

Husbandry Guidelines for

Australian Water Dragon

Physignathus lesueurii

(Reptilia: Agamidae)

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Front cover image: Eastern Water Dragon, *Physignathus lesueurii lesueurii*.
Photo: Rebekah Hosking.

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Image 1. Male Eastern Water Dragon. Photo: Rebekah Hosking

OCCUPATIONAL HEALTH AND SAFETY RISKS

The Australian Water Dragon, *Physignathus lesueurii*, is generally not an aggressive lizard to maintain in captivity; however like all large Agamids they are capable of inflicting a severe bite when agitated. They can also use tail whips as a way to discourage unwanted attention when cornered. This species also possesses long sharp claws which can inflict serious lacerations which at minimum will require first aid or even medical treatment. Care should be taken to examine the individual animal's temperament before entering the enclosure or restraining the animal. Please see the information on proper restraining techniques in section 7.3 on page 29.

Other Occupational Health and Safety risks presented by keeping this species in captivity include exposure to cleaning chemicals, the possibility of burns from heating devices and ergonomic injuries from bending and over reaching.

Keeping Water Dragons also presents the same zoonotic risks presented by all animals in captivity; zoonotic infection can occur from contact with organisms such as viruses, bacteria, protozoa, fungi as well as internal and external invertebrate parasites. Such organisms can be transferred to humans through coming into contact with excrement, uneaten food particles, sloughed skin and dirty water from enclosure pools. Good hygiene practices should be followed including regular hand washing.

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1 Introduction

The Latin name *Physignathus lesueurii* translates literally as “Lesueur’s puffy jaw”. The genus *Physignathus* was described by George Cuvier (1769-1832) in 1829 based on the type specimen of the genus; *P. cocincinus* the Green Water Dragon of South-East Asia (Jenkins & Bartell 1980:90. De Vosjoli 1992:7), and refers to the inflated bulging of the jaw. *Physignathus* comprises two recognised species; *P. lesueurii* and *P. concincinus*.

The species *P. lesueurii* was first described in 1831 by J.E. Gray based on the type specimen collected by French naturalist Charles-Alexandre Lesueur (whom the specific name honours) from Parramatta. The specimen was taken back to France on the Baudin expedition of 1800 (Ehmann 1992:134).

The Australian Water Dragon is Australia’s largest agamid lizard (Greer 1990:18), they can be found within and near most healthy riparian environments along the East coast of Australia as well as the upper reaches of the Murray-Darling basin in the south of its range (Ehmann 1992:134). Fossils belonging to the genus *Physignathus* and resembling the species *P. lesueurii* have been discovered in Miocene deposits in Riversleigh, Queensland, indicate that this genus has existed in Australia for at least 20 million years (Archer et al. 1994:78).

The species is the most southern living of the two species of the genus *Physignathus*. A closely related genus is *Hydrosaurus*, which includes the worlds largest Agamid; the Philippine Sail-Finned Water Dragon, *Hydrosaurus pustulatus* (Birkett & McCracken 1990). Both *Physignathus* and *Hydrosaurus* are very similar in habits but differ greatly in appearance due to the larger and more distinctive crests and dorsal sail featured in *Hydrosaurus* (De Vosjoli 1992:7).

This species has been kept in Australian Zoo collections for quite some time, as well as a pet species by private keepers and is reasonably represented in overseas collections in the well as private trade. The species is also familiar to many as free-ranging wild Water Dragons can often be found roaming the grounds of institutions such as Taronga Zoo and the Australian Reptile Park as well as many of the wildlife parks along the coastal regions of Queensland.

Water Dragons are of particular display value as their habitats include aquatic, terrestrial, burrowing and arboreal adaptations. They can be used as an ambassador species for both forested and riparian environments and they are also a rather bold species that will tolerate significant human attention in areas where their habitats overlap with urban environments.

1.1 ASMP Category

2008 ASMP Reptile & Amphibian TAG; No Regional Program; Management Level 3.

1.2 IUCN Category

Not evaluated

1.3 EA Category

Protected in all states and territories where it occurs naturally; Queensland, New South Wales, Australian Capital Territory and Victoria. Not listed as threatened in any state or territory. Requires import export permits from relevant State fauna authority for interstate transfer. Water Dragons are classed as category 1 by the NSW Exhibited Animals and Protection Authority (EAPA) so a transfer advice not required to transfer between and out of exhibiting institutions is not required. Check the conditions of transfer for your state or territory.

1.4 NZ and PNG Categories and Legislation

Not Applicable

1.5 Wild Population Management

Not Applicable

1.6 Species Coordinator

None appointed

1.7 Studbook Holder

None appointed

2 Taxonomy

2.1 Nomenclature

Class: Reptilia

Order: Squamata

Family: Agamidae

Genus: *Physignathus*

Species *Physignathus lesueurii*

2.2 Subspecies

Eastern Water Dragon, *Physignathus lesueurii lesueurii*.

Gippsland Water Dragon, *Physignathus lesueurii howittii*.

2.3 Recent Synonyms

No known recent synonyms

2.4 Other Common Names

In some parts of Eastern Victoria Water Dragons are sometimes referred to locally as crocodiles, alligators and salamander, the latter is often abbreviated to “sally” (Greer 1990:18. Worrell 1966).



Image 2. Juvenile Eastern Water Dragon, *P. l. lesueurii*, adapting to a human environment.
Photo: Peter Street © Peter Street Photography.

3 Natural History

Water Dragons, are appropriately named as they possess excellent adaptations to living in aquatic environments; a laterally compressed tail provides adequate forward propulsion in the water (Greer 1990:18). Water Dragons can also remain underwater for over an hour at a time (Wilson & Knowles 1992:54), remaining motionless to avoid detection by predators. Water Dragons are just as adept in the trees and on land as they are in the water. Long, strong claws allow these lizards to grip branches, which they frequent to find food, bask and avoid predation (Ehmann 1992:134). The preferred arboreal habitat of the Australian Water Dragon is near or above the water, which provides an escape when startled (Goulding and Green 2006). Water Dragons are often observed basking on sunlit rocks, logs or substrate near water. On the ground these dragons can run in a bipedal fashion at considerable speed to avoid danger or pursue prey (Goulding and Green 2006:7).

The Eastern Water Dragon, *P. I. lesueurii*, is most likely one of the most successful large reptiles to inhabit urban areas as large populations can be seen living in close proximity to human environments such as the north shore and beaches suburbs of Sydney and the Tweed heads region of NSW (Hobden 2003).

3.1 Morphometrics

The Australian Water Dragon can be identified by a distinctively deep angular head and nuchal crest with spinose scales, that extend across the dorsal surface and down the tail (Worrell 1966:75). Keeled spinose scales are also present across the lateral sides, unevenly distributed amongst regular scales (Cogger 2000:344-6). The jowls are large and the tympanum is exposed and almost in equal size to the eye. The dorsal ridge and tail is laterally compressed and the limbs are strong and robust with particularly long toes on the hind legs (Wilson & Knowles 1992:54, Ehmann 1992:134). The tail is laterally compressed and is capable of regeneration when lost, furthermore, regenerated tails can also grow back when severed (Rankin in Anonymous 1976:22).



Image 3. Eastern Water Dragon, *P. I. lesueurii*. Photo: Chris Hosking © Australian Museum.

Colouration differs between the subspecies, the Eastern Water Dragon, *P. I. lesueurii*, has a grey to brownish grey colour above with patterns of black stripes along the dorsal ridge as well as down the tail (Worrell 1966:1975). There is also a strip horizontally from the eye back over the tympanum and extending down the neck (Goulding and Greer 2006:3). The limbs are mostly black with spots and stripes of grey and the tail is patterned with grey and black stripes (see image 3). The ventral surface is yellowish-brown, mature males have a bright red chest and upper belly (Griffiths 2006:61-2, Wilson & Knowles 1992:54).

The Gippsland Water Dragon, *P. I. howittii*, is identical in morphology apart from slightly smaller spinose scales (Worrell 1966:75) but differs in colouration and patterning (see Image 4). Black stripes are present against a olive-green to brown colour from above. Most individuals have a coppery-blue-green colouration. Mature males have streaks of yellow and blue around the neck and throat (Jenkins & Bartell 1980).



Image 4. Gippsland Water Dragon *P. I. howittii*. Photo: Chris Hosking © Australian Museum.

3.1.1 Mass And Basic Body Measurements

The Australian Water Dragon is Australia's largest agamid lizard (Greer 1990:18) reaching a total length of 950mm and snout to vent length of 250mm (Ehmann 1992:134). Lengths and weights obtained by Daly (1992:37) of two males (both with noticeable tail loss) south of Sydney are presented in Table 1.

Measurements	Specimen 1	Specimen 2
Snout to Vent Length	235mm	22mm
Total Length	670mm	710mm
Weight	580g	510g

Table 1. Weights and measurements of two wild *P. I. lesueurii* recorded by Daly (1992).

Captive individuals are prone to weight gain so are likely to be heavier than wild specimens. Weights and measurements of two captive *P. I. lesueurii* recorded by the author are presented in Table 2.

Measurements	Specimen 1.	Specimen 2.
Total length	710mm	700mm
Snout - vent length	220mm	220mm
Head length (snout to last nuchal spinose scale)	85mm	88mm
Head width (tympanum to tympanum)	60mm	70mm
Girth at mid body	19mm	15.50mm
Girth at base of tail	110mm	100mm
Hind limb length (vent to longest toe.)	180mm	180mm
Weight	700g	605g

Table 2. Weights and measurements of two captive *P. I. lesueurii* recorded by Hosking (2009).

Maximum sizes were obtained by Thompson (1993); largest male was 304mm SVL and one male was heavier than 1000g. The largest female was 230mm SVL and the heaviest was 490g.

3.1.2 Sexual Dimorphism

Male *P. I. lesueurii* can be identified by the scarlet colouration on the chest, *P. I. howittii* have bands of yellow and blue on the throat. Males of both subspecies have noticeably wider heads and more prominent jaws than females (Wilson & Knowles 1992:54). Sex can be determined by approximately six months of age as males will develop the respective scarlet red chest and banded throat colouration in each subspecies (Wilson & Knowles 1992:54, Jenkins & Bartell 1980:91). By the age of one year the sex of the water dragons should be clear. Since sexual dimorphism is so obvious in this species sexing via probing is unnecessary and not recommended.

3.1.3 Distinguishing Features

Australian Water Dragons can be distinguished from other large Australian agamids from a number of key features. Bearded Dragons, *Pogona* sp. are much more dorsally compressed, have spinose scales along their sides and never have black stripes (Wilson & Knowles 1992:54). The Frilled Lizard, *Chlamydosaurus kingii*, has an obvious frill, but can also be distinguished from Water Dragons as *C. Kingii* is not as laterally compressed (Wilson & Knowles 1992:30-1) Forest Dragons *Hypsilurus* spp. have much larger spinose scales relative to body size and do not reach as large a size as Water Dragons (Wilson & Knowles 1992:52-3).

Where kept in collections with other non-Australian reptiles there are other species that it may be confused with. Green Water Dragon, *Physignathus cocincinus* which has a emerald colouration and lacks the banding seen in the Australian Water Dragon (De Vosjoli 1992). The world's largest agamid; the Sail-finned Dragon *Hydrosaurus pustulatus* (see Image 5), has a dorsal sail along its back and anterior third of its tail. This species also has a shiny sapphire-like colouration on the dorsal surfaces, tail and limbs (De Vosjoli 1992, Knowles and Vye 1991).



Image 5. Sail-finned Dragon *Hydrosaurus pustulatus*. Photo: Steve Vogel © Australian Museum.

3.2 Distribution and Habitat

Australian Water Dragons are found in Eastern Australia as well as New Guinea (Anonymous 2008. Cogger 2000. Worrell 1966:74). The Eastern subspecies, *P. l. lesueurii*, occurs along the east coast of Australia from Cooktown in the north down to the New South Wales south coast (approximately at Kangaroo Valley) where it is replaced with the Gippsland subspecies (*P. l. howittii*) which is distributed as far south and into the Gippsland region of eastern Victoria (see Figure 1). There is also at least one anthropologically introduced feral population found in the Mount Lofty Ranges near Adelaide in South Australia (Wilson & Swan 2004:326).



Eastern Water Dragon,
Physignathus lesueurii lesueurii.

Gippsland Water Dragon,
Physignathus lesueurii howittii.

Figure 1. The Australian distribution of the two subspecies of Australian Water Dragon. Image by Chris Hosking based on Ehmann (1992:134).

The habitats available to this species differ greatly over the species distribution from tropical rainforest in the north to alpine streams in the south. Flowing water with ample tree cover and basking sites appear to be the key to habitat preference for this species. Water dragons will be found in built-up urban areas provided that the above conditions can be found and water quality is fair (Goulding and Green 2006).

3.3 Conservation Status

This species is not listed in the IUCN Red List and populations appear to be stable. This species is very adaptable to human environments and sprawl of urban development should not have as great an influence on Water Dragons than other members of the herpetofauna. However both subspecies are dependant on suitable micro habitats, that is; trees, rocks, basking sites, and most importantly, clean water. These elements could be seen as limiting resources within the distribution of this species, so they could be of concern in the future.

3.4 Longevity

3.4.1 In the Wild

Life expectancy in the wild has not been formerly researched. A tag and release project is an area for future study Cogger (2009 pers. comm. 27th May). Peter Harlow (2009 pers. comm. 23rd July) has conducted unpublished research on the free-living wild population of *Physignathus l. lesueurii* on the grounds of Taronga Zoo which indicates that the wild lifespan of the species is at least 16 years.

3.4.2 In Captivity

Water Dragons are relatively long -lived reptiles with specimens recorded easily reaching 14 years (Hay 1972). Captive records of a single female kept by Harlow and Harlow (1997) indicate that the maximum captive age for this species can be as long as 25 or even 28 years. According to Griffiths (2006:13) one male in captivity lived 40 years.

3.4.3 Techniques Used to Determine Age in Adults

This is another area for further study (Cogger 2009 Per Comm.). A possible future research project would involve studying a wild population over several years, involving tagging individuals and taking photographs and measurements to establish morphometric trends. However according to Shea (2009, pers. comm. 16th July) aging of any ageing of any reptile based on size is difficult and may not be achievable, as growth rates are extremely variable and depend on temperature and food intake.



Image 6. Eastern Water Dragon, *P. l. lesueurii*. Photo: Roger Graf.

4 Housing Requirements

4.1 Exhibit/Enclosure Design

In the wild, Water Dragons can be seen sitting in trees, swimming in water bodies, foraging on the ground and basking on rocks. (Greer 1990. Anonymous 1976) Long-term enclosures need to provide opportunities for these natural behaviours. Since an enclosure should be fitted with both arboreal and aquatic sections, it should be both as tall and large as possible (Anonymous 2004).

