# Nutrition of Australian Reptiles

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The following is an overview of nutritional requirements for reptiles commonly held in captivity in Australia. As a food manufacturer and chemical engineer specialising in animal nutrition, formulating diets for reptiles pose some unique and interesting challenges, and it is from this perspective that the following information is presented.

Reptiles comprise a diverse array of species that cover a broad spectrum of dietary requirements. The table below outlines nutritional classifications of some Australian reptiles. It is important to note that all these species maintain some degree of insectivory or carnivory throughout their life cycle.

| Classification | Species Examples | Typical "Wild" Diet |
|---|---|---|
| **Insectivorous** | Small Skinks, Geckos, Juvenile Bearded Dragons. | Insects, small invertebrates. |
| **Omnivorous** | Adult Bearded Dragon, Blue-tongue and Shingleback Skink. | Insects, snails, invertebrates, plant material, flowers & fruit. |
| **Omnivorous** | Short-necked Turtles | Fish, crustaceans, invertebrates, algae, aquatic vegetation. |
| **Carnivorous** | Long-necked Turtles | Fish, crustaceans, invertebrates, carrion. |
| **Carnivorous** | Large goannas, snakes. | Small mammals, birds, frogs other reptiles. |

In the wild many reptiles forage for a wide range of dietary items, and there is considerable seasonal variation in the quantity and quality of nutrition available.

One study of Shingleback Skinks (*Tiliqua rugosa* – pictured on right) in South Australia showed them eating flowers, berries and leaves of 27 different plant species over 36 observation days throughout the year (Dubas & Bull, 1991). They were also found to feed on invertebrates, mainly the introduced land snail (*Theba prisana*). One of the authors noted however, that in previous observations over 15 years, he had observed Shinglebacks eating small skinks and nestling birds, browsing on dead kangaroos, and gorging on grasshoppers during a plague. Such diversity is clearly difficult to emulate in a captive situation.

**Shingleback Skink**

**Despite their fearsome appearance, studies have shown they consume a large variety of plant material.**

**Photo courtesy of Colin Rich.**

For insectivorous species, the wild-type diet may be equally varied. For example the Frillneck Lizard (*Chlamydosaurus kingii)* in the Northern Territory regularly takes 15 different orders of invertebrates, depending on seasonal availability (Griffiths & Christian, 1996). Stomach contents included termites, ants, grasshoppers, cicadas, caterpillars, centipedes, spiders and dragonflies.

Contrast to this to the captive situation where reptiles may be offered only two or three species of cultured insects at best (typically mealworms, crickets or woodies). Add to this the poor diets on which these feeder insects are often maintained, and the likelihood of nutritional deficiency is high. Some items consumed in the wild contain specific nutritional components that may not be easily catered for in captive diets. For example spiders contain about 40-100 times more taurine than insects (Ramsay & Houston, 2003).

## Common Nutritional Imbalances

The lack of nutritional variety provided to captive reptiles may result in a range dietary imbalances:

### Protein

The amino acids derived from protein are the building blocks for growth and development of skin and body tissue. A deficiency of essential amino acids is likely to lead to poor growth in juveniles and failed reproduction in adults (Donoghue, 2006). Studies on chickens have suggested that the limiting amino acids when feeding crickets are arginine and methionine (Nakagaki et al, 1987). In captive diets, essential amino acids can readily be supplemented by the inclusion of a range of quality animal proteins in the diet (eg lean meat, fish, eggs or whey protein). Many reptiles may be omnivorous as adults, but are largely insectivorous when young, to cater for the increased protein demands for growth (eg Bearded Dragons, Blue-tongue Skinks).

Both the quantity and quality of protein in the diet needs to be carefully controlled to cater for the type and life stage of the species in question. Excessive protein intake has been implicated with renal failure, gout and pyramiding of the carapace in turtles (Carmel & Johnson, 2014). However other factors such as dehydration and disease may be the primary causes of these problems (Donoghue, 2006).

