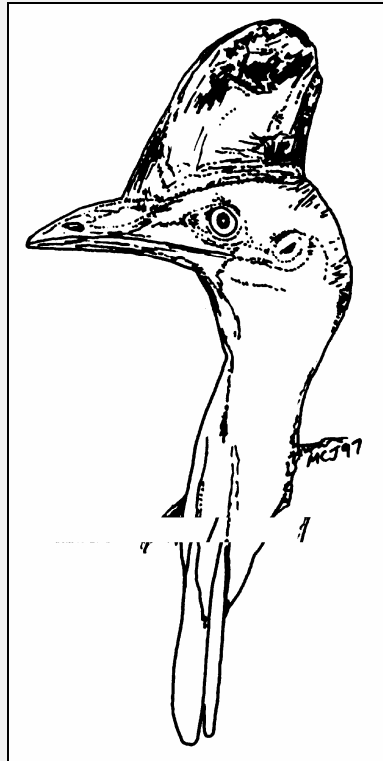


CASSOWARY HUSBANDRY MANUAL

**First Edition
December 1997**



**Edited by
Liz Romer**

Produced by Currumbin Sanctuary Conservation Unit



CASSOWARY HUSBANDRY MANUAL
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PREFACE

Cassowaries, a familiar rainforest species, are widely held in captivity for educational displays as they represent both a flagship species for rainforests and the unique group of birds known as ratites. The thick glossy black plumage combined with the striking reds, blues and purples of the head and neck, topped with a bony casque make it an unmistakable and outstanding looking animal.

The Southern Cassowary has a long history in captivity. In 1596 the first bird seen by Europeans was when a *Casuarius casuarius* from Banda Island was given as a gift to a captain of a Dutch Merchant vessel. The captain was subsequently murdered by the giver (which only goes to show how dangerous cassowaries can be!) but the live bird of the now dead captain was taken back to Amsterdam where it arrived in 1597 and was presented to the Holy Emperor Rudolf II as a gift and was put on public display for some years. Thus it was that discovery and captivity arrived at the same time for the Cassowary. (Moore 1994).

Records of breeding show London Zoo produced single chicks in 1862 and 1863 although neither survived. The first successful rearing (one chick) was probably San Diego Zoo in 1957. The male had lived there for 31 years. Taronga Zoo hatched a chick in 1962 but it is thought to have died soon after. From 1973 to 1982 the Australian Reptile Park in Gosford NSW was relatively successful in breeding them. Edinburgh Zoo (Scotland) documented breeding from a four year old pair. Since then results have been sporadic with Denver Zoo being perhaps the most productive with 98 chicks bred from 1977 - 1992 (ISIS Studbook data). Airlie Beach Wildlife Park have been the most prolific breeders in Australian Wildlife Parks with 22 birds being produced to this present time. Some pairs have had one or two good breeding seasons then produced no more while other pairs have still to breed.

The Australian sub-species of the Double-wattled Cassowary *Casuarius casuarius johnsonii* is now listed as endangered in the wet tropics and vulnerable nationally. It has been chosen as a priority species for zoos to concentrate on managing and breeding. As a studbook species the ultimate aim is to manage the population to provide a resource for the recovery program so that, if required, birds of known origin are available for release programs in the future.

Bearing in mind the relatively inconsistent breeding record for this species it was decided to hold a workshop on the captive management of cassowary in February 1996 at Currumbin Sanctuary. While concentrating on the Double - wattled Cassowary it was hoped that the data gathered would also be applicable to the Dwarf and Single-wattled Cassowary. Forty four people who had a great deal of information to share on their experiences in a large number and wide variety of zoos and parks attended the workshop held over two days. Of particular note was the attendance of Richard Rundel from Sonoma Bird Farm in California who has a wealth of experience with all three species. This husbandry manual represents the results of the workshop combined with relevant literature.

It is hoped that this manual will be added to over the years as our knowledge of the husbandry requirements increases. The information gathered was used in the formulation of the Queensland Wildlife Parks Association (QWPA) Minimum Standards for Exhibiting Ratites. The format followed is based on that suggested by the Australian Bird Taxon Advisory Groups for the Australasian Species Management Program (ASMP).

This manual will be primarily concentrating on the Southern Cassowary unless otherwise stated. More work is needed to be done on the other two species.

CASSOWARY WORKSHOP PARTICIPANTS FEBRUARY 1996

HELD AT CURRUMBIN SANCTUARY

Doug Anderson	Perth Zoo
Rosie Booth	Currumbin Sanctuary
Ken Bullen	Private
Terry Carmichael	Rainforest Habitat - Port Douglas
Ray Chafer	Dreamworld
Peter Clark	Rainforest Habitat - PNG
Charlie Finn	Billabong Sanctuary
Mark Geyle	Qld Department of Environment
Tony Gordon	Airlie Beach Wildlife Park
Anna Grimley	Currumbin Sanctuary
Zannah Gubler	Currumbin Sanctuary
John Hangar	Australian Koala Hospital
Allison Harmon	Currumbin Sanctuary
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The three species of cassowary from Beehler et al 1986. Copyright © 1986 by Princeton University Press. Reprinted by permission of Princeton University Press.

1. Northern Cassowary (*Casuarius unappendiculatus*)
2. Dwarf Cassowary (*Casuarius bennetti*)
3. Southern Cassowary (*Casuarius casuarius*)

1.0 NATURAL HISTORY

1.1 Taxonomy

Order Casuariiformes

Family Casuariidae

The word cassowary is of papuan origin, from “kasu” - horned and “weri’ - head (Boles 1987). Three species of cassowary are currently recognised. All three species occur in Papua New Guinea with only the Southern Cassowary occurring in Northern Australia. All three species are similar in appearance. The plumage is coarse, black and hair-like with two shafts to each feather. The wings are rudimentary and are visible externally only as a few long, stiff quills. The legs are strong and there are three forwardly directed toes, each armed with a long claw: the claw on the inner toe is long & dagger-like. The head and neck are naked or nearly so and variously coloured in reds, blues, purples and yellow. There is a horny casque on the head, largest in the Southern Cassowary *Casuarius casuarius*, smaller in the Single-wattled Cassowary *Casuarius unappendiculatus* and smallest in the Dwarf Cassowary *Casuarius bennetti*. (Olsen et al 1993). The Southern Cassowary has two wattles on the neck, while the Single-wattled, as the name suggests, has one wattle. The wattles are absent in the Dwarf Cassowary.

The Australian sub-species of the Southern Cassowary is also known as the Double-wattled Cassowary *Casuarius .c. johnsonii* and **is the sub-species that will be expanded upon in this manual unless otherwise stated.**



Double-wattled Cassowary (Mary Johnson)

TABLE One - The Casuariiformes (Crome & Moore 1988) (Whitehead & Mason)

Summary of the Distribution and Habitat of the Three Species of Cassowary.

Common Name	Scientific Name - Sub - species	Distribution	Habitat
Southern or Double-wattled	<i>Casuarius casuarius</i> <i>C.c.casuarius</i> <i>C.c.aruensis</i> <i>C.c.johnsoni</i> <i>C.c.sclateri</i> <i>C.c.bicarunculatus</i> <i>C.c.tricarunculatus</i> <i>C.c.bistriatus</i> <i>C.c.lateralis</i>	Ceram Aru Islands North Queensland Southern New Guinea Western Vogelkop West Geelvink Bay North New Guinea, Geelvink Bay to Tana Mera ? locality	Rainforest
Northern or Single-wattled	<i>C. unappendiculatus</i> <i>C.u.unappendiculatus</i> <i>C.u.occipitalis</i> <i>C.u.aurantiacus</i> <i>C.u.philipi</i>	Salawati & western Vogelkop Japen Is & nearby coast? Memberano to Sepik R. Sepik R. to Astrolabe Bay	Riverine and coastal swamp forests
Dwarf or Bennetts	<i>C. bennetti</i> <i>C.b.papuanus</i> <i>C.b.goodfellowi</i> <i>C.b.claudii</i> <i>C.b.picticollis</i> <i>C.b.hecki</i> <i>C.b.shawnmeyer</i>	Vogelkop Japen Is. Nassau Mts (Sth. Slopes) South-east New Guinea Huon Peninsula to Sepik R. Kratke Mts.	Montane forests (1,000 - 3,000 m)

1.2 Distribution

In PNG *C. casuarius* has the broadest distribution. On the island of New Guinea it is a bird of the lowlands; on the north Papua New Guinea coast it extends from Nankina River to Milne Bay, on the lowlands of the south side to the Mimika River, on the Vogelkop, and on the west side of Geelvink Bay. *C. unappendiculatus* takes its place in northern New Guinea from the western Vogelkop to Astrolabe Bay and on the islands of Salawati and Japen. *C. bennetti* is a montane species that occurs from the Vogelkop to the Kratke mountains and on Japen Islands. Outside New Guinea *C. bennetti* occurs on New Britain while *C. casuarius* occurs on the Aru islands, Ceram and Northern Australia. (Crome & Moore 1988).

C. casuarius johnsonii occurs in two or possibly three isolated populations in Northern Queensland. In the north it is found from the tip of Cape York Peninsula to as far south as the McIlwraith Range, though the population may be divided at Cape Grenville.

In the south it occurs between Cooktown and Townsville. Within this area some populations may be isolated, such as those in the Edge Hill/Mount Whitfield area, on the Graham Range and at Ella Bay. Others like those on the Dagmar Range, are connected to the larger rainforest blocks by narrow corridors (Garnett 1992).

1.3 Habitat

Cassowaries depend on rainforests because of the large number of fruiting plant species in this habitat. They need a year-round supply of nutritious fruits and recent studies have shown that the highest population densities of cassowaries do not appear to be in areas of continuous rainforest, but rather where the rainforest patches are interspersed within a complex of vegetation mosaics dominated by sclerophyll open forest and woodland genera such as *Eucalyptus*, *Acacia* and *Melaleuca*. They have also been seen using mangroves. It is unlikely that populations or even individual birds can be maintained permanently in non-rainforest habitats given their food requirements. Non-rainforest areas appear to be crucial habitat at particular times of the year and perhaps in certain years. The peak rainforest fruiting period is from November to February, whereas the peak fruiting period for many open forest shrubs is July to October which coincides with the breeding season of cassowary (C4 1995).

