



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

FIELD GUIDE

THE RESCUE AND REHABILITATION OF CROCODILIANS OF GANGA BASIN





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An aerial photograph of a wide river, likely the Ganga, with a small boat visible in the lower-left portion. The river's surface is a mix of green and yellowish-brown, indicating varying water depths and possibly some vegetation or sediment. The background is a solid green color.

Field Guide

The Rescue and Rehabilitation
of crocodilians of Ganga Basin

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PREFACE

The Ganga River Basin is one of the most ecologically diverse regions of the world. Its home to an equally diverse flora and fauna that depends on this aquatic habitat for their survival. Among these species, crocodilians- specifically the Gharial (*Gavialis gangeticus*), the Mugger crocodile (*Crocodylus palustris*) and Saltwater crocodile (*Crocodylus porosus*) are apex predators responsible for maintaining the health of the riverine ecosystem. Unfortunately, these ancient reptiles have become increasingly prone to extinction due to habitat loss, pollution, poaching and conflict issues. Their declining populations present an urgent need for comprehensive rescue and rehabilitation efforts to ensure their survival and the sustainability of the ecosystem they inhabit.

As the Ganga Basin continues to face the pressure of rapid urbanisation, industrialisation, and climate change, the rescue and rehabilitation of crocodilians assumes a broader environmental challenge. The sustained survival of these reptiles is closely linked to the health of the aquatic habitats they inhabit, making their protection vital for the region's overall ecological balance.



The National Mission for Clean Ganga (NMCG) and Wildlife Institute of India (WII)'s project "Planning and Management for Aquatic Species Conservation and Maintenance of Ecosystem Services in the Ganga River Basin for a Clean Ganga" aims at aquatic species restoration plan through science-based research and knowledge sharing. A part of this effort focuses on the rescue and rehabilitation of aquatic macrofauna.

This field guide, The Rescue and Rehabilitation of crocodilians of the Ganga Basin, is designed to serve as a practical manual for stakeholders, conservationists, veterinarians, and field personnel involved in crocodile management in the region. It aims to provide available best-practices for safe capture, handling, medical care, rehabilitation, and eventual release of crocodiles back into their natural habitat.

-The Authors



1 INTRODUCTION

Crocodilians are semi-aquatic reptiles of the Order Crocodylia that comprises of alligators, caimans, crocodiles and Gharials. They are apex predators in the habitats they occur (Mazzotti et al., 2009; Somaweera et al., 2020). The order represented by ~27 extant species placed under three families, Alligatoridae, Crocodylidae and Gavialidae, has suffered a drastic decline in numbers as well as the area of occurrence (Whitaker & Andrews, 2003). The distribution of the order extends from Australia in the east to Asia, Africa and the North and South Americas. In India, the order is represented by three species: the Gharial (*Gavialis gangeticus*), the Mugger or Marsh crocodile (*Crocodylus palustris*), and the Saltwater crocodile (*Crocodylus porosus*).

As apex predators, they play a crucial role in maintaining the health and balance of freshwater ecosystems by regulating the populations of fish and other aquatic organisms, thus preventing any single species from dominating the ecosystem. This predatory role aids in maintaining species diversity and ensuring the stability of the ecosystem.

They are large, dangerous animals that need to be rescued due to straying from their natural habitats into human habitation, entanglements in ghost nets, fishing nets and lines, and injuries that require rehabilitation. In addition to this, problem animals need to be identified and translocated.

This document aims to provide concise information to field personnel on the physiological and anatomical peculiarities of crocodilians, methods for their capture, restrain, transport and veterinary management of distressed animals to enable them to efficiently manage the rescue and rehabilitation of crocodilians.

2 PHYSIOLOGICAL AND ANATOMICAL SPECIALITIES OF CROCODILES

Crocodiles are ectothermic animals and rely on physiological and behavioural mechanisms to regulate their body temperature. Similar to other ectotherms, body temperature is maintained by specific heat-seeking and heat-avoiding behaviours. Their physiological functions, activity, and feeding occur within a narrow range of the species' preferred body temperature. Unlike most reptiles, crocodiles lead a semi-aquatic mode of life with extensive use of aquatic components of their habitat.

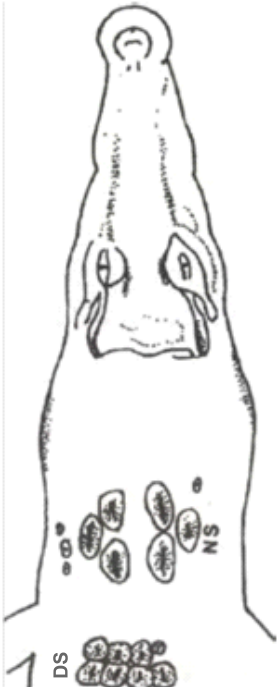
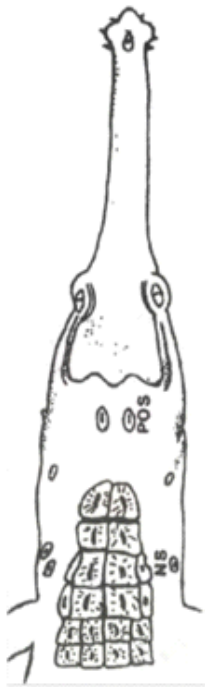
They appear to be lethargic, with the animal floating on the surface of water or basking on the banks of the water-bodies; however, this lethargy is punctuated by short sharp bursts of activities facilitated by anatomical and physiological adaptations that support anaerobic metabolism during these periods. The anatomical modifications include muscular nostrils, ear flaps and palatal valves that keep out water during diving. A pseudo-diaphragm and a four-chambered heart similar to aves and mammals, unlike other reptiles, are present. Prolonged submergence is enabled by their ability to shunt blood away from the lungs during prolonged diving and is facilitated by the presence of the Foramen of Panizza, an aperture connecting the right and left aortas that enables the flow of blood from the right ventricle into the systemic circulation instead of going into the lungs. Further, during diving, a set of connective tissue out-pushing in the pulmonary outflow tract restricts blood flow into the lungs.

Shunting blood into systemic circulation promotes a dependence on anaerobic metabolism for meeting energy needs. The extent of anaerobism is such that it can lead to severe acid-base imbalance, with pH dropping from 7.43 to 7.11 and an associated drop in bicarbonate levels. While crocodiles can have intense bursts of activity supported by anaerobic metabolism, they need to have compensatory periods for recovery, during which the blood pH is restored by lowering carbonate ion concentration and increasing bicarbonate ion concentration facilitated by aerobic respiration. The accumulated lactic acid in the blood, which can reach concentrations that would be fatal for other animals, also comes down to normal levels during recovery, which can take up to four hours or more. Anaerobic metabolism during inherently stressful capture events allows crocodiles to return to normal afterwards, though the level of lactic acid accumulation may be to the extent that it can lead to potentially fatal acidosis in other animal groups.

3 CROCODILES OF GANGA

The Ganga basin provides a home to three crocodilian species, namely the Saltwater crocodile (*Crocodylus porosus*), the Mugger (*Crocodylus palustris*) and the Gharial (*Gavialis gangeticus*). A brief description of the three species to enable field identification and management is provided below:

Characteristics	Gharial (<i>Gavialis gangeticus</i>)	Mugger (<i>Crocodylus palustris</i>)	Saltwater crocodile (<i>Crocodylus porosus</i>)
Colour	Dorsal: Olive with Dark cross bands. Ventral: White to light yellow in colour	Dorsal: Dark ash colour with light to dark brown coloured stripes. Ventral: White	Dorsal: Young: Yellow with dark patches; Adults: Dark Ventral: White
Size	Hatchling: 34-37 cm Adult: Males: 6.6 m Females: 4.5 m A large crocodile	Hatchling: 25-27 cm Adult: 4.0 m A medium-sized crocodile	Hatchling: 30-35 cm Adult: 7.5 m One of the largest crocodiles
Snout	Long and slender, with males having a earthen pot-like protuberance at the end of the snout.	Short and broad (slightly longer than broad)	Long and wide (Length approximately twice the width)
Post-occipital scutes	May be present	A single row of four large distinct scutes	Absent or indistinct



POS: Post-occipital Scutes, NS: Nuchal Scutes, DS: Dorsal Scutes

Distribution	Ganga-Brahmputra basin, Mahanadi, and Indus Rivers to the east	Southern Iran in the west, across the Indian subcontinent and Myanmar, south and south-east Asia, Papua New Guinea, and northern Australia	India in the west; across any freshwater habitat, avoiding the flooded areas during monsoons, moving into village ponds or other waterbodies that are close by.
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Characteristics	Gharial (<i>Gavialis gangeticus</i>)	Mugger (<i>Crocodylus palustris</i>)	Saltwater crocodile (<i>Crocodylus porosus</i>)
Habitat	Perennial rivers with deep pools	Marshes, lakes, rivers and artificial ponds	Estuarine rivers and creeks
Diet	Fish	Hatchlings feed on aquatic insects, crustaceans and fish fingerlings. Adults feed on a large variety of vertebrate prey.	Juveniles and sub-adults eat mainly crustacea, insects and small fish. Adults feed primarily on large vertebrate prey.
Nesting/ basking	Sandbanks at the river edge. Females guard the nests and take care of the hatchlings for the initial few months.	Dig nests inside burrows on high-sloping banks.	Mound nesters in mud banks of mangroves with females aggressively defending nests.

The methods used for rescue depend on the prevailing situation, habitat type, species, size of the animal (hatchling to adult), local practices, level of wariness of the animal, and weather conditions, as well as the experience and skill of the team involved, taking into account the safety of the rescue team.

4 CRITICAL CONSIDERATIONS FOR THE RESCUE OF CROCODILIANS

The success of a capture effort is influenced by multiple factors, such as the area where the animal to be rescued is present, its size, prevailing weather conditions and the time of capture.

4.1 Circumstances of rescue

The animal to be rescued/captured may be present in water, under cover or basking in the open. Prevailing weather conditions can influence the activity levels of the target animal. The animal will have relatively low activity levels as it emerges to bask on cold, overcast days and during periods with high ambient temperatures during peak summer, whereas the animal will be agile and may be extremely aggressive during periods of optimum temperature or after being in the sun. The technique to be adopted for capture will depend on the area of presence of the animal and weather conditions.

4.2 Stress during capture

In captures where the rescue operations are well planned and executed rapidly, resulting in quick capture and release of the animal, stress due to struggling is minimal. Maximum probability of the welfare being compromised and the animal being exposed to undesirable stress levels occurs during the capture process. Besides the capture itself, restrain and retention in a restraining device, handling, and transportation are critical areas when a crocodilian can be exposed to stress. It is important to ensure the animal's welfare and to adopt procedures that minimise stress during capture, transportation, and release. The presence of an unruly crowd at the capture site that continuously disturbs the animal can lead to a rapid build-up of stress in the animal, resulting in undesirable outcomes.

Key considerations to ensure optimum welfare and minimise stress are:

- Crocodiles struggle during the capture and restraining procedures. The metabolism during this phase is largely anaerobic and can lead to acidosis (build-up of lactate and hydrogen ion concentrations associated with a drop in bicarbonate ion concentration in the blood, causing a disturbance in the pH balance).
- The capture, restrain, and handling procedures must cause no or minimal damage to the skin and other injuries as these are indicators of poor handling and may cause complications/mortality subsequent to release.

- Cover the trap/cage/animal with suitable material to prevent direct sun exposure and avoid overheating the captured animals.
- Visual stimuli can lead to an increase in the stress level. Blindfolding the animal during restraint can reduce stimuli and lower stress.
- While every effort should be made to avoid injury to the animal during capture, some injuries are inevitable as the animal struggles during the capture process. A preliminary health assessment and providing first aid as required can ensure quick recovery.
- The struggle of the animal during capture causes the animal to shift to an anaerobic mode of energy utilization, which leads to a build-up of carbon dioxide and causes acidosis. To ensure full recovery on release, crocodiles need to breathe freely and deeply to eliminate the carbon dioxide build-up, this also helps in recovery from acidosis.