Outdoor enclosures are suitable for Water Dragons, provided that the species can or do occur naturally in the climatic zone it is being kept. Aviary-style enclosures are preferable over open-pit enclosures as Water Dragons can climb and may be able to climb or jump over open barriers. Aviaries also protect the animals from theft and predators such as cats (Weigel 1988:16-20).



Image 7. 'Pit - style' enclosure at Symbio Zoo used for displaying Eastern Water Dragons, *P. I. lesueurii*, other lizards and turtles. Photo: Chris Hosking © Australian Museum.

Thought should be given to materials used for the construction of indoor enclosures (vivaria), as Water Dragons have the habit of suddenly jumping from branches into water (as they do in the wild) and will splash water all over the walls, floor and ceiling of the enclosure. Marine or exterior grade plywood is preferable to materials that swell when wet such as particle board or MDF.

Although this species is found in the tropics, humidity does not appear to be beneficial to the health, normal shedding or behaviour. In fact higher than room temperature humidity (50%) supports the growth of mould and other organisms that can be dangerous to the health of these reptiles. Water Dragons at all times of year should be able to dry out completely (Goulding and Green 2006). Adequate ventilation and airflow will help keep the relative humidity down. Hygrometers should also be employed to monitor humidity levels (Anonymous 2004:4).



Image 8. Indoor vivaria at Sydney Aquarium for Eastern Water Dragons, *P. I. lesueurii*. Photo: Chris Hosking © Australian Museum.

Water Dragons also require a large amount (about a third of the total enclosure) of dry floor space featuring vegetation, to hide in and substrate to dig in. Water Dragons will be able to use open dry areas for, feeding, courtship and ritual displays as well as running in a bipedal fashion at great speed. Such areas are highly recommended for housing groups.

Being Australia's largest agamid (Greer 1990:18), Water Dragons can break weakly made enclosures. The enclosure should be strongly constructed and all doors fitted with latches and locks to prevent escape (Anonymous 1995:8). Keeper access points to the enclosure should never be directly open to the outside, as Water Dragons can move quickly and escape from sight. There should always be two doors between the exhibit or holding area and open spaces. Even when confined to a zoo grounds, a Water Dragon can be almost impossible to catch.

4.2 Holding Area Design

Short to medium-term holding enclosures are required for quarantine, veterinary observation, group management, and during maintenance to the main enclosure. Although smaller (see section 4.3), holding facilities should provide the same opportunities to Water Dragons such as being elevated above the cage floor on a shelf

or branches and being allowed to fully submerge themselves in a vessel of water. A thermo-gradient should be provided by positioning the heat source at one end only.

Water Dragons tend to sleep in the cooler end of the enclosure and prefer to be close to their natural escape strategy; falling in to water. It is therefore advisable to set up an enclosure with a large water container at the cool end and a shelf or branch above. Substrate can be the same as used on display however newspaper or other unnatural substrates are appropriate as the same aesthetics are not required as when they are on display and it is easier to remove soiled paper than wood chips or sand. Some form of hide or visual barrier will also help stressed individuals feel secure (Anonymous 2004:7).



Image 9. Holding facility suitable for Water Dragons at the Australian Museum.
Photo: Chris Hosking © Australian Museum.

4.3 Spatial Requirements

The NSW Exhibited Animal Protection Authority (EAPA) has spatial requirements for two lizards which is 2.5L x 2.5L (where L = the total length of the largest specimen) (Anonymous 2004:10-1). Water Dragons have a total length of 95cm, therefore the minimum floor space for two adult lizards (even if one is larger) is 237.5cm x 237.5cm. An additional 20% floor space is required for every additional animal. As water dragons are considered arboreal, a minimum enclosure height of 100cm is required, however based on the conventional display of this species in multiple institutions in Australia it appears that a height of at least twice that is used by most Zoos, Wildlife Parks and Aquaria.

The EAPA has standards for the minimum size of holding enclosures, this is 1.5L x 1.5L (where L = the total length of the largest specimen being held) therefore the minimum size would be a floor space of 142cm x 142cm. In order to provide suitable height the enclosure should be at least 100cm from floor to ceiling (Anonymous 2004:11).

4.4 Position of Enclosures

If kept outdoors it is important to position the enclosure so that at least part of the enclosure receives at least eight hours of sunlight a day and should be positioned in a way which prevents cold draughts from cooling the exhibit. Indoor enclosures can be positioned near heavily trafficked areas, however measures need to be made to reduce stress on the animals such as soundproofing of walls and glass, providing multiple hiding options for each animal and providing a standoff barrier from the viewing glass in order to keep the public at least 1 metre away from the enclosure glass.

4.5 Weather Protection

Outdoor enclosures require a sufficient area covered to protect from rain and provide shade on hot days.

4.6 Temperature Requirements

The preferred body temperature ranges 26.9-33.2° C with a mean of 30.1° C (Greer 2006:75). It is advisable to equip outdoor enclosures with a supplementary heated hide, to provide an optional refuge on cold days and nights. This would also be useful when keeping this species in areas outside of its natural distribution.

Indoors, this species can be kept at room temperature with a basking area ranging from 32-40°C at one end of the enclosure. It is important to provide a wide thermo-gradient with a minimum air temperature of 25°C and maximum of 32°C (Weigel 1988:103). If more than two individuals are being kept in the same enclosure, more than one basking site should be provided to reduce the instances of territorial behaviour over basking opportunities.

Providing a basking area can be done by allowing an animal to get directly below a heating fixture, such as a heat lamp, within a sufficient distance. For a 160w Oz Bright a distance of approximately 40cm is sufficient.

In order to prevent burns, all heating and lighting fixtures should be covered with a mesh cover which will not heat up greatly and melt. Heating equipment should be thermostatically controlled to prevent overheating and fire risk (Walls 2007:68). It is beneficial to the animals to provide a daily rise and drop in temperature to simulate natural cycles. Lowering the average temperature during the cooler months also provides a natural cycle and (combined with perceived day/night length) simulates seasonal change for the animals which will benefit breeding.

It is important that temperatures are not only recorded from the thermostat, but also checked by a fixed or portable thermometer. Temperature readings from multiple locations in the enclosure will ensure that a suitable thermo-gradient (mentioned above) is maintained (Weigel 1988:28).

4.7 Lighting

Like most agamid lizards, Water Dragons bask in sunny locations, therefore they associate heat with light. It is therefore beneficial to combine the heating of the enclosure with its lighting. One option is the combined use of UV fluorescent batons and a ceramic heater or globe. The other option is to use self-ballasted Mercury Vapour (OZ Bright, Reptile UV, Zoo Med, ExoTerra) or metal halide spot lights which provide both heat and light.

If Water Dragons are being kept entirely indoors the globes or batons used should provide an adequate balance of UVA/UVB radiation in order to provide vitamin D and help metabolise calcium. Section 8.4 (page 35) covers metabolic bone disease. Most batons and globes will only emit a beneficial level of UV for 6-12 months so the packaging should be checked and the date of installation should be recorded (Walls 2007:66-7).

Varying the day length over the seasons is also be beneficial for indoor enclosures. A timer should be used to control the spring and summer hours to 12 hours. During the winter months the day length should be reduced to 5-6 hours (Goulding and Green 2006)



Image 10. Metal Halide spot light above angled branch suitable for providing basking opportunities for Water Dragons. Photo: Chris Hosking © Australian Museum.

4.8 Water Filtration

Water quality is an important aspect of keeping Water Dragons, as good water can prevent many health problems from occurring. Both indoor and outdoor exhibits require an appropriately sized mechanical (physical removal of particles using mesh and filtration media) and biological (utilising beneficial nitrifying bacterial culture) filtration system. Canister filters are recommended for use with Water Dragons as they work by sitting outside of the pool or pond connected by hoses, thus making it easy to service the filters without disturbing the animals. This also prevents the Water Dragons from interfering with the equipment (Goulding and Green 2006).

Good water quality can be maintained in a system whereby the water is put through the system at least three times an hour. The water should be tested on a weekly basis and a neutral pH of 7.0 should be maintained. Water changes are required no matter how efficient the filtration system is, about 50% once a month is recommended, this is

important in removing excess ammonia and other wastes. Water temperature should be maintained between 16-28°C (Goulding and Green 2006).

4.9 Substrate

Young and adult Water Dragons exhibit digging behaviour in captivity. Suitable substrates for digging such as sand is required, however food must always be presented on a dish of sufficient size to prevent ingesting substrate which can lead to stomach impaction.

Other natural substrates such as potting soil and mulch can be used, however these substrates often harbour bacteria, fungi, protozoa etc. and should be heat treated before use. Off display, the same substrates can be used however it is not necessary to landscape in a naturalistic fashion, it is therefore often easier to use newspaper, cat litter pellets or other artificial materials that are easy to change.

4.10 Nestboxes and/or Bedding Material

Water Dragons sleep exposed on the higher sections of the enclosure, it is important to provide elevated ledges and branches of suitable width (maximum 80mm in diameter). No bedding material is required. Young Water Dragons (0-6 months) will burrow beneath large enclosure furnishings (rocks and logs) as is reported in the wild (Anonymous 1976), care should be made to prevent these furnishings from subsiding and crushing the animals. As the Dragons mature they will climb and spend an increasing number of nights in an elevated position.

4.11 Enclosure Furnishings

The main two elements that should feature in a Water Dragon enclosure are a suitably sized pool with clean water and branches of suitable diameter at various heights. The pool should have a minimum depth that allows all dragons to completely submerge simultaneously. Ideally the pool should be as big as possible in order to encourage the natural behaviour of active swimming, not just sitting in the water. The pool can have an underwater viewing window, however if this is the case there should be numerous visual obstacles such as logs and large stones as Water Dragons often use the water to hide, often preferring to sit at the bottom of the water even when there are numerous hide options on the land section of the enclosure. Branches should be placed (either horizontally at approximately at 45° angles) over water features and up high. Australian Water Dragons will often drop several metres from the canopy into the water, enclosures should be designed with this in mind by reducing obstacles that the dragon may hit when falling from a height, adult Water Dragons will use branches with a diameter of 80mm or more to sleep on. They will also utilise shelves or ledges which can be integrated into rock wall backgrounds.

Apart from being placed above water, branches should also provide access to heat fittings and UV light to allow proper basking. In the case of outdoor enclosures, elevated branches should be placed in certain area (such as a corner) which receives a varying amount of sunlight throughout the seasons.



**Image 11. Exhibit at Sydney Aquarium for Gippsland Water Dragons, *P. I. howittii*, which provides a suitable combination of water, land and climbing branches.
Photo: Chris Hosking © Australian Museum.**



**Image 12 Eastern Water Dragon, *P. I. lesueurii*, basking on branch.
Photo: Chris Hosking © Australian Museum.**

5 General Husbandry

5.1 Hygiene and Cleaning

Uneaten food and faeces should be removed on a daily basis. A weekly cleaning schedule should include cleaning cage surfaces such as branches, viewing windows and walls with a veterinary grade cleaning product such as F10 as well as replacement of any damaged plants.

Every six months the substrate should be completely removed and a stronger cleaning solution such as diluted bleach should be applied to all enclosure surfaces and rinsed clean. If possible substrate such as soil and mulch should be heat treated in a microwave, oven or left in the sun in a black garbage bag for 12 hours. Substrate such as pebbles and gravel should be thoroughly washed with detergent, rinsed well and left in the sun to dry.

Depending on the size of pool and filtration system used, water should be drained, pool scrubbed out with diluted bleach, rinsed and re-filled. This should be done on a weekly basis for pools without filtration and every six months for pools that have an advanced filtration system.

5.2 Record Keeping

A record sheet for each enclosure or group of enclosures should be kept in a secure area close to the enclosure(s). Ideally for inside situations the record sheet should be attached to the enclosure or access point. Dated information such as feeding, watering, shedding and behaviour notes should be recorded in writing on a daily basis. Other information that should be recorded include any noticeable health problems, veterinary examinations and treatments, reproductive events (courtship, displays between individuals, signs of aggression, matings or attempted matings and egg laying), skin sloughing, changes in diet (noting actual food eaten not just what was offered), weights and measurements and internal as well as external transfers. All records must be dated and identified as to which staff member recorded the observation.

5.3 Methods of Identification

Although females and males can be identified, Australian Water Dragons may be kept in groups consisting of multiple males and females where adequate space is provided. Although markings do differ between individuals of the same sex the most reliable way to identify individuals is through the use of an implanted microchip, such as a Passive Integrated Transponder (PIT) tag, which can be scanned and read.

5.4 Routine Data Collection

Information such as body measurements, weights, egg size and weight clutch size and growth should be collected and graphed over time in order to provide a better idea of reproduction and growth. Growth data should be collected every two to six months in order to interpret growth trends and detect health problems.

6 Feeding Requirements

The majority of dietary information found in the literature (Greer 2006) for this species is based on feeding observations of captive specimens, not based on observations of wild animals. Food items are often included as part of the 'diet' of Water Dragons based solely on whether a captive animal will feed on the item when it is presented. Keepers should be aware that many of these food items are not available in the wild or have never been observed as part of the diet of wild animals and therefore may not be nutritionally beneficial (Ofstedal & Allen 1996). Food items including *Gambusia* fish (P. Rankin in Anonymous 1976) and Water Skinks, *Phenomorphus quoyii* (G. Swan in Anonymous 1976) have been observed being eaten by Water Dragons, however it is not clear how commonly such food is consumed in the wild. Gippsland Water Dragons have been recorded feeding on the skink, *Lampropholis delicata*, in the wild (Meek et al. 2001a). More observations of wild feeding behaviour are required, however this species adaptability to captive diets are one of the factors that makes this species so hardy in captivity (Worrell 1966).

6.1 Diet in the Wild

Australian Water Dragons are completely insectivorous as juveniles with vegetation being consumed as they grow older and gradually increasing to make up almost half of the diet. Water Dragons have been observed in the wild feeding on the ground for insects such as ants (Greer 1990:19) as well as foraging amongst the branches of trees for arboreal invertebrates such as cicadas (P. Harlow in Anonymous 1976). The wild diet also includes molluscs and crustaceans (Wilson & Knowels 1992). Individuals have also been reported foraging for algae and crabs on intertidal zones in the Sydney region (Greer 1990:18). Juvenile Water Dragons have also been reported feeding on mosquitoes (M. Maddocks in Anonymous 1976) which they will jump in the air to catch. The herbivorous part of the diet observed being consumed in the wild includes figs, lily-pillies and flowers (Ehmann 1992).



