Western Swamp Tortoise

(*Pseudemydura umbrina*)

Husbandry Manual

Western Swamp Tortoise Husbandry Manual

Taxonomy and Biology

Taxonomy

Common Name:

Western Swamp Tortoise

Scientific Name:

Pseudemydura umbrina

Order:

Pleurodira

Family:

Chelidae

Recent Synonyms:

Emydura inspectata

Other Common Names:

Western Swamp Turtle

Status

ASMP Category:

Critically endangered

IUCN Category:

Critically endangered

EA Category:

Critically endangered
All movements and transfers must be cleared with the Western Swamp Tortoise Recovery Team and the Department of the Environment and Conservation (DEC) and be in line with the Western Swamp Tortoise Recovery Plan (2004).

Wild Population Management:

As per the Western Swamp Tortoise Recovery Plan (2004).

Species Coordinator:

Lyndon Mutter

Studbook Holder:

Bradie Durell

Natural History

1.1 Description:

The smallest of the Australian chelids, *Pseudemydura umbrina* males do not exceed a carapace length (CL) of 155mm or a physical weight of 550g, with females not exceeding 135mm in length (CL) or a physical weight of 410g (Kuchling, 2002). *P. umbrina* hatchlings typically have a carapace length of between 24 and 29mm, with weights ranging from 3.0g to 6.8g.

Pseudemydura umbrina possesses a rather flat carapace along with smooth posterior marginals. A medial depression on the second, third and fourth vertebrals develops when individuals reach adulthood. *P. umbrina* plastrons are relatively large (covering most of the carapacial opening), with a very large intergular scute. The intergular scute, which separates the humeral and gular scutes and partially separates the pectoral scutes, also forms the anterior edge of a Western Swamp Tortoise's plastron. *Pseudemydura umbrina* plastrons also possess a posterior notch.

P. umbrina feet possess well-developed claws on relatively short legs. Legs are covered in scale-like scutes, whilst the neck is covered with horny tubercles. Necks are short, with a large singular scute on top of the head, and two small barbels are located on the chin.

Pseudemydura umbrina colour is highly dependant on the age of the individual and the type of swamp it inhabits. Hatchlings typically possess a carapace that is dark grey and a plastron that is cream and black (generally cream scutes bordered by black margins). Adult carapace colour typically resembles that of the surrounding swamp water, varying from black with a slight maroon trace in the dark waters of sandy swamps to a yellowy-brown colour found in clay swamps. *P. umbrina* plastron colour varies from yellow to brown, and on rare occasions can even be black. Typically there are black margins to the plastron scutes, with black dots often found on the yellow background of the main scute surface. The head and neck of *P. umbrina* is usually light ochre to dark brown in colour, becoming lighter ventrally. Typically the jaw surfaces have a yellowish colouration. Like the head and neck, the limbs of *P. umbrina* are generally light ochre to dark brown in colour (Kuchling, 2002).

1.2 Known Distribution:

The Western Swamp Tortoise is known in only three small nature reserves (Figure 1), Ellenbrook Nature Reserve (Class A Reserve No. 27620), Twin Swamps Nature Reserve (Class A Reserve No. 27621) and Mogumber Nature Reserve, in the South-West of Western Australia.

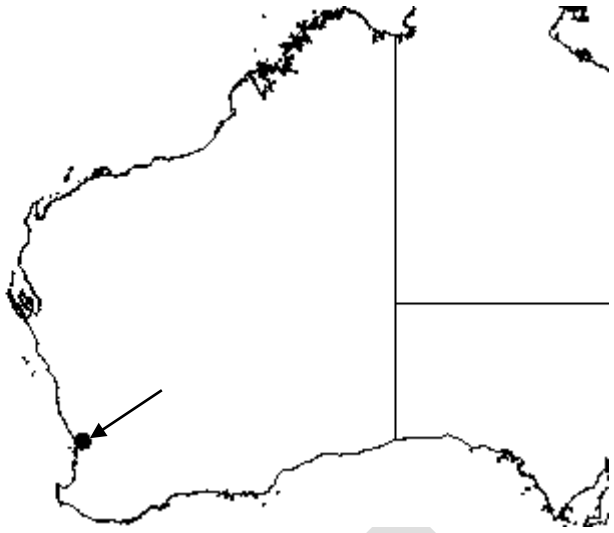

Figure 1. Map of Western Australia highlighting the location of known Western Swamp Tortoise colonies. Wild colonies are only found in Ellenbrook Nature Reserve, Twin Swamps Nature reserve and Mogumber Nature Reserve.

Pseudemydura umbrina has been recorded in the past from various scattered locations in a narrow strip of the Swan Coastal Plain. Running from the Perth Airport at Guildford to the Pearce Royal Australian Air Force Base at Bullsbrook parallel to the Darling Scarp, this narrow strip with largely alluvial soils consists of the only sites where *P. umbrina* have been officially recorded. Anecdotal evidence suggests that the clay soils of the Swan Valley used to be populated by *P. umbrina*, and unsubstantiated sightings suggest that individuals were once found as far North as Mogumber, and to the South in Pinjarra and even Donnybrook (Burbidge, 1967).

1.3 Habitat:

Pseudemydura umbrina inhabit shallow, ephemeral wetlands on clay or sand over clay soils in the Swan Valley region of Western Australia. This region is characterised by a Mediterranean climate (cool, wet winters and hot, dry summers) which provides the winter- and spring-wet swamps (completely dry over summer/autumn) which the tortoises prefer to inhabit.

The preferred ephemeral wetlands are surrounded by wooded areas, which provided suitable locations for the tortoises to aestivate in over the dry period. Typically these areas are dominated by *Banksia* species, which is reflected by the fact that most individuals have been observed aestivating under *Banksia* leaf litter or fallen branches (Burbidge and Kuchling, 2004).

1.4 General Habits:

Being a winter active reptile, *P. umbrina* will seek out and utilise the various micro-climates present in the wetlands for thermo-regulation, in particular the warmer, shallow sections of the swamps. *P. umbrina* are typically diurnal, with increased activity as the waters they inhabit are warmed by the sun. Nearly all activities are undertaken in water (feeding, breeding etc), with the main activities undertaken on land being basking, laying eggs (females) and aestivation.

P. umbrina are quite good climbers, in captivity they have been known to escape from enclosures by climbing up long grass/grass tussocks and wire fences, whilst in the

wild it is apparent that they will scale the fox proof fences erected around their habitat in order to seek more suitable conditions. All known wild populations exist in nature reserves. In general, *P. umbrina*'s terrestrial movement is almost cumbersome or uncoordinated in appearance. They are however capable of traversing over land, and whilst searching for appropriate laying or aestivation sites they have been known to travel a fair distance over dry land (several hundred metres).

1.5 Wild Diet:

Pseudemydura umbrina are carnivorous, predominantly insectivorous, and in the wild they only eat live food such as insect larvae (in particular mosquito larvae) and aquatic invertebrates (*i.e.* small crustaceans- choncostracans and cladocerans, earthworms etc). *P. umbrina* is also known to predate tadpoles in the wild.

1.6 Breeding Behaviour:

Pseudemydura umbrina are solitary in the wild, and mate selection appears to be random and purely opportunistic in nature. Mating and copulation typically begins in autumn, immediately after the ephemeral swamps fill with water, and mating and copulation only occurs in water (Kuchling, 2002). Matings will continue to occur during winter, when the wetlands are at their maximum levels, and will cease as spring arrives and swamps temperatures rise and water level recedes.