4.3 Skills of the rescue team

Crocodile rescue is a team effort, and each team member's skills play an important role in ensuring the success and safety of the operation. The team must have clearly defined roles and responsibilities for each member, with each member possessing the desired skills for their specific roles. The team must regularly practise the sequence of events for capturing, restraining, crating, and transporting crocodiles using appropriate surrogates (wooden logs, crocodile replicas of similar size, etc.). It is essential that the members trust and respect each other and work under the command of a person who is well-versed in the task at hand, irrespective of rank or social hierarchy.

4.4 Preparedness for rescue

The team must always maintain all capture equipment and transportation containers in a state of readiness. Transportation that can carry the team and equipment to the capture site must be readily available and be able to move easily over rugged terrain.

4.5 Actions at rescue site

On arriving at the site, the team needs to undertake an assessment of the site where the rescue has to be affected. The critical factors are the topography of the site, distance from water-body, size of the animals and ambient temperature. Identify the animal(s) to be captured and its/their size.

Based on the site and animal(s) assessment, the team can develop a plan of action and assign roles and responsibilities to each member to execute effective capture.

4.6 Ensuring safety

The plan and its execution must ensure the safety of the team, the public, and the animal. Suggested actions for achieving this are outlined below.

- Ensure that the local administration (Forest Department and Police personnel) are present, minimise disturbance and vandalism, ensure the safety of the animal, the team involved in the capture, and the public.
- Place the animal in a transport container of adequate dimensions and strength and initiate transportation.
- An additional precaution for Gharials is to place padding on the snout end to protect it from injury.

4.7 Human safety considerations in the capture of crocodiles

Crocodiles can cause injuries through their bite, and swinging their tails. These can result in serious injuries. During capture operations, it is critical to avoid approaching from the animal's line of vision and avoid the tail area till it is effectively restrained. Additionally, each team member should have the required skills and be an integral part of the team. Overtly aggressive animals that charge the capture team may be deterred using poles and maintaining a safe distance till safe capture is ensured.

It is, however, judicious to carry a supply of essential drugs and medicaments to address hypovolemic shock that may ensue as an outcome of bite injuries.

Liaison should be established with local healthcare authorities to ensure the availability of required healthcare professionals who can provide first aid before a victim can be safely moved to a better-equipped facility.

5 CROCODILE CAPTURE TECHNIQUES

A variety of capture methods are used to safely and humanely capture crocodiles. These include 'direct methods' (where a person or team actively captures a crocodile, e.g., noosing) and 'indirect methods' (where a person is not physically present at the time of capture, e.g., trapping). Below are the various capture methods used for capturing and transporting crocodilians.

5.1 Direct methods

5.1.1 Hand capture, tongs, and hand nets

Crocodilian hatchlings and juveniles (<0.8 m TL) may be captured directly by grabbing with hands around the neck or using Pills Trom/snake tongs (<1.2 m TL) that are commonly used for capturing snakes. Using tongs ensures the safety of the person carrying out the capture and limits direct physical contact. During hand capture, care must be taken to support the cloacal region to protect the genital organs from injury.



Figure 1: Hand capture of juveniles under 1 m



Figure 2: Hand capture of sub-adults under 1.75 m

The animal to be captured is grabbed at the back of the neck or in the tail region and quickly lifted up to minimise traction as it struggles. The animal is then restrained using hands. The cloacal region is supported with one hand to minimise the chances of injury to the delicate genital organs susceptible to injury as the animal struggles. The other hand is used to hold the neck firmly, with adequate force to immobilise the neck; however, the force used should be just adequate to avoid injury to the animal. The technique is suitable for capturing juvenile Saltwater and Marsh crocodiles; however, the risk of injury to the snout as the animal struggles during capture precludes its use in Gharials. Juvenile Gharials, Saltwater, and Marsh crocodiles (< 1.2 m) can also be captured using hands.

5.1.2 Nets

Crocodiles present in small water bodies and rivers can be captured using nets. A variety of nets are used globally for the capture of crocodiles. Dip nets handled by a single operator can capture smaller individuals. Larger nets with two or more operators, depending on the size of the animal being captured, are used for larger animals. They are used to block the animal as it swims, typically have a large mesh size (20-30 cm mesh size), and are designed to allow the head of a moving crocodilian through and entangle the body while ensuring that incidental fish catch is avoided. Fine nets, however, are also used (5-10 cm mesh size). They are designed to entangle the teeth and head when the crocodilian strikes the net. Nets are usually set in one location and monitored regularly for signs (bobbing floats) that a crocodilian is entangled. Practices that pose a minimum risk to the operator and the animal being captured are briefly described here.

5.1.3 Dip nets/Hand nets for Juveniles

For small crocodiles hand nets, scoop nets fitted on a pole, and dip nets (Fig. 4) can also be used for capture. The net being used is slipped into the water and slowly brought under the animal to be captured. Once the animal is taken into the net, it is removed from the water. Webb & Messel (1977) described the use of nets and recommended a rim diameter of 60 cm for effective capture. Nets have been used successfully in the capture of Saltwater crocodiles in Australia. A disadvantage of using nets is that they can get entangled in underwater vegetation.



Figure 3: Snake tongs for capturing juveniles

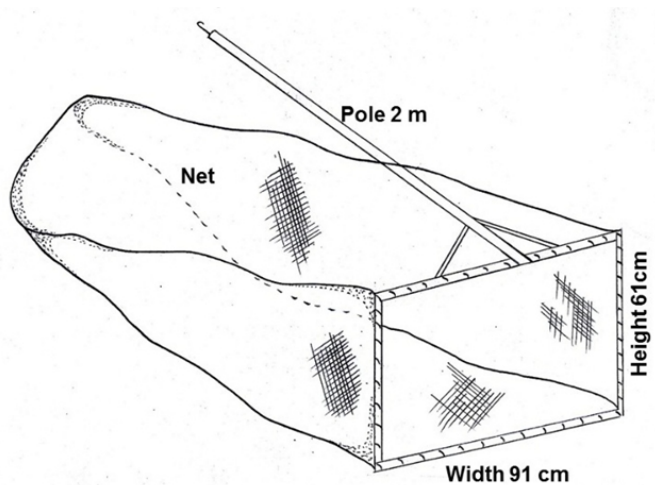


Figure 4: Steel framed handnet for capturing young crocodiles based on Wells and Messel, 1997

5.1.4 Seine, drag and set nets for Adults

Crocodiles in rivers, lakes and those trapped in canals, or small impoundments can be captured using nets. The nets used are similar to those used for fishing and are mainly seine/drag nets (Fig. 5). These have been used effectively for the capture of crocodiles in rivers and lakes. The nets are fabricated out of monofilament nylon threads, cords, cables, or braided cables depending on the strength desired and the size of the mesh of the net with a mesh size of 80 - 100 mm to avoid fish getting trapped in the nets.

5.1.5 Seine nets

Both ends of the net are fixed to poles, with the remaining net having floats on the top side and sinkers on the bottom (Fig. 5). This makes the net snug with the bottom while the top end floats on the surface. The pole on one end is held firmly on the bank, while the other end is used to sweep the water body in a curved path. The operator at the other end moves holding the bottom end slanting forward. The animal to be captured gets entangled, after which it is moved ashore for disentanglement from the net and suitably restrained for handling. Seine nets are effective for capture of crocodiles in waterbodies with a soft substrate. While in waterbodies with rocky bottoms or dense aquatic vegetation, the risk of net entanglement or the animal hiding in the bottom remains and poses a threat to the person involved.

It is essential that the nets use for capture be cleaned and properly dried for storage. The net and poles must be checked after use and any damaged parts must be immediately changed. The nets should be rolled onto the pole at one end so that it can be quickly opened when needed and remain untangled. The capture team must ensure that all members are aware of their roles and responsibilities and have the necessary skills and practice to carry out field capture.

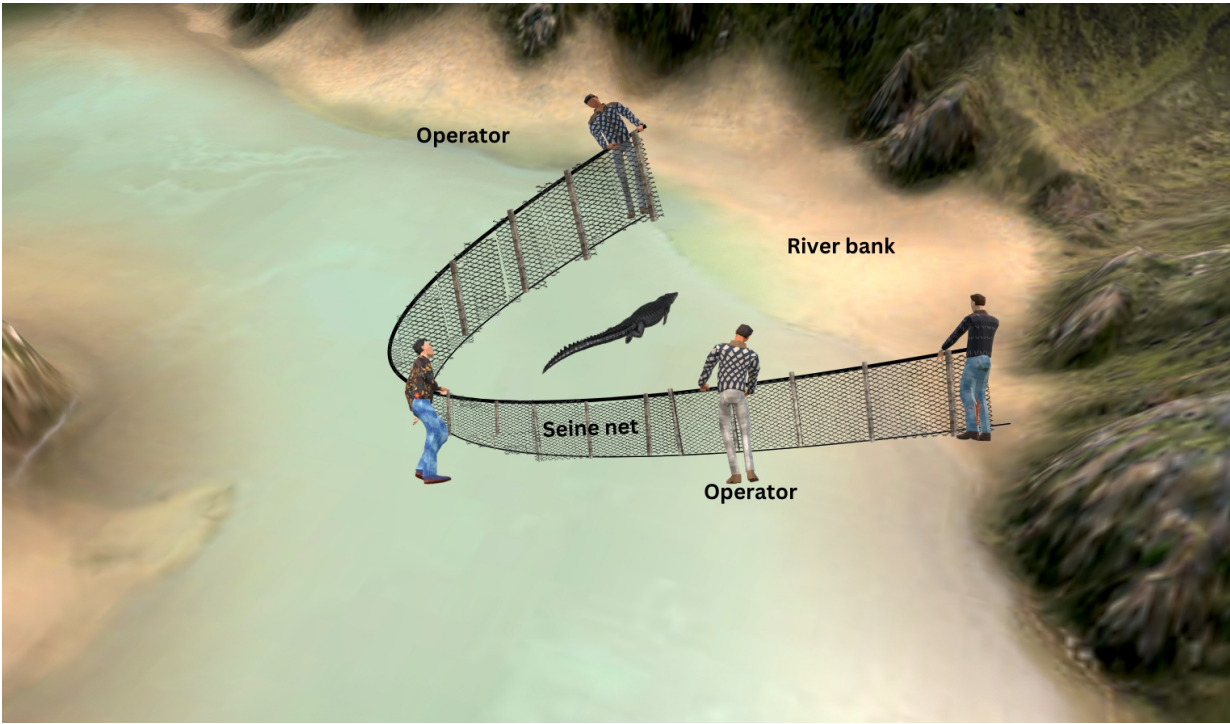


Figure 5. Seine net for capture of adults

crocodiles are powerful animals and can charge person(s) of the capture team. Additional people with poles should be present with the net operators to deter the animals. Further appropriate restrain equipment (stretchers with restraining straps) and transport must be in a state of readiness to meet all emergencies. Essential drugs and medicaments to deal with human casualties should be present with the team at all times.

5.1.6 Drag nets

Drag nets can be used to capture a specific crocodile in small water bodies. The nets are of a large mesh size to eliminate the chances of incidental turtle or fish capture. They are loose and dragged through water to capture crocodiles. Post-capture processing of animals is similar to that mentioned earlier. The nets are most effective in soft bottom waterbodies, while in waterbodies with rocky bottoms or dense aquatic vegetation, the animals may hide in the rocks or vegetation to avoid capture. Use of drag nets poses a risk to the operator carrying out the capture and should be done by persons experienced in capturing and handling crocodiles.

