geckos										
1	Gray's (Northland green), Elegant (Auckland green), Barking (Wellington green)	**Outdoor:** 50x50x100 **Indoor:** 30x30x50	1:2 (plus offspring for one year)**	3,4,6,8,9	**Arboreal** - forest and shrubs	**Summer:** 15-25/30 **Winter:** 10-20/25	**Summer:** 3-5/100-200 **Winter:** 1-2/20-50	Winter/ spring	Mostly autumn through winter*	Flies, moths, small crickets, coprosma berries nectar/honey-water/honeydew	*Elegant (Auckland green) and Gray's (Northland green) geckos have been recorded birthing between February and October depending upon location and weather conditions. **Some keepers prefer to separate offspring from their parents but both approaches seem to work.
2	West Coast green, Rough Starred (Nelson green), Marlborough green, Jewelled	**Outdoor:** 50x50x100 **Indoor:** 30x30x50	1:2 (plus offspring for one year)**	3,4,8,9	**Arboreal** - forest, shrubs and herb field	**Summer:** 10-25/30 **Winter:** 5-15/20	**Summer:** 3-5/100-200 **Winter:** 1-2/20-50	Winter/ spring	Late summer thro' autumn	Flies, moths, small crickets, coprosma berries nectar/honey-water/honeydew	**Some keepers prefer to separate offspring from their parents but both approaches seem to work.

ID	Species	Minimum viv. size (LxWxH cm)	Ideal group size (males:females) in minimum size vivarium	Suitable species mix	Habitat type	Temp. °C ambient/ basking	UV target (UVI/UVB)	Mating period	Birth period	Diet preference	Notes
3	Pacific*, Forest	**Outdoor:** 50x50x100 **Indoor:** 30x30x52	1:2	1,2,8,9	**Arboreal** - forest and shrubs	**Summer:** 15-25/30 **Winter:** 10-20/25	**Summer:** 2-3/100-150 **Winter:** 1-2/20-50		Late summer thro' autumn	Flies, moths, small crickets, coprosma berries nectar/honey-water/honeydew	*May be aggressive to smaller animals.
4	*Woodworthia** (Large Otago, Canterbury, Goldstripe, Kaikouras, Mount Arthur, Central Otago, Cromwell, Marlborough mini, Pygmy , Southern Alps, Southern mini, Common)	**Outdoor:** 50x50x100 **Indoor:** 30x30x52	2:3-4	1,2,6,8,9	**Arboreal** and **terrestrial** - forest, shrubs, rock piles, and cliffs	**Summer:** 15-25/30* **Winter:** 10-20/25*	**Summer:** 2-3/100-150 **Winter:** 1-2/20-50		Late summer thro' autumn	Flies, moths, small crickets, coprosma berries nectar/honey-water/honey-dew	*This group of geckos are highly variable and captive specimens across the country may originate from a wide variety of habitats and climates.
5	Duvaucel's	**Outdoor:** 70x70x150 **Indoor:** 50x50x100	1:1 (plus offspring for 1-2 years?)*	10(?),11(?)	**Arboreal** and **terrestrial** - forest, shrubs, and rocky shore	**Summer:** 15-25/30 **Winter:** 10-20/25	**Summer:** 3-5/100-200 **Winter:** 1-2/20-50		Late summer thro' autumn	Moths, beetles, cicadas, crickets, locusts, nectar/honey-water	*Duvaucel's gecko are highly predatory and though they appear to live communally in groups in the wild there is a risk in leaving offspring with the parents.