Based on observations in captivity, *P. umbrina* exhibits minimal courtship behaviour prior to mating. Courtship displays do not appear to exist as such, although less dominant males have been observed performing some investigation and "sniffing" prior to copulation. Typically upon male/female introduction the commencement of copulation is quite rapid.

Female *P. umbrina* will typically lay their eggs in late spring (October/November and sometimes into early December) just before their wetlands begin to dry out completely. Females will lay one clutch of between 2 and 6 eggs in an underground nest, which unlike other chelonians is actually dug utilising the forelimbs, and these eggs will remain unattended till they hatch out the following autumn (Kuchling and Bradshaw, 1993).

In captivity, females have been known to "double-clutch" in a season, typically laying one clutch of eggs in late October/early November and another clutch of eggs in early to late December. It is not known if "double-clutching" occurs in the wild.

1.7 Development of Young:

Pseudemydura umbrina are fully developed three months after laying takes place (approximately 90 days post laying) depending on the temperature of incubation. It is evident that eggs incubated at higher temperatures develop faster, and in captivity two different incubation temperatures are utilised (24º C and 29º C).

Hatching does not occur until after approximately five months post laying (approximately 150 days), even though the tortoises are fully developed. Hatchlings remain dormant inside their eggs for the extra two months, awaiting the onset of winter and the associated rainfall that inundates the ephemeral wetlands. Hatching prior to the reserves being inundated will typically result in the demise of the tortoise, largely due to hatchling being unable to feed and hydrate and the increased exposure

to predation and the elements. If suitable cover is able to be found, it is however possible that a hatchling may survive until rainfall arrives. Hatching is typically triggered by rainfall events, and it is indeed an observable trend that the majority of hatchings take place when a low pressure system occurs.

In captivity, eggs are incubated for between 150 and 180 days. Once eggs have been in the incubators for 150 days, the incubators are turned off and allowed to adjust to ambient room temperature. This helps to stimulate the natural hatching process by simulating the natural temperature drop that would be present in the wild. If eggs have still not hatched after 180 days, the eggs are removed from the incubator and exposed to direct light to further stimulate hatching. Typical hatching weights for *P. umbrina* are between 3 and 7 grams. The smallest recorded birth weight in captivity was recorded on 29.4.06, and the tortoise was only 2.8 grams.

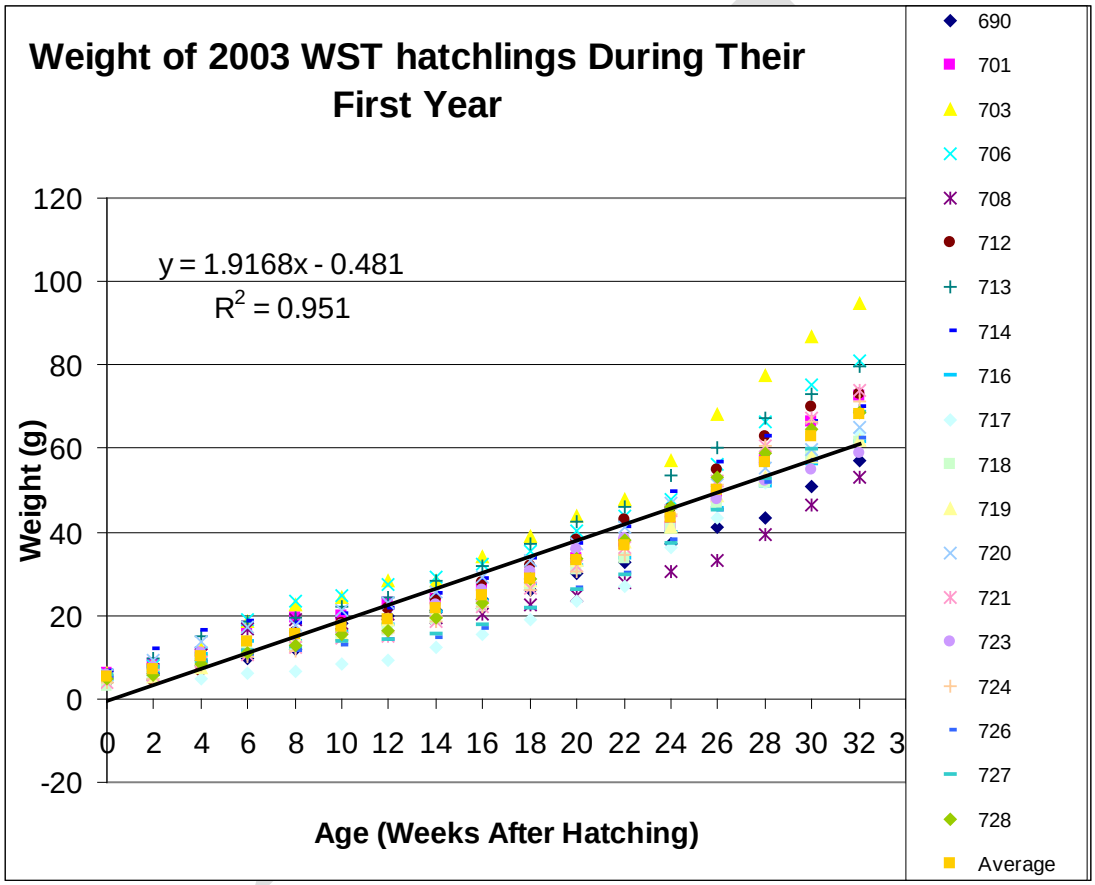

Figure 1. Graph showing the actual weight gains for the 2003 hatchling Western Swamp Tortoises. Average weights were calculated for all hatchlings at each weighing. Trend line for the average weights is shown.

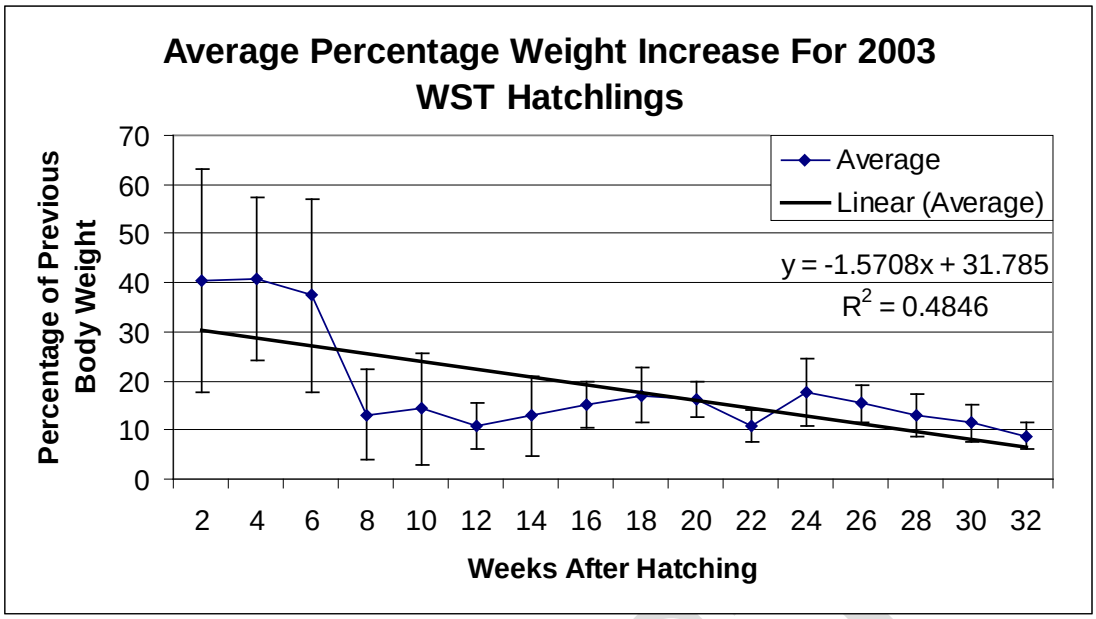

Figure 2. Graph showing the average percentage weight gain for each weighing (for the 2003 hatchling Western Swamp Tortoises). The trend is for relatively large weight gains in the first few weeks after hatching, levelling out after approximately 8 weeks to a steady 10 to 15% every two weeks.

