



Australian Government

CODE OF PRACTICE ON THE HUMANE TREATMENT OF WILD AND FARMED AUSTRALIAN CROCODILES

Endorsed by the Natural Resource Management Ministerial Council

2009

The Natural Resource Management Ministerial Council (NRMMC) consists of the Australian state, territory and New Zealand government ministers responsible for primary industries, natural resources, environment and water policy.

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Published under the title *Code of Practice on the Humane Treatment of Wild and Farmed Australian Crocodiles*.

The Code is based on the knowledge and technology available at the time of publication and may need to be varied in the light of new knowledge.

Suggestions on how the Code can be improved are welcome and should be forwarded to:

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This edition of the Code will be reviewed in five years time.

CODE OF PRACTICE ON THE HUMANE TREATMENT OF WILD AND FARMED AUSTRALIAN CROCODILES

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GLOSSARY OF TERMS

acidosis

A general acid-base disturbance in the blood caused by lactic acid (produced through anaerobic metabolism). Also termed lactacidosis or metabolic acidosis.

anaerobic metabolism

Metabolic pathway utilised in the absence of oxygen or where the oxygen demand of cells exceeds the supply capacity of the cardiovascular system. Energy is gained through the initial conversion of glycogen into pyruvate, which is then converted to lactic acid (rather than carbon dioxide and water as would occur with aerobic metabolism).

anaesthetic (anaesthetising agent)

An agent (usually chemical) that removes perception and physical sensations. Note that while anaesthetics immobilise an animal and are therefore by definition immobilising agents, immobilising agents do not produce anaesthesia.

body cavity

The space within the body holding the internal organs.

captive

Held in environmental conditions that are largely under immediate human control. Dependent on immediate human management for the maintenance of life functions.

capture

The action of establishing physical control of the subject that may involve physical constraint that the subject may or may not seek to avoid.

cephalic sinus

Venous sinus lying between the nuchal scales and the cranial platform. Also called the post-occipital or supravertebral venous sinus. One of the main sites for sampling of blood in crocodylians.

commercial purposes

Purposes designed to generate material wealth through sale of products.

crocodylians

All members (23 species) of the Order Crocodylia (i.e. crocodiles, alligators, caimans, gharials).

dart gun

A gun designed to fire a hypodermic syringe that delivers an agent to a subject at a distance. The syringe contains an agent under gaseous compression, which it releases through the hypodermic needle upon impact.

electrical stunning

Immobilisation of the animal by application of a low amperage electrical charge.

euthanasia

Process of inducing a humane death, with minimum pain, fear and distress.

harpoon

A hand-held pole with a detachable barbed head attached to a line, such that the head resists removal after penetration through the skin.

harvesting (sustainable)

Killing or taking of wildlife on a basis that ensures that current and future populations and ecosystems are not compromised.

humane treatment

Treatment that avoids inflicting unnecessary pain and suffering and seeks to optimise the physiological and psychological welfare of the animal.

immobilising agent

Any agent that impedes the physical movement of the subject without the application of physical force. Note that immobilising agents should not be confused with anaesthetising agents, as they do not have analgesic properties, and do not impair the perceptions of the subject.

intramuscular injection

The introduction of an agent through the skin and into (and only into) a muscle of a subject.

intravenous injection

The introduction of an agent into the venous system (vein) of a subject.

physically invasive

Invading the physical body through the skin or natural orifices of the subject.

pithing

Destroying the brain by inserting a stiff steel rod through the back of the skull into the brain, after severance of the spinal cord.

pole syringe

A syringe and hypodermic needle attached to a pole to enable injection of a subject at distance.

precautionary approach

Considering that the outcome of an action may be negative and injurious, and where there is an absence of evidence to the contrary, appropriate precautionary action must be undertaken.

respiratory distress

Increased respiration caused by a shortage of available oxygen, where such increased respiration cannot restore adequate oxygen uptake.

restraint

Prevention of action on the part of the animal.

stress

To cause distress and discomfort - to cause the animal to seek to avoid the action upon it. To suffer from distress - to seek to avoid an action but to be prevented from such avoidance.

wild

Environmental conditions beyond immediate human agency. Dependent on natural (non-human) biological processes for the maintenance of life functions.

Code of Practice on the Humane Treatment of Wild and Farmed Australian Crocodiles

I INTRODUCTION

1. The commercial crocodile harvesting industry in Australia is comprised of both wild take and captive breeding and raising activities on farms. Crocodile harvesting and farming currently occur in the Northern Territory, Queensland and Western Australia. Crocodile products (e.g. skins, manufactured leather products, teeth, flesh, taxidermy specimens) are traded domestically and internationally.
2. In Australia, the commercial export of products derived from native species is required to be approved under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Crocodile trade management plans and operations approved under the EPBC Act will be required to adhere to this Code. State and territory authorities are responsible for the enforcement of this Code as a normal component of their wildlife management, compliance and enforcement functions.
3. The requirements for the welfare of native species managed under wildlife trade management plans are set out in regulation 9A.05 of the EPBC Regulations 2000. The conditions for animal welfare are to ensure that the animal is taken, transported and held in a way that is known to result in minimal stress and risk of injury to the animal, and if the animal is killed it is done in a way that is generally accepted to minimise pain and suffering.
4. As the Australian crocodile industry continues to grow it is important that a nationally consistent set of minimum standards for the humane treatment of crocodiles is in place. This Code aims to ensure that minimum standards are readily available to industry and are consistently applied throughout Australia.
5. The minimum standards recommended in this Code are based on current knowledge about crocodile welfare issues and what is currently thought to be best practice in humane handling techniques. It adopts a precautionary approach in the light of incomplete knowledge. It is anticipated that the Code will be reviewed and updated within 10 years or at an earlier stage at the request of relevant jurisdictions.
6. This Code recognises that there are deficiencies in the experimental study of crocodile sensory perception, physiology, behaviour, discomfort and pain thresholds, and that mammalian models may not always be entirely transferable. Current knowledge is often based on subjective assessments rather than on well-founded experimental evidence. Therefore this Code takes a precautionary approach to the humane treatment of crocodiles while recognising the need for experimental work outside of its prescriptions, aimed at improving humane treatment. Maintaining best practice will be an adaptive process requiring modification as new information comes to light. Further, research into all aspects of captive husbandry is needed and is progressing rapidly around the world. This may alter current husbandry practices and policy.
7. The Code recognises and respects but specifically does not apply to the traditional, non-commercial methods of hunting, keeping and handling crocodiles by Aboriginal people, and the traditional knowledge that underlies these activities.
8. This Code is intended primarily for use by individuals or companies licensed by relevant state or territory authorities to: capture and/or take crocodiles and eggs from the wild (i.e. private or public lands); to keep crocodiles for commercial raising or captive breeding; to kill crocodiles; or, to incubate eggs in controlled conditions. The taking of crocodiles or crocodile parts from the wild or the keeping of crocodiles and their eggs is subject to state and territory legislation and requires permits be issued by the relevant authorities to individuals/companies with relevant experience. Specific permit conditions required by authorities may change from time to time. Undertaking the activities outlined above without permission from the relevant authority is an offence.

9. This Code applies to the humane treatment of wild and farmed crocodiles in Australia. The term 'captive' in this Code refers to crocodiles kept in captive situations on farms for use in the commercial harvesting industry. This Code does not apply to facilities that exhibit captive crocodiles on public display for exhibition or education purposes, which may have different requirements according to the particular state or territory. Its prescriptions for crocodile welfare are, however, generally applicable. Whilst this Code applies to the humane treatment of wild and farmed crocodiles it should not be read in isolation. Documentation relating to other aspects of farm management and production practices, especially those referring to the production of food items for human consumption should also be referred to, ensuring the appropriate management of crocodiles in these situations.
10. In this Code the term 'crocodile' refers to the two Australian species of crocodile: the estuarine or saltwater crocodile *Crocodylus porosus*; and, the freshwater or johnstone's crocodile *Crocodylus johnstoni*. The term 'egg' refers to the eggs of either species.