The stronghold of the species is in the lowland forest. The cassowary occurs at higher elevations but in lower densities and, in some areas, sporadically. Populations may migrate atitudinally (White 1913). They do not need virgin forest and survive well in logged forest, but do need large areas and high plant diversity. As coastal forests disappear to make way for cattle, cane, fruit and other crops, so too will this majestic bird. (Olsen et al 1993).

1.4 Habits

For most of the year cassowaries live alone. They appear to have some sort of home-range: individual birds - recognised by facial characteristics and particular colours on the head and neck - can usually be found time and again in the same areas. If two males meet accidentally, they stretch their bodies, fluff their feathers, and rumble at each other until one retires. But if a male meets a female, she can usually make him flee merely by stretching a little and staring quietly, or rumbling slightly at him. Females tend to be the dominant sex. (Crome 1993).

Cassowaries can be aggressive, particularly when guarding their chicks, and it seems that some individuals are naturally bad tempered. They are armed with formidable, though seldom used weapons (the claw of the inside toe of each foot is a large straight spike, 120mm long and 30mm wide at the base). When cassowaries fight they raise their feathers and bend their necks right under their body, roaring loudly. Raising their head back up they then charge each other, kicking with both feet at once. The bout is usually brief with neither opponent sustaining much injury (Crome 1993).

1.5 Diets

Cassowaries feed on fallen fruit, particularly of the family Lauraceae but will eat almost anything, including dead rats, birds, live skinks, reptiles and even fungi that they might find on the ground. Over 100 species of plants have been recorded in the diet. Unlike most seed eating birds which swallow grit to help in grinding up the food in the stomach, the cassowary's stomach appears to massage the flesh off the seed. At times the fruit completes the journey through the digestive system apparently unchanged with the flesh still attached and the seed viable. (See appendix of food trees). Many of these seeds excreted are still viable and in fact may benefit from the scarifying effect of the bird's stomach. Cassowaries are important disperser's of seed of the larger fruited forest trees which may be deposited many kilometres from where they were picked up. The survival of these plants is apparently intricately bound with the survival of the cassowary. Twenty one species of rainforest plants require passage through the cassowary's digestive system to germinate (C4).

The fruits of laurel trees are rich in protein and fat, far richer than our cultivated fruits, and most are produced in spring and summer, when the cassowary breeds. Breeding success drops off sharply when laurels fail to fruit, as they do every second or third year. (Olsen et al 1993).

1.6 Breeding

The cassowary breeds June-October coinciding with the maximum availability of fruit. With the approach of the breeding season females become more tolerant of the males and eventually form pairs with the males of their choice. The pair remains together for a few weeks until the female is ready to lay, and they go to a chosen nest site. The nest consists of a shallow scrape in the ground augmented by a few leaves only. Before copulating the male displays to the female by 'dancing' around her in a circle, his throat trembling and swelling and emitting a series of low 'boos'. The male then leads the female a short distance where she squats and allows him to mount. After egg-laying the female takes no more interest and leaves the male to incubate the eggs and rear the chicks. Once finished with a mate, the female may take another, and lay a second clutch of eggs. One female has been known to take three mates in succession in a season. The incubation period is 47 - 54 days during which the male is not seen in his usual haunts. Up to eight eggs have been seen in a clutch but rarely are that many chicks seen with the male parent. (Crome 1993)

Once the young are hatched, the male takes the striped offspring to his regular feeding places. The chicks begin to lose their stripes after about 3 months. By the time they are six months old, their brown sub-adult plumage is developed and the neck and head are beginning to colour. The male looks after the young for about nine months and then normally chases them away to fend for themselves though they have been seen in the company of the male when 16 months of age. It takes from about two to three & a half years of age for the glossy black plumage to develop fully. They may be mature before this as brown birds sometimes attempt to mate with adult females. However, in captivity breeding success hadn't been recorded before approximately 4 years of age, although in 1994, a 3 ½ year old male at Currumbin Sanctuary successfully fertilised a clutch of eggs. This contrasts markedly with a breeding male at Denver Zoo who was 31 years old when he first successfully mated (Whitehead & Masson)



Cassowary chicks (Mary Johnson)

1.7 Life time reproduction

Denver Zoo bred 98 chicks from 1977 - 1992 from the same pair. These were mainly pulled for artificial incubation which increases the amount of eggs produced. No wild data is available at this stage.

1.8 Longevity

They are long-lived, with a recent death of a bird recorded as being at least 61+ years at Healesville Sanctuary.

1.9 Adult weights and measurements

Southern Cassowary	<i>Casuarius casuarius</i>	up to 65Kg	1.4 - 1.7m
Single-wattled Cassowary	<i>C. unappendiculatus</i>		1.5- 1.8 m
Dwarf Cassowary	<i>C. bennetti</i>	25Kg	1.1m

Males are generally smaller than females and 20% lighter in weight.

Note: There has been a report of a Southern Cassowary with a reported weight of 86kg from PNG.

1.10 Ageing

The changes in plumage from hatching to adult occur at fairly constant ages and these can assist in aging young birds.

Table Two - Developmental Classes of Cassowaries (Moore 1994)

Class	Months	Plumage
Young Chick	0 - 5	Striped plumage, neck and body region covered with feathers. In company of male.
Old Chick	5-16	Dull brown plumage on back of neck and body. Cream plumage on underside of neck and body. Still in company of male.
Younger Subadult	17-24	Dull brown body plumage, increasing in darkness from back to front of body. Independent of male.
Older Subadult	24-48	Body plumage black with brown tips, neck & head slightly pigmented but still covered with fine brown or black feathers.
Adult	48+	Fully mature plumage, ie black feathers, bare face, neck and wattles all brightly pigmented.

The bony casque is small in young birds becoming large in the adults of the Southern Cassowary. It is thought that females will have a larger casque. (Beehler et al. 1986).

1.11 Sexing

The female is slightly larger and more brightly coloured (Simpson & Day 1995).

Richard Rundel (pers com) found that vent sexing chicks is difficult as all chicks have a flaccid phallus-like organ making them all resemble males. Observation of the vent when an adult bird defecates will sometimes indicate the sex. A prominent phallus is occasionally seen on the male bird, but the feathers surrounding the vent usually make it difficult to observe. Occasionally the adult female may be observed to have a similar though smaller organ. Observation of courtship behaviour can also be used. The male will constantly circle behind the female, preening her back, and even bumping her to encourage compliance with copulation.

Tully & Shane (1996) give the following description of sexing cassowary, emu & rhea: “Although adult females are larger than adult males, there is no sexual dimorphism in cassowaries. Male cassowaries have an intromittent organ commonly called a phallus. When relaxed, it lies within a pocket beneath the mucosa on the ventrum of the proctodeum of the cloaca. This phallic anatomy makes vent sexing difficult. The finger must be inserted deeply into the proctodeum and pressure exerted on the floor to force extrusion of the phallus as the finger is withdrawn. The juvenile male phallus is similar in shape to the adult but diminutive in size. The female has no phallus.”

9

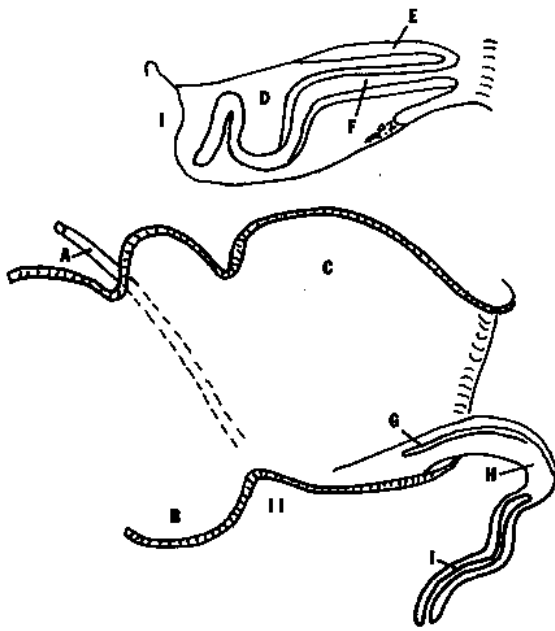


Figure 1.12 Diagram of left lateral view of a retracted and erect phallus of a male emu or rhea. Note: The top drawing represents the phallus within the pouch. A. vas deferens, B. urodeum, C. proctodeum, D. pocket to contain phallus, E. erectile wall of phallus, F. inverted hollow tube of phallus, G. phallic sulcus, H. erectile tissue, and I. erect phallus with blind hollow tube.

Figure One from Tully 1996 - Although this shows male emu & rhea anatomy it is similar to cassowary.

The following methods were described in Perron “Sexing is easiest when the cassowary is young and examination physically possible. There are a number of methods, including eversion of the cloaca as in waterfowl (which is suitable in chicks up to 2 weeks old), or the use of endoscopic speculums and optic fibre scopes, but the simplest, quickest and least traumatic for the older bird is direct palpation of the penis. The bird should be firmly held on its back by two people, one sitting down with the bird’s head held into the groin while holding the chest and neck, while the other grasps a leg firmly in each hand to minimise any movement. A third person, using a lubricate surgical glove, can then try to explore, after the spasms have ceased, into the cloacal region for the presence of a penis or much smaller clitoris”.

DNA sexing of cassowaries has proven unsuccessful to date however further work is being carried out in this field. The most definite sexing method is the advent of a fertile egg!!

2.0 CAPTIVE HUSBANDRY - HOUSING REQUIREMENTS

2.1 Shelter

As a rainforest species, cassowaries require enclosures which provide shade within the enclosure at all times. Anecdotal evidence shows that cassowaries maintained in enclosures without suitable shade are prone to the development of cataracts. Shelter from extremes of cold is required in areas that fall below the minimum temperatures in their natural environment. In coastal areas this would rarely be below 10°C. Philadelphia Zoo did however keep a bird outside with only a roof for shelter for a number of winters.