5.1.7 Set nets

Set nets (Fig. 6) have been used for the capture of Saltwater crocodiles in Australia. The choice of the net depends on the size of the water body and the size of the animal to be captured. For crocodiles larger than 3 m, nets with a mesh size of 25 cm with a breaking strain of 40 kg have been effectively used. The net is fabricated in a manner that allows for considerable sag when erected in water, with around 1 m of net for every 15 cm of float line used. The top side of the net has float fixed to the float line, while the bottom end has sinkers that prevent the water current from causing the net to drift with the water current. The large mesh size allows for fish to pass through unharmed while crocodiles, as they swim past, get entangled in the net. As the crocodile struggles to free itself, it gets further entangled and can be easily handled.



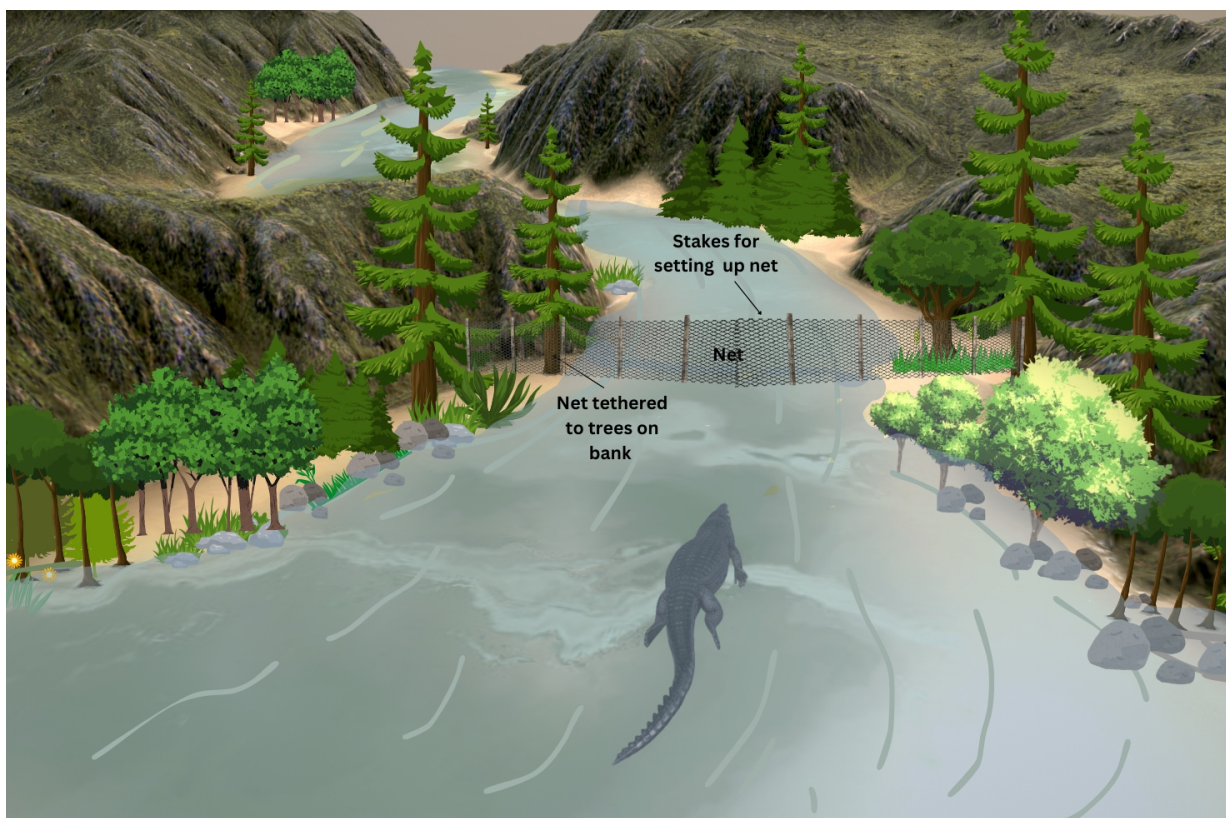


Figure 6. Set nets for capture of adults

A net of sufficient strength with a mesh size of 6-10 cm is used for crocodiles smaller than three metres. Fish caught in the net struggle to get free and serve as bait for attracting crocodiles. The teeth of crocodiles get entangled in the netting as they try to take the fish. The crocodile, in its struggle to get free, gets further entangled in the net and can be safely brought ashore.

Key considerations for capture of adult crocodiles using nets

Seine and set nets are placed either in streams or in the path to the regular basking sites of crocodiles and need to be intensively monitored to avoid accidental drowning of the captured animals.

After the animal is trapped in the net, it should be quickly brought ashore for release from the net and further restrain and handling.

Personnel involved in reclaiming nets and capturing crocodiles should be wary of attacks from other crocodiles in the area. A few persons may watch for such animals to warn and avert any attacks.

5.1.8 Noosing

Noosing is a technique extensively used in the Indian scenario. It is effective in situations where it is possible to approach the animal close enough to place the noose around the neck of the animal. A nylon rope with a running loop on one end or a self-locking wire cable are the preferred nooses used for capture. A suitable noose can also be devised using locally available material. A nylon rope of sufficient strength depending on the size of the animal is used for preparing the noose using a slipknot. The noose is tethered to a strong rigid pole of bamboo/fibreglass/wood using adhering tape (Fig. 8). The noose is placed over the snout of the animal and tightened; the struggling animal releases the noose from the pole, leaving the animal tethered by its snout. The operator holds the other end of the rope and allows the animal to tire itself out by struggling. Once tired the animal is suitably restrained.

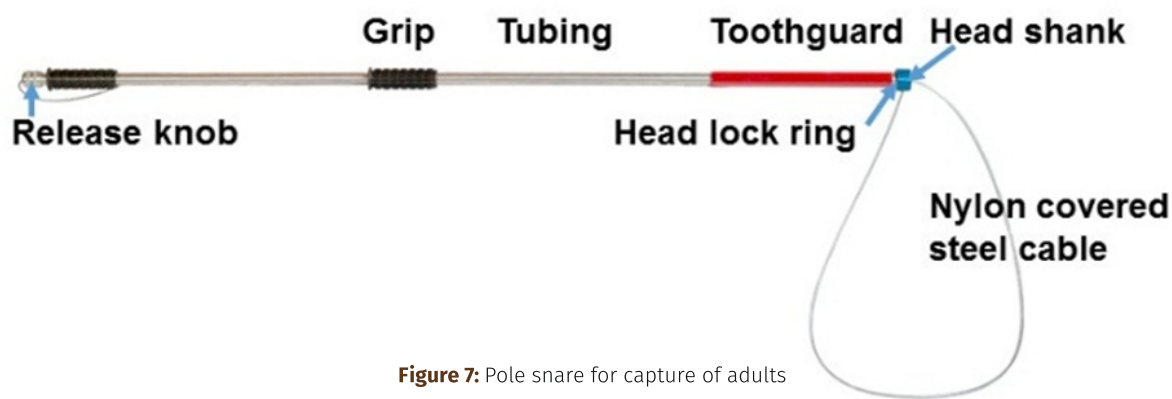


Figure 7: Pole snare for capture of adults

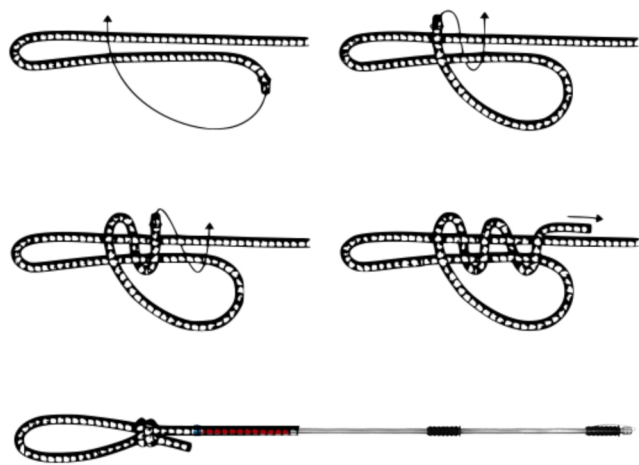


Figure 8: Preparing a pole snare

Pole snares (Fig. 7) or ketch all poles that meet the requirements for capturing crocodiles are commercially available and can form effective tools for capturing and restraining crocodiles. The open noose is fixed to a long, thin, light, and rigid pole with tape or other suitable methods (tape or spring clips) so that the pole is detached as the noose is pulled tight around the animal's neck (Figs. 8 and 9). This allows the animal to tire itself out without exposing the capture team to unnecessary risk. The noose once in place is quickly tightened and the animal led to an area clear of obstructions that can make further restrain difficult. After noosing, the animal is restrained and its eyes covered.

The preparedness and equipment required post-capture are as described earlier.

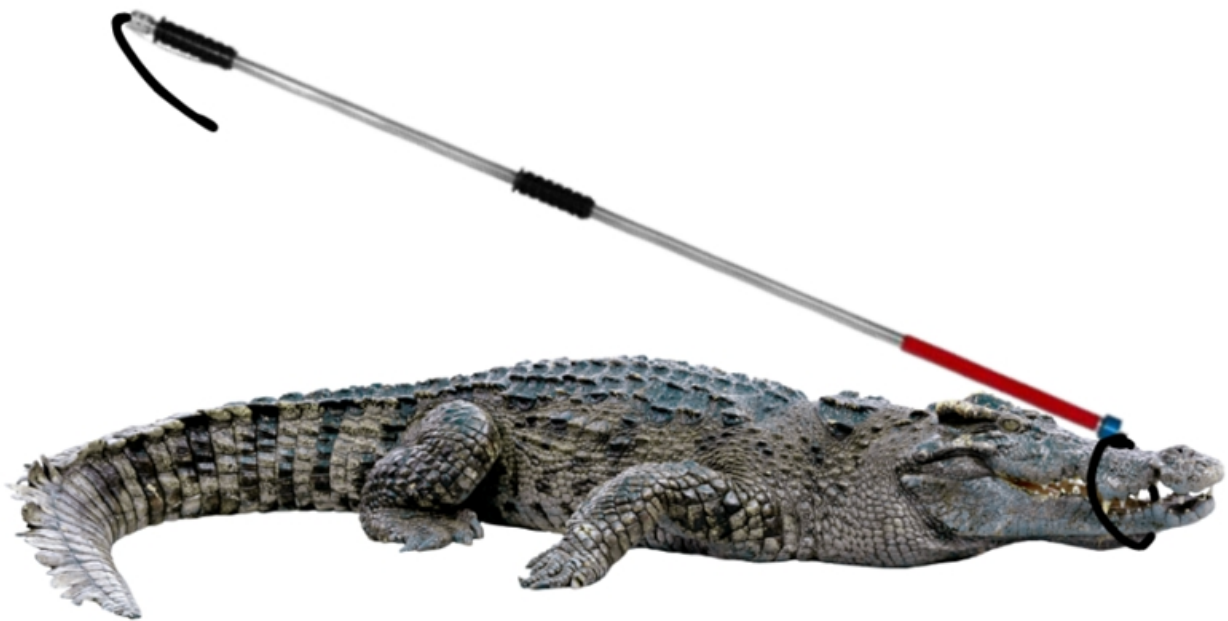


Figure 9: Crocodile captured using a noose pole

5.2 Trapping or indirect methods

A variety of trapping devices are used for the capture of crocodiles, with some common features that include:

- All traps are usually designed to be twice the size of the largest individual of the species to be captured;
- The trap includes a rigid, sturdy framework around which a wire mesh is placed to restrict the animal;
- Chain link mesh is preferred over welded mesh to minimise injury to the captured animal as it struggles to free itself.
- The traps are baited, and as the animal attempts to take the bait, a trigger mechanism releases the trap gate, effectively capturing the animal.
- The equipment used for capture must be periodically checked and should be in perfect working order to avoid difficulties during emergencies.
- The inside surfaces should be free of sharp/abrasive surfaces to minimise chances of injury to the animals.
- The traps must be set in shaded areas to avoid the animals getting overheated or dehydrated.
- They must be regularly monitored and the animals removed from the traps at the earliest to minimise stress.
- The trap must be firmly tethered to prevent complications during capture.