II EGGS Collection

11. Female crocodiles sometimes guard/defend their nests in the wild but usually guard nests in captivity, and may play a role in uncovering the nest, releasing the young and attending to the young if eggs are allowed to incubate in the nest. Female crocodiles may be very maternal, at least for a period of time after their eggs hatch. Female saltwater crocodiles may guard their nests, even if the eggs are all dead, while wild female freshwater crocodiles do not guard or defend their nests. In the case of the freshwater crocodile, the female that uncovers the nest and attends the young is not necessarily the mother. Natural mortality rates of eggs in the wild can be very high, approaching 100 per cent each year in some areas. In some situations adult saltwater crocodile females nest on floating mats of vegetation and can kill all the embryos in their eggs by basking on the nest and pushing it underwater. Both species appear well adapted to coping with high natural mortalities of eggs and hatchlings. In both species, large individuals are the main predator on smaller ones. Soon after hatching, the young disperse away from the nest site.
12. Saltwater crocodiles are highly mobile and there is probably mixing between populations within Australia and between populations in Australia and neighbouring countries such as Papua New Guinea and Indonesia. The collection of eggs, most of which would not have contributed to the gene pool, is unlikely to affect genetic diversity. Indeed, most current populations in Australia have recovered from relatively few adults at the time of protection. The population dynamics of crocodiles indicates that if large numbers of eggs hatch, the proportion of hatchlings surviving to one year is low, whereas if few hatch, a high proportion of them survive to one year (Webb and Manolis 1992).
13. A risk of crocodile attack may be incurred when wild and captive-laid eggs are collected for research and/or incubation. It is advisable to ascertain the location of adult crocodiles before entering breeding enclosures as adult females, and occasionally adult males, in captive situations, may attack egg collectors. Such attacks are best thwarted with a stout pole (5 cm diameter; 2.0-2.5 m long) that can be used to block attacks. If on solid ground, hitting the ground with the pole near the crocodile, making a noise, may sometimes scare it away. If not successful, it may be necessary to deliver a sharp tap to the crocodile's head, which will usually deter it without any injury to the crocodile. Normal crocodile behaviour involves head to head contact with the full strength of a crocodile. The upper part of the snout and skull is thick boned, and the risk of injury to the crocodile from a sharp tap is negligible.
14. A minimum of two people should be involved with the collection of saltwater crocodile eggs – one to collect the eggs from the nest and one to keep watch for crocodiles. Although the female may not actively guard or defend the nest, it is likely that she is nearby but not visible. Wild freshwater crocodile eggs can be collected by one person, but the situation in captivity may necessitate the involvement of an additional person, as captive freshwater crocodile behaviour (males and females) often differs from those in the wild – an increase in aggressiveness is not unusual. Hence egg collection in captivity should proceed with due care. In small breeding enclosures, it may be possible to put a rope over the female's top jaw from outside the pen, and tether her away from the nest (see paragraph 44).

15. Eggs can be collected at any stage of development, but ideally within 12 hours of being laid. As late stage embryos show signs of consciousness (movement, vocalisation, etc), they must be treated humanely. Where the goal of collection is to maximise the survival of embryos, and the collectors are not at risk, the following procedure is recommended:
- the uppermost surface of each egg should be marked with a soft pencil or other non-toxic indelible mark, while it is in the nest.
 - the eggs should be kept horizontal with the marked top surface uppermost as the egg is removed from the nest and placed into the collection crate or box.
 - eggs must not be exposed to conditions that will lead to egg temperatures higher than 34°C.
 - if eggs are likely to overheat (>34°C) collection crates or boxes must be insulated, or kept cool.
 - eggs must not be exposed to dry conditions where they are likely to dehydrate.
 - eggs must be packed in material (e.g. nest vegetation, vermiculite) that will restrict rolling and maintain humidity.
 - if embryos are late-term or are intended to be held in containers for long periods (>5 hours), adequate ventilation in the container must be provided to maintain gas exchange between the embryo and the environment.
 - rough handling or jolting of eggs must be avoided at all times.
 - the temperature within the clutch can be measured (amongst the eggs) to ensure the nesting material has not generated excess heat and resulted in lethal nest temperatures (>34°C) and embryo deaths prior to collection.

Transport

16. Eggs may be successfully transported at any stage (age) of development, but care should be taken to:
- avoid mechanical injury through rough handling or jolting of eggs and/or containers.
 - pay particular attention to avoiding mechanical stimulation when eggs are near hatching (it may stimulate premature hatching) or between 8 and 16 days of age (embryos are delicately attached to the eggshell and can be dislodged and die).
 - ensure eggs do not overheat (>34°C) at all, nor get too cold (<24°C) for extended periods (>24 hours).

Processing

17. Prior to incubation, eggs should be examined in order to detect and remove dead specimens, which may inadvertently introduce contaminants into the incubator. Dead eggs can usually be identified by candling, and comparing the stage of development of the opaque band among eggs in a particular clutch (Webb *et al.* 1987b). Care must be taken to:
 - ensure eggs do not overheat (>34°C) at all, nor get too cold (<24°C) for extended periods (>24 hours).
 - maintain the orientation of the egg relative to the marking on the top (see paragraph 15).
 - wash surface contaminants off eggs using clean water (24-34°C).
 - avoid mechanical injury through rough handling or jolting of eggs.

Incubation

18. To maintain high survival rates of embryos during incubation, the incubation environment must provide for control over: temperature (31-33°C); humidity (99+ per cent, no free water); and, gas exchange (oxygen levels need to be maintained). Over and above these basic environmental parameters:
 - in incubators with precisely controlled environmental conditions, eggs can be incubated on open racks.
 - in incubators without precise control of temperature and humidity, eggs must be packed in moist media (e.g. vermiculite, nest vegetation) to buffer them against extremes.
 - eggs should be inspected and dead specimens removed throughout the incubation period.
 - any swelling of eggs indicates the incubation environment is too wet.
 - any appearance of air spaces under the eggshell (as evidenced by the eggshell membrane peeling away from the eggshell) indicates the incubation environment is too dry.
 - when due to hatch, eggs should be positioned so that waste fluids released at hatching do not fall onto incubating eggs below them.

Hatching

19. When the first eggs of a clutch hatch, the hatchlings should be checked to determine whether the residual yolk has been withdrawn completely into the abdominal cavity. If so, and if incubation conditions have been identical for all eggs (they can be expected to have developed at the same rate), then the remainder of the eggs in the clutch may be opened by hand. This may avoid mortality of some individuals that may otherwise have difficulty pipping the eggshell at the time of hatching.
20. Hatchlings can be washed with warm water (28-32°C), and transferred to other housing that provides an appropriate environment (see Section V). Warm conditions (32-34°C) are required immediately following hatching to ensure absorption of residual yolk.
21. Obviously weak or deformed hatchlings can be euthanized by intravenous injection into the cephalic sinus (between the cranial platform and the nuchal scales), or into the body cavity (intraperitoneal), of a suitable euthanising drug (e.g. 60mg/ml sodium pentobarbitone – which can be delivered as a 1:5 dilution of Lethabarb®). Instant decapitation (e.g. with a sharp knife,

III CAPTURE METHODS

22. Crocodiles can be dangerous animals, and it is essential that emergency procedures be developed for all stages of handling for any purpose, from initial capture through to killing. At all times contingency planning is a key priority. First-aid and remote first-aid training is strongly recommended for all members of crocodile handling teams.
23. The capture or taking of wild crocodiles can only be undertaken under a permit from the appropriate state or territory authority and these should only be issued to people with appropriate training or demonstrated experience in crocodile capture and handling techniques (see Section IX). Depending on the method of capture and size of crocodile involved, capture typically involves a team of two or more people.
24. Where a choice of methods is available for the capture, handling, transport and killing of crocodiles, methods must be chosen to minimise pain and suffering. During capture, crocodiles will struggle, and when doing so can injure themselves, other crocodiles or the handlers. Methods must be chosen that aim to minimise struggling by the crocodile.
25. The method of capture, restraint and transport will vary according to the situation (wild/captive) and the size of the animal. The choice of method will be determined by a person with training and experience relevant to the situation.
26. It is important to note that some commonly used capture techniques (e.g. skin harpoon, steel cage traps, rope traps) were developed at a time when there were few wild saltwater crocodiles as a result of decades of unregulated hunting, and where the objective was to capture animals alive for research/study and later release back into the wild (Webb and Messel 1977). Thus the welfare of the animals was a key consideration in the development of these capture methods. That they are still used successfully, 25-30 years after their development, in countries around the world, is testimony to their effectiveness in meeting that objective.