ID	Species	Minimum viv. size (LxWxH cm)	Ideal group size (males:females) in minimum size vivarium	Suitable species mix	Habitat type	Temp. °C ambient/ basking	UV target (UVI/UVB)	Mating period	Birth period	Diet preference	Notes
6	Goldstripe	**Outdoor:** 50x50x100 **Indoor:** 30x30x50	2:3-4 (plus offspring for 1-2 years)	1,2,3,8,9	**Arboreal** - forest and shrubs (esp. flax)	**Summer:** 15-25/30 **Winter:** 10-20/25	**Summer:** 3-5/100-200 **Winter:** 1-2/20-50		Late summer thro' autumn	Flies, moths, small crickets, coprosma berries nectar/honey-water/honey-dew	
	Skinks										
7	Otago, Grand, Scree	**Outdoor:** 150x70x70 **Indoor:** 100x50x50	1:1	*	**Terrestrial** - alpine tussock, scrub and rocks/scree	**Summer:** 10-25/35 **Winter:** 5-15/20	**Summer:** 5-7/150-250 **Winter:** 1-2/20-50	Autumn and spring	Late summer	Crickets, beetles, locusts, moths, korokia and coprosma berries	*Grand skinks have been kept successfully with jewelled geckos at Auckland Zoo.
8	Copper, Ornate, Whitaker's	**Outdoor:** 100x50x50 **Indoor:** 70x30x30	1:1	1,2,3,4,6	**Terrestrial** - forest floor, and meadow	**Summer:** 15-25/30 **Winter:** 10-15/20	**Summer:** 2-3/100-150 **Winter:** 1-2/20-50		Late summer thro autumn*		*Whitakers may not birth until early winter.
9	Moko, Shore, Grass (Common skink clade 2-5), Small-scaled, Spotted, Speckled	**Outdoor:** 100x50x50 **Indoor:** 70x30x30	2:2-4	1,2,3,4,6	**Terrestrial** - forest edge, meadow, scrub and shoreline	**Summer:** 15-25/35 **Winter:** 10-15/20	**Summer:** 3-5/100-200 **Winter:** 1-2/20-50		Late summer thro' autumn	Flies, small cickets and locusts, woodlice (slaters), native berries	

ID	Species	Minimum viv. size (LxWxH cm)	Ideal group size (males:females) in minimum size vivarium	Suitable species mix	Habitat type	Temp. °C ambient/ basking	UV target (UVI/UVB)	Mating period	Birth period	Diet preference	Notes
10	Falla's (Three Kings)	**Outdoor:** 150x70x70 **Indoor:** 100x50x50	1:1	5(?)	**Terrestrial** - forest edge and rocky shore	**Summer:** 20-25/35 **Winter:** 15-20/25	**Summer:** 5/100-200 **Winter:** 2/20-50		Mid-late summer	Crickets, beetles, locusts, moths, cicadas, native berries	Though predominantly terrestrial, love to climb and fond of water.
11	Robust, McGregor's	**Outdoor:** 150x70x70 **Indoor:** 100x50x50	1:1	5(?)	**Terrestrial** - forest floor and seabird burrows	**Summer:** 15-25/30 **Winter:** 10-15/20	**Summer:** 2-3/100-150 **Winter:** 1-2/20-50		Autumn to early winter	Crickets, beetles, locusts, moths, cicadas, earth worms, native berries	Can be aggressive so avoid mis-matched sizes of animals.
12	Green	**Outdoor:** 150x70x70 **Indoor:** 100x50x50	1:1	?	**Terrestrial** - scrub, meadow, tussock and boulder fields	**Summer:** 15-25/35 **Winter:** 5-15/20	**Summer:** 5-7/150-250 **Winter:** 1-2/20-50		Mid-late summer	Crickets, beetles, locusts, moths, cicadas, native berries	Very aggressive. Match animal sizes and provide lots of compex habitat with visual barriers and ample access to all resources for each animal

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www.doc.govt.nz/nature/native-animals/reptiles-and-frogs/lizards/

Department of Conservation (DOC) Threat Classification System lists (for scientific and common names)—
http://www.doc.govt.nz/about-us/science-publications/conservation-publications/nz-threat-classification-system/nz-threat-classification-system-lists-2012-14/

New Zealand Herpetological Society (NZHS)—www.reptiles.org.nz

NZ Lizards Database—https://nzlizards.landcareresearch.co.nz

Society for Research on Amphibians and Reptiles in New Zealand (SRARNZ)—
www.srarnz.org.nz