**Image 13. Wild Eastern Water Dragon, *P. I. lesueurii*, eating a worm.
Photo: Peter Street © Peter Street Photographer.**

In the wild Water Dragons are believed to forage underwater, however this is based on one observation (P. Rankin in Anonymous 1976) of diving Water Dragons returning to the surface and moving their jaws.

6.2 Captive Diet

The recorded food intake of this species in captivity is quite extensive. However it is recommended to provide adult Water Dragons with a variety (Phillips 2008:51-4) from the following three groups:

Live Food – Snails, Yabbies, Feeder Cockroaches, Mealworms, Silkworms, and Crickets.

Meat - Whitebait, Young Mice, Rat Pinkies, Kangaroo Mince, as well as Canned Cat Food (jelly meat).

Vegetables – Peas, Corn, Carrot, Flowers (especially yellow flowers), Lettuce, Tomato, Broccoli, Cauliflower, Boc Choy, Spinach, Sweet Potato, Figs, Banana, Apple, Strawberries and Stone fruits.

Water Dragons will also feed on commercially available Bearded Dragon Pellets (available from manufacturers such as ZooMed and ExoTerra). Food preferences can vary between individuals even those from the same clutch and raised with the same diet (per ob.)



Image 14. Vegetables and Fruits being prepared. Photo: Chris Hosking © Australian Museum.

A selection of about five vegetables which are readily available, should be chosen as part of a 'veggie mix' which can be prepared and frozen for later use. The veggie mix should consist of hard fruit and vegetables such as apple, sweet potato, carrot, broccoli etc, as well as leafy greens such as spinach and boc choy. Soft fruits such as strawberries, banana and stone fruits should be served on an occasional/seasonal basis, as they consist of high sugar and fat but do not provide much jaw activity. Like all lizards, Water Dragons can develop weak jaws if feed an all soft fruit diet.

Adults should be fed two to three times a week during warm months. A recommended weekly feeding schedule is as follows:

1st feed
Veggie Mix

2nd Feed
Kangaroo Mince

3rd Feed
Crickets or Soft Fruit

During colder months, this feeding regime can be reduced to two feeds a week consisting of crickets and kangaroo mince which is alternated with a veggie mix the next week. When kept outside in colder climates feeding should be reduced and then stopped completely based on the reduced activity of the animals. If kept outdoors with no additional heat source, Water Dragons will reduce feeding and activity and hide under and amongst objects (Harlow & Harlow 1997). The feeding regime should be reduced based on outdoor temperatures and the activity of the animals, during the spring Water Dragons will become more active and feeding should be increased to up to three times a week. This should correlate with increased courtship and mating behaviour (described in section 10). The diet for juvenile Water Dragons is described in section 11.6.

6.3 Supplements

Vitamin and calcium (phosphorous free and with D3) powder are recommended to supplement the diet of Australian Water Dragons. Like all agamids, Water Dragons require adequate calcium in order to prevent condition and skeletal health problems (Weigel 2004:55-6). Vitamin supplements are also important to prevent vitamin deficiencies, as captive animals are often unable to acquire all the supplements that they would in the wild (Oftedal & Allen 1996). Over dosing food with supplements can lead to health problems and should be carefully measured and the frequency recorded.

Vitamin and calcium powder can be mixed together to form a 50/50 supplement mix to make dosing easy. About a pinch (quarter teaspoon) of the powder per animal should be sufficient per adult Water Dragon and can be added to the food by either 'dusting' live food such as crickets with powder in a clear paper bag, shaken with the insects and powder inside. The other option is to sprinkle the mix over the veggie or meat mix. A supplemented feeding should be done every two weeks to prevent supplement overdosing (Phillips 2008:54).

6.4 Presentation of Food

Food should be presented on a large shallow dish. Food pieces need to be cut to approximately half the size of the smallest animals head. A single feeding dish should be fine for one to two individuals however if one animal becomes more dominant, they may need to be fed separately, by removing one animal or supplying a second dish. For larger groups a second and even third feeding station should be provided to reduce competition for food. Feeding dishes should be removed and washed as soon as the food is eaten. If the food has not been eaten within a few hours of being presented it should be removed. Live invertebrates such as snails and mealworms should be placed in a deep dish, while more active live feeders like cockroaches and crickets can either be target fed with forceps to prevent food animals escaping as well as to control the amount of food given to each animal, or a handful of ten to twenty live food items can be let loose in the enclosure to promote active predation by the Water Dragons.

7 Handling and Transport

7.1 Timing of Capture and Handling

Australian Water Dragons can be captured early in the morning or in the evening when they are less active. While resting or sleeping Water Dragons can be captured from their elevated perch or when sitting in the water. During the animals active hours, keepers will have to be quick and attempt to reduce the chances of the animal fleeing and injuring itself. When keeping Water Dragons outdoors, capturing should only take place on days of low to moderate temperature to prevent the animals succumbing to hyperthermia.

7.2 Catching Bags

60x30 cm cotton catching bags can be used to catch adult Water Dragons. Smaller bags can be used to transport smaller dragons and in the case of hatchlings; plastic containers are suitable. A suitable way of securing the catching bag is to twist the opening together and fold over the end and secure with a rubber band. Bags should not be wetted for transport.

7.3 Capture and Restraint Techniques

Water Dragons can inflict deep wounds through biting and clawing. Strong gardening gloves should be worn on at least one hand when restraining Water Dragons unless the animal is well adjusted to handling. To restrain a Water Dragon, grip the animal firmly by the back of the neck and base of the tail (see image 15). Resting the body of the Water Dragon on the keepers arm or other part of the body will most likely result in lacerations. Do not grab the dragon by the tail as this can damage the animals spine and ligaments (Goulding and Green 2006), Water Dragons can also lose part of their tail if it is damaged (Rankin in Anonymous 1976:22).

The sharpness of the claws and power in the limbs are much more similar to those of a similarly sized varanid lizard than that of other large agamids. Keepers should show caution with all individuals but also attempt to condition Water Dragons to be handled in order to make husbandry procedures easier. Water Dragons are easiest caught when the animals are submerged underwater as they will attempt to remain unseen. If restraining an animal on branches or on land, all but the most calm of dragons will most likely attempt to run or jump from the branches.

If bitten by a Water Dragon, place the animal on the floor or bench and tap it on the hind leg or tail, the lizard will release its grip to bite the new threat to its hindquarters (Goulding and Green 2006).

7.4 Weighing and Examination

Once inside the bag the animal can be weighed on either a platform (digital) scale or spring balance scale. Once released the bag should be weighed and this number should be deducted from the total to establish the weight of the animal. Weighing should be done every 1-2 months and more frequently for animals with health complications.



Image 15. Recommended Restraint Technique of an Eastern Water Dragon, *P. I. lesueurii*, note the use of gardening gloves to protect against scratches. Photo: Rebekah Hosking.

A simple way to examine a Water Dragon that is restrained in a capture bag is to use a secure fixed object such as a bench or top of the enclosure to support the weight of the bagged animal. Locate and hold the head from the outside of the bag and with the other hand reach inside and securely hold the animal from the back of the head. Once the neck is firmly gripped the head can be released from the outside and the bag can then be gently peeled back to expose the animal for examination. By securing the base of the tail the animal can be rotated and examined on both dorsal and ventral surfaces.

7.5 Release

The method described above for removing a Water Dragon from the bag should be followed. When releasing Water Dragons, they will most likely run at high speed away from the people. It is best to 'aim' the animal away from fixed objects and barriers so they don't run straight into them when they are released. It is a good idea to release Water Dragons within sight of the exhibit water feature or hide which will allow the animal to conceal itself. Do not place the Dragon on an elevated branch, since they will almost always jump (or fall) off to hide at the ground level anyway. One strategy described by Goulding and Green (2006) to condition Water Dragons to being handled and restrained is to place the animal on the enclosure floor while still holding it. Wait until the Dragon has relaxed and then release it, the animal will then learn that if it relaxes and stops struggling that it will be released.

7.6 Transport Requirements

When it is necessary to transport a Water Dragon, the time the animal is confined should be kept to a minimum. Road transport should only be used as long as the temperature inside the vehicle can be controlled and the journey is not too long.

The preferred method of transport in between capital cities and regional areas is overnight air services. The International Air Transport Authority (IATA) outlines regulations for transporting live animals by air, The regulations for the transport of all Lizards and Tuatara are outlined in Container Note 41 (Appendix 1) and should be followed for air transport of Water Dragons (Anonymous 2009:225-8).

7.6.1 Box Design

Boxes should be clearly marked indicating that they contain a live animal. The address details of the sender and recipient should be clearly visible, emergency phone numbers should also be displayed. Instructions on the outside of the box should also say "KEEP OUT OF SUN" to avoid hyperthermia. There should also be an obvious "THIS WAY UP" label so that the box is transported correctly.

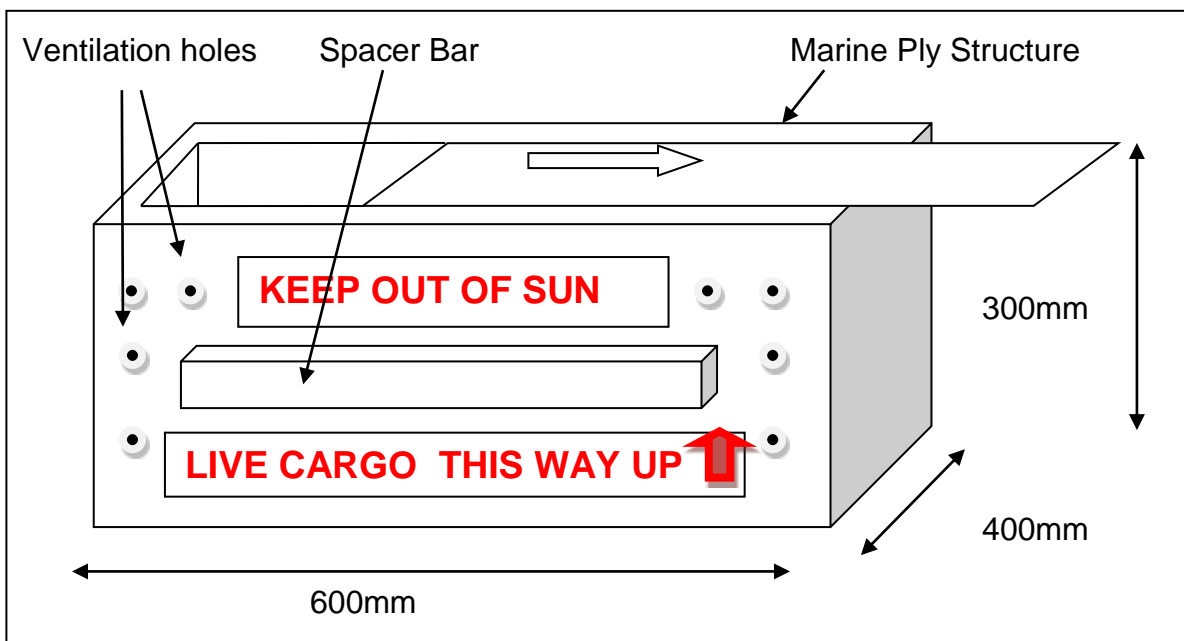


Figure 2. Transport box suitable for reptiles such as Water Dragons. Note the labels and wooden buffer on the side to maintain ventilation. The top panel slides out and has a plastic pouch to contain shipping details and contact information.

Boxes should be built of solid material which allows adequate ventilation and can be securely closed. The size of the box depends on the number of animals being transported and the size of the animal(s). A box designed to transport two adult Water Dragons should be at least 600mm long X 400mm wide X 200mm high. During transport, boxes often will be placed directly next to other boxes and on the side of the vehicle compartment, a 10mm spacer bar made of wood or other material should be built into the transport box in to ensure that ventilation holes on the side of the box are not blocked (see Figure 2).

7.6.2 Furnishings

A single animal should be placed in a cotton or other well-ventilated bag, secured with a rubber band and placed in the box. The animal should not be in contact with any other object than the bag, however shredded paper should be placed around the bagged animal to avoid injury during transport.

7.6.3 Water and Food

Water Dragons should not be fed during or on the same day of transport, but may be fed the day before transport (Goulding & Green 2006). The animals intended for transport should be adequately hydrated before transport, this is fairly easy with Water Dragons as they are often caught while sitting or hiding in the water. Placing the animal in a shallow dish of water for ten minutes prior to transport is recommended if the animal has not been recently in water (Goulding & Green 2006).

7.6.4 Animals per Box

Multiple animals can be transported in the same box provided that the box is of suitable size and that the animals are individually bagged. Although the IATA regulations do not specify the genus *Physignathus* as a group of lizards requiring individual transport (Anonymous 2009:226), species of this genus can become aggressive to others of the same species, especially smaller individuals, therefore single bagging is recommended. A box designed to transport two adult Water Dragons should be at least 500mm long X 400mm wide X 200mm high. Transportation of young Water Dragons can be carried out using polystyrene packages in a multi-compartment container arrangement outlined on page 228 of the IATA regulations.

7.6.5 Timing of Transportation

Reptiles should not be transported during periods of excessively high or low temperatures. Nor should they be transported when higher than average delays are expected such as problems with couriers (Goulding and Green 2006). A transport plan should be developed before transporting the animal. Time confined in the transport box should be kept to a minimum.

7.6.6 Release from Box

Once the box has been opened, the welfare of the animal should be established and this is a good opportunity to weigh the new animal (Goulding and Green 2006), unless it is indicated that it was weighed before transport. The animal can then be removed from the bag, but simply putting your hand in the bag when releasing any recently transported reptile is asking for trouble. Water Dragons can be released from the bag using in the method described in section 7.4 above.

8 Health Requirements

8.1 *Daily Health Checks*

During the daily husbandry routine, health signs to look out for are:

- Any shedding problems, such as old bits of skin that have been unable to be sloughed off. As well as any possibly constricting bits of skin around tail or toes.
- Any visible wounds.
- Loss or damage to toes, claws or tail tips.
- General alertness and activity (this will depend on knowing the normal activity level of the individual animal and may be difficult to judge in newly acquired animals).
- All limbs appear to be moving freely.
- Feeding well.
- Eyes clear and fully open.
- General appearance - body condition and condition of coat.
- Discharges - any nasal, ocular or cloacal discharges of note.
- Any noticeable changes in behaviour.

Consistency of faecal matter is difficult to judge in Water Dragons due to their habit of defecating in the water. Faecal samples can be obtained and inspected if the Water Dragons are taken out of the enclosure and placed in a temporary holding container. After five to ten minutes the Dragons may have defecated and the sample can be checked to see if it is sloppy, not the normal colour or containing blood.