Captive crocodiles

27. Crocodiles in captivity will, from time to time, need to be caught and moved between pens, and methods vary depending on the situation (e.g. size of crocodiles, nature of enclosures, distance to be moved).
28. The recommended capture methods are shown in Table 1.

Table 1. Recommended capture methods.

METHOD	SIZE RANGE (m)	NOTES (*)
Hand capture	<1.0	Around neck
Hand noose	1.0-1.5	Around neck/upper jaw
Ropes	>1.5	Around upper jaw
Electrical stunning	1.0-2.4	Neck
Trap	2.0-7.0	Large lagoon situation
Skin Harpoon	2.0-7.0	Neck/tail; Large lagoon situation
Nets	0.5-7.0	Large lagoon situation

* method applied to crocodile body part or habitat type

29. Smaller crocodiles (<1 m) are often easier to catch by hand if there is sufficient water left in their enclosure for them to submerge. They can be manoeuvred and caught with less fuss.

30. As soon after capture as possible, the eyes must be covered with a wet cloth material (e.g. wet hessian bag) and the jaws tied with rubber bands, cord or tape (see paragraph 47).

Wild crocodiles

31. Wild crocodiles are killed and/or captured by people for many reasons, including consumption (commercial and subsistence purposes); public, local community and individual safety (e.g. problem crocodiles, crocodile attacks); research (e.g. conservation and management); skin and meat sales; or for relocation to the wild, an abattoir or a captive facility.
32. Methods used to capture and kill crocodiles are regulated by state or territory authorities. They are continually being developed, refined and modified in the light of experience and new information. They vary with the aim and context of capture: dead or alive; the urgency with which a crocodile needs to be caught (threats to public safety or catching a crocodile suspected of killing a person), the requirement to minimise pain and suffering, the goal of minimising damage to the skin and/or meat; habitat type (open or heavily vegetated waters); size (40 g hatchlings to 1000 kg adult male); level of wariness (approachable or highly secretive); remoteness of the location (access to capture equipment); effects of season on access and natural history (wet versus dry season; cool versus hot periods); experience; tradition; and, skill of the people involved.
33. In considering the most appropriate humane capture method (minimising pain and suffering) the following must be taken into account:
- crocodiles usually struggle before they can be restrained.
 - metabolism during struggling is anaerobic and acidosis (an increase in lactate and hydrogen ion concentrations in the blood which causes an acid base disturbance) results.
 - where live capture is undertaken, crocodiles need to breathe freely and deeply after capture to flush out carbon dioxide and recover from acidosis.
 - restraining methods and anaesthetics or immobilising agents, if used, must not impair breathing, especially with large crocodiles (>4.5 m) that have struggled excessively.
 - electrical stunning (see paragraphs 73 and 74) has been demonstrated as a less stressful alternative to manual capture techniques, although it may have limited utility in wild situations (e.g. see Joanen and Perry 1971).
34. There are four main periods where stress is most likely to occur: the capture itself, retention in a capture device, handling and transportation. Capture methods can be subdivided into direct take methods (where the team actively captures or kills an individual wild crocodile) and indirect take (where the team is not present when the crocodile is caught or killed).
35. With direct methods of capturing live animals (e.g. hand capture, skin harpoon, hand-noose) the time of struggling should be reduced to a minimum to reduce stress, and the crocodile must be killed or restrained as soon as practical after the initial capture effort.
36. Harpooning is a method of attaching a barbed detachable harpoon head and line to the skin of a crocodile, and is a quick and efficient means of capturing a wide size range of crocodiles with the same piece of capture equipment. With experience (see paragraph 38) the time of struggling can be reduced to minutes, and thus stress can be greatly minimised relative to crocodiles caught in unattended capture devices. Harpooning is the preferred method of capture where other capture methods present an increased risk to human safety and/or the safety of the crocodile, or are inappropriate for the situation.

37. The preferred target area for harpooning is the neck, which is usually exposed, highly muscular and relatively free of skin bones (osteoderms). Skin harpoons pierce the thick skin but minimise unnecessary penetration into muscle (Webb and Messel 1977; Walsh 1987). If smaller crocodiles are to be caught with this method, and the tail is visible, it can be an alternative target site. Where the animal is to be killed or where urgent capture is paramount (e.g. after attacks on humans), harpooning may be directed into the bony armour of the back to ensure capture. In the latter case, all efforts must be made to kill the crocodile as soon as possible after capture. The use of two or more harpoons on an individual animal may also reduce time and risk of escape.
38. Caution needs to be exercised with harpoons fired by a rifle or bow, as the power of the shot is inversely proportional to the distance from the animal, which is not easily controlled in a field situation where both animal and boat are moving. A hand-held harpoon pole involves a sharp jab, just sufficient for the barbs to penetrate the skin and the force needed is controlled and adjusted for each animal caught. Training in harpoon capture typically involves the use of small floating objects as targets.
39. Indirect capture methods include steel cage traps, rope traps (Webb and Messel 1977; Walsh 1987), baited fishing hooks and snares (Murphy *et al.* 1990), which are unattended, and thus all have a risk of causing prolonged suffering in unforeseen circumstances. These methods must only be used where direct methods are not practical or appropriate. Baited fishing hooks and snares may be used only where direct or other indirect methods (i.e. trapping) are not possible or appropriate due to type of habitat or wariness of the crocodile, and there is an urgency of capture due to the risk to human life and as endorsed through established animal ethics arrangements within each jurisdiction.
40. Indirect methods must be established in such a way that captured crocodiles have access to shade or permanent water so that they do not overheat, dehydrate or drown after capture. Cage traps set in tidal waters should have adequate flotation (e.g. pontoons; see Walsh 1987) so that drowning of captured crocodiles does not occur. Capture devices such as traps should be checked daily where possible, or fitted with devices (e.g. radio-alarms) that indicate when a crocodile has been captured: the crocodile should be removed or dispatched promptly. Logistics and conditions permitting, devices such as baited fishing hooks and snares should be checked as often as practicable but, as a minimum, must be checked at first and last light on a daily basis. Where nets are used (e.g. with freshwater crocodiles), they should not be left unchecked for more than 10-20 minutes, and entangled crocodiles removed as soon as they are found.
41. Due to the risk of injury and suffering, baited fishing hooks and snares must be employed only in the following circumstances:
- where human life is threatened by the crocodile in question.
 - the crocodile is living in the wild (i.e. not in crocodile farm or other managed situation).
 - the method is considered the only practical way to deal expeditiously with the crocodile.
 - the circumstances of employment of the method have been specifically notified to, reviewed and approved by, the authority (state, territory or commonwealth) issuing the permit for the capture/destruction of the wild crocodile.
 - the method is employed directly by a person with prior experience in its use, and only used under a permit or similar authority.
 - the details of the specific outcomes of the use of the method are reported to the permit issuing authority.
42. The use of immobilising agents (see paragraphs 56-71) is encouraged when removing crocodiles from traps, hooks or snares when delays are unavoidable, or to minimise the risk of injury to crocodiles (through struggling) and handlers.