5.2.1 Traps

A variety of traps have been used globally for the capture of crocodilians. Their use in the Indian context is recommended for capturing Marsh and Saltwater crocodiles; however, their use for capturing Gharials is not recommended due to the risk of the snout breaking. Traps (Fig. 10) may be set at the usual site of sighting or basking of the animal.

A variety of trap designs are available, with materials used ranging from metal to fortified nets fixed on metal frames. The traps are primarily cylindrical or rectangular tubes with a sturdy frame on which netting made of steel or nylon wires is fitted. The rear end of the trap is suitably baited to lure the target animal to enter the trap. A gate on the other end is released by a trigger mechanism as the bait is taken, thereby effectively trapping the animal. The traps can also be mounted on pontoons/floats to enable them to move with the water level. A basic design of a trap is provided in Fig. 10. A key consideration while setting traps is to keep the top covered to prevent overheating of the captured animal. Additionally, the traps need to be periodically monitored to carry out further desired actions after capture.

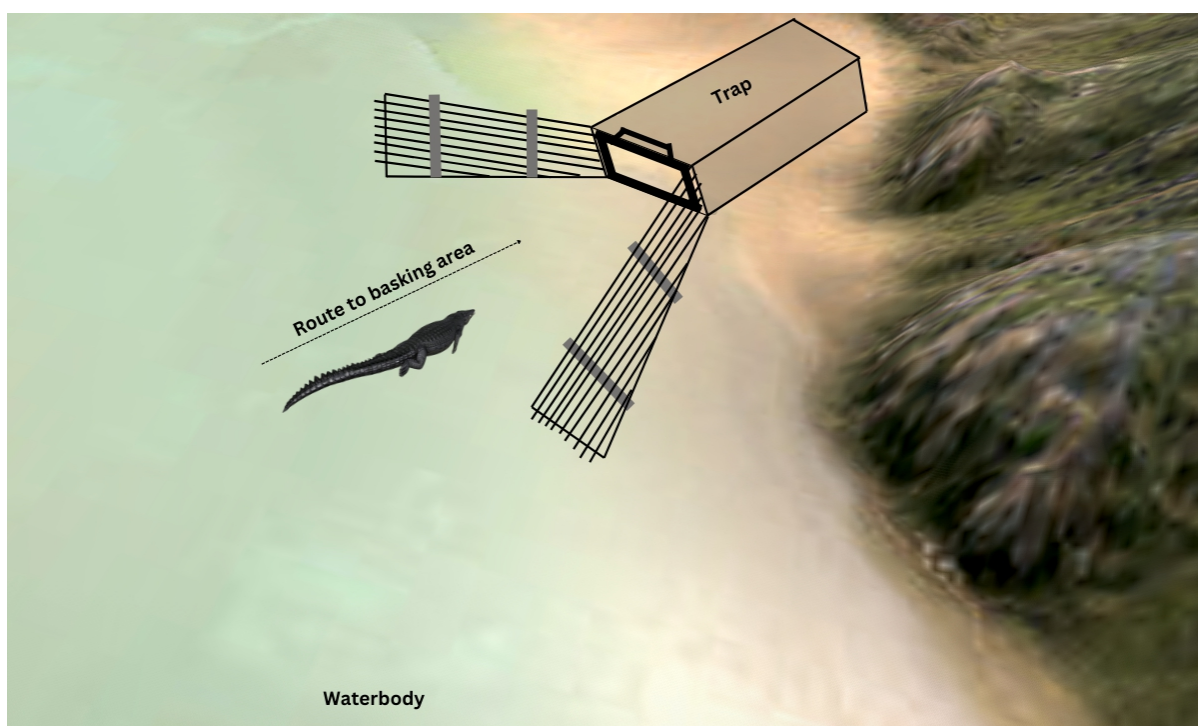


Figure 10: Trap for capture of adults

6 HANDLING AND RESTRAIN

During capture the target animal puts up a strong struggle and is stressed. The energy requirements are met through anaerobic metabolism that leads to acidosis and can cause morbidity/mortality in the captured animals. It therefore becomes imperative to minimise stressful conditions post-capture. The animal should be placed in a shaded area with eyes covered and disturbance kept at a minimum. The sequence of steps involved in the restrain of crocodiles is outlined below.

6.1 Controlling the head

Crocodilian hatchlings and juveniles less than or equal to 1 m can be approached directly from behind by grabbing and firmly holding by the neck, over the shoulders, or on the front half of the torso. The restrain procedure for adult crocodiles is initiated by gaining control of the head using a rope noose around the jaws or neck of the animal. The animal is immobilized using a stick or pole, depending on its size, while keeping a tight leash with the noose. The eyes of the animal should be covered using a wet towel or hessian sack to minimise visual stimuli. Gharials have fragile, elongated snouts, making them vulnerable to injury during capture. Care must be taken to prevent injury to the head or limbs.

6.2 Securing the jaws

The jaws can then be secured using adhesive tape or rubber bands, depending on the size of the animal. For smaller animals (hatchlings and small juveniles), rubber bands can effectively be used, while for larger animals tape, rubber straps, or cords can be used to bind the jaws. Placing a mechanical obstruction such as a block of stick, wood, etc., between the teeth, while securing the jaws to keep them slightly open will allow for the removal of regurgitated fluids and facilitate breathing. While taping the snout, nostrils should be left open with the ties around the anterior end of the snout behind the nostrils. After securing the jaws, the eyes are covered with the covers held in place using tape.

Even after its jaws are bound and eyes covered, the crocodile remains dangerous and should be handled carefully. The animal can cause severe injuries by swinging its head from side to side. The handlers should remain out of the arc (Fig. 11 B) where the animal can swing its head, and the animal should be approached from the back only.



Figure 11: A: Restraining the jaws

6.3 Restraining the limbs

The securing of the limbs of a captured crocodile is essential for the safety of the team engaged in handling the animal. The securing of limbs prevents the captured animal from gaining traction, thereby limiting its mobility and agility. This can be done by tying the legs against the lateral side of the body in the normal limb position of the animal during swimming. This is the least stressful position for the animal and lowers the risk of oedema and as the limbs are off the ground, excessive struggling is controlled. The limbs may be restrained for durations not exceeding two hours to minimise chances of oedema.

Sub-adult or adult crocodilians of smaller size (<2m) can be restrained using catch pole or pole snares, with greater control over the animal achieved when a second person takes control of the tail. The jaws are closed by applying pressure through the pulling of the snares. Once the animal is restrained by the team, the jaws are taped by a third person.

In the case of adult crocodilians of larger size ($\geq 2\text{m}$), restraining depends on the manpower and logistics, considering the safety of the team. To restrain an animal measuring 2.5 to 3 m, a team of at least 3 to 4 members is necessary, while more than 4 members are necessary for specimen greater than 3 m.

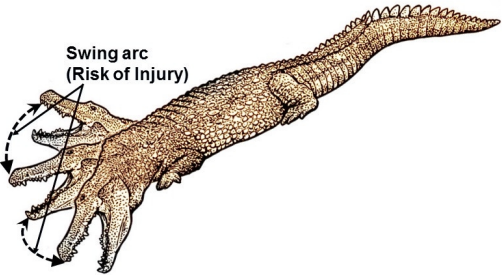


Figure 11: B: Swing arc of crocodile

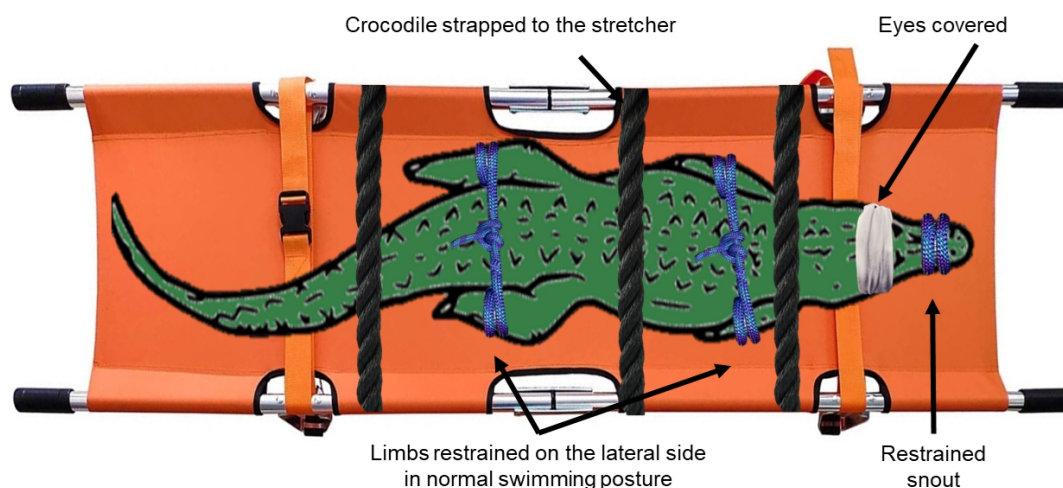


Figure. 12: Crocodile restrained on carry board/stretcher

If animals have to be maintained in temporary captivity for longer durations, it is suggested that they be held unrestrained in transport boxes specifically designed for the species or in floating cages. In the eventuality of both being unavailable the animal may be restrained by tying the upper jaw behind the eye & teeth and then taping the two jaws together. The rope used to tie the jaws can be used as a tether for holding the animals. In such conditions, the animal must always be held in shaded areas. If crocodiles must be held for more than one day, the animal may be covered with hessian sacking and watered periodically to prevent the skin from drying and cracking. Care also needs to be taken to ensure that the restrained animals are not attacked by vermin. The animal must be periodically monitored to ensure its well-being.

6.4 Rolling or pulling crocodiles

Large crocodiles may require to be rolled or lifted up using ropes. The procedure can cause injury to the limbs and phallus of males if the animals are improperly restrained. The limbs should be restrained parallel to the body and held in place by tying carefully with ropes. Only if necessary, should crocodiles be dragged with ropes used for restraining the upper jaw. The limbs of the animal should not be used as levers or vantage points for holding and lifting crocodiles to protect them from injury.

7 EMERGENCIES DURING CAPTURE AND RESTRAIN

Crocodiles are large, aggressive animals that have the potential to cause grievous injuries to the personnel engaged in capture and restrain. As a result of improper handling and restrain, the animals are also susceptible to injuries ranging from minor abrasions to oedema of the limbs. Major concerns during capture and restrain are discussed below.

7.1 Cloacal prolapse

The cloacal region of crocodiles contains the reproductive and excretory organs in a delicate sac with weak musculature. Lifting or transporting crocodiles without cloacal support can result in severe injury and even death. It is, therefore, advisable to place a binding sack or other suitable support around the base of the tail to avoid injury. The binding for cloacal support must be removed at the earliest to allow normal comfort movements.

7.2 Dehydration

If left exposed to direct sunlight, restrained crocodiles will rapidly dehydrate, and the skin will crack in places, leading to sores. Thus, it is recommended that restrained animals be held in the shade and wet periodically with drinking water readily available.

8 TEMPORARY HOLDING AND TRANSPORT

Crocodiles, after capture, may need to be held in captivity for varying time periods depending on further management interventions required/planned. Critical considerations that need to be followed while crocodiles are in captivity are:

- Keep crocodiles in a shaded area, avoiding direct sunlight, which may lead to overheating. The animals must be maintained in a thermal regime between 20°C and 30°C to avoid hyperthermia and hypothermia.
- The head should be raised higher than the body to prevent regurgitated fluid from flowing back into the lungs and causing pulmonary complications.
- Crocodiles should not be maintained with limbs restrained for long periods of time, as it may cause oedema.