The provision of a hut or shelter may also encourage the pair to nest within or against the side of the structure.

A formal shelter may be required for the cassowaries depending on the climate and amount of shade trees in the enclosure. In very cold climates there may be the need to provide heat in these holding areas. It is recommended that the enclosures be heavily planted with large shady rainforest trees. Those providing natural food sources are recommended.

2.2 Water

Fresh water should be available at all times for drinking. Cassowaries also have a particular fondness for bathing and should be supplied an area that allows them to do this. A mud bath is highly enjoyed and sprinklers appreciated.

Cassowaries swim well and will wade chest deep in water given the opportunity. A large stream running through the exhibit is ideal. Sprinklers can also be installed.

2.3 Enclosure furnishings

Enclosure furniture (logs, rocks, trees and shrubs) should be available in pens used for pairing to allow birds to separate visually if required. These obstacles should be avoided around the fence boundary. Rocks and logs can provide homes for prey items. They may also encourage the birds to nest as they provide a suitable backing.

2.4 Design considerations and spatial (size) requirements.

The aggressive nature of cassowaries can necessitate the separation of pairs. The enclosure should be designed to allow isolation of one animal from the other if the need arises but should still allow visual or auditory contact to be maintained. Additionally, enclosures need to be designed to enable servicing of the enclosure with the birds being locked into holding areas to eliminate the risk of injury to staff servicing them. Ideally routine feeding and watering should be possible without the need to enter the enclosure.

It is also useful to provide suitable access for a vehicle to the enclosure to facilitate transportation of birds.

Cassowaries have been bred in enclosures as small as 200 square metres though this was divided in half to separate the pair and was additionally heavily planted (Hopton 1992). It has been suggested that the small size of cassowary enclosures has contributed to the poor breeding record experienced in captivity. The size of an enclosure for a breeding pair is not as important as obtaining a compatible pair. However for introduction purposes a larger pen is required. If the pen is large, then a pair can possibly remain together at all times including while incubating and raising young. Rundel recommends a good size pen for breeding would be 10m X 30m combined with good cover facilities. QWPA minimum standards require 200 square metres for an individual bird and 300 square metres for a compatible pair.

A suggested minimum size enclosure for a pair of cassowaries is 2 adjacent enclosures each measuring 18m x 12m with a safety passage 1.5m wide designed so that during the breeding season the birds have access to both enclosures. There should also be a separate feeding area that can be shut off from the birds for servicing while also acting as a holding facility while the main enclosure is serviced. A minimum suggested size is 5m x 4m.

2.5 Boundary

Chain link fences are commonly used. Foliage, particularly climbing plants, planted along the perimeter fences provide cover and protection for the birds. Solid concrete rendered walls and tin fences have both been successfully used. Fence heights have varied from 1.4m to 1.8m. Several jump outs have occurred at the lower height while one recorded jumpout has occurred at 1.8m. These jump outs have generally been associated with cassowaries attacking other cassowaries or

people. QWPA standards require a minimum height of 1.8m. A double fence may be necessary if the birds are aggressive. This can contain a planted barrier to improve the appearance.

Chicken wire is not recommended as toes can easily get caught in the small mesh and is not strong enough to contain an adult bird if aggressive or frightened. Vertical panels must also be avoided due to similar injury potential (whole legs and heads may get caught).

Mesh size needs to be considered carefully as large mesh can lead to heads being pushed through causing irreparable damage to the casque with a potential for the bird to break its neck. Additionally kicks through the mesh can lead to torn and peeled leg scales and infections. QWPA recommended mesh size is 50mm x 50mm.

The fence needs to be of solid construction, not easily lifted and should follow the contour of the land as well as being secured into the ground to a depth of 40 cm **or** of similar stability as birds have been known to go through a fence if they can't go over it.

Fences should be free of obstacles or loose wires. All fence posts and straining wires should be positioned on the outside of the enclosure. Where the park perimeter forms part of the boundary provisions need to be made to protect the birds from outside disturbances such as the public, traffic and dogs.

Moats were tried unsuccessfully at LA Zoo. Melbourne Zoo was successful in the use of a wet moat. Careful thought into the design needs to be made. The moats should allow the birds to use it for swimming. This would be beneficial from a display point of view.

3.0 GENERAL HUSBANDRY

3.1 Heat

Heat is only required in very cold climates where temperatures regularly fall below approximately 0°C. In these cases a heated shed may need to be provided. This is a necessity in any area where snow is known to fall or regular heavy winter frosts occur. Cassowary chicks in particular are not cold hardy. (see rearing section)

3.2 Hygiene

Cassowaries regularly eat their faeces in captivity. It is however still important to remove the faeces especially in small enclosures. Lack of removal of faeces may contribute to a high worm burden. It is important that clean water and feed containers be provided. Small scatter feeds may add behavioural enrichment thus making it important to keep the enclosure clean. Appropriate measures need to be taken to ensure keepers can enter the enclosure safely - thus routine cleaning and watering should be possible without the need to enter the enclosure with the birds present. Care should also be taken not to disturb an incubating male. Regular checks of the enclosure with particular attention given to problems that cause leg trauma eg broken fencing, need to be carried out.

4.0 HEALTH REQUIREMENTS

4.1 General Examination

(i) Visual examination

Due to the difficulty of conducting a physical examination, information must be gathered by history, observation of the bird, both stationary and walking, noting behaviour, posture and any obvious abnormalities. It should also be possible to examine faeces and feathers for any abnormalities at this stage.

Having made an assessment as to the condition of the bird, it is necessary to decide whether the benefits of a detailed physical examination warrant the risks associated with capture and restraint.

(ii) Physical examination

The bird should be captured quickly to avoid stress and potential hyperthermia. (See handling section 6.1). Once restrained by strategically placing weight over the bird's centre of gravity, a hood or dark cover placed over the bird's head may be helpful in settling the bird. If this does not produce the desired result the hood may need to be removed. It may be advantageous to sedate the bird at this stage depending on circumstance. Once restrained, a complete physical examination should be performed which may identify a clinical condition or abnormality in addition to the primary problem and provide a baseline for subsequent examinations.

Sexing is covered in section 1.11.

(iii) Blood sampling

Blood collection techniques should minimise stress and patient contact time. In the cassowary, the right jugular and medial metatarsal veins are accessible but, due to vestigial wing development, the brachial vein is very small. As with most avian species, the left jugular vein is relatively small. It is important to ensure adequate haemostasis after blood collection as haematoma formation can represent significant blood loss, especially from the jugular vein.

Blood should be collected into plain and heparinized blood tubes as avian blood is adversely affected by EDTA. Cassowary blood has a quick clotting time which necessitates use of a heparinised syringe or fast transfer into a heparinised blood tube for diagnostic haematology. A blood smear should be made at the time of collection. An air-dried, thin smear provides better cell morphology than samples stored in heparin.

Further work is required to establish reference ranges. The following reference ranges have been obtained from ISIS from the MedARKS program.

TABLE TWO: CLINICAL PATHOLOGY ISIS REFERENCE RANGES

Southern Cassowary *Casuarius casuarius*

	UNIT	Mean	S.D.	Minimum	Maximum	(N)
WBC	x10 ⁹ /L	17.55	7.604	8.58	31.6	7
RBC	x10 ¹² /L	3.1	2.65	1.55	7.07	4
Hb	g/L	174	34	135	200	3
PCV	%	48.1	7.9	33.5	58	8
MCV	fl	167.3	103.8	47.4	229.3	3
MCH	pg/L	97.3	9.1	87.1	104.5	3
MCHC	g/L	451	9	444	457	2
Heterophils	x10 ⁹ /L	11.14	4.749	6.43	20.9	7
Lymphocytes	x10 ⁹ /L	5.063	2.878	2	9.45	7
Monocytes	x10 ⁹ /L	1.09	0.987	0.086	2.844	6
Eosinophils	x10 ⁹ /L	0.3	0.149	0.194	0.405	2
Basophils	x10 ⁹ /L	0.429	0.268	0.186	0.81	4
Glucose	mmol/L	9.63	2.92	5.45	12.8	7
BUN	mmol/L	1.07	0.357	0.357	1.43	7
Creatinine	umol/L	26.5	8.84	8.84	35.4	3
Uric Acid	mmol/L	65.2	170	0.242	450	7
Calcium	mmol/L	2.73	0.3	2.28	2.98	7
Phosphate	mmol/L	1.81	0.517	1.16	2.36	6
Sodium	mmol/L	141	2	138	143	6
Potassium	mmol/L	2.7	0.8	1.8	4.1	6
Chloride	mmol/L	100	2	97	102	6
Bicarbonate	mmol/L	21.7	4.6	17	28	6
Total protein	g/L	56	9	45	75	8
Albumin	g/L	31	11	18	44	6
Globulin	g/L	23	15	11	42	6
AST	U/L	581	351	269	1399	8
ALT	U/L	49	27	21	84	4
Alk. Phos.	U/L	241	291	54	821	7
T. Bilirubin	umol/L	3.42	1.71	1.71	6.84	6
Bile Acids	umol/L					
Cholesterol	mmol/L	1.92	0.416	1.25	2.37	6
CPK	U/L	736	442	365	1335	4

Comment [TC1]:

(iv) Anaesthesia

Sedation and/or anaesthesia can facilitate a safe and thorough approach to physical examination and sample collection as well as providing immobilisation and analgesia for surgical procedures. As with other species, anaesthetic complications can occur especially during induction and recovery. Potential complications can be minimised by good planning and thorough monitoring during anaesthesia.

Anaesthesia can be induced and maintained with a variety of parenteral and inhalation agents. The choice depends on a combination of factors including the age, ease of handling, physical condition of the bird and available facilities. Young birds which can be easily physically restrained can be induced with an inhalation agent (preferably Isoflurane) via a face mask where as larger, more intractable birds or birds in a field situation may require intravenous or intramuscular anaesthetic administration. For lengthy procedures, birds should be intubated and maintained with an inhalation agent, preferably isoflurane.