Recommended methods for the efficient capture of different sized crocodiles are shown in Table 2.

Table 2. Recommended methods for the efficient capture of different sized crocodiles.

METHOD	SIZE RANGE (m)	NOTES*
<i>FOR LIVE CAPTURE</i>		
<i>Crocodiles can be approached and/or situation requires.</i>		
Hand capture	<1.0	around neck
Skin Harpoon	1.0-1.2	Tail
Skin Harpoon	1.2-4.5	Neck
Electrical stunning	1.0-2.4	Neck
<i>Crocodiles cannot be approached</i>		
Trap	2.0-6.0	
Snare	1.0-6.0	Use is subject to conditions in paragraph 39
Net	0.5-6.0	
<i>FOR DEAD CAPTURE (see VII, Killing)</i>		
<i>Crocodiles can be approached</i>		
Shooting	0.5-6.0	back/side of cranial platform
Harpoon/Shooting	1.0-6.0	back for harpoon, head for shooting
Hand capture/Hammer blow chisel	<2.0	between skull and 1st cervical vertebra
<i>Crocodiles cannot be approached</i>		
Hook/Shooting	1.0-6.0	
Snare/Shooting	1.0-6.0	
Trap/Shooting	2.0-6.0	
Net/Shooting	1.0-6.0	

*method applied to crocodile bodily part

IV RESTRAINING OF CROCODILES

43. When crocodiles struggle (e.g. when capturing prey), they do so through anaerobic metabolism, and experience metabolic acidosis, the levels of which are determined by the extent of struggling or exercise and size of the animal (Bennett *et al.* 1985; Seymour *et al.* 1987). When capturing crocodiles, particularly large ones (>4 m), all attempts must be made to limit undue struggling, thereby reducing the chances of high levels of acidosis. The condition of restrained animals must be monitored regularly.
44. If the goal is to capture the crocodile alive, the jaws should be securely tied/tethered to prevent injury to handlers and to the animals themselves. If the animal cannot be maintained with the head higher than the body, so that any regurgitated fluids flow back into the oesophagus, then a piece of thick rope, rubber pipe or similar material should be placed between the jaws before they are tied, to ensure the mouth is open enough so that it does not choke if it does regurgitate. Where the crocodile has been restrained by the use of top jaw ropes, the thickness of the ropes may suffice. Problems with regurgitation may be greater if the crocodile has a full stomach (water or food) when restrained.
45. Depending on the size of the crocodile, tethering the jaws can be achieved with rubber bands, tape or cord. The tether should be placed towards the anterior end of the snout behind the nostrils. Care must be taken to ensure that the nostrils are not covered. If using tape or rubber bands, ensure that they are not applied too tightly, thereby restricting blood flow. If too tight, rubber bands or tape can produce deep depressions in the skin and/or cause local cutaneous necrosis that may take weeks to heal.

46. For larger animals, it is suggested that one or more snout ropes be placed over the top jaw behind the largest teeth, to secure the animal, and after closing the jaws, cord or tape is tied around both jaws. The use of plastic cable-ties, applied with an appropriate device, has been found to be effective in closing the jaws prior to placement of tape to secure them. With large crocodiles in captivity, a useful safety mechanism involves passing tape through a rope loop when the jaws are taped shut. When the crocodile is to be released, a metal hook can be placed into the rope loop and the tape can be pulled off. This ensures that the crocodile can only open its jaws and bite after handlers are well out of range. This is also useful when two adult saltwater crocodiles are being introduced to each other in a new pen, because it prevents them biting each other when they first make contact. Snout ropes should be commensurate with the size of the crocodile, and ideally have a spliced loop and be applied as a noose so that they can be tightened and undone easily and without knots
47. As soon as the jaws are secured, the eyes should be covered to reduce visual stimulation, before additional tying is carried out. This can be achieved with a wet sack (hessian bag), cotton wool pad or moistened crepe, taped to the head to avoid it being shaken off by the crocodile. The use of duct tape alone has also been found to be very effective.
48. A crocodile whose eyes are covered is still very dangerous until its jaws are secured. Handlers should stay out of range of the jaws even when secured, as large crocodiles (>2 m) can cause serious injuries by swinging the head and battering – a behaviour they use with each other. Problems have sometimes occurred with crocodiles placed in thick woven hessian or burlap sacks that have been dampened, especially in hot weather, where suffocation and/or overheating occurs. In addition, if crocodiles are placed in hessian bags without their jaws tied, they are still capable of biting someone handling the bag.
49. Restraining crocodiles without tying their legs is preferred, but for larger crocodiles (generally >1.8 m long) that are not immobilised (see paras 33 to 43) this can be dangerous to the crocodiles and handlers. To struggle and batter with their head, crocodiles typically need to anchor their claws. They are much less likely to struggle, and much less efficient at struggling, if they cannot move their legs freely. As well as improving safety, the risk of acidosis is reduced.
50. In nature, when crocodiles dive rapidly the front legs are held backwards and over the back of the animal, and the hind legs are lifted and held beside the tail. Both can be secured in this position without harm or apparent discomfort. If cord is used, it is important that it be locked with a non-slip knot so that it does not tighten on the limb joint. Wide tape can achieve the same thing but may not be strong enough with larger crocodiles (>2.5 m). With rope or cord, it is important to ensure that the knots are firm but sufficiently loose to allow normal blood flow into the limbs. Crocodiles must not be lifted by their tied limbs as with large heavy crocodiles this could cause dislocation of limb joints.
51. Tying the legs over the back for extended periods of time (>4 hours) may cause severe oedema of the pectoral and pelvic joints. If crocodiles must be bound for such periods, the bindings must be loosened at regular intervals and immediately if any swelling is noted.
52. When crocodiles are to be restrained in the field pending release, they are best tethered in shallow water with a snout rope or cord secured around the top jaw and tied to a solid object. The nostrils must be free of tape or rope and the crocodiles unhindered in their ability to raise their head and breathe. They will tend to remain calmer if they can submerge. The snout rope must be of sufficient strength that it cannot break if the crocodile struggles.
53. Crocodiles must always be restrained in a shady situation [natural or artificial (e.g. tarpaulins)] and protected from the sun. They may require to be doused with water to avoid dehydration of the skin. Care must be taken to ensure crocodiles restrained on land do not attract ants or other insects that tend to congregate around moist parts, particular the eyes and nostrils, and either bite or sting.
54. Round PVC pipe, may be used to restrain crocodiles up to about 2 m long – the diameter of the pipe is determined by the size/girth of the crocodile. If animals can be led (e.g. Samure *et al.* 2002) or placed directly into the pipe, the jaws do not need to be tied. Removable caps at each end of the pipe allow the crocodile to be released.

55. The use of a stout cloth sheet or blanket to wrap (restrain) and lift small crocodiles “hammock-style” may be of use in some situations, doing away with the need to noose them.
56. Immobilising drugs (e.g. Pavulon®) may be used to quieten animals (particularly large ones) as they are being restrained (see Table 3).