Alternate methods may be used for crocodiles that have to be kept in captivity for longer durations. These include tethering the top jaw with a rope to a solid object that allows the animal limited mobility and allows it to be approached as required. Alternatively, the animal may be strapped to a carrying board (Fig. 12) with straps placed in several locations along the body, including over the neck, across the shoulders just behind the forelimbs, across the centre of the torso just in front of the hind limbs, at the base of the tail just past the pelvis, and one or more straps across the anterior half of the tail. Smaller animals may be held in transport containers without restrain.

8.1 Transport containers

A variety of containment methods may be used for the transportation of crocodiles. For short distances, the animals may be transported in the traps they are captured in, with the tops covered using materials that allow air passage. Animals captured using a snare may be restrained as described earlier for transport. In conditions where the transport duration is longer or over long distances, the animals may be exposed to extreme stress, both physical and psychological. The animals in such conditions can be transported in transport crates that are proportional to the animal's size and of sufficient strength.

The containers for adult animals should be made of plywood not below 19 mm of thickness, mounted on a sturdy steel frame with smooth interiors and padding around the snout. The transportation of Gharials is particularly challenging due to their fragile snouts. Appropriate padding using foam or other suitable material may be placed at the snout end for safety.

The transport containers should have the necessary ventilation and an examination window to assess the status of the animal during transport (Fig. 13).

The snout of the animal should be taped and the eyes covered with a soft material held in place using tapes. For juvenile crocodiles less than 60 cm in size, cardboard containers as shown in Fig. 14 can be used for transport. The animals may be placed unrestrained singly in each compartment and the ends closed, as in a cardboard box.

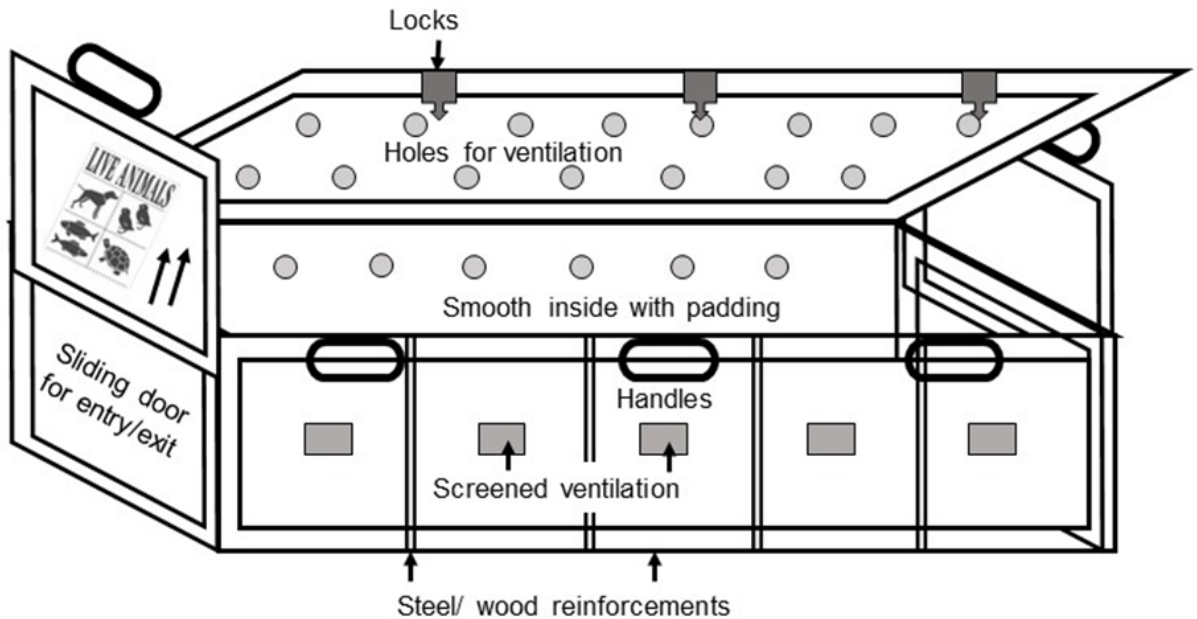


Figure 13: Transport containers for adult individuals

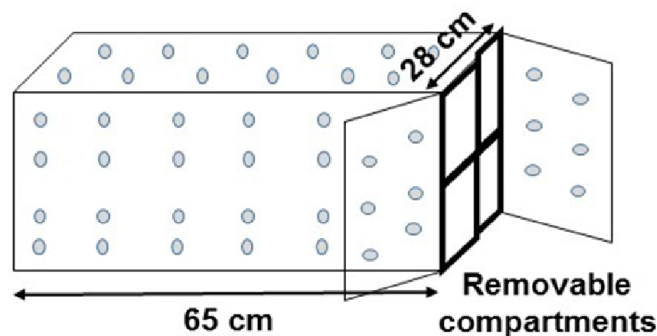


Figure 14: Transport container for juveniles

9 REHABILITATION

As defined by the International Wildlife Rehabilitation Council (IWRC), **rehabilitation is the "act of providing temporary care for injured, sick or orphaned wildlife with the goal of releasing them back into the wild".**

A veterinarian must conduct a comprehensive evaluation of the health of the animal under rehabilitation. This assessment should encompass various essential components, including a thorough physical examination of the animal. Diagnostic tests such as haematology, serum biochemistry, and imaging techniques can give an understanding of any underlying conditions. Examining faecal samples for the presence of parasites or other abnormalities is crucial in evaluating the animal's gastrointestinal health. Applying these standardised procedures consistently across different cases ensures a systematic and accurate clinical assessment of rehabilitation animals (Vogelnest, 2008).

10 TREATMENT & MANAGEMENT

10.1 Chemical restrain of crocodiles

Chemical immobilisation of crocodiles post-capture provides a protocol ensuring the safety of both the operator and the animal being restrained. It aids in preventing the animal from struggling, thereby stabilising blood pH and preventing acidosis by reducing lactic acid build-up. General anaesthesia of crocodiles is challenging due to their unique cardio-vascular physiology, difficulty in assessing anaesthetic depth, and aggressive disposition. The lack of standardised doses, limited knowledge on the effects of drugs indicate that chemical immobilisation may be used only in situations where methods of physical restrain can not be used.

Key considerations: The effects of the immobilising agents/anaesthetics used vary with species and between individuals of the same species. Additional factors such as the extent of struggling (build-up of lactic acid in the body) and ambient body temperatures also influence the outcomes of the chemical immobilisation effort.

Choice of drugs: The drugs used for chemical immobilisation have a range of effects that extend from ones producing deep anaesthesia to others that produce a sedated state. Some but not all drugs produce analgesia along with anaesthesia. The choice of drug, therefore, depends on the procedure's objectives, efficacy, and safety in producing the desired state of anaesthesia/sedation/analgesia. Additionally, the drug(s) opted for should be known to have produced consistent effects and should have rapid induction while causing minimal physiological changes and allowing for rapid recovery after the procedure.

10.2 Immobilising agents

A preferred combination of drugs for immobilising crocodiles is still to be developed, and a variety of drugs that are classified as barbiturates, narcotics, neuromuscular blockers, benzodiazepines, and dissociative agents have been used with varied effects (Table 1). Many of these are, however, highly variable in their anaesthetic effect,

have prolonged induction and recovery times, narrow margins of safety, and likelihood of overdose. Their effects are also not always reversible and threaten the immobilised animal and the team involved.

Table 1. Sedative, anaesthetic and restrain agents for crocodilians

Drug	Dose (mg/kg)	Reversal agent (mg/kg)	Remarks
Diazepam hydrochloride	0.22 - 0.62	Flumazenil [1:13 of flumazenil to diazepam; 1:20 of flumazenil to zolazepam]	Administered 20 min before succinylcholine provides a smooth induction, lower drug dose, decreased heart rate, respiratory rate, and recovery within 3 hours (Loveridge & Blake, 1972); Combination with ketamine provides a recovery time of 8 hours (Frye, 1991).
Gallamine	0.4 - 1.0	Neostigmine (0.03 - 0.06)	Deaths reported in alligators and false gharials
Ketamine	20 - 100	None	Doses at 20 - 50 mg/kg for sedation and 50 - 100 mg/kg for anaesthesia. High doses may require assisted ventilation and have prolonged recoveries
Medetomidine	0.04 - 0.15	Atipamezole (0.2 - 0.75)	Prolonged recovery without reversal
Propofol	10 - 15 (Adults) 3 - 5 (Juveniles)	None	Intravenous administration with 30 - 60 minutes for recovery (adults); IV in caudal/ventral coccygeal vein with recovery in 25 to 40 minutes (juveniles)
Succinylcholine	0.5 - 5.0	None	Prolonged recovery (> 6 hours)
Tiletamine-zolazepam	1.0 - 2.0	None	Prolonged recovery (several hours)
Xylazine +Ketamine	1 - 2 (1 M) 20 (1 M)	Yohimbine (0.1; 1 M) Atipamezole (0.2 - 0.75)	Atipamezole is a more reliable reversal agent Ketamine is applied after some time of Xylazine

***Source:** Lloyd (2003)

The immobilising and reversal agents are injected intramuscularly between the scales on the tail, front leg, or on the top or side of the neck using a syringe or pole-syringe.

10.3 Triage and initial assessment

Developing a triage system for crocodilians is essential in formulating prognosis and adopting treatment protocols. Time and depth of injury must be determined to develop a prognosis, which can be categorised as excellent, good, fair, guarded, or grave. First, the crocodilian is observed from a safe distance to get an idea of its overall health, extent of injury, and ability to lift the body above the ground. One should check for general appearance, abnormal posture, rapid or shallow respiration, etc. One should also check for the animal's ability to swim and observe its general activity and pattern of locomotion. Audible, irregular, rapid, or excessive respiration indicates trouble with breathing.

Physical appearance can be alert, depressed, non-responsive, or hyper-responsive to external stimuli. Abnormality may be indicated by the inability to raise and tilt the head, tremors, and ataxia.

10.4 Body condition

Assessing body condition is a crucial part of the examination, which provides information about nutritional status and helps understand the animal's overall health condition.

The criteria for assessing body condition are attached as Annexures I for Gharials, Muggers, and Saltwater crocodiles, respectively.