8.2 *Detailed Physical Examination*

8.2.1 **Chemical Restraint**

To fully anaesthetise an Australian Water Dragon veterinarians can use either Propofol 10mg/kg IV (Ventral tail vein) or Alfaxalone 5 to 8mg/kg. Doses are quoted in milligrams of drug per kilogram of the animal's body weight (Vella 2009. pers. comm.).

8.2.2 **Physical Examination**

In addition to those mentioned above for daily health checks, the following features should be looked for when conducting a physical examination:

- Any swelling or unusual features around the cloaca.
- Mites, ticks or any other parasites, particularly between scales and near the orifices.
- Swelling around gums, jaw or any discoloration in the mouth.
- Any noticeable loss of weight (this is first visible around the base of the tail) or body condition.
- Any lesions or skin problems.

An easy way to examine the inside of the mouth of a Water Dragon is to gently 'tap' the top of the snout between the nostrils and the eyes. This will in most cases cause the Dragon to open its mouth in a threat posture, exposing the gums, teeth and tongue. Since this is probably a negative experience for the animal, it should only be done occasionally and when there is a suspicion of mouth infection.



Image 17. Eastern Water Dragon, *P. I. lesueurii*, showing healthy mouth.
Photo: Rebekah Hosking.

8.3 Routine Treatments

Routine treatments for Water Dragons include monthly worming with ingestible worming medication such as Worm-Rid (Reptile Sciences®) which will also kill protozoa as well as nematodes. This can be given by dosing a piece of kangaroo mince or similar food item at a rate of 0.4ml (8 drops) per kilogram of body weight. Separating individuals while using this method to worm will ensure that all animals receive the correct dose.

Insecticides such as 'Top of Decent' are safe to use with Water Dragons for routine treatment of mites. Be sure to follow directions (see appendix 2). Enclosures should be sprayed with such insecticides during routine pond drainages, so that the chemicals do not affect the water chemistry.

8.4 Known Health Problems

Ulcerative Stomatitis (also known as Canker or Mouth Rot)

Cause: Bacterial infection of the gums due to poor enclosure hygiene, but also found in some wild specimens (Irvine 1973:23).

Diagnosis: Early signs appear as swelling and hemorrhaging around gums. However these symptoms can be preceded by general listlessness which is a sign of bacterial infection (Tilbrook 1972:20). Advanced cases will produce a cheesy yellow white mucus around the gums.

Treatment: The condition can be treated by scraping away the mucus from the gums followed by rinsing the mouth with a 3% dilution of hydrogen peroxide and finally a course of antibiotics to stop the infection. Vitamin C supplements are advised in order to promote tissue healing.

Prevention: Improve hygiene in enclosure and review protocols. Reducing stress has also been shown to be beneficial in preventing such infections (Weigel 1988:60). Canker can be caused by a variety of different bacteria so the use of antibiotics has also been shown to reverse the symptoms, combined with keeping the animal hydrated and warm (Tilbrook 1972).

Mites

Cause: Mites are parasitic arachnids, the main species of concern to reptile keepers is the Snake Mite, *Ophionyssus natricis* (Klingenberg 1993:44). These animals become established in collections due to ineffective (or the lack of) quarantine and husbandry protocols.

Diagnosis: Raised scales, tiny white specks on the infected dragon's scales (these are mite faeces). The mites themselves are small eight legged 'dots' that can most often be observed on enclosure floors (Simpson 2008:20).

Treatment: Infected animals can be treated with a diluted mixture (10%) of Orange Medic[®], a human head lice treatment, available at pharmacies. The mixture can be applied directly to the animal using a spray bottle, avoiding all of the animals orifices.

Prevention: Routine use of mite spays such as Top of Decent as part of enclosure hygiene protocols. Quarantine all newly acquired animals (Goulding and Green 2006:36).

Ticks

Cause: Ticks are parasitic arachnids that feed on the blood of vertebrates.

Diagnosis: The parasite can be found visually as a 3-12mm disk-shaped animal with its mouth parts buried into the host in easy to get to parts such as between scales, ear openings and between skin folds.

Treatment: Physical removal is the best option, this can be done by dabbing the tick with methylated spirits which will cause it to release and can then be removed using forceps.

Prevention: Ticks usually only occur with animals housed outdoors and the use of insecticides are not feasible. Regular inspections of all animals and quarantine protocols are the best preventive measures (Goulding and Green 2006:36).

Abscesses

Cause: Bites or other injuries to the body that come into contact with hard surfaces, usually on the ventral surface.

Diagnosis: Hard lump beneath the skin.

Treatment: A veterinarian will need to make an incision and drain the liquid. This should be followed with a course of antibiotics.

Prevention: Ensure that there are a variety of substrates to choose from of various hardness. Observe and manage groups to reduce aggressive behavior and bites.

Internal Parasites

Cause: Various organisms such as Nematodes, Protozoans, Cestodes (round worms) and Trematodes (flukes).

Signs: Drop in weight and body condition. Lack of appetite and poor reproductive ability. Faeces will also appear different and the parasite concerned can be identified by performing a faecal analysis.

Treatment: Once the organism has been identified a specific medication can be prescribed by a veterinarian.

Prevention: Regular (monthly) use of wide spectrum worming medications such as Worm-Rid (Reptile Sciences®) (Klingenberg 1993:51-70).

Physical Injuries

Cause: Injuries caused by falls, burns, contact with physical objects and aggression between animals

Signs: Damage to scales, loss of tail tip and toes

Treatment: Injuries should be examined by a veterinarian however all open wounds can be treated with an antiseptic such as Betadine.

Prevention: Good enclosure design including preventing burns and keeping animals from falling from heights onto hard surfaces are good preventative measures. Groups should also be managed for aggressive behavior, there should be sufficient visual barriers and multiple escape options to prevent animals from being cornered (Goulding and Green 2006:35).

Sloughing Problems

Cause: Dryness in exhibit, lack of abrasive objects to assist sloughing, no access to water due to over-crowding or other health issue.

Signs: Sections of unsloughed skin around tail, top of head and on toes.

Treatment: Place animal in a water-tight container with 5cm of luke warm water until the un-sloughed skin has loosened.

Prevention: Provide an adequate sloughing environment (as above) (Weigel 1988:57-8).

Metabolic Bone Disease

Cause: Nutritional imbalance or a systemic illness such as renal, liver or thyroid disease.

Signs: Inability to close jaws, postural abnormalities, bone fractures, lameness, muscle spasm, spinal curving and skeletal deformations.

Treatment: Correcting husbandry practices and treating any pathological fractures. Oral doses of calcium gluconate twice daily (23mg per kg of bodyweight) and weekly injections of vitamin D₃ (400 IU/kg) and calcitonin (50 IU/kg).

Prevention: Supplement diet with fortnightly calcium carbonate and vitamin D₃. Provide access to natural sunlight or full spectrum UVA/UVB lighting when kept indoors.

8.5 Quarantine Requirements

Newly acquired animals and established animals which show signs of disease should be isolated from the rest of the collection in a holding enclosure such as the one described in section 4.2. New animals should be quarantined for a minimum of 90 days during which time blood and faecal tests and a veterinary examination should be carried out before releasing the animal into the main collection (Woodford 2000).

Established Water Dragons showing signs of ill health should be held separate from other animals until the animal has completely recovered and tests have been conducted by a Veterinarian (Goulding and Green 2006:34). The quarantine space should be indoors and physically separated from the rest of the animal collection, separate handling tools, containers, food dishes and water bowls (Aland 2007) should be used to that of non-quarantined animals.

To further reduce the chances of pathogens spreading, husbandry for quarantined animals should be done last and hands should be thoroughly sanitised (Ross 2007:42. Aland 2007:45).

9 Behaviour

9.1 Activity

Australian Water Dragons have quite contrasting activity patterns which is dependent on the season and average daily temperature within the animals range. During spring and summer, Water Dragons of various ages and sizes can be seen in the various riparian environments they inhabit, basking on riverbanks and rocks, lounging in trees, swimming as well as foraging for food on land (Ehmann 1992. Worrell 1966:75). They can sometimes be hard to observe but even animals accustomed to human attention will be quick to escape if approached too closely by either dropping from rock ledges and branches into the water (Cogger 2000:346) or running bipedally to the water or thick cover. Young Water Dragons prefer to be on the ground (R. Wells in Anonymous 1974:21) animals appear to be more wary than the larger adults, juveniles of *P. I. lesueurii* have been observed staying completely still when found by humans on a grassy section metres from the water, relying heavily on its dull grey camouflage to blend in with the grass and fallen leaves.



Image 22. Juvenile Eastern Water Dragons, *P. I. lesueurii*, such as this one can often be seen basking on rocks and concrete surfaces during the spring, summer and even autumn months. Photo: Peter Street © Peter Street Photography.

In captivity, this behaviour can be sustained throughout the year, as long as sufficient heating and lighting is maintained. Water Dragons prefer to sleep either in an elevated position or in a secluded corner of the water vessel. Water Dragons can appear quite lazy in captivity, however if the exhibit is of sufficient size and requires the animal to exercise by moving between basking and swimming opportunities, then all animals

should be moving for a satisfactory part of their day. Captive Water Dragons can however suffer from obesity if their dietary intake is greater than the animal's daily activity. An enrichment program (see Section 9.7) should be developed for Water Dragons that maximises movement throughout the enclosure.

Water Dragons have a much lower preferred body temperature than other Australian agamid lizards, of 30.1°C, compared to a range recorded between 34.6-39.0 from 12 other species (Greer 1990:19) the species is therefore active for much longer into the colder periods than other Australian lizards. In the Sydney region, Eastern Water Dragons, *P. I. lesueurii*, are still active throughout June.

In the wild, Water Dragons escape low winter temperatures by slowing down their metabolism and entering a state of brumation (Goulding and Green 2006:24). Water Dragons will use established burrows or scrape their own between boulders and logs in or near riverbanks to overwinter, which they will pack dirt into the opening and seal themselves off to brumate until the spring (Griffiths 2006:61). One wild adult male *P. I. lesueurii* was observed at Taronga Zoo in the middle of August (Pers. Ob.) as the only visible individual in the zoo, where a large wild population is known. This was most likely due to the fact that this animal had figured out that the pool of the Freshwater Crocodile, *Crocodylus johnstoni*, was heated.

Water Dragons will usually decrease food intake when the air temperature drops to between 18-22°C, and brumate when the average day temperature reaches below 12°C (Goulding and Green 2006:24). The change in activity is also affected by the reduction of the photoperiod, which many reptiles will use as a seasonal indicator (Swan 2006:29).

Water Dragon kept in stable temperature but with access to natural light levels will slow down during winter, despite there being sufficient heat to thermo-regulate and digest food (Pers. Ob.). It is important to reduce food intake during the colder months especially for Water Dragons kept outside, after a few weeks the animals will eventually take no food for approximately six weeks. During brumation, captive animals kept outdoors will bury themselves in leaf litter beneath logs and other furnishings (Goulding and Green 2006:24).

Indoor animals may choose to hide beneath furnishings or sit in the water vessel almost completely submerged. Sitting in the water over winter is also observed in the wild, the tannins in the water will stain the lizard's skin, making the dragon appear discoloured until the next slough (Aland 2008:461).

9.2 Social Behaviour

In the wild, Water Dragons can be found in large numbers in areas of suitable habitat. These groups are usually comprised of several females, juveniles of various ages and a dominant male who will defend as much of the territory as possible from other males. Water Dragons can be observed interacting through a variety of domineering a submissive signals including; head-bobbing (R.Wells in Anonymous 1976:21), saluting and substrate licking, the actual meanings of displays are not understood.

9.3 Reproductive Behaviour

Males of similar size will fight each other when confronted. Males of larger size will tend to easily chase away smaller males but if this does not occur aggressive behaviour will

occur. Male Water Dragons will first attempt to deter their opponent through intimidation; by walking tall and puffing the jaws with mouth open wide (see Image 18) and will try to appear as large as possible to each other (Griffiths 2006:57), if this does not deter one of the males, ritual combat will result.



Image 18. Open-mouthed aggressive display by male Eastern Water Dragon, *Physignathus l. lesueurii*. Photo: Peter Street © Peter Street Photography.

Daly (1992:37) described such combat involving two males at Stanwell Park. The two animals were found motionless on the ground, sided up to each other so that each animal had its head next to its opponents hip area. Suddenly, both animals proceeded to circle each other while taking short bites of each others hip area. This would be interrupted by staying still again, then erupting into action again and repeating this pattern several more times. These two animals (which were measured and weighed; see Table 1), as well as one at nearby Coalcliff had wounds from battle on their hips (Daly 1992:37). M. Maddox (in Anonymous 1976:21) observed the fighting between males as lasting for ten minutes in which scratches and bites were delivered to the necks of both animals.

Apart from intra-sexual aggression of males, other reproductive behaviour recorded includes arm waving or saluting and head bobbing from males which is a sign of readiness to court females. The male will chase the female and hold onto her neck or shoulders with his jaws as he aligns their cloaca and inserts one of his hemipenes in order to copulate (Goulding and Green 2006:27).

Once gravid, female Water Dragons will increase the amount of time they spend basking as the eggs develop inside her (Goulding and Green 2006:27). The female will dig test holes in sandy soil areas of her enclosure or wild home site, up to a week before actually laying. Potential burrows are inspected by the female by placing her snout into the burrow, presumably to test that the temperature is sufficient to incubate the eggs (Harlow and Harlow 1997:17).

9.4 Bathing

Swimming and sitting in the water is an important behaviour for Water Dragons. In the wild water dragons can be found diving in deep dams and rivers or sitting in shallow streams and ponds (Anonymous 1976) Sitting or swimming in the water is observed in both wild and captive Water Dragons as water is used as a refuge but also as a safe place to slough skin and defecating without attracting predators. Turner (1999) made several observations of *P. I. howittii* sleeping in the water, completely submerged except for the nostrils protruding above the surface. In captivity (Pers. Obs.) most defecating and sloughing occurs in the water and animals will normally submerge themselves to avoid human contact. Some large individuals will sleep underwater or amongst waterlogged logs and may spend a period or all of the winter in the water (Aland 2008:461).

9.5 Behavioural Problems

If crowded, large individuals may be unusually aggressive to other animals including females. Keepers should observe minimum space requirements for this species (see Section 4.3), and provide multiple feeding and basking areas as well as visual barriers between individuals. There are otherwise no documented 'behavioural problems' associated with this species such as stereotypical pacing or other abnormal activities. Any observed problems such as inactivity and lack of coordination are likely to be caused by some form of health problem and should be investigated by a veterinarian. Water Dragons will instinctively be wary of people and other animals and have a tendency to suddenly leap away and hide, however this behaviour is understood as very natural and keepers should adjust to this through proper exhibit design and husbandry techniques.