Immobilising agents

57. The use of veterinary chemicals (as defined under the Commonwealth’s *Agricultural and Veterinary Chemicals Act 1994*) in crocodiles that are being captured, bred or reared for flesh may be subject to state and territory veterinary chemical control of use legislation. This legislation prescribes a number of limitations on chemical use and veterinarian and/or user responsibilities (record keeping, withholding periods, number of animals to be treated etc).
58. Treatments listed below may not be permitted in all animals or all classes of animals. Users must make themselves aware of their legal responsibilities with regards to chemical use. A list of the relevant state legislation is contained in Appendix 1.
59. Immobilising agents or other drugs should not be used on crocodiles being culled for their flesh. If capturing crocodiles over 2 m long, which may injure themselves or other crocodiles, the use of immobilising agents, injected with a pole-syringe apparatus or dart-gun prior to noosing, is recommended.
60. Immobilising agents (e.g. Flaxedil®, Pavulon®, Scoline®; see below) do not have the same effect as anaesthetics, and although the animal cannot move, it can feel pain. Valium, a sedative, has been shown to be very effective in calming agitated crocodiles (see paragraph 70).
61. Note that Pavulon, Scoline and Flaxedil are not registered for use in Australia by the Australian Pesticides and Veterinary Medicines Authority.
62. Procedures with the potential to cause pain must not be undertaken whilst crocodiles are immobilised with neuromuscular blockers alone (i.e. without anaesthesia). For example, minor surgical procedures may require the use of local anaesthetics (e.g. lignocaine, procaine, xylocaine). The effects of general anaesthetics (e.g. phencyclidine hydrochloride, ketamine hydrochloride) vary greatly between crocodilian species (Bates 2001; Huchzermeyer 2003), often involving long induction and recovery times and/or high risk of death (Loveridge and Blake 1987).
63. Drugs must be administered by a qualified person and care taken when administering any drugs. Accidental injection of drugs to handlers can lead to serious symptoms such as respiratory distress. Appropriate authorisations and protocols must be followed.
64. Intramuscular injections can be made between scales on the tail, or into the front leg. The tail is the preferred site of injection as it results in the least discomfort for the animal. As a consequence it is safer for handlers. Injections with a dart gun into the top or side of the neck have proven effective in situations where the tail cannot be reached (e.g. in the water during harpoon capture).
65. Where possible, it is recommended that the full dose of drug be injected at a number of sites rather than as one large dose at one site, for a more rapid effect. It is important to ensure that the crocodile does not move as it is being injected, to avoid needles being broken or harm to the handlers. Injection into a fat layer, which slows metabolism of the drug, can be difficult to predict, and may result in a lower drug response than expected. Drugged crocodiles should be approached with the same caution following injection as if they had not been injected at all.
66. A snout rope should first be placed on crocodiles that may go under water after injection with immobilising agents, so that the head can be held out of the water. When the animal is under water, relaxation of the palatal valve due to the effect of immobilising agents can allow water to flow back into the lungs, thereby drowning the crocodile.
67. Immobilised crocodiles must never be lifted with their limbs, but by supporting the body and tail. Lifting an immobilised crocodile by its limbs may result in dislocation.

68. Immobilised crocodiles can not control their body temperature by behavioural means (moving in and out of sun/shade), and must be kept cool (24-32°C) and doused with water frequently. The effects of any drug may vary greatly between individual crocodiles, and be influenced by other factors. In particular, the extent of struggling and temperature conditions may need to be considered before applying recommended dose rates.
69. Flaxedil® (gallamine triethiodide) is widely used for crocodiles (Loveridge and Blake 1972), but is no longer available in Australia.
70. Pavulon® (pancuronium bromide) has been identified as a suitable replacement for Flaxedil® (Bates 2001; Bates *et al.* 2004), and is now used by researchers, wildlife agencies and farms for immobilisation of crocodiles. The effects of Pavulon® are reversed by Neostigmine® (neostigmine methylsulphate). Injection rates for Pavulon® (immobilisation agent) and Neostigmine® (antidote) are in Table 3.
71. Due to the time for Pavulon® to take full effect (10-30 minutes), the recommended dose of Pavulon® (Table 3) is sometimes mixed with 2 ml of valium ("Pamlin®", 5mg/ml diazepam), and used for crocodiles that are struggling excessively (typically animals greater than 2 m in length) (PWSNT, unpublished data).
72. In the specific case where immobilising drugs have been administered to large (>4.5 m) crocodiles immediately after prolonged periods of struggling, artificial ventilation of the lungs is sometimes undertaken to enhance the removal of carbon dioxide, and bring about quicker recovery from the acidosis effects of capture (see paragraph 54).

Table 3. Injection rates for Pavulon® (pancuronium bromide; 2 mg/ml concentration) and Neostigmine® (neostigmine methylsulphate; 2.5 mg/ml concentration) for different sized captive [adapted from Bates (2001) and Bates *et al.* (2004)] and wild (PWSNT, unpublished data) saltwater crocodiles. Rates for prolonged immobilisation of large crocodiles (>4 m) are extrapolated and should be used with caution. Line indicates change of dosage rate in larger crocodiles. Doses may be reduced if animals are considered thin relative to their length, and increased if they are considered fat.

Agent	Pavulon® (ml)	Pavulon® (ml)	Pavulon® (ml)	Neostigmine® (ml)
Captive/Wild Crocodiles	Captive	Captive	Wild	
Period of Immobilisation	< 2 hours	2-6 hours	-	
Total length (m)				
1.5 - 1.9 m	0.05-0.1	0.1-0.2	-	0.1
2.0 - 2.1 m	0.1-0.2	0.3	0.3	0.2
2.2 - 2.3 m	0.2-0.3	0.4	0.4	0.3
2.4 - 2.5 m	0.2-0.4	0.5-0.6	0.5	0.3-0.4
2.6 - 2.7 m	0.3-0.5	0.7	0.7	0.4
2.8 - 2.9 m	0.4-0.6	0.8-0.9	0.8	0.5
3.0 - 3.2 m	0.3-0.5	0.5-0.8	0.8	0.5-1.0
3.3 - 3.4 m	0.4-0.6	0.7-1.0	0.8	0.5-1.0
3.5 - 3.6 m	0.5-0.7	0.8-1.2	1.0	1.0
3.7 - 3.8 m	0.6-0.8	0.9-1.4	2.0	1.0
3.9 - 4.0 m	0.7-1.0	1.1-1.7	2.0	1.0
4.1 - 4.3 m	0.8-1.2	1.3-2.1	2.0	1.0
4.4 - 4.6 m	1.0-1.5	1.6-2.7	2.0	1.0
4.7 - 5.0 m	1.2-2.0	2.1-3.5	2.0-4.0 *	1.0

* Wild crocodiles of this size have not been sampled. It is recommended that doses at the lower end of the scale of the dosage rate be administered in the first instance, and additional immobilising agent injected as considered necessary to achieve immobilisation.

73. Scoline® (suxamethonium chloride) is also an agent that produces muscle relaxation without anaesthesia, but is not widely used. Injection rates for Scoline® (concentration= 50 mg/ml) are in Table 4. Care should be taken when using Scoline®, as the period of action is very short (30-60 minutes). Dosage rates for saltwater and freshwater crocodiles vary significantly (see Table 4). There is no specific antidote for Scoline®.

Table 4. Injection rates for Scoline® (suxamethonium chloride, 50 mg/ml concentration) for different sized crocodiles [adapted from Messel and Stephens (1980)].