10.5 Physical examination after restrain

Physical examination is impossible without restraining the animal. Assess the animal for severity of wounds, injuries or illness to determine the mode of action (Caulkett and Haigh, 2007). Once the animal has been restrained properly, physical parameters like body temperature, heart rate, muscle reflexes, eyelid movement, and respiratory rates should be periodically monitored till the release (Template given as Annexure IV). Morphometric measurements can also be taken after restrain and maintained in a database (Template given as Annexure VI)

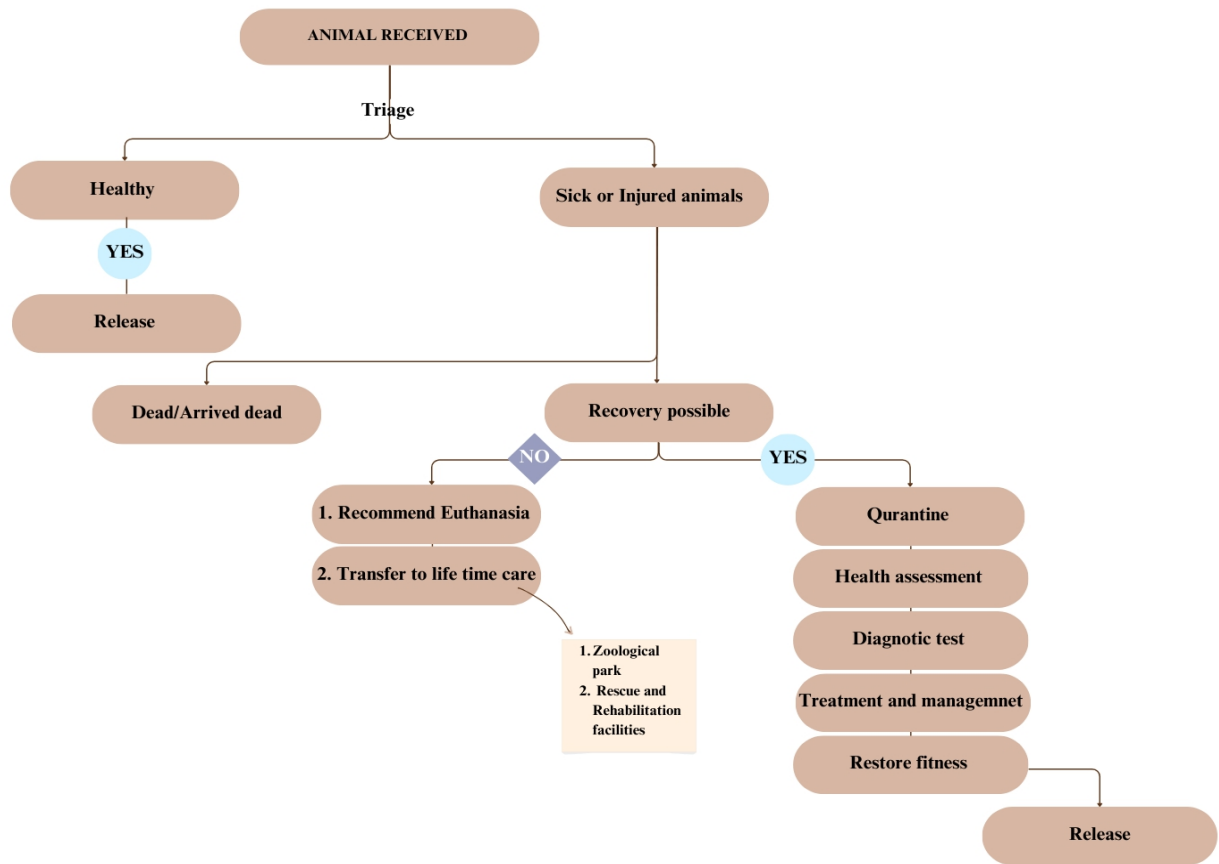


Figure 15: Decision tree for implementing a holistic approach

10.6 Quarantine

Quarantine is an essential practice for preventing the transmission of infectious diseases between the animals undergoing rehabilitation and resident animals at a rehabilitation centre. It is a good practice to quarantine all the animals arriving in the facility, considering the potential of infection spread.

Quarantine protocols

- Maintain a designated quarantine area that is physically separated from the main rehabilitation area. This helps prevent the spread of potential diseases or parasites to other animals.
- Establish a minimum quarantine period to monitor the animals for any signs of illness or infection. The duration can vary depending on the species and specific requirements, but it is generally recommended that aquatic animals be quarantined for a minimum of 30 days.
- Thoroughly assess each animal's health upon arrival. This includes physical examinations, checking for signs of disease, assessing body condition, and conducting diagnostic tests as necessary (e.g., blood tests, etc.).
- During the quarantine period, keep the newly arrived animals isolated from other animals. This prevents direct contact and potential transmission of diseases.
- Monitor the animals closely for any signs of illness, abnormal behaviour, or changes in appetite. Regular observations will help detect any potential health issues that may require further evaluation or treatment.
- Provide appropriate veterinary care during the quarantine period.
- Follow strict biosecurity measures, including proper hand hygiene, disinfection protocols, and the use of personal protective equipment when handling the quarantined animals. Reduces the risk of cross-contamination.
- Monitor and maintain optimal water quality parameters, such as temperature, pH, ammonia, nitrite, and nitrate levels, to ensure a suitable and healthy environment for the quarantined animals.
- Maintain detailed records of each animal's health status, treatments given, observations made, and any significant changes observed during the quarantine period. This documentation is valuable for tracking progress and sharing information with veterinary professionals if needed.

10.7 Fluid therapy

There are some ways to assess an animal's hydration status. Fluid therapy is required in cases of shock, dehydration, and loss of body fluid due to any other reason.

Estimation of Hydration status

Per Cent Dehydration	Signs of Dehydration
4 per cent	Difficult to detect
5 to 7 per cent	Increased thirst Slight lethargy Dull corneas Tacky mucus membranes Loss of skin elasticity Wrinkled skin
8 to 10 per cent	Sunken eyes Severe lethargy Thick and ropy saliva Dry skin fold

To calculate the amount of fluid to be given, calculate the percentage of dehydration, the animal's body weight, and recommended fluid for maintenance (i.e., 10 to 30 mL per kg of body weight per day for reptiles). Ensure that total fluid does not exceed 3 per cent of body weight. Fluid can be given in divided doses.

For example, A 600-gram juvenile gharial with 5% dehydration

1. To calculate deficit:	$600 \times 0.05 = 30 \text{ mL}$ Replace the deficit over three days. $30 \div 3 = 10 \text{ mL per day.}$
2. To calculate maintenance rate: (10 mL per kg per day)	$0.600 \text{ kg} \times 10 \text{ mL} = 6 \text{ mL}$
3. Deficit + maintenance = total fluid per day	$10 \text{ mL} + 6 \text{ mL} = 16 \text{ mL per day.}$

For rehydrating, immersion in water can be efficient only if the animal is found to be stable at first sight. The rehydration takes place via oral and cloacal intake. Care must be taken in debilitated animals so they don't drown. Other methods, such as intracoelomic (IC), subcutaneous (SC), or intravenous (IV) routes of fluid administration, can also be considered by a veterinarian. The most preferred site for SC fluid administration is loose skin on the lateral aspect of the front limb or hind limb (give 3-5% of body weight at a time). This site is also useful for delivering other medications.

10.8 Wound care

Trauma and entanglements in fishing gear are common causes of injuries in crocodiles. The aquatic environment contaminates all traumatic injuries. Evaluate the severity of the wound and whether or not it requires veterinary attention. If the wound is deep or bleeding heavily, it requires immediate intervention. To remove debris, flush the wound with sterile saline or diluted chlorhexidine (0.05%). If the wound involves a coelomic cavity, flushing should be avoided. Debride the wound with a pair of sterilised tweezers or forceps, i.e., remove dead or damaged tissue from the wound. Animal rescuers and rehabilitators should check for dislocation or fracture by inspecting thoroughly, listening to any audible gas released from the fracture site, or noticing bubbles when the animal is underwater. All of these require immediate attention as the prognosis is poor. Injury may involve internal organs such as the liver, intestine, or stomach.

10.9 Control bleeding

Apply direct pressure on the wound using a clean cloth or towel for 10-15 minutes. This will help stop the bleeding. Tourniquets should be used with caution. They may cause significant tissue damage. Severe bleeding requires immediate veterinary intervention.

10.10 — Drugs and Antimicrobial therapy

Standardised drugs and doses are not available for most reptile species, including crocodilians. The limited information available is the result of published case histories of treatments provided and extrapolation from mammals and avian dosages, which are not based on long-term scientific studies. Drugs which are safe in mammals and birds have to be used with caution in reptiles as they can be dangerous in reptiles. The preferred choice of antibiotic should be based on diagnostic testing and the type of bacterial infection. Enrofloxacin is usually well tolerated and is effective for both gram-positive and negative bacteria. Reptiles have unique metabolic rates and drug pharmacokinetics compared to other animals. crocodilians, similar to other reptiles, have a unique renal portal circulation that results in faster metabolism and excretion of the drugs administered, resulting in a reduced half-life of the drug and reduced efficacy. Any drugs or medicaments to be administered to crocodilians should be used cautiously.

Routine use of antibiotics to prevent disease in healthy animals is not advisable as it increases the risk of antimicrobial resistance. Antibiotics should only be administered if a disease is diagnosed in the animals or in others of the same population (WHO, 2017). Broad-spectrum antibiotics may be used as prophylactics in cases of open wounds (trauma) to avoid secondary bacterial infections. Antibiotics used for the treatment should only be prescribed by the veterinarian and used under their supervision.

11 — HUSBANDRY PRACTICES

11.1 — Temperature

Ambient temperature management is essential for thermoregulation in all exothermic reptiles. A preferred optimum temperature zone (POTZ) range for crocodilians is 28-34° C. Factors such as metabolic rate, digestion, growth, cardiovascular function, acid-base regulation, water balance, reproduction, immune function, locomotion, and prey acquisition are temperature-dependent. Temperature also has clinical implications as such

- Most antibiotic pharmacokinetics are affected by the body temperature.
- The effectiveness of many drugs is temperature-dependent.
- Higher body temperature leads to rapid recovery from the effect of anaesthesia.
- Excessively higher or lower temperatures may hinder recovery and healing in the reptiles.

11.2 — Water quality

With aquatic animals, water quality is crucial. But keep in mind that a straight forward setup makes cleaning up much simpler. Clean water is crucial to good health, and the best way to ensure this is through frequent complete water changes. By using an effective filter, the water will be clearer, and it will also reduce the manual labour of more frequent water changes. Good-quality mechanical and biological filtration is required. Chemical water treatment methods are not suggested as they may be toxic to the animals, even at low concentrations, and pose an additional hazard for the animals.

11.3 — Humidity

Low ambient humidity can cause anorexia, dehydration, and slower gastrointestinal transit times. The onset of dermatitis and respiratory illnesses is commonly correlated with excessive humidity. A hygrometer may be used to measure humidity levels (Gairhe, 2007).

11.4 — Nutrition

Crocodiles and Gharials kept in captivity are often fed a diet that includes rodents, chicken, fish, and meat. It is advised to have a diversified diet. Three or more different kinds of fish should be included in diets that are predominantly composed of fish, and 30-35 mg of thiamine and 100 IU of vitamin E/kg of fish should be included as supplements. Crocodilians that are fed fish were insufficiently supplemented with vitamin E have been observed to exhibit vitamin E deficiency symptoms, such as steatitis. Captive reptiles kept without regard for their thermoregulatory and specific environmental requirements may suffer from poor feeding management and faulty diets. Common problems include malnutrition (nutrient imbalance) in all groups of reptiles, dietary deficiencies of calcium, cholecalciferol (vitamin D3), and vitamin A (Grigg and Krishner, 2024).

11.5 Housing

The Central Zoo Authority prescribed minimum standards and norms for housing animals in the zoo and another similar environment for education, conservation, and healthcare purposes as per amendment of the Wildlife Protection Act, 1972, and recognition of zoo rules, 2009. The specifications laid down by Central Zoo Authority were envisioned for the exhibit of healthy animals for visiting public; however, for the purpose of rehabilitation, enclosures to house crocodilians require additional considerations. These should address the needs for frequent restraining of animals for veterinary examinations, managing animals by caretakers, observation of animals, segregating animals based on needs and capturing animals for release/transfer. The barrier of the holding area should ensure that the animals are not able to escape out of the enclosures. For Gharials, a short wall of 1 m height may be sufficient as they are unable to climb and have difficulty in moving on land; however, for the other species, strong barriers with overhangs towards the inside that restrict escapes are required.

Large, naturalistic enclosures with deep water pools may result in difficulties in managing animals.

A separate area for quarantine of new animals entering the facility should to be present. These should be situated at a distance from the main holding areas to prevent the spread of infections.

- The land and water bodies in the enclosure should be proportionate, with a mosaic of sun and shade areas to enable the animals to regulate their body temperature.
- Maintain a proper temperature gradient within the enclosure, including a basking spot and heat lamps. If natural lighting is not available, UVB light for the synthesis of vitamin D and calcium metabolism may be added to the enclosure.
- Minimum size of enclosure for the animals recommended by CZA for the land : water body ratio is 400 : 150 sqm.
- For the crocodilians and Gharials, the depth of the water body should be 2 meters with a provision for rapid emptying of pool. Store chlorinated water for 24 hours in the pond before using it.
- If multiple animals are housed in the same enclosure, the subordinate animals should have areas for concealing themselves from the dominant animals.