The age of *P. umbrina* at sexually maturity is very diverse, and is typically not limited by age of the individual itself. It appears that sexual maturity is determined by the size, or more importantly the weight and carapace length, of the individual rather than the age. Once a tortoise reaches 100mm in carapace length, or between 180 and 200g in weight, the individual reaches sexual maturity. Depending on the condition of the habitat in which the individual lives, the number of years taken to reach sexual maturity can differ quite significantly. In the wild, sexually maturity is reached anywhere between 8 and 20 years of age, whilst in captivity, where food is abundant and there is no risk of predation, sexually maturity can be reached in as little as seven years of age and rarely over 14 years (Kuchling, 2002).

1.8 Adult Weights and Measurements:

The largest recorded weight for a *P. umbrina* male was 450 grams. That individual also possessed the largest recorded carapace length for *P. umbrina* at 135mm.

The largest recorded weight for a *P. umbrina* female was 422 grams. Once again this individual possessed the largest known carapace length for a female at 132mm.

Both of these individuals were captive members of the species and fully mature (50+ years of age), and as such they had greater access to food supplies so they would be expected to be larger than wild individuals that have to deal with competition for resources, predation and other extenuating circumstances. Members of *P. umbrina* are deemed to be adults once they reach 100mm in carapace length, so the minimum size of an adult would be 100mm carapace length and 180 grams.

1.9 Longevity (maximum and average):

In the wild the maximum and average longevity of *P. umbrina* is unknown.

In captivity the longevity of this species is also unknown, with some tortoises currently being housed in captivity having been there since their capture from the wild in the late 1950's as full grown adults. A safe estimate of their age at capture would be approximately 30 years of age (based on weights and carapace lengths), putting their age now at approximately 80 years of age. As of the 2006 breeding season, these individuals (both male and female) are still reproducing as normal.

Captive Husbandry

Housing Requirements

2.0 Housing: Exhibit and Off Exhibit:

Design: There are four main types of housing for *P. umbrina* at Perth Zoo, Rearing ponds, Holding/Breeding ponds, aestivations pens and a display exhibit. Aestivation pens are a simple square/rectangular 10mm X 10mm wire mesh cage (with wire base as well) with small half-pipe lengths of pvc tubes used as artificial burrows. The rear three quarters of each aestivation pen is covered in 30-40cm of leaf litter. Ideally banksia leaf litter is utilised, but eucalypt leaf litter can also be utilised if necessary. Aestivation pens are designed as to provide sufficient shade during the summer months so that the temperature does not exceed 30ºC, and yet get enough sunlight over the cooler months so that the temperature does not drop too low (ideally over 10ºC). Due to the surrounding area lacking sufficient natural cover, shade cloth is utilised to cover all of the aestivation pens during the warmer times of year.

Rearing ponds and the Holding/Breeding ponds are relatively similar in design. Each is created by making a depression in a sand base, contouring edges to allow for deeper and shallower sections of the pond once it is filled with water. Ponds are then lined with plastic pond-liner, made from polyethylene, and an area of land approximately 25cm wide is the fenced off around the pond (Holding/Breeding ponds). Holding/Breeding ponds are designed in order to create a series of different depths, no deeper than 40cm at the deepest part, which create a thermal gradient. All ponds are positioned to receive the maximum amount of sunlight that is possible. The shallowest portions of the pond are arranged so that they receive the most sunlight, which results in ponds warming up as much as possible, even on overcast days. In order to help reduce the risk of accidental tortoise drowning, all changes in depth are made with gentle slopes, and as the pond is lined with the polyethylene liner the plastic is "wrinkled" (See Figure 3).

"Wrinkling" of the plastic simply involves pulling the plastic liner in towards the centre (or deepest part) of the pond, and creating horizontal wrinkles, approximately 1-2cm in length, in

the plastic along any slope that may be present. Wrinkles can also be made in the flat portions of the pond. As the pond fills with water, the pressure of the water on the wrinkles helps hold these plastic folds in place, and as such they provide footing for the tortoise. These horizontal folds along the gradients of the pond, coupled with the addition of blue metal, allow tortoises to walk to shallower areas of the pond when temperatures drop to levels where swimming is no longer possible, thus reducing the risk of drowning occurring.

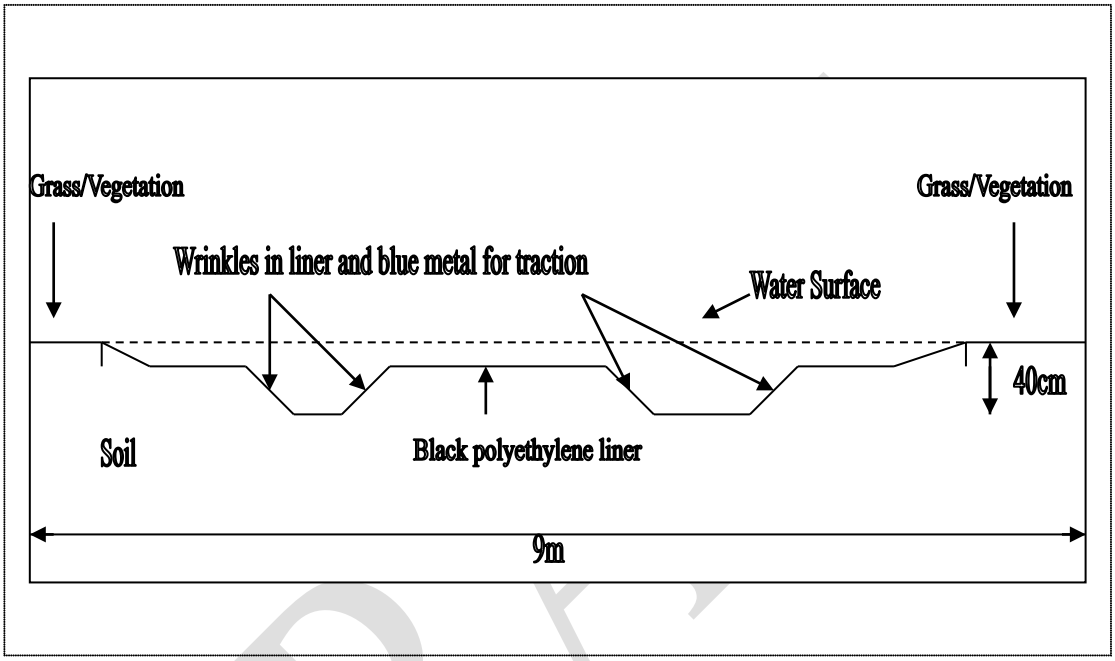

Figure 3. Longitudinal section through a standardised breeding/holding pond. Locations for the plastic folds and blue metal shown.