Saltwater crocodile		Freshwater crocodile	
Total length (m)	Scoline® (ml)	Total length (m)	Scoline® (ml)
1.2	2.0	1.1	0.16
1.5	2.4	1.2	0.21
1.8	3.6	1.5	0.28
2.0	4.8	1.6	0.38
2.5	5.2	1.8	0.42
3.0	6.0	2.1	0.54
3.5	10.4		
4.0	16.2		
4.5	21.5		

74. An alternative method of immobilising crocodiles is the use of techniques to stun with an electrical charge. Trialled on American alligators in the early 1970s (Joanen and Perry 1971), the methodology was refined and tested with saltwater crocodiles in Australia (Peucker *et al.* 2004). A study to evaluate stress responses (by measuring corticosterone, glucose and lactic acid levels in the blood) of captive juvenile saltwater crocodiles subjected to electrical stunning compared to manual capture by noosing and roping, concluded that the stress response of electrically stunned animals was significantly less than those subjected to manual capture, and recovery was more rapid for stunned animals (Franklin *et al.* 2002, 2003; see also www.dpi.qld.gov.au/croc/12516.html).
75. Electrical stunning is achieved by delivery of a 110 V charge for 4-6 seconds (depending on size and body condition of the crocodile) via a set of metal forks placed on the skin on the back of the crocodile's neck (contact with the cranium or skin osteoderms can greatly reduce the effectiveness of stunning). Crocodiles become rapidly immobilised during stunning, which is then followed by a period of 5-10 seconds of rigor and tail twitching. After this period the animal is relaxed with legs splayed backwards, parallel to the body. Crocodiles remain immobilised for 3-10 minutes, although some individuals may begin to regain movement after about 3 minutes. During the period of immobilisation they can be handled and restrained accordingly. The method requires the crocodile to be wet, and it has been found to be effective with crocodiles housed in both fresh and salt water.

Transport of live crocodiles

76. The method of transport used for live crocodiles will generally be determined by the size of crocodiles involved. Care must always be taken to avoid dehydration, overheating (>34°C), excessive cooling (<24°C), struggling and to minimise transport time. Smooth interiors for containers and padding around the snout of the crocodile can minimise snout damage and are recommended. The transport of crocodiles unrestrained within specially built wooden crates makes it easy to load and unload the animals.
77. Pavulon® may be used to quieten animals and minimise struggling during transport, particularly for large crocodiles. (see Table 3 for dosage rates).
78. The type of crate used for transport of live crocodiles by air will need to comply with established airline regulations (e.g. IATA Live Animals Regulations – http://www.iata.org/whatwedo/cargo/live_animals/index.htm).

Crocodiles <0.6 m total length

79. Small crocodiles can be transported in a variety of ventilated containers, including plastic prawn crates, wooden boxes and hessian bags. Damp materials such as hessian bags on the bottom of a container, and regular dousing with water may be required if animals are out of water for prolonged periods (e.g. more than 1-2 days). For the transport of crocodiles in cool conditions (<24°C), insulated and/or heated containers with holes for ventilation are recommended.

Crocodiles 0.6 m to 1.5 m total length

80. Medium sized crocodiles can also be transported in many different ways. Capped PVC pipe with the diameter varying according to the size of the crocodile is one efficient means, although these need to be ventilated and prevented from overheating or cooling excessively and have no sharp edges. Crocodiles can also be transported in large sacks; although care must be taken that they are not placed on top of each other, which may cause animals underneath to suffocate. They can also be tethered in a variety of ways, or allowed to burrow into loose straw. If numbers are to be transported together, their jaws must be tied to prevent biting, and they should be separated so that adjacent crocodiles do not cut each other with teeth that protrude on either side of the jaws.

Crocodiles >1.5 m total length

81. There are many methods for moving large crocodiles, and they vary with the size of crocodile, the movement context (remote versus non-remote areas), the available logistics, and the distance and/or time they are likely to be in transit. Key goals during transportation are to prevent undue struggling, prevent the individual breaking free if it does struggle, prevent injury to the crocodile from struggling, reduce the risk of vomiting and choking, lessen visual, auditory and mechanical stimulation during transportation, prevent the possibility of injury to handlers through biting and ensure the animal does not overheat, become excessively cool or dehydrate. In this regard:

- ensure that the head is not lower than the body so that any regurgitated fluids can flow back down the oesophagus rather than pool at the opening of the glottis, and/or use a thick rope, piece of pipe or other material to keep the jaws slightly apart (see paragraph 43).
- stop feeding for at least three days prior to transport.
- ensure ropes around the body are locked (i.e. not slip knots that can continually tighten), thus ensuring blood circulation and deep breathing are not impaired.
- tying crocodiles to “carry boards” assists in preventing undue struggling during transport, and allows animals to be carried more easily into and out of vehicles, airplanes, etc, or into pens.
- minimise mechanical shock and jolting during transport.
- minimise visual stimulation by covering the eyes or by keeping the crocodile in a dark container.
- if excessive struggling has not occurred, chemical immobilisation (see Table 3) can be considered.
- regularly douse the crocodile with water during transport.
- protect the crocodile from overheating and excessive cooling.

82. Larger crocodiles may be transported within secure purpose-built ventilated crates (e.g. with removable ends and lifting points). Crocodiles to be released immediately following transportation may be transported with the limbs and jaws unrestrained so that the animal does not struggle against the restraints during the trip. However, care must be taken to ensure that the animal does not have sufficient room in the box to attempt to turn around, as injury or death may occur if it becomes jammed. On rough roads, the transport box must be placed on some form of material to reduce vibration and sharp shocks to the box (e.g. canvass-covered mattresses). This may also insulate the crate from heat generated from the vehicle (if appropriate).

Release of crocodiles

83. As the effects of capture stress may persist for many days, close monitoring of crocodiles is recommended for the first few days after release.
84. At the time of release, the animal's eyes should be kept covered (e.g. wet hessian bag or other cloth material) as ropes are being untied/cut. Ropes or tape binding the limbs and around the body should be untied/cut first, and those on the jaws last. Care should be taken when removing bindings around the jaws to prevent injury to handlers. A rope loop around taped jaws (see paragraph 44) improves safety.
85. Where immobilising drugs have been used, an antidote (if applicable) may be administered to speed up recovery (e.g. see Table 3).
86. Where possible, crocodiles should be released on land within two metres of the water. If crocodiles are recovering from immobilising drugs or anaesthetics, or from the effects of struggling (acidosis), they should be released (untied) in a quiet, shaded area near shallow water, in case recovery time is more protracted than has been predicted. Immobilised crocodiles, particularly large ones, must not be released into the water, but rather allowed to recover sufficiently until they can move to the water themselves. There is a risk that immobilised crocodiles released prematurely in the water may be unable to surface to breathe and may consequently drown.
87. With crocodiles that have not eaten for several days, the provision of food and drinking water is a priority after release and recovery from immobilisation. It should be noted that animals may not feed readily after transport, or if ambient conditions are cool. Their metabolism and physiology in nature is well adapted to coping with long periods of time without food. For example some freshwater crocodiles in nature do not feed throughout the 5-6 month dry season (Webb *et al.* 1982).

V

HOUSING AND MAINTENANCE

88. The type of housing and maintenance schedules used for crocodiles varies according to their size and the purposes for which they are being raised. Farms must provide the animal with optimum conditions for its physiological functions. Consideration may be given to pen designs that improve safety for workers, without compromising optimal conditions for the animals (e.g. see WHSQ 2005), and which reduce interactions between people and the animals (e.g. egg collection).
89. This Code categorises stock as hatchlings (0 to 1 year), raising stock (>1 year) and adult breeding stock (saltwater crocodiles >2.2 m for females and >3 m for males; freshwater crocodiles >1.0 m for females and >1.2 m for males). Specific housing requirements (e.g. pens, fences) for crocodiles are determined by state or territory authorities, and vary greatly between facilities. Housing requirements are always a compromise between the security of the facility (i.e. to prevent escapes, to prevent entry of people), and the goals of the operation (e.g. tourism and/or farm production), but in all contexts maintaining appropriate welfare standards is a priority. All housing requirements must comply with the relevant state or territory welfare legislation.