12 PATHOLOGICAL EXAMINATION

12.1 Collection of biological samples

12.1.1 Blood

A thorough veterinary health assessment must include blood sample analysis. As a thumb rule, reptiles' blood volume is approximately 5-8% of the total body weight. This means a 100 gm reptile will have 5-8 ml of total blood volume. Generally, drawing of a maximum of 10% (0.5 - 0.8ml) of the total blood volume can be considered safe for an animal. Reptilian blood should always be collected in sodium or lithium Heparin tubes because EDTA (Ethylene-Diamine-Tetra-acetic Acid) may lyse erythrocytes in some species.



Source- Javier Nevarez

Figure 16: Blood collection from supra-vertebral venous sinus in crocodile

Collecting blood in crocodiles is a challenge, but with regular practice and proper technique samples can be collected as required. A person handling crocodiles should have a thorough knowledge of animal positioning for blood collection. Sodium or lithium heparin vials, serum separator vials, glass slides, spirit gauze, needles, and syringes should be handy once the animal is positioned for blood collection. In small to medium-sized crocodilians, the caudal or ventral vein and supra-vertebral venous sinus are accessed through a 90-degree; dorsal midline approach behind the occipital region in medium and large crocodilians (Herrin, 2017). The collected blood may be used for further analysis as required by the veterinarians.



12.1.2 Parasitological samples

Gastrointestinal parasites are a major health concern in reptiles; hence, regular faecal sample examinations should be carried out of animals during rehabilitation. Animals should also be screened for the presence of internal parasites by faecal examination before release. Faeces in reptiles are usually brown to black colouration and should never be confused with the white colour urates; the parasite stages are present in the faeces and not in the urates. The flotation and sedimentation techniques as performed for other animals can be used to check the presence or absence of the parasites. During necropsy, ecto and endoparasites (roundworm and tapeworms) should be collected in 70% ethyl alcohol or methanol.

12.1.3 Swabs

Animals which exhibit signs of lethargy, anorexia, dullness, poor health, and any discharge from natural orifices or ulcerative lesions are suspected to be diseased. When required and feasible, swabs can be used to collect samples from the eyes, ears, nose, mouth, and cloaca to diagnose infections. Use of appropriate transport media while shipping to a diagnostic laboratory is essential. Most transport media are buffered fluid or semisolid fluid with nutrition. Once the swab is taken into the medium, it must be allowed to remain at room temperature for 30 minutes to 1 hour before refrigeration. For bacteriological examination, the swab can be taken into the BHI (Brain Heart Infusion) medium and stored at 4°C, while the virological screening swab can be taken in a viral transport media such as DNA/RNA Shield or Phosphate Buffer solution (PBS), and can be stored at -20°C or lower temperature until analysis.

In addition to these samples, other diagnostic tests, such as radiographs (X-rays) or ultrasounds can be used to assess a crocodiles overall health.

Additional tips:

- Crocodiles can be stressed by handling; it is important to be gentle and patient when taking biological samples
- The type of equipment that you use to collect biological samples will vary depending on the type of sample that you are collecting and the species.
- Label samples carefully with species, age, sex, date, animal ID, and other details of the samples.
- Store the samples properly.

12.2 Pathological examination

Pathological examination in crocodilians is a type of diagnostic testing that is used to determine the cause of death or illness, which involves an examination of tissue and organs under a microscope. Samples that are collected during necropsy are sent to a laboratory for histology, cytology, microbiology, and serology. The sample collected for histopathology examination can be preserved in 10% formalin. The volume should be 10 times that of tissue samples. A small piece of tissue, approximately 0.5 cm³, should be sufficient for the histopathological examination. All tissue samples (spleen, lung, liver, heart, kidney, brain, stomach, intestine, and lymph node) along with affected organs (both normal/abnormal areas of the tissue) with associated lymph nodes should be collected using a sharp surgical blade. The result of the pathological examination will help the veterinarian to develop a line of treatment or preventive health plan.

12.3 Necropsy examination

Necropsy, or post-mortem examination, is the systematic and scientific examination of an animal's body, tissue, and organs to determine the cause of death. The document (Suggested best practices for necropsy examination of select freshwater reptiles of the Ganga basin) presents the best practices in use for performing necropsies, as performing necropsy of a crocodile requires special considerations due to their unique anatomy and physiology.

13 DECIDING THE FATE OF ANIMAL

Return to the wild: The welfare, disease, conservation cost, and origin of rescued animals pose potential hazards to the environment. Releasing animals to the wild without first subjecting them to an on-site medical examination by a qualified veterinarian, genetic testing, other screening procedures, and a well-designed post-release monitoring protocol should be avoided.

Transfer to rehabilitation facilities: If the animal is found to be unhealthy during physical examination, it should be retained in a temporary facility and quarantined. The animal should be monitored, treated by an expert veterinarian, until it is fit for release.

Transfer to lifetime care facilities: Animals that cannot be released to the wild due to illness, injury, or captivity are moved to lifetime care facilities. Wild animals are typically referred to zoos, aquariums, and rescue centres.

Humane euthanasia: The decision of euthanasia should be taken on the basis of the recommendation of the committee constituted by the Chief Wildlife Warden of the state on the basis of the following recommendations:

Terminally ill animals are in a state of excruciating pain and agony, and it is cruel to keep them alive. Besides, keeping an animal alive that is suffering from incurable disease or infection poses a serious threat to the health of other animals.

Euthanasia in reptiles is tricky and can only be performed as an absolute necessity by a designated officer authorised to undertake the activity. While crocodiles are extremely resilient, healing is unusually slow. They take five times longer to heal than mammals and birds. Hence, the criteria for euthanasia are different for mammals and birds. If euthanasia is truly indicated, use a two-stage approach. Start with a pre-euthanasia with Telazol at 25-50 mg per kg of body weight, followed by Ketamine HCL at 100 mg per kg body weight intramuscular.

The following are NOT acceptable methods of euthanasia:

- Freezing (inhumane)
- Inhalant (ineffective)
- Exsanguination (inhumane)
- Decapitation

Remarks: Euthanasia of any animal in contravention of these guidelines would be illegal hunting under Section 9 of the Wildlife Protection Act, 1972, read with Sub Section (16) a of Section 2 (Wild Life Protection Act, 1972).

14 MARKING/TAGGING

It is essential that all animals being captured be appropriately marked for individual animal identification, prior to release. It aids in the monitoring of released animal(s), supports ecological studies and assists in the monitoring of free-ranging populations. A variety of marking methods available for marking crocodiles prior to release are summarized below.

Scute-clipping

Crocodilians are marked in the field by removing a combination of raised vertical scutes on the tail. On the posterior end, there is a single row of scutes, while on the anterior end, a double row of scutes is present. The scutes are removed in accordance with a predetermined numbering system (e.g., Richardson et al., 2002). The scutes are removed at the base of the tail using a sharp-edged scalpel or knife; for hatchlings, scissors are used.

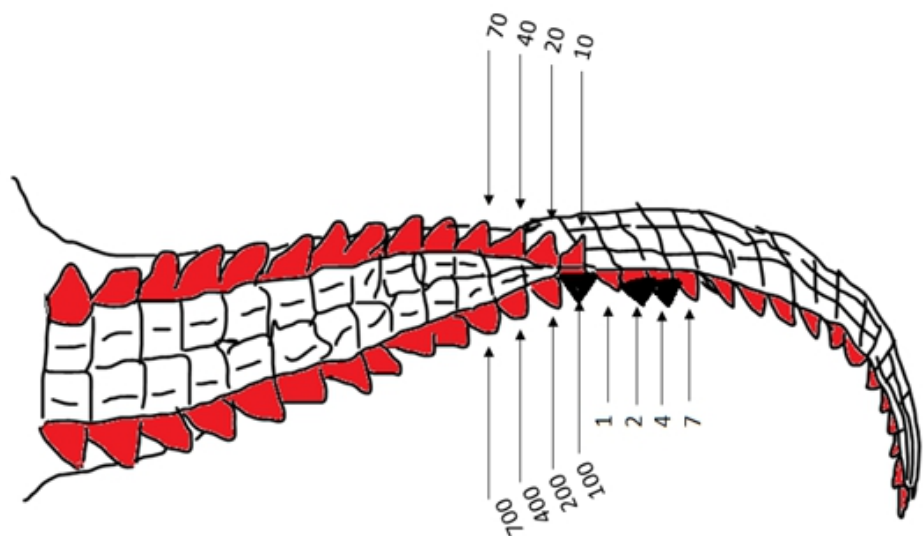


Figure 17: Scute clipping of crocodiles

Webbing tags

Metal tags bearing unique numbers are fixed between toes on the hind feet in crocodilians. The tags are fixed in place using a crimping tool that fixes the tag in place. They are however, susceptible to tag loss and causing problems as the size of the foot grows with time.

Passive integrated transponders (PIT) tags

PIT tags are radio frequency identification tags, with each transmitting a unique alphanumeric code when subjected to an electromagnetic field. The unique code transmitted can be read using appropriate detection antennas (readers) and used for individual animal identification. Their small size (about the size of a rice grain), ease of implantation, minimal side effects, and extremely long lifetimes make them suitable for use in detection systems; however, a major challenge in their use is their low detection distance (the readers must be within 10-100 cm of the tag).

The technique has been used effectively for marking hatchlings. The tags are injected subcutaneously using a modified syringe applicator at the base of the tail on the dorsal side of crocodiles. The tags implanted here have low migration probabilities as the animal grows. Intraperitoneal implantation of the tags should be avoided as the tags are likely to migrate within the body cavity. Additionally, the tags may move out of detection range as the animals grow. A disadvantage in their use in crocodiles is the necessity for capturing large and dangerous animals for identification.

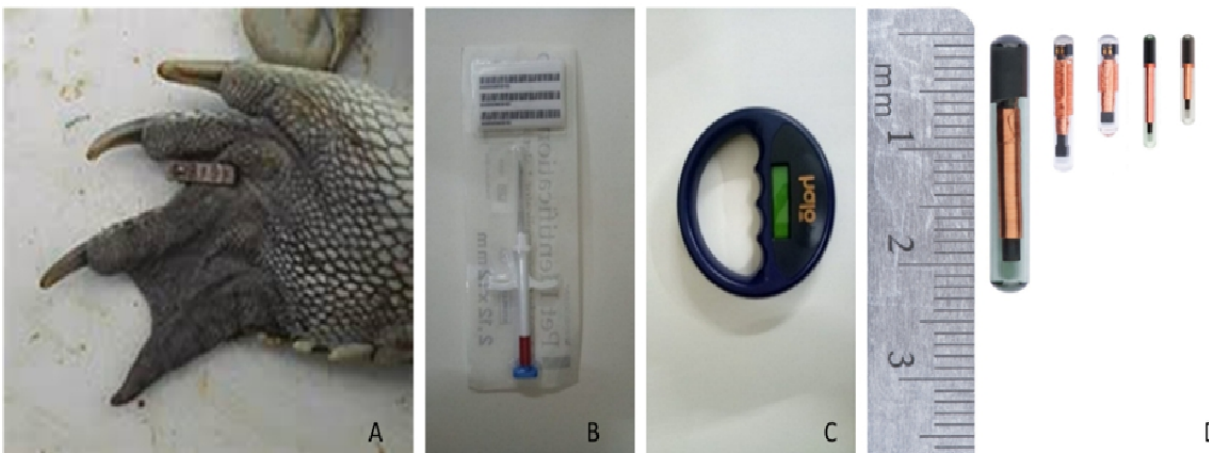


Figure 18: Different types of identification marking used for crocodilians
A: Webb tags (metal), B: PIT injector, C: Reader device, and D: Tags

Livestock ear tags are made of flexible plastic and are visible from a distance. They are applied using an applicator that rivets the tag into position. The newer versions include 'radio frequency identification' (RFID). They can be attached to crocodiles on the osteoderms on the back of the neck or on the vertical tail scutes. The tags are visible from a distance and can be easily seen when the animal comes to bask or surfaces. The loss of tags is a frequent problem and cannot be used for extended monitoring.