Whilst it is recommended that adult ratites be fasted for 12-24 hours to minimise the risk of regurgitation and aspiration, this recommendation may prove unnecessary in the cassowary which has a short digestive tract and corresponding fast G.I. Tract clearance time.

Cassowaries should be well padded during the anaesthetic period to minimise neuropathy and myositis. The ostrich is susceptible to peroneal nerve paralysis when placed in lateral recumbency for as little as one hour (Cornick-Seahorn). Wherever possible, cassowaries should be maintained in sternal recumbency to minimise interference with normal respiration.

Thermoregulation is impeded during anaesthesia and body temperature should be carefully monitored to avoid hypothermia and hyperthermia.

Fluid administration may be required during prolonged procedures or where significant blood loss is anticipated.

Comprehensive records should be completed during the anaesthetic including sequential monitoring of heart rate, respiratory rate, body temperature and any other salient observations. A complete physical examination including measurements and weight, sexing and blood collection should be

performed whenever possible.

Cassowaries should be allowed to recover from anaesthesia in sternal recumbency in a small, dark and quiet environment. Ideally the head should be supported until the bird is able to maintain normal head posture.

See Appendix One for Anaesthesia Form.

Potential complications

As with other species complications can arise during anaesthesia. These can be minimised by thorough planning, careful monitoring and adjustment of anaesthetic regime in response to physiological parameters. The respiratory rate of 6-12 breaths/minute should remain regular, deep and stable during anaesthesia. Apnoea is not uncommon during general anaesthesia in ratites and may be caused by hypocapnia associated with excessive ventilation, but is more likely due to extreme depth of anaesthesia. When apnoea occurs, depth of anaesthesia should be assessed and decreased as indicated. Ventilation should be supported at 2-4 breaths/minute and the cardiovascular system should be evaluated because apnoea may indicate impending cardiac arrest. Administration of *Doxapram* (5mg/kg IV) may be beneficial. Cardiac arrest is associated with a poor prognosis and efforts at resuscitation are often unsuccessful in avian species.

Regurgitation may occur during general anaesthesia. Slight elevation of the neck may help to prevent passive regurgitation and intubation with an appropriately sized endotracheal tube minimise the risk of aspiration pneumonia.

The most common postoperative complication is self trauma during recovery. This can be avoided by confinement to a padded box during recovery or physical restraint until coordinated movement has been regained.

Exertional rhabdomyolysis may occur rarely in ratites and the risk increases if induction is rough and prolonged and if the ambient temperature is high. Risks can be minimised by smooth induction, monitoring body temperature and taking appropriate action if body temperature exceeds 41 ° C.

4.2 Post Mortem examination

Due to the inherent difficulties in conducting routine clinical examinations on cassowaries, it is most important to utilise the opportunity to conduct a thorough post mortem examination as a matter of priority on any bird that dies. Little is known of diseases of cassowaries so the results of a detailed post mortem will add to the body of knowledge and assist in the management and disease prevention in other cassowaries.

The examination should begin with a review of the birds history and any medical record. A standardised post mortem form assists with the development of a thorough technique. The identity of the bird should be verified and the body weight measured and recorded.

Following external examination of the carcass, the feathers are dampened with a disinfectant to prevent aerosolisation of feather debris and potential pathogens. The thoraco-abdominal cavity is opened and the organs are examined in situ. Routine microbiological samples from liver, lung, mesenteric lymph nodes and heart blood should be collected aseptically at this stage. Organs are then removed and examined in more detail. The sex of the bird should be confirmed and recorded. If no gross lesions are detected it is appropriate to take samples of all major organs for histological examination. Care should be taken when handling organ sections to avoid compression artefact of the tissues. Slices of tissue should be cut with a sharp blade and gently transferred to the formalin pot. Air sac tissue should be placed on a small piece of paper before fixation to facilitate identification of the tissue for processing. Sections of intestines should be opened to ensure proper fixation of the mucosa. Proper labelling of the formalin pots is essential to assist the pathologist in identification of the tissues. Parasites are best preserved in 70% ethanol.

See Appendix Two for Post Mortem Form.

4.3 Diseases of cassowaries

Cassowaries have a long life span, sometimes in excess of 60 years in captivity. Few records exist of diseases in cassowaries and little is known of the impact disease has on the status of wild populations.

With much of the focus of captive cassowary management being directed towards breeding, it is imperative that the birds are in optimal health for a successful outcome. Much has been discussed about the compatibility of pairing, but as much attention should be directed towards husbandry. In

the wild situation, the breeding season coincides with fruiting of Laurels which are high in fat and protein.

4.4 Diseases seen in captive cassowaries

Feather loss has been observed as a seasonal occurrence in captive cassowaries from January -April. It occurs in adult birds and is associated with some feather plucking. The exact aetiology is unknown although it appears to be self limiting.

Paresis and paralysis, with the presumptive diagnosis of botulism occurred in an adult cassowary at Currumbin Sanctuary after the pond sediment from another aviary was allowed to leach through the cassowary enclosure. Supportive therapy yielded an uneventful recovery.

Nutritional disease.

Leg deformity and stunted growth are both manifestations of nutritional disease seen in young chicks. An imbalance in calcium or phosphorus will lead to a dietary deficiency manifested as abnormal bone development and in immature birds, depressed growth. Congenital and environmentally induced leg abnormalities (osteodysplasia) are common in all young ratites due to rapid growth of the tibiotarsal and tarsometatarsal bones. Rotation of either of these bones will produce a valgus or varus deformation of the hock joint. This may progress to unilateral slipped tendon.

Cassowaries are precocial and whilst they require adequate warmth from hatching they also require an appropriate diet with a protein content <15% , a Calcium:Phosphorous ratio of approximately 2:1 and a graded amount of daily exercise and access to sunlight to allow normal development. By providing a sole chick with a companion bird (eg chicken) will encourage behavioural development and stimulate exercise.

4.5 Diseases seen in wild cassowaries

Tuberculosis has been diagnosed in several cassowaries on post mortem. Whilst it is likely that *Mycobacterium avium* is the organism involved, this has not been verified by culture. The prevalence of this disease in wild cassowaries is not known nor is it's role in population dynamics understood. Further sampling of the wild population is required to address this issue. Avian tuberculosis is a zoonotic disease which is transmitted via inhalation or ingestion of the organism.

Immunocompromised people are most susceptible. Safety precautions including the use of a face mask during post mortems and normal hygiene practices should be emphasised to minimise the risk of infection. Intradermal tuberculin testing in an individual bird may be a useful adjunct to clinical assessment.

Parasitism of the intestinal tract by large numbers of tapeworm of the family Davaineidae has been recorded in several cassowaries as an incidental post mortem finding. The clinical significance of this is unknown.

Aspergillosis is a potential secondary disease of debilitated birds causing respiratory symptoms and ultimately mortality. Consideration should be given to prophylaxis in birds on antibiotic therapy of any duration.

Trauma, as a result of road accidents and dog attacks are the most significant cause of presentation of cassowaries for veterinary attention. Prognosis is often poor due to either their injuries or the subsequent stress of captivity and treatment. Wherever possible injured birds should be treated in situ by erecting a temporary enclosure around the bird and providing food and water until the bird is sufficiently recovered to fend for itself

Cassowaries, along with other avian species, have a renal portal system which means that drugs may be excreted by the kidneys prior to exerting their effect if administered distal to the kidney. This means that a higher dose may need to be administered to achieve the desired effect when given in the muscles of the leg. In treatment of cassowaries, much is gained from extrapolation from the wealth of information published on other ratite species commonly farmed in various parts of the world.

Some useful therapeutics.

Amoxicillin	15-20mg/kg BID	IM	Antibiotic
Enrofloxacin	5mg/kg BID q 2days	IM	Antibiotic
Ketaconazole Rx/prophylaxis	5-10mg/kg SID	PO	Antifungal - Aspergillosis
Itraconazole Rx/prophylaxis	6-10mg/kg SID	PO	Antifungal - Aspergillosis
Flunixin meglumine	0.2mg/kg	IM	Non-steroidal anti-inflammatory
Dexamethasone	4mg/kg BID q 2 days	IM	Shock
	2mg/kg BID q 2 days	IM	Trauma

5.0 CAPTIVE BEHAVIOURAL NOTES

5.1 Social structure

Cassowaries are solitary animals in the wild, normally only coming together to breed. Some institutions have been able to keep a pair together year round even when the male is incubating. Other institutions need to keep the pair apart in the non-breeding season and when the male is incubating. Males with chicks can be particularly aggressive towards the female (and keepers). Groups of young birds have been kept together but is not recommended as breeding is often interfered with by the other birds .

5.2 Aggression

Cassowary are a particularly aggressive species. In some institutions a pair can easily be kept together year round with no apparent aggression problems (except to the keeper). In other institutions the birds may only be introduced to each other at the beginning of the breeding season and need to be separated once the clutch has been laid. Often aggression problems can be solved by ensuring the enclosure is large enough and well landscaped with areas where the birds can avoid visual contact.

Some institutions have experienced difficulty even getting a pair together without severe fighting. Aggression towards the keeper can be a particularly dangerous situation. This can be solved by good exhibit design - allowing the animals to be penned up separately to where the keeper needs to work. Additionally being able to feed & water the birds without entering the enclosure can assist and protect the keepers from injury!

It is of utmost importance that the keeper must not incite or encourage aggressive behaviour in the cassowary.

5.3 Courtship

In the early stages of breeding the birds are often noticed in close contact - feeding and foraging together.

Before copulation the male displays to the female by “dancing” around her in a circle, his throat trembling and swelling and emitting a series of low “boos” . The male then leads the female a short distance where she squats and allows him to mount (Crome in Readers Digest 1993). The female has also been seen to display. The female stands with her neck upright and her head tucked into the

neck. The neck is then filled with air all the way down to the breast - the neck diameter stretched to twice the size. She then emits a low frequency rumble - the whole neck is seen to vibrate. This is done for a few minutes (Z.Gubler pers com).