9.6 Signs of Stress

Stress in Water Dragons can be identified in individuals who consistently hide from humans and other Water Dragons. Even very nervous Water Dragons should hold their ground and observe people for a few seconds before fleeing. Similarly, Water Dragons in a natural state appear to be tolerant of each other, so constant aggression and avoidance of other animals in captivity is most likely a sign of overcrowding or inappropriate social dynamics (for example more than one adult male and a single female). Stressed animals will stop eating, can lose weight and increase their susceptibility to parasites and disease (Goulding and Green 2006:27,34).

9.7 Behavioural Enrichment

Behavioural enrichment is the management of the captive environment in order to decrease the predictability of captivity and encourage animals to exhibit natural behaviours. The benefits of 'enrichments' if executed correctly are that such programs can increase physical and mental exercise of captive animals, thus improving the health and well being of animals in captivity. Although most enrichment programs have been developed for birds and mammals; reptiles, amphibians and even invertebrates now

have enrichment programs, with such programs only being limited to a keepers imagination and commitment. Based on encouraging natural behaviours, enrichment programs are important educational tools to demonstrate natural history concepts. For a suggested enrichment calendar see appendix 2.

Outdoor Composting Feeding Strategy

When kept outdoors in an aviary, Water Dragons will feed on naturally occurring invertebrates that blunder into the enclosure (Harlow and Harlow 1997:14). Since the invertebrates enter the enclosure in no pre-determined way, such feeds are random and act as an enrichment activity. Such feeds will occur in any situation where lizards are kept outside however this can be encouraged by keepers. Invertebrates such as flies, beetles and cockroaches can be lured into the exhibit by using a mix of fruit and vegetable scraps.



A 'composting cage' can be created from wire mesh and a plastic pot saucer (see Image 19). Designs can differ but all such devices are suitable provided they achieve the following functions: a) keep the fruit dry. b) allow the fruit to be accessed by keepers and changed. c) prevent the Dragons from feeding on the rotten fruit. d) allow easy access between the mesh for insects to enter and leave the cage. The downside to this method is that it is impossible to know how much individual dragons are eating.

Image 19. A composting cage which can be used to attract insects into an outdoor enclosure.

Photo: Chris Hosking © Australian Museum

Blue Light Trap

Similar to the method described above, blue lights mounted within or adjacent to outdoor enclosures can be used to attract nocturnal insects such as moths and beetles. These night-time snacks will provide occasional enrichment feeds. Similarly Huntsman Spiders are often attracted to places where moths are often found and can provide further feeding opportunities. Like the last enrichment method it is impossible to know how much additional feeding this enrichment is providing the dragons.

For Water Dragons kept indoors, light traps can be purchased which utilise a blue-light and a fan to trap moths outdoors which can then be fed out to the Dragons in the morning. This way the amount of food being eaten can be recorded.

Mealworm Tube

Mealworm tubes have the advantage of allowing a measured amount of mealworms to be fed out, which can then be recorded by keepers. Mealworm tubes are PVC pipes that can be made to varying lengths and capped at each end. A series of 3-4mm holes are drilled into one of the sides and the tube can be mounted horizontally, with the holes facing down, in an elevated location such as a wall or ceiling. One of the caps can be removed and a measured amount of mealworms can be added and the cap replaced. The worms will then wiggle around and fall randomly over the course of a few hours, providing unpredictable feeding opportunities for the Dragons.

Furnishings

A simple non-feeding form of enrichment is a scheduled re-arrangement of enclosure furnishings. Moving rocks, logs, branches and plants in the captive environment provides new opportunities to explore, also by moving heating equipment, new basking opportunities are available when being kept indoors. However, if heating devices are moved, keep in mind the need to ensure a thermo-gradient which allows all animals to maintain their preferred body temperature (see Section 4.6).

9.10 Introductions and Removals

Introducing new Water Dragons to a group should only be done if the enclosure physical space allows and if the group dynamic is considered prior to release (e.g. not introducing a mature male to a group which already has a dominant male). Sufficient visual barriers and hiding opportunities should be provided so that the new animal has the opportunity to conceal and defend itself from possible aggression in the established group. New animals can be provided with visual contact to the group by being housed initially next to the groups enclosure before being physically introduced. Similarly, animals that are removed can be placed in nearby enclosures to maintain visual contact with other animals, which may reduce the stress of isolation.

9.11 Intraspecific Compatibility

Numerous Water Dragons can be housed together providing that there is sufficient space (on both land and water), feeding stations and basking opportunities. Young Water Dragons should not be held with adults to prevent the possibility of cannibalism and injury. Only a single dominant male should be held in a captive group, otherwise there will be numerous fights leading to injuries. That said, the species is quite social in the wild and they should not be held as solitary animals, numerous females can be held together and different mature males can be rotated through a single exhibit.

9.12 Interspecific Compatibility

Australian Water Dragons have been kept in captivity with a variety of other species including fish, turtles, birds and as well as some mammals. Water Dragons appear to be fine with other animals as long as they are the largest predator in the exhibit and the other species are not seen as food.

At Sydney Aquarium, Eastern Water Dragons, *P. I. lesueurii*, are housed with Platypus, *Ornithorhynchus anatinus*, Macquarie Turtles, *Emydura macquarii*, Eastern Long-neck Turtle *Chelodina longicollis*. In the same institution Gippsland Water Dragons, *P. I. howittii* are kept with various species of turtles, fish and birds. At Sydney Wildlife World, Eastern Water Dragons, *P. I. lesueurii* juveniles have been successfully kept with Scrub Pythons, *Morelia kinghorni*. Oceanworld at Manly keeps a small colony of Eastern Water

Dragons, *Physignathus l. lesueurii* with Eastern Bearded Dragons, *Pogona barbata*, Eastern Blue Tongue Lizards, *Tiliqua scincoides scincoides*, and Land Mullet, *Egernia major*, as well as Macquarie Turtles, *Emydura macquarii*, Eastern Long-neck Turtle *Chelodina longicollis*, and freshwater Eel, *Anguilla reinhardtii*. Adelaide Zoo displays Gippsland Water Dragons, *P. l. howittii* with various species of turtle of short and long necked turtles.

According to Tom Vowell (2009 pers. comm. 24th August), the Australian Reptile Park has exhibited Red-bellied Black Snake, *Pseudechis porphyriacus*, with Water Dragons as well as juvenile Water Dragons with Saw Shell Turtles with so far with no negative effects on either species. There may be other species that are compatible with Water Dragons, as long as adequate space, the number of feeding stations and basking sites are considered as well as the possibility of interspecific predation.



Image 20. A male Eastern Water Dragon, *P. l. lesueurii*, sharing an exhibit with a Red-bellied Black Snake, *Pseudechis porphyriacus*, at the Australian Reptile Park. Photo: Peter Street © Peter Street Photography.

9.13 Suitability to Captivity

According to Worrell (1966:75) the Eastern Water Dragon is one of the hardiest species to keep in captivity. When young or newly acquired, Water Dragons will be nervous and dislike human company, however given enough privacy and quiet conditions will adjust to people over time (Weigel 1988:103). Although they do have a tendency to bite keepers and are less likely to be easily handled like Bearded Dragons, *Pogona spp.* Water Dragons do not appear to stress easily provided that basic housing needs of space, water, and climbing opportunities are met and the health of the animal is maintained.

10 Breeding

10.1 Mating System

Australian Water Dragons are socially arranged into harem groups consisting of a single adult male, several females and various immature offspring. All animals stay within a home range with males defending against interlopers and dispersing maturing offspring through aggressive displays and combat (Thompson 1993).

10.2 Ease of Breeding

This species will breed readily in captivity as long as males and females are of breeding age, good health and sufficient space is provided. Females also need adequate nesting substrates and a selection of temperatures in order to dig test holes and select nesting sites.

10.3 Reproductive Condition

10.3.1 Females

Female Water Dragons show reproductive condition by at least 4-5 years of age. However in captivity, where food intake and conditions are more stable than the wild, young Water Dragons are able to grow faster, attain adult size and become mature at as young as 13 months (Harlow and Harlow 1997:17). Females will increase food intake following cooler periods. After mating, as the eggs develop in the gravid female, she will spend increasing time basking (Goulding and Green 2006:27).

10.3.2 Males

Increased activity including domination displays towards other males and male combat (See Reproductive Behaviour in Section 9.3). Male Eastern Water Dragons, *P. l. lesueurii* develop scarlet colouration on the chest from the neck to the vent, Gippsland Water Dragon males develop black, yellow/orange and blue markings as well as green or blue colouration on the ventral surface (Aland 2008:463). Males of both subspecies will perform courtship displays towards females which include waving (or saluting) and stamping of the forearms and head bobbing displays towards females (Goulding and Green 2006:27).

10.4 Techniques Used to Control Breeding

Breeding should only be controlled by means of housing same-sex groups together over the breeding season as breeding control is not possible chemically and not necessary through surgery. Keepers should be aware of the species ability to store sperm within a single breeding season, therefore viable eggs may be laid up to four months after the female has been separated from mature males. Keeping only juvenile animals as display animals is another way to prevent offspring however it is not a long term solution to controlling breeding as the animals grow older.

10.5 Occurrence of Hybrids

Some individuals occurring in Kangaroo Valley appear to show mixtures of features from both *P. l. lesueurii* and *P. l. howittii* subspecies (Rankin in Anonymous 1976:22). This is expected since it is the southern limit and northern limit for each subspecies respectively. Such crossing of subspecies may occur in captivity if keepers are not aware of the differences between the subspecies and are not identified as such. There are no records of hybridization between *P. lesueurii* and *P. cocincinus* or any other related species.

10.6 Timing of Breeding

The timing of breeding is determined by the onset of warmer weather in spring which occurs sooner in populations occurring in north Queensland and later in populations living in Gippsland. In the Sydney region, the breeding season begins after the brumation period begins in September when courtship and mating begins and concludes in January when the last clutches of eggs are laid (Greer 2006:76).

10.7 Age at First Breeding and Last Breeding

Males are thought to be sexually mature at a snout-vent length of about 210mm and a mass of 400g (Thompson 1993:). In the wild this occurs at approximately 5 years of age in captivity this can occur as early as 2 years. Harlow and Harlow (1997:15) recorded the first breeding in a single female at four years of age and last breeding for the same individual at 27 years of age. It is unclear how long males can reproduce.

10.8 Ability to Breed Every Year

Harlow and Harlow (1997:15) recorded a single female which bred during 22 out of 23 seasons between 1971 and 1993, it is therefore likely that this species can breed every year at least in captivity under optimal conditions. Wild female *P. l. lesueurii* were palpated in one field study to detect the presence or absence of oviducal eggs (Thompson 1993:617). The results were a low proportion of oviducal eggs, indicating that female Water Dragons do not breed every year in the wild.

Malformed infertile eggs have been recorded being laid by the captive female mentioned above during the only breeding season when there was no male access (Harlow and Harlow 1997:15)

10.9 Ability to Breed More than Once Per Year

Females can reproduce twice a season in captivity (Harlow, in Anonymous, 1976), however this was not recorded as occurring in the wild based mark and recapture research by Thompson (1993:617). A captive female *P. l. lesueurii* recorded by Harlow and Harlow (1997:15) laid her first double clutch at the snout-vent length of 178mm and laid two clutches for twenty consecutive breeding seasons until her last season in 1993 when a single clutch was laid. On two occasions this same female produced a second clutch without being mated between laying the first and second clutch, demonstrating this species' ability to store sperm within a breeding season (Harlow and Harlow 1997:16).

10.10 Nesting, Hollow or Other Requirements

Females begin digging test holes in sandy soil from a week to three days prior to laying (Hay 1972:2). Records collected of the nesting behaviour of a single female by Harlow and Harlow (1997:15-16) showed interesting breeding behavioural observations:

- Eggs were laid on days when the daily maximum temperature and global radiation (which indicates the total amount of the sun's energy which arrives at ground level) measurements was higher than those of ten days previous.
- Test burrows were observed being dug up to a week prior to actual ovipositing.
- Burrows would be dug at all times of the day, however the majority of digging activity was undertaken during the last two hours before sunset.

- Actual egg laying would similarly only occur in the last few hours before sunset. During which time the female would become increasingly wary and freeze at the slightest disturbance.
- Upon digging the nesting burrow the female would investigate the depth and temperature with snout.
- The female laid the eggs lying flat over the hole to deposit the eggs with her entire body exposed. The front limbs were used to excavate and the hind limbs were used to back fill the nest.
- Dried grass was scattered over the hole once filled to disguise the nests location.

Harlow and Harlow (1997:16) also described that this usually placid female would defend the nesting site very aggressively, biting any person or other lizard that would approach the nest.

Wild nest temperatures of *Physignathus lesueurii* (presumably *P. l. howittii* although not stated in the literature) were recorded by Meek et al (2001) at the Australian Botanical Gardens in Canberra. Results showed that nest temperature remained relatively constant (23.7-29.2°C daily averages) despite high levels of temperature fluctuations (25-50°C) on the surface (Meek et al 2001:26-7).

10.11 Breeding Diet

No change in diet is required to induce breeding however Water Dragons do naturally increase their feeding at the onset of spring after the cooling period therefore lizards should be provided with an increased quantity and even frequency of food, however it should be nutritionally balanced as described in section 6. Females will be seen basking more often to digest food while eggs are developing (Goulding and Green 2006:29).

10.12 Incubation Period

The incubation period ranges from 68-120 days (Harlow and Harlow 1997:19, Greer 2006:76). The maximum incubation period of 120 days was recorded in a nest incubated at room temperature (Harlow and Harlow 1997:17). It should be noted that all of these figures were recorded from *P. l. lesueurii* and that the other subspecies *P. l. howittii*, may have a different incubation period range.

10.13 Clutch Size

Water Dragon clutch sizes range from 6 to 18 eggs (Harlow and Maddox in Anonymous 1976:20-1, Harlow and Harlow 1997:19). Mean mass of individual eggs varies from about 4.0 to 5.1g (Harlow and Harlow 1997:19).

10.14 Age at Weaning

Not applicable to reptiles.

10.15 Age of Removal from Parents

Not applicable to reptiles.

10.16 Growth and Development

Growth is highest in the first year with hatchlings from a mark and recapture project growing 2.25mm or 1.25g per month (Thomson 1993:613). One juvenile individual was measured in its first season in March 1990, 78mm from snout to vent (SVL) and weighed 17g. The following year in January this same individual had a SVL of 101mm and was 34g (Thomson 1993:616).