Figure 19: Plastic tags used for identification marking

Telemetry devices

The ongoing advancement and miniaturisation of electronic tagging technology have provided the means to effectively mark crocodiles for individual identification that facilitates further study and monitoring. Once fixed, the electronic tags can be remotely monitored, and the information obtained can be used for further studies. The osteoderms and scutes on the dorsal surface of the animal provide a number of sites for attaching the tags. They are commonly attached to the head, mid-dorsal neck, or tail using pins, wires, or nylon lines.

Critical considerations in using electronic tags are that they should be retained for long enough to provide the necessary data, they should be small enough and fixed so as to allow for unimpeded movement, and they should not damage the underlying tissue or restrict growth at the site of fixation.

15 — TRANSPORTATION AND RELEASE

Restrain crocodilians for release by securing jaws, limbs, and covering eyes to reduce visual stimulation. If necessary, temporarily restrain limbs, but not for a longer duration. Mark the animal before transportation. A veterinarian with experience in managing crocodilians must assess the animal's fitness for release. Crocodilians in rehabilitation settings may be released once their fitness is restored. Determine whether the release criteria for crocodilians are fulfilled. It is not a geriatric animal and is not compromised due to age-related conditions.

(Performa for animal release is attached as Annexure IV).

The release of juvenile crocodilians should follow a soft-release or hard-release approach. Crocodilians should be released in streams with low water levels and always on the river banks. Post-release monitoring of the animal is always recommended to ensure its survival and standardise rehabilitation protocols.

Transport

The method used for transport of crocodiles is determined by their size and the distance to be covered. Critical considerations during transportation are avoiding exposure including dehydration, overheating (temperatures > 35°C), excessive cooling (<20°C) and struggling, and minimising the time taken for transport. The containers used for transportation should be free of sharp edges. Padding around the snout, particularly for Gharials can reduce chances of injury to the snout. During transportation, the head, body and tail base should be adequately supported to prevent injury to vital organs. It is essential that if the snout of the crocodile is tied during transport

a wooden block or stick must be placed between the teeth and the head kept slightly elevated to prevent the regurgitated fluids from entering the lungs.

Release of crocodiles

All crocodiles must be released in close proximity to water-bodies that are a part of the natural habitat of the species and provide foraging opportunities. The animal must be freed of all ties binding it with the eyes covered. The binding from the jaws must be carefully removed while ensuring safety of handlers. A rope loop tied around the jaws (held by a handler not involved in opening the bindings) that may be loosened after the binding of the jaws is removed to improve the safety of handlers. The ill-effects of capture often take considerable time to fully go away, all animals should be closely monitored wherever possible for at least two days after release.



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17 ANNEXURE I

Criteria for Assessment of Body Condition Score of crocodilians

BCS	Criteria
1	Limbs- Very bony and thin limbs Jowls- Shrunk jowls and thin neck Spinal column- Very visible spinal column Tail girth- Very bony or thin tail
2	Limbs- Thin Limbs Jowls- Lean jowls Spinal column- Barely visible spinal column Tail girth- Lean tail and tail girth
3	Limbs- Muscular, Fleshy limbs Jowls- Full fleshy and bulky jowls Spinal column- No visible spinal column Tail girth- Plump tail and larger tail girth
4	Limbs- Fatty and Fleshy Jowls- Bulky Spinal column- Not visible Tail girth- Fatty tail, huge girth
5	Limbs- Huge limbs, unable to lift the body up the ground Jowls- Thick jowls, fat deposit clearly visible Spinal column- Not visible covered with fat, convex Tail girth- Huge rounded tail

18 ANNEXURE II

Physical Examination

Date of Examination : _____

Species : _____ Animal ID : _____

Sex : _____ Age : _____

ASSESSMENT OF ANIMAL IN WATER

- I. Ability to swim : _____
- General Activity : _____
- Swimming posture : _____
- Respiration underwater : _____
- Vision : _____
- II. Buoyancy : _____

ASSESSMENT OF ANIMAL ON LAND

- I. Body weight : _____
- II Demeanour : Non-responsive/Alert/Depressed
- III. Scales integrity : _____
- IV. Bleeding (if any) : _____
- V. Any signs of visible injury : Yes/No
- VI. Palpation : _____
- Front and back legs : _____
- Nails : _____
- Range of motion : _____
- Planter surface : _____
- VII. Auscultation : _____
- Heart Rate : _____
- Respiration Rate : _____
- Temperature : _____
- VIII. Discharges (if any) : _____
- Mouth : _____
- Eyes : _____
- Ears : _____
- Cloaca : _____
- IX. Describe abnormal findings : _____

Veterinary Officer

19 ANNEXURE III

Template for crocodilian Rescue

Template for Crocodilian Rescue

Initial Observation

Stranding Number : _____ Name of Observer : _____

Common Name : _____ Scientific Name : _____

Local Name : _____ Number of Individuals : _____

Date : _____ Ambient Temperature : _____

Location

State : _____ District : _____

City/Village : _____ Canal : _____

Latitude : _____ Longitude : _____

Condition at Initial Observation (Check ONE)

Alive : _____

Fresh Dead : _____

Advanced Decomposition : _____

Moderate Decomposition : _____

Mummified/Skeletal : _____

Condition Unknown : _____

Morphological Information

Sex (Male/Female/Unknown) : _____

If Female, Pregnant (gravid): _____

Estimated Age Class

Adult : _____

Subadult : _____

Yearling : _____

Hatchling : _____

Unknown : _____

Forest Range Officer

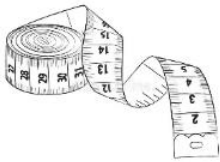
20 ANNEXURE IV

Proforma for Animal Release

	Pre-Release Assessment (within 72 hours of release)		Release Determination Assessment (within 2 weeks of release)	
History	Yes	No	Yes	No
Foraging Ability				
1. Animal is nutritionally dependent.				
2. Animal is not a geriatric animal and is not compromised due to age-related conditions.				
Behavioural Criteria				
3. Animal demonstrates appropriate breathing, swimming, and diving behaviours.				
4. Animal does not exhibit aberrant behaviour including attraction to or desensitization to the presence of humans.				
5. Animal does not exhibit auditory or visual dysfunction.				
Medical Clearance				
6. The attending veterinarian has ascertained that the animal was apparently healthy from two weeks before the date of release based on a visual assessment.				
7. The attending veterinarian has reviewed animals history and medical records, including behavioural records and found the animal healthy.				
8. The required health screening and assessments were conducted with good results.				
9. Hands-on physical exam performed by attending veterinarian within 72 hours of release				
10. CBC compatible with good health.				
11. Blood chemistry profile compatible with good health.				
12. Serum banked upon admission and prior to release.				
13. Free of drugs (exclusive of sedatives used for transport) minimum of 2 weeks prior to release.				
14. Veterinarian's signature on health certificate.				

21 ANNEXURE V

List of essential equipment for rescue of crocodilians

	Nets		Measuring equipment
	Knives/ scissors		Animal treatment kit
	Wooden plank		GPS
	Ropes		Duct Tape
	Cloth/gunny bags		Snare pole
	First aid kit for humans		Transport cage
	Boat		Transport vehicle
	Water buckets		Skilled Manpower

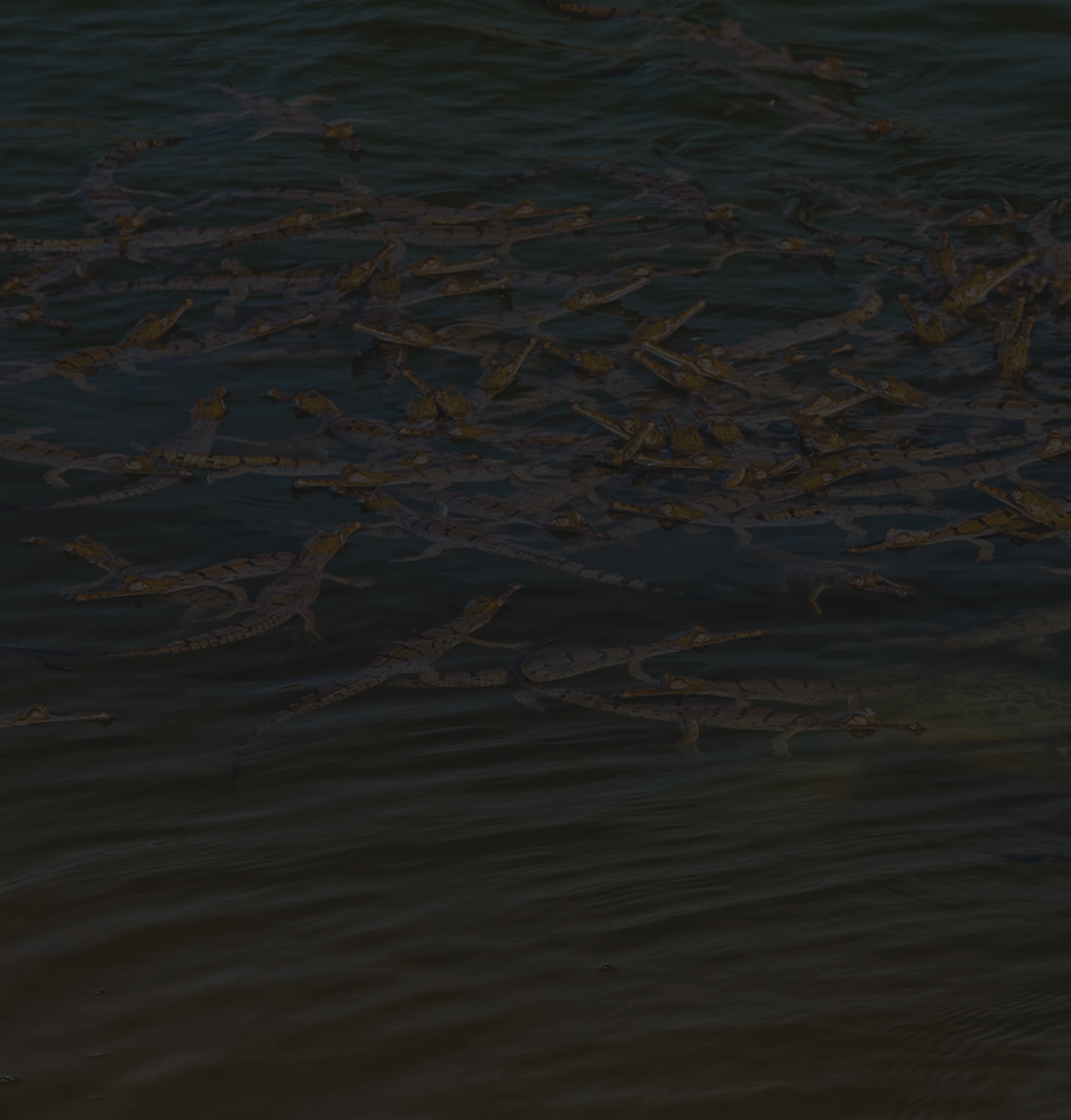
Crocodilian Morphometry

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31

NOTE

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NMCG

National Mission for
Clean Ganga
Department of Water
Resources, River
Development & Ganga
Rejuvenation, Ministry of
Jal Shakti, Major Dhyan
Chand Stadium, India
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wii.gov.in/nmcg/national-mission-for-clean-ganga

GACMC/NCRR

Ganga Aqualife
Conservation Monitoring
Centre/National Centre for
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