Cassowary mating is somewhat prolonged. Often the male ruffles his plumage and pecks the ground whilst slowly approaching a resting female. If she remains still, he pecks her neck, adopts a squatting stance and eventually mounts from behind. Copulation continues between the laying of each egg.(Whitehead & Masson). Crome & Moore 1988 state copulation is brief (maybe like humans some are studs & some are not!)

Richard Rundel's observations of mating are described as follows "Breeding commonly lasts 30 minutes from the time the male starts circling behind the female, preening her to induce her to lay down and present herself , to the final moment of copulation. In order for their respective cloaca's to touch the male must lock his legs under the female and lean way back. Since they copulate frequently he is used to the ritual and knows that once contact is made she will jump to her feet, causing him to fall over backwards. At this point he is desperately trying to get to his feet and run because she by now is performing a Mexican Hat dance on top of him."

In some institutions where the pair must be kept apart the birds are kept in visual contact. When the birds are seen interacting together at the start of the breeding season they are introduced to each other. (*See breeding section for more details*)

As a general rule it is found that the best way to establish breeding pairs is to start with young birds that will bond as they mature. Some adult birds put together may take up to a year or two to establish a viable pair.

5.4 Common captive behavioural problems

Aggression is the most common problem in relation to husbandry. Some people have noticed beak rubbing, fence pacing (resulting in the wattles being worn off) and a seasonal over-preening (possibly mite related).

5.5 Mixed species compatibilities

Because of their aggressive nature it is not advisable to house other species with cassowaries. Cassowaries have been known to kill other animals that stray into their enclosure such as an ibis at Currumbin Sanctuary. Also Eastern Wallaroos accidentally entering an enclosure have been attacked.

Worrell (1975) describes how the Australian Reptile Park did house cassowaries with Alligators which were thought to have eaten the first chicks that hatched in 1971.

Fleay's Wildlife Park also house Pademelons in with their Cassowaries without problems. However introduction of a new animal has resulted in the individual being attacked.

Some species that have had access to cassowary enclosures have included herons, a range of waterfowl, Brush Turkeys and Jabiru.

The main problem is at the time of introduction of new stock. This is probably due to the fact the new animals are a bit disorientated and draw attention to themselves by moving in areas that the cassowary is not used to seeing other animals move.

5.6 Behavioural enrichment activities

Behavioural enrichment activities can consist of numerous scatter feeds of a wide variety of food items. The provision of ponds and muddy areas large enough for bathing will also enrich a cassowary's life.

Edinburgh Zoo uses a 20cm diameter plastic pipe with a screw-on lid and mesh base. They put pieces of fruit in this and hang it from a tree. The birds must then work at the mesh to get the fruit.

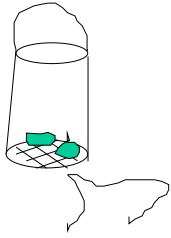


Figure Two Behavioural Enrichment Idea

(You may have to watch out for beak damage.)

5.7 Keeper safety

It is important that enclosure design considers aspects of keeper safety by enabling the birds to be locked out of feed or enclosure areas whilst they are being cleaned. It is advisable that keepers not enter an enclosure with the birds during times of high aggression, ie breeding season. If people need to enter the enclosure more than one experienced staff should be in attendance. They should be armed with a broom or suitable implement for stopping the cassowary from attacking them. Keepers should also not incite aggressiveness in the birds.

6.0 HANDLING AND TRANSPORTATION

6.1 Handling requirements

Cassowaries, because of their aggressiveness and large toe nails, must be handled with the greatest caution of any bird. Large, padded sheets of plywood will allow handlers to move a cassowary into smaller areas or crates. Handlers should be braced to withstand a solid blow to the moving board at all times (Bruning & Dolensek 1986). Handlers must be aware of the birds jumping ability.

Capture can be quickly & effectively done by i) 2-3 persons cornering the birds, ii) grabbing the bird from behind and putting body weight squarely on its back, till it sinks into a crouched position, iii) second person can then grab lower tarsus to immobilise them. This can all be achieved in less than 30 seconds (David Wescott, pers com). Hooding a bird is not usually recommended as this does not have the same calming effect as in ostrich. Instead the cassowary will tend to run around blindly. It can be attempted and removed if the desired result is not achieved.

Care must be taken of the legs to ensure they are not broken or dislocated. Also the possibility of gastric reflux and subsequent choking needs consideration - thus it is advisable to hold the head upright.

Adelaide Zoo have a small corridor for feeding the birds. When the need arises to catch one it is lured into the corridor moved to the end with a baffle board and pressed down fairly hard onto the ground. Vets can then administer drugs through the wire. (M.Johnson, pers com).

6.2 Transport requirements

IATA regulations do not seem appropriate due to the large box size which causes the bird to thrash around and injure itself and the requirements for water containers which can easily cause injury to the bird.

Successful transportation with the animals arriving in good condition has been carried out using a box made of structural ply 900mm high, 650mm wide and 1200mm long. A padded roof is recommended. Numerous air holes are required. A sliding door at each end allows for easy entry and exit. This is the recommended box size and design. Handles need to be attached in some form for manoeuvring. Screws should be inserted into the doors to lock them in place (See Figure 3).

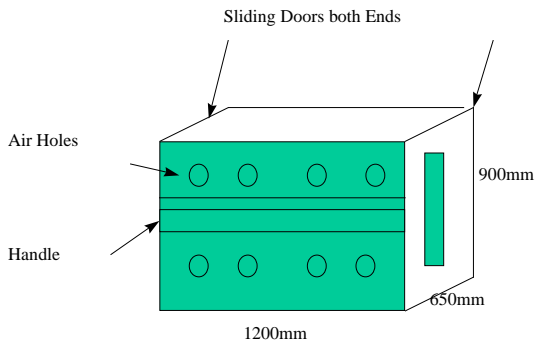


Figure Three Cassowary Transport Box

After transport Vitamin B and Vitamin E injections are advisable. Sedatives should not be necessary in the majority of cases. Most transports have occurred successfully without their use.

Generally by placing the box in the enclosure prior to the transport the bird can get used to it particularly if feeding occurs in it. Birds can after some time then be easily herded in and crated up.

At Taronga Zoo (Atchison & Sumner 1991) a pair of cassowaries were moved to a new enclosure within the zoo by placing a box measuring 160cm x 50 cm x 135 cm high with sliding doors at each end in an access gate between their two yards. The birds were enticed (one at a time) by a favourite food item into the box until the birds confidence with the box was gained and then the doors on either end dropped. Once boxed the birds were injected with 10mg of Valium through a gap at the top of the box and transported without event.

Hartley's Creek Crocodile Farm in North Queensland had great success in the transport of an adult male to Dreamworld on the Gold Coast (approximately 2,000 km away) by conditioning the bird to voluntarily enter a box (Geoff McClure, pers comm). The box measuring 1000mm long x 970mm high x 620mm wide was placed in the enclosure with a hessian race built using star pickets and tie wire, to a height of approximately 1.8m. This started with a width of approximately 1.5m, with a 90° corner, and narrowing to the width of the box (see figure 5). The corner of the race was an advantage in that minor adjustments could be made to the box without the cassowary seeing (eg testing the drawbridge).

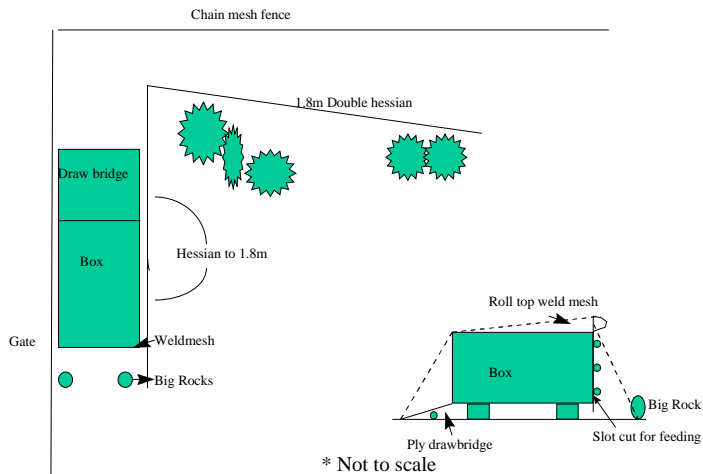


Figure Four Race & Box Layout at Hartley's Creek Crocodile Farm

Both the front and sliding back doors were removed from the box; the back door being replaced by weldmesh with a small hole in the bottom to allow feed to be put in. The front door was replaced by a drawbridge of thick plywood. One piece of rope was passed from each top corner of the drawbridge, over the box and through the top of the mesh. The ropes were kept relatively taut by placing the ropes around a large rock each (which kept the rope in place). This meant the cassowary would not trip on them, and they were well positioned to spring the drawbridge up. The drawbridge was solid so it did not flex under the weight of the birds.

The bird was then conditioned by feeding on the ground in the race and gradually getting closer to the box. The quantities were gradually reduced. The next stage involved the keeper coming in at the back of the box and handfeeding 2 bananas, 4 times per day through the mesh holding the ropes while the bird ate. The whole conditioning exercise took approximately 3 weeks.

Only 2 bananas were fed 24 hours before capture. For capture the 2 bananas were placed in the box as normal. The bird ate 2 small pieces of banana as the drawbridge was pulled up. A blanket was placed over the front of the mesh and the bird sat down. The proper door was then slid in behind the drawbridge.

Excess food was removed because of the risk of regurgitation. The second drop door was slid down as ties were cut to remove the weldmesh. The vet gave the bird two I.M. injections by lifting the rear door slightly. These were

1. Azaperone as Stresnil 1ml.
2. Vit E as E-Se (50mg/ml) 8ml.

The bird was released 5 hours later in good condition though it took approximately 1 week for the bird to resume eating normally.

7.0 IDENTIFICATION - Individual

Trovan Microchip implants are recommended to be inserted by a trained veterinarian. The recommended site is the left thigh (as recommended by ISIS), though dorsally in the neck muscle has been successfully used. The placement needs to consider enclosure design and the ability to scan the implant site. It is of vital importance that a proper record is kept of the site used. As cassowaries are extremely long lived (ie may outlive their keepers!) this ensures that the birds are permanently identified. Tattoos can also be used on the thigh area. Bands of any sort (leg or wing) must not be used.