11 Artificial Rearing

11.1 Incubator Type

Water Dragon eggs have been incubated in commercial reptile incubators as well as home-made devices that are built using an insulated container (such as an esky or old fridge), heat cord and thermostat (Goulding and Green 2006:30). Another improvised incubation method is to place a vessel containing substrate and eggs on two blocks in the middle of an aquarium with water just above the bottom of the container. Using a controllable aquarium heater, the water is heated to 28°C which maintains both the temperature and the humidity of the eggs. A marker should be used to record the original depth of the water and this should be topped up to maintain the same depth and prevent too much water being lost to evaporation (Goulding and Green 2006:30). The important factor to consider when incubating eggs is to monitor and control the temperature.

Substrate used to successfully hatch Water Dragons include slightly damp sand, damp vermiculite or using the suspension method (Aland 2008:464). A 50/50 blend (by weight) of vermiculite and water is the recommended incubation media used by most breeders. The species has also been incubated in soil kept at room temperature (Longley 1947:29, Harlow and Harlow 1997:17).

11.2 Incubation Temperature and Humidity

Nest temperatures recorded by Meek et. al. (2001:26) of wild Water Dragons indicate that incubating eggs have daily temperature fluctuations of between 0.6-2.8°C and that eggs are subjected to a wide range of temperature over the term of incubation; from as low as 22°C one day to 32°C on another. Water Dragon eggs can be hatched under natural ambient temperatures outdoors in soil (Harlow and Harlow 1997:17) as well as within an unheated vivarium which has direct morning sun (Longley 1947:29). Incubating the eggs at room temperature has been recorded by Harlow and Harlow (1997:17) as taking between 85-120 days.

Water Dragon eggs can be hatched at between 56-64 days at 20-31°C (Aland 2008:466) Incubation at 28°C with a 50/50 mix (by weight) of water and vermiculite (actual humidity is not recorded however should be kept high) is recommended by Goulding and Green (2006:30-1).

11.3 Desired % Egg Mass Loss

Not applicable to reptiles.

11.4 Hatching Temperature and Humidity

The incubator temperature and humidity do not need to be changed to assist hatching. Full spectrum UVB lighting should be provided as well as a spotlight at one end of the hatchlings enclosure. A thermo-gradient of 18-20°C at the cool end and no higher than 32°C under the spot light should be provided to the hatchlings as soon as they are free from the eggs.

11.5 Normal Pip to Hatch Interval

The pip to hatch ratio has not been recorded for Australian Water Dragons.

11.6 Diet and Feeding Routine

From hatching, Water Dragons will feed only on live insects of an appropriate size; about one quarter the size of the hatchlings head. As the lizards grow, the size of the insects offered should be increased appropriately. Hatchlings should be fed 4-6 insects every second day and should be separated into smaller groups if they are kept in large groups in order to ensure that all animals receive sufficient food.

Finely diced vegetables (as recommended for adult specimens; see Section 6.2) should be offered twice a week on a dish or shallow bowl. Food should be removed after four hours of being offered. Secondary feed bowls should be used if more than four individuals are being housed together. Pre-made 'dragon pellets' formulated for juvenile Agamids are readily eaten and is a great source of nutrition.

Providing a lettuce leaf to hatchlings provides little nutritional benefit to young dragons, however it allows healthy jaw development and is a good source of water. Once a fortnight a feed should be supplemented with vitamin and calcium supplement added. At the Australian Museum a mix of 50/50 vitamin powder and calcium powder is used once a fortnight and is either sprinkled on the food or coated on live insects by shaking them together with the powder in a plastic bag.

Small crickets and roaches are usually used to feed young Water Dragons, however small worms, isopods, caterpillars, earwigs and cake crumbs have also been fed to hatchlings (Longley 1947:29).

11.7 Specific Requirements

The use of sand instead of newspaper as an enclosure substrate prevents uneaten crickets from hiding beneath the paper. Hatching Water Dragons are vigorous diggers and will excavate numerous depressions over a small area, any heavy furnishings such as rocks and logs should be firmly secured in order to prevent such heavy objects from shifting and crushing the animals.



Image 21. Juvenile Eastern Water Dragon, *P. l. lesueurii*. Photo: Rebekah Hosking.

Lighting globes or batons used should provide an adequate balance of UVA/UVB radiation in order to provide vitamin D and metabolise calcium for growing lizards. Section 8.4 (page 35) covers metabolic bone disease. Most batons and globes will only emit a beneficial level of UV for 6-12 months so the packaging should be checked and the date of installation should be recorded (Walls 2007:66-7). Temporarily housing young dragons outside under natural sunlight is another way to provide adequate UV exposure. Mesh enclosures and small aviaries can be used to contain the lizards for a few hours a week. A water bowl and shaded refuge should be provided at all times in order to prevent dehydration and overheating.

11.8 Data Recording

Accurate record keeping is an important part of captive animal management, particularly during the early stages of an animal's life. The following data should be recorded as much as possible in order to establish trends and improve husbandry.

- Incubation time and temperature.
- Number of eggs as well as the mass and length of each.
- Pip to hatch interval.
- Mass, Total Length (TL) and Snout Vent Length (SVL) of hatchlings
- Growth data.
- Food offered and taken.
- Behavioural notes.

11.9 Identification Methods

Hatchling Water Dragons look very similar when young and are therefore hard to tell apart. Hatchling dragons are generally too young to implant with a microchip identifier, however images can be taken of each animal and the distinctive features of each animal can be recorded. This information should be sufficient to distinguish each animal from the rest.

11.10 Hygiene

If newspaper is used it should be replaced daily to prevent faecal build-up. When sand or another form of substrate is used, the soiled section should be removed daily and replaced as needed. Such substrates should be completely changed out between breeding seasons. Uneaten crickets should be removed within 4 hours of being offered. Hatchlings will sit in and foul their water dishes so the dish should be cleaned and refilled every day.

11.11 Behavioural Considerations

From hatching, young Water Dragons will regularly be observed digging in substrate and sitting in water bowls. They will signal to each other through head bobs and 'salutes'.

Young Water Dragons will hide behind, beneath and inside furnishings. However by the age of approximately three to six months of age they will increasingly try to stay elevated, especially to sleep. Therefore the young of this species should not be kept in standard fish aquariums unless the hood is completely sealed and will prevent the young animals from escaping. A series of angled branches and elevated shelves should be provided in order for the lizards to express their arboreal habits.



Image 22. Juvenile Eastern Water Dragon, *P. I. lesueurii* under a suburban house.

Photo: Ian Dihm.

Hatchlings that occur as a second clutch should not be housed with the hatchlings of the first as there will be a considerable size difference which can lead to the smaller lizards not being able to sufficiently feed.

Lightly spraying hatchlings with water can be done on a daily to weekly basis in order to keep the young lizards hydrated as well as an enrichment activity.

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Image 23. Male Eastern Water Dragon, *Physignathus l. lesueurii*. Photo: Rebekah Hosking

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Glossary

Agamid – A member of the family Agamidae, one of the five families of Australian lizards commonly known as dragon lizards.

Arboreal – Tree dwelling.

Basking – Remaining in one location to receive heat or UV light from the sun or device.

Thermo gradient – A difference in temperature (usually of about 10-12°C) over a measured area (such as an enclosure).

Nuchal crest – A collection of spike located behind the head and back of the neck.

Spinose scale – Scales of elongated and triangular appearance. Often coloured different to surrounding regular (non spinose) scales.

Cloaca – singular vent located between the hind legs (or at the base of the tail in the case of snakes) occurring in amphibians, reptiles, monotremes and birds. Both the reproductive organs and the end of the digestive tract are located within this singular hole.

Varanid – A member of the family Varanidae, one of the five families of Australian lizards commonly known as monitor or goanna lizards.

Gravid – A female carrying eggs.

Brumation – A phase in the life cycle as known as ‘hibernation’ whereby an animal becomes inactive, stops feeding and retreats from view into a secure hiding place (usually during colder months),

Necrotic stematosis - Also known as Canker or Mouth rot, a bacterial infection effecting the jaw and or teeth of reptiles, often caused by an initial injury which exposes the area to infection.

Bacteria – One of the five kingdoms of life consisting of single cell prokaryotic (without nucleus) organisms which occur in all environments on earth and have a variety of ecologies. Some bacteria can create problems for both human (as a form of Zoonosis) and non-human animals.

Supplements – Any added nutrient provided in addition to normal diet such as calcium and vitamins.

Mites Snake Mite – Common species include *Ophionyssus natricis*, a parasitic Arachnid of concern to Herpeticulturalists.

Arachnid – An arthropod with two body segments and eight legs. This group also includes spiders, scorpions, ticks among others.

Enclosure – An area with defined boundary.

Hygiene – A desired state or required level of sanitation or cleanliness.

Protocol – A defined procedure of action to be taken under defined situations.

Ventral - A term describing the bottom side of an animal or object.

Dorsal - A term describing the top side of an animal or object.

Lateral – A term describing one or more parallel sides of an animal or object (for example a an image of a dog standing on its side with tail at one end and head at the other is a lateral view).

Zoonosis – An infection caused by contact with organisms such as viruses, bacteria, protozoa, fungi as well as internal and external invertebrate parasites.

Antibiotics – Drugs used to kill bacterial and fungal infections.

Substrate – Any loose or removable material used to cover the floor of an enclosure or garden area.

Sloughing – The act of removing the outer cuticle of the skin in order to allow an animal to grow.

Quarantine – A state of isolation intended to stop the spread of parasites and pathogens in the captive environment.

Thermo-regulate – A process where an animal will move around its environment to attain a desired temperature. Basking will occur to warm up and hiding in the shade allows an animal to cool down. Animals such as reptiles will also regulate their behaviour and movements in order to thermo-regulate the best.

Hemipenes – A pair of male sexual organs possessed by snakes and lizards.

Squamata – The reptilian Order which snakes and lizards belong to, characterised by the presence of hemipenes.

Nocturnal – Active mainly during the day.

Diurnal – Active mainly during the day.

Listlessness – Lack of normal activity as well as inability to sit, balance or rest without undue effort. Often a sign of stress, illness or injury.

Oviposition - The deposition of eggs from a females body to the outside world, usually into a nest.

Palpation – A gentle feeling around an animals body in order to detect the presence of eggs or any abnormalities within the body.

Appendix 1. Annual Cycle of Maintenance Activities

Activity	Month											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Breeding Season	■								■	■	■	■
Enclosure Repairs						■						
Enclosure Renovations						■						
Full Cleaning of Enclosure								■				
Routine Health Checks (Monthly)	■	■	■	■	■	■	■	■	■	■	■	■
Annual Vet Checks								■				

- Breeding season between September and January.
- Enclosure Repairs done over June while animals are in brumation.
- Enclosure Renovations are done in June before emerging from brumation and the beginning of the breeding season.
- Full Cleaning of Enclosure and Annual Vet checks are done in late August as the animals begin to become more active before the breeding season starts again.
- Routine Health Checks done monthly (see Chapter 8).

Appendix 2. Suggested Enrichment Calendar for Water Dragons.

1	2	3	4	5	6	7	8	9	10
Cricket activity feed			Roach activity feed						
11	12	13	14	15	16	17	18	19	20
	Setup composting feeding cage				Reorganise some or all of the enclosure furnishings				
21	22	23	24	25	26	27	28	29	30
	Setup Mealworm tube					Activate blue light overnight			

Appendix 3. IATA Live Animal Regulations relating to Water Dragons.



Container Requirements

CONTAINER REQUIREMENT 41

The illustrations shown in this Container Requirement are examples only. Containers that conform to the principle of the written guidelines for the species but look slightly different will still meet the IATA standards.

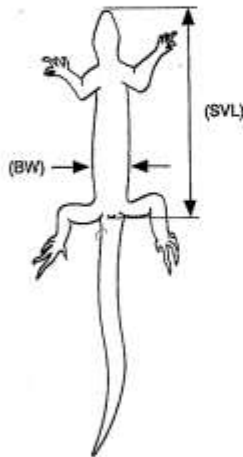
Applicable to Lizards and Tuataras

See *USG Exceptions in Chapter 2 and Exceptions CO-01 and UA-05 in Chapter 3.*

The following instructions must be complied with in addition to the principles laid down in the General Container Requirements for Reptiles and Amphibians.

Measurement

Lizards (including Chameleons) and tuataras should be measured by snout-to-vent length (SVL) and in body width (BW).



Specific Requirements

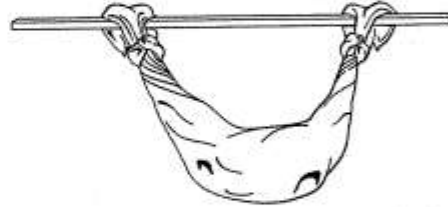
All containers and bags should have some kind of packing material (i.e. crumpled paper). Animals in the same containers or bags should belong to the same size class to avoid damage to smaller individuals.

The maximum number of animals per bag or container must not be increased even when larger bags or containers are used.

Packing Density for Lizards and Tuataras (not including Chameleons and farmed Iguana iguana):

Snouth-vent-length (SVL)	Body-width (BW)	Maximum no. of animals per bag	Minimum bag size
≥ 20 cm (8 in)	≥ 5 cm (2 in)	1	Depending on the size of the animal
≥ 15 < 20 cm (6 < 8 in)	≥ 2.5 < 5 cm (1 < 2 in)	15 10	45 × 60 cm (18 × 24 in) 30 × 45 cm (12 × 18 in)
≥ 10 < 15 cm (4 < 6 in)	< 2.5 cm (1 in)	30 20	45 × 60 cm (18 × 24 in) 30 × 45 cm (12 × 18 in)
< 10 cm (4 in)	< 2.5 cm (1 in)	30	30 × 45 cm (12 × 18 in)

If the bag is suspended the bag must be suspended horizontally from opposite ends of the bag the maximum number of animals per bag should be divided by two.



For lizards, rigid containers can be used instead of bags with a maximum of 25 animals, under the same conditions for the snake containers.

Arboreal geckos will be provided the use of the surface area of the floor and wall space of rigid containers.

Large Animals

Lizards whose length range from 90–120 cm (36–48 in) SVL require double bags for shipping.

Lizards of 120 cm (48 in) or more in length must follow the same primary enclosure requirements as crocodiles excluding the taping or banding of the mouth.

The direction of the head should be indicated on the outer enclosure.