Rearing ponds differ from the holding ponds in the fact that they are raised above ground level, and a smaller land area is provided around the pond. The same type of design is utilised, except rather than blue metal, clay soils from near Ellenbrook Nature Reserve or more recently river sand, is used to improve traction on gradients present in the pond.

The display exhibit is designed as a “half-pond”. A fibreglass pond shell was created, and half of this was utilised for the exhibit. A glass window, which allows the public an underwater view of an artificial *P. umbrina* habitat, is sealed to the fibreglass shell and acts as a barrier between the exhibit and the public viewing area. A large land area is provided should the tortoises desire to remove themselves from the pond, along with sufficient branches/logs in the water for utilisation as basking points. Shallower and deeper locations are provided in the pond to provide thermal microclimates and allow for thermoregulation.

Enclosure size:

Pond size can vary depending on the number of tortoises and the space available. A pond 2m x 1m x 35cm at the deepest point can hold 2 adults or it can hold 5-6 juveniles 60-70mm in size. All ponds should have sufficient basking points with a strip of dry land 25cm around its perimeter where a tortoise can exit if it so desires.

According to the draft EAPA (Exhibited Animal Protection Act 2004) enclosure requirements, small swimming turtles (including all Australian freshwater turtles and terrapins) require:

a) Animal Display Establishments: Minimum floor area for 2 specimens = 5L x 2.5L (L = length of longest specimen)

b) Temporary/mobile exhibit: Minimum floor area for 2 specimens = 1.5L x 1.5L (L = length of longest specimen)

c) Pools for freshwater tortoises/turtles shall be at least 2L (L = length of longest specimen) deep. The enclosure must allow all turtles/tortoises to submerge themselves at the same time.

More specifically, members of the family Chelidae require:

a) Freshwater turtles must be provided with sufficient water to cover the animal and provide sufficient room for exercise (minimum of 2L depth). An additional area of ground surface must be provided to allow a dry basking site, with a temperature of 28-32 degrees Centigrade.

b) A gently sloping floor, or other appropriate means, must be provided to enable the animals to enter/exit from the water to their basking site.

c) Water temperature must be thermostatically controlled within the naturally occurring temperature ranges on a daily, and preferably seasonal, basis. Recommended water temperatures of 24-28 degrees Centigrade are suitable for tropical species, 22-26 degrees Centigrade for temperate species.

Due to the specific and somewhat unique biology of *P. umbrina* some of these recommendations are not applicable. The minimum depth for a pond holding *P. umbrina* is not 2L (L = length of longest specimen), due to the fact that the holding/breeding ponds are outside enclosures that are naturally heated by the sun. The majority of the pond should be 10cm deep, with one or two deeper sections of approximately 40cm depth. Any deeper than this and pond temperatures will become too low (below 10ºC) for the safe housing of *P. umbrina*.

The recommended water temperatures are also not applicable due to *P. umbrina* being a winter active species. Pond

temperatures should be maintained above 14ºC as best as possible, not being allowed to drop below 10ºC in the cooler months. During the warmer portion of the year, whilst *P. umbrina* are still out of aestivation, pond temperatures should not be allowed to rise above 30ºC.

Position: Because *P. umbrina* are a winter active reptile, and therefore reliant on winter sun for thermoregulation, it is a prerequisite for ponds to be positioned to receive the maximum amount of sunlight at this time of the year.
When aestivating the opposite is required i.e. the maximum amount of shade is required for the aestivation pens over the warmer summer months.

Substrate: In the rearing ponds, two types of substrate are acceptable. Clay soil from Ellen Brook Nature Reserve is a wonderful substrate, which is difficult to collect and maintain (very manually straining to collect, and disturbs easily with rainfall) but provides the added bonus of containing native vegetation seeds and dormant aquatic invertebrate eggs from *P. umbrina*'s natural habitat. Commercially bought river sand (preferably as coarse as possible) is also acceptable, and whilst it does not allow for the possibility of vegetation seeds or invertebrate colonies, it is far easier to obtain and manage.

Holding/breeding ponds do not have a substrate as such, but blue metal or other stones are utilised on the slopes of the deepest parts of the ponds. This is done to give the tortoises some purchase on the possible slippery sides, which enables them to get to shallower water even when cold, and thus helps to prevent the risk of drowning.

Materials: Polyethylene pond liners are used as they are the most inert, and unlike other liners, such as pvc based products, polyethylene will not leach chemicals into the pond water over time.

Fibreglass ponds are an option, but the major draw backs of this type of pond are the expense, problems creating suitable microclimates, and the possibility of breaking if a keeper stands in the pond (and associated repair problems).

2.1 Housing Conditions:

Microclimates: At Perth Zoo *P. umbrina* have access to several different microclimates depending on which enclosure type they are being housed in. Whilst housed in aestivation pens tortoises have access to soil and leaf litter (to aestivate in and under) and the different temperature gradient which this environment provides. Individuals also have access to a water bowl, which provides relief from dehydration (common during aestivation)

and a small aquatic environment individuals can utilise if desired. Only one water bowl is provided to each aestivation pen, and this is utilised as for sitting and re-hydration as desired. Water given is replaced with fresh water every three days or sooner if required.

Holding and Breeding ponds posses thermal gradients associated with the differential heating and cooling of shallow and deeper waters by the sun. This allows the tortoises to select what temperatures they wish to be at and helps with thermoregulation. Individuals also have access to grassed dry areas where they can bask.

Water: Fresh water is trickled into all ponds holding *P. umbrina* everyday. Tortoises have access to water all year round. Water bowls provided in aestivation pens have their water replaced every third day. Animals are only withheld from water if they are being dry-docked for health reasons. Fresh water is trickled into all ponds for two major reasons. Firstly, trickling in new water everyday replaces contaminated pond water with fresh water. This helps maintain the water quality of the enclosures and reduces the chance of algae blooming. Secondly, trickling in fresh water during the night helps to maintain a stable temperature overnight. Reducing the temperature loss of the pond water overnight is vitally important, as if temperatures drop too low tortoises caught in deep sections of the pond will drown.

Heating: Ponds are heated by the sun. No additional heating is utilised under normal circumstances. Power is available to all ponds (in particular our rearing ponds) in case a heat source is needed. Aquarium heaters can be used to keep pond temperatures between 14°C and 30°C. Pond temperatures can on occasion drop lower than 14ºC without severe implications to the tortoise, providing they have sufficient traction available to remove themselves from deeper sections of the ponds. It is important to keep pond temperatures above 10ºC however, as below this temperature tortoises have great difficulty even walking, and consistent low pond temperatures can result in respiratory and other health issues. This is even more important when dealing with hatchlings. Water flushing into the ponds overnight helps to maintain temperatures above 14ºC, but due to the depth and positioning of the display pond this is not enough. As such an aquarium heater is utilised to help maintain appropriate temperatures.

Cooling: If water temperatures become too hot, solid wood boards are utilised to provide shady areas in the water. Placing a wood board over any given area of a pond is enough to ensure that the water temperature remains optimal during heat waves.