Photographic identification can be used in older birds for in-house identification.

A new method of establishing identity based on familial relationships is DNA fingerprinting. This is performed by the submission of a blood sample for analysis.

8.0 CAPTIVE DIETS

8.1 Diets and supplements

Cassowaries are mainly frugivorous though they also eat some animal matter. Cassowaries have a very short digestive system and hence a fast passage of ingesta. This results in a high dietary requirement which can reach 10% their body weight in daily intake. A large variety of fruits are fed including tomato, banana, apple, pear, paw paw, watermelon, grapes, mango, plums, nectarines, cherries, kiwi fruit, figs, rockmelon, eggplants, and cooked sweet potato and carrot. Dead mice, rats, day old chickens and some fish are readily taken. One of the cassowaries at Adelaide Zoo also considered house sparrows a delicacy.

As a general rule most institutions feed between 4 & 5 Kg of fruit per day per bird though amounts vary seasonally.

Some institutions also have a number of fruiting trees in their enclosures which supplement the captive diet.

Supplements of calcium carbonate and petvite multivitamin supplement have been successfully used in some institutions that have bred cassowaries. Wombaroo insectivore mix sprinkled on their food has also been used. Wheatgerm is sprinkled daily on the fruit at Fleay's Wildlife Park.

Dog biscuits are not recommended due to their high fat content.

Other dietary items used include brown bread, boiled rice, turkey pellets, trout chow, hydroponics (7 day oat grass), cotoneaster berries, canned raspberries, Eugenia berries, pyracantha berries, soaked raisins, horse cubes, kangaroo pellets, waterfowl pellets and horse meat. Rocks are also eaten to aid digestion.

It is noted that cooked vegetables are utilised (metabolically) better than raw, though if overcooked and mushie they will clog around the bill and be flicked away.

The diet at Birdworld U.K. is 50% fruit and 50% cereal food containing pheasant pellet, flaked maize and zoo A pellets (1:2:2 parts respectively). This is fed through hatches in the night shelter. Native fruits should be incorporated where possible - this may be achieved by having native food

trees in the enclosure.

Note cassowaries in captivity will also eat their own faeces.

The female at Adelaide Zoo was also observed scooping up and eating reasonable amounts of orange coloured builder's sand that was dumped in a damp spot in her enclosure at one stage.

Between March & June soft fruits are decreased at Fleay's Wildlife Park to coincide with the normal dry season in North Queensland, with increased protein foods offered daily eg, rats, mice, day old chicks and fish.

In the USA a pelleted diet is used on birds from 1 month of age. The primary nutritional problem is providing sufficient level of vitamins A and E. Sonoma bird farm use a diet formulated by Purina Mills and sold under their Mazuri label that is specifically blended for cassowaries with additional A, E, and D vitamins.

At this stage it is recommended that more analysis is done on native fruits for assistance in formulating diets & trigger diets. It is known that the Laurels are high in protein and when they don't fruit in the wild breeding drops off. Toxins in unripe fruit also needs to be investigated.

The National Capital Botanical Gardens Papua New Guinea hold both Double-wattled Cassowary (*Casuarius c. scalterii*) and Dwarf Cassowary (*C. bennetti*) The adult birds are fed the following daily:- 2 apples, 1 whole pawpaw, 2 hands of sweet banana, 1 loaf wholemeal bread, 2 mangoes, Pandanus fruit when available, cooked kaukau and rice when available (J. Tkatchenko per com).

8.1 Presentation of food

Food may be presented in large containers on the ground or slightly elevated. Two containers may be required where there is a pair. In areas where feral pigeons and other pest species are too competitive for the food feeding may need to be done in a shelter or other similar enclosed area.

The food should be cut to around the size of a billiard ball. For behavioural enrichment reasons the food may be scatter fed.

9. 0 BREEDING

9.1 Ages at maturity

Breeding ages appear to cover a wide span. One breeding male first mated when 31 years old at San Diego Zoo. (Whitehead & Mason). The youngest mature male known to breed was a 3½ year old at Currumbin Sanctuary fertilised a clutch. Most breeding activity appears to start around 4 years. A female at Rockhampton is still breeding at 37 years of age. The best combination appears to be an older hen with a younger cock bird.

9.2 Season

Breeding season - in the wild appears to be from May to October/November with the main period being June to October (Crome & Moore 1988) coinciding with the maximum availability of fruit.

In the Northern Hemisphere breeding appears to begin around March.(Fisher 1968).

Females in the wild may take more than one mate with up three being seen (Crome & Moore 1988).

9.3 Pair formation & breeding

Many institutions have experienced difficulty getting a pair together. Some years there is no problem while other years the amount of aggression causes the pair to remain segregated. Other pairs appear very compatible and even if separated there is not a problem getting them together later.

The best approach appears to be pairing birds as juveniles allowing the bond to develop as they mature. If this is not possible and the birds are already adults it can take up to a year to get the birds together. Cassowaries generally don't like change and it takes time for them to adjust. It is best to try putting them together after an interest is shown in each other but no aggression. If the birds are not compatible and aggression is being displayed after 15 minutes separate them and attempt introduction again later.

If worried about aggression the introduction pen can be lined with plastic to avoid injuries.

Once a good pair is together it is best to leave them together.

As the breeding season nears both birds are likely to exhibit more aggression towards the keepers.

Some institutions find the female shows more aggression whilst others find the male more aggressive. At this time the male will sometimes be seen sitting in a favoured nesting spot to show his parental suitability.

9.4 Nesting requirements

In the wild nests are made up of leaves, grass and debris, and are about a metre in diameter and up to 2 to 5 cm thick, supposedly placed in a sheltered position such as between buttresses or beside a log.

Nests in captivity generally are in strange and problematic places ie near paths, Brush Turkey mounds and on the sides of hills. The use of dummy eggs can be of use to change nest site position.

The provision of a hut or shelter will often encourage the pair to nest within it. This can be of use for management purposes.

Nests are always in the shade and in some leaf litter.

High humidity is thought to be essential for incubation. Irrigation may be needed in drier climates during the day provided it is not too cold.

9.5 Diet changes prior to breeding

Increase in protein and vitamin B may be necessary prior to the breeding season. A chick which hatched at Taronga Zoo and died shortly after showed a vitamin B deficiency. Supplementation with Petvite solved this in the subsequent clutch. Fleay's Wildlife Park increase the protein levels between March & June with the female feeding keenly on the protein. After July the interest in high protein food drops. Adelaide Zoo supplement with calcium prior to breeding.

A possible Vitamin E deficiency was seen in a nearly formed chick at Currumbin Sanctuary. The muscles at the back of the neck used for pipping the egg were not developed.

Cassowaries will breed on a fruit only diet however.

More research into wild animal food preferences would be beneficial to assist in formulating

breeding diets in captivity.

9.6 Clutch size

Generally four but up to nine eggs have been recorded in captivity. Double clutching is possible by pulling the chicks at one - two weeks. Pulling eggs as laid will also increase the amount of eggs laid - up to 28 being recorded. However not all were fertile. Generally the more laid the lower the fertility.

9.7 Incubation period

49 - 57 days have been recorded. The smaller eggs tending to hatch sooner than larger eggs. The male will brood the eggs until the full clutch is laid. A male incubating eggs for more than 65 days after the last egg is laid calls for consideration of a decision to take the eggs for examination.

9.8 Time to lay clutch

Eggs are generally laid at 4-5 day intervals. The male will commence incubation when all eggs are laid but may commence after the 4th egg. He may however brood the eggs until incubation commences.

9.9. Egg weights and measurements

Weight range - 500 - 800g

Measurements of six eggs:-

137mm x 95mm

129.6mm x 91.7mm

134.7mm x 95.3mm

143.4mm x 97.8mm

130.1mm x 92.4mm

138.1mm x 98.4mm

9.10 Diet changes while rearing young

Chicks being parent raised will require food to be provided in smaller portions though the males are known to break up the food and drop it in front of the chicks. Insects such as mealworms can be provided for the chicks.

The cock bird will pick up food items and drop it in front of the chick followed by a short burst of

beak clapping to gain the chicks attention and direct it to the food. Once the chick understands what happens at feed time it will feed independently taking food only occasionally from the father though the cock bird would continually offer food indicating that it was simply a progressive behaviour. This will happen for many months (Wexler 1995)

9.10 Age of removal from parents and age of independence

Chicks can remain with the male up to 18 months of age but are likely to be independent before then. However if any aggression is displayed by the male or female if still in the enclosure the young should then be removed. Ideally the young should be removed prior to the next breeding season to allow the pair to breed again. Though in the wild the chicks can remain with the male resulting in his breeding every two years (David Westcott, pers com).

9.11 Use of foster species

Emus have been used to hatch cassowaries at Wildworld (Bullen pers com). Three eggs apparently late in incubation were placed under an emu that was incubating eggs at that time. The eggs successfully hatched and the chicks were hand raised.

10.0 ARTIFICIAL INCUBATION

There is a wealth of information on artificial incubation techniques. This section will be dealing with specifics relating to cassowaries and assumes some understanding of artificial incubation techniques.

10.1 Reasons for artificial incubation/handrearing

Aggression by the parents towards the chicks or the continual breaking of eggs by either bird may prompt people to remove the eggs. The maximisation of egg/breeding potential is a common reason and used extensively in aviculture. However it has been found that the more eggs that are pulled for artificial incubations the greater the rate of infertile eggs. The male becoming sick, dying or displaying some form of mis-parenting are all reasons for removal of eggs or chicks.

10.2 Incubator type

Currumbin Sanctuary - Multiplo Electric Incubator - fan forced - manual turn 3 times daily.

A number of other incubators have been used. For manual turning 3 times seems adequate - results are no different if eggs are turned more often. The eggs should be set on their sides. They should be turned 180° each time rotation alternating clockwise then anti clockwise. The eggs don't need to be turned for the last 7 days before hatching

10.3 Incubation temperatures and humidity

Temperature should be measured at the same level that the eggs are located in the incubator.