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CONTAINER REQUIREMENT 41 (cont'd)

Lizard species that should be packed singly because they are either aggressive, cannibalistic or delicate:

- Malagasy leaf geckoes (*Uroplatus* spp.)
- New Caledonian giant geckoes (*Rhacodactylus* spp.)
- Asian gliding agamid (*Draco* spp.)
- Sail-finned lizard (*Hydrosaurus* spp.)
- Angle-headed dragon (*Gonocephalus* spp.)
- Helmeted basiliscs (*Corytophanes* spp.; *basiliscus* spp.)
- (except hatchlings and juveniles)
- Caiman lizard (*Dracaena* spp.)
- Emerald tree monitor lizard (*Varanus prasinus*)
- Black tree monitor lizard (*Varanus beccarii*)
- Solomon Island pre-hensile tailed skink (*Corucia zebrata*)

Venomous lizards that must be handled and packed like venomous snakes (see Container Requirement 44), these are:

- Gila monster, beaded lizard (*Heloderma* spp.)

Specific Requirements for Chameleons including African Dwarf Chameleons (*Rhampholeon*) and Malagasy Dwarf Chameleons (*Brookesia*)

All species with the exception of young and small specimens (see below) must be packed individually.

Chameleons 10 cm (4 in) or greater in SVL need to be packed in adequate space to rest naturally. The enclosure needs to conform to the body shape and size. Specimens should be packed one per inner enclosure. The inner enclosure may be cloth, woven material, or rigid container. Crushed or crumpled paper must fill at least 25% of inner enclosure.

Chameleons of 2.5–10 cm (1–4 in) in SVL must be packed one per inner enclosure. Inner enclosures may be fibrous woven tubes with each open end of tube securely enclosed in a manner that can be resealed, cloth, rigid container, or heavy gauge paper enclosures. Heavy gauge paper should be defined as a container that is sufficient to hold specimens without escape.

Inner enclosures must be easily opened and closed. If heavy gauge paper enclosures are used as inner enclosures, they must be secured to a frame of support bars in the primary or outer enclosure with tacks or nails with head diameter of at least 0.6 cm (¼ in). No burlap (hessian) bags as inner enclosures are permitted.

Chameleons less than 2.5 cm (1 in) SVL can be packed with a maximum of 10 per 0.5 liter rigid enclosure. At all times, the specimens must be able to have full contact with the container floor. At least 50% of the inner enclosure must be filled with loosely crumpled paper.

Crushed or crumpled paper must be provided to ensure a foothold for the animal.

Packing Density for Farmed Green Iguanas (*Iguana iguana*)

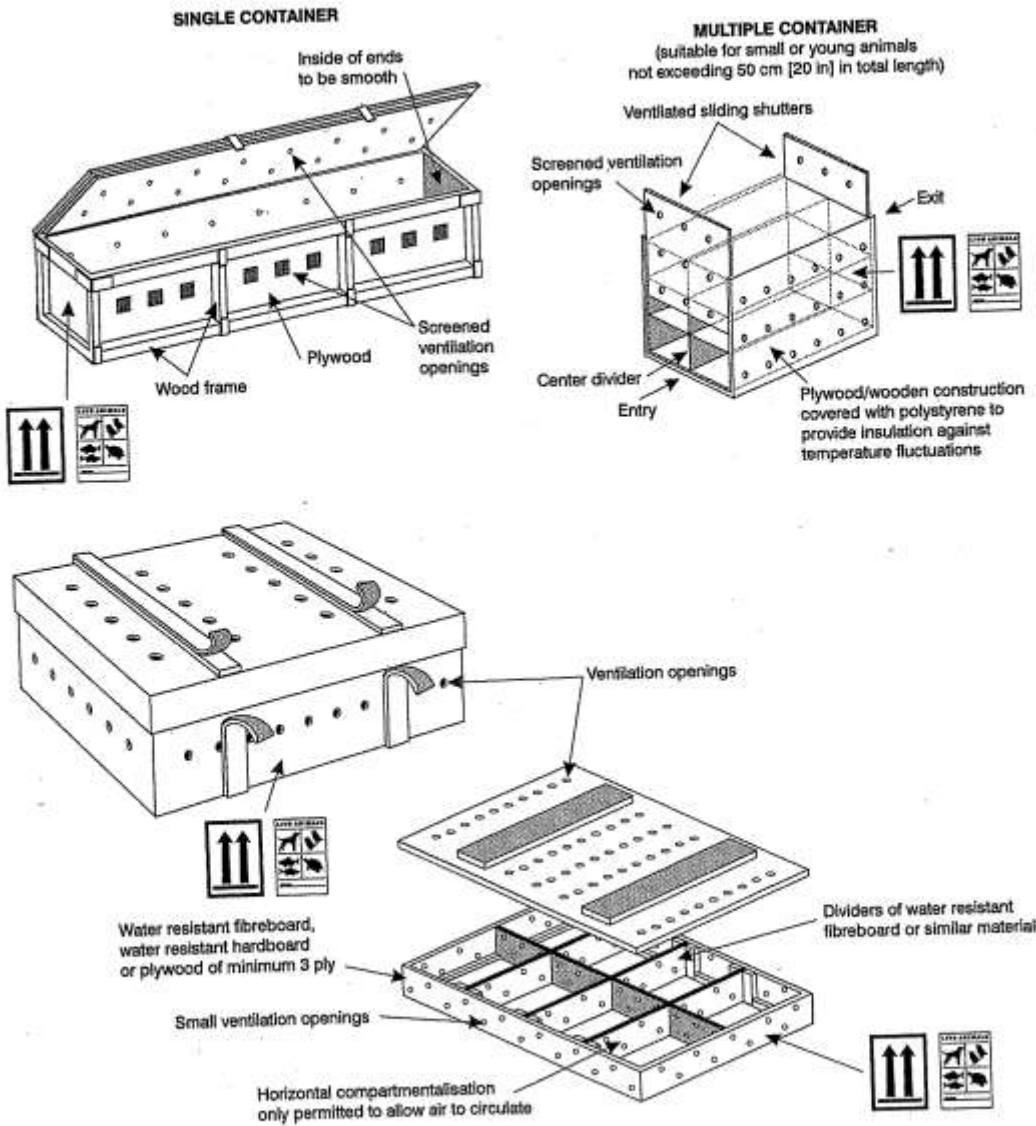
Since farmed Green Iguanas (*Iguana iguana*) are usually in good condition, free of diseases and used to handling, the use of following special packing density is allowed.

Snout-vent-length (SVL)	Maximum no. of animals per bag/ box	Minimum bag size	Minimum box size
> 25 cm (10 in)	1	Depending on the size of the animal	—
> 20 cm (8 in)	6	45 x 85 cm (18 x 34 in)	—
> 17.5 cm (7 in)	6	30 x 60 cm (12 x 24 in)	20 x 40 x 9 cm (8 x 16 x 3½ in)
> 12.5 cm (5 in)	20	30 x 45 cm (12 x 18 in)	20 x 40 x 6.5 cm (8 x 16 x 2½ in)
> 10 cm (4 in)	30	30 x 45 cm (12 x 18 in)	20 x 40 x 4.5 cm (8 x 16 x 1¾ in)
> 8.75 cm (3.5 in)	40	30 x 45 cm (12 x 18 in)	20 x 40 x 4.5 cm (8 x 16 x 1¾ in)
0–8.75 cm (3.5 in)	50	30 x 45 cm (12 x 18 in)	20 x 40 x 4.5 cm (8 x 16 x 1¾ in)

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CONTAINER REQUIREMENT 41 (cont'd)

EXAMPLE:

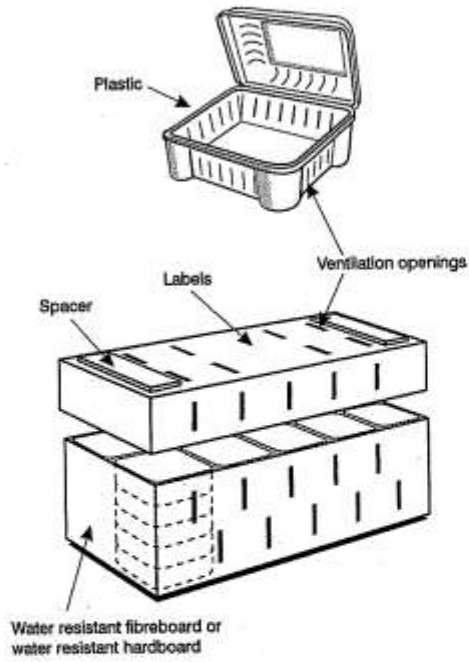


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CONTAINER REQUIREMENT 41 (cont'd)

MULTICOMPARTMENT CONTAINER



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Appendix 4. Materials Data



TECHNICAL DATA SHEET

REPTILE ENCLOSURE INSECTICIDE

Code 4502/100/R

(Top of Descent) Spray For Killing & Control of Mites

APVMA Approval No. 59308/100g/0108

DESCRIPTION

Reptile Enclosure Insecticide (Top of Descent) effectively and safely kills and controls mites. The aerosol spray leaves an invisible residue that works against mites as well.
Active Constituents: 20g/kg d-phenothrin 20:80

ADVANTAGES

- APVMA Approval No. 59308/100g/0108
- Complies with WHO specifications for insecticides.
- Has Aircraft Approvals e.g. Boeing Approval.
- Approved by Australian Quarantine & Inspection Services.
- Approved by the NZ Ministry of Agriculture & Fisheries.
- The propellants have been tested and approved by the PAFT Committee.
- Scientifically evaluated by University of Western Sydney.
- Low toxicity, safe for humans and reptiles.
- Effectively kills and controls mites.
- Non-flammable.
- No need to rinse off after application.
- Aerosol spray easy for application.

DIRECTIONS FOR USE

- Remove water bowl/tub from the enclosure before spray, clean it and leave it out for 24 hours.
- Remove the reptile from the enclosure.
- Spray the interior of the enclosure to form enough fume in the enclosure.
- Suggest spray 2-3 seconds for a standard 2 x 3 foot size enclosure.
- Leave the enclosure closed for 10-15 minutes, then return the reptile.
- After 24 hours, return the water bowl/tub to the enclosure.
- After another 48 hours, clean out enclosure and destroy any substrate (it helps to remove mite eggs).
- Spray the enclosure surrounding area as well.

- Do not rinse the enclosure and the reptile after spray.
- Re-spray the enclosures about seven days later after first application, a third application might be necessary depends on the situation.

Other Tips

- After treating the reptile and the enclosure, spray a line around the enclosure to create a barrier.
- Frequently (every day or two) spray around the enclosure to keep the barrier working during treatment.
- Suggest use paper as bedding during treatment so that change bedding is easier.
- Do not wait to treat mites as they are No.1 killers of reptile.

SAFETY PRECAUTIONS

Keep the can away from direct heat as the can is pressurised.

Avoid contact with eyes and skin.

Wash hands after application.

PACKAGING

Available in 100gm aerosol can. 12 cans each carton.

WARRANTY – All statements, information and data presented herein are believed to be accuracy and reliable but are not to be taken as a guarantee, expressed or implied, for which seller assumes legal responsibility and they are offered solely for your consideration, investigation and verification. Statements or suggestions concerning possible use of this product are made without representation or warranty that any such use is free of patent infringement and are not recommendations to infringe on any patent.

10 October 2008

CALLINGTON HAVEN PTY LTD

Incorporated in New South Wales

ACN 000 632 404 ABN 28 000 632 404

30 South Street Rydalmere NSW 2116

PO Box 144 Rydalmere NSW BC 1701 Australia

T: (61-2) 9898 2788 F: 9684 4215

E: enquiries@calhaven.com.au W: www.callingtonhaven.com

MATERIAL SAFETY DATA SHEET**COMPANY DETAILS**

AUSTRALIAN DISTRIBUTOR:
 COMPANY: Chemical Essentials (Pty) Ltd
 Address: 13 Abella Str, Doncaster East,
 Victoria 3111
 Emergency Telephone number: +03 9841 9901
 Fax: +03 9841 9909

MANUFACTURER:

Health and Hygiene (Pty) Ltd
 P O Box 347, Sunninghill 2157,
 South Africa.
 Tel: +27 11 474-1668
 Fax: +27 11 474-1670
 e-mail: info@healthandhygiene.co.za

IDENTIFICATION

PRODUCT NAME: **F10SC VETERINARY DISINFECTANT**

UN Number: None

OTHER NAMES: **F10 SUPER CONCENTRATE DISINFECTANT**

D G Class: None

Hazchem code: None

Poisons Schedule: 5

**HAZARDOUS ACCORDING TO CRITERIA OF WORKSAFE AUSTRALIA IN THE PACK CONCENTRATE ONLY
 (eyes and skin irritant)**

USE: Biodegradable multi purpose Disinfectant for all hard surfaces, equipment and airspaces

PHYSICAL DESCRIPTION/PROPERTIES

Appearance: Clear, colourless liquid, with a slight natural odour.
 Boiling Point: 110°C
 Vapour Pressure: Not known
 Specific Gravity: 1.00
 Flash Point: Not flammable
 Flammability Limits: Not flammable
 Solubility in water: Soluble

INGREDIENTS

	CAS Number	Quantity (w/w)
Benzalkonium Chloride	68424-85-1	5.4%
Biguanide	27083-27-8	0.4%
Ingredients not determined to be hazardous		to 100%

HEALTH HAZARD INFORMATION**HEALTH EFFECTS:****Acute**

SWALLOWED: Low. Substantial ingestion may cause irritation to mouth, throat and digestive tract.

EYE: Low. Will cause irritation but not serious damage.

SKIN: Low. Concentrate may act as mild degreasant to sensitive skin.

INHALED: Low. No significant hazard.

Chronic

INHALED: Low. No significant hazard

FIRST AID

SWALLOWED: DO NOT induce vomiting. Give milk or water to drink. Seek medical advice where necessary.

EYE: Rinse eyes with water. Seek medical advice where necessary.

SKIN: Wash affected area with soap and water.

INHALED: Non-toxic. Avoid long term inhalation of neat liquid. Remove to fresh air.

FIRST AID FACILITIES: Contact a doctor or Poison Information Centre (phone 131126)

ADVICE TO DOCTOR: Treat symptomatically

**F10SC VETERINARY DISINFECTANT
F10 SUPER CONCENTRATE DISINFECTANT**

PAGE 2 OF 2

PRECAUTIONS FOR USE

EXPOSURE LIMITS: No data found
Engineering controls: None required
PERSONAL PROTECTION: Not required
FLAMMABILITY: Not Flammable

SAFE HANDLING INFORMATION

Storage and Transport: Store below 30°C in dry conditions
SPILLS AND DISPOSAL: Soak up on an inert material e.g. dry earth and dispose of in an area approved by local authority by-laws. Flush small spills with copious amounts of water
FIRE/EXPLOSION HAZARD: The product is not flammable or explosive.
OTHER INFORMATION: Ensure good industrial hygiene.
DO NOT mix with soaps or other chemicals.