	Aestivation pens are covered in shade cloth to ensure the tortoises do not overheat during aestivation.
Humidity:	Nothing is done to alter the humidity within Western Swamp Tortoise enclosures. The aquatic environment and surrounding grasses and browse provides a fairly humid environement.
Lighting:	One 100W light bulb is utilised in the Western Swamp Tortoise display enclosure. This not only provides more light into the enclosure (allowing visitors to see more clearly), but highlights the most commonly used basking spot, adding to the aesthetics of the exhibit. No extra lighting is added to any of our other Western Swamp Tortoise enclosures, due to the fact that they are completely open, allowing natural light (U.V.) to penetrate through.
Ventilation:	All enclosures are completely open allowing for natural ventilation. During the coldest times of the year solid lids are added to the rearing ponds in order to reduce the amount of temperature lost overnight. This reduces the ventilation drastically, although due to the fact that lids are not a perfect fit some ventilation is still available.
Filtration:	Holding, Rearing and Breeding ponds are partially fed with fresh water, with excess water overflowing out of the opposite end of the pond. Water is fed into the ponds from approximately 4:00pm till 8:00am everyday (roughly 16 hours). When ponds are initially set up water is fed in continually, but once the system is fully operational water is only fed in overnight. Plant life is used to naturally filter out nutrients from the pond water.

2.2 Cage Furnishings:

Rearing ponds contain eucalypt browse and small logs. Logs are either raised with the majority out of the water, or arranged to permit a tortoise to comfortably fit underneath. Both of these furnishing provide shelter for the tortoises should they seek a place to hide, and at the same time allow locations for hatchlings to climb out of the water and bask in the sun. Logs are raised utilising two bricks, one at either end of the log, and before any tortoises are placed into the pond it is important to ensure the logs are stable and secure. This helps to prevent any hatchlings getting stuck under heavy objects, or dislodging the logs, which could both result in individuals drowning.

Holding and Breeding ponds contain blue metal to allow the tortoises to gain a purchase on the substrate and remove themselves from ponds easier. Browse (typically eucalypt) can be added into ponds to provide shelter and basking locations as required. Acacia species can also be utilised for this purpose, but these species lose their leaves much quicker once placed into the ponds, which results in branches needing to be changed more often, dead leaves needing to be removed from ponds more often, and as such more disturbances to the tortoises.

The Western Swamp Tortoise Display enclosure contains several logs to allow tortoises further basking locations, as well as places to seek seclusion. Small rocks are placed securely on the base of the pond to allow further refuges. One side of the enclosure has a small amount of eucalypt browse added to provide extra sheltering locations.

2.3 Spatial Requirements:

Pond size can vary depending on the number of tortoises and the space available. A pond 2m x 1m x 35cm at the deepest point can hold 2 adults or it can hold 5-6 juveniles 60-70mm in size. All ponds should have sufficient basking points with a strip of dry land 25cm around its perimeter where a tortoise can exit if it so desires.

Aestivation Pens 1.7m x 1.5m (height not an issue, as tortoises only utilise the ground surface and leaf litter) can hold no more than 10 adult tortoises or 15 juveniles 60-70mm in length. Sufficient leaf litter, at least 20-30cm in depth, must be supplied. A 1m x 0.5m area without leaf litter should be present, and a water bowl should be added.

Health Requirements

3.0 Quarantine Issues

As *P. umbrina* are a critically endangered species, the entire colony is kept in strict quarantine. No other reptile species, or people who have had contact with other reptile species, are admitted into the Western Swamp Tortoise Breeding Facility at Perth Zoo.
Any individuals coming in from the wild must undergo a quarantine period. If the tortoise is going to be housed long term at the zoo, the quarantine procedure follows standard veterinary protocol. This would involve a minimum 30 day quarantine period undertaken at the Veterinary department. During which time, three faecal parasitology screens would be undertaken to check for internal parasites, along with a thorough health check (typically under manual restraint). Blood samples can be collected, but this is not standard procedure for *P. umbrina*.

P. umbrina are a special case, and on occasion wild individuals (in particular males) are brought into the zoo for breeding purposes. In this scenario, the wild individual is caught as the breeding season begins and is brought into the zoo to mate. After a successful mating has been observed the individual is then returned back to the wild population to breed naturally. As such, the wild individual is only in the captive colony for a very short period (typically around one week at most). A 30 day quarantine period is unable to be utilised in this situation, as the breeding season would be over before the wild male managed to mate, as such the standard procedure at present is to pair the wild individual in an isolated pond with a captive animal. Once the mating has been observed, the wild male is released back into the wild, and the captive individual is quarantined in the isolated pond for the 30 day quarantine period (undergoing the typical quarantine protocol).

The quarantine protocols and procedures for *P. umbrina* at Perth Zoo are currently under review to try and improve the quarantine standards maintained to the best possible levels.

3.1 Known Health Problems and other Problems

The most common health problems for *P. umbrina* in captivity are skin lesions; shell rot and allantoic openings failing to heal fully. Other less common problems are abscesses, fungal infections of the skin, swollen feet, respiratory infections and notch infections.

Skin lesions have been treated with a variety of methodologies over the years of the program. Initially applications of Betadine were applied to affected areas, and if the lesions did not clear up, or were quite severe to begin with, anti-bacterial washes were administered. Now however, treatment consists of applications of Silvazine to affected areas, in conjunction with dry-docking for as little as 3 hours or as much as five days, depending on severity. If caught early, all skin lesions in recent years have healed well under this treatment regime.

Shell rot was treated with a daily application of Tricin/Fungifite. Now shell rot is treated with injections of anti-biotics (such as Baytril). If the case is severe, Fortum has been given via injection, and anti-bacterial washes can be administered to aid in recovery. Shell rot is not very common in the captive population at present, with only one or two cases observed every few years, and it typically only affects older individuals. If caught early, Betadine soaks and applications of Silvazine of Conveen cream can be utilised.

The treatment for allantoic openings that have not completed healed over has remained fairly consistent over the years. Depending on severity of the opening, Betadine can be applied to the area (best case scenario) or an antiseptic bandage/Duoderm can be applied to the allantoic opening and the individual can be dry-docked for up to five days (worst case scenario).

Abscesses are typically treated by being lanced by a Veterinarian with follow up treatments of Silvazine being applied to the affected area. Fungal infections of the skin are treated with daily applications of Tricin/Fungifite cream, or coupled with anti-bacterial washes if severe.

Swollen feet are bathed in Purogene/Activator crystal solutions (or Silicea 200 has been utilised) in conjunction with feet scraping by a Veterinarian. Depending on severity, Betadine has been used to treat swelling of the feet. If this causes bleeding of the affected feet, alternatives are Canaural, Loctogon or Ickaway solutions. If these have no effect, 50ppm Formalin or Oxytetracycline/Nilstat BID can be utilised.

Individuals exhibiting signs of respiratory infections are given a Gentamycin injections (or an anti-biotic injection), and given access to heated water. If an individual develops an infection in fresh notches (notches in marginal scutes used as an identifier in released *P. umbrina*) a Neosporin injection is typically administered.

3.2 Cleaning Routine

Water bowls in aestivation pens are scrubbed clean and fresh water given at a very minimum every three days. If a tortoise is present the water bowl, that particular bowl is left till the tortoise has returned itself to aestivation and then cleaned thoroughly.

Holding ponds do not require much in the way of cleaning. Food is placed into ponds every afternoon, and any remnants of food are removed from the pond utilising a pond net the following morning. This same routine is followed for the Western Swamp Tortoise display exhibit.