Multiple thermometers should be used. These should be of good quality. A cryometer is useful in measuring temperatures - this should be left on for ½ - 1 hour.

Relative humidity can be measured using a dial hygrometer.

One critical factor influencing hatching results appears to be incubator humidity. Cassowaries naturally occur in areas of high humidity and their eggs may be particularly susceptible to embryo desiccation following excessive water loss.

Temperature does appear to be critical also. A temperature that is too high results in premature hatching and the chicks will not survive. It is recommended that the temperature not go above 36.1 °C dry bulb. Late deaths are often related to high temperature.

Denver Zoo had success with a dry bulb reading of 36.1°C and a wet bulb reading of

30.6°C.(Birchard et al 1982). Relative Humidity 68%.

Currumbin Sanctuary - Dry - 35.5 - 36.7°C (Av 36.4)

Wet - 27.2 - 30.6° C(Av 28.3)

Melbourne Zoo - Dry - 36.5° C

Wet - 31.1 - 31.7° C

Ten days before hatching the humidity increased to a wet bulb reading of 31.7 - 31.8°C and the temperature decreased from a dry bulb reading of 36.5° to 36.2 °C.

10.4 Desired % weight loss

12-15% weight loss is the generally desired range for most eggs. Rundel finds that 12-15% is most successful but successful hatches have occurred from 12% to 20% weight loss. Currumbin Sanctuary successfully hatched a chick with an 11% weight loss.

10.5 Normal pip to hatch interval

1 - 24 hours

10.6 Assisted hatch

Assisted hatch is sometimes necessary. Male birds have been observed assisting chicks out of the shell. Rundel has had a problem with mal-positioned chicks with an estimated 20% exhibiting this problem. This can be seen with an infrared candler - the chick expanding through the air cell. It is not always a disaster.

For an assisted hatch, create a hole in shell at the top where the air cell is - do not break the membrane. The movement of the chick can then be checked by holding a torch against the membrane. Prick the membrane with a dull probe if required. If membrane starts to bleed, STOP. Exposing the nostrils of the chick will increase the activity of the chick. The head can be located by x-ray or by flicking the shell with a fingernail while holding the egg to the ear to listen for the location of the call.

10.7 Other

Eggs can be left for a number of days on a table in a well ventilated area before being set in the incubator. It is better to set a clutch together for synchronised hatching and easier handrearing.

To detect movement in eggs you can place a piece of straw from a straw broom on the top of the egg attached with a piece of blue tack. By watching for movement you can detect the heartbeat.

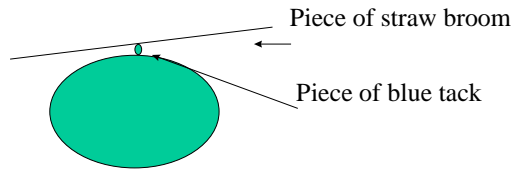


Figure 5 Simple method for detecting a heartbeat in an egg

When hatching, the eggs can be placed on the floor of the incubator on a towel or similar solid surface to give them adequate secure footage when hatched.

11. 0 ARTIFICIAL REARING

11.1 Brooder types/design

Boxes measuring approximately 2m x 1m x 0.8m high have been used by Currumbin Sanctuary, Taronga Zoo, Fleay's Wildlife Park and Rundel. All four had solid sides with an overhead light - Rundel uses a 100 watt bulb and a heating pad at one end.

Currumbin used a heat lamp at one end to create a slight temperature gradient.

11.2 Brooder temperatures

Cassowary chicks are not cold tolerant and must be kept reasonably warm. It is best to maintain the chicks initially at 30°C. A slight temperature gradient is advisable.

11.3 Diets

Feeding - chicks generally do not eat for 2-6 days as the yolk is absorbed. To start the chick feeding a day old chicken tutor may be used. This also provides any single chicks with company which appears to be important (Roy Dunn pers comm)(Rundel). Otherwise tapping the feeding dish with a pen or similar object will stimulate the chick to show interest. A low bowl of water should be provided always and will usually be used before food is eaten.

It is important to weigh birds daily at first to ensure weight gain is not too much. As with other ratites too much weigh and too much protein coupled with a lack of exercise can cause leg problems.

The diet is fairly similar to the adults. Soaked sultanas and diced tomato and banana are good starting foods . This can be sprinkled with Wombaroo Insectivore. Nekton S has also been added to supply trace vitamins and minerals. Mealworms will be readily eaten . Calcivet has also been added to their drinking water.

Insectivorous food is necessary for the first 2 weeks of the cassowary chicks life. (Lint 1981)

Birds should be fed 2-4 times daily. Pinkies can be offered from 2 weeks of age.

Grit is offered in a separate dish by some breeders (Lint 1981).

Dietary Deficiencies:

Flieg (1972) listed the following visible signs of vitamin and mineral deficiency that can be recognised in young ratites :

Vitamin A - Failure of newly hatched chicks to gain weight - older individuals get runny eyes and formation of pustules on the palate and a general stunting of growth.

Vitamin B1 - Chick becomes listless and stops eating.

Vitamin B2 - Curled toe paralysis evident or suspected (clenched fist as toes curl inward)

Vitamin B6 - Goose stepping gait when half grown

Vitamin D3 - Occurs mainly when the chicks are kept indoors - deficiency is marked by slow and apparently painful gait in chicks 3-4 weeks old.

Iron - Anaemia, listless and weight loss

Manganese - Slipped tendon disease

Calcium & Phosphorus - Deficiency will cause nutritional secondary hyperparathyroidism, while excess will prevent absorption of other minerals.

11.4 Special requirements

As with all ratites it is of vital importance that the chicks are exercised daily preferably 2-3 times. The chicks will follow staff as they jog around a suitable area. Thirty minutes 2-3 times daily is a suggested starting point.

Company is important for the chicks either other cassowary chicks or a young chicken can substitute. The provision of a chick also assists in stimulating exercise.

A dirt bath is appreciated from about 2 weeks of age. Dig out a depression in the soil and run water into the depression. The chicks will roll on back in the mud.

Brooder box substrate should be a non slip surface such as astro turf. Do not use soft sand as a substrate. Indoor/ outdoor carpet is a good substrate or rubber matting which can be easily cleaned.

11.5 Marking methods

Until chicks are old enough to implant marking methods such as stock spray on various parts of the body can be used.

11.6 Table Three Growth charts/ developmental notes

Chick 1 Adelaide Zoo Artificially incubated 51 days - hand-raised

Chick 2 Adelaide Zoo Naturally incubated - hand-raised

Chick 3 Adelaide Zoo Naturally incubated - hand-raised

Chick 4 Adelaide Zoo Artificially incubated for final 33 days - hand-raised

Chick 5 Adelaide Zoo Artificially incubated for final 33 days - hand-raised

Chick 6 Adelaide Zoo Artificially incubated for final 37 days - hand-raised

Chick 7 Billabong Sanctuary Townsville Naturally incubated - hand-raised

Chick 8 Currumbin Sanctuary Artificially incubated - hand-raised

	Chick 1	Chick 2	Chick 3	Chick 4	Chick 5	Chick 6	Chick 7	Chick 8
Day	Weight	Weight	Weight	Weight	Weight	Weight	Weight	Weight
Hatch	466g		402g	460g	470g			499g
1	429g	394g	380g	440g	455g	362g		
2	408g	377g	364g	414g	417g	346g		
3	394g		392g	426g	401g	333g		460g
4	387g	338g	383g	416g	381g	324g		459g
5	391g	326g	393g	391g	373g	314g		478g
6	404g	340g	410g	428g	362g	310g		485g
7	395g	379g	402g	441g	351g	312g	210g	480g
8	413g	390g	439g	445g	342g	304g	265g	501g
9	421g	394g	464g	454g	335g	292g	388g	545g
10	431g	348g	479g	458g	328g	295g	404g	546g
11	403g	330g	484g	474g	339g	323g	400g	600g
12	412g	356g	500g	503g	358g	329g	390g	584g
13	459g	376g	498g	530g	356g	299g	360g	557g
14	450g	383g	556g	570g	346g	310g	412g	550g
15	494g	403g		592g	321g	332g	432g	600g
16	478g	420g	591g		328g	353g	432g	597g
17	528g	392g		538g	316g	362g		609g
18	560g	427g	608g	613g	328g	360g		603g
19	583g	464g		647g	330g	364g	436g	652g
20	593g	460g	653g	673g	336g	404g	490g	660g
21	651g	467g	677g	685g	338g	399g	524g	684g

22	699g	503g		724g	352g	391g	608g	740g
23	730g	496g		742g	357g	410g	622g	750g
24	734g	532g	698g	760g	372g	415g	636g	855g
25	785g			740g	423g	435g	665g	793g
26	815g	576g	865g	772g	437g	474g	620g	
27	799g		884g	844g	450g	500g	690g	
28	894g	605g		837g	490g	545g	692g	936g
29	871g		992g	888g	503g	562g	694g	890g
30	936g	655g		894g	577g	540g	778g	900g
31	942g	697g	1025g	920g	541g	555g	744g	970g
32	965g			987g	550g	591g	762g	997g
33	952g		1075g	956g	601g	600g	802g	
34	974g	761g		987g	661g	630g	870g	1073g
35	1179g			1089g	711g	617g	938g	
36	1226g	902g		1156g	734g	635g	940g	1196g
37	1251g			1136g	700g	691g	988g	1260g
38		919g		1078g	720g	698g		1240g
39	1413g			1157g	728g	714g	1050g	1247g
40		1049g		1175g	728g	767g	1074g	1274g
41				1202g	769g	809g	1170g	1295g
42		1125g	1591g	1222g	762g	854g	1176g	1335g
43	1668g			1185g	850g	887g	1148g	
44		1216g		1155g	851g	956g	1194g	1364g
45				1288g	890g	999g	1238g	
46	1822g			1342g	933g	1108g	1230g	
47				1350g	982g		1267g	
48				1399g	986g	1096g	1302g	1546g
49				1366g	980g	1218g	1342g	
50				1428g	1001g		1500g	
51				1379g	986g		1624g	1704g
52				1374g	1006g			
53		1816g		1368g	1047g			
54				1454g	1066g		1530g	1745g
55			2394g	1468g	1078g		1590g	
56				1501g	1136g		1960g	

57				1565g	1104g		1760g	
58	2512g			1520g	1179g		1880g	2025g
59				1591g				
60					1223g			2010g
61				1725g	1217g			
62				1682g	1248g			
63				1724g	1253g			2030g
64				1742g	1274g			
65				1763g	1222g			
66		2963g		1742g	1332g			2600g
67				1880g	1405g			
68				1918g	1533g			
69				1938g	1545g			
70				2043g	1585g			
71				2137g				3000g
72					1591g	1893g		
73				2127g	1680g			3200g
74				2231g				
75						2022g		
76					1753g	2308g		
77				2272g	1750g	2121g		3300g
78				2270g		2310g		3300g
79				23880g	2122g	2414g		3300g
80				2412g	1933g			3800g
81				2482g				4100g

11.7 Hygiene and special precautions

As with all species it is important to maintain enclosure hygiene and provide the food on clean plates.