90. As a minimum standard, all captive crocodiles will require:

- a source of water of sufficient depth to allow the animals to submerge completely.
- a water area of sufficient width/length (see paragraph 90-92) to promote good health.
- a gradual entry/exit slope into and out of the water.
- control over water quality to prevent pollution.
- where crocodiles are housed together in enclosures, visual and/or physical barriers to allow separation and reduce aggression (separation fences, semi-submerged logs, boulders, islands, etc).
- if housed in saline conditions, fresh drinking water to be available at all times.
- temperature conditions that allow the animals to maintain body temperatures in the 30-32°C range, and not to be subjected to only hot (>34°C) or only cool (<24°C) conditions for prolonged periods (e.g. access to shade, sun and basking areas)..
- a source of high quality animal protein food (e.g. meat products).
- adequate amounts of calcium and phosphorus for skeletal growth and vitamins (e.g. multivitamin premix) if not provided for in the food. Specific requirements for vitamins and minerals will vary greatly according to animal size/age, environmental conditions and diet.
- protection from physical abuse such as hitting with sticks, rocks, etc.
- substrates that are not unduly abrasive on the skin.
- keepers with an understanding of reptile husbandry, particularly thermoregulation and stress-related problems.

Hatchlings

91. Hatchling crocodiles are susceptible to mortality from inadequate housing and husbandry, and mortality rates over 10 per cent in the first year may indicate a husbandry problem. As a minimum, they will require:

- outdoor pens with adequate shade for all individuals.
- water temperatures maintained in the range 30-32°C and/or heated areas on the land allowing crocodiles to rapidly heat to 30-32°C.
- protection from wind likely to cause prolonged cooling.
- protection from undue visual disturbance.
- protection from greatly changing noise levels.
- protection from predators.
- unnecessary handling should be avoided.
- provision of water areas sufficient for all crocodiles to be submerged.
- topography of pen surface should facilitate easy movement by the crocodiles between land and water.

- if no land areas are provided, the water must be temperature-controlled (30-32°C) and have sufficient shallow areas for crocodiles to lie with their back exposed and feet and tail on the substrate.
- densities of animals vary with size and pen design, but in the first few months of life should not exceed 10-15 individuals per square metre of water and land (0.1 to 0.75 m² per individual). Density is reduced and area per individual increased as size increases throughout the first year of life.
- regular grading and separation on the basis of size to minimise aggressive interactions between fast and slow growing individuals.
- feeding at least 3 times per week (if the temperature environment is adequate). In the first few months of life more regular feeding (5-7 times per week) may be required.
- changing or filtering of water after feeding.
- a source of clean, fresh water.
- size of food to reflect size of crocodile (minced food for the smaller individuals to chunks/pieces for larger individuals).

Raising stock

92. Once they have attained one year of age, raising stock are generally robust and if provided with reasonable conditions can be expected to maintain good health. Attention must be given to:
- water and/or land temperatures that allow the crocodiles to maintain body temperature in the 30-34°C range.
 - protection from wind likely to cause prolonged cooling.
 - provision of water areas sufficient for all crocodiles to be submerged.
 - if no land areas are provided the water must be temperature controlled (30-32°C) and have sufficient shallow areas for crocodiles to lie with their back exposed and feet and tail on the substrate.
 - outdoor pens must be provided with adequate shade to cover all individuals.
 - densities of animals vary with size and pen design, but should be around 2-4 individuals per square metre of water and land at 1 m long (0.5 to 0.25 m² per individual) and 1-2 individuals per square metre of water and land at 2 m long (1 to 0.5 m² per individual).
 - reduction of aggressive interactions between individuals through regular grading and separation on the basis of size or dominance, and/or with modifications to pen design (e.g. barriers) that reduce interactions.
 - feeding at least 2-3 times per week (if the temperature environment is adequate). A typical juvenile crocodilian will consume about 15-20 per cent of its body weight in food every week at a constant temperature of 32°C. However, in outdoor pens, food consumption will vary depending on ambient conditions and season.
 - avoiding aggressive competition at feeding time by spreading out food or feeding within separate areas.
 - changing or filtering of water after feeding.
 - size of food to reflect size of crocodile (smaller pieces of food for smaller individuals).

Adults

93. Pen designs for adult crocodiles vary greatly, as do the numbers and sex ratios of adult crocodiles housed together, and the maintenance schedules applying to them. In general terms the following conditions should be provided:
- provision of adequate shade for all individuals.
 - water and/or land temperatures that allow the crocodiles to maintain body temperature in the 30-34°C range during their feeding and/or nesting period.
 - water of sufficient depth (>0.8 m) to allow crocodiles to fully submerge and lie on the bottom. Depths of 2-3 m may assist thermoregulation in areas that are excessively cold in winter and very hot in summer.
 - land areas that can be used for basking or to escape aggressive interactions with other individuals.
 - fences that are sufficiently robust to prevent crocodiles attacking those in adjacent pens. Visual barriers on the fences reduce visual stimuli and aggressive behaviour of animals in adjacent enclosures.
 - feeding at sufficient intervals (1-2 times per week) to maintain body weight and condition.
 - for captive breeding situations, provision of appropriate nesting materials if reproduction is a goal.
 - where crocodiles are housed together in single pairs, visual and/or physical barriers to allow separation and reduce aggression (separation fences, semi-submerged logs, boulders, islands, etc), with at least 25 m² per pair. Low density or spacious enclosures do not necessarily lead to less stress, as one individual may dominate all the other animals in the enclosure. On the other hand, adults may be housed in relatively high densities where internal structures reduce visual stimuli and aggressive interactions.

VI SICK OR INJURED CROCODILES

94. Sick or injured crocodiles must be treated expeditiously, and if necessary sick animals isolated from other animals. Symptoms of sickness may include: loss of weight, loss of appetite, inactivity, isolation from other crocodiles, external appearance (wounds, fungal lesions) and loss of coordination. Dead crocodiles must be removed from enclosures as soon as they are detected.
95. Particular attention must be given to monitoring the health of hatchlings in the first year of life as this is when crocodiles are most susceptible to disease problems related to husbandry. Hatchlings are very susceptible to poor husbandry practices, which can result in loss of appetite and disease due to opportunistic organisms. Preventive medicine and good husbandry are important because by the time obvious signs such as weight loss occur, treatment may be ineffective.
96. Crocodiles can be euthanased by various methods (see section VIII). It is important to use the most humane method of killing so the animal is killed instantly or instantaneously rendered insensible to pain until death supervenes.

VII MARKING CROCODILES

97. Marking of crocodiles for later identification is often undertaken in both field and captive situations. A common method involves cutting a combination of the single and double vertical scutes of the tail [see Richardson *et al.* (2002) for numbering system]. In hatchlings the scutes may be removed with a pair of small sharp scissors. In large crocodiles a sharp knife or scalpel can be used. Scute-clipping is typically a quick process that does not require the use of local anaesthetics.
98. PIT tags (Passive Integrated Transponder) are tiny identification chips that can be used to identify individual crocodiles. The transponder chips are injected with an applicator (modified hypodermic syringe fitted with a needle) under the skin and are read using an electronic reader placed near the site of "injection".
99. Web tags placed in webbing of the feet of crocodiles are sometimes used, but tag loss is a problem with this method of identification.
100. The other way of marking crocodiles is through fixing satellite or radio transmitters, which is done in accordance with relevant animal ethics approvals.

VIII KILLING

101. The killing of wild crocodiles can only be undertaken under a permit from the appropriate state or territory authority. A permit should only be issued to people with appropriate training or demonstrated experience (see section IX). Use of firearms must comply with relevant state or territory legislation.
102. In captivity, killing of crocodiles generally involves raising stock destined for processing into skins and flesh. Depending on the method being used, crocodiles may be killed after being restrained or while free-ranging within an enclosure.
103. For specimens in the wild, depending on size and whether the crocodile is secured on a rope or line, secured within a capture device, or is free-ranging, the methods of dispatch vary. Due to the variety of situations in which crocodiles may have to be killed, various options are outlined below.
104. For a humane kill, the International Union for Conservation of Nature Species Survival Commission (IUCN-SSC) Crocodile Specialist Group currently recommends total destruction of brain function by either humane captive bolt pistol or appropriate calibre bullet directly to the brain, or by instantaneously severing the spine behind the head and immediately inserting a rod into the brain (pithing).