Rearing ponds are "spot-cleaned" twice everyday, once in the morning and once in the afternoon (both just prior to feeding). "Spot-cleaning" involves syphoning out any left over food (apart from live mosquito larvae) or faecal matter that is clearly visible. Branches, logs and artificial shelters are not disturbed during these "spot-cleans" to limit animal stress. A thorough clean is undertaken once every week when the hatchlings are removed from the pond for their weekly weigh. At this time, old branches are replaced with freshly cut browse and all furnishings are moved in order to remove all faecal matter that is present. Water is only replaced into the rearing ponds at this time if the amount of water removed from the pond during the siphoning process is excessive. The siphoning process is designed to limit the amount of water removed, mainly due to the fact that mosquito larvae are typically present in the ponds, and it is not desirable to remove too many whilst cleaning.

Fresh water is trickled into rearing, holding and breeding ponds every night. Allowing fresh water to flow through the ponds every night is the main method utilised to clean the pond water and maintain suitable water quality. Coupling this with the presence of grass roots, which take up nutrients from the pond water, helps ensure that the pond water is as clean as possible without utilising an artificial filtration system.

3.3 Enclosure Maintenance

Typically not much enclosure maintenance is needed for the Western Swamp Tortoise compound. During the wet months, ponds maintain themselves. The trickle system is turned on to all ponds overnight, and then off again first thing in the morning. Any major repairs to ponds are typically carried out over the summer months when the ponds are dry and the tortoises are in aestivation. If a pond manages to get a hole in the liner, it is possible to patch the hole using electricians tape, and this will typically make do till a proper fix can be done over summer.

The Western Swamp Tortoise Display is serviced in the morning before the zoo opens for business. This involves cleaning the display window (using windex/sparkle or another window cleaner) ensuring that at no time are cleaning products used inside the display. The inside of the window can be cleaned using a damp cloth if need be, but nothing else. It also involves turning both the trickle system and any artificial heating source off, and the display lights on. In the afternoon, the trickle system and heaters are turned on and the display light is turned off.

The main maintenance that is required in the Western Swamp Tortoise Captive Breeding Facility is the cutting of grass. The kikuyu that is present in all of the below ground ponds, whilst beneficial in the filtration, shelter and pond exit points that it adds to the enclosures, is quite high maintenance. If kept in check and cut back

regularly, it is not too much of a problem. Keepers are typically required to cut back grass for at least two hours per day. Sometimes this is not possible (meetings, animal health issues, major works, digging of new ponds etc.), and if the grass cutting is missed for several days the amount of maintenance required compounds. For this reason the kikuyu is not the best grass to be utilised, and trials of native grasses/sedges found at the natural habitat of *P. umbrina* is being investigated.

3.4 Animal Records and Routine Checks

Hatchlings are initially checked and weighed weekly for approximately four months. Once they are established, fortnightly checks are sufficient until the end of their first year. Juveniles, sub-adults and non-breeding adults are checked/weighed monthly. Weighing and checking for the adults is carried out in conjunction with the pairing/breeding process to avoid double handling and reduce stress (typically these types of events occur at least once every month). Additional checks are carried out if necessary.

All observations/data collected for any individual are recorded on the daily report, a copy of which stays on file at the Western Swamp Tortoise office, a copy stays on file in the veterinary department, and a copy goes directly to the records officer (where it is updated onto ARKS daily). Each individual also has an electronic records file on the Western Swamp Tortoise computer (which is backed up regularly on the zoo mainframe), and any information is entered into the corresponding file.

Behavioural Notes

4.0 General Behaviour

The most common behaviours exhibited by *P. umbrina* in captivity are related to thermoregulation. Individuals can be observed basking out of ponds, either on branches/logs in the water or on the grassed edges of the ponds themselves, or moving to areas of different temperature in the water (typically shallower areas are utilised in the morning as these warm up quickest, with deeper areas being preferred overnight or if the animal feels exposed).

Western Swamp Tortoises are not territorial by nature, but if males are housed in dense numbers over the breeding season problems can arise. Dominant males will mount inferior males, in some cases constantly throughout the day, and this behaviour can be problematic. Injuries can occur to the hind limbs of the male being mounted, and if left unchecked infections can occur. Biting can also cause injuries, with less dominant males trying to bite their aggressors to gain some respite.

4.1 Mixed Species Compatibilities

Due to being a critically endangered species, and being under strict quarantine, *P. umbrina* has never been housed with any other reptile species. Two local frog species, *L. adelaidensis* and *L. moorei*, were introduced into the Western Swamp Tortoise breeding complex at Perth Zoo, as it was evident that *P. umbrina* would predate upon the tadpoles of these species. Whilst some individuals were originally introduced, wild individuals of both species found within the zoo grounds have a tendency to migrate towards the great habitat provided in the form of the breeding/holding ponds.

In the future, depending on how successful the breeding program continues to be, it is possible that other species could be trialled in mixed exhibits. It would be feasible that small fresh water fish species could be housed in an exhibit with adult or sub-adult Western Swamp Tortoises, but considerations would need to be made in regards to choosing species from the same habitat types as the Western Swamp Tortoise.

Dependant upon the availability of keeper time and funding, it would also be possible to create an exhibit that not only displays the Western Swamp Tortoise, but also displays a variety of their natural prey items. Mosquito larvae, small crustaceans, fly larvae, choncostracans, cladocerans and brine shrimps are all examples of *P. umbrina* prey that could be kept on display. Not only would these species add extra variety to the existing diet of *P. umbrina* in captivity, it would also help to educate members of the public to the types of invertebrates that inhabit our local wetlands.

4.2 Behavioural Enrichment Ideas

It is often difficult to add behavioural enrichment to reptile enclosures, particularly the aquatic species. One possible idea for enrichment for *P. umbrina* would be to add an extra type of food to their diet. Adults, sub-adults and juveniles receive an artificial diet (See captive diet in 5.0 Diets and Supplements), which is quite different to what they would sustain themselves on in the wild, so adding in a live feed once or twice per week could help stimulate captive individuals, and also help prepare them for release into the wild.

Invertebrates such as mosquito larvae, brine shrimp and black-worm are already utilised for *P. Umbrina* hatchlings, so it would be feasible to try adding mosquito larvae and brine shrimp once a week into the adult diet as enrichment. The main problems facing the addition of invertebrates into the Western Swamp Tortoise diet would be time and money. With over 200 individuals in captivity, maintaining invertebrate colonies would be fairly labour intensive, and there would be increased costs associated with ordering in more live food. It would also be difficult to ascertain with any degree of accuracy what the daily food consumption was, which would become an animal management issue.

4.3 Animal Introduction

When male and female *P. umbrina* are introduced, both individuals are placed on dry land at opposite ends of the pond. Tortoises are allowed to make their own way into the water (a standard procedure when placing tortoises back into ponds), and observations on any interactions are made every 30 minutes. Typically mating occurs relatively quickly, and once a mating has been observed (which can last for several hours), or if a female is observed being constantly out of the water, the pair is separated.

It is important, when pairing individuals for breeding, that the pond being utilised is correctly furnished. As males will be mounting females for hours at a time, and the ability of these females to swim is therefore severely compromised, the amount of blue metal present in the deeper parts of the pond needs to be adequate. Ensuring there is blue metal up the entire slope of the deeper sections means that any female mounted at the bottom of the pond, will still be able to climb up to shallower sections in order to reach the surface and breathe.