On hatching some people recommend the use of betadine on the navel to reduce the risk of “egg yolk” infection.

Birds in the wild would normally spend a lot of their day on the move with the male looking for food. In captivity the chicks will normally readily follow humans and can be taken for walks. If release is an option then a cassowary costume should be considered.

11.8 Behavioural considerations eg. use of puppet/ tape

The use of a mirror in the brooder and a cassowary head hand puppet when teaching the chick to eat may reduce imprinting, though imprinting does not appear to present a great problem.

Aggressiveness to other chicks can start at 12- 14 months though has been seen in chicks under 6 months. Aggressiveness towards staff may start under 2 years.

11.9 Weaning

Cassowaries are a fairly precocial species and will learn to eat within a few days from a dish on their own.

11.10 Rehabilitation procedures

If breeding for rehabilitation then it is ideal that the birds are parent reared. Important considerations include diet recognition, social skills and lack of association between humans and food.

Ideally the birds would be housed in a large natural enclosure preferably at the release site which could then be used for a soft release.

12. Acknowledgments

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14.0 Glossary of Terms

ARAZPA: Australasian Regional Association of Zoological Parks and Aquariums

Brood: Sitting on eggs without actually incubating them. Incubation requires copious transfer of heat from the bird to the egg. This requires close contact between the egg & the blood stream of the bird. During brooding this does not occur.

C4 : Community for Coastal and Cassowary Conservation, Mission Beach

Cloaca: The single vent opening of a bird located on the underside just above the tail. The cloaca is the combined opening for the digestive and reproductive system of the bird.

Clutch: A set of eggs

Double Clutching : If a pair either suffers a nest failure or has their first clutch of eggs removed early in the breeding season they may produce another clutch within a short period.

Dry Bulb : Ordinary dry thermometer used for measuring heat without regard for humidity.

Dummy Egg: A non-viable or artificial egg placed under a bird when its own egg is removed or it may be placed in a preferred nest site to encourage a more suitable nest position. It can also prolong incubation in a target pair.

Hygrometer: Instrument used to measure humidity in the air

Incubation: Process of applying heat to eggs to cause embryonic development to take place

ISIS: International Species Information System.

Malposition: Term used to describe an embryo that is in the incorrect hatching position when hatch time arrives

QWPA: Queensland Wildlife Parks Association

Wet Bulb : Wet bulb thermometer has a moist wick on it used for measuring heat. The reduction in temperature due to the water evaporation is directly related to the relative humidity in the surrounding air.

15.0 Products Mentioned in text

Petvite (vitamin & mineral powder)

Marrickville Holdings Ltd

I.G.Y. Veterinary Products,

74 Edinburgh Road,

Marrickville NSW

Wombaroo Insectivore Rearing Mix

Wombaroo Food Products

P.O. Box 151

Glen Osmond SA 5064

Nekton S

Nekton Produkte

75177 Pforzheim

Germany

Calcivet

Vetafarm

3 Bye Street

Wagga Wagga NSW 2650

Betadine

Antiseptic Solution

Faulding Pharmaceuticals

1538 Main North Rd

Salisbury SA 5108

POST MORTEM RECORD Sheet - Appendix 2

SPECIES:

SEX: DOB / AGE: ARKS NO:

ID: OTHER:

DATE OF DEATH: _____ LOCATION: _____ PM DATE: _____

POST MORTEM CODE: _____ VET: _____

FINAL DIAGNOSIS:

HISTORY:

GROSS POST MORTEM FINDINGS:

Wt. _____

General Body
Condition

Gastrointestinal

Respiratory

Musculoskeletal

Urogenital

Neurological

Cardiovascular

Reticuloendothelial

Endocrine

SAMPLES COLLECTED

Histopathology

Microbiology

Parasitology

Other
Research
Samples

TENTATIVE DIAGNOSIS

REGIONAL STUDBOOK: LOCATION GLOSSARY

ADELAIDE	Adelaide Zoological Gardens Frome Rd., Adelaide, South Australia, AUSTRALIA, 5000, 61 8 267 3255.
AIRLIE BE	Airlie Beach Wildlife Park P.O. Box 21, Airlie Beach, Queensland, AUSTRALIA , 4802, 61 79 461377.
AMBER PAR	Amber Park Ostrich Farm Joadja Road, High Range Mittagong, New South Wales, AUSTRALIA, 61 48 78 5258.
BEERWAH	Queensland Reptile & Fauna Park Glasshouse Mountains, Beerwah, Queensland, AUSTRALIA, 4519, 61 71 941134.
BILLABONG	Billabong Sanctuary Bruce Highway, Townsville, Queensland, AUSTRALIA, 4816, 61 77 78 8344.
CAVERSHAM	Australian Animal & Bird Rehab Caversham, West Australia, AUSTRALIA.
CUDLEE CK	Gorge Wildlife Park Redden Dr., Cudlee Creek, South Australia, AUSTRALIA, 5232, 61 8 389 2202.
CURRUMBIN	Currumbin Sanctuary 28 Tomewin St., Currumbin 4223, Queensland, AUSTRALIA, 61 7 5534 1266.
DOONSIDE	Featherdale Wildlife Park 217 Kildare Rd., Doonside, New South Wales, AUSTRALIA, 2767, 61 2 9622 1705.
DREAMWRLD	Dreamworld Dreamworld Parkway, Coomera, Queensland, AUSTRALIA, 4210, 61 7 5588 1111. (Note also known as COOMERA)
EACHEM CP	Lake Eachem Caravan Park Lake Eachem, Queensland, AUSTRALIA.
FLEAYFAUN	Fleay's Fauna Centre P.O. Box 612, Burleigh Heads, Queensland, AUSTRALIA, 4220, 61 7 5576 2411.
GONDAWANA	Gondawana Rainforest Sanctuary PO Box 3888, South Brisbane, Queensland, AUSTRALIA, 4101
GOSFORD	Australian Reptile Park P.O. Box 192, Gosford, New South Wales, AUSTRALIA, 2088, 61 43 284 311.
HALIFAX	Halifax Wild location, Queensland, AUSTRALIA.
HAMIL ISL	Marineland of Hamilton Island P.O. Hamilton Island, Hamilton Island, Queensland, AUSTRALIA, 4803, 61 79 46 9999.
HARTLEY C	Hartley Creek Wild location, Queensland, AUSTRALIA.
HARTLEYS	Hartley's Creek Crocodile Farm PO Box 171, Palm Cove, Queensland, AUSTRALIA, 4879, 61 70 55 3576.
INNISFAIL	Johnstone River Crocodile Farm PO Box 381, Innisfail, Queensland, AUSTRALIA, 4860, 61 70 611121.
INNISFIL	Innisfail Wild location, Queensland, AUSTRALIA.

IRON RNGE	Iron Range Wild location, Queensland, AUSTRALIA.
KATHERINE	Ted Mckechnie Katherine, Northern Territory, AUSTRALIA.
KURANDA	Kuranda Wild location, Queensland, AUSTRALIA.
LONE PINE	Lone Pine Koala Sanctuary Jesmond Road, Figtree Pocket, Queensland, AUSTRALIA, 4069, 61 7 33781366.
MELBOURNE	Melbourne Zoological Gardens P.O. Box 74, Parkville, Victoria, AUSTRALIA, 3052, 61 3 285 9300.
MISSION B	Mission Beach Wild location, Queensland, AUSTRALIA.
MOURILYAN	Mourilyan Wild location, Queensland, AUSTRALIA.
PALMGROVE	Wildworld Australia Captain Cook Highway, Palm Grove, Queensland, AUSTRALIA, 4870, 61 70 553 669.
PEARL CST	Pearl Coast Wildlife Park Lullfritz Dr., Broome, West Australia, AUSTRALIA, 6725, 61 91 921703.
PERTH	Perth Zoological Gardens P.O. Box 489, South Perth 6151, West Australia, AUSTRALIA, 61 9 367 7988.
PHILIP IS	Phillip Island Wildlife Park Cowes Road, Victoria, AUSTRALIA, 61 59522038.
PROSERPIN	Proserpine Wild location, Queensland, AUSTRALIA.
PTDOUGLAS	The Rainforest Habitat Port Douglas Rd., Port Douglas, Queensland, AUSTRALIA, 4871, 61 70 99 3235.
ROCKHAMPT	Rockhampton Botanic Gardens Zoo PO Box 243, Rockhampton, Queensland, AUSTRALIA, 4700, 61 79 311254.
ROWLEY RE	Rowley Reserve Western Australia, AUSTRALIA.
SANDERSON	Crocodylus Park PO Box 530, Sanderson, Northern Territory, AUSTRALIA, 0812, 61 889 472510.
SUGAR WRL	Sugar World Queensland, AUSTRALIA.
SYDNEY	Sydney's Taronga Zoo P.O. Box 20, Mosman, New South Wales, AUSTRALIA, 2088, 61 2 9969 2777.
TULLY NQ	Tully Wild location, Queensland, AUSTRALIA.
YARRABAH	Yarrabah Wild location, Queensland, AUSTRALIA.