CONTACT POINT: Managing Director, +03 9841 9901
Chemical Essentials Pty Ltd

KEEP OUT OF THE REACH OF CHILDREN

Issue number: 2
Issue Date: August 2004

MATERIAL SAFETY DATA SHEET – BLEACH

STATEMENT OF HAZARDOUS NATURE

Not classified as hazardous according to criteria of WorkSafe Australia.

COMPANY DETAILS

Company: CHEMICAL FORMULATORS PTY. LTD.
 A.C.N. 008 905 119
 Address 7 Kirke Street, Balcatta, WA 6021.
 Phone (08) 9344 2455
 Fax (08) 9344 4360

IDENTIFICATION

Product Name : BLEACH
 Other Names : Hypochlorite Solution
 UN Number : None allocated
 Dangerous Goods Class : None allocated
 Subsidiary Risk : None allocated
 Hazchem Code : None allocated
 Poisons Schedule : None allocated
 Use : Bleach

Physical Description / Properties

Appearance : Clear liquid (chlorine odour)
 Boiling Point : Above 100°C
 Vapour Pressure : Not Available
 Specific Gravity : 1.05
 Flashpoint : Not Relevant
 Flammability Limits : Not Relevant
 Solubility Limits : Miscible in all proportions.

Other Properties:

Corrosiveness : Corrosive to non-ferrous metals & fabric
 pH (undiluted) : 12.5

Ingredients

All hazardous substances as defined by the NOHSC Code are listed by chemical name and CAS No. Other ingredients which are determined to be non-hazardous are listed by generic name or as non hazardous ingredients.

Chemical Name:	CAS No:	Proportion:
Sodium Hypochlorite	7681-52-9	Less than 10%
Water		Up to 100%

HEALTH HAZARD INFORMATION

Health effects

Acute:

Swallowed : Corrosive. Causes burns to mouth, throat and gastro-intestinal tract.
 Eye : Very corrosive. Causes severe burns. Risk of serious damage to eyes.
 Skin : Corrosive. Causes severe burns.
 Inhaled : Corrosive mist.

Chronic:

Prolonged exposure to low concentration solutions may cause skin irritation to skin, eyes and mucous membranes.

First Aid

Swallowed:

Contact a Doctor or Poisons Information Centre. Do NOT induce vomiting. Give a glass of water. Repeat if vomiting occurs. If the patient is not fully conscious do not give anything by mouth.

Eye:

In case of contact with eyes, rinse immediately with plenty of water and contact a doctor or Poisons Information Centre. Get urgent medical attention.

Skin:

Remove contaminated clothing immediately and wash skin thoroughly with water.

Inhaled:

Leave contaminated area.

First Aid Facilities:

Eye wash. Fresh water.

Advice to Doctor:

Corrosive product. Treat chemical burns if present.

PRECAUTIONS FOR USE

Exposure Standards:

No value assigned for hypochlorite solution by Worksafe Australia

Engineering Controls:

Avoid generating and inhaling mists without appropriate ventilation.

Personal Protection:

Avoid contact with the skin and eyes. Avoid breathing mist. Wear face shield, overalls or apron, protective footwear and natural rubber or PVC gloves when using undiluted product.

Flammability:

Not flammable or combustible.

SAFE HANDLING INFORMATION

Storage and Transport:

Store in a cool, well ventilated area away from all other chemicals, keep containers closed at all times.

Spills and Disposal:

May be flushed to sewer with water but prevent larger spillages from entering stormwater drains or water courses. To contain spillages, absorb on sand or similar absorbing material, such as Attapulgate, and collect in drums. Residues may be flushed away with water.

Fire/Explosion Hazard

Not applicable as product is non-combustible.

Other Information

Do not mix with acids as toxic chlorine gas may be liberated.

This MSDS is valid for five years from date of issue but readers should contact Chemform to ensure that this is the latest issue. As per the Worksafe Guidance Note NOHSC 3017, each user should review the information in the specific context of the intended application.

Contact Point: Technical Manager (08) 9344 2455

ISSUE DATE: APRIL 2001

Material Safety Data Sheet

Betadine® Solution
(10% povidone iodine) Version: 14-July-05

1. CHEMICAL PRODUCT/COMPANY IDENTIFICATION

Material Identification: Betadine® Solution (10% povidone iodine)

Chemical Name

1-(2-hydroxy-2-pyrrolidone) homopolymer compound with iodine

Synonyms

P57-1

Molecular Formula: (C₄H₆NO)_nI₂

Molecular Weight: not available

CAS Number: 25655-41-8

Product Use: topical microbicide

Company Identification

Manufacturer

Purdue Products L.P.
One Stamford Forum
201 Trosser Boulevard
Stamford, CT 06901-3431
Telephone: (888) 726-7535

EMERGENCY CONTACT

Chemtec (800) 424-9300. For all international transportation emergencies call Chemtec collect at (703) 527-3882.

2. HAZARDOUS COMPONENTS

Material	CAS Number	%
1-(2-hydroxy-2-pyrrolidone) homopolymer compound with iodine	25655-41-8	5.0-5.5
contains either of the following:		
glycerin	56-81-5	
parath 25-0	68131-39-5	

3. Hazards Identification

1 of 8; Betadine Solution (10% povidone iodine) MSDS

Purdue Products L.P.

Remove contaminated clothing. Flush skin with plenty of water and wash thoroughly with soap and water. If irritation (redness, itching, swelling) develops, seek medical attention. Wash contaminated clothing before reuse.

EYE CONTACT

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. If easy to do, remove contact lenses. Get medical attention.

INGESTION

If swallowed, do not induce vomiting. Drink several glasses of milk or water. Never give anything by mouth to an unconscious person. Get medical attention.

Notes to Physicians

No special first aid. Provide supportive measures.

5. Fire Fighting Measures

Flammable Properties

Non-Flammable.

Extinguishing Media

Water spray, carbon dioxide, dry chemical powder, or foam as appropriate for the surrounding material.

Fire Fighting Instructions

Evacuate personnel to a safe area. Move containers from area if it can be done without risk. Wear protective clothing and positive-pressure, self-contained breathing apparatus with full protective gear.

6. Accidental Release Measures

Safety (Personal)

NOTE: Review FIRE FIGHTING MEASURES and HANDLING (PERSONNEL) sections before proceeding with clean-up. Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean-up to minimize exposure to this material. Evacuate personnel from the area.

Initial Containment

Prevent material from entering sewers, waterways, or low areas. Dike area for later disposal.

Spill Clean-up

Wear suitable protective clothing and equipment. Vacuum or mop up liquid and place in a container suitable for chemical waste; avoid generation of aerosols. Place collected material into a suitable container for disposal. Thoroughly wash

3 of 8; Betadine Solution (10% povidone iodine) MSDS

Emergency Overview

Normal handling should not constitute a hazard. The following information is provided for those circumstances where uncontrolled exposure may occur.

Reddish-brown, clear liquid

Characteristic odor

Harmful by inhalation, skin contact, or ingestion

May cause eye irritation and mild skin irritation

Target organs: respiratory system, gastrointestinal tract, skin, eyes, kidneys, thyroid.

Potential Health Effects

Betadine® Solution is a topical microbicide. Its active ingredient is povidone iodine.

Betadine® Solution is generally non-irritating to skin. However, prolonged exposure to wet solution may cause irritation or, rarely, severe skin reactions. Povidone iodine may cause skin sensitization. Betadine® Solution may cause eye irritation.

Prolonged contact of large skin areas with Betadine® Solution may lead to excessive absorption of iodine and should be avoided.

Overexposure from breathing aerosols and/or iodine vapors may cause irritation to the respiratory tract, bronchitis and absorption through the lungs.

High concentrations of iodine in the blood from inhalation or ingestion may cause thyroid disorder (hyperthyroidism), renal disturbances, acidosis, and electrolyte disturbances such as increased iodine levels and severe hypotension.

Conditions that may be aggravated by exposure to povidone iodine: asthma, chronic bronchitis, and thyroid disorders.

Carcinogenicity Information

None of the components of Betadine® Solution are listed by IARC, NTP, OSHA, or ACGIH as a carcinogen.

4. First Aid Measures

First Aid

INHALATION

If aerosols or iodine vapor are inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

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area with detergent and water. Dispose of all solid waste and wash and rinse water in accordance with federal, state, and local regulations.

7. Handling and Storage

Handling (Personal)

Avoid procedures that will generate aerosols. Do not get in eyes, on skin, or on clothing. Wash thoroughly after handling. Wash contaminated clothing after use. Use with adequate ventilation.

Handling (Physical Aspects)

Close container after each use. Do not generate aerosols.

Storage

Store in an airtight container. Keep container closed. Store at room temperature. Keep from contact with oxidizing materials.

8. Exposure Controls/Personal Protection

Engineering Controls

Handle material under adequate ventilation. Keep container tightly closed.

Personal Protective Equipment

Wear safety glasses with side shields. Wear full-face protection when judged that the possibility exists for eye and face contact.

Wear an appropriate NIOSH-approved air purifying respirator or positive pressure air-supplied respiratory in situations where a respirator is judged appropriate to prevent inhalation.

Wear impervious clothing such as gloves, lab coat, shoe covers, apron, or jumpsuit, as appropriate, to prevent skin contact. Consult the site safety professional for additional guidance, as needed.

Exposure Guidelines

Exposure Limits

None established for Betadine® Solution.

None established for Povidone iodine.

None established for Parath 25-0.

For Iodine:

PEL (OSHA): 0.1 ppm

TLV (ACGIH): 0.1 ppm

For Glycerin:

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Haz Chem Unit EYE In or min ING If or Sec Notes to PH No s Flammable Non Extinguish Water Fire Fight Evac with hose Spill Clean Wipe place Place 2 of 3 Data	Purdue Products L.P.
	PEL (OSHA): 15 mg/m ³ , total dust 3 mg/m ³ , respirable fraction TLV (ACGIH): 10 mg/m ³ (total)
	Exposure Guidelines Comments none
	9. Physical and Chemical Properties
	Physical Data Odor: slight characteristic Form: liquid Color: reddish brown Vapor Pressure: no information available Melting Point: no information available Solubility: soluble in water and in alcohol
	10. Stability and Reactivity
	Chemical Stability Low stability based exposure at normal operating temperatures.
	Reactivity A mixture of equal parts of a 10% povidone iodine solution and hydrogen peroxide 3% oxidized about 100 minutes after mixing.
	Incompatibility with Other Materials Strong oxidants or reducing agents
	Decomposition Will not decompose under conditions of usual handling.
	Polymerization Material will not polymerize.
	11. Toxicological Information
	Animal Data Irradiation Solution has not undergone toxicity testing in animals. The information presented below is for povidone iodine, glycerin and parab 25-9.
	Skin/Eyes Povidone iodine Povidone iodine has been reported to be a mild skin and eye irritant in animals. Glycerin Glycerin has been reported to produce mild skin and eye irritation in rabbits.
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Haz Chem Unit EYE In or min ING If or Sec Notes to PH No s Flammable Non Extinguish Water Fire Fight Evac with hose Spill Clean Wipe place Place 2 of 3 Data	Purdue Products L.P.
	Glycerin No information available.
	Parab 25-9 No information available.
	Corrosivity Povidone iodine No information available.
	Glycerin No information available.
	Parab 25-9 No information available.
	Mutagenicity/Genotoxicity: Povidone iodine Bacterial mutagenicity: negative Ames screen (S-metast): negative Dominant lethal assay (mouse): negative Mouse lymphoma: negative Mouse micronucleus: negative
	Glycerin Bacterial mutagenicity: negative
	Parab 25-9 No information available.
	Developmental/Reproductive Toxicity Povidone iodine No information available.
	Glycerin No information available.
	Parab 25-9 No information available.
	12. Ecological Information
	Ecotoxicological Information No information available.
	Chemical Fate Information
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	Parab 25-9 No information available.
	Acute Povidone iodine Oral LD ₅₀ rat: 18 g/kg Oral LD ₅₀ mouse: 8.1 g/kg Intravenous LD ₅₀ rat: 840 mg/kg Intravenous LD ₅₀ mouse: 400 mg/kg Intravenous LD ₅₀ rabbit: 110 mg/kg
	Glycerin Oral LD ₅₀ rat: 12.6 g/kg Oral LD ₅₀ mouse: 4.1 g/kg Intravenous LD ₅₀ rat: 3.6 mg/kg Intravenous LD ₅₀ mouse: 4.2 mg/kg Dermal LD ₅₀ rabbit: >10 g/kg
	Parab 25-9 No information available. Parabens are substituted long-chain alcohols and are reported to have low acute oral toxicity, e.g., the acute oral LD ₅₀ for Parab 25-9 is 2000 mg/kg.
	Subacute Subchronic Toxicity Povidone iodine In a 13-week dietary study in rats, ingestion of povidone iodine at an average povidone iodine dosage of approximately 75 to 750 mg/kg/day produced a dose-dependent increase in serum protein-bound iodine and nonspecific, reversible microscopic changes in the thyroid. No other gross or microscopic povidone iodine-induced changes were observed. At equivalent iodine dosages, dietary potassium iodide produced similar thyroid changes of equal or greater severity.
	Glycerin No information available.
	Parab 25-9 No information available.
	Chronic Chronic Toxicity Povidone iodine No information available.
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	No information available.
	13. Disposal Considerations
	Disposal This material is not listed under US RCRA. Disposal of this material must be in accordance with federal, state/provincial, and local regulations.
	14. Transportation Information
	Shipping Information This material is non-hazardous under US DOT.
	15. Regulatory/Statutory Information
	US Federal: none International: none EC Labeling: none FDA: The Approved Drug Products with Therapeutic Equivalence Evaluations List identifies currently marketed drug products, including povidone-iodine, approved on the basis of safety and effectiveness by FDA under Sections 302 and 307 of the Federal Food, Drug, and Cosmetic Act.
	16. Other Information
	The information contained in this Material Safety Data Sheet is believed to be accurate and represents the best information available at the time of preparation. However, no warranty, express or implied, with respect to such information, is made. The data in this Material Safety Data Sheet relate only to the specific material designated herein and does not relate to use in combination with any other material. The data in this Material Safety Data Sheet are subject to revision as additional knowledge and experience are gained.
	This MSDS was prepared for Purdue Products L.P. by the Occupational and Environmental Assessment Section of Purdue Pharma L.P.
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