Once paired, regular observations are necessary, as males can get quite aggressive when mounting, and sometimes the pair can become overturned. If two tortoises managed to get themselves in this situation, the male will not cease mounting, and as such they are unable to right themselves. If this occurs, it is standard procedure to slowly approach the pair and place them the correct way up in the shallower section of the breeding pond. Once this is done, the pair should be observed for at least 10 minutes or until both tortoises have taken a breath. If either individual appears to be having respiratory problems it may be necessary to manually separate the pair.

Breeding can get quite aggressive, particularly if the female has been mounted for several days. Females will try and bite the males head and neck, and if this is observed repeatedly, manual separation may be required.

Introducing same sex individuals into ponds is carried out in the same manner as breeding interactions. Typically females do not get aggressive around members of the same sex, but males can exhibit aggression and dominance. If any male is observed being overly dominant, he is isolated and placed into a separate enclosure (or an enclosure with a lower density of animals). Housing males together at the height of the breeding season can be quite difficult, particularly when aggression levels rise too high. It is important to try and keep several ponds empty at this time of year that can be utilised to house overly aggressive males in isolation. If this is not possible, and males are being housed together, it is important tor regularly observe the ponds and try to sight the individuals, particularly the less dominant males, and check for any injuries that may have been caused by repeated mountings (typically wounds on the hind limbs, forelimbs and neck are the most common).

Feeding Requirements

5.0 Diets and Supplements

Pseudemydura umbrina hatchlings are fed a diet of brine shrimp, mosquito larvae and black-worm twice a day for their first five months. For the remainder of their first year they are fed invertebrates in the morning and finely cut pieces of the adult diet in the afternoon.

Adult, sub-adult and juveniles *P. umbrina* are fed an artificial called “tortoise pudding” that is made from the following ingredients:

- 1kg ox/lamb heart
- 960g skinned rat
- 640g white fleshed fish (e.g. Dory)
- 280g marron
- 4 egg yolks
- 460g gelatine dissolved in 1.4L of hot water
- 20g calcium carbonate
- 15g herptivite

Adult, sub-adult and juvenile *P. umbrina* get fed “tortoise pudding” every afternoon, with a maximum of 2.5g of pudding per individual being fed per day. Any invertebrates naturally present in the ponds, along with small tadpoles, are also eaten by *P. umbrina*.

5.1 Preparation and Presentation of Food

Brine shrimp, mosquito larvae and black-worm require little preparation. Both the shrimp and the mosquito larvae are added freely into tortoise ponds, whilst the black-worm is placed onto small terracotta bowls that are present in the rearing ponds.

Preparation of the "tortoise pudding" involves:

- Skinning and removing the tail, head and feet or the rats,
- Trimming the fat from the lamb/ox heart,
- Placing the skinned rats, trimmed heart, fish fillets and marron through a fine mincer,
- Adding four egg yolks to the minced meats,
- Dissolving the gelatine in the hot water and adding to the minced meats and egg yolk,
- Stirring thoroughly until the gelatine is evenly distributed throughout the mixture,
- Once the temperature of the mixture drops below 40º C, adding in the calcium carbonate and the herptivite, mixing thoroughly. This is vitally important as if the vitamins and minerals are mixed in when the temperature is too hot they are denatured and effectively useless. If not mixed thoroughly then some tortoises will not receive the nutrients they need, whilst others will receive too much. Both these situations can result in a reduced hatching rate and other health issues.
- Poor final mixture into four trays before gelatine has a chance to begin setting (Trays are 28cm x 18cm x 3cm in size),
- Place trays into fridge for two hours to set,
- Once set, slice into 12 even portions per tray and place in plastic bags,
- Place finished "tortoise pudding" into the freezer.

To feed in "tortoise pudding", slice off 2.5g portions and cut into nine small cubes. Each pond has one quarter which is free from cover (such as branches or logs); pudding gets placed into the shallow portion of the pond that is free from cover. Food is fed into the same place everyday. Live food is present in all of the Western Swamp Tortoise ponds, and consists of tadpoles and native invertebrates.

5.2 Dietary Changes

When first housed in captivity, *P. umbrina* were fed mainly on small marine fish like whitebait (*Hyperlophus vittatus*), beef heart. The whitebait was frozen, being thawed before fed to the tortoises, and the beef heart was powdered with calcium and a mineral supplement for pets (Kuchling, 2002).

This changed to a diet based on gelatine food first developed by Walter Sachsse (first documented by Pauler in 1981). Components over time have included minced prawns, mice, fish, beef heart, rats, squid, marron, *Daphnia*, carrots, algae powder, calcium carbonate and a mineral supplement called "Supradyn", all mixed into a gelatine solution (Kuchling, 2002).

Now the components utilised are as mentioned above (Section 5.0).

5.3 Feeding Regime

Adults are fed daily from the end of aestivation (June) to the time of ovulation (September to October). After ovulation adults are fed once every two days. Adults are fed mid to late afternoon.

Sub-adults and juveniles are fed once per day from the end of aestivation (May to June) till the beginning of the next aestivation period (December to January) in the mid to late afternoon.

Hatchlings are given a constant supply of invertebrates over their first year. At age 5 months (or the beginning of spring) they are weaned onto non-living food ("tortoise pudding"). At this point in time they get fed the non-living food in the mid to late afternoon, and an invertebrate feed in the mid morning.

Capture, Restraint and Transport

6.0 Capture Equipment and Methodology

In captivity, the best method for capturing *P. umbrina* is to simply catch by hand. Tortoises, in particular adults, can often be found on the edges of ponds basking in the sun, and as such can be very easy to locate. If a tortoise is in the water, checking under the weed mat around the edges of the pond, underneath any branches or logs that may be present in the pond, or in any debris that may act as shelter in the deepest part of the pond, is the easiest way of locating tortoises. As *P. umbrina* like to hide in grass roots or underneath obstacles, it is often difficult to utilise a net or their capture. Hand capturing the tortoises also provides the added bonus of reducing the risk of injury to the individuals, as there is no possibility of them getting claws caught in a net etc.

Once captured, the best method of transport for short distances within the compound is to place the tortoise in a bucket of appropriate size (dependant on the age of the animal). No more than two adults should be placed into a regular sized bucket, and leaf litter should be added to make the tortoises feel safe and secure. Up to 8 hatchlings can be placed in a container 30cm X 15cm X 10cm provided sufficient leaf litter is provided. Depending on the height of the container used, it is advisable that it have a securable lid (with ventilation holes or a mesh lid can be used) as *P. umbrina* are very good climbers.

When handling *P. umbrina* it is important to note that they do posses reasonably sharp claws. Injuries from an individual struggling to escape have not been recorded, but if the handler has weak skin it is a distinct possibility.

Trapping members of *P. umbrina* does not occur. In captivity they are easily located within the confines of a pond (either in the water or on the banks), and in the wild individuals are completely carnivorous, showing no signs of interest in carrion (non-moving food) and are not attracted to baits (meat, fish, etc) (Kuchling, 2002).

The best method for collecting in the field is similar as that in captivity, using ones hands. Most known individuals in the wild are radio-tracked, as such locating them is made easier, and once caught they are best kept in a high walled container, such as a

bucket, that contains either leaf litter or loose news paper for shelter. Cardboard boxes can be used, but due to the fact that capture in the wild typically takes place in water knee- to waist-deep, something that is water proof is more desirable.