### Fats

These are used as an energy source to enable reptiles to deal with seasonal fluctuations in temperature and food availability. They are also important components of cell membranes and supply essential fatty acids for development of vital tissues, especially brain (Donoghue, 2006). However excess dietary fat can lead to fatty liver and obesity-related disease. This usually occurs when reptiles are overfed, particularly with high fat items. For example turtles fed fatty beef mince, snakes fed obese mice or insectivorous species consuming large quantities of mealworms. Some snake keepers supplement prey items with "muttonbird oil", claiming it to be beneficial for certain species (Eipper, 2012). Muttonbird oil is harvested from the stomach contents of Short-tailed Shearwater (*Puffinus tenuirostris*) chicks. The oil predominantly contains wax esters (Connan et al, 2005), which are structurally different to the triglycerides found in most reptile prey items. Studies on Eastern Fence Lizards (*Scleroporus undulatus*) in the USA showed a reduced ability to assimilate wax esters in the diet (<60%), compared to Triglycerides (>90%), which clinically results in steatorrhoea (Place, 1992). On this basis, it is questionable whether feeding muttonbird oil to captive reptiles is necessary or nutritionally sound, and the practice could exacerbate problems with dietary fat imbalances.

### Vitamins & Minerals

The precise requirements for vitamins & minerals are largely unknown for Australian reptile species. This makes accurate provision of these nutrients problematic in a captive diet. The majority of nutritional issues are linked to deficiencies in calcium, vitamin A or vitamin $D_3$ (Calvert, 2004). For most reptile keepers calcium is the primary mineral supplemented, but this is rarely balanced with other mineral & vitamin intake. There may be a fine line between deficiency and toxicity, with the narrowest ranges of safe intakes (established in non-reptile species) being for calcium, selenium, vitamin A & vitamin $D_3$. Potential problems may arise from antagonistic interactions between nutrients, for example excessive dietary calcium may lead to secondary deficiencies in other minerals such as zinc, copper or iodine (Donoghue, 2006). This calls into question the rather simplistic and single-minded focus on calcium supplementation by many keepers.

# Improving Captive Diets

## Variety, Variety, Variety

It is important to increase the diversity of reptile diets, in order to provide a broader, more balanced nutrient profile. In particular, the emphasis should be on providing as much natural food as possible. For insectivorous species this means going beyond the commercially available mealworms, crickets & woodies and expanding into other invertebrates. These may be readily harvested from the garden or around the home, including termites, slaters, snails, spiders, earthworms & moths. A large array of flying insects can be attracted by using moth traps, and these bounties can be stored frozen for extended periods.

For carnivorous species, variety can mean more than the standard fare of commercially produced mice or rats. Birds such as frozen quail, squab or day old chicks may also be taken by many species. Non-protected reptile species like the introduced Asian House Gecko (*Hemidactylus frenatus*) may also be an option (Eipper 2012).

For turtles, a varied natural diet includes the provision of live feeder fish, yabbies, earthworms, beetles & snails.

Omnivorous species which take some plant material, can also be offered items other than what is found in the supermarket fruit & veg aisle. This may include a range of fresh-picked garden weeds such as dandelion, or native flowers and fruits.

## Feed the Food Well

When feeding cultured insects, such as mealworms and crickets, consideration should be made to the diets on which these insects are maintained. Mealworms are usually kept on nutrient-poor substrates (eg wheat bran). Crickets and woodies are often transported and sold without any meaningful nutrition other than a piece of carrot for moisture

Often insects are "gut-loaded" just prior to being fed out. However it is questionable how effective this practice is, considering the gut-fill volume of insects is very small.

To overcome this problem Wombaroo has developed a complete insect food called Insect Booster™ for fortifying the nutritional composition of feeder insects. This works by incorporating additional vitamins, minerals and essential nutrients into the body tissue of insects over a period of time. This was found to be more effective than short-term gut-loading of insects raised on inadequate diets, or dusting with powdered calcium.

The table below shows selected nutrient content data for crickets, woodies and mealworms after feeding trials using Insect Booster for 14 days, in comparison to control diets.

| Nutrient Content in Insect | Crickets & Woodies (average) | | Mealworms | |
|---|---|---|---|---|
| | Control Diet (Mouse Cubes) | Insect Booster™ (100%) | Control Diet (Wheat Bran) | Insect Booster™ + Bran (50:50) |
| Calcium (g/kg) | 1.8 | 11.8 | 0.4 | 4.3 |
| Ca:P Ratio | 0.3 | 2.0 | 0.05 | 1.1 |
| Vitamin A (IU/kg) | None detected | 3600 | None detected | 70 |
| Vitamin E (mg/kg) | 9.1 | 45 | 1.5 | 16 |
| Carotenoids (mg/kg) | 3.6 | 16 | 0.14 | 0.38 |

Analysis courtesy of Brian Rich from insects housed at the Adelaide Zoo Animal Health Centre.