Shooting

105. Crocodiles of any size may be shot through the back or side of the cranial platform, or between the eyes (see Schedules 1 and 2). A rifle should be used, although a captive bolt pistol can be used if the animal is firmly secured (e.g. Campos 1999). The spinal cord must be severed between the skull and the first cervical vertebra as soon as possible after shooting. Care must be taken to ensure that the trajectory of the shot is away from handlers in the vicinity.
106. For free-ranging wild crocodiles greater than 1.5 m long and less than 3 m, centre-fire, high velocity calibre rifles (·222, ·243, ·270 or any ·30+ calibre) must be used. For free-ranging crocodiles greater than 3 m long a ·30+ calibre must be used. 12 gauge shotguns are only suitable at very close range using an appropriate shot size commensurate with the size of crocodile being targeted. Care must be taken to avoid water ricochet.

107. For captive or restrained crocodiles, .22 shorts with solid projectiles (low velocity) are suitable for individuals up to 2 m long. With increasing size of crocodile, more powerful cartridges are required. For animals 2-3 m long, rim fire .22 long rifle or .22 magnum with solid projectiles would be appropriate, and for large crocodiles (>3 m), only high velocity centre-fire rounds would be suitable.
108. The point of aim when shooting a crocodile should be the brain, which lies under the cranial platform (see diagrams). The crocodile should be stationary and, where the crocodile is free ranging, be within a range that permits accurate placement of the shot. On recovery of the crocodile, the spinal cord must be severed (between skull and first vertebra).
109. In some cases, where immediate removal of a wild crocodile is paramount (e.g. in the interests of human safety), and where shooting may be the only method that can be applied to do so, it may be necessary to employ multiple shooters to ensure the crocodile is killed. In these situations heart-lung shots have proven more effective and successful than cranial shots when the crocodile is lying out of the water and is clearly visible.

Other methods

110. Crocodiles under 2 m long that are firmly secured can be killed rapidly and humanely using a hammer and sharp chisel. Spinal cord severance must be achieved instantly with one blow of the heavy hammer on the sharp metal chisel positioned between the skull and the first cervical vertebra, just behind the cranial platform (Hutton 1992). Immediately after severing the spine, the brain must be destroyed by pithing (insertion of a rod into the brain). Due to the anaerobic physiology and neural organisation of crocodiles, some reflex activity may be evident after killing. This is not indicative of inhumane or improper methods of killing or that any pain or suffering is involved. It simply reflects the ability of muscles to continue operating independently after the brain has been totally destroyed.

IX TRAINING AND EXPERIENCE

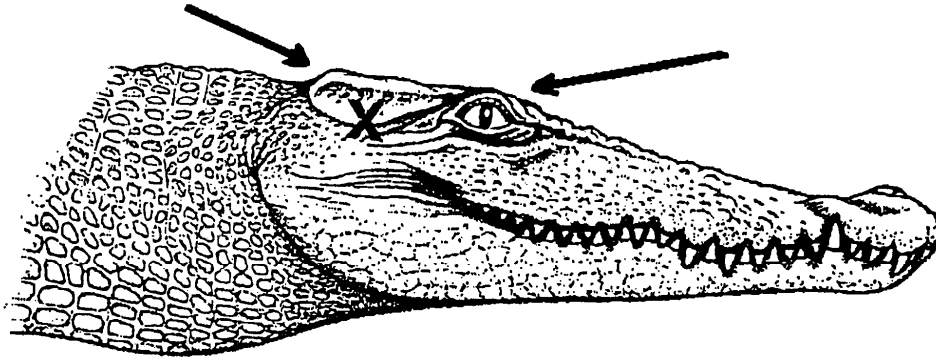
111. Personnel involved in the capture, transportation, immobilisation, housing and killing of crocodiles must have adequate training, qualifications or an acceptable and demonstrated degree of competency and experience. This will be demonstrated to the satisfaction of the relevant state or territory authority. New employees or trainees must operate under the supervision of an experienced person, until they have reached the required levels of competency.
112. Formal vocational education and training in crocodile capture and husbandry, is available through the "Seafood Industry Training Package" (www.seafoodtraining.com.au/trainingpackage.html), and additional training on veterinary and animal care and administration of drugs is in the "Animal Care and Management Training Package" (www.rtca.com.au/ACMTP/acm_default.asp). Both packages are nationally recognised, and in the case of crocodiles, require most levels of competency to be achieved in a workplace environment.
113. Having a sound understanding of basic reptilian biology, physiology and anatomy is advantageous and can be acquired from a large number of readily available books (e.g. Webb *et al.* 1987a; Richardson *et al.* 2002; Huchzermeyer 2003) and herpetology courses within learning institutes.
114. Crocodiles are dangerous animals, and Occupational Health and Safety should be considered at all times during the course of capture and handling operations. First-aid training is strongly recommended for members of crocodile capture teams, as is contingency planning for emergency situations.

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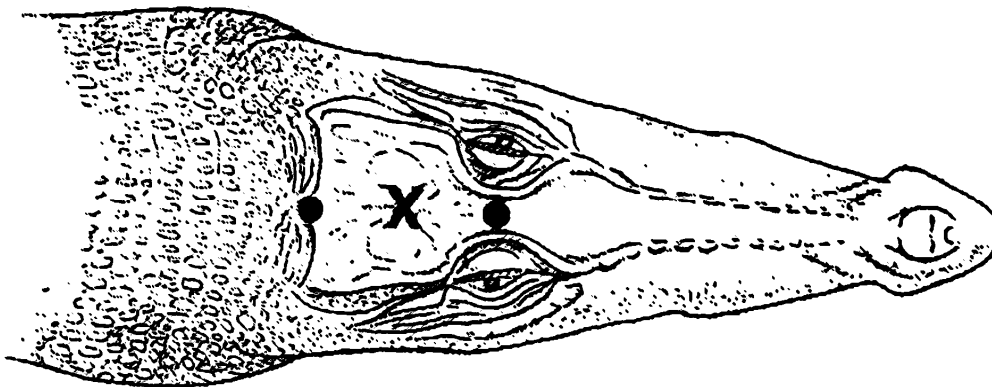
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Schedule 1 Point of aim (x) for a shot to the side of the head, and location of the brain. Arrows indicate preferred trajectory for a shot to the back or front of the head.



Schedule 2 Dorsal view of the head, showing location of the brain (x). Points of aim (black dots) for shots to the back or front of the head (see trajectories in Schedule 1).



APPENDIX 1 Veterinary chemical control of use legislation

ACT

- Environment Protection Regulation 2005 (clauses 54 & 55)

NSW

- Stock Medicines Act 1989
- Stock Medicines Regulation 2005

NT

- Agricultural and Veterinary Chemicals (Control of Use) Act 2004
- Agricultural and Veterinary Chemicals (Control of Use) Regulation

QLD

- Chemical Usage (Agricultural and Veterinary) Control Act 1988
- Chemical Usage (Agricultural and Veterinary) Control Regulation 1999

SA

- Agricultural and Veterinary Products (Control of Use) Act 2002
- Agricultural and Veterinary Products (Control of Use) Regulations 2004
- Livestock Act 1997

TAS

- Agricultural and Veterinary Chemicals (Control of Use) Act 1995
- Agricultural and Veterinary Chemicals (Control of Use) Regulations 1996 (Legislation refers to the veterinary Code of Practice)

VIC

- Agricultural and Veterinary Chemicals (Control of Use) Act 1992
- Agricultural and Veterinary Chemicals (Control of Use) Regulations 2007

WA

- Biosecurity and Agriculture Management Act 2007
- Veterinary Chemical Control and Animal Feeding Stuffs Regulations 2006