6.1 Handling and Restraint

As indicated above, the most likely injury sustained to a handler is a scratch from *P. umbrina*'s claws. If this occurs it is important that the wound is washed thoroughly as soon as possibly, preferably with an antiseptic soap/wash. Once washed, the wound should not need more than a small dressing (*i.e.* a band-aid or a small piece of gauze).

There has only been one recorded instance of *P. umbrina* biting a handler. If a bite does occur, the same treatment as a claw scratch is recommended.

6.2 Health Checks, Weighing and Measuring

Hatchling *P. umbrina* are weighed once per week for their first five months. Weights are measured to the nearest 0.1g (mainly due to the equipment that has been used since the program began), and the percentage change in body mass is calculated from the last recorded weight ([(New weight – Old weight) ÷ Old weight] x 100 to the nearest 0.1%). After five months, hatchlings are then weighed every second week.

Juveniles and sub-adults are weighed once per month. The same procedure as weighing hatchlings is utilised. Adults are weighed whenever they are handled for breeding management purposes. This is to reduce the number of times they are disturbed, and typically works out to weight being taken once per month.

P. umbrina are measured using callipers once per year, typically one month after exiting aestivation. Carapace length, plastron length, carapace width and carapace height are all measured to the nearest 0.1mm. Tortoises are first measured immediately upon hatching, and then once a year after aestivation for the remainder of their stay in the breeding program.

Tortoises are visually checked for any health concerns every time they are handled or weighed. The most common concerns are any skin lesions/bacterial infections, or in adults, wounds on the limbs/claws associated with aggressive mounting. These are all typically easy to spot when visually checking. If a tortoise has lost weight over several months, or lost an excessive amount of weight over the course of a single month, the individual is taken to the Veterinary department for a thorough examination.

Captive Propagation

7.0 Enclosure Modifications/Specifications

The only differences between regular holding ponds and breeding ponds are the length and the amount of land available. Breeding ponds are typically one to two metres longer than regular ponds, and at one end there is two metres of dry land (typically sand, but with some grass present depending on the time of year). When it comes time for females to start laying, the area of dry land has all the grass removed to aid in the females search for a suitable nesting site, also the grassed areas that border the pond are cut back as short as possible (to increase the likelihood of finding

a nest that may have been dug in the grass). These are the only differences between holding ponds and breeding ponds, and the only modifications that are needed.

7.1 Season and Behaviour

Breeding season for *P. umbrina* begins in late June/ early July (dependant on the amount of rainfall in the wild, in captivity adults begin getting paired in the first 2 weeks of July), and due to the fact that females and males are housed separately, there is no real change in behaviour to indicate the onset of the breeding season. Once males and females are introduced copulation is typically quite fast, with lesser males sometimes observed cloacal "sniffing" prior to mounting.

Once a female has been successfully mounted, or if she is continually being harassed by an unsuitable male, she will remove herself from the pond, and can be found out of the water for extended periods. Typically the only factor that would make a sexually active male unsuitable would be size. A large female is likely to find a small mall unsuitable, and whilst this does not mean a mating will not occur, it is more likely to occur if the male is the same size or larger than the female.

7.2 Diet Changes

Adults are fed the same during the breeding season as they are at all other times of year when they are out of aestivation. No more than one slice (2.5g) of the artificial diet per individual is fed into ponds. After females have ovulated, their feeding regime changes to one feed every second day. This change takes place in order to limit the number of females that "double-clutch" in a season.

7.3 Gestation, Laying Period and Incubation

P. umbrina typically exhibit an oviducal period (time from becoming gravid to the laying of eggs) of between 30 and 40 days. In captivity, females are given an ultra-sound scan in the first week of September to determine if they are gravid or not. If a female is not gravid at the time of the first scan, she will be scanned every three days until it is evident she has eggs.

Once a female is gravid, she is not expected to lay until the beginning of November. The laying period for *P. umbrina* is typically from the beginning of November till the end of December (at the very latest). When a female is ready to lay, she will exit her pond and find a suitable nesting site. In captivity it is evident that females prefer to dig their nests in sandy areas that possess a hard boundary of some sort (*i.e.* the fibreglass barriers that separate ponds, edges of grass or near small bushes/trees).

Once eggs are laid, they are very carefully collected and processed. This involves measuring the length, width and weight of the eggs, placing them into their incubation chambers, and finally placing them into their incubators. *P. umbrina* eggs are incubated for an average of 140 to 150 days, at either 29ºC or 24ºC (dependant upon how many eggs are laid and what temperature the females eggs were incubated at the previous year).

7.4 Fecundity

Female *P. umbrina* can lay clutches of one to six eggs. Typically clutches are of three or four eggs, clutches of five eggs do occur on occasion, with clutches of six eggs being very rare. In captivity, if food is overly abundant females can "double-clutch" within a given season. If this occurs with any regularity in the wild is unknown.

Due to the length of time it takes for members of *P. umbrina* to reach sexual maturity, information on sex ratios is continually being collected. Eggs are incubated at 24ºC and 29ºC to ensure that there are no problems associated with temperature dependant sex determination, but at present it appears that the sex ratio between the two temperatures is roughly 50/50.

7.5 Development of Young

P. umbrina hatch weights are typically between 3.0g and 7.0g. The smallest recorded hatching weight in captivity is 2.8g. Sexual maturity is determined by size rather than age, and as such is highly dependant on the conditions individuals are raised under. In the wild, sexual maturity can be reached anywhere between 10 and 20 years of age. In captivity sexual maturity can be reached in seven years under optimal conditions. Individuals are capable of breeding in their first year of sexual maturity, whilst the maximum breeding age is still unknown (due to the fact that one of the original males the program obtained is still sexually active).

Due to the fact that *P. umbrina* females are thought to be able to store sperm for up to two years, it is difficult to determine precisely if males are still siring offspring. Genetic material has been collected from all tortoises hatched at Perth Zoo since 1990, and a project is planned to determine the exact sires for all tortoises in the near future.

As eggs are laid just prior to females entering aestivation, and eggs typically hatch before adults are out of aestivation, there is no parental investment involved after the eggs are laid.

7.6 Propagation Techniques

Males and females are paired at the beginning of July for up to three days at a time. If a successful mating is observed, pairs are separated and returned to their respective holding ponds. Pairing continues up until the first week of September, at which point females are scanned with an ultrasound machine to determine if they are gravid or not. If females are not gravid they are repaired with their respective males.

Females are typically gravid after the second week of September, and are ready to begin laying by the last week of October or the first week of November. Laying can occur all the way till the end of December, depending on how late in the season a female became gravid.

All breeding is done off display. The main factors that can affect breeding are the size of the male, and diet. Mating is more likely to be successful if the male is larger, or at least of a similar size to the female. If the artificial diet is not prepared correctly, it can affect the condition of females, and thus their likelihood of mating and successfully

producing young. Incorrect diet preparation can also result in lower success rates of hatchlings, and health issues in future generations. The main issue when preparing the diet that can result in problems with animal health and breeding is the addition on the vitamin supplements. If the Herptivite and Calcium carbonate are added when the pudding mixture is to hot, the vitamins are denatured/broken down and are basically useless. This means that the tortoises would not be receiving the vitamins that they require, which is the possible cause of most health issues.

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