**Male Tawny Crevice Dragon**

***(Ctenophorus decresii)* from the author's collection, showing orange colouration around the head.**

**Feeding trials at Wombaroo indicate that the intensity of this colour is probably impacted by dietary carotenoid content.**
**Photo courtesy of Colin Rich.**

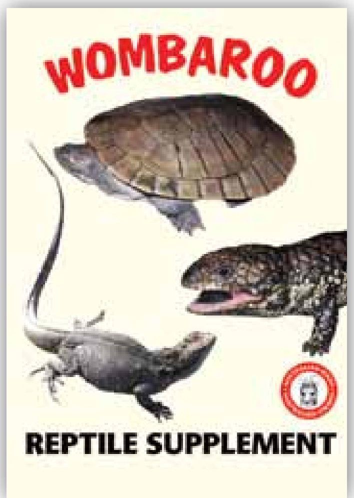
These results indicate that calcium levels and calcium to phosphorous ratios were significantly improved by dietary supplementation. The concentration of other essential minerals, vitamins and nutrients were also enhanced.

For example there were increased levels of carotenoids, which may function as potent antioxidants in scavenging free radicals, and thus help reduce oxidative stress. Carotenoids are also responsible for enhancing yellow-red pigment and involved in sexual signalling in some species eg Frillneck Lizards (Hamilton et al, 2013). Extensive diet analysis at Wombaroo has found that carotenoid levels are generally much lower in captive diets than wild-type foods.

In general, the nutrient value of adult insects (ie crickets and woodies) appears superior to that of juvenile insects (ie mealworms or fly pupae), but they all appear to respond well to fortification of the diet. Clearly an improved diet also has a role in enhancing the quality of vertebrate prey such as mice and rats, and the same principle of "feed the food well" would apply to suppliers of these foods.

## Nutritional Supplements

Supplementation of artificial diets also has its role in improving reptile nutrition. This is readily achieved by using powdered products applied to moist, palatable food items to encourage intake. These supplements can be used to balance out deficiencies in typical meat-mix or fruit & veg recipes commonly fed to reptiles. It may be preferable to use a "complete" supplement that contains a balance of protein, fat, and essential nutrients (as opposed to simply a vitamin/mineral supplement). This way, gross deficiencies in macronutrients (eg amino & fatty acids) are addressed as well as supplying micronutrients (vitamins & minerals). A complete supplement should contain all 14 essential vitamins and eleven minerals (Donoghue 2006). To this end Wombaroo Reptile Supplement™ was developed, which is a dry, powdered diet with a basic analysis given in the table below.




| | |
|---|---|
| Protein | 55% |
| Fat | 14% |
| Carbohydrate | 10% |
| Fibre | 5.0% |
| Calcium | 1.2% |
| Phosphorus | 0.8% |
| ME | 14.6MJ/kg |

The high protein / low carbohydrate composition of Reptile Supplement™ allows it to be added to meat, fish or egg mixes without causing dilution of protein content. This is ideal for insectivorous or carnivorous species that rely on protein as their major energy source.

### Meat Mix

**50:50 minced meat, fish or hard-boiled eggs with Reptile Supplement™. Extra water may be added to soften the mix.**

### Pellets

**Meat Mix pellets can be rolled into balls and fed to larger specimens. Can be fed underwater to aquatic species such as turtles, without fouling of water.**

## Nutritional Supplements

Reptile Supplement™ may also be added to fruit & veg mixes, providing a significant enhancement to protein and essential nutrient content of these otherwise high-carbohydrate diets. This is ideal when supplementing omnivorous species such as bearded dragons or blue-tongue lizards. Example of veg-mix diets with added Reptile Supplement™ are shown below.

**Veg Mix**

**50:50 chopped vegetables with Reptile Supplement™.**

**Blue-tongue Skink**

**Injured wild animal in rehabilitation, enthusiastically eating veg-mix.**

**Photo courtesy of Anne Fowler.**

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